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Life Cycle Assessment of Adobe Construction Materials: A Carbon Footprint Evaluation of Locally Sourced Earthen Building Materials in Northern Cyprus

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ABSTRACT

The construction sector is a significant contributor to global greenhouse gas emissions, creating an urgent need for low-carbon and environmentally sustainable building materials. Earthen construction has re-emerged as a promising alternative due to its low embodied energy, local availability, and recyclability. This study aims to evaluate the carbon footprint and environmental performance of earthen building materials produced from locally sourced soils in Northern Cyprus using a cradle-to-gate Life Cycle Assessment (LCA) in accordance with ISO 14040 and ISO 14044 standards. The assessment considers the environmental impacts associated with raw material extraction, transportation, material preparation, gypsum stabilization, manufacturing, and end-of-life scenarios. Primary experimental data obtained from previous investigations on the physical and mechanical properties of Northern Cyprus soils are integrated with life cycle inventory data to estimate embodied carbon (kg CO_2-eq), cumulative energy demand, and selected environmental impact indicators. The environmental performance of gypsum-stabilized earthen materials is compared with that of conventional fired clay bricks and concrete masonry units. The results indicate that earthen building materials manufactured from locally available soils have a substantially lower embodied carbon than conventional masonry materials, primarily because they eliminate energy-intensive firing processes and reduce transportation-related emissions through the use of local resources. Although gypsum stabilization slightly increases embodied carbon, it significantly enhances the mechanical strength and durability of the earthen materials, resulting in an overall improvement in environmental and structural performance. Furthermore, the reuse and recyclability of earthen materials strengthen their contribution to circular economy principles and reduce life cycle environmental impacts. These findings demonstrate that locally sourced gypsum-stabilized earthen materials are a viable low-carbon solution for sustainable construction in Mediterranean regions and highlight the value of integrating life cycle assessment into the evaluation of earth-based construction materials. The study provides scientific evidence supporting the wider adoption of earthen materials as sustainable alternatives to conventional masonry products and contributes to the development of climate-resilient and resource-efficient construction practices.

KEY WORDS:
Life Cycle Assessment (LCA); Earthen materials; Embodied carbon; Gypsum stabilization; Sustainable construction