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Characterization, reproduction and optimization of traditional adobe bricks

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Adobe bricks were first introduced 10-12,000 years ago. Extensive use of the material throughout the centuries has led to strong local traditions of building with earth and has established adobe masonry as an important feature of the international architectural heritage. Today, despite no longer being a prevalent building material, adobes are still in use, since a number of earthen structures survive worldwide. Furthermore, the simplicity, low cost and almost negligible embodied energy associated with the production of adobes, as well as their good thermal and acoustic properties, render them an attractive option for use in contemporary sustainable construction. Therefore, several ongoing research projects internationally investigate the physicochemical and mechanical properties of traditional adobe bricks and the design/production of optimized adobes, with improved characteristics, for use in contemporary architecture.

Here, we present ongoing research on adobe bricks carried out in the framework of the project ΕΠΙΧΕΙΡΗΣΕΙΣ/ΠΡΟΙΟΝ/0609/41, which is co-funded by the European Regional Development Fund and the Republic of Cyprus, through the Cyprus Research Promotion Foundation. Our work focuses on the characterization of traditional adobes, their reproduction and optimization in the laboratory to produce materials with improved physicomechanical properties.

Results up-to-date show that traditional adobes are mostly composed of random quantities of silt and clay. Calcite is also predominant in relevant X-ray diffraction analyses. The average capillary water absorption coefficient (measured against a saturated sponge surface) of samples collected from market suppliers rarely exceeds 1 $mm/min^{1/2}$, while their thermal conductivity is around 0.55 W/mK.

The response of traditional adobes to compression is characterized by intense deformability. The average compressive strength recorded depends on the form of test specimen (cube, cylinder, prism). Samples with aspect ratio 1:1 produce results ranging from 1-2 MPa, whereas prisms with height-to-width ratios < 1 give values from 2.5-9 MPa. Differences are noted among the properties of: (a) adobes produced by different manufactures; (b) adobes made by the same manufacturer but originating from different production batches and (c) specimens originating from the same brick.

When subjected to three-point bending, the behaviour of adobes is influenced by the presence of discontinuities within their mass. Hence, flexural strength is rather variable and weakly correlated to compressive strength. This abnormal mechanical behaviour is attributed to the inherent inhomogeneity and natural randomness of adobes which is “enhanced” by the adoption of empirical non-industrialized production methods. Discrepancy in the outcomes of laboratory tests is further affected by the lack of standardized testing methods and formal failure criteria.

Laboratory designed and produced adobes show improved mechanical properties and lower thermal conductivities. The addition of wood dust in the mixture, at quantities up to 60% by volume, seems particularly beneficial, as it raises the compressive strength of the material over 6 MPa, while at the same time it reduces its capillary water absorption coefficient to about 0.35 $mm/min^{1/2}$. The latter is further reduced by the use of commercially available water repellents in the mixture. Wood dust also reduces the thermal conductivity of adobes. Among the stabilizing additives used, gypsum proved to be the most beneficial. In general, simple modifications to the procedure followed during the laboratory production of adobes, such as in the filling of moulds, lead to higher density and compressive strength of the end-product.