

Developing a Framework for Energy Efficiency and Climate Resilience in House Construction in Tropical Lowlands and Uplands

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Abstract

Residential buildings in tropical climates face growing challenges from high cooling energy demand and indoor thermal discomfort, creating a need for energy-efficient housing strategies. This study investigates how building envelope and geometric parameters affect thermal behaviour in residential buildings, with particular relevance to Sri Lanka's lowland tropical climate. The study adopts a dynamic building performance simulation approach using DesignBuilder and EnergyPlus to evaluate the effects of wall and roof construction, window-to-wall ratio (WWR), and building orientation. Wall and roof materials were selected based on their relevance to Sri Lankan residential construction. A sensitivity analysis dataset was generated to evaluate variations in annual cooling energy demand under different design configurations. Preliminary results indicate appreciable differences in cooling energy demand among alternative wall and roof constructions, with roof construction showing a comparatively higher influence within the simulated configurations. Wall construction also influenced cooling energy demand, with Autoclaved Aerated Concrete (AAC) blocks and Expanded Polystyrene (EPS) based wall configurations exhibiting lower mean cooling energy demand than conventional brick and cement-block constructions in the simulated cases. The results demonstrate the importance of material selection in tropical residential building performance and provide a basis for subsequent sensitivity and data-driven analysis. The completed study will further evaluate the interactions among building, climatic, and operational parameters and translate the identified relationships into a practical climate-responsive design framework. The study is expected to contribute to improved decision-making for energy-efficient and thermally resilient residential construction in tropical climates.

Keywords: *building envelope and geometry; DesignBuilder/EnergyPlus; energy-efficient housing; sensitivity analysis; tropical climates*