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Form-Material Relationship and Digital Manufacturing Methods in Rammed Earth Blocks

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Abstract:

Although rammed earth and adobe structures offer economic and ecological solutions that promote the use of local resources, they have a limited area of use in the modern construction industry due to technological limitations in production practices. Today, earth blocks are traditionally produced by being rammed with human power in molds or by being compressed with hydraulic/mechanical vertical pressure forces in industrial briquette making machines. The main focus of this study is to examine the traditional shaping processes of rammed earth stabilized with gypsum and lime (ALKER) and to compare these processes with automation-based digital manufacturing methods (3D printing technology) in the context of structural performance and material rheology. Existing technologies based on compaction and molding only allow the material to be produced in predetermined mold geometries; whereas, digital manufacturing methods eliminate mold dependency, granting the freedom of dimensioning in free and complex forms. However, the most critical engineering challenge in digital manufacturing technology, unlike traditional pressing, is ensuring the rheological (fluidity, viscosity, and shape retention) behaviors required for the material to flow from the computer-controlled nozzle without clogging and to maintain its own form without collapsing under the stacking pressure of the upper layers. Within the scope of the study, the production dynamics, labor-time costs, and structural integrities of earth blocks produced by pressing in molds with hydraulic cylinders and earth modules produced by extrusion-based 3D printing devices will be comparatively analyzed. In particular, in cases where the internal strength of the material itself is low, the contribution of hollow and curved forms with topological optimization, modeled with digital design tools (CAD/Rhino), to stability will be examined instead of traditional solid/block forms. Modules printed in different cross-sectional patterns and molded traditional blocks will be subjected to dynamic analyses in a laboratory environment, and the variation of the form-material relationship depending on the manufacturing technology will be measured. In conclusion, this research aims to present to the literature via a technological comparison how the right manufacturing algorithms can increase the performance of load-bearing elements by revealing the potentials and limitations of the transition from traditional manufacturing to digital manufacturing in earth-based architecture.

Keywords: Rammed Earth Blocks, Comparison of Manufacturing Technologies, Material Rheology, Form-Material Relationship, Hydraulic Pressing.