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AN INTERPRETATION OF TECHNICAL ASPECTS OF EARTH BUILDING IN DEVON, UK

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Summary

The Cob Construction Company specialises in cob repair and maintenance and is also very interested in new earth building. The company has a multi-skilled team to cater for all aspects of building and recent projects have caused great interest in ëcarthy worldsí. This paper highlights some of the important technical aspects of the companyís earth building experiences in Devon and places them in the context of the use of earth in buildings worldwide.

What is Cob?

Cob is a building material traditionally used in South West England made by combining sub soil with straw and water. The straw acts as a binder and reinforcing fibre and, with the addition of water, makes a cohesive and workable mix. Other natural materials have been used successfully as binders. A typical cob mix might be 80% soil, 18% water and 2% straw measured by weight.

It is very important to know the component properties of the soil because the various components have different advantages and disadvantages. The mixing process is also very important to ensure adequate binding. These days it is usually mixed with a tractor although many years ago it was mixed in the farmyard by bullocks and this accounts for the dung that is found in some walls.

Cob is normally constructed in lifts or layers. According to historians, this form of construction can be traced back to the 13th Century although most of the cob buildings in Devon were constructed between the 17th and 19th Centuries.

Lime mortars and renders were generally used as finishes because of suitability and compatibility with cob and are still used today for the same reasons. There are normally three coats of lime putty-render including a smooth or scat coat, and then finished with a lime wash.

Maintenance of earth buildings

In general, with earth mixtures, reducing the moisture content of the mix results in a stronger wall; conversely, the wetter the mix the weaker the wall. Water is the main enemy and it is vital to prevent water penetration into the wall. To do this cob buildings require a good overhang from a roof and a tight ground level plinth. . Vertical moisture penetration does a lot of damage by eroding the wall from its core and therefore should be attended to immediately and similarly with rising damp from a poor plinth. Rat runs and other rodent

burrows are very common and do greatly weaken the walls by eroding the inner core and once again need repairing.

Renders

Renders on an earth wall are not always necessary; it depends on the location with regard to weathering, and availability of lime. Our renders are often mixed with hair .

Cement renders are not recommended because they are rigid and do not allow the cob to breathe, any moisture content is sealed and cannot escape. Cob needs to breathe, and therefore there is a certain movement with the drying out of the wall. Lime is porous and allows the cob to do just this and gives an additional layer of protection to the cob.

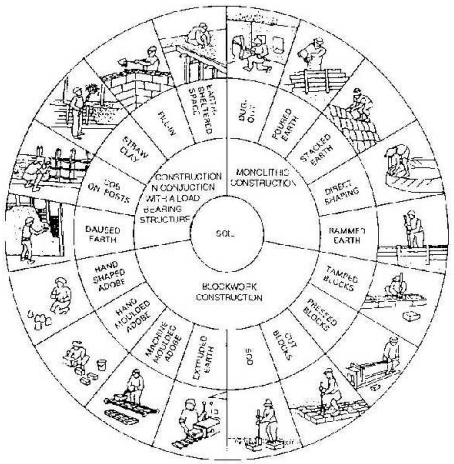

Figure 1 : Methods of building with Earth

There are various techniques used in building with earth. The choice of which to use depends on availability of materials, suitability of the local soil and of course, the climate.

The most common methods are:

1. ***Mass earth construction:*** Making a mix with sub soil and water and loading this onto the wall in lifts of approximately 2-3.ft. Allowing to dry ad then forming another lift on top. The width of the wall is then usually tapered as the height increases.

2. ***Shuttered earth:*** Making a drier mix with minimal water added. Wooden shuttering is then constructed using 2 pieces of ply which are bolted together. The mix is then loaded into the shuttering and tamped down manually or mechanically, compressing the earth and forcing into a dense state to make it adhere.. The shuttering is then removed and installed adjacent and the process is repeated.
3. ***Earth blocks or adobe:*** Sub soil and minimal moisture is mixed and pressed into wooden or metal block mould. The blocks are then removed from the moulds and the blocks left to dry naturally. Various shapes and sizes of moulds can be used.

All these methods can be stabilised with lime or cement to improve the wet strength of the finished wall.

Advantages of different methods

Each method has its adherents and its particular advantages in the right conditions.

1. ***Mass earth*** - once mixed, the walls can be constructed fairly quickly. The addition of straw or fibre prevents slumping on the wall and also acts as a tensile reinforcement. It requires only a low pressure to make it adhere. The disadvantage is that the wall would need dressing to give a smooth finish and also there has to be good drying weather. Some shrinkage and settling would occur. Working is dependent on good (dry) weather.
2. ***Shuttered earth*** - a neater finish from the shutters and no finishing required. However, requires compaction for adhesion and shuttering can be heavy and difficult to handle. Minimal shrinkage and settling are advantages of the finished construction.
3. ***Earth blocks*** - Can be made in advance and stored, unskilled labour can be employed for making blocks. At the point of building there would be no shrinkage from the blocks.

The preparation for building with earth

Materials Investigation

Firstly, the soil has to be tested for suitability as a building material. The soil must have good cohesion (plasticity) and it will be necessary to look at the effect of moisture on the mix (liquid limit). Through soil analysis it can be determined whether the soil is too clayey or too silty.

The more clay in the soil the higher the plasticity and liquid limit, the more silt the less plasticity and binding and the more it will absorb water. The general accepted norm for clay content is between 5 and 30%.

A good site test for plasticity is to take a small sample of the sub soil and mix it with a little water to make a ball. If it remains clean and not too tacky then that is good; if it fails to make a ball then it would be unsuitable. Alternatively, the Ribbon test can be done on site by moistening a small sample of soil and gently rolling it into a strip. If it breaks rapidly, the soil could be too silty: it should roll to a diameter of approximately 3mm.

The shine test can be used to determine the clay content with a small, moistened sample of approximately 3cm in diameter when rolled. If the sample is dull and textured it could be too silty; if there is a slight sheen, the clay content would be suitable, if it is very shiny it could be too clayey for building.

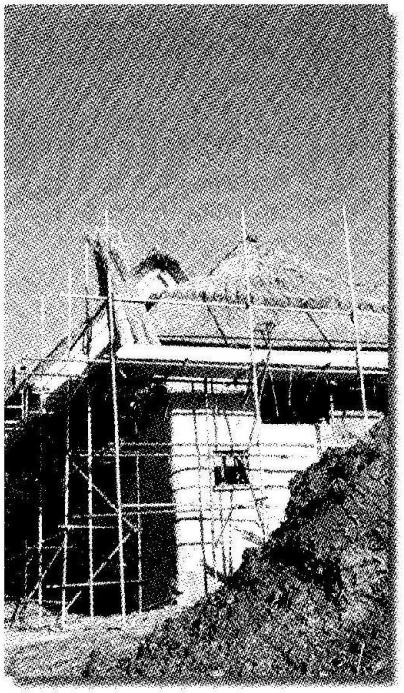

Figure 2 : Traditional Devon earth building methods

At this point the builder would then need to know how much the mix would shrink when dry. Therefore shrinkage tests would be required and this can be carried out very simply by making a rectangular wooden boxes approx. 600mm x 40mm, and filling them with the soil mixture. These would be allowed to dry, after which the shrinkage could be measured. If the shrinkage were less than 15mm, the soil would be unsuitable unless more clay is added. The optimum (according to David Webb at the UK Building Research Establishment) would be a shrinkage between 15mm - 60mm.The shrinkage results could also determine the stabiliser recommendations.

Production

The production process will influence the performance of the mix. Mixing may be done manually or with a tractor. More clayey soils have a higher plasticity and liquid limit and will take longer for the water to sink in and soften them. The addition of straw makes a more manageable mix for mass earth building and collapse is less likely at high moisture levels. This of course would not be a problem for rammed earth and earth blocks when the soil would need to sifted and could be stabilised with lime or cement.

Materials failure

Commonly, failures result from increased moisture content. Moisture reduces the cohesion in the mix and gradually separates out the binding particles. Normally a stone plinth up to 1.2 metres in height above the ground is provided to avoid rising moisture penetration. At the top of the wall, a tight roof prevents vertical moisture penetration. Cracking of the wall (from drying shrinkage, for example) can also allow water into the earth mix. If moisture content remains below 9% the strength of the wall should be adequate and failures will be avoided.

Cracking may also result from movement in a building or inadequate load bearing. The highest vertical stresses will be at the base of the gable end walls and under roof trusses where wall plates help to distribute the load. From our own experience, most of the structural cracking is common on the gable ends, at quoins and under the eaves.

Repairs of earth buildings

Because of the nature of earth repairs can be very successfully undertaken, especially when repairing with earth. Earth mixes can be remixed and therefore will form a good bond with the original. If cracking does appear, providing the cause of cracking is amended, cracks can be repaired in a variety of ways. Usually, stitching is the most successful, achieved by bridging or

stapling the crack. Erosion can be repaired and demolished walls can be rebuilt. Our current project is to reconstruct a 16th Century Devon Long house that has required numerous repairs and extensive rebuilding. Now, with a new thatched roof, it is almost ready for habitation once more

Blockmaking and stabilisation

Cob blocks and rammed earth blocks can both be made simply by pressing or tamping the mix into metal or wooden moulds and allowed to dry naturally. The blocks can be stored under cover until required.

In 1987, Dr David Webb (UK Building Research Establishment), was constructing a school from stabilised earth blocks in Sudan, Africa. That summer, the River Nile flooded, overtopping its banks. The building stood in 900mm of water for approximately 3 weeks. It was the only building not damaged by floodwater and demonstrated the flood-resistant properties of this method of earth construction.

Stabilisation can be a very effective method of water proofing earth walls and only small quantities of cement or hydrated lime are needed to produce good water resistant blocks. Our work in South Devon, on rammed earth walls exposed to prevailing winds and facing the sea, enabled us to examine the process of stabilisation. The earth was sieved and then mixed with 7% cement. The walls are without cracks or erosion even though they are unrendered.

Conclusion

Earth is an excellent building material providing people (builders, owners and specifiers) understand how it behaves in construction. It can still be an economical alternative to other materials and if used in block form, size and constituents of mix can be standardised and monitored Blocks can be stabilised to withstand moisture penetration and when made, can be stored until required. Today some 30 to 40% of domestic buildings around the world are made in earth making it still the most widespread construction material. The combination of scientific research and traditional skills makes it possible to build safe, low cost homes whereever they are needed.

Reference

Performance consideration for the use of stabilised soil building blocks with cob construction, in Out of Earth II, University of Plymouth.