Masonry Construction Explained

Guidance on housing applications and thermal performance

Mineral Products Association

Contents

About this publication

This guide provides an introduction to the use of masonry and concrete in low-rise housing, starting with the benefits they provide. This is followed by an overview of block and brick types/sizes (page 4), external cavity walls (page 13) and beam and block ground floors (page 17). Each of these sections cover the basic format, material options and performance properties. The second half of this guide provides key thermal performance information for masonry and concrete, starting with thermal bridging considerations (page 20) and followed by extensive U-value and thermal property data for a range of external walling systems (page 21). The U-value information complements the limited examples provided by the Future Homes Hub in its Part L masonry guide, and uses the same technical specification/assumptions. The final part of the guide provides an overview of the passive thermal performance provided by the thermal mass in masonry and concrete, which has the ability to reduce the risk of summertime overheating (page 32) and reduce space heating loads in the heating season using Passive Solar Design (page 33).

Broader technical guidance on areas relating to the current edition of Part L and the Future Homes Standard is provided by the Future Homes Hub, and includes publications such as 'Part L 2021 – Where to Start', which covers topics including air leakage, space heating and renewables as well as example housing specifications. Links to further sources of information, trade bodies and The Concrete Centre publications can be found at the end of this guide.

Guidance relating to the carbon performance of masonry and concrete is covered elsewhere by The Concrete Centre and MPA Precast and includes the following publications:

- The UK Concrete and Cement Industry Roadmap to Beyond Net Zero.
- The latest Precast Concrete and Masonry Sustainability Report.
- Industry average and manufacturer's Environmental Product Declarations.

Cover image: Project 80 housing development, Birmingham.
For more information, see case study on page 34.

Use of masonry and concrete

The best housing over the coming decades will be built in a way that adapts to our changing climate whilst also meeting our health, wellbeing and changing life style needs. Additionally, it must provide a high level of carbon and energy performance. Underpinning all this must be a construction that is resilient and durable. Collectively, all of these needs are most easily met using masonry and concrete as their inherent properties greatly simplifies the overall design challenges, some of which are outlined below:

Fire

Concrete and masonry are classed as A1 under EN13501-1:2018[1], meaning it is a material that cannot contribute to a fire at any stage as it is considered non-combustible both as an engineered structure, and as a material in its own right. Concrete and masonry provide built-in fire protection – there is normally no need for additional measures, simplifying the design process.

Noise

The minimum Part E (Resistance to the passage of sound) airborne sound resistance for the dividing walls and floors between new build homes is currently 45dB. This can easily be achieved using heavyweight materials, due to their inherent mass, stiffness and damping properties. Concrete and masonry separating wall and floor solutions are detailed in Part E and also in the Robust Details scheme, which offers a practical alternative to the pre-completion sound testing that is otherwise required by Part E. Specific requirements for finishes and any additional acoustic insulation are also set out in Part E and Robust Details.

Security

This is perhaps the most basic design requirement of a home and, from a home buyer's perspective, it seems security and other health and wellbeing considerations rank more highly than energy bills[2]. Concrete and masonry walls provide secure and robust enclosures, able to withstand criminal attack with little or no additional measures. Other ways in which the building fabric can be used to enhance home security include specifying concrete floors below and/or robust walls between shared attic spaces in apartment blocks, and masonry or concrete facades in vulnerable locations such as road sides.

Overheating

Part O of the Building Regulations deals with overheating mitigation, with an emphasis on the removal of excess heat through solar control and ventilation. Alongside this, the beneficial thermal mass properties provided by heavyweight materials is also accounted for when the dynamic thermal modelling option is used to assess Part O compliance. The use of thermal mass in combination with night-time ventilation can significantly enhance a dwelling's overheating resilience and general level of comfort (see section on use of thermal mass to reduce overheating).

Flood resilience

A key recommendation of BS 85500, Flood Resilient Construction is the use of a range of concrete and masonry structures, as they retain their structural integrity in flood conditions. Masonry construction can be designed to have the strength to keep water at bay, and provide a stable support for a water proof barriers where resistance is required. It is also resistant to rot or fungal growth when water does get in, facilitating recovery after a flood event.

Thermal performance

UK Building Regulations (Part L) have seen many improvements in thermal performance requirements over the past decades, with 1985 marking a key change that saw cavity wall insulation becoming a standard requirement in new homes. More recent years have seen further uplifts for all aspects of thermal performance, including insulation, airtightness, thermal bridging and overheating measures. Throughout this progression, masonry construction has continued to keep pace with changing thermal performance standards, without compromising its key qualities of strength, durability and simplicity of construction. Examples of external masonry and concrete wall build-ups that satisfy current and future U-value requirements can be found later in this document, in the section on U Values and thermal mass properties (page 21). Another useful quality of heavyweight construction materials is the passive thermal performance provided by their thermal mass which, alongside enhancing overheating performance, can also be used to reduce space heating loads in the winter months. This is achieved through the material's ability to store and release useful solar gains from south facing windows and is referred to as Passive Solar Design (see page 33).

Whole life carbon

At the material level, whole life carbon encompasses the lifecycle emissions arising from manufacturing, installation, maintenance, replacement, and end-of-life processing. The lifecycle emissions from masonry and concrete are lowered by their durability, which ensures a long service life that ultimately ends with virtually all the material being reused or recycled. Concrete also recarbonates over its life cycle, meaning that it steadily absorbs atmospheric CO_2, helping offset some of the initial manufacturing emissions. At a building level, the passive thermal performance offered by heavyweight materials can reduce the energy demand for heating and cooling, helping enhance whole-life carbon performance. More information on whole life carbon can be found in the publication *Life cycle carbon analysis of a six-storey residential building*, published by The Concrete Centre, which details the findings of research into the performance of a contemporary, high thermal mass, concrete residential building in London.

Concrete block types and uses

Concrete blocks are the most common structural component in the construction of UK homes, and have been for over 100 years. They provide a well understood, flexible means of building low-cost, durable homes. Blocks also offer a number of other useful attributes, such as good acoustic performance, fire resistance, flood resilience, and thermal mass, which helps provide a stable year-round temperature. From an environmental perspective, they are locally produced and can have a high recycled content. There are essentially two types of concrete block: aggregate blocks, which as the name suggests contain aggregates; and aircrete blocks, made from a type of concrete that contains air pores and has no aggregates larger than ground sand. Both types are well suited to housing, and are available in a range of sizes and densities, offering different structural and thermal characteristics (see Figure 1). Blocks are manufactured to the BS EN 771 standard and CE and/or UKCA Marked. All types are fire resistant i.e. classed as non-combustible and require little or no maintenance over their life span.

Aggregate blocks

Aggregate blocks come in a wide range of densities and compressive strengths, which are grouped into the three categories of ultra-lightweight, lightweight and dense (see Figure 1). Ultra-lightweight and lightweight blocks are manufactured from cement together with one of a variety of natural or man-made expanded aggregates. These include: granulated or foamed blast-furnace slag, expanded clay, pumice, or shale, furnace bottom ash and fly ash from power stations. The density of the aggregate is generally proportional to the strength of the block. Ultra-lightweight and lightweight blocks are typically used in internal and external walls and applications that do not require the additional strength provided by dense aggregate blocks. They also provide a lower level of thermal conductivity, so offer slightly better insulating properties. Block weight is typically in the range of 8.5-20 kg for widths of 100mm, with lower weights offered by cellular and hollow aggregate blocks. Dense aggregate blocks offer the highest levels of compressive strength, acoustic performance, thermal mass and low air permeability, which can enhance year-round thermal performance and comfort.

Aircrete blocks

Invented in the mid-1920s, aircrete blocks are made from cement, lime, sand, fly ash and water, which are mixed to form slurry. A small amount of aluminium powder is then added, which reacts with the lime to form tiny bubbles, causing the mixture to expand into a 'cake'. When the mixture is partially set, it is cut to form blocks and then cured in a steam autoclave. Aircrete blocks are the lightest option, giving them better insulation properties in comparison to aggregate blocks, reducing heat loss through external walls and junctions. They are a popular choice for external walls and foundations, performing a similar range of functions as aggregate blocks, but they are not suitable for applications requiring compressive strengths greater than around 9N/mm^2, although some aircrete products offer an equivalent compressive strength to 10.4N blocks. Their relatively light weight makes them easy to handle and work with on site.

Typical block density (kg/m^3)	Aircrete block (generic description)	Aggregate concrete block (generic description)	Approximate compressive strength (N/mm^2)	Approximate thermal conductivity (W/mK)	Approximate thermal mass (ISO 13786) (kJ/m^{2}k)
460	Lightweight	-	2.9-3.6	0.11	46
600	Standard	-	3.6	0.15	60
730+	High strength	-	7.3-9.0	0.19	73
850	-	Ultra-lightweight	3.6-7.3	0.28	85
1450	-	Lightweight	3.6-10.4*	0.6	145
1900+	-	Dense	7.3-40	1.33	200

*17.5Nmm^2 lightweight blocks are also available from some suppliers.

Figure 1: Basic block types and properties

Block strength

For dwellings of one or two storeys, blocks with a compressive strength of 2.9N/mm² or higher are generally suitable for the inner leaf of cavity walls (refer to Building Regulations - Approved Document A). For three storeys or where the storey height is greater than 2.7m, blocks with a compressive strength of 7.3N/mm² or more may be needed for specific parts of the structure.

However, structural design may show that lower strength blocks are acceptable. In addition to structural loading, specific project circumstances, such as the need for sulphate resistance for blockwork below ground, can also determine the strength requirement.

Block sizes

Blocks are produced in a broad range of sizes, but for general building work the most commonly used is referred to as a standard block and measures 440mm x 100mm x 215mm (see Figure 2). Usefully, this is the same length as two bricks and the height of three bricks with 10mm mortar joints. Alternative widths are available to meet particular design needs (see Figure 3), although some of the options may be specific to either aircrete or aggregate blocks only. In addition to the standard face size of 440mm x 215mm, there are several alternative options that can improve site productivity. In general, the lower weight of aircrete enables blocks with a larger face size to be specified while still meeting manual handling requirements (see 'Large format aircrete blocks'). Aggregate concrete blocks can be specified with slightly smaller face sizes, helping to reduce weight and aid handling, which can be useful when working with dense blocks. Figure 4 shows the main options.

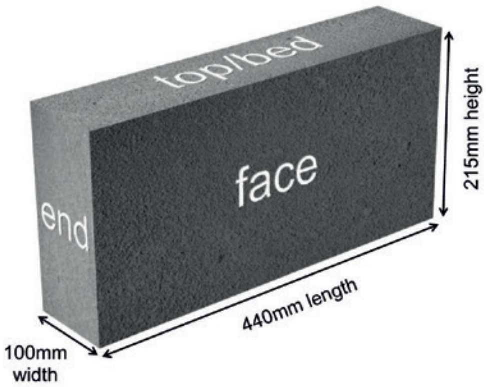


Figure 2: Standard block dimensions

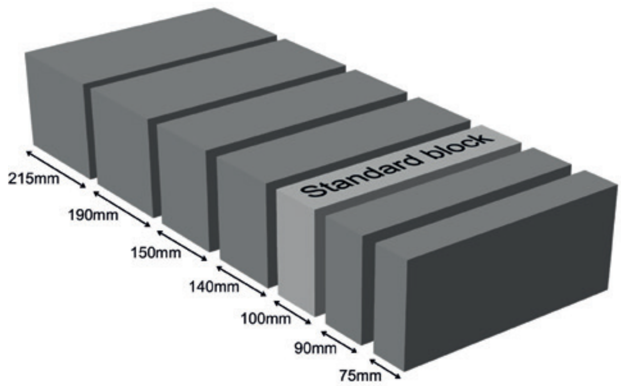


Figure 3: Commonly available block widths for general construction
(width options may vary with face size and block type)

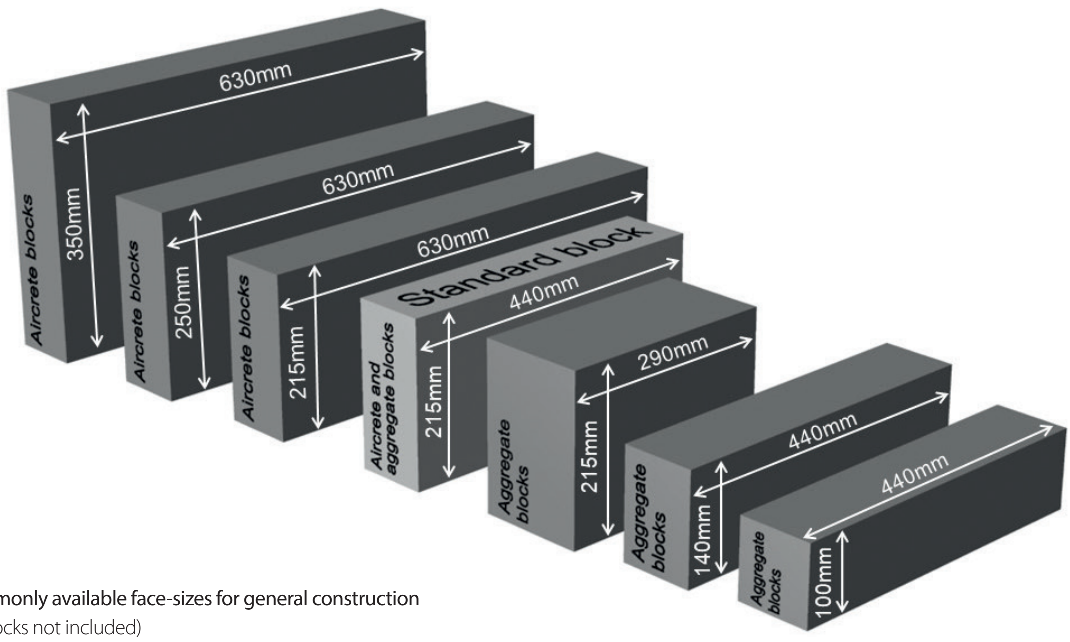


Figure 4: Commonly available face-sizes for general construction
(foundation blocks not included)

Large format aircrete blocks/thin-joint construction

The relatively light weight of aircrete makes possible the manufacture of large-format blocks that can also be produced to a high standard of dimensional accuracy (see Figure 4 on previous page). This allows much thinner mortar joints of only 2-3mm, using a special adhesive that starts setting in around 10-20 minutes and reaches full strength in only 2-3 hours; conventional mortar takes around 24 hours before further loading can be applied. The system, known as thin-joint, enables faster build times and is capable of delivering around 3m (or one storey height) per day, as compared to the 1.5m (seven courses) recommended for standard blocks with traditional mortar joints.

It is also possible to build the inner thin-joint leaf of a cavity wall independently of the outer leaf, by the use of purpose-made helical wall ties that do not have to be installed as the blocks are laid (see Figure 5). Instead, they are fitted by hammering them directly into the blockwork as the outer leaf is constructed (they do not need to align with the block joints). The ability to build the inner leaf independently means follow-on trades can start work sooner in a weatherproof environment, while retaining the flexibility of on-site construction. The thermal characteristics of large format blocks are the same as for other aircrete blocks, although the thinner mortar joints afford a small reduction in thermal bridging compared to standard mortar joints.

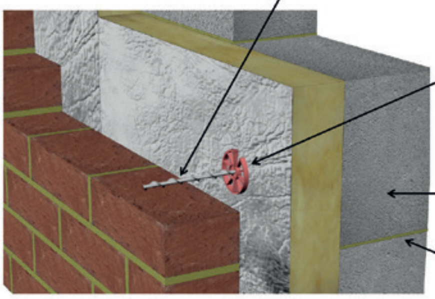


Figure 5: Thin-joint construction wall ties (large format blocks)

Foundation blocks

Foundation blocks are specifically designed for use below ground level and provide a fast and convenient means to construct a base to support cavity and solid walls, plus beam and block floors. They are available in both aircrete and aggregate formats, providing resistance to moisture, freeze/thaw and sulphate attack, while also offering a useful level of thermal performance. Compressive strengths are in the range of 3.6-7.3N/mm^2, for aircrete and aggregate blocks. A higher strength option of 10.4N/mm^2 or more is available but limited to aggregate blocks. Foundation blocks come in a range of sizes that will span cavity walls of varying widths (see Figure 6). Many foundation blocks can also be used above ground, for solid wall construction.

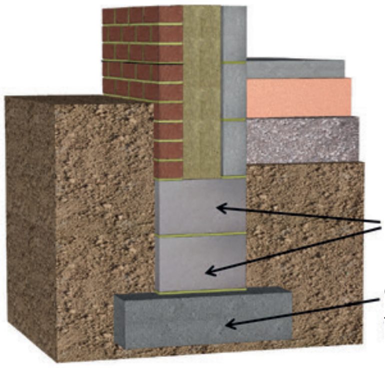


Figure 6: Foundation blocks supporting a cavity wall

Concrete coursing blocks

Concrete coursing blocks have a reduced height, typically 65mm (the same height as a standard brick), and are used for infilling small areas in walls so that a consistent level (coursing height) can be maintained when laying blocks. For example, they may be used in conjunction with lintels, above windows or doors and when installing a beam and block floor (see Figure 7). They are generally suitable for all types of construction above and below damp-proof course (DPC) level, helping to simplify the build process and reducing the need to cut blocks on site. Coursing blocks are manufactured in aggregate and aircrete formats, both of which are available in a range of strengths and sizes to complement whichever block type is being used for the general build.

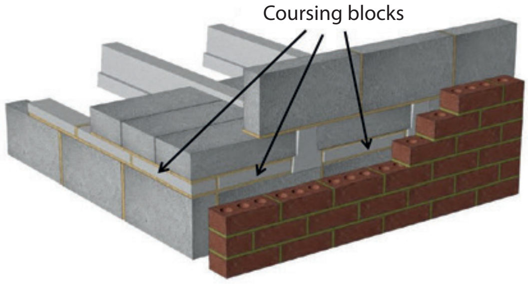


Figure 7: Example of coursing blocks being used with a beam and block floor

Paint grade blocks

Paint grade blocks are manufactured with a close texture, making them suitable for painting. The close texture helps to deliver a smooth, low-maintenance finish when left unpainted but slight variations in colour may be discernible. Blocks are usually supplied on the basis of one good face and end.

Facing blocks

Facing blocks are available in a large variety of colours and textures for use both externally and internally. They combine decorative appeal with the inherent strength and durability of concrete, while also providing a maintenance-free finish. Facing blocks are intended for projects where colour consistency and texture are important. Blocks are usually supplied on the basis of one good face and end.

Hollow blocks (aggregate blocks only)

Hollow aggregate blocks contain one or more voids that pass through from top to bottom (see Figure 8). They are available in a range of sizes and strengths and have around 30%-40% the weight of a solid block of the same size, making manual handling easier. Hollow blocks are suitable for general purpose construction and are often used in agricultural and commercial applications. A useful benefit is the ability to build very strong reinforced walls by filling all or some of the cores with poured concrete and steel rebar. They can typically be used above and below DPC level.

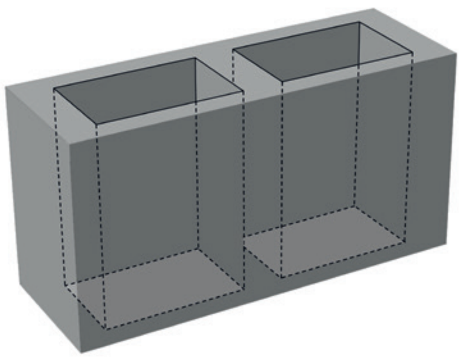


Figure 8: Hollow blocks have voids that pass through

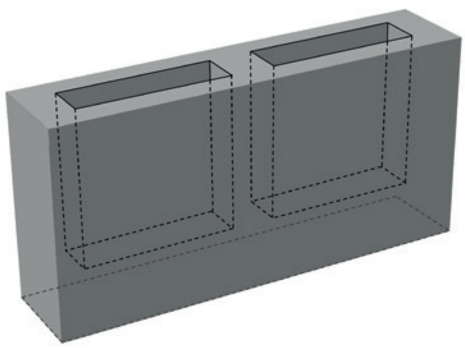


Figure 9: Cellular blocks have blind voids

Cellular blocks (aggregate blocks only)

Cellular blocks contain one or more blind cavities – in other words, the voids do not pass fully through like a hollow block, allowing a full bed of mortar on one face, and thereby making construction easier (see Figure 9). They can be used in one or both leaves of cavity walls up to three storeys, making them a lower-weight alternative to solid aggregate blocks. For example, a typical standard dense cellular 140mm-wide block can weigh up to 7 kg less than its solid counterpart, while providing similar properties. Other applications include internal partitions and infill walling for framed structures. Further benefits include improved thermal properties and a saving in materials, helping to enhance environmental performance. Cellular blocks are available in compressive strengths from 2.9-10.4N/mm^2, but are more commonly available within the range of 3.6- 10.4N/mm^2.

Image: Mark Waugh/Alamy Stock Photo

Brick types and uses

For centuries, bricks have been a defining feature of our built environment, being one of the most commonly-used materials for external walls in the UK. There are good reasons for the enduring popularity of brick, which centre on its aesthetic and practical qualities, including durability, fire and flood resistance, flexibility and good acoustic performance, with the need for little or no maintenance over its considerable lifespan. Alongside its inherent performance benefits, brick remains a cost-effective and simple product to use, supported by a well-established and knowledgeable UK supply chain. The vast majority of bricks are made of clay, offering a wide range of types, shapes, colours and finishes available to suit all needs.

Basic types of brick

Bricks are categorised by use, which is covered by three types: facing, common and engineering bricks. These represent the starting point when specifying, with a wide range of finishes and varying levels of strength, durability and frost-resistance.

Facing bricks

These are the most widely used brick type in the UK, particularly for housing. Facing bricks are typically specified on the basis of colour and texture, which can significantly influence a building's appearance. The finish and appearance is partly determined by the manufacturing process, which also has a bearing on cost (see Colours and textures). There is a broad range of facing bricks to choose from, ensuring that many options can be found for all types of project and individual preference.

Engineering bricks

These are specified for their physical properties rather than appearance as they provide high compressive strength and a low rate of water absorption. They are primarily used in civil engineering applications and where resistance to water penetration and/or frost damage is required. Applications include damp-proof courses, retaining walls, groundworks and manholes. Engineering bricks are rated as either Class A (compressive strength greater than 125N/mm^2) or Class B (compressive strength greater than 75N/mm^2), with the latter being more commonly used. Both types have a smooth finish and are typically reddish in appearance, although blue engineering bricks are also available.

Common bricks

These are actually the least common type of brick used in the UK and are suited to internal applications, sometimes being referred to as a 'fill' brick. They are relatively cheap to produce and are of a lower quality than the other types, with lower strength and less resistance to water and frost damage. Since common bricks will typically be hidden by an internal finish, limited emphasis is placed on appearance in the production process and product range.

Other brick types

Concrete bricks

These provide an alternative to clay bricks and are available in the usual formats – facing, common and engineering – making them suitable for a wide variety of internal and external applications, including below ground, where strength and durability are prime considerations. Concrete coursing bricks are also widely available for general coursing work, infilling small areas, and maintaining the coursing over lintels and at sills. For external walling and other visual applications, concrete facing bricks are produced in a range of colours and formats.

Image: Cultura Creative RF/Alamy Stock Photo

Calcium silicate bricks

These are made by mixing lime, sand and/or crushed flint or stone containing silica with water, and moulding the mixture into bricks under high pressure. These are then steam-autoclaved, causing the lime to react with the silica. In their natural state, the bricks are pale white, but pigments can be added during the mixing stage, enabling a wide range of colours to be produced. Calcium silicate bricks offer good freeze/thaw resistance, but, as with concrete bricks, it is important that they are used correctly – their detailing in respect of shrinkage and expansion differs from other types of brick.

Specials

These describe anything that is a non-standard shape (See Figure 10). They are a useful feature in masonry construction, delivering a range of design requirements while also providing a decorative touch that enhances the overall visual appeal. Suppliers offer a standard range of specials, covering the most popular options such as radials, cants, bullnose and angle bricks. Many suppliers can also provide non-standard specials when something more unusual or bespoke is needed.

Figure 10: Examples of brick Specials

Sizes and strength

Bricks are produced to a standard size of 215mm x 102.5mm x 65mm (face x bed x header), see Figure 11. This gives a coordination dimension of 225mm x 75mm when used in conjunction with a 10mm-wide mortar joint, which is usual. Non-standard brick sizes are also available if required, for example with an alternative header height of 73mm or 75mm. Some reclaimed bricks may conform to the old Imperial size of 3" or 2 ⁵⁄₈" instead of 65mm, making them incompatible with modern bricks. Requirements for the design strength of bricks are given in the British Standard PD 6697:2019. Typically, clay bricks with a minimum compressive strength of 9N/mm^2 are suitable for one- and two-storey dwellings and 13N/mm^2 for three storeys.

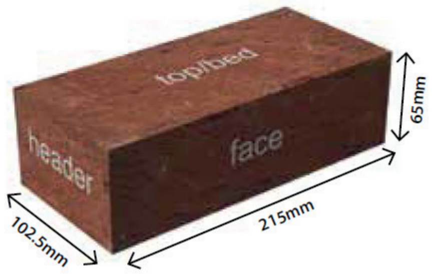


Figure 11: Standard brick dimensions

For guidance on setting out brickwork for buildings and determining the coordinating size in various applications see 'Designing to Brickwork Dimensions', published by the Brick Development Association (BDA).

Image: Simon Turner/Alamy Stock Photo

Brick colours and textures

The combination of different colours and textures results in thousands of different brick types. The UK brick industry makes products with varied surface textures and a rich diversity of colours, both facilitating the creation of innovative brickwork and allowing credible brick-matching when working with existing builds. A blend of different brick types and finishes can also be used in the same construction in order to create a unique appearance.

The body colour is largely dependent on the clay type. However, variation can also be achieved through methods such as body staining, surface sanding and different firing conditions.

Extruded products can be left with their initially smooth finish, but may also be modified, for example, by removing a sliver from the top and sides using a taut wire to produce a 'wiredrag' effect. (see Figure 12).

Extruded and semi-dry pressed bricks can also be textured by placing textured rollers around the brick column to create a rusticated or patterned effect when impressed into the clay.

Machine-made soft mud bricks generally have a sanded face and, as a result of the clay being dropped into the moulds, can also have a creased surface texture. The sand, which is used as a releasing agent, also greatly affects the finish of the brick. Water-struck bricks have a relatively smooth, sand-free texture as a result of water being used as the release medium. Handmade bricks have subtle creases and other natural irregularities that contribute to their individual appearance and charm. Further possible modification of fired products includes rumbling, whereby bricks are turned over in a machine similar to a large tumble dryer. The resulting attrition removes the sharp edges by chipping and rubbing.

For more information on colours, textures and brick making, see 'The UK Clay Brickmaking Process', published by the BDA.

Figure 12: Brick textures

Brick bonds

The bond describes the pattern in which brick is laid, with the various formats depicted in Figure 13. For further information, see 'Brick Bonds', published by the BDA.

Stretcher bond	
	Originally used for half-brick-thick walls, it became the obvious choice for cavity walls as it required the least amount of cutting. It is therefore the most economical bond pattern and is extensively used in modern building.
Header bond	
	A brick course laid flat with the short end of the brick exposed. This method is particularly strong as the width of the wall is the whole length of the brick. Historically, it was used for buildings of high quality, and often used for curved brickwork.
English bond	
	This comprises alternate courses of headers and stretchers. It provides a strong bond when the wall is one brick thick, and is the preferred bonding pattern for bridges, viaducts, embankment walls and other civil engineering architecture.
Stack bond	
	In stack bond the bricks do not overlap and therefore the arrangement is inherently weak. To compensate for the lack of bonding, stainless steel ladder reinforcement is typically built into every third bed-joint.
Flemish bond	
	Flemish bonds can be replicated in the half-brick outer leaf of a cavity wall by using whole bricks as stretchers, while the headers are created by half bricks called bats or snap-headers. At one brick thick, it is not as strong as English bond.
Monk bond	
	This has two stretchers between the headers in each row, and the headers centred over the join between the two stretchers in the row below. It was commonly used in the region around the Baltic Sea until the turn of the 13th and 14th centuries, until it was gradually replaced by the Flemish bond.

Figure 13: Types of brick bond

Brick durability

Durability is determined by resistance to the effect of freeze/thaw cycles. The recurring action of water freezing and thawing in saturated brickwork can result in surface spalling. There is also a risk that the soluble salts in some types of clay brick will react with the constituents of the Portland cement used in the mortar, leading to cracks and crumbling of the mortar. The physical properties of the bricks and mortars must therefore be taken into account, as must the degree of exposure to which parts of the building will be subjected. In severely exposed locations this may require the use of F2, S2 brick (where the term "F2" means it's rated to cope with repeated freeze/thaw conditions and "S2" indicates it has a low category of active soluble salts) and reduced sulphate cement in the mortar. Exposure and durability guidance is provided by the BDA and in NHBC technical guidance. The level of exposure is largely determined by geographical location and is a primary factor when designing and specifying the walls of buildings. External works such as freestanding garden and retaining walls and chimneys should always be considered as very severely exposed to frost attack, regardless of geographic location.

Combining brick with other durable construction materials will help to ensure a structure's longevity and long-term viability. This is achieved most readily in masonry external walling using cavity construction – that is, brick outer leaf with a concrete block inner leaf.

For more information and design guidance on durability see *Severely Exposed Brickwork*, published by the BDA.

Mortar

Mortar is a workable paste (generally comprising sand, cement and water) used to bind bricks and other masonry units together.

A mortar joint acts as a sealant and a bearing pad. It is the glue that sticks bricks, blocks and other masonry units together yet keeps them apart, and in this sense performs as a gap-filling adhesive. Its role is also to seal irregular gaps between masonry elements and to provide a barrier to the passage of moisture. Mortar joints can also be a source of heat loss, as they form a repeating thermal bridge in external walls (see section on Thermal Bridging). The correct designation of mortar is very important for providing not only strength to the wall construction but also durability against water ingress. Mortar accounts for approximately 17.5% of the brickwork built in stretcher bond, so it is important to specify it correctly – it can be designed or prescribed in accordance with BS EN 998-2-2016 Specification for mortar for masonry.

Key characteristics for consideration when selecting mortar include:

- Appearance (joint profile and colour)
- Structural requirements
- Type of construction and position in the building
- Degree of exposure
- Compatibility between brick and mortar strength.

For guidance on these considerations and issues including mortar types, selection and performance, visit www.mortar.org.uk, which offers a broad range of practical information.

Image: Radharc Images/Alamy Stock Photo

Masonry cavity walls

Masonry cavity walls have been the most popular choice for UK housing since their use became widespread in the 1920s. There are good reasons for this, including their proven all-round performance and the fact that they are the least expensive of the main walling options. Another reason is the general availability of the materials and labour needed to build them. Over the last century, the basic method of construction has adapted well to changing performance standards and regulations, resulting in homes built today that offer the highest levels of fabric energy efficiency while maintaining the inherent strength and durability of masonry (see Figure 14).

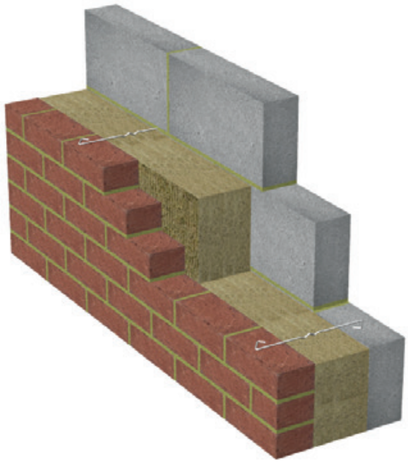


Figure 14: A contemporary cavity wall

Flexibility is another useful attribute; masonry allows you to make small changes to the design and layout of a house during construction, also the build program can be adjusted to changes in the market or project needs. Additions and alterations further down the line are also more straightforward. The lead time for the supply of blocks tends to be short and they are readily available throughout the UK.

Key benefits:

- Very durable, ensuring a long life span.
- Does not rot or burn, making it highly resilient and essentially maintenance-free.
- Local builders' merchants stock all the materials needed.
- Best understood method of construction, familiar to all contractors/ builders.
- Cost-effective option compared to alternative walling systems.
- Able to deliver the highest levels of fabric energy efficiency.
- Accommodates future extensions and alterations very easily.
- Very forgiving: small foundation-level irregularities can be addressed in the first few courses.
- Good thermal mass, for enhanced comfort and a reduced risk of summertime overheating.
- Allows for the robust fixing of shelves, cabinets and other units.
- Good acoustic performance provided by the concrete blocks.

Cavity wall construction

As the name implies, a cavity wall comprises an inner and outer wall, often referred to as leafs. These are separated by a cavity that is typically 100 mm to 150+ mm, which is spanned by ties connecting both leafs (see Figure 15). The cavity prevents the transfer of moisture from the outer to inner leaf and also provides space to locate insulation, which is either fully or partially filled. The inner leaf carries the structural load and is usually built from standard concrete blocks, finished on the inside with plasterboard or wet plaster. The outer leaf is non-loadbearing and typically constructed from brick, but blockwork with a render finish may also be used. Its main role is to keep the weather out and provide a robust, long-lasting external finish. Any water that does find its way into the cavity is drained back out through weep holes in the outer leaf, keeping it away from the inner leaf. The resilience and protection provided by the cavity means low-cost insulation batts are commonly used (see Figure 16).

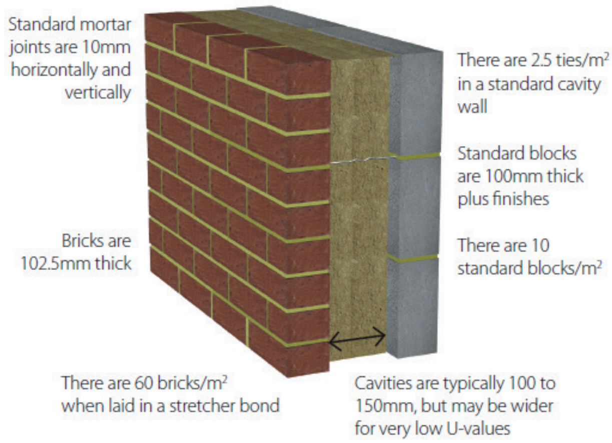


Figure 15: Standard cavity wall specification

Exposure requirements for cavity walls

Wind-driven rain can lead to water penetration through the outer leaf of a cavity wall, particularly in areas subject to conditions of severe exposure i.e. high wind speeds and/or rainfall. To help, Approved Document Part C of the Building Regulations sets out specific requirements in terms of the minimum width of full-fill insulation that is permitted in such locations. This is based on the widely recognised understanding that as the cavity width increases, the likelihood of rain penetration decreases. Similarly, Part C sets out minimum requirements for the width of the residual cavity with partial-fill insulation.

For partial-fill cavities it is more straightforward. Essentially, the residual/ clear cavity between insulation and outer leaf should be at least 50mm, except in areas of very severe exposure, where it must be 75mm if the outer leaf is fairfaced masonry.

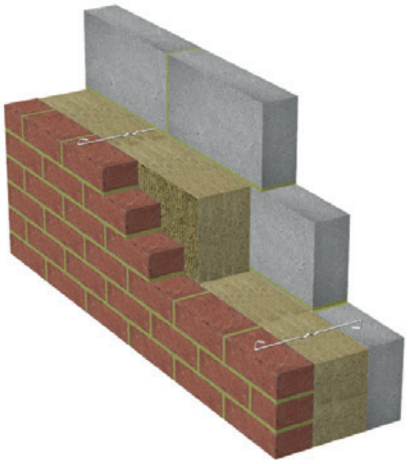
Cavity insulation

Figure 16 shows four of the most commonly used options for cavity wall insulation and summarises their specific attributes. Full-fill insulation is the most commonly used option in the UK. It typically comprises semi-rigid mineral wool batts fitted as the wall is built, but alternatively, loose-fill mineral wool or expanded polystyrene (EPS) beads can be blown or injected into the finished wall, offering a similar level of thermal performance (see Figure 16). The use of loose-fill insulation can help deliver faster builds as its installation is unaffected by weather conditions and the need to interrupt brick/block laying to fit rigid insulation is avoided. The thermal performance of full-fill insulation is generally lower than the insulation materials used for partial fill. This may result in the need for a slightly thicker layer if a relatively high performance U-value is required. However, in practice a standard 150mm cavity will provide a similar U-value whether fully filled with mineral wool, or constructed with a 50mm clear cavity and partial-fill insulation panels. A third option comprises the use of ridged PIR or phenolic insulation panels specifically designed as a full-fill solution. These are available from the major insulation manufacturers, and deliver U-values of around 0.18W/m^{2}K in a traditional 100mm cavity, albeit at a slight cost premium.

More comprehensive thermal performance information for a range of masonry concrete external walling systems is provided in Figure 24.

Figure 16: Common cavity wall insulation options

FULL-FILL INSULATION (SEMI-RIGID MINERAL WOOL BATTS)



Key points:

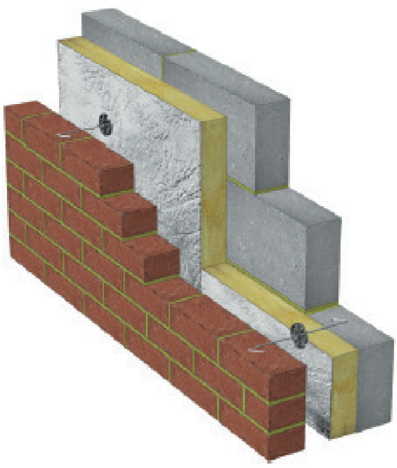
- Low-cost and is a commonly used option
- Potential loss of performance if there is air movement in cavity
- May absorb water, but can be treated with a water-repellent additive to resist moisture ingress
- Non-combustible. Classified as Euroclass A1 - the highest classification
- Absorbs any surface irregularities on the inner leaf.

Overall wall width including finishes:

- 0.18 U-value: 380 - 405mm*
- 0.15 U-value: 420 - 430mm (420mm requires insulated plasterboard)*

*See page 21 for technical details/assumptions.

PARTIAL-FILL INSULATION (PIR, PUR AND PHENOLIC PANELS)



Key points:

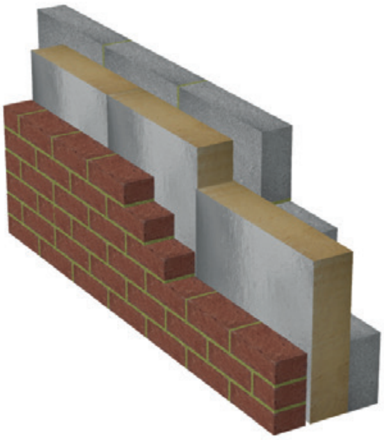
- Most thermally efficient insulation of all the commonly used cavity wall options
- Provides the thinnest solution for partial-fill cavities
- Closed cell structure resists both moisture and water vapour ingress
- Can be used with a fair-faced masonry outer leaf in all exposure zones (75mm residual cavity may be required)
- Must be installed appropriately to avoid air gaps between and behind panels

Overall wall width including finishes:

- 0.18 U-value: 365 - 380mm*
- 0.15 U-value: 390 - 405mm*

*See page 21 for technical details/assumptions.

FULL-FILL INSULATION (100MM PIR/PUR)



Key points:

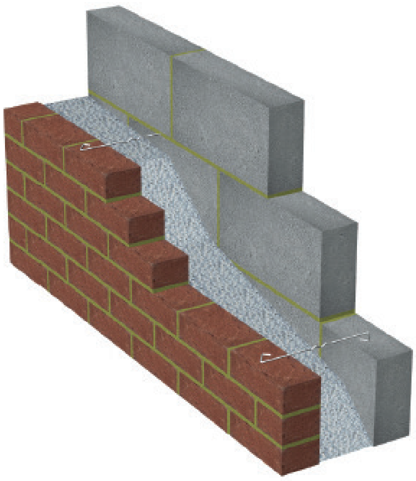
- Can achieve a U-value of 0.16 - 0.17 W/m²K in a 100mm cavity
- Modest cavity width helps maximise plot efficiency and floor space
- Available with profiled plastic facing to provide a channel for water drainage, giving added protection from wind-driven rain that may penetrate the outer leaf
- Also available in thicker panels for larger cavities / lower U-values

Overall wall width including finishes:

- 0.16 U-value: 330mm*
- 0.14 U-value: 355mm*

*See page 21 for technical details/assumptions.

BLOWN INSULATION (POLYSTYRENE BEADS / LOOSE-FILL MINERAL WOOL)



Key points:

- Low-cost and can achieve a faster build, through fewer interruptions to brick/block laying
- Reduced risk of weather delays associated with other forms of insulation
- Beads are usually combined with a binding agent to help prevent movement
- White expanded polystyrene beads have a thermal conductivity of around 0.038-0.040W/mK
- Grey expanded polystyrene beads have a thermal conductivity of around 0.032-0.034W/mK
- Loose-fill blown mineral wool has a similar thermal performance to polystyrene beads, with a thermal conductivity of around 0.034-0.04W/mK

Overall wall width including finishes:

Overall wall width including finishes:

- 0.18 U-value: 430mm*
- 0.15 U-value: 445mm (includes 40mm of insulated plasterboard)*

*See page 21 for technical details/assumptions.

Cavity wall ties

Wall ties provide structural stability by ensuring both leaves work together to provide strength and resist loading. Their selection and spacing is determined by a number of design factors, including:

- Building type and height
- Geographical location
- Cavity width
- Type of masonry used
- Thermal bridging performance

Choosing the correct wall tie and spacing for a specific application is critical to the structural integrity of a cavity wall and the manufacturer's advice should be sought. The construction and properties of ties vary depending on the application (see Figure 17) and are categorised into four basic types to suit different masonry applications and loads:

Type 1 (heavy-duty applications) – Suitable for most building types and sizes, but not very flexible. They are typically made from steel are relatively substantial and may result in moderate thermal bridging i.e. heat loss.

Type 2 (general-purpose applications) – Suitable for domestic dwellings and small commercial buildings on flat sites with wind speeds up to 31m/s, making them suitable for all UK regions.

Type 3 (basic applications) – Suitable for domestic dwellings and small commercial buildings on sites where the basic wind velocity is 27m/s or less, making them unsuitable for parts of northern Scotland and Ireland.

Type 4 (light duty) – Suitable for domestic dwellings of box-form construction with leaves of similar thickness, on sites where the basic wind velocity is 27m/s or less, making them unsuitable for parts of northern Scotland and Ireland.

More detailed information on the selection of wall ties is provided by the following sources[3].

- Eurocode 6 – Design of Masonry Structures (BS EN 1996-1-1: 2005). In 2010, Eurocode 6 became the main code for the design of reinforced and unreinforced masonry. Eurocode 6 refers to EN 845-1 for wall ties and sets the density of ties per square metre.
- BS EN 845-1: 2013 Specification for Ancillary Components for Masonry - Part 1: Ties, Tension Straps, Hangers and Brackets. This Standard sets out the requirements for wall ties used for interconnecting masonry and for connecting masonry to beams, columns or other parts of the building. For tie types and qualifying criteria refer to PD 6697.
- PD 6697: 2010 Recommendations for the design of masonry structures to BS EN 1996-1-1 and BS EN 1996-2. This provides noncontradictory, complementary information from the withdrawn British Standard BS 5628.

	**Heavy-duty steel tie** A substantial Type 1 tie used in the construction of all building types and heights, anywhere in the British Isles. They are suitable for partial and full-fill cavities, generally up to 225mm.
	**Wire wall ties** Stainless steel wire ties are the cheapest and most widely used option for cavities up to 150mm. They are typically produced as Type 2 and 4
	**Basalt-fibre wall ties** A range of very low thermal conductivity ties made using basalt fibres is available. Ancon's Teplo tie has negligible thermal conductivity and hence heat loss. They are available in a range of diameters and lengths to suit partial and full-fill cavities from 50mm to 450mm and Type 1 to 4 applications.
	**Helical wall ties** Helical wall ties are used in thin-joint construction, where the joints between the large-format aircrete blocks are only 3mm thick, preventing the use of traditional ties. Helical ties are installed by hammering them directly through the insulation and into the blockwork. In partial-fill cavities, circular plastic retainers hold the insulation firmly against the inner leaf. Helical ties are generally suitable for Type 2 and 3 applications

Figure 17: Types of cavity wall ties

Beam and block ground floors

Beam and block ground floors are the most commonly used construction solution in new-build homes and larger extensions (see Figure 18). The installation is quick and requires very little ground preparation. They are also the preferred option where there is a large depth of fill below the floor and where heave or subsidence may occur – for example, close to trees. The concrete beams can span up to 8m without the need for subfloor walls, although a typical span is around 6m or less.

Key benefits:

- Quick to install, with minimal ground work required
- Extremely robust and strong
- Can span up to 8m without the need for a subfloor wall
- Excellent thermal performance and works well with underfloor heating
- Overcomes ground movement problems
- All-weather method of construction
- No shrinkage, flexing, bouncing or squeaking
- Rot proof and fire resistant
- Can be used as a first (or upper) floor solution, providing thermal and acoustic benefits.

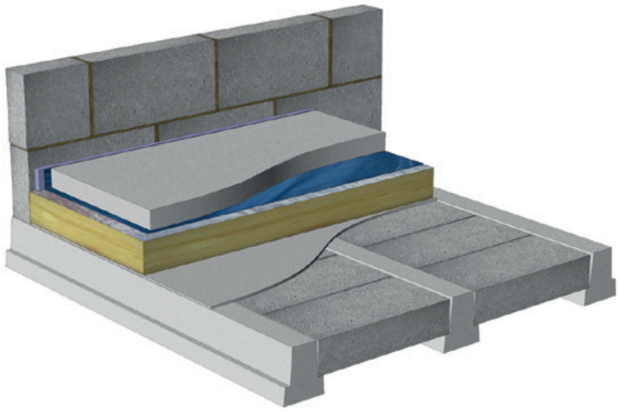


Figure 18: Typical beam and block ground floor

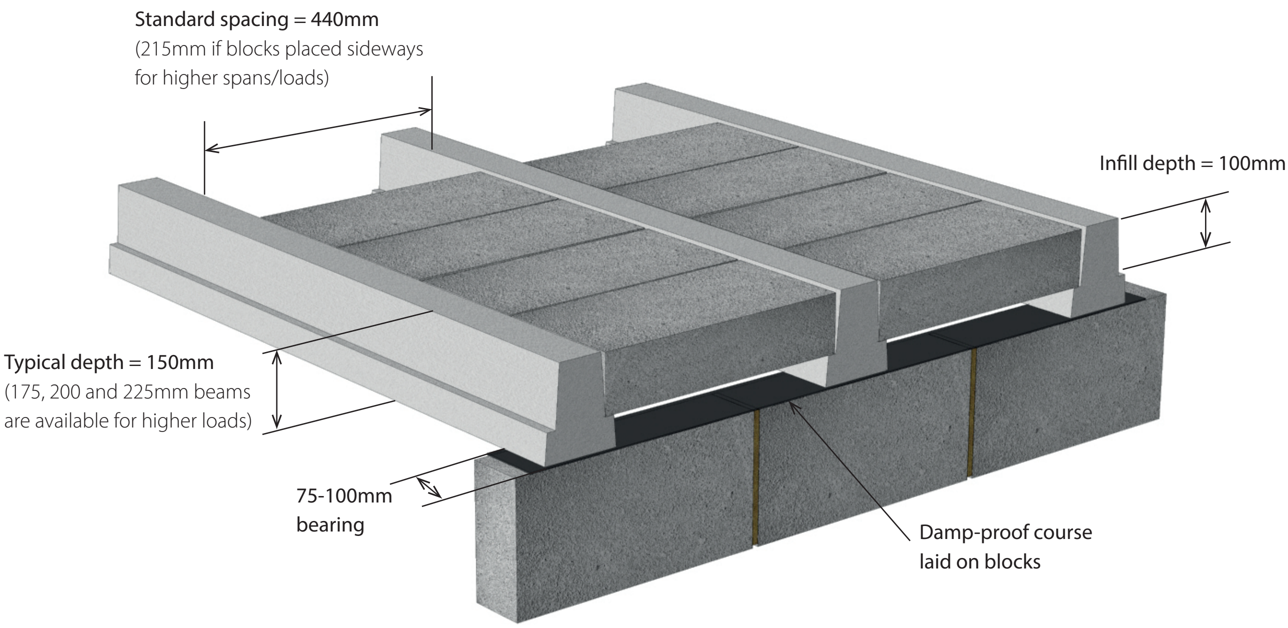


Figure 19: Basic beam and block floor layout

Floor construction

The construction of beam and block floors is straightforward. The precast concrete beams are laid in rows with the ends supported by the blockwork inner leaf of a cavity wall. A damp-proof course (DPC) is located between the beams and supporting blocks to prevent rising damp (see Figure 19).

Other damp proofing is likely to be limited to a membrane below the screed (see Figure 22). The beams are supported by the inner leaf, with a bearing of 75-100mm. The profile of the beams resembles an inverted T, which provides a recess of 100mm to accommodate standard blocks on their side. The spacing of the beams is determined by the longest side of the block i.e. 440mm, but if greater floor strength is needed, the blocks can be turned sideways and the beams spaced at 215mm intervals. One or more beams can be placed immediately adjacent to each other requiring an in-situ concrete infill to support internal non loadbearing walls. The use of multiple beams in this way requires in-situ concrete to be placed between them (see Figure 20).

Internal loadbearing walls require a supporting wall constructed in the floor void, with appropriate footings. The ends of the beams sit on the supporting wall and overlap each other by 100mm (see Figure 21).

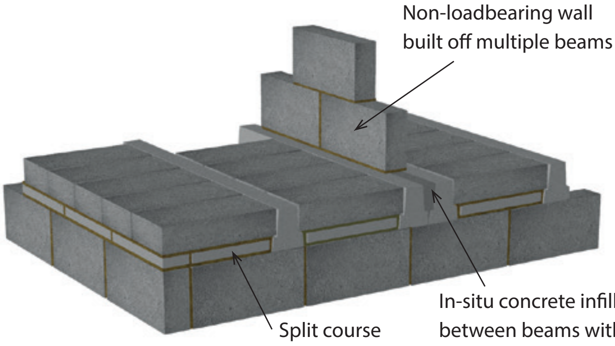


Figure 20: Supporting internal non-load bearing walls

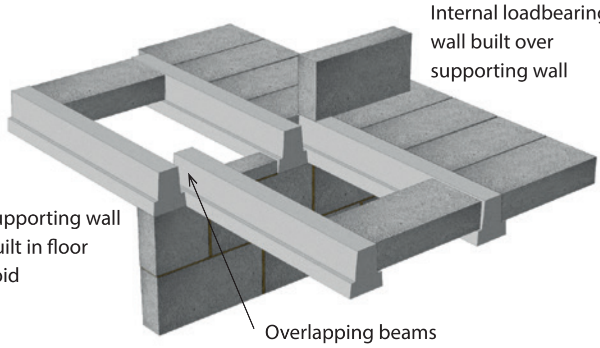


Figure 21: Supporting internal load bearing

The beams

The beams are made from pre-stressed concrete and manufactured in standard lengths, available in 50mm increments. Typically they are 150mm deep, but for larger spans and loads deeper beams of 175mm, 200mm or 225mm can be used. To ensure loads are transmitted safely, beams must be used in accordance with the manufacturer's guidance, and compliant with design standards. The typical span for 150mm beams in a residential ground is around 4 to 6m. The span is determined by the imposed load, beam type/width and self-weight of the floor.

The blocks

Standard size blocks are normally used (440mm x 215mm x 100mm) although larger aerated floor blocks are also available. In terms of strength, 100mm aggregate blocks conforming to BS EN 771-3 must provide either 7.3 N/mm^2 or greater compressive strength. This requirement will be meet by blocks with a 3.5 KN transverse strength that have been tested in accordance with British Standards. Most block manufacturers provide BBA certificates to confirm the strength of their products. Aircrete and aggregate blocks can be used, with densities ranging from around 600kg/m^3 to 2,000kg/m^3. 'Split course' blocks are used to make up heights and infill between the beams (see Figure 20). They are available in a range of thicknesses to suit different beam depths, but for a standard 150mm beam, they are generally 385mm long, 100/140mm wide and 40mm deep, with a minimum compressive strength of 7N/mm^2. 'Closure blocks' specifically designed to fit between the ends of beams can also be used to help speed up floor edge construction.

Ventilating the floor void

The void under the floor should be ventilated in accordance with the Building Regulations. Requirements will generally be met with a void of at least 150mm deep that is adequately ventilated to remove moisture and prevent any build-up of ground gases such as methane. The openings should be at least 1,500mm^2 per linear metre or 500mm^2 per m^2 of floor (whichever is greater) and should ideally be achieved with openings on at least two opposite sides.

Levelling screed and grouting

The blocks need to provide a relatively smooth and flat surface for the insulation, with a tolerance of about 5mm or less over a 2m span, measured with a straight edge. This is about the same as the upward camber of the concrete beams (which is a normal feature), so a levelling screed may or may not be needed, but is generally recommended. In practice, the grout used to infill between blocks can also act as a levelling screed, so the two jobs can be tackled together. Typically a 4:1 sharp sand/cement grout is brushed into all joints and left overnight to provide a rigid construction ready for laying the insulation.

Floor insulation

Floor insulation is supplied in boards with a standard size of 2.4m x 1.2m. These are most commonly made from expanded or extruded polystyrene, polyurethane foam (PUR) or polyisocyanurate (PIR). Expanded polystyrene is the cheapest option but gives a lower level of thermal performance than PUR and PIR. Extruded polystyrene offers a level of performance that lies between the two. The choice of material is one of the factors that determine the thickness of insulation needed, along with the required U-value and the perimeter-to-area ratio (P/A) of the floor. Insulation manufacturers provide look-up tables to simplify the calculation process and also generally offer a free calculation service or online U-value calculator. As a rough guide, around 150mm of PUR/PIR insulation or 200mm of expanded polystyrene insulation is needed to achieve a ground floor U-value of 0.13W/m^{2}K with a worst-case P/A ratio of approximately 0.7.

Damp proof membrane (DPM)

The DPM, which may sometimes be referred to as a vapour control layer, separating layer or slip layer, is located on the top surface of the insulation (see Figure 22). This keeps warm, moist room air on the warm side of the insulation, preventing the risk of condensation within the floor structure. It also acts as a protective barrier for the insulation, reducing damage from wet screed. Any particular requirements for the vapour control layer will be specified by the insulation manufacturer, but will typically need a 1,000-gauge polythene sheet to be placed over the insulation board. However, there are insulation products available that incorporate a resilient facing material, enabling the screed to be applied directly.

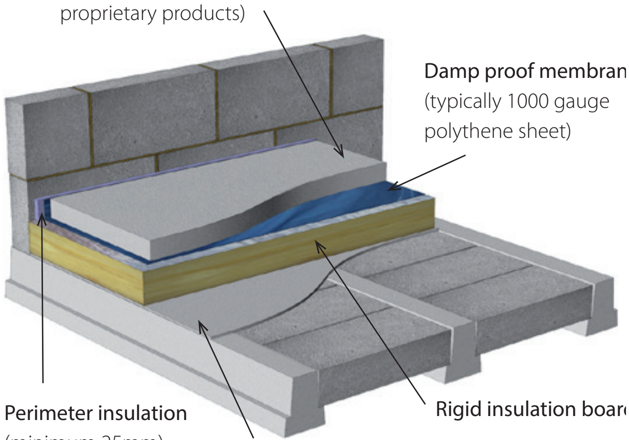


Figure 22: Typical insulation and screed build up

Beam and block upper floors

The beam and block system is widely used for ground floors but is also well suited to upper floors, where it offers a number of performance advantages over alternative timber based options. These centre on the resilience and solidity concrete provides, resulting in:

- Acoustic separation is excellent between floors and squeaking floor boards are avoided; a regular source of irritation to home owners and amongst the most common complaints in new properties.
- Fire resistance: concrete is non-combustible, reducing risk to occupants and lessening the extent of damage to property in the event of fire.
- The thermal mass provided helps lower the risk of summer overheating by absorbing heat inside the dwelling during the day and releasing it during the night when windows can be opened for ventilation and cooling.
- Robustness and longevity; beam and block flooring will easily last 120 years or more. Concrete is an inherently durable material that is resilient to rot, water damage and general wear and tear.

In terms of installation, fixing any product at height should only be carried out by qualified installers and there are many companies that have a good track record of installing beam and block upper floors. All members of the Precast Flooring Federation adhere to its Code of Practice, which has been compiled by Health and Safety experts. The Code gives a guide to the current good practice for the installation of all types of precast flooring i.e. beam-and-block, hollowcore, etc. It is available to download along with other precast concrete flooring guidance from www.mpaprecast.org.uk.

Installing services is relatively straightforward; beam and block suppliers will provide 'ceiling clips' that sit on the shoulder of the floor beam, dropping beneath the level of the floor and are typically suited to a 50 x 38mm batten. This leaves a void between the soffit of the floor and the top side of the batten, allowing services to be run to the underside of the floor. The cost of installing a beam and block upper floor is moderately higher, although it should be remembered that it represents a premium product with performance to match. It is suited to most types of masonry housing, particularly self-build projects, high quality developments and any project where performance is a key driver.

Thermal bridging

The two main types of thermal bridging that occur in construction can be a significant cause of heat loss if not adequately addressed during design. These comprise firstly of repeating thermal bridges that occur when there are regular interruptions in the building fabric such as mortar joints and wall ties, both of which are accounted for in the U-value calculation for walls. The other type of thermal bridge is non-repeating, which are typically found in junctions located within the external envelope of the building and occur when materials with different thermal conductivities meet to form part of the envelope. The resulting heat flow is described by a specific 'psi' value for each junction, which should be accounted for on an individual basis to ensure heat loss is minimised. The option within Part L of applying a default value to account for the overall heat loss from non-repeating thermal bridges is no longer a viable approach, leaving two remaining methods of compliance. These are to assess thermal bridges on an individual basis or to use a database of independently assessed details such as Recognised Construction Details™ (RCD).

Recognised Construction Details

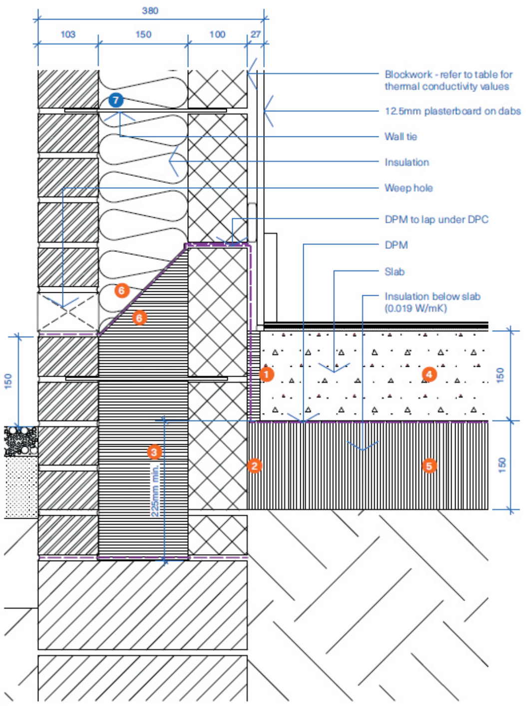
The RCD database has been developed by the masonry sector and certified for use as means of demonstrating thermal bridging compliance for Part L 2021 and the anticipated thermal performance requirements of the Future Homes Standard.

In addition to providing an assessment of psi values, Recognised Construction Details also includes a guide to constructing homes that meet the requirements of Approved Document B1 on fire safety. Additionally, some details may also include an f-value, which relates to likelihood of internal condensation: essentially, a value above 0.75 is "safe" with regards to mould growth.

All the junctions included in the RCDs have been modelled in accordance with BRE Report BR 497 - Conventions for calculating linear thermal transmittance and temperature factors (2nd edition, 2016) with minimum temperature factors considered in accordance with BRE Information Paper 1/06 – 'Assessing the effects of thermal bridging at junctions and around openings in the external elements of buildings (2006)'. In addition, the psi values given were produced using Physibel TRISCO software which complies fully with the standard BS EN ISO 10211: 2017 – 'Thermal bridges in building construction. Heat flows and surface temperatures. Detailed calculations'.

The work undertaken to produce the RCDs was commissioned by members of MPA Masonry and delivered by the Building Alliance and architects Studio Partington. To access this resource visit: www.recognisedconstructiondetails.co.uk

Construction Detail



Calculated Ψ (Psi) value for use in SAP Calculation

Insulation thermal conductivity (W/mK)	Internal leaf block thermal conductivity (W/mK) 0.11	0.15	0.19	0.28	0.6	1.33
0.032	0.051	0.062	0.070	0.068	0.105	0.169
0.034	0.052	0.062	0.071	0.068	0.105	0.168
0.037	0.054	0.063	0.072	0.069	0.106	0.168

f-values: 0.908 - 0.952 (values above 0.75 indicate low risk of condensation and mould)

Ψ (Psi) value Thermal Compliance Notes

1. Minimum 20mm perimeter insulation with $\lambda \leq 0.022$W/mK.
2. Ensure the floor insulation is tightly butted against the external wall.
3. Continue full fill rigid cavity insulation at least 225mm below slab. Insulation below DPC to provide thermal resistance equal to or better than main wall insulation.
4. 150mm Ground bearing slab.
5. 150mm insulation (0.019W/mK) below slab.
6. Ensure insulation is cut and fitted around the angle of the cavity tray.

Construction Notes

7. Wall tie: No greater than 450mm vertical spacing.

General Notes

Rigid insulation below DPC to provide structural stability and stop water ingress.

recognised construction details | Masonry Full Fill | 150mm Cavity | 150mm Insulation | MFF-150-E5-07 | Ground bearing slab, insulation below

Date: | Sign off:

Figure 23: Example of a Recognised Construction Detail (E5-07, ground floor, insulation below slab)
Sourced from the free-to-access site www.recognisedconstructiondetails.co.uk.
A project delivered by Building Alliance and supported by the concrete block and aircrete sector groups of MPA Masonry and Studio Partington.

U-values and thermal mass properties

U-values and thermal mass information for a broad range of concrete and masonry external walling systems are provided in Figure 24. The U-values expand upon and complement the more limited examples provided by the Future Homes Hub (FHH) in the publication 'Part L 2021 where to start - guidance for masonry construction'. The examples, featured here, align with the technical assumptions/approach used by the FHH in its U-value guidance.

For each walling system and block type, five calculated U-values are provided where possible. These are 0.25, 0.19, 0.18, 0.15 and 0.13 W/m^2K or as close to these values as the commercially available insulation thicknesses will typically allow. The lowest value of 0.13 W/m^2K goes a little further than the FHH's examples, which stop at 0.15 W/m^2K. This is to provide some additional scope for minimising heat loss.

The thermal mass information provided for each of the walls includes areal heat capacity, k-values, admittance and decrement properties. A full explanation of what each of these values represent is provided in 'Measuring thermal mass properties' on page 31.

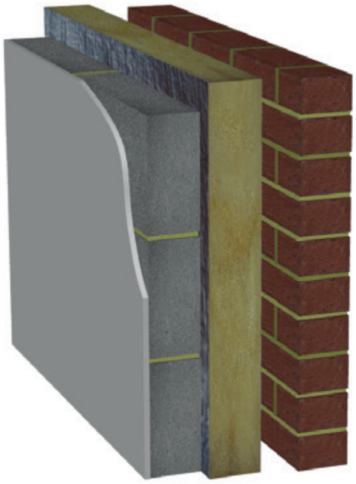
Technical assumptions for values provided in Figure 24, which begins on page 22:

- The thermal conductivity of the insulation materials used aligns with corresponding products provided by several leading UK manufacturers. Slightly lower U-values may be achievable using higher performing products from other suppliers.
- For some of the required U-values, it is necessary to use two layers of insulation in the cavity. Where this is the case, it is highlighted in the "insulation thickness" column.
- For some of the lower U-values, insulated plasterboard has been specified. This is highlighted in the "insulation thickness" column. Insulated plasterboard can be avoided in favour of additional cavity insulation, although this will of course further increase the cavity width.
- The wall ties are assumed to be stainless steel, with 2.5 ties per m^2. Wall ties offering a higher level of thermal performance may be an option.
- Mortar bridges are in accordance with BR443. Air gap correction = 1. Partial fill insulation solutions have a low-E (0.05) cavity. BRE U-value calculator version 2.04g was used.
- The thermal mass properties are calculated with a U-value of 0.18 W/m^2K or as close to this value as practicable. Two different finishes are assumed: plasterboard and wet plaster. All the thermal mass properties have been calculated in accordance with BS EN ISO 13786 using The Concrete Centre's Dynamic Thermal Properties tool. An explanation of the thermal mass properties is provided in the section 'Measuring thermal mass properties'.
- The total wall thickness includes finishes unless otherwise indicated.

Image: Ian Hubball Alamy Stock Photo

Figure 24: Thermal properties of external walls (the U-values shown cover the requirements for both the Future Homes Standard and levels down to the Passive House standard)

BRICK AND AIRCRETE BLOCKWORK – PARTIALLY FILLED, PIR INSULATION



Details:

- 100mm aircrete blocks (λ=0.15 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Rigid PIR insulation (λ=0.022 W/mK)
- 50mm low emissivity residual cavity (ε = 0.05)
- Stainless steel wall ties

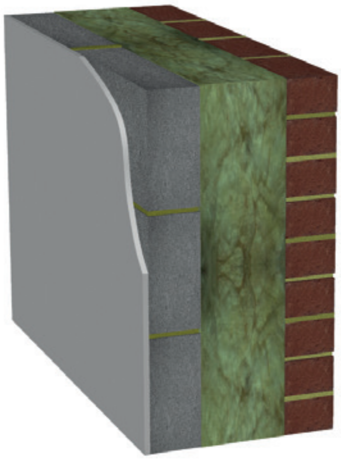
*Insulated plasterboard (PIR, λ=0.022 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 27 / 35 kJ/m²K
k-value - plasterboard / wet plaster: 52 / 65 kJ/m²K
Admittance – plasterboard / wet plaster: 1.9 / 2.5 W/m²K
Decrement delay – plasterboard / wet plaster: 11.2 / 10.8 hours
Decrement factor – plasterboard / wet plaster: 0.25 / 0.31

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.25	50	330
0.2	75	355
0.18	85	365
0.15	85 + 25 internal*	390
0.13	85 + 50 internal*	415

BRICK AND AIRCRETE BLOCKWORK – FULLY FILLED, MINERAL WOOL INSULATION



Details:

- 100mm aircrete blocks (λ=0.15 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Mineral wool insulation (λ=0.032 W/mK)
- Stainless steel wall ties

*Insulated plasterboard (PIR, λ=0.022 W/mK)

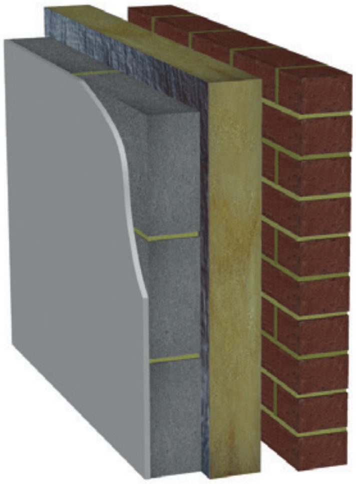
Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 27 / 35 kJ/m²K
k-value - plasterboard / wet plaster: 52 / 65 kJ/m²K
Admittance – plasterboard / wet plaster: 1.9 / 2.5 W/m²K
Decrement delay – plasterboard / wet plaster: 11.0 / 10.4 hours
Decrement factor – plasterboard / wet plaster: 0.26 / 0.33

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.24	100	330
0.2	125	355
0.18	150	380
0.15	200 (2 x 100)	430
0.13	150 + 40 internal*	420

Figure 24 (continued)

BRICK AND THIN-JOINT AIRCRETE BLOCKWORK – PARTIALLY FILLED, PIR INSULATION



Details:

- 100mm thin-joint aircrete blocks (λ=0.11 W/mK)
- 12.5mm plasterboard on 15mm dabs
- PIR insulation (λ=0.022 W/mK)
- 50mm low emissivity residual cavity (ɛ = 0.05)
- Stainless steel wall ties

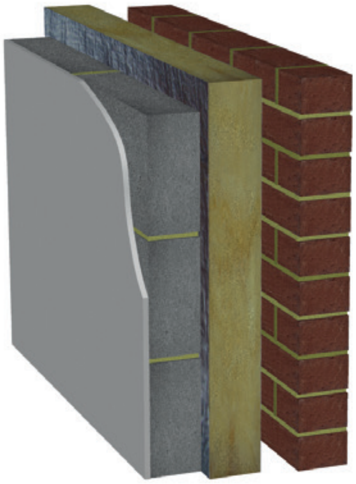
*Insulated plasterboard (PIR, λ=0.022 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 24 / 30 kJ/m²K
k-value - plasterboard / wet plaster: 42 / 52 kJ/m²K
Admittance – plasterboard / wet plaster: 1.7 / 2.1 W/m²K
Decrement delay – plasterboard / wet plaster: 10.8 / 10.3 hours
Decrement factor – plasterboard / wet plaster: 0.29 / 0.34

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.24	50	330
0.19	75	355
0.18	80	360
0.16	100	380
0.13	100 + 25 internal*	405

BRICK AND ULTRA LIGHTWEIGHT BLOCKWORK – PARTIALLY FILLED, PIR INSULATION



Details:

- 100mm ultra lightweight blocks (λ=0.28 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Rigid PIR insulation (λ=0.022 W/mK)
- 50mm low emissivity residual cavity (ɛ = 0.05)
- Stainless steel wall ties

*Insulated plasterboard (PIR, λ=0.022 W/mK)

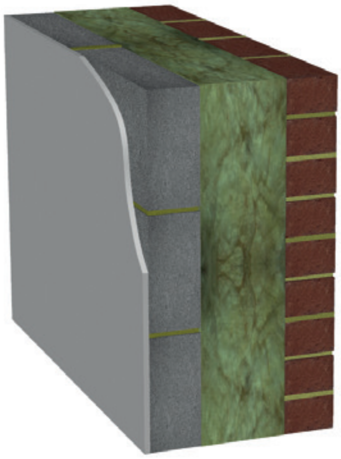
Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 32 / 46 kJ/m²K
k-value - plasterboard / wet plaster: 70 / 87 kJ/m2K
Admittance – plasterboard / wet plaster: 2.3 / 3.3 W/m²K
Decrement delay – plasterboard / wet plaster: 11.1 / 10.4 hours
Decrement factor – plasterboard / wet plaster: 0.23 / 0.31

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.24	60	340
0.19	85	365
0.18	90	370
0.14	85 + 40 internal*	405
0.13	85 + 50 internal*	415

Figure 24 (continued)

BRICK AND ULTRA LIGHTWEIGHT BLOCKWORK – FULLY FILLED, MINERAL WOOL INSULATION



Details:

- 100mm ultra lightweight blocks (λ=0.28 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Mineral wool insulation (λ=0.032 W/mK)
- Stainless steel wall ties (type 4)

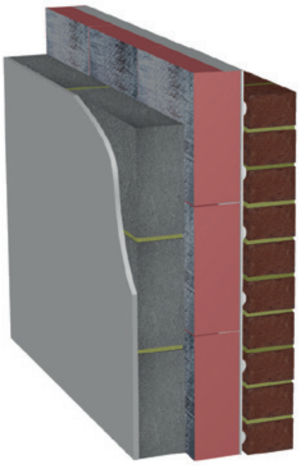
*Insulated plasterboard (PIR, λ=0.022 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 32 / 46 kJ/m²K
k-value - plasterboard / wet plaster: 70 / 87 kJ/m²K
Admittance – plasterboard / wet plaster: 2.3 / 3.3 W/m²K
Decrement delay – plasterboard / wet plaster: 11.1 / 10.4 hours
Decrement factor – plasterboard / wet plaster: 0.23 / 0.31

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.26	100	330
0.18	150	380
0.15	200	430
0.13	150 + 50 internal*	430

BRICK AND ULTRA LIGHTWEIGHT BLOCKWORK – FULLY FILLED, PHENOLIC INSULATION



Details:

- 100mm ultra lightweight blocks (λ=0.28 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Phenolic insulation (λ=0.019 W/mK)
- 10mm low emissivity residual cavity (ε = 0.05)
- Stainless steel wall ties

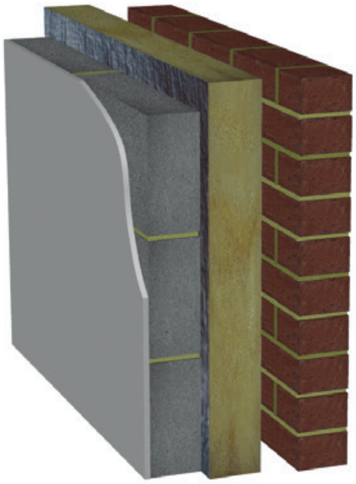
Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 33 / 46 kJ/m²K
k-value - plasterboard / wet plaster: 70 / 87 kJ/m²K
Admittance – plasterboard / wet plaster: 2.4 / 3.3 W/m²K
Decrement delay – plasterboard / wet plaster: 11.5 / 10.8 hours
Decrement factor – plasterboard / wet plaster: 0.23 / 0.3

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.16	90	330
0.14	115	355

Figure 24 (continued)

BRICK AND LIGHTWEIGHT BLOCKWORK – PARTIALLY FILLED, PIR INSULATION



Details:
- 100mm lightweight blocks (λ=0.6 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Rigid PIR insulation (λ=0.022 W/mK)
- 50mm low emissivity residual cavity (ε = 0.05)
- Stainless steel wall ties

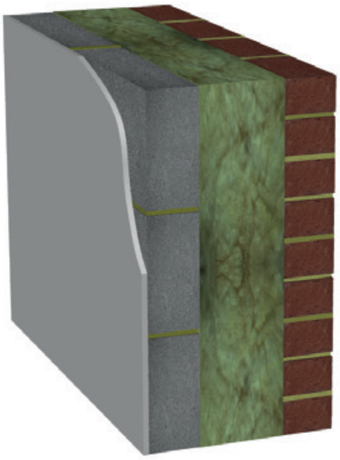
*Insulated plasterboard (PIR, λ=0.022 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 37 / 60 kJ/m^{2}K
k-value - plasterboard / wet plaster: 114 / 141 kJ/m^{2}K
Admittance – plasterboard / wet plaster: 2.7 / 4.3 W/m^{2}K
Decrement delay – plasterboard / wet plaster: 11.5 / 10.8 hours
Decrement factor – plasterboard / wet plaster: 0.16 / 0.25

U-value (W/m^{2}K)	**Insulation thickness (mm)**	**Total wall thickness (mm)**
0.25	60	340
0.19	90	370
0.18	100	380
0.15	85 + 40 internal*	405
0.13	85 + 60 internal*	425

BRICK AND LIGHTWEIGHT BLOCKWORK – FULLY FILLED, MINERAL WOOL INSULATION



Details:
- 100mm lightweight blocks (λ=0.6 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Mineral wool insulation (λ=0.032 W/mK)
- Stainless steel wall ties

*Insulated plasterboard (PIR, λ=0.022 W/mK)

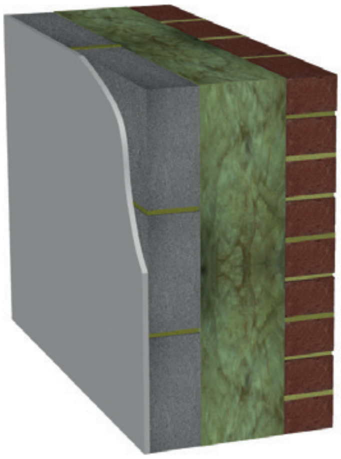
Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 37 / 60 kJ/m^{2}K
k-value - plasterboard / wet plaster: 114 / 141 kJ/m^{2}K
Admittance – plasterboard / wet plaster: 2.7 / 4.3 W/m^{2}K
Decrement delay – plasterboard / wet plaster: 11.8 / 11.1 hours
Decrement factor – plasterboard / wet plaster: 0.16 / 0.24

U-value (W/m^{2}K)	**Insulation thickness (mm)**	**Total wall thickness (mm)**
0.22	125	355
0.19	150	380
0.17	175 (150 + 25)	405
0.15	200	430
0.13	150 + 50 internal*	430

Figure 24 (continued)

BRICK AND DENSE BLOCKWORK – FULLY FILLED, MINERAL WOOL INSULATION



Details:

- 100mm dense blocks (λ=1.33 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Mineral wool insulation (λ=0.032 W/mK)
- Stainless steel wall ties

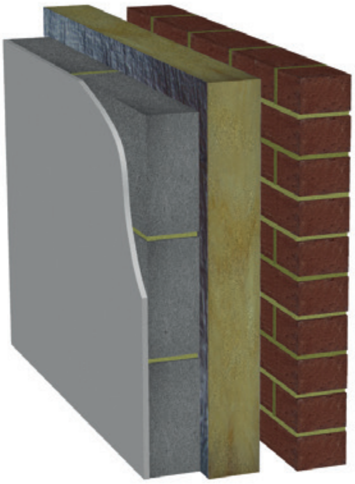
*Insulated plasterboard (PIR, λ=0.022 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 40 / 69 kJ/m^2K
k-value - plasterboard / wet plaster: 147 / 182 kJ/m^2K
Admittance – plasterboard / wet plaster: 2.9 / 5.0 W/m^2K
Decrement delay – plasterboard / wet plaster: 11.5 / 10.8 hours
Decrement factor – plasterboard / wet plaster: 0.13 / 0.22

U-value (W/m^2K)	Insulation thickness (mm)	Total wall thickness (mm)
0.23	125	355
0.19	150	380
0.18	175 (150 + 25)	405
0.14	150 + 40 internal*	420
0.13	200 + 25 internal*	455

BRICK AND DENSE BLOCKWORK – PARTIALLY FILLED, PIR INSULATION



Details:

- 100mm dense blocks (λ=1.33 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Rigid PIR insulation (λ=0.022 W/mK)
- 50mm low emissivity residual cavity (ε = 0.05)
- Stainless steel wall ties

*Insulated plasterboard (PIR, λ=0.022 W/mK)

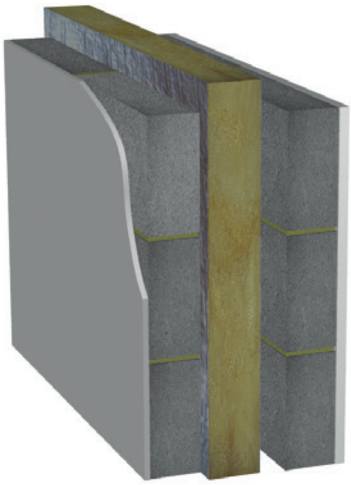
Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 40 / 69 kJ/m^2K
k-value - plasterboard / wet plaster: 147 / 182 kJ/m^2K
Admittance – plasterboard / wet plaster: 2.9 / 5.0 W/m^2K
Decrement delay – plasterboard / wet plaster: 11.3 / 10.6 hours
Decrement factor – plasterboard / wet plaster: 0.13 / 0.22

U-value (W/m^2K)	Insulation thickness (mm)	Total wall thickness (mm)
0.23	70	350
0.19	90	370
0.18	100	380
0.15	100 + 25 internal*	405
0.13	100 + 40 internal*	420

Figure 24 (continued)

LIGHTWEIGHT BLOCKWORK (BOTH LEAFS) – PARTIALLY FILLED, PIR INSULATION



Details:
- 100mm lightweight blocks (λ=0.6 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Rigid PIR insulation (λ=0.022 W/mK)
- 50mm low emissivity residual cavity (ε = 0.05)
- Rendered external finish
- Stainless steel wall ties

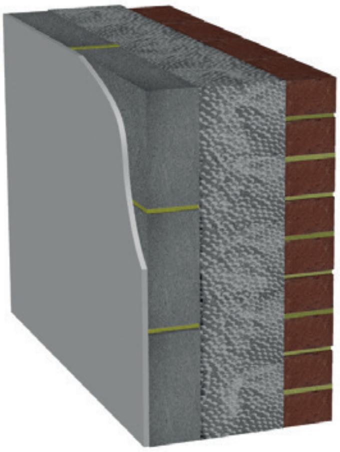
*Insulated plasterboard (PIR, λ=0.022 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 37 / 60 kJ/m^2K
k-value - plasterboard / wet plaster: 114 / 141 kJ/m^2K
Admittance – plasterboard / wet plaster: 2.7 / 4.3 W/m^2K
Decrement delay – plasterboard / wet plaster: 11.4 / 10.7 hours
Decrement factor – plasterboard / wet plaster: 0.16 / 0.26

U-value (W/m^2K)	Insulation thickness (mm)	Total wall thickness (mm)
0.25	60	346
0.19	90	376
0.17	50 + 50 internal*	386
0.15	100 + 25 internal*	411
0.13	100 + 40 internal*	426

BRICK AND LIGHTWEIGHT BLOCKWORK – FULLY FILLED, POLYSTYRENE BEAD INSULATION



Details:
- 100mm lightweight blocks (λ=0.6 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Expanded polystyrene beads (λ=0.033 W/mK)
- Stainless steel wall ties

*Insulated plasterboard (PIR, λ=0.022 W/mK)

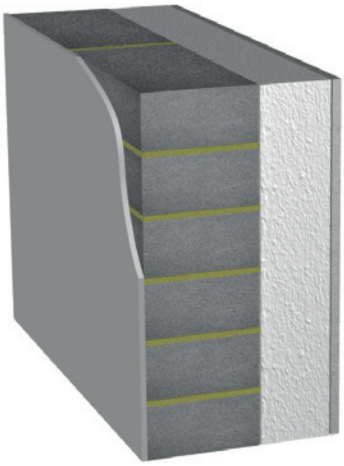
Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 37 / 60 kJ/m^2K
k-value - plasterboard / wet plaster: 114 / 141 kJ/m^2K
Admittance – plasterboard / wet plaster: 2.7 / 4.3 W/m^2K
Decrement delay – plasterboard / wet plaster: 11.2 / 10.5 hours
Decrement factor – plasterboard / wet plaster: 0.16 / 0.25

U-value (W/m^2K)	Insulation thickness (mm)	Total wall thickness (mm)
0.25	115	345
0.19	155	385
0.18	165	395
0.15	200	430
0.13	200 + 25 internal*	455

Figure 24 (continued)

SOLID MASONRY, LIGHTWEIGHT BLOCKWORK – EXTRUDED POLYSTYRENE INSULATION



Details:

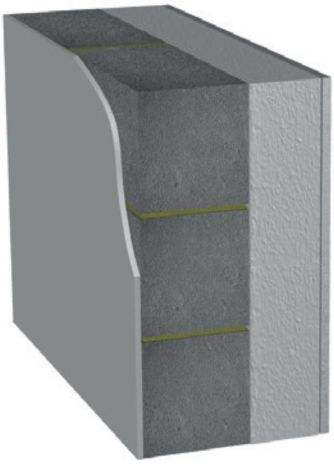
- 215mm lightweight blocks (λ=0.6 W/mK)
- 12.5mm plasterboard on 15mm dabs
- External render finish
- Extruded polystyrene (λ=0.029 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 34 / 54 kJ/m²K
k-value - plasterboard / wet plaster: 114 / 141 kJ/m²K
Admittance – plasterboard / wet plaster: 2.5 / 3.9 W/m²K
Decrement delay – plasterboard / wet plaster: 12.0 / 11.5 hours
Decrement factor – plasterboard / wet plaster: 0.08 / 0.12

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.24	100	351
0.19	130	381
0.18	140	391
0.15	170	421
0.13	200	451

SOLID MASONRY, THIN JOINT AIRCRETE BLOCKWORK – EXTRUDED POLYSTYRENE INSULATION



Details:

- 215mm aircrete blocks (λ=0.11 W/mK)
- 12.5mm plasterboard on 15mm dabs
- External render finish
- Extruded polystyrene (λ=0.029 W/mK)

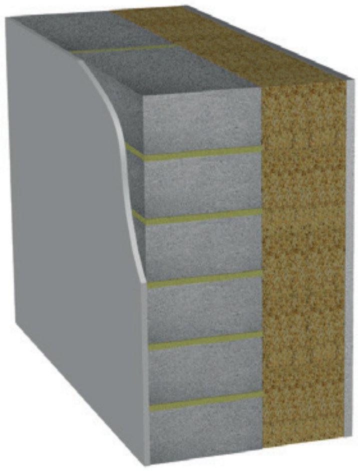
Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 22 / 28 kJ/m²K
k-value - plasterboard / wet plaster: 42 / 52 kJ/m²K
Admittance – plasterboard / wet plaster: 1.6 / 2.0 W/m²K
Decrement delay – plasterboard / wet plaster: 12.5 / 12.1 hours
Decrement factor – plasterboard / wet plaster: 0.13 / 0.15

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.26	50	288
0.19	90	328
0.18	100	338
0.15	130	368
0.13	160	398

Figure 24 (continued)

SOLID MASONRY, ULTRA LIGHTWEIGHT BLOCKWORK – WOODFIBRE INSULATION



Details:

- 215mm ultra lightweight blocks (λ=0.28 W/mK)
- 12.5mm plasterboard on 15mm dabs
- External render finish
- Woodfibre insulation (λ=0.04 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 29 / 40 kJ/m^{2}K
k-value - plasterboard / wet plaster: 67 / 83 kJ/m^{2}K
Admittance – plasterboard / wet plaster: 2.1 / 2.9 W/m^{2}K
Decrement delay – plasterboard / wet plaster: 14.3 / 13.4 hours
Decrement factor – plasterboard / wet plaster: 0.09 / 0.12

U-value (W/m^{2}K)	Insulation thickness (mm)	Total wall thickness (mm)
0.25	120	371
0.19	170	421
0.18	180	431
0.15	220	471
0.13	260	511

INSULATING CONCRETE FORMWORK – EXPANDED POLYSTYRENE INSULATION

Details:

- In-situ concrete (λ=1.75 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Brick slips (λ=0.77 W/mK) see note below
- Note: Alternative rendered finish provides comparable U-values
- Expanded polystyrene insulation (λ=0.031 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard: 10 kJ/m^{2}K
k-value - plasterboard: 9 kJ/m^{2}K
Admittance – plasterboard: 0.74 W/m^{2}K
Decrement delay – plasterboard: 8.7 hours
Decrement factor – plasterboard: 0.03

U-value (W/m^{2}K)	Insulation thickness (mm)	Total wall thickness (mm)
0.19	150 (75 + 75)	343
0.16	185 (110 + 75)	378
0.13	225 (150 + 75)	418

Figure 24 (continued)

CELLULAR WOODCRETE SYSTEM

Details:

- Woodcrete (λ=0.083 W/mK)
- In-situ concrete (λ=1.75 W/mK)
- Mineral wool insulation (λ=0.032 W/mK)
- 12.5mm plasterboard on 15mm dabs
- Rendered external finish

*Insulated plasterboard (PIR, λ=0.022 W/mK)

Thermal mass properties:

Areal heat capacity - plasterboard / wet plaster: 22 / 28 kJ/m²K
k-value - plasterboard / wet plaster: 108 / 146 kJ/m²K
Admittance – plasterboard / wet plaster: 1.6 / 2.0 W/m²K
Decrement delay – plasterboard / wet plaster: 16.2 / 15.9 hours
Decrement factor – plasterboard / wet plaster: 0.04 / 0.05

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.26	100	343
0.19	165	408
0.16	165 + 25 internal*	428
0.13	165 + 50 internal*	458

PRECAST CONCRETE SANDWICH PANEL

Details:

- Precast concrete (λ=1.75 W/mK)
- PIR insulation (λ=0.022 W/mK)
- No internal or external finishes included

Thermal mass properties:

Areal heat capacity – without finishes: 85 kJ/m²K
k-value – without finishes: 230 kJ/m²K
Admittance – without finishes: 6.2 W/m²K
Decrement delay – without finishes: 9.5 hours
Decrement factor – without finishes: 0.25

U-value (W/m²K)	Insulation thickness (mm)	Total wall thickness (mm)
0.26	80	275
0.21	100	295
0.17	120	315
0.15	140	335
0.13	160	355

Measuring thermal mass properties

This section provides an explanation of the thermal mass properties included in Figure 24. These were calculated using The Concrete Centre's Dynamic Thermal Properties tool, which is compliant with BS EN ISO 13786[4]. This Standard is used in the Home Energy Model to calculate the 'areal heat capacity' of construction elements i.e. their thermal mass.

Areal heat capacity and k-values

Areal heat capacity replace the use of k-values (also called kappa values) that were previously used in Part L/SAP. Figure 24 provides areal heat capacity and k-values for each of the wall constructions. A rough indication of thermal mass is provided by k-values, however the simple calculation used to produce them can significantly overestimate values for materials that are lighter than masonry and concrete. Another limitation of k-values is that they only include the fraction of the construction build-up that is estimated to be involved in storing and releasing heat to the internal space. In contrast, areal heat capacity values used in the Home Energy Model includes the full construction build up and uses five mass distribution classes that describe in general terms the position of the mass (from internal to external) relative to thermal resistance. This provides a more accurate assessment of the thermal mass properties of walls and floors etc.

Admittance values

Admittance values provide a simple measure of a wall or floor's ability to exchange heat with a space when it is subject to a 24 hour heating and cooling cycle i.e. as experienced across a typical day/night. The method takes account of the resistance to heat flow at the surface of the material, along with its thermal capacity, conductivity and density. The output of the admittance method is thermal admittance values, ranging between around 1 to 6 W/m^2K, with higher values indicating greater thermal mass performance. Figure 24 provides admittance values for a range of concrete and masonry external walls.

Decrement values

Decrement is a term that represents a specific characteristic of building elements that is related to its thermal mass. It describes the way in which the density, heat capacity and thermal conductivity of a wall for example, can slow the passage of heat from one side to the other (decrement delay), and also attenuate those gains as they pass through it (decrement factor).

Decrement delay – Designing for a long decrement delay of around 10 to 12 hours will ensure that during the summer, peak heat gains passing from the outer to inner surface will not get through until late evening/night, when the risk of overheating has moderated, and the relatively cool night air can off set the effect of a warmer surface more easily. Shorter periods can still be helpful but effectiveness reduces with decreasing delay, and a value of less than around six hours is of limited benefit. Medium and heavyweight walls insulated to the Future Homes Standard will slow the passage of heat by around 10 to 12 hours, providing an optimal level of decrement delay. Lighter-weight construction typically provides a shorter period ranging from just a few hours up to around 7 or 8 hours, with the latter usually in walls with a masonry outer leaf. Figure 24 includes values of decrement delay for a range of concrete and masonry external walls.

Decrement factor - As well as delaying heat flow on summer days, the dynamic thermal characteristics of a wall or roof construction will also determine the effect that heat reaching the internal surface will have on its temperature stability. This is represented by the decrement factor, which is basically the ratio between the cyclical temperature on the inside surface compared to the outside surface. For example, a wall with a decrement factor of 0.5 which experiences a 20 degree daily variation in temperature on the outside surface, would experience a 10 degree variation on the inside surface. So, a low decrement factor will ensure greater stability of the internal surface temperature, and is another means of helping reduce the risk of overheating. Medium and heavyweight walls insulated to current standards have a low decrement factor of around 0.3 to 0.1 Using the previous example, a decrement factor of 0.1 would cause the inside surface temperature to vary by only two degrees over the day. For lightweight walls, the decrement factor will typically be in the order of 0.5 to 0.8, with the lower end of this range often found in walls with a masonry outer leaf. Figure 24 includes decrement factors for a range of concrete and masonry external walls.

Use of thermal mass to reduce overheating

Overheating is already thought to affect up to 20% of the housing stock in England and is expected to increase in the future. In response, new Building Regulations (Part O)[5] came into force in 2022 to deal specifically with overheating in new residential buildings. Part O of the Building Regulations provide two main routes to compliance:

1. Simplified Method – Project risk is considered at the most basic level and is used to set limits for solar control and ventilation. The maximum area of glazing is determined in response to floor area, orientation, location risk and whether or not cross-ventilation is achievable. To ensure adequate ventilation, the Simplified Method also determines the minimum opening (referred to as free area) needed, which is governed by floor area, glazing area, location risk and whether or not cross ventilation is achievable. Thermal mass is not accounted for in the Simplified Method.

2. Dynamic thermal modelling - This provides a site specific assessment and can be used to demonstrate compliance providing it is in accordance with the CIBSE Technical Memorandum 59 (TM59)[6]. This provides a method for assessing overheating in homes using dynamic thermal modelling and includes a compliance criteria that must be passed. Overall, the modelling option offers a broader range of strategies for limiting solar gain and greater design flexibility for reducing overheating. This includes the use of thermal mass, which can further reduce overheating risk and help optimise other areas of the design e.g. by allowing slightly larger windows for improved daylighting.

Reducing overheating risk with thermal mass

The primary approach in Part O for addressing overheating centres on limiting solar gains and removing excess heat with adequate ventilation. Alongside these measures, the thermal mass provided by masonry and concrete can also be used to good effect, helping further reduce overheating risk of a dwelling. Thermal mass essentially describes the ability of these materials to soak up excess heat inside buildings, without the material warming significantly. As a consequence, walls and floors with thermal mass, can help maintain a relatively comfortable and stable internal temperature (see Figure 25). Thermal mass also moderates and slows heat travelling through external walls from the outside surface, delaying the peak internal temperature to later in the day when it is much less problematic (see Figure 25). This is called 'decrement' and a more detailed explanation is provided in section on Measuring thermal mass properties (page 31).

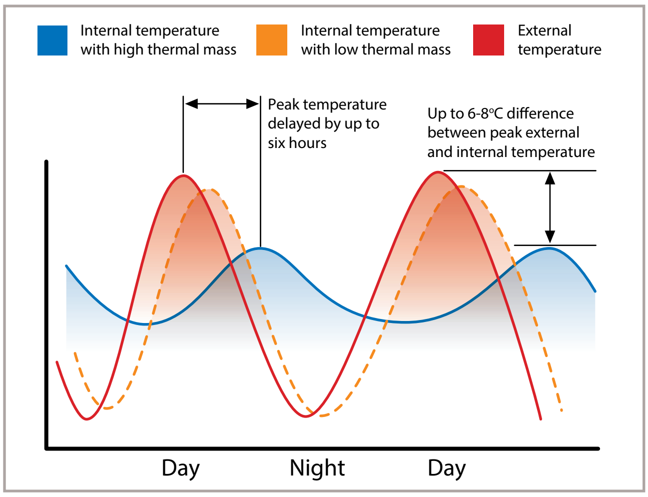


Figure 25: Stabilising effect of thermal mass on internal temperature

How does thermal mass work in summer?

On warm summer days, walls and floors with thermal mass will steadily absorb heat at their surface, conducting it inward, and storing it until exposed to cooler air at night. At this point, heat will begin to migrate back to the surface and is released. In this way, heat moves in a wave-like motion alternately being absorbed and released in response to the change in day and night-time conditions. The ability to absorb and release heat in this way enables dwellings with thermal mass to respond naturally to changing conditions and, to some extent, regulate their own temperature. To use thermal mass, it is therefore important that the heat absorbed during the day is removed overnight, so the walls and floors can repeat the cycle. This is most commonly achieved with night-time ventilation, using the cool night air to draw heat out of the fabric of the dwelling. This process is integral to the effectiveness of thermal mass which, viewed another way, enables the benefit of comparatively cool night air to be carried forward to the following day when the higher external temperature makes ventilation less effective.

More detailed guidance can be found in The Concrete Centre publication *Designing to Avoid Overheating.*

Use of thermal mass in the heating season (Passive Solar Design)

A benefit of thermal mass that is perhaps less well known in the UK, is its ability to help reduce the energy needed for space heating. This is achieved by applying the simple principles of Passive Solar Design (PSD). This seeks to maximise the benefit of solar gain in the heating season, using the thermal mass to absorb gains from south-facing windows, along with heat produced by cooking, lighting, people and appliances. This is then slowly released overnight as the temperature drops, helping to keep the building warm and reducing the need for supplementary space heating. By applying simple Passive Solar Design techniques, useful energy savings can be delivered across a building's life cycle, with minimal user interaction or need for maintenance.

In the UK, PSD has mostly been used to reduce domestic heating requirements, although it is increasingly being used in non-domestic buildings, where the emphasis is often on maximising daylight without unduly increasing the cooling load. PSD requires a whole-building approach to design, in which the envelope (particularly the glazing) is designed in unison with the structure's thermal mass to ensure optimal admission and absorption of solar gains during the heating season.

Whilst Part O (Overheating mitigation) of the Building Regulations seeks to reduce solar gain by limiting window size, it also acknowledges the benefit of PSD, stating that solar gains in winter can reduce the amount of space heating required and that limiting glazing areas to reduce overheating will impact winter solar gain and increase the need for space heating. To balance competing design requirements of Part O and Part L, the dynamic thermal modelling option should be used for the purposes of Part O compliance and to provide an effective thermal evaluation of the design. Thermal mass is accounted for in dynamic modelling and its presence can help reduce conflicting thermal design objectives.

The basic requirements for applying PSD in housing are outlined below:

- A sufficiently clear view of the sky from the south.
- An adequate area of south-facing windows (or within 30° of south) to maximise solar gain during the heating season. The optimal area will be determined by multiple design needs, but ideally it should be at least twice that of any north-facing windows.
- A minimal area of north-facing windows to avoid excessive heat loss. Over the course of the year north-facing windows have a net heat loss and the area should be limited to that needed for adequate daylighting and ventilation.
- A medium to high level of thermal mass. Masonry walls and/or concrete ground floor with a finish that partially or fully exposes the thermal mass will work well.
- Adequate shading to block the high angle summer sun from south facing windows. Overhangs, balconies and brise soleils are particularly effective but other forms of shading can be used. Shutters are also highly effective, with the added benefit of offering a means of secure ventilation and reduced heat loss in winter.

For more information on PSD, see The Concrete Centre publication, *Thermal Mass Explained*.

St Matthew's keyworker estate, Brixton. A multi award-winning and highly energy-efficient building that combines high levels of insulation and air tightness with thermal mass and Passive Solar Design features. Courtesy of Benedict Luxmoore/arcaid.co.uk.

Exemplar case study: Project 80 housing development, Birmingham

Reaching future housing standards

Project 80, Birmingham, is a landmark housing development delivering high-performing, energy-efficient and eco-friendly homes, paving the way for a new era of sustainable residential construction.

The brainchild of forward-thinking housing association, Midland Heart, its design and construction has been significantly influenced by the Future Homes Standard, set to be introduced in 2025.

Future Homes Standard is set to usher in a new age of energy-efficient, low-emissions housing. Midland Heart was keen to ensure it met the stipulated low u-values on its upcoming developments, leading to the initial concept of Project 80 and the objective of delivering a fully 'Fabric First' development.

To meet its aims of achieving Part L compliance, Midland Heart needed to specify materials that could deliver maximum efficiency, yet also deliver safe, secure, comfortable and affordable dwellings.

Furthermore, they were keen to work with local businesses, ensuring a small supply chain with the minimum amount of energy and fuel consumption possible.

As the project took shape, in the form of Eco Drive, comprising 12 new homes built using fabric first principles, Midland Heart, an advocate of traditional construction methods, embraced tried and tested cavity wall construction. A traditional method, they understood that this system would deliver the desired thermal efficiency without reinventing the wheel.

This approach not only achieved the required thermal efficiency, the use of high-performance aircrete blocks, which are lightweight and easy to install, supported the air-tight structures and reduced the chance of thermal bridging. It also significantly sped up the construction process.

Further information

Further reading:

- Part L 2021. Where to start, Future Homes Hub, April 2023
- Thermal Mass Explained, MPA The Concrete Centre, 2019.
- Designing to avoid overheating, MPA The Concrete Centre, 2022.
- Life cycle carbon analysis of a six storey residential building, MPA The Concrete Centre, 2021
- Concrete floor solutions for passive and active cooling, MPA The Concrete Centre, 2017
- The UK Concrete and Cement Industry Roadmap to Beyond Net Zero, MPA UK Concrete, 2020
- Precast Concrete and Masonry Sustainability Report, MPA Precast, 2023.

Links to more information:

- MPA Masonry: www.mpamasonry.org
- MPA Precast: www.mpaprecast.org
- MPA Mortar: www.mortar.org.uk
- Future Homes Hub: www.futurehomes.org.uk
- Recognised Construction Details: www.recognisedconstructiondetails.co.uk
- Brick Development Association: www.brick.org.uk

References

1. BS EN 13501-1:2018 Fire classification of construction products and building elements. Classification using data from reaction to fire tests
2. A Dream Home: An Exploration of Aspirations, MPA Masonry, 2018
3. Based on information provided by the Ancon website (www.ancon.co.uk)
4. BS EN ISO 13786, Thermal performance of building components – Dynamic thermal characteristics – Calculation methods.
5. Approved Document O, Overheating mitigation, The Building Regulations 2010, 2021 edition.
6. CIBSE - TM59: Design methodology for the assessment of overheating risk in homes, Chartered Institution of Building Services Engineers, May 2017.

The Concrete Centre provides design guidance, seminars, courses, online resources and industry research to the design community.

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