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A revisited vernacular stabilization technique for a durable earth mix

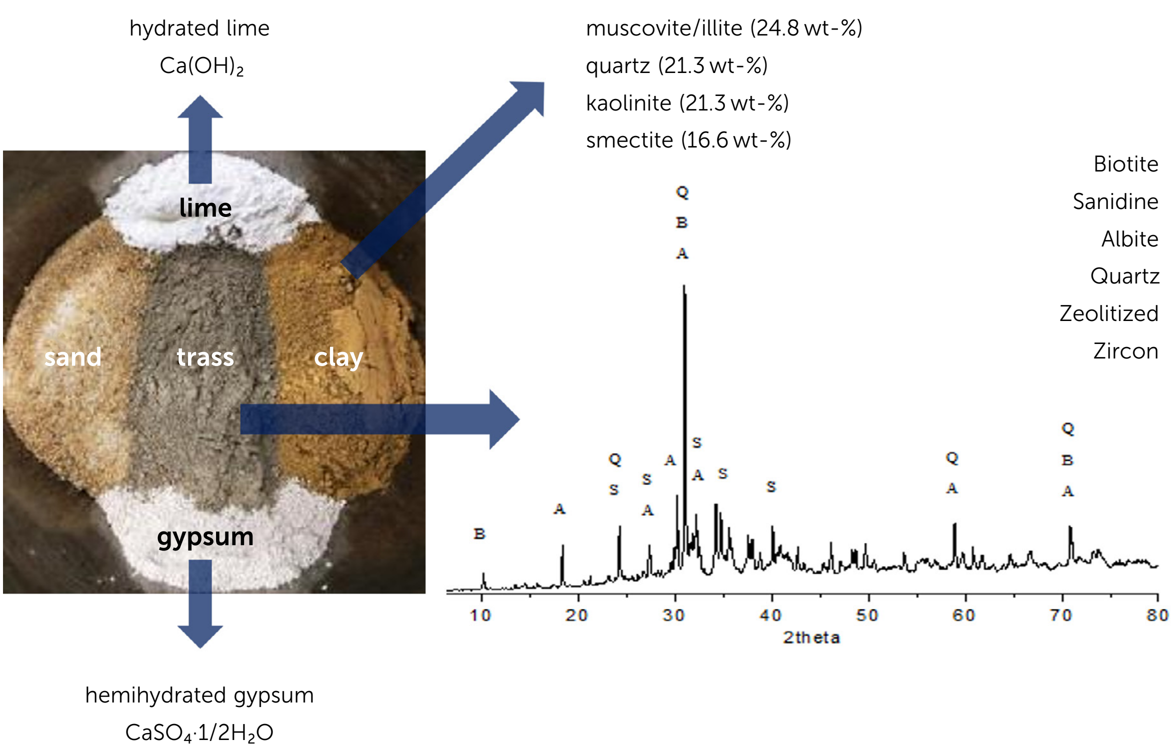
The low resistance of earthen material to water and erosion, and especially the assumption that it could not be applied to form highly smooth surfaces and sharp lines in comparison to other modern constructions, have been the most prominent reasons for choosing the new building materials. On the other hand, laboratory investigations on stabilization in the new discourse of the 20th century run counter to the inequitable arguments such as earth was a primitive construction material and due to moderate strength it was vulnerable to earthquakes, which is stated as a reason for the abandonment of the use of unfired earth as a construction material. To overcome the common drawbacks of earth, utilizing the stabilization effect is a significant application. However, in contemporary earthen architecture, cement is being commonly used to stabilize the earth. An environmentally friendly strategy to substitute cement with other additives is needed. For this purpose, a variety of alternative materials with lower environmental impacts can be used. Their use is based on the importance of minimizing CO_2 emissions, as well as increasing interest in the production of cementitious materials that develop good mechanical properties and good stability in corrosive environments [1].

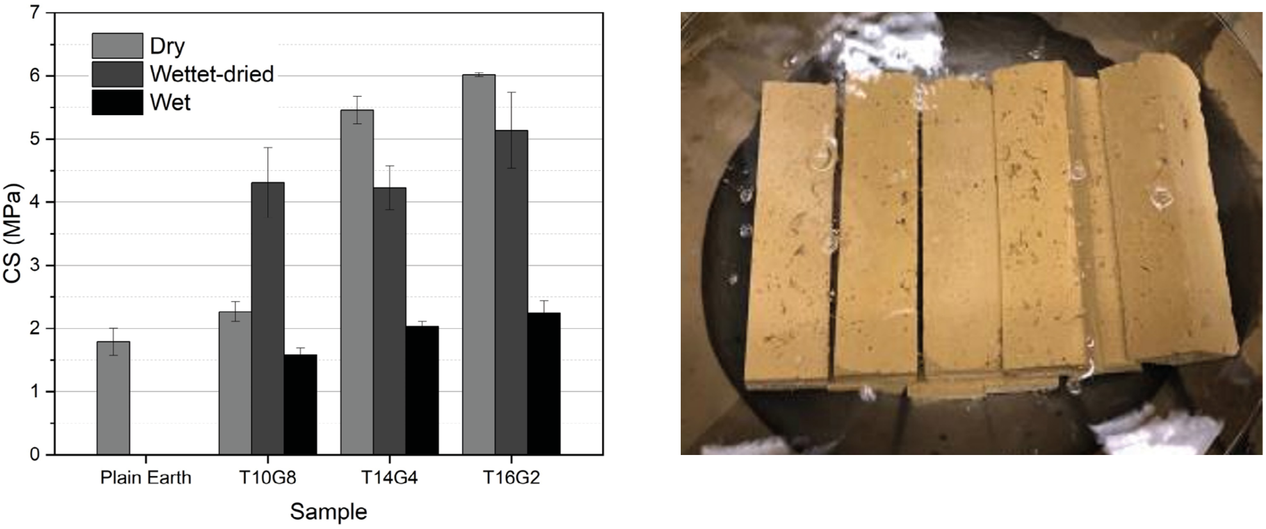
This research deals with an alternative solution, consisting in combining trass, gypsum, and lime to replace the use of cement for earth stabilization in a vernacular way.

Stabilization

The soil stabilization is very ancient and, is today an important research subject, succeeded in test-

01 Composition of mix-design used for preparation of stabilized earth specimens





02 Compressive strength of stabilized specimens with dry, wetted-dried, and wet conditions

ing earthen constructions as a significant alternative against highly energy consuming new products. It is known as the process that enables the control of dimensional changes that clays suffer when they come into contact with water [2].

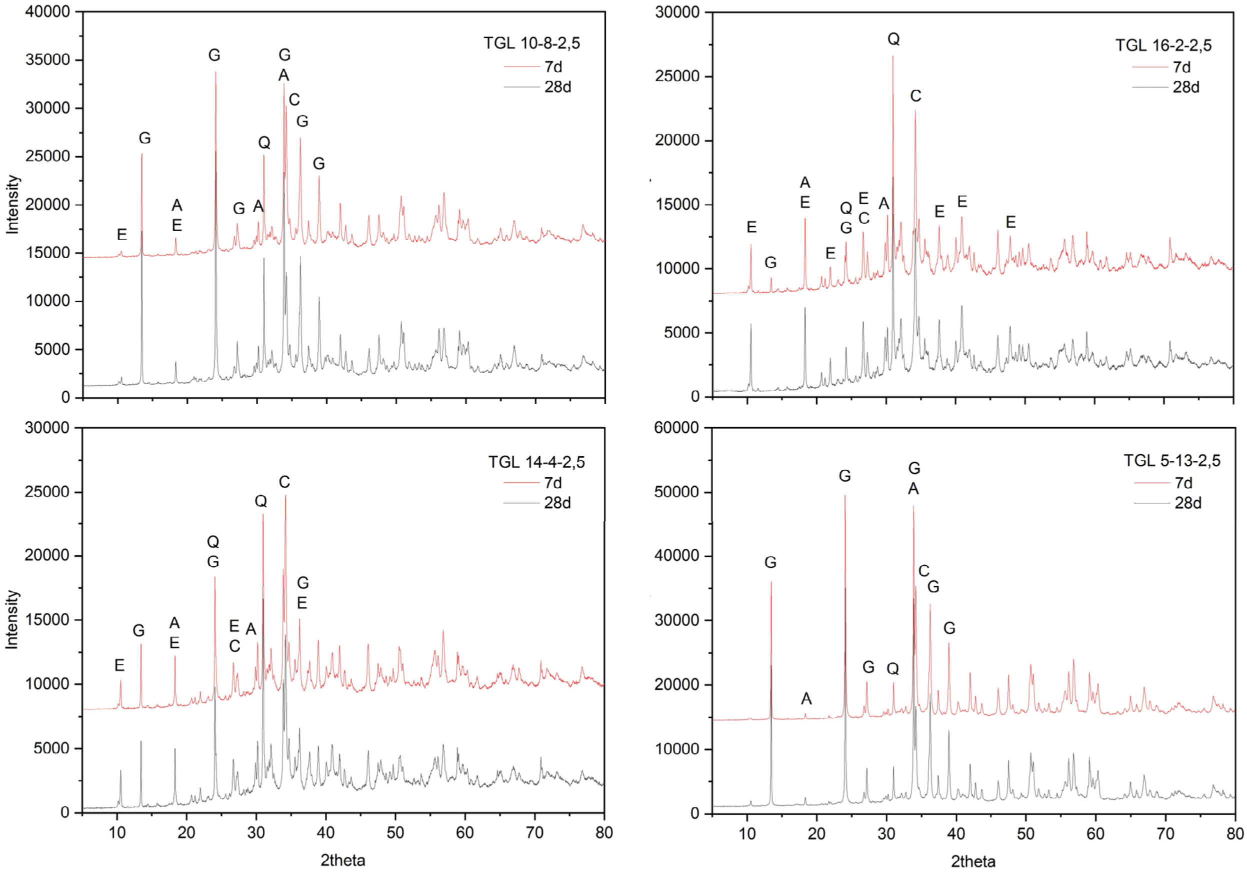
Mechanical stabilization

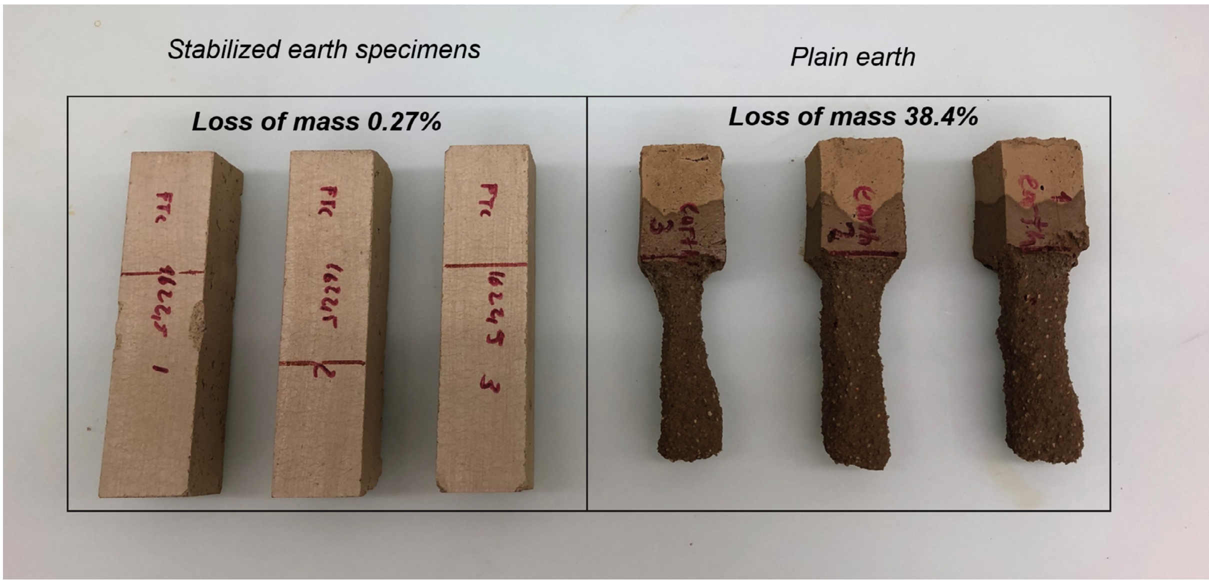
refers to compaction of the material resulting in changes in its density, mechanical strength, compressibility, permeability, and porosity. [3] [4] It allows controlling the binder and water repellents. [5]

Physical stabilization

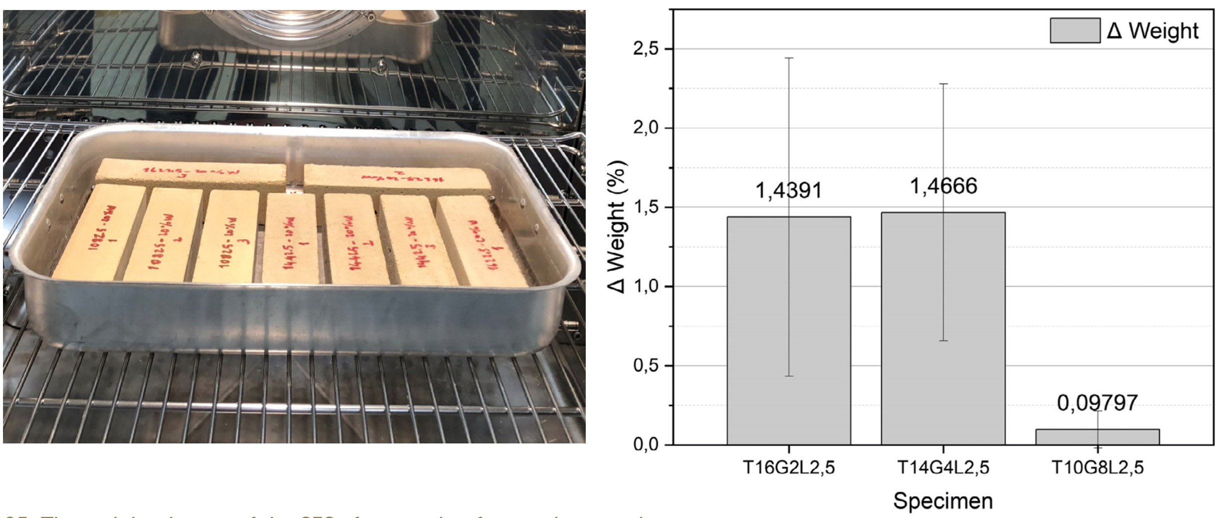
refers to changing the materials texture. This includes controlled mixing of different grain fractions or natural soils and mixing of fibres (i.e. straw, animal hair etc.) into the soil. [3] [4]

03 7 and 28 day XRD patterns of the studied mixes of additives (without earth).
(E; Ettringite, G; Gypsum, A; Analcime, Q; Quartz, C; Calcite)





04 Stabilized earth specimens and plain earth after ten minutes of insertion



05 The weight change of the SES after treating freeze-thaw-cycle

Chemical stabilization

is the treatment of a soil with water-soluble salts (Fig. 1) to induce a chemical reaction [6], resulting with water insoluble compounds. It allows the dost control, water erosion-control and micro and macro structural stability [5]

Choice of Stabilization

In this study a chemical stabilization was aimed. Because, a *mechanically and/or physically stabilized soil specimen is still soluble in presence of water*, as it is not possible to efficiently reduce the micro voids and/or air voids and to chemically bind the clay particles or transform them into a water-insoluble form.

Strategy

When lime, trass and gypsum are added to soil (Fig. 1), pozzolanic reactions take place. Amorphous or weakly crystallized silica and alumina compounds have to dissolve in a highly alkaline environment such as the one created by a solution of calcium hydroxide [2]. Here, the lime creates a high PH condition. Lime reacts with the clay minerals of the soil, or with any other fine, pozzolanic components such as hydrous silica, to form a tough water-insoluble gel of calcium silicate, which cements the soil particles. The cementing agent is thus exactly the same as for ordinary Portland cement [7]. Addition of gypsum supplies sulphate to the solutions, which further contributes the precipitation of ettringite (Fig. 3). The alumina will also react to form phases of hydrated calcium aluminates and hydrated calcium silico-aluminates normally crystalline, which contribute to the process of cementing and the increase on the strength of the whole [2]. Precipitation of water insoluble products increases the compressive strength of stabilized earth specimens (Fig. 2). Together with this, the water resistance of the stabilized earth material significantly increases (Fig. 4) and the material shows a durable character even by freeze-thaw-cycles (Fig. 5)

Outlook

- It is possible to stabilize earth with environmentally friendly binder inspired from vernacular stabilization.
- The water-resistance and the compressive strength of the plain earth were improved by the presence of trass, gypsum and lime. Ettringite, which is typical cementation product, could be produced with the proposed mix design.
- Freezing-thawing cycles did not have an observable effect on the stabilized earth.

References

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