PRACTICAL ACTION
Technology challenging poverty

MUD AS A MORTAR

technical brief

Introduction

Clay is the inherent binder of soils which are used in building, including for soil-based mortars. Such mortars are generally used with adobe and compressed soil block or, sometimes, fired clay brick and soft stone construction.

Figure 1: House, Built of stone laid in mud mortar with paving stone yard of stones in mud mortar. Photo: CRATerre/EAG.

A mud mortar is prepared by simply mixing soil with water until it is in a plastic (workable) state. Once applied, a mud mortar sets quite rapidly on drying without the need for elaborate curing procedures.

Mud mortars are still widely used in many parts of the world and many different types of soil can be used in mortar preparation. Each type of soil has different characteristics which make it suitable to a greater or lesser extent in particular applications. However, optimum use can be made of most soils by choosing particular preparation techniques and construction practices including, sometimes, the addition of stabilizers or other additives. Recent advances in soil construction practice have enabled soil-based mortars to be used reliably in a wide variety of construction applications.

Mud mortar applications

The beneficial characteristics of mud mortars including good bond to compatible surfaces, relatively high compressive strength and ease of preparation allow them to be used in a range of applications of which the following are common:

- Cob walls

Cob walls are built of mortared mud balls in courses 40 to 80 cm high, with a drying period of several days in-between the courses. Additional soil blocks or stones are often incorporated.

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- Masonry structures

Adobe blocks, used in wall construction, are usually bonded with a mud-based mortar, but mud mortars can also bond walls of field or cut stones, compressed earth blocks and fired clay bricks.

Mud mortars are also used for arches, vaults and domes built with these materials and the fact that they can be built without any form of shuttering is an acknowledgement of the adhesive strength of mud mortar

- Wattle and daub

In wattle and daub construction mud mortar is used to fill in a secondary framework supported by the primary structure of a building. This framework can be single skin - the mortar simply applied to the panels of interlocking wood, cane or bamboo strips; or double skin, with the mortar sandwiched in between two panels.

- Plasters and renders

Mud-based mortars can be applied to masonry, monolithic walls and wattle and daub, and even to flat roofs, vaults and domes. They function as a waterproofing coat and also improve the appearance of a building. External renders are liable to wear away at a rate depending on the harshness of the exposure conditions. They require regular maintenance and periodic repair, although if well-protected they can last a very long time indeed.

Figure 2: The good cohesion of mud mortar allows construction of vaults and cupolas without shuttering. Photo: CRATerra-EAG.

Limitations of mud mortars

Mud mortars have a rather low tensile strength and are subject to shrinkage. With an increasing proportion of clay in a soil, as well as clays with high plasticity, the tensile strength will increase but with the penalty of increased shrinkage. Above a particular clay content shrinkage effects will cause large numbers of microcracks in the mortar which will reduce its bond strength and therefore the strength of the whole structure, and possibly cause visible cracks to appear in the structure several days after construction.

If using a soil of high shrinkage for building it is usually possible to take account of the effects of shrinkage in the building design and, indeed, this has traditionally been done empirically based on experience in areas where earth construction is practised. Recent trends to reduce construction costs by reducing the bulk of structures, labour requirements

and the time spent on building have necessitated a more rigorous scientific understanding of soil properties to enable optimum use to be made of local soils.

In addition, mud mortars are liable to increased erosion and loss in strength if used in humid or wet conditions. For this reason they need protection from such conditions by appropriate building design, by using them with complimentary water-resistant materials or by incorporating special protective materials and structures in the building.

Improvements to mud mortars

Although measures to improve the durability of earth as a building material, as well as building techniques with earth with very low level of risk of failure, have been well-documented, to a large extent based on recent research work, it is always worthwhile to study traditional building practices in a particular area.

Problems with earth-based buildings can generally be avoided by regular maintenance -noting any parts of the building which have become weakened or eroded and immediately repairing them before any more serious problems develop. However maintenance requirements of mud based mortars can be reduced by incorporating special protective measures in the design of the building and by avoiding use of mud mortars in the more exposed parts as well as by improving the performance of the mortars themselves.

Protective measures

These include provision of:

- water-resistant copings or overhanging roofs
- A water-resistant foundation and wall base, possibly complemented by a damp-proof course to prevent moisture penetrating the mud mortar
- Rendering any exposed walls with a mortar which allows passage of water vapour. This facilitates drying and thus reduces the risk of loss of bond between the render and the wall. Otherwise, if passage of water vapour through the mortar is too slow, some other means of anchoring the render to the wall would be needed, such as wire mesh or netting, or steel nails
- Repointing of mortar on the outside 1.5 to 3 cm of joints with a more water resistant material

Improved performance

Performance of mud mortars can be improved with various additives such as:

- straw, which reduces the shrinkage considerably without decreasing the bond strength much;
- sand, which reduces shrinkage but also reduces the bond strength;
- cement, which increases bond strength and also somewhat reduces the shrinkage, although while reducing the incidence of microcracks it does increase the likelihood of major structural cracks, appearing every 4 to 6 metres - but these can be compensated for by inserting shrinkage joints every 4 to 6 metres.

A number of other additives can be used and further information is given in the accompanying leaflets “Additives to Clay".

Testing mud mortars

It is advisable to carry out tests on the mortars before using them in construction. If similar mortars have already been used for building in the area, and the soils used and methods of preparation can be identified, then it can simply be a matter of checking on the performance of those mortars.

Without such information test samples need to be prepared. Ideally test walls should be built and left in actual exposure conditions for some time, but a minimal exposure test can be

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done on two bricks or blocks mortared together with a layer of mortar on top. Several such samples need to be made up to avoid the acceptance of rogue results and to enable comparisons to be made. Observations of weathering and erosion of the samples can be complemented by a number of other tests, which can be varied according to the desired properties of the construction. Such tests can be started after one day of curing, but it would be preferable to have a longer curing and drying period, especially if stabilizers are used.
Field tests which can be used include:

- the force required to separate two bricks or blocks
- abrasion resistance, using a metal brush
- water resistance, using a watering can
- cohesion, i.e. resistance to crushing of a mortar sample
- shrinkage measurement.

Additional laboratory-based tests which can be used include:

- wet and dry crushing strength
- shear strength of small walls.

Figure 3: Test carried out on unstabilised and stabilised mortars to determine the optimum soil/sand ratio. Photo: CRATerre/EAG

Using mud mortars

The use of ordinary mud mortars doesn't require any special precautions. However they should not contain any particles larger than one third the thickness of the joints, and, to avoid possible shrinkage problems subsequently, the prepared mix should be just workable enough for smooth and easy laying of the building elements (bricks, blocks,. ..).

On the other hand some additional operations are necessary when the mud mortar is stabilised. To get a good homogenous distribution of the stabilizer in the mixture, it is necessary to sieve out or crush the lumps in the soil that

Figure 4: Demonstration house in Jos, Nigeria, built with adobe laid in mud mortar and plastered with mud mortar. Photo: CRATerre/EAG

are bigger than 5 to 8 mm. Mixing of materials in small batches is also important so that the mortar mix can be used quickly and any significant setting of the stabiliser before the mortar is used is then avoided. Stabilised mud joints are quite expensive so that there is always a tendency to reduce their thickness. However, it generally becomes more difficult to sieve out the oversize fraction in the soil the smaller the chosen maximum particle size in it. The minimum thickness for the joint is 1cm but this renders the laying process difficult, so a more realistic minimum effective joint thickness would be 1.5 cm.

If the stabiliser sets by reaction with water, Ordinary Portland cement for example, some precautions have to be taken in order to avoid the applied mortar drying out too quickly. In particular the elements to be laid have to be wetted before, but not immediately before, applying the mortar, - otherwise the water is not absorbed by the element and remains as a surface film which prevents good bond between the mortar and the element. In dry areas, it would also be necessary to keep the wall wet for several days after construction to achieve a high level of cure of the mortar, but this is generally very difficult to achieve, due to shortage of water for example. If this is cannot be done then it is best to increase the proportion of cement in the mortar so that the loss in quality would be compensated for. Pointing should be done just after laying (that is when the mortar starts to set). Repointing is always a much lengthier process and is really only applicable in the case of application of a protective stabilised mortar finish to an unstabilised mortar core.

Reference and further Reading

- *Alternatives to Portland Cement* Practical Action Technical Brief
- *Additives to Clay: Organic additives derived from Natural Sources*, Practical Action Technical Brief
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