

Cavity Walls

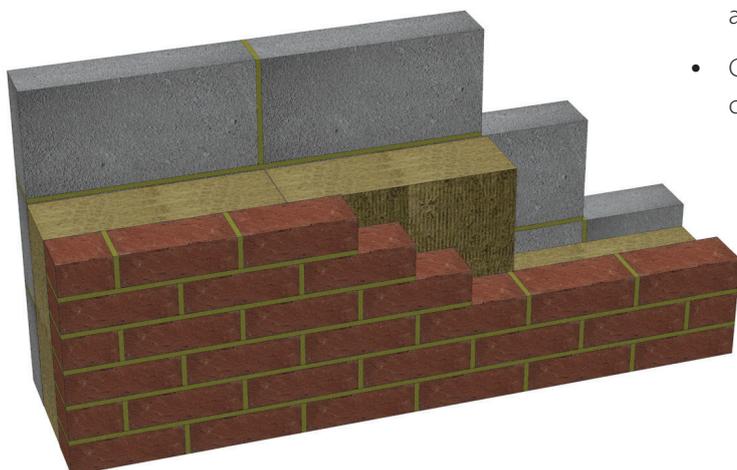
This Easy Guide on cavity walls aims to provide an overview of this method of construction for housing. The guidance is a practical introduction to the characteristics, performance benefits and latest design guidance for masonry cavity walls. For detailed design guidance and requirements for regulatory/warranty compliance, refer to further guidance listed on the back page. Our series of Easy Guides for Housing are available at modernmasonry.co.uk

Introduction: Masonry Cavity Walls

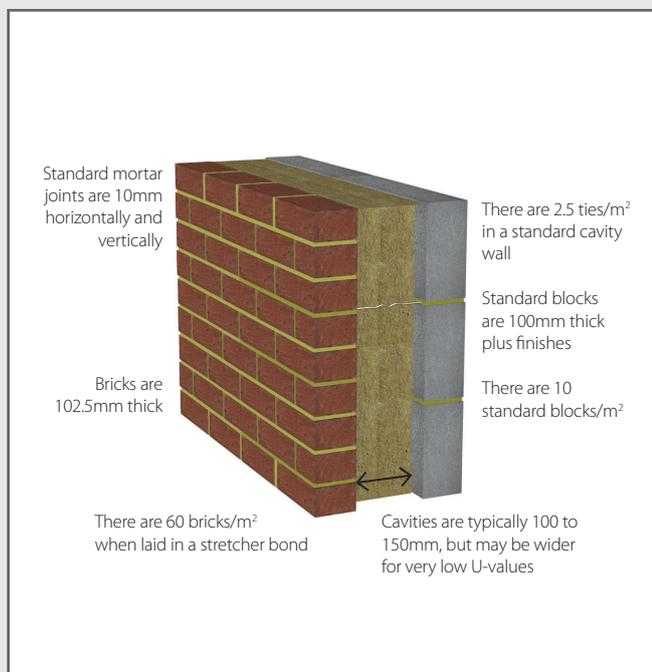
Masonry cavity walls have been the most popular choice for UK housing since their use became widespread in the 1920s. There are good reasons for this, including their proven all-round performance and the fact that they are the least expensive of the main walling options. Another reason is the general 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. 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

- Robust and durable: does not rot or burn, making it essentially maintenance-free
- Local builders' merchants stock all the materials needed
- Best understood method of construction, familiar to all contractors/builders
- Most 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.



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Cavity wall construction

As the name implies, a cavity wall comprises an inner and outer wall, often referred to as leaves. These are separated by a cavity that is typically 100mm to 150mm, which is spanned by ties connecting both leaves. 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 1, page 4).

Concrete blocks and bricks

Two types of concrete block are used in cavity walls:

Aggregate concrete blocks

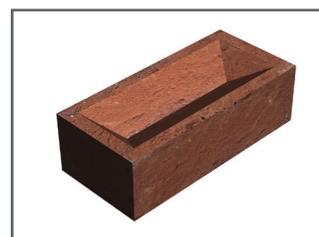
– As the name suggest, these contain aggregates that are either natural or man-made. They are available in three densities/weights: ultra-lightweight, lightweight and dense. The highest level of thermal mass is found in dense aggregate blocks.



Aircrete blocks – These are lighter than aggregate blocks, as they are made from a type of concrete that contains millions of tiny air bubbles trapped within the block. No aggregates larger than ground sand are used. The presence of air bubbles reduces the block density, which can aid manual handling and provides an increase to the overall insulation properties of the wall.

Both types of block are well suited to housing, and are available in a range of sizes and strengths, offering different structural and thermal performance properties to suit specific project needs (see our Easy Guide on concrete blocks for more information).

Bricks offer one of the cheapest and most durable external finishes, with a broad range of textures and colours to choose from. The vast majority of bricks are made of clay, although concrete and calcium silicate are also used. They are categorised by use – i.e. facing, common and engineering bricks – which relate to their strength, durability and frost resistance. The outer leaf of a typical cavity wall is constructed from facing bricks which, depending on the required finish and budget, can be either handmade, stock or wirecut, each of which describes the manufacturing process used and will determine the external appearance.



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. Part C requirements for areas of severe exposure differ slightly from those of the LABC/NHBC, which place greater restrictions on the use of full-fill cavities with fair-faced external masonry walls; something that is permitted under Part C providing the insulation is at least 150mm thick. Scotland does not permit cavities to be fully filled with insulation in any new-build homes.

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 fair-faced masonry.

Thermal performance compliance with Building Regulations

Part L1A of the Building Regulations requires all new dwellings to be assessed for their fabric energy efficiency and carbon emissions using a compliance tool known as SAP (Standard Assessment Procedure). To help with the design process, a thermal performance specification for all elements that make up a dwelling (walls, roofs, windows etc) is provided in Part L1A, which will ensure compliance if adopted wholesale. This is the simplest method of achieving compliance, but an alternative approach is to tailor the performance of individual elements to suit specific project needs. This offers a reasonable level of design flexibility and is acceptable, providing the overall performance targets set by Part L1A are still met or exceeded. For external walls, Part L1A suggests a U-value (which is the measure of thermal performance for walls, floors and roofs - the lower the U-value, the lower the heat loss) of 0.18W/m²K. This is easily

achieved by masonry cavity walls, although a slightly higher value may be more cost effective in some projects and is permissible using the flexibility afforded by the Building Regulations. Figure 1 shows a number of insulation options for achieving U-values of 0.18 and 0.2. A fuller explanation of Part L1A and how it relates to masonry dwellings is provided in the publication Thermal Performance – Part L1A 2013, available at concretecentre.com/publications.

Cavity insulation

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 1). 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.

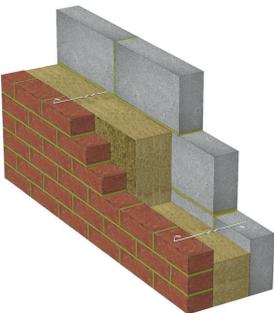
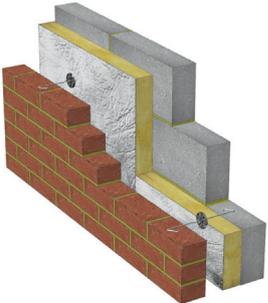
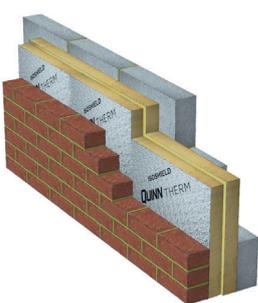
The thermal performance of full-fill insulation is generally lower than the insulation materials used for partial fill. This may result in the need for a slightly thicker layer if a relatively low (high performance) U-value is required. However, in practice a standard 150mm cavity will provide a similar U-value whether fully filled with mineral wool, or constructed with a 50mm clear cavity and partial-fill insulation panels.

In recent years, a third option has also become available, which comprises ridged PIR or phenolic insulation panels specifically designed as a full-fill solution (see Figure 1). These are available from the major insulation manufacturers, and deliver U-values of around 0.18W/m²K in a traditional 100mm cavity, albeit at a slight cost premium.

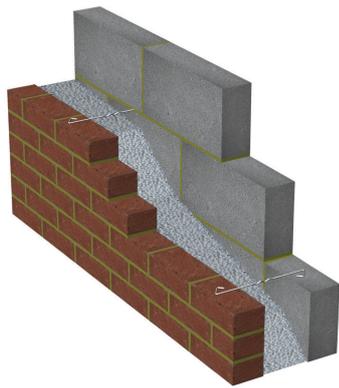
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A broad range of illustrated cavity wall insulation options and corresponding U-values can be found in Thermal Performance – Part L1A 2013, available at concretecentre.com. Figure 1 shows the most commonly used options for cavity wall insulation and summarises their specific attributes. This includes the thickness of insulation needed to achieve a low U-value.

Figure 1: Key options for cavity wall insulation

<p>Full-Fill Insulation (semi-rigid mineral wool batts)</p> 	<p>Key points:</p> <ul style="list-style-type: none"> • 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. <p>Cavity width for 0.18 U-value: 140-160mm (insulation conductivity 0.032W/mK), 160-180mm (insulation conductivity 0.037W/mK)</p> <p>Cavity width for 0.2 U-value: 125-140mm (insulation conductivity 0.032W/mK), 140-160mm (insulation conductivity 0.037W/mK)</p>
<p>Partial-Fill Insulation (PIR, PUR and phenolic panels)</p> 	<p>Key points:</p> <ul style="list-style-type: none"> • 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. <p>Cavity width for 0.18 U-value (50mm residual cavity): 140-150mm (insulation conductivity 0.021W/mK)</p> <p>Cavity width for 0.2 U-value: 125-140mm (insulation conductivity 0.021W/mK)</p>
<p>Full-Fill Insulation (100mm PIR and phenolic panels)</p> 	<p>Key points:</p> <ul style="list-style-type: none"> • Delivers high performance U-values of around 0.18W/m²K in a traditional 100mm cavity • Modest cavity width helps maximise plot efficiency and floor space • Available with profiled plastic facing to provide a small gap for water drainage, giving added protection from wind-driven rain that may penetrate outer leaf • Also available in thicker panels for larger cavities / lower U-values • Products available from Quinn, Xtratherm, Kingspan, Celotex and Recticel. <p>100mm cavity width: U-value will be in the range of 0.18-0.2 depending on the specific insulation product used and type of concrete blocks used (insulation conductivity 0.021-0.022W/mK).</p>

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 or sagging over time
- White expanded polystyrene beads have a thermal conductivity of around 0.038-0.040W/mK
- Grey expanded polystyrene beads have a thermal conductivity 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 0.034-0.04 W/mK.

Cavity width for 0.18 U-value: 190-200mm (insulation conductivity 0.04W/mK), 150-160mm (insulation conductivity 0.032W/mK)

Cavity width for 0.2 U-value: 160-180mm (insulation conductivity 0.04W/mK), 130-145mm (insulation conductivity 0.032W/mK)

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.

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.

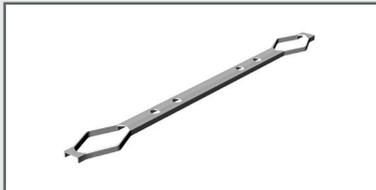
The construction and properties of ties vary depending on the application, but they are categorised into four basic types to suit different masonry applications and loads:

- **Type 1 (heavy-duty applications)** – Suitable for most building types and sizes, but not very flexible. Type 1 ties 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.

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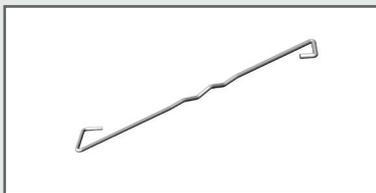
Wall ties continued...

Common wall tie designs



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.



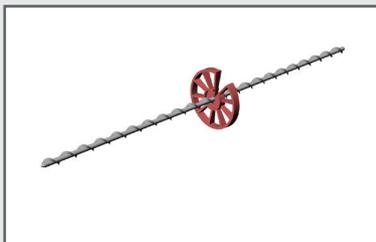
Wire wall ties

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 (see our Easy Guide on concrete blocks for more information), 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.

Thermal bridging and construction details

In modern housing design, the need to minimise thermal bridging is as important as good airtightness and effective insulation, all of which are essential for achieving good fabric energy efficiency. The term 'thermal bridging', describes heat loss that occurs within the building envelope where an area has significantly higher heat loss than the surrounding fabric due to the geometry or the presence of materials with poor insulating properties—thereby creating a bridge for heat to escape. Common examples of a thermal bridge include lintels, balconies and the junction between floors and walls. In addition to impacting energy efficiency, the resulting cold

patch can attract condensation, which may in turn lead to a mould problem.

While some thermal bridging is inevitable in all forms of housing, its impact can be greatly reduced by careful attention to the detailing and construction of junctions. For masonry housing this is most easily addressed through the use of standardised, high-performance construction details that are freely available from a number of sources (see page 7). Each detail has its own calculated heat loss rating (psi value) for use in SAP, and is also accompanied by a simple 2D drawing showing how it is constructed, along with dimensions and specification of key components (see Figure 2 for an example).

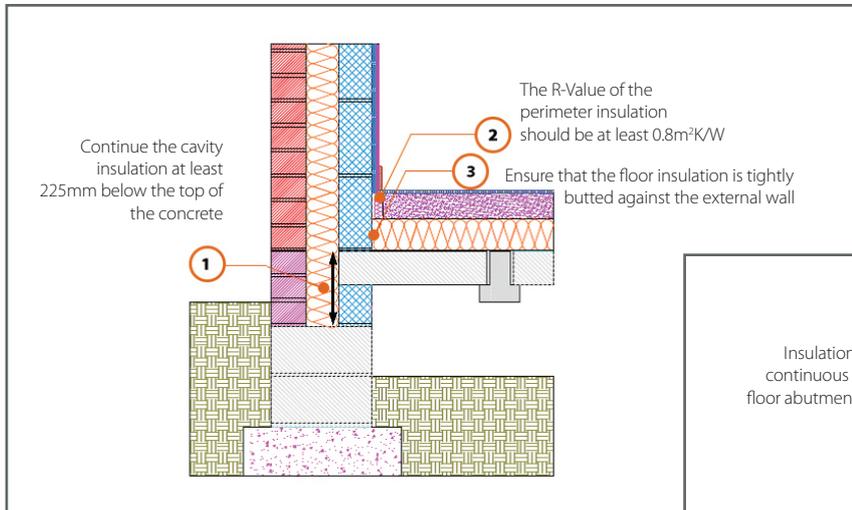
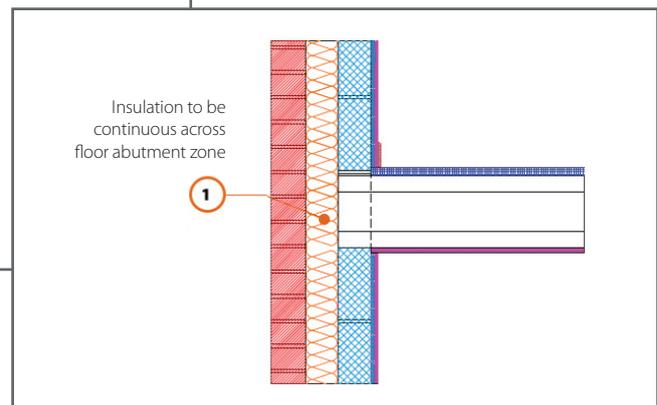


Figure 2: Left: An example junction - between a cavity wall and beam and block ground floor. Below: An example junction - an intermediate floor within a dwelling.



Use of these details offers an easy win, as they provide a low-cost means of enhancing thermal performance and are fully compliant with the Building Regulations. The alternative option of using unverified construction details will attract a significant performance penalty in the SAP assessment, resulting in up to a 60% increase in heat loss from junctions than would otherwise occur. It will also require greater effort and cost to be spent on other aspects of the design to compensate for the loss of performance and ensure that the fabric energy efficiency target set by Part L1A of the Building Regulations is achieved (see 'Thermal performance compliance with Building Regulations').

Sources of high-performance masonry construction details (see back page for details)

- Local Authority Building Control (LABC): Details for aggregate and aircrete block construction
- Concrete Block Association: Details for aggregate block construction
- Constructive Details Limited: Details for aircrete block construction.

Sustainability considerations

Blocks typically contain a high level of recycled material, which is often around 80%. This includes aggregates made from by-products of other manufacturing processes such as fly ash, furnace bottom ash, industrial slag as well as recycled concrete. Around 40% of the energy used to make the cement used in blocks and mortar, comes from burning biomass and waste-derived fuels. The UK concrete and masonry industry

uses around 116 times more waste than it produces^[1]. The brick industry has also reduced the volume of waste generated per tonne of production^[2].

In terms of embodied carbon or CO₂, it is a common misconception that the average masonry house, which represents the majority of homes, contains a lot more than an equivalent timber-frame house. Actually, the difference is quite small with a maximum difference of around 4 per cent^[3]. This is because, with the exception of the timber frame and the inner leaf of blockwork in the masonry house, all the other materials used are essentially the same for both options. Over the life of a masonry home, research has shown that the thermal mass properties provided by a blockwork inner leaf can reduce in-use energy consumption and ultimately lead to lower CO₂ emissions than the equivalent timber-frame home over its lifetime; with a payback period^[4]. The embodied CO₂ of masonry homes will also decrease over time due to a natural process known as carbonation, which describes the absorption of atmospheric CO₂ by the cement contained in the blocks and mortar.

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Suggested further guidance for regulatory compliance and new-build warranty purposes (different requirements may apply outside England):

Building Regulations Approved Document –
Part A: Structure

Building Regulations Approved Document –
Part B: Fire safety

Building Regulations Approved Document –
Part L: Conservation of fuel and power

BE EN 1996:2006 – *Design of masonry structures to Eurocode 6*

PD 6697:2010 – *UK supporting document to BS EN 1996:2006*

NHBC Standards – *Part 2: Introduction to the standards and technical requirements*

NHBC Standards – *Part 6: Superstructure (excluding roofs)*

Thermal Performance Part L1A, The Concrete Centre, 2016.

How to design masonry structures to Eurocode 6 (Introduction/Vertical Stability/Lateral Stability), The Concrete Centre, 2014.

Thermal Mass Explained, The Concrete Centre, 2015.

Concrete and Fire Safety, The Concrete Centre, 2018.

How to Achieve Good Levels of Airtightness in Masonry Homes, The Concrete Centre, 2011.

Further information on specific building products

The Aircrete Products Association: www.aircrete.co.uk

The Concrete Block Association: www.cba-blocks.org.uk

Brick Development Association: www.brick.org.uk

Mortar Industry Association: www.mortar.org.uk

British Precast Buyers Guide: www.britishprecast.org

References

^[1] 10th Concrete Industry Sustainability Performance Report, 2016 performance data, MPA The Concrete Centre, 2017

^[2] 2016 Brick Sustainability Report, Brick Development Association

^[3] Operational and embodied carbon in new build housing, NHBC Foundation, October 2011

^[4] Embodied and operational carbon dioxide emissions from housing: A case study on the effects of thermal mass and climate change, JN Hacker et al, Energy and Buildings, 2008

Sources of further information

Guidance from The Concrete Centre

Download all of these guides from
www.concretecentre.com/publications

Masonry Junctions – best practice tips and illustrated guidance, Zero Carbon Hub, 2011.

About these Easy Guides

This series of guides has been authored by Tom De Saulles, The Concrete Centre, on behalf of Modern Masonry. Tom would like to thank the Modern Masonry technical working group, the Concrete Block Association and the Aircrete Products Association for their contributions in developing these guides.

To download the Housing Easy Guides and to access information about masonry construction visit
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The Modern Masonry Housing Easy Guides are part of the Better Built in Blockwork campaign to share best practice for the design and construction of high performance housing.

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