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Analysis of ancient mortars and design of compatible repair mortars: The case study of Odeion of the archaeological site of Dion

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HIGHLIGHTS

- Analysis of ancient mortars from the Roman Odeion of the archaeological site of Dion.
- Design, manufacture and testing of repair mortars, compatible to the old ones.
- Criteria for the selection of suitable repair mortars are presented.

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ABSTRACT

Ten mortar samples (structural, plaster, floor substratum), taken from Roman Odeion of the archaeological site of Dion, were analyzed, regarding their physico-mechanical, microstructural and chemical properties. The evaluation of test results led to the definition of their structure and consistency, while proposals for repair materials were made. Compositions of repair mortars were tested (physico-mechanical properties, behavior in ageing) and results showed the suitable mixtures, meeting the requirements of resistance to the extreme environmental conditions of the site (humidity, salt accumulation), as well as of compatibility to old materials. Through the analysis, the criteria for the selection of suitable repair mortars are presented, aiming in the preservation of ancient structures and the maintenance of their integrity and authenticity.

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1. Introduction

Mortars constitute a significant structural, as well as aesthetic element of historic masonries, often closely related to their longevity and durability [1–3]. Their structure and properties usually differ according to their functional role (structural mortars, renders-plasters, flooring), the technology of each era and the availability of raw materials [1,3]. Their study reveals a great source of information regarding the type and proportions of raw materials used (binders, aggregates, additives, admixtures), their application technology, as well as their resistance to ageing and to environmental factors [1–4].

The analysis and characterization of old mortars is performed by many researchers and various methods and tools have been proposed during the last decades, focusing in the physical [4–8], mineralogical [9–12], chemical [4,5,11,13–14] and mechanical [4,11,14] properties of mortars. The difficulty in understanding the properties of historic mortars could be attributed to the variety of raw materials used for their production (clay, lime, pozzolan, gypsum, brick dust, different types of aggregates), which are met in a range of proportions. In addition, other parameters such as the application technique or the environmental conditions could also influence their properties. This interrelated system results in facing a rather complex problem, during the analysis of historic mortars. In all cases the basic aim is to determine their characteristics, understand the applied technology and even proceed to intervention proposals [15–18].

A holistic methodology has been developed in the Laboratory of Building Materials of the Aristotle University of Thessaloniki during the last 20 years and has been applied for the analysis of more than 2000 mortar samples of approximately 300 Greek monuments and historic buildings [1,3,17–23]. It takes into account not only the analysis results but also other aspects (environmental parameters, application technique, etc.), while it is flexible, since it can be applied in any kind of mortar sample (regardless its type or size) [1,3,7,17–23]. Its aim is to define the principles that should be followed during the selection and application of repair materials, in

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Fig. 1. Masonry type of Odeion (opus-mixtum).

Fig. 3. State of preservation of building materials (mortars, bricks).

order to maintain the authenticity and integrity of historic structures [1,17–23].

According to this methodology the microstructural, physico-mechanical and chemical characteristics of mortars are analyzed through a series of tests. The results are evaluated and lead to the understanding of the nature and technology of the tested samples and to the design of repair mortars aiming at retaining the physico-chemical properties of the old ones.

This paper focuses in the application of the holistic methodology in mortar samples taken from Roman Odeion of the archaeological site of Dion. Odeion is located in the complex of the Great Thermai (public baths) of Dion, built at the end of 2nd C AD, in order to form a new urban center of the town [24,25]. It served as a small theatre (with a capacity of 400 viewers), where performances and other cultural activities took place [24]. Its ground plan was semi-circular consisting of the orchestra and the auditorium, boxed in an orthogonal perimeter wall (dimensions 28×19 m), which formed totally 11 rooms. Masonry walls were built according to the opus-mixtum system, where stone masonry was enriched with zones of bricks (Fig. 1).

Floors presented a variation regarding their covering, as well as their substratum. The orchestra was covered with ceramic plates, while the perimetric rooms' floor was covered with a well-compacted reddish mortar (Fig. 2).

The main deteriorating factors of Odeion, as well as of the whole archaeological site of Dion, are the rising humidity and floods, due to the great number of underground and upperground streams and springs on site. Building materials (mortars, stones, bricks) are

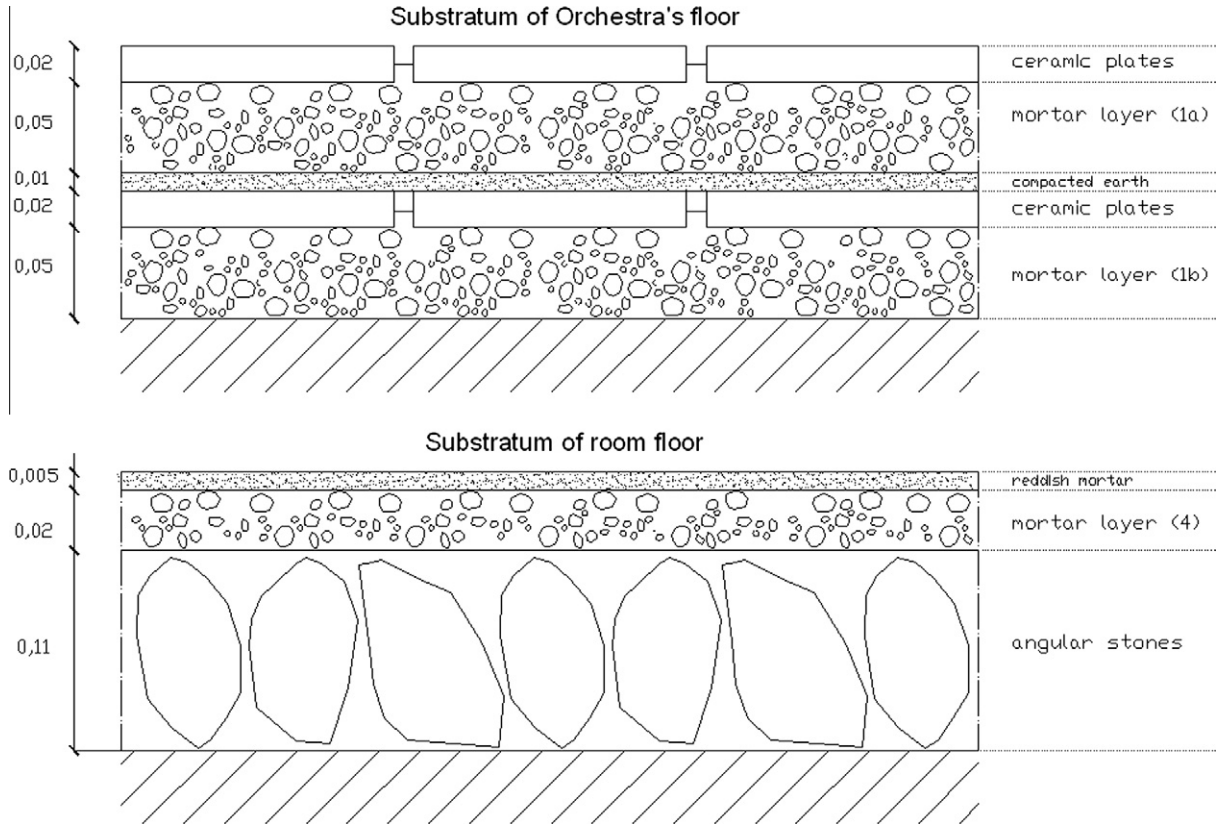

Fig. 2. Statigraphy of Orchestra's (samples 1a, 1b) and room's 6 floor substratum (sample 4).

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