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A Comparative Analysis on A Sustainable Material, Rammed Earth: Tapia in Fez and Sevilla

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ABSTRACT

Earth is one of the primary materials used by humans to meet their housing needs. From an environmental perspective, earth-based construction materials stand out due to their low embodied energy, minimal carbon footprint, and strong potential to support sustainable and climate-resilient building practices. Especially in traditional architecture, there are unique examples of earth-based materials in different countries. This paper presents a comparative analysis of tapia (rammed earth) architecture in Fez, Morocco and Seville, Spain, examining construction systems, earth-based materials, and the differential impacts of UNESCO World Heritage designation on these shared Almohad architectural traditions. The study aims to evaluate the application of earth-based material in traditional architecture with examples from Morocco and Spain considering sustainable approaches. Fez, the first Moroccan site to be included in the UNESCO World Heritage List in 1981, represents architectural heritage preserved through various conservation approaches, while the Cathedral, Alcázar, and Archivo de Indias in Seville were registered as UNESCO World Heritage Sites in 1987. Within this context, tapia, a material made of compressed earth, is examined in both Fez and Seville in terms of building material characteristics, construction techniques, sustainable approaches, and UNESCO-related effects. Both cities developed distinctive rammed earth construction traditions that define their urban characteristics, reflecting material and technical diversities shaped by local geological and climatic contexts. Although both traditions employed wooden formwork and systematic layered compaction, they evolved unique regional characteristics through material adaptation to local conditions. The comparative analysis highlights how shared architectural origins diverged over time due to these contextual differences. Furthermore, the effectiveness of UNESCO-led conservation depends critically on scope, funding mechanisms, and the relationship between conservation authenticity and urban contexts. From an environmental perspective, the study further evaluates tapia construction in terms of embodied energy and carbon footprint, positioning earthen architecture as a low-impact alternative to conventional building materials. Literature-based evidence indicates that rammed earth and similar earthen materials typically exhibit embodied energy values below 1 MJ/kg, significantly lower than fired clay bricks (≈2.5–3.5 MJ/kg) and reinforced concrete systems. Likewise, the embodied carbon of earthen materials (approximately 0.02–0.05 kg CO_2/kg) remains substantially lower than that of brick and cement-based construction, primarily due

to the absence of firing processes and cement production. By integrating architectural analysis with environmental performance considerations, the study frames tapia not only as a culturally significant heritage material but also as a viable component of contemporary sustainability and climate-resilient construction strategies.

KEY WORDS:
Tapia, Fez, Seville, embodied energy, carbon footprint