The ideal building material would be 'borrowed' from the environment and replaced after use. There would be little or no processing of the raw material and all the energy inputs would be directly, or indirectly, from the sun. This ideal material would also be cheap. Mud bricks come close to this ideal, or they can do.

Basic mud bricks are made by mixing earth with water, placing the mixture into moulds and drying the bricks in the open air. Straw or other fibres that are strong in tension are often added to the bricks to help reduce cracking. Mud bricks are joined with a mud mortar and can be used to build walls, vaults and domes.

At its simplest, mud brick making involves placing mud in moulds which, after initial drying, are removed to allow the bricks to dry slowly (not in direct sun). Moulds can be made from timber or metal – anything that can be shaped to provide the desired size for the bricks.

Virtually all the energy input for mud brick construction is human labour (indirectly, fueled by the sun) and after a lifetime of use, the bricks break back down into the earth they came from. The most effective use of mud bricks in building healthy, environmentally responsible housing, comes from understanding their merits and accepting their limitations. Mud brick construction is often referred to as 'adobe' which is an Arabic and Berber word brought by Spaniards to the Americas, where it was adopted into English.

The use of earth construction is well-established in energy efficient housing. There are many aspects to earth construction and despite the fact that most of the world's buildings are made of earth and it is one of the oldest known building materials, there is much about its properties and potential that remains undeveloped and poorly researched.

PERFORMANCE SUMMARY

APPEARANCE

The appearance of mud bricks reflects the material they are made from. They are thus earthy, with colour determined by colour of clays and sands in the mix. Finished walls can express the brick patterns very strongly at one extreme or be made into a smoothly continuous surface.

STRUCTURAL CAPABILITY

With thick enough walls, mud brick can create load bearing structures up to several stories high. Vaults and domes enable adobe to be used for many situations other than vertical walls. The mud brick may be used as infill in a timber frame building or for load-bearing walls, although its compressive strength is relatively low. Typically, Australian adobe structures are single or double storey. In the Yemen there are buildings 8 stories high and more that have stood for centuries! [See: Construction Systems]

THERMAL MASS

Adobe walls can provide moderate to high thermal mass, but for most Australian climatic conditions, as a rule of thumb, walls should be a minimum of 300 mm thick to provide effective thermal mass. [See: Thermal Mass]

INSULATION

Contrary to popular belief mud bricks are not good insulators. Since they are extremely dense they lack the ability to trap air within their structure, the attribute of bulk insulation that allows it to resist the transfer of heat. Insulation can be added to adobe walls with linings but is not intrinsic to the material, and, depending on the building design may not be needed in some climate zones. [See: Insulation Overview]

SOUND INSULATION

A well-built adobe wall has very good sound insulation properties. In fact, it can be almost equivalent to a monolithic masonry structure in its capacity for sound attenuation. [See: Noise Control]

FIRE AND VERMIN RESISTANCE

Since earth does not burn, and earth walls do not readily provide habitat for vermin, mud brick walls generally have excellent fire and vermin resistance.

DURABILITY AND MOISTURE RESISTANCE

Adobe walls are capable of providing structural support for centuries but they need protection from extreme weather (eg. with deep eaves) or continuous maintenance (the ancient structures of the Yemen have been repaired continuously for the centuries they have been standing). As a general rule, adobe needs protection from driving rain (although some adobe soils are very resistant to weathering) and should not be exposed to continuous high moisture.

BREATHABILITY AND TOXICITY

Mud bricks make 'breathable' walls but some mud brick recipes include bitumen, which potentially results in some outgassing of hydrocarbons. Ideally earth should be used in its natural state or as near it as can be achieved. [See: Indoor Air Quality]

SUSTAINABILITY (ENVIRONMENTAL IMPACTS)

Mud bricks have the potential to provide the lowest impact of all construction materials. Adobe should not contain any organic matter – the bricks should be made from clays and sands and not include living soil. They require very little generated energy to manufacture, but large amounts of water. The embodied energy content of mud bricks is potentially the lowest of all building materials but additives, excessive transport and other mechanical energy use can increase the 'delivered' embodied energy of all earth construction. [See: Embodied Energy]

In a similar way, the greenhouse gas emissions associated with unfired mud bricks can (and should) be very low. To keep emissions to an absolute minimum, the consumption of fossil fuel and other combustion processes have to be avoided. [See: Materials Use Introduction]

BUILDABILITY, AVAILABILITY AND COST

Mud bricks provide a forgiving construction medium well suited to owner-builder construction. There are a number of proprietary mud brick makers and builders able to provide good information and a strong owner-builder oriented network. There are good networks in Australia including a broad based national organisation, the Earth Building Association of Australia (EBAA), which is a not for profit organisation 'formed to promote the use of Unfired Earth as a building medium throughout Australia.'

The materials for making mud bricks are readily available in most areas and may be sourced directly from the site of the building in some cases.

Low costs in construction can only be effectively achieved by self-build, reducing the labour costs associated with manufacture and/or laying of bricks. Commercially produced mud brick construction can be as expensive, or even more expensive, than brick veneer.

TYPICAL DOMESTIC CONSTRUCTION

CONSTRUCTION PROCESS

Mud brick wall construction has generally been the province of owner-builders, but a large proportion of mudbrick buildings are now constructed by or with the help of commercial builders. The potential for sourcing the main wall construction material from one's own site, making the bricks, and building the walls, can be very appealing as both an economic and lifestyle choice. As a result, the first stage of construction may involve excavating the 'mud' from the site.

The clay content of adobe can range between 30 and 70 per cent and the overall earth content may also include silt, gravel and stones. There are a number of tests for suitability of the earth and the approval process may require an erosion test. Before excavating for on-site mud, consider the site layout to minimise carrying and transport and ensure there is space to keep any topsoil separate for use on the garden.

Owner builders should recognise that mud brick making is a labour intensive activity. A house may require around 10,000 bricks, but a working couple would be lucky to average a production rate of 200 a week. Mud brick moulds can be made from wood or metal. Bricks must dry evenly to avoid cracking and they should be covered to avoid direct sunlight and overly quick drying out. There are a number of mud brick manufacturers that cater to the market for people who do not have the time or resources to make their own.

A typical standard mud brick is between 300-375mm long, 250-300mm wide and 125mm high and can weigh up to 18kg – as much as a straw bale! Smaller brick sizes are recommended for owner building. Mud bricks can be made in a range of sizes and moulds and can be made in special shapes for fitting around structural elements and accommodating pipes and wires. Stabilised mud bricks may contain materials such as straw, cement or bitumen [See: Construction Systems - Straw Bale]

Although adobe can be load bearing, there is also widespread use of frames. The advantages of this are that a roof structure can be erected to provide weather protection for both mud brick making and construction. Disadvantages include the need to connect with and build around frame structures.

After the footings have been placed and the bricks are ready for laying, the building process is similar to that of any other masonry construction.

All structural design should be prepared by a competent person and may require preparation or checking by a qualified engineer. Qualified professionals, architects and designers provide years of experience and access to intellectual property that has the potential to save house builders time and money as well as help ensure environmental performance. All masonry construction has to comply with the Building Code and Australian Standards. For example, all masonry walls are required to have movement/expansion joints at specified intervals.

FOOTINGS

It is possible to make footings from rubble, but unconventional construction may make it harder to obtain building approvals and the usual method is to employ strip or raft concrete footings. A raft concrete slab can provide a clean, flat surface for making mud bricks. A damp proof course must be laid between the footings and brick wall to prevent rising damp. A 'splash course' of fired bricks is advisable to prevent erosion of the lower course of mud bricks resulting from heavy rain.

FRAMES

Mud bricks can be load bearing but it is also usual Australian practice to build mud brick walls between timber or steel frames.

LOAD BEARING WALLS

Load bearing mud brick wall construction requires particular attention to good bonding (avoiding continuous vertical joints) and ensuring stability by having returns on the walls that buttress them against sideways forces. Again, normal, traditional masonry practice applies to the pattern in which bricks should be laid. It is possible to create arches, squinches and domes in mud brick and although these have featured in adobe structure since time immemorial, they are rare in modern building structures of this type.

JOINTS & CONNECTIONS

Mud bricks are laid on thick mortar beds that are essentially the same mix as the brick, but in its 'muddy' state. It is also common practice in the commercial mudbrick industry to use a sand-cement mortar. Once dried, it can be difficult to distinguish between mortar bed and brick and some adobe aesthetics exploit this 'seamless' appearance to create a monolithic effect. The roof timbers or steel members can spring from the columns (particularly in the case of steel) or bear on wallplates. It is generally recommended that roofs have considerable overhang in order to provide some protection to walls from driving rain. In more sheltered areas this requirement is less vital, but care must be taken to provide a good quality render and waterproofing finish – see 'Finishes', next page.

Walls are laid in the traditional manner of masonry with string lines to provide a guide to vertical and horizontal alignments.

The mud mortar bed is normally quite thick and needs to provide complete bedding for the bricks. Perpends are similarly thick (about 20 - 30mm). The intention is to produce a wall that is effectively monolithic, ie. as if it were a single piece of material.

FIXINGS

Fixings to mud brick need to allow for the relatively poor 'pull-out' strength of the material. Strong fixings can be achieved by embedding dowels or plugs into a wall – the depth and type of which should be determined by reference to a skilled builder or engineer if the load carrying capacity of the fixing is critical.

OPENINGS

Lintels can be in any structurally appropriate material, although timber is typically used. Beams and lintels can be formed from quite 'rough and ready' timber and readily blended into the mud brick construction. Mud bricks can be also be laid to form arches, particularly over small spans (less than a metre), and even domes, although this requires high levels of bricklaying skills as well as more stringent demands from engineering and approvals processes.

After brushing to get a fairly even surface, the final finish is a mud slurry, typically finished by hand. This slurry may also be the final waterproofing coat (eg. A mud and cow dung mix) or it may have a further clear coat of proprietary waterproofing material. Linseed oil and turpentine can be used to provide a final finish.

FINISHES

Linseed oil and turpentine can be used to provide a final finish. This is also a very effective method of protecting walls susceptible to erosion. There is even the option of using the 'natural plastic' of cellulose, processed by bovine beasts, to create mud and manure slurry, although this is seldom used in Australia. Finishes can range from rustic to smooth with this typical flexibility of approach being one of the material's many appealing qualities.

ADDITIONAL KEY REFERENCES

Bianco, A. *The Mud Brick Adventure*. 2002. Earth Garden Books, Trentham, Victoria.

Lawson B. 1996. *Building Materials and the Environment, Towards Ecologically Sustainable Development*. RAIA, ACT, Australia.

BDP Environmental Design Guide, RAIA

CSIRO Division of Building, Construction and Engineering. 1995. *CSIRO Australia Bulletin 5: Earth Wall Construction*. CSIRO North Ryde,

Simmons G and T Gray A T (Editors). 1996. *The Earth Builder's Handbook*. Earth Garden Books, Trentham, Victoria.

Rich R and Smith K. 1991. *The Earth Garden Building Book: Design and Build Your Own House*. Viking/Penguin, Australia.

EARTH BUILDING ASSOCIATION OF AUSTRALIA
http://www.ebaa.asn.au

Principal Author: Paul Downton