

Quantitative Appraisal of the Sustainability of Compressed Stabilized Earthen Masonry

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Abstract:

Compressed stabilized earthen block (CSEB) masonry presents a sustainable and economically attractive alternative to conventional residential construction materials such as clay brick or concrete masonry (CMU). Earthen masonry is locally sourced and manufactured on site, thus minimizing costs associated with raw material extraction and transportation. Furthermore, CSEB requires very little use of electricity and water during both the manufacture and construction processes, and it is expected to have high thermal resistivity while in use, allowing for cost and energy savings during most phases of its life cycle. While this general understanding is common, there is need for a more quantitative and comparative study to verify these claims. Analyzing the life cycle trade-offs in a comparative study between CSEB and clay brick masonry supplements the existing recent research on earthen masonry and encourages a wider adoption of the technology around the world. In this study, a comparative Life Cycle Analysis (LCA) is conducted between CSEB and clay brick using an exterior residential wall constructed for a proposed single-family dwelling on the Winnebago Native American Reservation in Nebraska, USA. The scope of this LCA is narrowed to the impacts associated with choosing one construction material over the other, and the system boundary includes the raw material extraction, manufacturing, and transportation phases of construction. Thermal conductivity is an important aspect of the energy efficiency of a building envelope during the use phase of a building's life cycle. As part of this study, an experimental program was conducted using a modified hotbox apparatus to obtain a thermal conductivity value for the CSEB blocks under investigation. The thermal conductivity of the CSEB analyzed in this study is determined to be $0.361 \text{ W/(m}\cdot\text{K)}$ ($0.209 \text{ BTU/(h}\cdot\text{ft}\cdot\text{°F)}) \pm 20.0\%$ compared to $1.024 \text{ W/(m}\cdot\text{K)}$ ($0.592 \text{ BTU/(h}\cdot\text{ft}\cdot\text{°F)})$ for clay brick. The three indicators for measuring the environmental or economic impacts of each material in this study are: 1) Energy, measured in $\text{kW}\cdot\text{h}$, 2) Global Warming Potential (GWP), measured in $\text{kg CO}_2 \text{ eq.}$, and 3) Cost, measured in US Dollars. The results of this Life Cycle analysis indicate that CSEB is the more economic and environmentally sustainable option, with the transportation phase of the life cycle of highest impact on cost.

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