Building with earth is undergoing a revival in industrialised countries as an environmentally friendly technology

Earth building today

BY SUMITA SINHA AND PATRIK SCHUMANN

One third of the world's population lives in earth buildings, yet the widespread innovation in other construction technologies has passed earth architecture by. Any advances have been guided by performance standards for concrete blocks, by contemporary industrial production and construction practices, and low budgets.

Wider use of earth in buildings is constrained by regulations, planning controls, loss of know-how and desire for materials with a more advanced image. Yet earth building has many advantages.

It has a low environmental impact as it reduces the use of cement, steel, timber and other resource-intensive materials. Earth-building materials use fewer toxic chemicals, are more recyclable and have low embodied energies. Engineering and site excavations often leave behind excess material which can be used directly. If suitable deposits are found nearby, transportation energy is saved, and despite semi-mechanisation in the production of both modular blocks and monolithic walls, only minimal energy inputs are required.

Low-, intermediate- and high-technology options exist for most situations. Earth-block and fired-brick masonry techniques are very similar, while rammed earth is comparable to modern concrete construction. From entirely manual to fully mechanised, production and construction processes can fit local circumstances and building briefs.

Cost savings for local self-build in France have been estimated as high as 40 per cent for materials, transportation and labour. However, while earth is often considered ideal for self-building due to the labour-intensive nature of materials preparation and construction, self-build is less widely practised than is often assumed. Whether in urban Sudan or rural New Mexico, the bulk of earth buildings are erected by independent contractors.

Good use can be made of the insulation properties of earth and the thermal capacity of exposed walls. For example, a 600mm cob (soil and straw) wall has a U-value of around 0.6W/m^2 °C. A DIN standard has been established covering thermal conductivity, which varies with density ranging from 0.25W/m°C at 750kg/m^3 to 1.25W/m°C at 2000kg/m^3. Compaction and the addition of stabilisers also influence performance. Typically, compacted earth blocks have a thermal conductivity of 0.34W/m°C compared with brick at around 0.85 and mineral-fibre insulation at around 0.035.

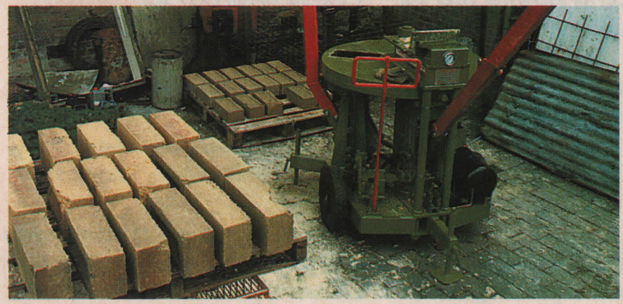
This page, below: a soil-cement block from Isle d'Abeau, France, an earth-constructed social housing project built in 1984. Opposite page, from top: a rammed-earth building in the same scheme and an overall exterior view; an adobe house in Santa Fe; a CARTEM block maker

SUMITA SINHA

SUMITA SINHA

SUMITA SINHA

ECOASYS



ECOASYS

Compressive strengths can range from the recommended minimum of 2.8MN/m^2 for straw-clay, through 7.5 for adobes (earth blocks) up to 12 for mechanically compressed cement-stabilised soil blocks.

Designing with earth

Siting is clearly important to avoid ground and surface water, to capitalise on location of raw materials and optimise orientation. The most important concerns for earth walls are protection from water and tensile forces. A solid foundation, water-resistant base and well-drained roof are essential. The saying, 'All a cob building needs is good shoes and a hat' holds true for earth building in general. Making interior walls is relatively straightforward. Openings require special attention to positioning on the façade, relief of load forces, shape and size, drainage and solar exposure.

Much earth construction is generally like masonry and concrete construction. Additional requirements for earth building include understanding of the material, knowledge of local precedent and quality control in production and construction. Although domes and vaults are attractive, they are really only suited to arid regions and require additional structural details and building skills.

Sampling, testing, and experimentation should always precede the use of earth for building as the way it is used will depend on its composition and ambient moisture pattern – these influence its plasticity, strength and durability. Ideally, building earth should comprise 10-25 per cent clay, 15-30 per cent silt, and 45-75 per cent sand. If there is too little clay the material crumbles; if there is too much it cracks. Since soils differ from place to place, an optimum composition may not be available. Any of the constituents can be augmented, and natural or artificial additives can be used as modifiers.

However, an idea of the soil composition is not enough, as behaviour of the clay and the water content are also important in determining how plastic the earth will be. Efficient compaction is particularly dependent on water content. A plasticity index therefore needs to be determined, indicating an optimum water content for forming the earth, which in turn influences its ultimate strength. These tests can be carried out with reasonable accuracy using ordinary kitchen utensils.

Construction techniques

Austin and Smith[1] have classified some 16 traditional and modern earth-building techniques worldwide. Broadly, techniques can be grouped as:

- Wattle and daub. A light wooden framework of thin branches and other vegetation with a mixture of mud applied thickly on both sides as both infill and surface rendering. The lattice gives tensile and shear strength, reducing the thickness required, and the soil provides compressive strength plus some thermal mass and insulation
- Cob. A wetted mixture of suitable soil with a good amount of straw is hand-packed in deep lifts directly on to a thick wall. The next course is laid after a few days setting, and a free-standing height of 10m can be achieved. Cob is widely found in South-west England
- Infill. Both the above techniques are also used as infill for timber-framing or other primary structure. Recent innovation has focused on pre-fabricated modular panels of lattice clay or straw clay (equivalents of wattle and daub and cob), most notably in Germany and Switzerland
- Earth blocks. Modular building blocks of earth (adobes) are made by moulding moist soil inside forms, packed manually or pressed mechanically. Machine-compressed blocks are of higher strength, durability, tolerance, and consistency. Blocks are cured in the shade for several weeks and laid up with mud or cement mortars. Two British companies manufacture earth-block machines, though one deterrent to their use is their high cost. If they can be bought collectively or rented, block-building can be an appropriate technique
- Rammed earth. This allows uninterrupted construction of monolithic, compressed-earth walls. It involves tamping down lifts of moist earth between formwork. Density is increased significantly beyond that gained by hand-laying, so wet and dry strengths and durability are increased. Mechanical

tamping can further improve these properties. But formwork restricts flexibility of design, heavy compaction limits the treatment of openings and monolithic walls are difficult to change or extend

- Geltaftan. This intriguing process involves firing ceramic products in an earth building. In the process the whole building is baked by the waste heat from firing, producing a monolithic, water- and earthquake-resistant structure. However, although greater hardness, compressive and tensile strengths are gained by using this technique, brittleness also increases

Increased water resistance, compressive and tensile strengths can be achieved by the addition of stabilising and binding agents to the raw material for either earth blocks or rammed earth. Experimentation has led to standards for lime-, cement- and asphalt-stabilised earths. The relative ease of adding stabiliser is offset by the increased care required and costs incurred. The optimum proportion of these additives is about 10 per cent by weight, depending on soil composition, properties, and performance requirements.

Earth walls can be finished with many types of render, though the best are usually mud-based. The important principle is to match the composition of the render to that of the walling so that the wall can breathe, ie exchange moisture with the atmosphere, and differential heat expansion is avoided. Tolerances of less than 5mm can be achieved, so it is possible to combine earth walling with other building components.

Modern earth building

This country has a great heritage of earth buildings, nearly 50,000 of which survive. For example, the village of Portmeirion by Clough Williams-Ellis is constructed partly of earth. However, almost all recent earth building has been limited to conservation and the adaptation of existing structures. A few houses are now under way in the South-west, but before them the last new earth house was designed in 1912 by Ernest Grimshaw, the Arts and Crafts architect, in Devon. In contrast, in Europe, Australia and America traditional techniques have been updated in many new, innovative building projects.


ECOASYS

Above: rammed-earth wall detail

In France, Isle D'Abeau is a social housing project of more than 60 units built near Lyon in 1984 using a variety of techniques. In Australia, rammed earth is employed by both independent self-builders and small contractors. A recent large hotel complex, for example, demonstrates the range of modern earth-construction techniques. And in the South-west US, a small industry of building-material producers, solar designers and builders satisfies a growing demand from the well-heeled for the regional archetype.

So, where does one start in 1994? Tristan Peat, a town planner with Teignbridge District Council, Devon, has investigated the barriers to new earth building in Britain, and has found the main concerns are dampness and structural stability, despite earth-building heritage and modern developments. Planning controls appear to be guided by mis-conceptions.

Dr David Webb was head of research and development of soil-cement block technology at BRE before his retirement, and now works as a consultant. (He is also behind the CARTEM block press: see below). He believes there are only three outstanding technical issues for earth building: climatic design criteria, rationalisation of standards and specifications, and health factors.

A significant practical problem is that of financing earth building in Britain. Mortgage and insurance companies are not willing to risk lending money or insuring new buildings made of earth. Ironically, some companies will only provide insurance cover to cob buildings rendered with cement. This is the finish that is often cited for differential heat expansion and trapping moisture, leading at best to spalling and at worst to collapse.

With concerns growing over the impact of building on the natural environment and human health, the case for earth construction must be re-examined. Overseas, rapid urbanisation and increasing housing need still provide a role for both traditional and modern earth building.

An appropriate architecture with earth as the primary walling material requires re-education in materials and methods, and updating of the relevant codes and standards. But research and development work over the past two decades has brought us to the threshold of new and innovative earth building, even here. □

Sumita Sinha, chartered architect, and Patrik Schumann, built-environment consultant, practice as an architectural and environmental partnership promoting appropriate building

REFERENCE

[1] *Adobe, Pressed-earth, and Rammed-earth Industries in New Mexico. G S Austin, and E W Smith. Bulletin of the New Mexico Institute of Mining & Technology. No 127. 1989. From Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801, US.*

SOURCES

- *Building in Cob, Pisé, and Stabilised Earth. Clough Williams-Ellis and John and Elizabeth Eastwick-Field. Country Life publications. 1919.*
- *Natural Energy and Vernacular Architecture. Hassan Fathy. University of Chicago Press. 1986.*
- *Earth Construction: A Comprehensive Guide. H Houben and H Guillaud. CRATerre-EAG/Intermediate Technology Publications. 1994. From CRATerre (see below) or IT Bookshop (071 436 9761).*
- *Adobe and Rammed-Earth Buildings - Design and Construction. P G McHenry. University of Arizona Press. 1989. From Eurospan, 3 Henrietta Street, London WC2 8LU.*
- *Building with Earth – A Handbook. John Norton. Intermediate Technology Publications. 1986.*
- *Elephant compressed-block machine– CARTEM, Billesden, Leicester LE7 9AE. CRATerre – the main world centre for information on earth building developments – BP 53, 38090 Villefontaine, France. Contact Hugo Houbden.*
- *Indigenous systems, domes, vaults – Development Workshop, BP 13, 82110 Lauzerte, FRANCE. Contact John Norton.*
- *Cob building consultant – Alf Howard, Westleigh, Morchard Road, Copplestone, Crediton, Devon EX17 5LS.*
- *Rammed-earth design and building – Simmonds-Mills Architects, 2 Studridge Farm Cottages, Ibstone Road, Stokenchurch, Bucks HP14 3XR.*
- *Soil-cement block consultant – David Webb, 54 Woodland Drive, Watford, Herts WD1 3BZ.*
- *Low-energy design and building in earth – Environment by Design, 19 Girdlers Road, London W14 0PS.*