



Comparison of adobes from pre-history to-date



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ABSTRACT

This paper presents a comparative study between prehistoric, traditional (19th–20th century) and contemporary adobe bricks from Cyprus. Reported experimental results include grain size distribution analyses, qualitative and/or quantitative mineralogical and chemical analyses, methylene blue and Atterberg Limits tests of the raw material used for the production of the aforementioned adobes. The experimental results are complemented by a thorough literature review of Cypriot adobe production.

The findings of the study show that contemporary as well as traditional adobes are to a great extent similar to the prehistoric ones tested in the framework of this research, taking into account the inherent non-homogeneity of the material. This conclusion derives both from the literature review and from the tests conducted in the laboratory. Although similarities are evident in the principles of production and curing, there are differences in the actual composition and mix design that may potentially influence the physico-mechanical characteristics and durability of adobe bricks.

It is anticipated that the investigation of early adobe samples and the comparison of traditional methodologies and practices of adobe production with respective contemporary ones, will contribute towards the enhancement of existing knowledge regarding adobe production technology. The ultimate aim is to use the results of this study in order to improve the practices applied in the current production of adobes. It is also expected that this study will further assist towards the development of methods for the quality control of earthen building materials, thus promoting, the use of adobe in contemporary architecture as an alternative, sustainable form of construction.

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1. Introduction

The use of raw earth as a building material was introduced worldwide in antiquity. Sun-dried mud bricks first appeared around 10,000 BCE (Morton, 2010), while evidence of the earliest production of moulded adobes dates back to the 6th century BCE in Mesopotamia (Wright, 1985).

The international and widespread use of earthen materials is evident today in the thousands of earthen monuments of built heritage existing worldwide. Around the Mediterranean, the Middle East, the Aegean Sea, Syro-Palestine, Anatolia, India and China, archaeological findings from the Neolithic Era onwards testify the existence of earthen buildings and the use of adobe bricks in particular (Houben and Guillaud, 1994; Philokyprou, 2015). These bricks were either hand-moulded or produced using rectangular timber moulds.

Cyprus' earthen architectural history dates back to the Neolithic era (8500 BCE–4500 BCE) (Demetriou et al., 2003; Philokyprou, 2015). Although other earth building techniques, such as rammed earth (pisé)

and cob, existed extensively in the greater area of the Mediterranean, Middle East, Syro-Palestine and Anatolia, in Cyprus examples of such techniques are scarce (Philokyprou, 2015), and adobe brick production seems to have prevailed.

In fact, up until the first half of the 20th century, adobe bricks (together with rubble/ashlar stone) were the predominant building materials on the island; these were used extensively for the construction of load-bearing masonry walls in single or double storey dwellings or workshop/commercial buildings (Illampas et al., 2011b). In the past 60–80 years, both in Cyprus and internationally, the use of traditional earth building techniques, including adobe construction, declined (Illampas et al., 2011b). This is mainly attributed to the modernization of the local society, the urbanization trends (especially during the second half of the 20th century), the introduction of industrialized building materials, and the adoption of national building codes and regulations, which imposed the implementation of engineering design (Illampas et al., 2011b). As a result of the decline in the use of adobe bricks, the empirical techniques and know-how regarding the production and use of this material were gradually lost.

Today, there is a generally accepted renewed and growing interest, both in the industry and academia, especially in countries with a large tradition in earthen architecture, for the re-introduction of adobe

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construction and the re-use of earthen materials in contemporary architecture, in the framework of promoting environmentally friendly, sustainable construction (Houben and Guillaud, 1994; Minke, 2009). The private and public sectors, individuals and professional building and engineering associations are showing increased interest in the re-discovery and assessment of earthen architecture, both for improving restoration practices, but also for promoting contemporary, environmentally friendly earthen construction. Furthermore, numerous adobe buildings of vernacular heritage can still be found in historic and prehistoric settlements around the world (Houben and Guillaud, 1994). These buildings, in most cases, are protected and require conservation and restoration approaches and interventions which will secure their durability for future generations.

In Cyprus, adobes produced by a limited number of local manufacturers, using random raw materials and empirical techniques, are currently mostly used in restoration projects. The end-product is, to a great extent, non-homogeneous and has variable physico-mechanical properties (Illampas et al., 2014). Hence, there is a great need to investigate the characteristics of the raw materials used in adobe production and their effect on the properties of the final products. This will help improve the quality and durability of adobes and will encourage their use, not only in the restoration of vernacular buildings, but also in contemporary sustainable structures.

This paper presents a comparative study on adobes from Cyprus belonging to three specific periods: prehistory (i.e. first appearance of adobes in Cyprus), 19th–20th century (wide use of adobes in vernacular architecture) and present day. The research aims at compiling a firm database of information and at determining similarities and differences regarding the raw material, composition, production and curing methods of Cypriot adobe bricks from prehistoric times until today. It is important to define and highlight changes that may have been introduced in adobe production through the centuries. Such information may potentially be utilized by archaeologists and restorers to improve conservation practices on archaeological findings/remnants and earthen heritage. Adobe producers may also use the findings of this study to enhance contemporary adobes. Last but not least, the research results may be used by local authorities for the preparation of standards and regulatory documents regarding adobe production.

2. Review of Cypriot adobe production and use

There is limited information from archaeological investigation reports on Cypriot adobe production and use from antiquity until today

(Demetriou et al., 2003; Philokyprou, 1998; Thomas, 1995). The earliest adobes found on the island were used in a number of Neolithic Settlements, such as Khirokitia and Kalavassos-Tenta in the south, but also in Bronze Age Settlements, such as the one in Marki-Alonia, which is located in the central part of the island (Fig. 1). The soil used for prehistoric adobe manufacturing came from the immediate environment of each settlement (Philokyprou, 2015).

Neolithic adobes were irregular in shape and of various sizes to start with, as they were hand-moulded. The practice of hand-moulding adobes prevailed during the Neolithic period, but was later replaced by casting adobes in uniform rectangular shapes using timber moulds. The latter practice has survived until today, as it provides advantages such as the regular dimensions of the end-product and consequently easier/faster building (Philokyprou, 1998).

For moulding adobes, two methods seem to have been followed in prehistoric times (Philokyprou, 1998). According to the first method, which was probably the most common on the island and which is also similar to the current method applied in vernacular adobe production, a timber mould was first placed on the ground; it was then filled with mud, straightened on the upper side and removed, allowing the adobe to dry. The second method implied placing an amount of wet mixture on the ground. This was then pressed with a rectangular timber mould on top to cut out the extra material (Philokyprou, 1998). The first method led to adobes of larger size and straight parallel surfaces all around; the second method was faster but produced adobes with a *plano convex* upper surface (Russell and Leick, 1991).

Cypriot adobes since the Bronze Age were generally rectangular in shape. A great variety of sizes has been documented (Le Brun et al., 1994; Todd, 1991). The use of a fixed unit of measurement is absent, most probably due to the fact that the human palm was used for measuring the end-product (Philokyprou, 1998). The thickness of prehistoric rectangular adobes ranged from 0.10 m to 0.15 m, while some fixed ratios of dimensions were noted, such as (l:w:h) 4:3:1, 4:2:1, 2:3:1, 5:4:1, 5:6:1. Additionally, some dimensions such as 0.50 × 0.60 × 0.10 m were found repeatedly in a variety of settlements (Philokyprou, 2015; Thomas, 1995). In some cases, in the same settlement, adobes of different dimensions were used for the construction of more complex walls or walls of larger thickness; this proves the versatility of early adobe builders and their ability to adapt to the needs of each structure, producing site- and use-specific adobes. In areas where adobes of the same width were produced, these were often laid in floors with continuous joints (Philokyprou, 1998).

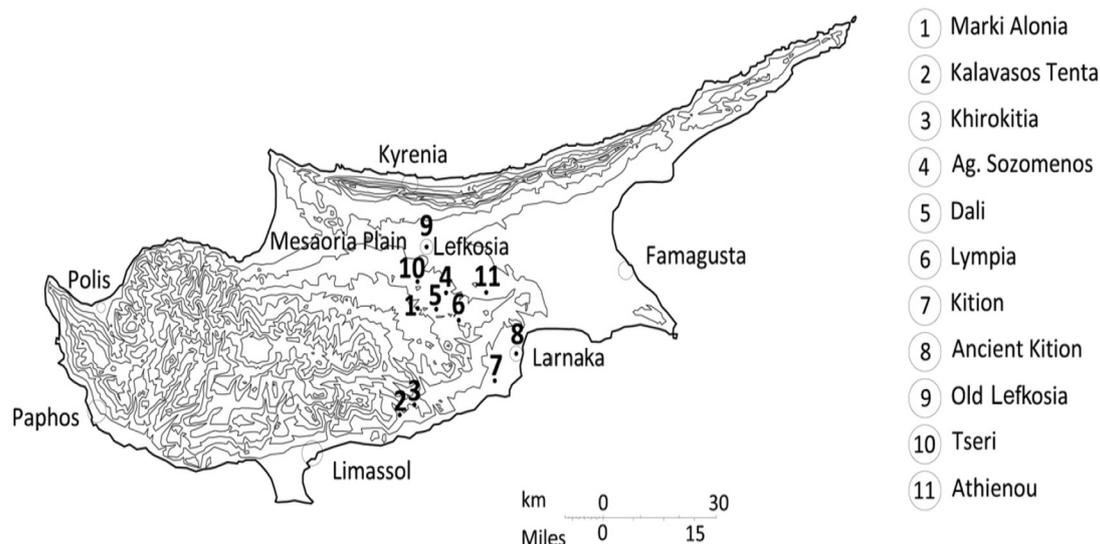


Fig. 1. Map of Cyprus showing the sampling locations.

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