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Earthen Materials - To stabilise or not.

My major conclusion about the use of stabilisers is this:
If you are building in an area where good earth building can be done with unstabilised material then there is no reason or possible excuse for using stabilisers.

According to the Old Testament, man was fashioned from clay. We make buildings from it.

Earthen building materials use raw subsoil which contains a percentage of clay. It is the clay which makes earth building earth building. It is the clay which provides the cohesion and waterproofing in the soil. It is the clay which can regulate humidity. It is the clay which provides waterproofing and weather resistance. It is usually the clay which provides most of the colour to earthen materials. Natural clay. Earthen buildings have been marvelous feats of clay and have proved their worth over many centuries. We want to avoid feet of clay,

When we come to use earthen materials for structures, however, we sometimes find that the properties of the material are not always adequate to meet the performance we require from a building material.
The NZ Earth Building Standards generally do not distinguish between stabilised and unstabilised materials. They do give performance levels that are to be met and how these are met is not proscribed.
Stabilisers may be used to enhance properties such as strength or durability.
However, a material must be able to be formed into an earth building product by itself. This is to ensure that earthen materials have enough clay in them to contribute to their performance. Otherwise we are not dealing with earth building.
A mixture of sand and gravel is not cohesive. Add enough clay for cohesiveness and you have earthen material.

Clay particles are microscopic and form microscopic platelets. When there is water around it gets betweens the platelets and pushes then apart. If enough water is added the clay gives up is cohesiveness and becomes liquid slurry. When the clay dries the water comes out and the platelets shrink back closer together, thus causing shrinkage in the body of the material. The electrostatic charges on the particles come into play and we get the clay forming a hard mass, which gives us the toughness of dried clay.
Additives such as straw, sand, gravel, are commonly added to the raw earth to alter the performance of the natural soil's strength or durability.

To limit shrinkage, if it is excessive for our building needs, we can increase the amount of larger and inert soil particles such as sand and gravel. The particles are massive in comparison to the clay particles, and do not swell and shrink with wetting or drying. If we get enough of them in a soil mix we can limit shrinkage close enough to zero and still leave enough clay in the mix for cohesion.
We can also add fibers, typically relatively strong, stable cereal crop stems, i.e. straw. Fibres interrupt cracks if they should develop and prevent them from growing larger and cracking the material. The fibres also act as reinforcement giving tensile strength to the material.

The addition of sand and gravel also helps prevent water from eroding or damaging the material, thereby vastly improving durability.
Earth builders have used these properties for over 10,000 years.
This is the basis of cob mixes of clay, sand gravel and straw where walls are built up directly into walls.

Similar materials are used to make mud bricks or adobe, but as the bricks dry before they are laid, shrinkage is not so critical to control allowing higher clay content materials to be used compared with cob building.

Drier mixes of clay, sand and gravel are used to make rammed earth walls.

You may have noticed that I have not mentioned "modern" stuff such as cement or asphalt once. I would strongly discourage the use of such additives in earthen building materials.

Sadly, and my own experience, which has been confirmed by other earth building colleagues from

several different countries, suggests that you can talk about the durability and environmental benefits of buildings made using clay as the cohesive “glue” in the structure until you are blue in the face, but when you mention cement and steel as additives people relax - something “modern” has been done to the soil so that makes it OK.

Earth's beneficial attributes include the ready source of locally sourced material, the solidity and massiveness of the walls, the thermal and acoustic performance of the walls, and the subtle variation of the natural earth colours if left exposed.

Earth walls, floors, or earthen plasters also balance humidity levels, possibly help filter impurities from air, and are generally of low toxicity. These latter attributes are lost if the clay is neutralised by stabilisers, or given unsuitable coatings, which do not allow it to breathe.

Energy is still used in producing earth buildings. Yet it is clear that by digging up soil from near the building site, and using it in as unmodified and unprocessed form as possible, the energy used is low compared to virtually all other building materials. If machinery is used it is generally relatively uncomplicated and requires fairly low amounts of fuel .

In addition, very few other building materials can arise from the substance of the site and return directly to it later with virtually no pollution at all.

"Cradle to grave" analysis gives earth an extremely attractive environmental profile as long as additives such as cement are not used to turn it into a low grade concrete.
However, cement is still commonly added to earth as a readily available “stabiliser”. Asphalt which is a petro-chemical derivative is used also used overseas but rarely used in NZ

The point of adding a stabiliser to clay is to stabilise the clay particles against the effects of moisture, and there is no doubt that cement can do this.
Sometimes.
It works by altering the chemical charge between the clay platelets by overcoming them and then eth cement gel that forms in the mix glues the particles together. If the proportions are wrong, or some particular types of clay are used, the result is a weakening rather than a strengthening of the material. The clay has been “neutralised” but there is not enough cement gel to act as “glue” and I have seen some spectacular failure of cement stabilised materials because of this deflocculation.
The result is a kind of very lousy concrete. I was persuaded once that the amount of cement used in earth building was in fact small at typical rates of around 10% or so. However, when you consider the thickness of an earth wall and the structural ability of much thinner concrete walls with vastly increased strength using less cement the argument does not hold water. This is especially so when earthen materials can be made for many applications that do not require the use of cement at all with good material selection and good building design.

Cement uses a great deal of energy to produce, and creates a large amount of greenhouse gases to produce. Some eco-building sources have given me figures of 6-10% of the earth’s CO2 emissions. Although cement is an amazing material, with a vast range of very useful applications, I think its use should be limited from an environmental perspective, and a lot of work is going into doing just that.

Material that is cement stabilised loses its natural waterproof-edness that comes about from the clay on the surface being able to swell if it gets wet and form a watertight skin that keeps water out. The result of throwing in cement is a more brittle, porous material that can soak up water like a sponge.

I have used cement stabilised material in the past in many jobs, often in situations when I certainly would not do so now. I have now found that a large range of soils can be modified to make durable and useful building material with the addition of aggregates.
Nevertheless, I believe that there are occasions when the use of cement as a stabiliser can be justified. These are situations where local clays are simply not suitable for unmodified building, or where the end application is, egg, an exposed garden wall where the wall is continually exposed to water. This is a different situation to a wall in a building where good design will use the earth in a manner which suits the material at hand.

There are also times when the use of earth building-like technology can be useful as a way of making building material out of poor quality locally found aggregates which lack natural cohesion such as silts, gravels, or sometime volcanic materials. However, it must be realised that in these situations the product is not really earthen. It is low grade concrete. Without enough clay for cohesiveness in the material being used you do not have earthen building material and the Earth Building Standards do not apply. I have on occasion added clay to improve natural gravels to

make a useful product.
If you try and make a brick out of a particular soil, be it a mud brick or a pressed earth brick, and it won't make from a brick that holds together, the addition of cement does make it an earth brick even if an earth brick making process is used. It might make it a suitable building product nevertheless.

Stabilised clay loses its ability to act as a humidity buffer. Clay has a remarkable property of being able to absorb excessive humidity and release it again when there is lower humidity. Thus is can raise average humidity in low humidity climates, and lower it in high humidity climates and clays ability to do this is very marked. There are mixes using special mixes of clays such as bentonite to moderate humidity in climate controlled areas such as museums.
Earth with cement in it also has a higher equilibrium moisture content in service than natural clay, and so needs to be separated away from timber in a similar way to regular concrete, whereas natural clay is drier and acts as a preservative for wood.

Earth building is often automatically associated with passive solar design, a design technique that utilises the natural seasonal rhythms of the sun's position in the sky to help heat and cool buildings. It's not surprising. One of the components of passive solar design is massive materials, and earth walled buildings usually have plenty of this. Earth walls store and then slowly release heat.
Massive structure that also moderate humidity reducing air conditioning demand, thus lowering the financial and environmental cost of running a well designed earth building. A win-win.

The final test for distinguishing between natural clay material and cement stabilised material is to put one alongside the other and feel them - the difference to the touch is marked.

Exciting developments are occurring using clay as a binder for recycled paper materials and with other fibred such as wool and flax too.

For some of the reasons above, as well as making walls from mud brick and cob, I have been using earthen plasters for applying to interior walls and ceilings, as a finish to timber frame houses as well as earth houses, and also to make natural earth floors.