PRACTICAL ACTION
Technology challenging poverty

technical brief

CLAY AS A BINDER

AN INTRODUCTION

Figure 1: House near Rennes in France built at the end of the 19th Century Photo: CRATerre/EAG.

Clays are the main binders of earth and are made up of very small mineral particles (<2 microns), leached out during erosion of rock. The molecular structure of clays consists of sheets of silicate and aluminate ions. Electrostatic forces set up within such structures produce binding properties.

Clays have a variety of uses, especially for ceramics, but it is their use as binding materials in the unfired state which is described in this leaflet. Although they have the limitation that they soften when wetted, they are also undoubtedly the cheapest binders, with very low energy consumption, and are deeply embedded in traditional building cultures in many parts of the world.

It is estimated that over a third of the world's population are living in houses of earthen construction.

Historical uses of clay as a binder

Throughout history clay has been the most widely used binder in the world, not just for vernacular building but also for castles, public and religious buildings, and monuments such as the 35-metre-high minaret of Tarim in Yemen and the thousands of kilometres long great wall of China.

The world's earthen architectural heritage is rich and diverse, with a wide variety of techniques providing a fabulous wealth of know-how in an extremely wide range of natural, historic, cultural and socio-economic environments. There is hardly an inhabited country which has not developed a tradition in earth, and all the great civilizations in the past built with it.

The development of the technology of building with earth has been continuous and, in Western countries, was particularly significant during the 18th century under the patronage of the great French builder François Cointeraux and his enlightened disciples. More recently the energy crisis and growing concern for the environment has led to a revival of interest in the technology by many scientists and builders.

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Clay is still the most commonly used building material in developing countries. Since the 1950s, but mainly in the 1970s, many research centres developed a scientific basis for clay technology. Many universities, training institutions and governmental or non governmental organisations are now teaching or promoting it for almost all types of building.

Why use clay as a binder

The binding properties of clay are generally low compared with cement and, as already noted, reversible with water. Buildings of unstabilised earth face the risk of erosion unless special design precautions are taken to reduce exposure to rain and moisture.

On the other hand, stabilizers and other additives or physical methods such as good compaction and grain size optimization can reduce swelling, shrinkage, and cracking, so increasing strength and water resistance, thus allowing economy in building.

When clay is mixed with increasing quantities of water it becomes malleable, plastic or liquid, allowing it to be shaped. When drying, clay sets and recovers its cohesive properties, and so can bind the soil together.

Most soils consist of clay together with proportions of silt, sand and gravel. The larger particles give structure to a soil, while the clay holds it together and to a great extent provides the cohesion.

Earth is a ready building material and needs little further processing. Generally, a fairly wet mix with higher proportions of clay is used in moulding and spreading applications, while a mix with less clay is best suited to compaction in a moist or damp state.

Building design

For durability, earth should only be used where it is not prone to water or damp and, for maximum advantage, appropriate designs and construction techniques need to be selected. Optimum designs will depend a lot on the environment (natural drainage, water table...), the climate (rainfall quantity and intensity, and strength and direction of winds during rains...), and on the maintenance practices of the users, as well as on the sensitivity of the soil to water.

Figure 2: Private house built in the town of Amran in Yemen in 1985 Photo: CRATeere/EAG

Stabilization

To reduce or completely eliminate the reversibility of its cohesion and swelling properties on wetting and drying, earth can be stabilized using a diverse range of physico-chemical stabilizers.

Traditional stabilizers, which are usually obtained as or derived from naturally occurring substances, are mainly used with traditional building techniques. They are of three different types: glues (gum Arabic, animal glue...), oily products (sheanut butter, linseed oil...) and tannins (horse urine, decoction of néré tree bark...). The efficiency of these products is very variable, and often depends on local skills. Few have been scientifically studied even though many can be very efficient.

The main industrial stabilizers are cement, lime, and bitumen, and comprehensive information exists about these. Many other synthetic products have been tried but their performance is questionable, and doubts exist on their cost effectiveness.

Types of clay and soil

The proportions of the different components in a natural soil (clay, silts, sand, gravels and pebbles) are very variable. Ideally for building, a soil should have a continuous grainsize distribution.

Another fundamental point is that the quality of the clay obtained can be very variable in composition and in characteristics.

The three principal types of clay are:

- Kaolinite, which is relatively stable and has relatively low cohesion;
- Illite, which is of average stability and cohesion, and;
- Montmorillonite, which is highly sensitive to water and has high cohesion.

A soil usually contains a combination of these clay types.

Although the properties of different soils vary widely, there are some characteristic soils (laterites, terra rossa, black cotton soils, loess, saline soils, and alluvial soils) the properties of which are relatively well known.

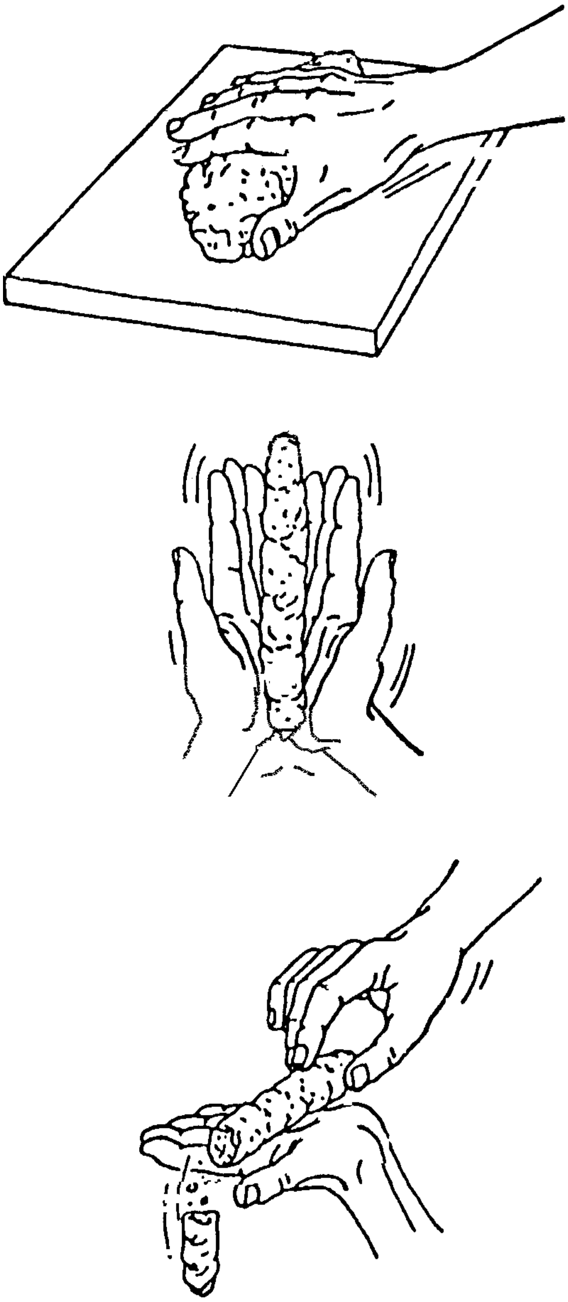
Suitability of soils

Some soils are suitable for use without any additives. Others can be improved (by addition of inert materials or by physico-chemical stabilisation of the clays). Finally, some have to be rejected (mostly soils with a high clay content or with montmorillonite clays).

There are some general requirements for the suitability of a soil for construction, but other requirements are specific to a particular construction application.

To get a good building material, strong and easy to use, the proportion of clay in a soil should be 15 per cent on average.

However, depending on cohesiveness of the clay relative to specific surface of the inert elements, generally 10 to 20 per cent clay content would be acceptable. The sand should be 40 to 80 per cent, the gravel 0 to 40 per cent and the silt 10 to 25 per cent.



The 'cigar' test

If the clay content in a soil is too high, some minerals (sand, gravels…) or fibres (straw, hair…) can be added.

Identification of soils

Some simple field tests can be used to estimate the proportions of components in the soil to assess its suitability and to indicate how much stabilizer to use. They are also very useful for quality control.

Feeling the texture of the soil gives an indication of sand and gravel proportions as well as, when wet, its cohesiveness and strength. By letting the soil settle in water in a transparent container the sizes of the different layers indicates proportions of the components.

To estimate cohesion make a small biscuit or briquette of soil and observe if shrinkage is excessive after drying. After that, estimate its cohesiveness by the effort needed to break it. You can also roll a cigar (3cm in diameter) from a moistened and well-kneaded piece of soil and push it gently across the palm of the hand until a piece breaks off (see diagrams above).

Figure 3: Church biult in pisé (rammed earth) at Charancieu in the Dauphiné region of France.
Photo: CRATerre/EAG

If the length of this piece is less than 5 cm, the soil contains too much sand, between 5 and 15 cm the soil is good, more than 15 cm and the soil contains too much clay.

Laboratory-based tests have also been developed and these are more accurate indicators.

Use of clays for mortars and plasters

An important application of earth for building, whether stabilized or not, is in mortars, plasters and renders. An essential requirement of these applications is that the materials used should not be significantly stronger than the background materials, otherwise the background can be damaged.

Figure 4: The Kasbah of the Glaoui at Ouarzazate in Morocco. Built by the beginning of the 20th century.
Photo: CRATerre/EAG

Plasters or renders are important in protecting walls from damage by rain, wind and abrasion, as well as for decorative effect, and earth-based materials are quite often used. Mud mortars are an ideal jointing material for use in earthen based walls and other structures as well as in constructions using other relatively soft and yielding materials such as field kiln fired clay bricks and porous stones. Two further leaflets in this series describe these important applications of clays as building materials.

References and further readings

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*These publications can also be ordered from:

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