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Thermal Performance of Adobe Building Envelopes Under Future Climate Scenarios: A Case Study of Traditional Houses in Kütahya

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ABSTRACT

Architecture is a discipline that not only organizes human activities spatially in accordance with functional requirements but also aims to ensure that these activities are carried out under healthy and comfortable indoor conditions. Central to this objective, thermal comfort is a parameter with a direct influence on occupants' cognitive performance and physiological well-being. The energy expended to maintain such comfort conditions accounts for approximately 25–30% of global energy consumption, a share largely attributable to the performance of the building envelope, which defines the thermal boundary between indoor and outdoor environments.

In traditional architecture, material choices pertaining to the building envelope have been predominantly determined by raw material availability, climatic conditions, and regional topography. This determinism has enabled the thermal, structural, and environmental performance requirements of the envelope to be met through local materials and construction systems. In this context, adobe has been extensively employed as the principal envelope component of traditional buildings in Anatolia's continental climate zone, owing to its high thermal mass and hygroscopic buffering capacity. Accordingly, adobe building culture embodies a systematic body of knowledge, encompassing climate-responsive passive thermal regulation principles, material behavior, and construction techniques, that remains transferable to contemporary architectural practice. However, climate change and the accompanying urban heat island effect now necessitate a fundamental reassessment of established design assumptions for the built environment. Rising average temperatures and increasingly frequent extreme weather events are markedly intensifying building cooling loads, thereby elevating the criticality of architectural form and envelope decisions from an energy performance standpoint. Within this context, the present study examines the Bay Halit Yarligayan, Mutafzade Hasan Efendi, and Bandimzade houses as representative adobe-envelope examples of Kütahya's traditional residential fabric.

The selected buildings will be digitally modeled in the DesignBuilder simulation environment, which operates on the EnergyPlus calculation engine, and existing adobe envelope configurations will be compared against improved envelope scenarios through comparative energy simulations.

The analytical process is not confined to static meteorological data; rather, it draws upon the most current future climate projections (SSP scenarios) presented in the IPCC Sixth Assessment Report (AR6). This approach aims to systematically reveal how the characteristics of the adobe envelope, including high thermal mass, low thermal conductivity, and geometric configuration, affect annual energy demand under the extreme heat waves projected for the 2050 and 2080 time horizons. Accordingly, the extent to which the inherent passive thermal regulation advantage of adobe can remain robust against changing climatic conditions, along with its climate resilience capacity, will be quantitatively examined.
Within this framework, the study directly tests the effectiveness of the thermophysical properties of adobe envelopes under future climate scenarios. As the vernacular architecture literature also emphasizes, interventions that depart from traditional construction principles by replacing natural materials with synthetic and industrial alternatives adversely alter indoor temperature profiles and diminish occupant comfort. This study, while evaluating the performance of adobe under future climate projections and its capacity for adaptation to changing conditions, opens a discussion on the potential contribution that adobe construction knowledge can offer to the sustainable architectural practices of the future.

KEY WORDS:

Adobe building envelope, thermal performance, future climate scenarios, energy simulation, Kütahya traditional housing