Feat of clay

Moves to develop UK production of unfired clay bricks are driven by the growing demand for sustainable construction materials to displace conventional products. Tom Morton, Principal Architect at Arc, Fife, UK, examines the key factors in achieving a scale of use that would yield significant benefits, such as standardisation and low cost.

Top: making the unfired bricks. Bottom: building with unfird bricks
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The main advantages of using unfired clay as a binder in building materials instead of cement, gypsum or fired clay are a healthy indoor environment and low environmental impact over the whole life cycle of the material. These attributes have been well established over the last fifteen years in Germany, where a small specialist construction sector has experienced sustained growth through the development of national standards in using unfired clay and the use of sophisticated products in prestige projects.

But application in the UK has been hampered by the lack of guidance and standardisation in available materials and the expense of importing modern products from Germany. The development of best practice guidance and low cost materials manufacturing in the UK would remove significant barriers. Attention now focuses on ways to realise this shift in attitude.

In order to assess the potential of unfired clay bricks in the UK, a test house was built and monitored in a research project funded by the DTI Partners In Innovation programme. This two-year project reveals the technical advantages of using unfired clay materials and highlights practical implications of their use.

Low impact manufacturing

Unfired clays are natural materials with varying properties, commonly combined with fine aggregates and fibres to make a range of products such as bricks, blocks, boards, mortars and plasters. Clay materials produce very little waste, as there is no fundamental chemical change or ceramicisation involved in their manufacture and use. The materials are easily recycled or cleanly disposed of.

Although clay manufacture uses a finite resource, the environmental impact can be benign, with low value agricultural land being transformed into biodiverse wetland habitats. Sources of clay are shallower and less remotely located than sources of gypsum and cement or lime.

Unfired clay materials also have relatively low embodied energy and carbon. The brickwork in the test house had embodied energy of 146 kwh/tonne and embodied carbon of 44.6 $kgCO_2$/tonne. This is about 14% of comparable fired brickwork and 24% compared to light-weight blockwork. While the bricks were removed from production before kiln firing, they still required two days of artificial air drying. The estimated saving in this building is 24.9MWh and 7036kg of CO_2 over common bricks, and 14.5MWh and 4104kg CO_2 over light-weight concrete blocks.

Healthy living

An ability to regulate moisture is another key quality of unfired clay materials. Their hygroscopic scope to absorb and desorb atmospheric moisture allowed the 15mm clay plaster surface in the house to strongly regulate short-term peaks. In the bathroom, the clay plaster had such a strong ability to absorb peaks of air moisture after showers that it cleared the air without surface condensation. The effect of the extractor fan was of no statistical significance. The brick core had a longer term moderating effect, peaking at two hours after exposure to moisture, but continuing for over 24 hours.

The ability of a building's fabric to passively avoid conditions where condensation will occur

Top: The finished house. Bottom left: clay paster texture. Bottom right: window curve

improves its long-term durability and avoids the need for vapour control membranes, which are prone to defects from poor workmanship. However, the main advantages in moisture terms are to human health through the regulation of internal air relative humidity (RH).

The UK has some of the highest rates of asthma in the world and allergens from house dust mites are known to cause asthmatic sensitisation and trigger symptoms. Recent research recommends maintaining internal RH below 60% to ensure that the dust mites critical equilibrium humidity will not be reached. Designing dwellings with a high level of insulated thermal mass can help to achieve this.

Allergy to mould spores is a major health risk associated with fungi in buildings, and the inhalation of mould spores can also cause toxic reactions and cancer. Relative humidity levels below 70% are thought to avoid mould growth. Avoidance of high RH levels can also reduce the viability of bacterial disease transmission. Although low relative humidity can cause respiratory disease through the drying of the throat, the risk is considered less than that presented by dust mites and mould at high humidity levels.

When monitoring the test house, the target of regulating levels to between 40% and 60% was generally met. While there were short-term values outside this range, these were attributable to periods of very high ventilation or the use of showers. While external air relative humidity fluctuated considerably, between 24.9% and 96.1%, the mean external value was around 65%, while the mean internal value was around 45% (see graph above).

Comfort levels

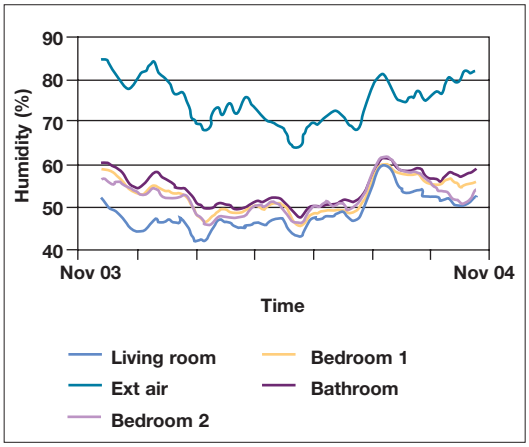
Used on the inside of a layered construction, the unfired clay bricks made a significant contribution to thermal comfort, with warm surfaces and thermal mass that moderated atmospheric temperature swings for up to a week. Effective U-value (the rate of heat loss) of the walls was 32% better than the design calculation, though the reason for this was unclear. The improvement may relate to optimisation of the density of the cellulose insulation or a better than predicted performance by the earth brick and plaster related to air in the earth pore structure.

Occupants of earth buildings often report better perceived thermal performance than is predicted by steady state U-value calculations, which can prove inaccurate predictors of real building performance for a number of reasons. Whatever the explanation, the walls of the building performed significantly better than was indicated by the design calculations and exceeded the requirements of the contemporary building regulations.

Down to earth

The future for earth construction in the UK remains uncertain. Unfired clay's fundamental properties as a flexible, healthy, low-energy binder give it great potential in an evolving sustainable construction industry. Earth masonry construction is simple and cheap, and could help establish a basic mass-market for earth materials in the mainstream sector, fostering more exciting research and development into prefabricated composite materials and spray applications.

But the commercial reality is that while some major brick producers are developing unfired products, the kind of investment that is needed for a progressive leap is still some way off.



Air relative humidity was regulated to the target range of 40-60% by using unfired clay materials for building

	Thermal resistivity R (mK/W)	U-value (W/m²/K)
Regulation wall value	3.33	0.3
Wall design value	6.33	0.157
Recorded wall performance	9.34	0.107

Further information

Arc Architects led this research in association with Dundee University, UK, and Robert Gordon University, UK. Tom Morton is the Principal Architect at Arc, e-mail: tom@arc-architects.co.uk. Website: www.arc-architects.co.uk/archive.