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From Escher to Earth: Tessellation Strategies for Modular Rammed-Earth Blocks

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ABSTRACT

Contemporary developments in earthen construction increasingly combine traditional material practices with digital design and fabrication techniques, expanding the geometric and constructional possibilities of rammed earth. Recent research has demonstrated the potential of modular rammed-earth systems through digitally designed blocks, prefabrication, and fabricated formwork (Abdelaal et al., 2024; Arsevenoğlu et al., 2025), while studies on compressed-earth block systems have examined the physical behavior and assembly of geometrically defined units in dry-stack construction (Sturm et al., 2015). In parallel, Escher-inspired periodic tessellations have previously been investigated as a strategy for generating repeatable modular architectural groupings (Serrentino, 1999). Building upon these existing research directions, the application of tessellation-based geometric systems to physically fabricated modular rammed-earth blocks, particularly in relation to material and fabrication tolerances, appears to remain insufficiently investigated.

This research explores the development of a tessellation-based modular rammed-earth tiling system informed by the geometric logic of M.C. Escher's periodic tilings. Rather than reproducing Escher's figurative patterns, the study adopts tessellation as a construction logic in which complementary units repeat through geometric transformations to form an idealized continuous assembly without geometric gaps or overlaps. Repetition, translation, and rotation are investigated as design operations for generating modular block geometries beyond conventional rectangular units.

The research follows a design-to-fabrication methodology. Geometric development begins with a basic planar cell constrained to maximum dimensions of 15 × 15 cm. Selected portions of its boundary are removed and transferred to corresponding boundaries through translation, generating complementary protrusions and recesses while preserving the unit's ability to tessellate. This operation can be applied multiple times to different portions of the cell using profiles of varying dimensions and geometries, enabling more complex outlines while maintaining the underlying tessellation logic. Rotation is additionally explored to generate alternative periodic configurations. The resulting two-dimensional profiles are developed into

three-dimensional modular blocks. A corresponding formwork system is digitally designed and fabricated using 3D printing. Rammed-earth specimens are produced by incrementally placing and manually compacting a prepared earth mixture within the formwork. Following demolding and drying, the blocks are assembled into a horizontal configuration according to the predefined tessellation logic.

The physical assembly investigates how mathematically precise complementary geometries respond to the material and fabrication variability of rammed earth. Potential dimensional changes are systematically tracked by comparing the digital model, freshly demolded state, and fully dried state. Dimensional variation, edge deformation, joint gaps, and complementary fit are documented to evaluate how material deviations affect geometric continuity and assembly. By positioning tessellation as a construction logic rather than solely a visual pattern, the study aims to identify the potential and limitations of translating geometrically precise principles into materially variable modular rammed-earth systems.

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KEY WORDS:

Rammed Earth, Tessellation, Modular Blocks, Digital Fabrication, Material Tolerance