ADDITIVES TO CLAY

ORGANIC ADDITIVES
DERIVED FROM NATURAL SOURCES

Introduction

Figure 1 Surface stabilisation of soil with palm oil, Nigeria
Photo credit: CRATerre/EAG

Earth has been used for building for thousands of years throughout the world spanning a diverse range of climates and cultures. Earth itself is a multi-component system usually consisting of stones, sand, silt, clay, water and, near the ground surface, organic humus. Structural stability of earth buildings is maintained by the structural integrity of the sand and stone framework, by the pore filling capacity of the silt and, most importantly, by the binding qualities of the clay, which are in turn influenced by the moisture content of the soil.
Compared with some building materials earth can be considered to have some disadvantages – it has relatively low compressive strength, tensile strength and abrasion resistance. It may also lose a lot of its rigidity in the presence of water. Nevertheless it is very cheap, very widely available, environmentally friendly, strongly linked to local cultures and traditions and, with skilful construction, can contribute significantly to the aesthetic appeal and user comfort of buildings.

Good and durable earth buildings can be built provided certain precautions are taken. These precautions will depend on local conditions and structural requirements, but can broadly be classified into four categories:

Soil selection
Different soils can have very different characteristics. The quality of a soil for building is strongly dependant on grain size distribution and excluding humus.

Soil preparation and construction methods
Builders should be familiar with soil pulverising, proportioning, mixing, maturing and curing as well as masonry techniques.

Building design
The design should take account of the properties of the raw material by appropriate load distribution and structural dimensions, and by incorporating protective elements against damp, rain, impact and abrasion. Protection can be achieved by adding more durable but complimentary materials at places such as the wall base, roof overhang and the copings, and by using plasters and renders.

Improving the raw material quality
Different treatments or additives, collectively known as stabilisation, can modify the properties of soils to control their shrinkage and swelling characteristics and so improve the binding ability of the clay in the soil. These stabilisation methods are described in this leaflet.

Compaction

Compaction increases the soil's density and hence its strength and resistance to mechanical damage. It also reduces water absorption but, with the associated reduction in porosity, durability may be reduced.

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Compaction is done in a mould or form:

- statically (i.e. in a single pressing), with cylindrical rollers, wheeled rollers or presses;
- dynamically (i.e. repeated), with tampers or rammers, vibrating rammers or pick hammers;
- surface, with a beater – mainly for floors or roofs, although sometimes used on rammed earth walls before they dry.

Effectiveness of compaction depends on applied pressure or energy, soil type and water content.

Vegetable additives

Fibres

Fibres are widely used when building with earth. Generally fibres can be most easily mixed in with the soil if it is in a plastic or liquid state that is not too dry. The fibres act to increase the tensile strength, reduce density, accelerate drying and reduce cracking by dispersing stresses.

Figure 2: Soil-based render - stabilised with bark of Néré, Nigeria. Photo credit: CRATerre/EAG

Fibres vary in shape, size, strength, elasticity and their bond strength with earth, so possible improvements with different types of fibre will vary, as will the amount of a particular fibre required. Usual proportions range between 1 and 4% by weight, representing in bulk a volume which can be as high as the volume of soil.

The most common fibres used include straw, for example from wheat, rice or barley. The chaffs or husks of these crops can also be used. Other suitable vegetable fibres include hay, hemp, millet, sisal, filao needles, and elephant grass. Cow dung and, less frequently, horse and camel dung have also been used as additives because they contain short fibres which make the soil workable for plastering and rendering. Synthetic fibres such as colophane, steel or glass wool have found very limited application. Best results are obtained with fibre reinforcement if the wet mix is prepared several days before use.

One drawback of vegetable fibre is variable durability. Dry fibres will generally last a very long time but when wet they are liable to rot. Also some are attacked by insects, especially termites, but others are not and often local knowledge exists to identify the most resistant types.

Vegetable Oils and Fats

The best additives of this type are those which dry, thereby harden, quickly and are insoluble in water. Such additives include coconut, cotton and linseed oil as well as castor oil – which is very expensive. Kapok, palmitic oil and shea butter have also been tried, but with variable results, so local trials are recommended. Shea butter can repel termites, and an addition of around 3% is recommended, although it can also be painted or sprayed on surfaces.

Tannins

Tannins often act to disperse clay particles so that they coat sand grains in the soil more evenly and, also help to break up clay lumps during compaction as well as reducing permeability of the soil and improving water resistance.

The amount of tannin required varies from a small percentage of the mixing water for the most active types to completely replacing the mixing water in the case of decoctions – solutions obtained by boiling the natural products. In some regions of West Africa a decoction of the bark of the “Néré” tree (*parkia biglobosa*) is used for surface protection and it can also be used to stabilise gravelly soils with good results. Other tannins are prepared from the bark of oak, chestnut and scorpioid acacia.

Gum arabic
This is a product obtained from the acacia tree. It acts primarily as a flocculant, that is it helps to form flocs of clay particles within the soil which help to increase dry compressive strength and slow down water absorption, hence reducing shrinkage. However, it is soluble in water and so offers little protection to long-term moisture exposure. It is best used inside a building, added at 5 to 10% proportions.

Palmo copal
Copal is a resin obtained from certain tropical trees. It is usually added at 3 to 8% concentration to sandy soils. One variety, manilla copal, has waterproofing qualities.

Sap and latexes
The latex of certain trees, such as euphorbia, hevea rubber and concentrated sisal juice, reduces permeability slightly and improves cohesion. Proportions between 3 and 15% are normally used and best results are achieved with neutral rather than acidic soils. The juice squeezed from banana leaves, which is subsequently precipitated by mixing with lime to clean it, is another material which has similar properties.

Molasses
Dehydrated sugar molasses contain aldehydes which can be converted into polymers at high temperatures with the aid of phenolic catalysts. The resinous material obtained is similar to asphalt and other resins in its effects. It improves the strength and reduces permeability. Normally a proportion of about 5% is used.

Animal additives
Care must be taken with animal products. In particular it is important that the animal has not suffered from a contagious disease for humans, such as anthrax.

Fibres
Hair and fur from animals are used with plasters and renders to reduce shrinkage and improve adhesion and impact resistance.

Excrements
These can contain chemicals such as phosphoric acid and potassium minerals which have beneficial effects. In addition excrements contain fibres. Additions of up to a third are possible, or even half for a finishing mix. Cow, horse or camel dungs are normally used. Goat dung can be used to lighten the soil. It is normal practice to leave a soil and dung mix to ferment for several days before use.

Urine
Horse urine, added to a soil, reduces its shrinkage and makes it more resistant to erosion. It can replace the mixing water and is sometimes mixed in with straw before adding to soil. The strong smell disappears on drying.

Blood
Animal blood, preferably in fresh rather than powdered form, can be an effective additive when combined with lime or polyphenols.

Casein
Proteinic casein, in the form of whey – a product formed by the souring of milk, sometimes mixed with animal blood, can be used for stabilisation. Milk powder has also been used. One proprietary mix is known as Poulh’s soup and is a mixture of diluted casein and brick dust beaten to a paste.

Animal glues
These improve strength and water resistance. They are made by boiling the skins and bones of animals in water.

Termite mounds
Termite mound material can be mixed with soil for a stabilising effect. Termite mounds are cemented with a cellulosic binder produced by the insects.

Oils and fats
Fish oil and animal fats can serve as waterproofing agents with stearates being the active component. Proportions from 5% are used but the effect can be variable.

The need for additives

It should be noted that there is not always a need to add stabilisers. Soil properties will dictate need and there are many examples across the world of the effective use of unstabilised soil. Stabilisers also add significantly to cost.
If a stabiliser is deemed necessary the choice of which one to use will depend on a number of factors including:

- the part of the building on which the soil is used and its exposure to the elements
- the property of the soil which needs improving; e.g. dry strength, wet strength, water erosion, abrasion resistance, surface protection, etc.
- the level of improvement required
- the quantity of stabiliser required
- the cost and availability of the stabiliser
- whether production of the stabiliser is carried out locally or whether it needs to be imported.

The precise quantities of additives often need to be determined empirically by trial and error for each particular situation. The results of laboratory tests often cannot be transferred directly to field practice, although they do provide useful guidance and a starting point for field tests. In the field, relatively simple and inexpensive tests such as the observation of the durability of blocks on soaking in water, and the use of a simple press to assess the load a block can carry in flexure can provide information on stabiliser requirements. As preparation of soil mixes and their use for building is often carried out under less rigorous conditions than for testing a judicious compensatory increase in stabiliser dosage is recommended.

References and further reading

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