

Innovative Approaches to Protecting Heritage and Historical Buildings: Utilizing Spray Techniques for Macro, Micro, Nano, and Pico Additives in Geotechnical Engineering

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ABSTRACT: Intelligent additives and modern technologies for the protection of heritage and historical buildings, as well as their use in earthen architecture, are very important due to their close relationship with geotechnical engineering. These additives have played the role of stabilizers in various earthen buildings from ancient times to the present. Most archaeologists, architects, and anthropologists are involved in the conservation of heritage and historical buildings. They use traditional techniques and materials in various conservation methods. A new revolution has begun for the protection of these types of buildings, utilizing spray techniques for the conservation of historical structures. The size of particles is very important for spray techniques and conservation. Therefore, this research evaluates the existing work of the authors' team on the importance of particle sizes in spray techniques and related methods for future conservation of heritage and historical buildings. Existing and traditional additives were often grouped under one category for all activities. However, recognizing the importance of separating particle sizes into macro, micro, nano, and pico can initiate a new approach to the protection of heritage and historical buildings in various countries.

1 INTRODUCTION

Most traditional stabilizers are used as powder, liquid, or paste in various traditional earth buildings. Traditional earthen buildings have been constructed in various countries such as Iran, Egypt, Yemen, etc. Sarooj has been used as a building material in traditional and historical earthen buildings in Iran. Although traditional and historical buildings were built using traditional engineering techniques, they require various modern techniques and materials for protection to ensure their longevity. These buildings are important as they represent the history of their respective countries.

The role of geotechnical engineering in earth buildings is crucial because architects, archaeologists, and anthropologists need strong support in engineering knowledge and the development of new additives, materials, and techniques for the protection of earthen buildings. Traditional earthen buildings require traditional and vernacular materials and techniques to maintain

historical conditions. Therefore, modern materials such as concrete are not suitable for their preservation.

Due to these limitations, in addition to existing materials and techniques such as powder, liquid, and paste, two new theories have been developed. These theories involve the separation of particle sizes from macro to pico and the combination of spray techniques to enhance the performance of penetration and absorption of materials in heritage and historical buildings. New titles are emerging in this discipline, such as Macro Spraying Technique (MaST), Micro Spraying Technique (MiST), Nano Spraying Technique (NaST), and Pico Spraying Technique (PiST). These can be evaluated in future research, practical projects, and physical modeling in geotechnical engineering. Although the spray technique can be used in various industries, it can also develop new methods for protecting various applications.

2 MACRO TO PICO SPRAYING TECHNIQUES

New techniques of spraying with various particle sizes have been used by the authors' team. This section describes the importance and achievements of spraying techniques with particle sizes ranging from macro to pico in various case studies of heritage and historical buildings.

2.1 Macro to Nano Montmorillonite

Khaksar et al. (2023) developed a spray-based method for the protection of adobe buildings (Figure 1). They selected a traditional and historical building in Iran and used various types of spray with different sizes of montmorillonite. This method improved the performance of adobe walls in various conditions, such as filling cavities, reducing pores on the surface of the adobe, increasing compressive strength, and reducing water absorption and hydraulic conductivity. This study proved the importance of particle size and the spraying method for the protection and conservation of historical and heritage buildings. As most historical buildings and heritage sites in Iran are built with earthen materials, this technique can be used in Iran and various other countries. It can develop a new way for the protection of traditional earthen buildings, preserving the history of various countries.

2.2 Macro to Nano Bentonite

Jalalifar et al. (2024) developed a new spray for the protection and conservation of historical buildings. They used commercial bentonite in their tests. This research used traditional buildings in Iran and evaluated the performance of various sizes of bentonite, down to nano size, on mortars. In this study developed a new theory of Nano Geotechnics (NaG) for the conservation of historical buildings. Various sizes of clays were applied using a spray technique to mitigate holes and cracks caused by erosion and various climate issues. According to their laboratory tests on real specimens of historical buildings and heritage sites, field emission scanning electron microscopy imaging (FESEM/SEM), X-ray

diffraction (XRD), X-ray fluorescence (XRF) analyses, inductively coupled plasma optical emission spectroscopy (ICP-OES), Brunauer-Emmett-Teller (BET) analysis, porosity tests, water absorption time measurement, and weathering tests were used. They proved the role of particle size and the spray technique in the conservation and protection of historical buildings in various countries (Figure 2). They developed and confirmed the role of smaller sizes of clay soils, such as bentonite, in improving and protecting various environmental aspects of these types of earthen and vernacular materials and buildings.

According to these examples and a few studies by the authors' team, it seems these techniques need further development for future applications (Khaksar et al., 2023, and Jalalifar et al. (2024)). They need to be advanced in various aspects and explore new methods for physical modeling in geotechnical engineering, as the role of geotechnics is crucial for the protection of earthen buildings. Evaluating soil particles from macro to pico scales appears to be a new approach in geotechnical engineering. This can revolutionize the future of additives, stabilizers, and various technical aspects in civil engineering, the building industry, and related fields. The spray technique can assist in addressing various issues and crises, such as dust problems in Arabic countries and the Middle East. Engaging with particle sizes and various aspects of geotechnical engineering can also reduce existing concerns regarding challenges in ground improvement. This research and particle size evaluation can also initiate new theories and ground improvement techniques, such as Micro Subsidence or Nano-Subsidence, which are relevant to the national crises faced by various nations today.



Figure 1. Macro to Nano Montmorillonite in and Earthen Building (Khaksar et al., 2023)

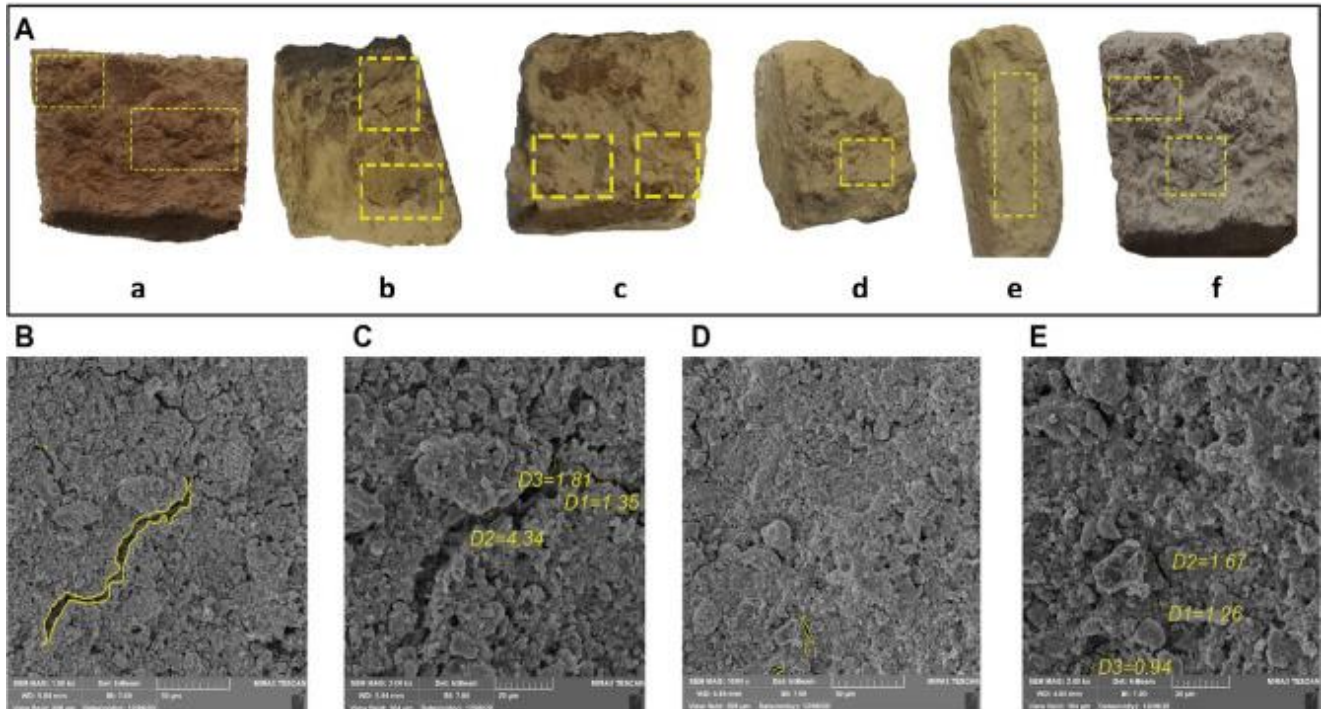


Figure 2. Macro to Nano Bentonite in and Earthen Building (Jalalifar et al., 2024)

3 CONCLUSIONS

According to this research, the importance of particle sizes of soils and additives, modern techniques such as spray for the protection of historical buildings, the selection of sustainable and green materials such as clay types, controlling various additives and their performance in the laboratory before field scale based on different historical building projects, and the development of intelligent additives have been proven. Clay has played a main role in earthen buildings for many years, from traditional and historical buildings until now, and it can be used as a main player as a basic material or intelligent additive with various parameters and modifications. Clay can decrease air pollution because it is a natural material that can be found in various areas and countries. Using new techniques such as spray can help us protect various historical buildings and heritages. The combination of this technique and various sizes of materials in macro, micro, nano, and pico scales can change everything for the lifespan and future protection and conservation of historical buildings such as earthen buildings because these buildings must be preserved as part of the history of countries and Earth. Due to various crises and challenges such as earthquakes, land subsidence, sinkholes, etc., the importance of these techniques is very significant for related agencies, organizations, and industries. The spray technique can also be used for another crisis, dust, which can be controlled in the Middle East and Arabic countries.

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