Light earth

What do you get if you mix straw or woodchip with clay slip (clay and water in a creamy solution), place them within a frame and let them dry to form a solid, insulating wall? Light earth construction, that's what. A newcomer to the UK but popular across the globe, it could prove a useful option for ecological designers and builders following recent research and development funded by the DTI. **Chris Morgan** and **Cameron Scott** explain...

Light earth construction as practised today was only recognised in the middle of the 20th Century as a discrete technique and first documented in Germany in the 1930s. It did not develop widely until the 1980s when, along with a number of 'ecological' or 'neo-traditional' techniques, it was promoted and developed by enthusiasts, first in Germany but later across the world.

Several hundreds of examples have been built across Europe and the US, but it is only in Germany and New Mexico where Light Earth Construction has been recognised within official documentation on building regulations and standards.

Research project for the DTI

Gaia Architects were commissioned as Lead Partner to run an 18 month research contract for the DTI within the 'Partners in Innovation' programme. A Steering Group for the project also consisted of Gaia Research, Rebecca Little Construction and WS Atkins Project Officers.

The first aim of the project was to introduce the potential and benefits of light earth building to the UK construction industry. Second, it was intended to establish the technical viability of the technique in the UK so that, third, the work would support compliance with building standards and lenders' / insurers' requirements.

The three deliverables of the project were a demonstration building constructed and monitored near Melrose in Scotland, a website and a report. The report contains the results of a series of tests to establish the technical characteristics of light earth, guidance on the construction, maintenance and costs of light earth buildings and a number of case studies from around the world. Best practice advice throughout is based on the the involvement of an Advisory Group of experienced practitioners from around Europe. The website presents a distilled version of what is written in the report. The demonstration building is described later in this article.

Construction and maintenance

(see photos at top of page)

Clay rich sub-soil is mixed with water to form 'slip' at a certain consistency. This is mixed with fill material such as straw, woodchip or some other fill material to provide the light earth "mix". The fill material, particularly straw, must be kept dry before use and be completely covered by the clay slip. Both mixing processes may be manual or mechanical.

A structural frame (usually timber) provides the loadbearing elements of the building. In monolithic construction, either temporary or permanent shuttering is fixed to this framework and the light earth mix is placed between and lightly compressed or tamped to form a monolithic mass. This dries to form a solid wall. Care must be taken to ensure that the wall dries as quickly and completely as possible. Walls should be no wider than 300mm in general.

The construction sequence of light earth building:

(left to right)

viscosity test

tossing slip and straw together to form the light earth 'mix'.

tamping the mix into shuttering fixed to the timber frame

fixing shuttering for the second lift

lift lines clearly visible

more work is involved at higher levels

An alternative to monolithic construction is to use pre-dried blocks. Blocks are laid in earth based mortar but otherwise it is the same as any other type of block construction. The use of blocks speeds up construction time on site, reduces the shrinkage that can occur in monolithic construction and enables work to be carried out at almost any time since drying out is less of an issue. However, block construction tends to be more expensive, either due to the cost of bought blocks, or the additional time spent in the double handling of materials.

As you might expect, light earth walls are generally but not exclusively finished in lime or clay based plasters and renders. Cladding over a ventilation gap is also used externally. Paints or other surface coatings must be chosen so as not to adversely affect the vapour permeability of the wall.

Services are surface mounted or placed within conduit and fixtures may be fixed directly to the light earth but are more usually fixed to the frame.

A nominal amount of maintenance should be undertaken regularly on light earth buildings and this will ensure their longevity. The repair of buildings is easy and no more onerous than conventional construction.

Light earth can be used in the renovation of existing buildings. It is often of particular value being fairly insulative but with some thermal capacity and with similar movement characteristics to many traditional materials.

Only a small percentage of the costs associated with light earth are related to materials, the majority is that associated with labour. Thus any labour saving techniques tend to have a considerable effect on the overall cost and programme.

Technical characteristics

Well designed, constructed and maintained light earth properties will last indefinitely. The only significant risk to the durability of light earth comes from prolonged and excessive wetting which can lead to decay.

The thermal properties of light earth can be adjusted by design and are intimately linked to its density; the lighter the mix the greater its insulative capacity, while the greater the clay content, the greater its ability to store heat (thermal capacity). In practice light earth is both insulative and thermally massive which is a valuable and unusual combination offering both energy efficiency and moderated thermal comfort. Density can also be adjusted by the extent of compression of the mix on site which can make establishing a single density impractical. Most practitioners suggest a range of densities within which they can confidently maintain consistency.

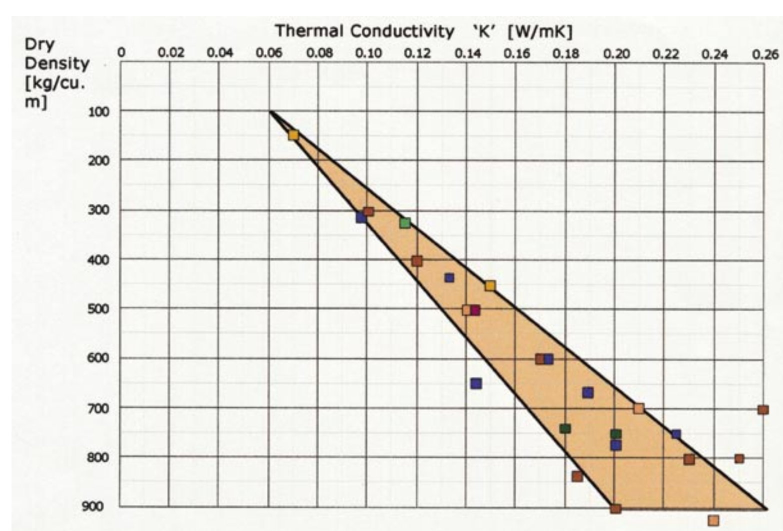
Samples of light earth were tested by Plymouth University Civil Engineering Department for thermal conductivity and capacity as part of the research. These confirmed the validity of the various European tests which have been previously conducted. The results are shown in Fig.1. The lighter mixes can be effectively used in the UK for external walls being reasonably insulative, but trade-offs may be required under the new regulations.

Light earth construction operates as moisture transfusive construction and so is inherently protected against the risk of interstitial condensation because of the vapour permeability and hygroscopicity of the materials used. In addition, the ability of these materials to absorb moisture allows light earth walls, in conjunction with earth based coatings, to moderate internal humidity levels with considerable benefits to the health of occupants. Paint or other finishes must be vapour permeable or microporous for this to remain the case.

Acoustic criteria only apply in limited situations but while dense earth performs well in insulating against sound transfer, light earth, having less mass, performs less well. Light earth walls can be designed to perform as required but require cavities in much the same way as timber frame walls.

Light earth is difficult to ignite but officially classed as combustible due to the presence

Fig.1 Graph indicating the several test figures for thermal conductivity of light earth against density from across Europe showing a fairly consistent pattern.



of combustible fill material (unless mineral fill is used). Even without plaster coatings, its resistance to fire is good but the presence of plaster coatings in use allows it to be used for all situations under the Building Regulations except those requiring non-combustible materials only. Mineral fill mixes can be used in all situations.

Indicative Fire Resistance Tests were undertaken by Chiltern Fire International on two sample panels. An unplastered straw-clay panel of light earth density 145 kg/m^3, less dense than would be normal in a building, lasted 36 minutes in a furnace with temperatures over 1000 degrees C. before burning through. A woodchip panel of density 450 kg/m^3 lasted 2 hours and didn't burn through at all. Significantly the temperature on the 'cold' side did not raise much throughout the test, see Fig.2.

Even without plasters, the tests showed that combustible materials like straw and woodchip can be effectively protected by the light clay coating. The tests should dispel any residual fears lenders, insurers, latent defect insurers and valuers have with the technique.

Advantages and comparisons:

Light earth vs earth and straw bale

BFF readers will be familiar with most of the ecological advantages of light earth which are in common with straw bale and other earth based construction types; the materials used have little embodied energy, can usually be sourced locally, are neither themselves toxic nor require additional chemicals or energy to make into something useful and can be safely composted back to the earth after use.

Like the other techniques, the materials are cheap, but the labour required is greater than most conventional construction methods. This shift in the relative costs of labour and materials should allow self-builders, for example, to make considerable overall savings, depending on their accounting system. In addition it is an easy, flexible and safe method of building requiring less specialised skills and tools. Another reason why it may appeal to self builders and others not necessarily interested in its 'eco-credentials'.

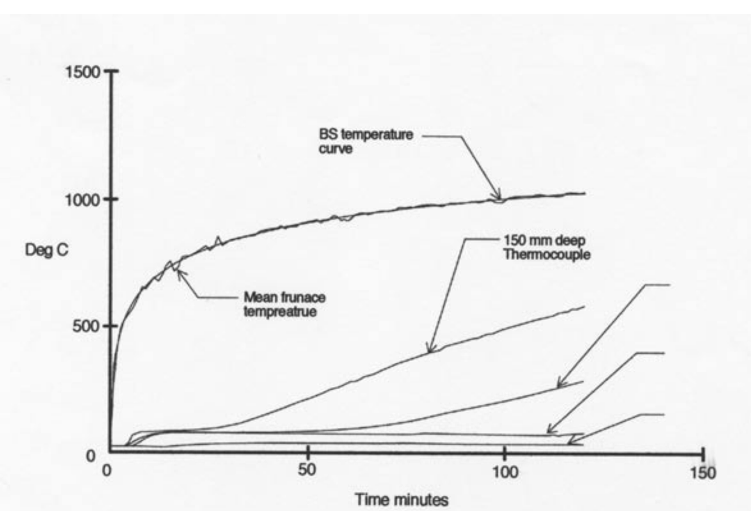


Fig.2. Graph showing the temperatures of the woodchip-clay sample at various depths within the sample when exposed to a furnace of about 1000 degrees C. Note how little the 'cold' face warms up showing excellent insulative properties. The sample did not burn through during the two hour test.

Like the other methods noted, the finished buildings are potentially very healthy, being both non-toxic, moisture transfusive and capable of balancing the internal climate.

Unlike the other methods, however, light earth can be adjusted in several ways to suit the particular conditions. Most obviously it can be adjusted in density from under 250kg/m^3 (less than straw bale) to 1200 kg/m^3, beyond which it is formally no longer 'light' earth and becomes - in terms of density and thermal values etc., much the same as cob, adobe and the others. In this way the technique can respond to varying environmental criteria for different situations, using denser mixes on south facing walls, lighter mixes on north facing, for example.

The materials used can also be adapted, more or less anything suitable can be coated in clay, set and called 'light earth' though straw and woodchip are by far the most common. Expanded glass or clay beads are used sometimes on the continent. Other materials used have been cherry stones, hemp, wood shavings, sawdust and others.

Light earth construction benefits from the advantages of frame construction such as speed of construction, the separation of structure and mass freeing design possibilities, and being able to construct the roof early allowing work to continue in the dry. The technique fits into the existing industry preference for, and experience of timber frame construction so may be more readily adopted than the other radical 'ecological' methods.

Like dense earth construction, the thermal capacity of a light earth wall contributes to a moderation of temperature swings, raises the internal surface temperature of the walls reducing the radiative heat loss of occupants and improves the thermal comfort of the space overall. The technique has much in common with the French 'Isochanvre' system piloted in the UK recently by Modece Architects and using hemp and lime. The use of clay rather than lime, however, is preferable in terms of embodied energy and hygroscopicity of the finished mass.

In comparison with dense earth construction it has been suggested before in BFF that we should accept the limitations of earth construction and not tamper with what is undeniably a great material. The trouble with this is that it takes no account of the equally undeniable advantage of increased insulation and moreover seems to infer that dense earth construction is somehow 'better' than its light earth cousin. Having said that, using dense earth for what it is good at - compression and thermal and moisture mass, and insulating externally with a material designed to insulate well, such as the wonderful Aitec building at CAT, makes a lot of sense. Even so, not every situation is the same and it is always good to have a number of options at your disposal. This is how we wish to promote light earth - not as the solution in all cases, but as a hitherto overlooked but useful option.

Light earth achieves neither the exceptional insulative value and simplicity of straw bale, nor the thermal capacity and freedom from moisture risk as solid earth building. Because of the need to dry out in relatively warm dry weather it also has a shorter construction season, unless blocks are used. On the other hand, it has some of the insulative value of straw bale, but takes up far less space than thick bale walls, adding floor area and valuable thermal capacity which is otherwise only present in the plaster. Unlike solid earth construction, it can be used for external walls without additional applied insulation. In many ways it combines the advantages and disadvantages of both to produce a method ideally placed to respond to the varying needs of buildings which must last many years serving many masters with different requirements. And this is potentially its greatest strength.

Dil Green spoke warmly of woodwool in a previous edition of BFF noting that it did "a little bit of everything rather than a lot of one thing." If buildings need to last over generations satisfying housing occupants' requirements that we could not anticipate - a thermal

/ insulative envelope which does a little of everything is perhaps better suited than one which does one thing very well but not another.

In practice the lack of thermal mass in straw bale construction can be remedied by thermal mass elsewhere, such as in the floors, and the lack of insulation in dense earth doesn't matter if you don't use it for external walls... We know this, but to reiterate - its good to have options, especially flexible ones.

Approval for light earth

Planning departments are not likely to have a specific problem with light earth since it is immaterial to most of their normal considerations. Of the three completed light earth buildings in the UK, only one has needed to be submitted to building control. In this case the officer had three particular concerns; thermal behaviour, vapour permeability / condensation risk, and fire behaviour.

In the case of fire, he accepted that with the use of proven non-combustible coatings either side, surface spread of flame was not a problem. He was provided with German literature regarding the thermal and vapour permeability characteristics of light earth which he accepted, but asked for a condensation risk analysis. This suggested a very slight theoretical risk in very cold spells, but he further accepted that the hygroscopic materials used would render such a theoretical risk negligible in practice.

The research is now in its final phase in which mortgage lenders, insurers, latent defects insurers and valuers, among others involved in the technical and financial support of the construction industry are giving feedback on their view of the technique so that, hopefully, all obstacles to the eventual uptake and development of light earth have been overcome as part of the project. Initial feedback indicates that approval from all sectors will not be problematic with one of the main problems being valuation because of the lack of precedent.

Future scenarios

Based on observation of European development of light earth, there are three likely ways in which it can develop in the UK. The first is the simple, low-tech way in which self-builders in particular take up the technique because it offers significant material cost savings coupled with useful energy saving and health benefits. The additional labour required is absorbed by the self-builders.

The second is through development of mechanical means of mixing and installation which render light earth not only economical in materials but in labour too. The technique would then appeal more to larger scale operators who could marry economy with obvious sustainability 'brownie points'.

The third - which is already underway - is the introduction and development of light earth products, mainly blocks but also pre-fab panels, boards and such like which simply replace less ecologically benign products.

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Light earth case studies

50m^2 3-room stand-alone building near Melrose, Scotland built 2001-2 with full building control approval. Mix of straw-clay and woodchip-clay walls with clay plasters and embedded heating pipes in the walls and floor. Suspended timber floor and clay/sand external render with a limewash finish - Architect: Chris Morgan

20m^2 single storey extension to a 1930's brick semi-detached family home in South Devon built in 1997. An oak frame clad in rough sawn boards externally and internally, with walls and suspended floors infilled with light earth (straw-clay). Untreated timber was used throughout and there have been no problems to date - Designer: Cameron Scott

50m^2 Studio Workshop near Swindon on an exposed site built 2000-2001. Straw-clay infilled timber frame with thick lime plaster and external render. Beaten earth floor over light earth insulative layer and free draining leca beneath - Owner/Designer: Lysana Robinson

127m^2 family house built in 1997 in Raisio, near Turku in Finland. Timber frame with straw-clay block infill. The blocks were made as a one-off by a nearby farmer who now makes blocks on a semi-commercial basis. Walls are lime rendered externally at ground level and timber clad at first floor with lime plaster internally - Architect: Teuvo Ranki.

Approx. 200m^2 Community Church in Jarna, near Stockholm, Sweden, built 1999-2001. Built by the community using large, thick planks vertically as structure and internal finish with straw-clay blocks placed around the outside as insulation, coated with clay based render. Straw-clay is also used as the ceiling finish and insulation in the Entrance Lobby - Architect: Walter Druml

Summer Cottage in the Mauritzberg Estate, Norrkoping in Sweden built by students over 8 weeks in the summer of 1992. The walls are of straw-clay blocks using on-site clay, also used for clay/sand renders. Originally intended for brick construction the design remained unchanged and does not have the overhangs normally needed for unbaked earth construction - Architect: Prof. Sverre Fehn

Refurbishment of an early 18th C town house in Potsdam, Germany as part of major upgrading works following reunfication in 1993-4. The block has rendered brick walls at ground floor but 'half-timbered' first and attic floors in which the original bricks were replaced with more insulative expanded rock / straw - clay and lime plastered both sides. Light earth was also used in the floors as deadening and insulation - Architect: Simone Haase

Social Housing Block of four units in Scweicheln, near Herford, Germany where the labour cost of monolithic light earth construction was offset by the use of the project as a training project for unemployed people. The walls use woodchip-clay between reed lath permanent shuttering, clay based internal plaster and wode - stained timber cladding externally - Architect: Klaus Beck

Approx. 180m^2 family house near Kaikohe, Northland, New Zealand where the owner / self-builder used woodchip from his own land in preference to imported straw for the light earth mix. Built during 1996 with a timber frame, large overhangs and lime based coatings inside and out - Architect: Martyn Evan

Contacts

For copies of the DTI Report, contact Gaia Architects on 0131 557 9191.
For bibliographies and further contacts, refer to the website: www.lightearth.co.uk

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