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UNFIRED CLAY MASONRY

An introduction to low-impact building materials

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This Information Paper provides a broad view of the benefits and limitations of non-loadbearing unfired clay brick or block for those considering its use in construction projects.

Compared with many alternative products, unfired clay masonry is a low-impact building material, and has one of the longest histories of any building material. Its basic properties make it a relatively robust, fire-resistant material, with the benefits of thermal mass and the capacity to moderate internal humidity levels. Unless stabilised, unfired clay masonry is not resistant to prolonged water exposure and should normally be protected from rain.

This is one in a series of five Information Papers and parallel case studies on low-impact building materials. The others cover hemp lime, straw bale, cross-laminated timber and natural fibre insulation.

Figure 1: Internal rendered partition walls using unfired clay block at Wales Institute for Sustainable Education (WISE), Centre for Alternative Technology (CAT), Machynlleth

Unfired clay masonry construction can be used for both loadbearing and non-loadbearing walls. In the UK, traditional unfired clay block ('clay lump') buildings are commonplace in some areas of East Anglia. The modern use of unfired clay (green) bricks offers opportunities for much thinner clay block wall construction (approximately 105 mm) than traditional practice (150–300 mm). However, such thin walls of unfired clay are best suited to non-loadbearing partition walls within a weatherproof building envelope. Unfired clay blocks are traditionally bonded with clay- or lime-based mortar. Recent work has shown, however, that such traditional mortars are not necessarily suitable for thinner walls, and sodium silicate or lignosulfonate-stabilised clay-based mortars will provide higher bond strengths. The construction of unfired clay brick or block walling can be undertaken by bricklayers with little or no retraining (Figure 2).

There are many regional variations of unfired clay (earth) building throughout Great Britain and around the world that reflect available materials, climate and culture. Rammed earth is a technique in which solid walls are formed by compacting soil in layers within temporary formwork. Cob, a vernacular form of construction relatively common in southwest England, is formed from a mixture of clay, straw and aggregate built up in 'lifts' of 500 mm at a time. Unfired clay can also be utilised as an internal render and/or plaster finish, where it brings its hygroscopic benefits to the internal environment to moderate humidity. This in turn can help to reduce numbers of house-dust mites and associated allergies.

While it is theoretically possible to form your own blocks in the manner of traditional adobe construction, unfired clay bricks or blocks are more usually mass produced. The manufacturing process is largely the same as that for fired bricks, extracting appropriate clays from

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the earth and forming the brick or block shape with moulds or, more commonly, by extrusion (Figure 3). Some mainstream brick manufacturers produce unfired clay (green) bricks, and it is their use of fired brick-extrusion machines that causes the typical oversizing of unfired clay bricks: the firing process for standard bricks results in a slight shrinkage not present in unfired versions. Unfired clay blocks can also be formed by pressing (compaction). The moisture content for raw material going into this machine is much less than for extruded blocks and is typically kept at around 10–13%.

Once moulded, unfired bricks are left to dry in controlled conditions, rather than fired, which significantly reduces the overall embodied energy of the resultant brick. When delivered to site, unfired clay is not as resistant to damage as fired clay, hence care should be taken with site storage, most importantly ensuring bricks are kept dry, including protection from rising moisture from the ground or very high humidity levels (Figure 4).

Prior to site work, unfired clay does require an awareness of its unique properties during the detailed design stage (Figure 5). Most notably, protection from high humidity and prolonged wetness must be considered. Usually, unfired clay should be used protected from excess moisture and sited above the damp-proof course/damp-proof membrane level. If protected from direct wetting, unfired clay materials can be used in internal wet areas such as bathrooms and kitchens, where their additional vapour permeability is of benefit. They can be used in exterior walls when protected from weathering (Figure 6). It is advisable to bed unfired clay bricks or blocks on plinths formed from a few courses of fired brick (or other similar water-resistant material) to avoid damage in case of accidental flooding. In other respects, unfired clay can be detailed comparably to aircrete blockwork.

Unfired clay masonry has a compressive strength similar to aircrete blockwork, around 2–3 N/mm^2, although this can vary more widely depending on the clay content and method of block manufacture; individual product details should be checked. Unfired clay blocks also provide sufficient strength for normal-duty fixings, such as plumbing, electrics and shelves. As with aircrete, it is possible to use oversized self-tapping screws without wall plugs, aiding installation times. It is advisable to use casing for any plumbing or electrics going through an unfired clay brick wall. The material is generally also workable on site to the same extent as aircrete, using mechanical hand tools or manual (brick) saws. Due to the relatively soft nature of unfired clay bricks, a simple skutch tool can be used to score the brick before breaking, to make a custom fit. Off-cuts from construction can be immersed in water on site, reverting to clay suitable for use in landscaping or (with additives) as clay mortar, thereby minimising waste considerably.

Unfired clay notably differs from aircrete in its stability. This is partly due to the weaker bonding capacity of both the clay in the bricks and the clay or lime mortars (over their cement equivalents). Consideration should be given by the designer and structural engineer to the head restraint of the wall, together with its overall slenderness. Typically, this issue can be resolved with thicker walls

Figure 2: Unfired clay bricks can easily be laid by bricklayers with little or no further training
(Courtesy of Ecoterre)

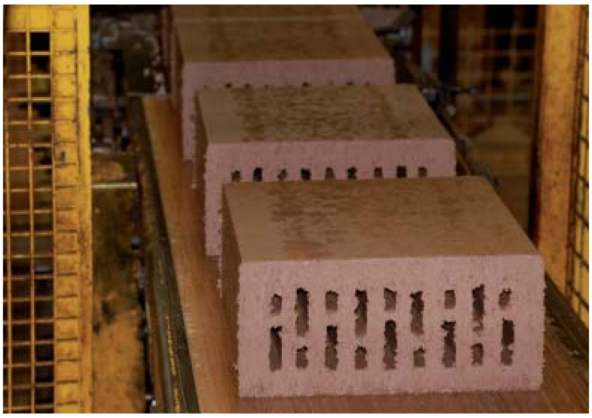

Figure 3: Extrusion of clay bricks using conventional brick-making machinery
(Courtesy of University of Bath)

Figure 4: Careful storage of unfired clay bricks is important
(Courtesy of University of Bath)

when using clay mortars, or by the use of specialist, preformulated sodium silicate mortars (sodium silicate, clay and sand). These can deliver bond strengths broadly comparable with traditional masonry construction and hence allow wall thicknesses of 100 mm, much thinner than traditional uses of earth building.

A wide variety of methods are used, both traditionally and in contemporary builds, to improve the performance of unfired clay (earth) building materials. The simplest is compaction (densification), which removes air voids and improves strength and durability. Traditionally, the

Box 1: Why specify unfired clay brick and block?

Advantages

- Familiar form of construction
- Hygroscopic environmental regulation
- Low-carbon form of masonry
- Low waste and ease of reuse/recycling
- Thermal mass
- Vapour-permeable wall construction

Limitations

- Careful detailing needed for exposed areas
- Low strength
- Natural soil units are prone to water deterioration
- Requires time and shelter during drying on site before finishes can be applied
- Specialist mortars can be required for thin walls
- Suitability of rendered external finishes limits application
- Use limited to above damp-proof course or equivalent level
- Very low U-values will require thicker walls than some competing materials

use of straw reduces shrinkage cracking, and the use of fibres can also reduce weight and improve both thermal resistance and fixing capacity. Since the early twentieth century, cement has commonly been used as a soil stabiliser in civil works as well as earth building, most notably in compressed earth blocks and rammed earth in Australia. Cement generally improves strength and dramatically improves water resilience, but at the cost of using a high-energy binder. Some earth builders feel that cement-stabilised clay should be regarded as 'poor concrete', rather than earth. Historically, lime has also been used, and is particularly successful in soils with a higher clay content.

On site, the use of unfired clay block is comparable with fired block construction; it is usually laid with a mortar to provide an even distribution of load from each brick to those beneath. Traditionally a clay or lime mortar was used. However, for thin (105 mm) green brick walls, clay mortars with stabilisers are likely to be required to provide sufficient bond strength. Cement-based mortars are generally not recommended as they have poor vapour permeability and, while they have high strength, they form a poor bond to clay blocks. Careful consideration is therefore needed on mortar type (and bond performance) depending on wall thickness; advice should be sought from brick manufacturers and specialist suppliers. Bricks should be lightly wetted on the surface to be mortared (whichever mortar is used) in order to prevent rapid dewatering of the mortar, although overwetting the bricks is to be avoided. Site working speeds should be the same as for fired bricks after an initial familiarisation period for bricklayers. Once laid, unfired clay and any finishes will require drying time to reach full strength and will have some shrinkage during this period. This drying need not preclude occupation in most instances, although it is best practice not to apply top-coat internal finishes until the mortar joints from the wall have largely dried out.

Unfired clay brick or block can be left exposed internally in appropriate environments, where the aesthetic impression is similar to standard brickwork (Figure 7). More commonly, it will be rendered and painted. In this case, vapour-permeable renders or plasters, such as lime or clay, should be used to allow the migration of moisture and prevent build-up within the unfired clay. Both lime and clay finishes retain the hygroscopic performance of the unfired clay and can moderate the humidity of the internal environment. Importantly, the vapour-permeable performance of the render must be matched by any paint or wall covering used; this must be highlighted in the building manual and building owners appropriately advised. Vapour-permeable paints, which include mineral paints, are now widely available and this should not overly restrict end users. Some of these paints, if exposed to a considerable transfer of moisture, such as from a leaking roof, may facilitate mould growth and surface blistering. However, treatment should focus on fixing the leak rather than constraining the transfer of vapour.

FURTHER READING AND SOURCES OF INFORMATION*

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* All URLs accessed October 2011. The publisher accepts no responsibility for the persistence or accuracy of URLs referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

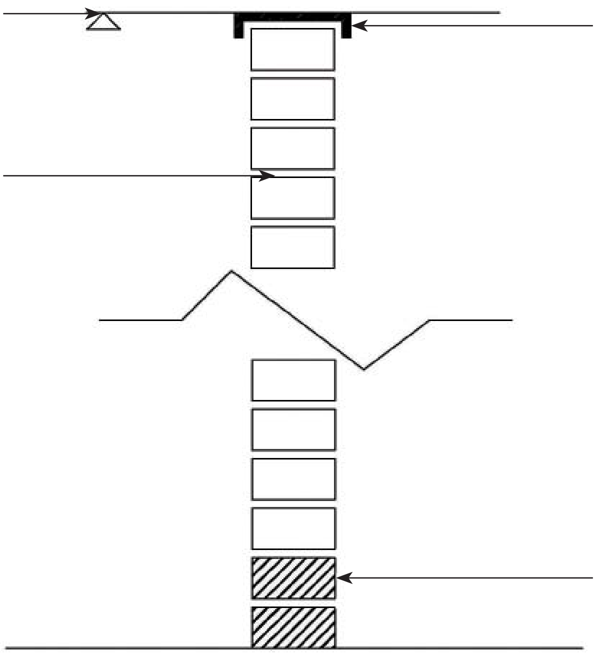

Figure 5: Section detailing of an example unfired masonry construction (similar to solid masonry construction)

Figure 6: Unfired clay block construction should be used in protected situations, including internal leaves of external walls – this wall is protected by wood fibre insulation and external lime render
(Courtesy of University of Bath)

Figure 7: Unfired clay brick walling at Neal's Yard, Dorset (Courtesy of Feilden Clegg Bradley Studios)

Box 2: Typical properties of unfired clay brick

As a natural product, performance can vary slightly, but commercially supplied unfired clay block systems tend to achieve:

- dry density: 1700–2200 kg/m^3
- compressive strength (depends on moisture content): 1–4 N/mm^2
- thermal conductivity (depends on density): 0.5–1.0 W/mK

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