# *Abstract*


Amidst global concerns over climate change and fossil fuel depletion, designers are increasingly integrating energy-saving measures inspired by ancient architectural techniques, emphasizing indoor comfort and daylight exposure without relying on non-renewable resources. The significance of thermal comfort and daylight in buildings for occupant well-being and productivity, energy efficiency, and sustainability aligns with environmental goals, and fostering a connection to the external environment. This shift towards passive design strategies is particularly pronounced in solar-rich regions such as India.

Analysis-based design, utilizing simulations and computational models, is crucial for informed decision-making. The present study thus employs the Building Energy Simulation-Optimization (BESO) approach, enabling a comprehensive evaluation before physical construction and ensuring compliance with performance objectives and regulatory standards. The central goal is enhancing thermal performance, especially in tropical climates where heat, cold, and humidity present challenges. The BESO framework optimizes the Tropical Summer Index for natural conditioning and minimizes air conditioning loads through strategic building design.

Traditionally, Genetic Algorithms (GA) are preferred for optimizing building parameters, but their limitations require exploring more efficient alternatives. The Grasshopper Optimization Algorithm (GOA), known for computational efficiency, suitability for discrete variables, and local optima avoidance, emerges as a compelling choice. This study pioneers GOA's application in building parameter optimization, conducting a comparative analysis with GA. Results show that GOA enhances thermal performance by 0.44% to 1.47% in naturally conditioned buildings and 2.32% to 12.37% in air-conditioned buildings compared to GA.

The study expands to address lighting's role in energy consumption and occupant well-being, emphasizing harnessing daylight in tropical climates through expansive windows. Using GA and GOA-based BESO, it compares their efficacy in maximizing daylight admittance with the Perez sky model. GOA achieves a visual performance enhancement of 0.22% to 0.27%. Further, balancing daylight admission and heat mitigation highlights the multifaceted nature of tropical climatic objectives. A multi-objective optimization analysis, using multi-objective forms of GA and GOA (NSGA-II and MOGOA), is conducted across three Indian climatic zones. Results show improvements in solutions by MOGOA compared to NSGA-II. Moreover, execution of GOA and MOGOA leads to significant reductions in computational time, ranging from 0.04% to 57.22%.

Further, algorithm optimization relies on precise parameter configuration. The study explores two methodologies: meta-optimization using an auxiliary algorithm for calibration, and dynamic modulation of parameters through Reinforcement Learning (RL) principles. These approaches, previously unexplored in the BESO domain, hold the promise of untangling nuanced optimization challenges. Fine-tuning parameters leads to enhancements, with meta-optimization improving by 0.04% to 2.76%, and RL-based fine-tuning demonstrating a further enhancement of 0.22% to 5.94% in the results. Results also demonstrate that the diverse decision variables interact with each other, and their holistic consideration is a critical factor in sustainable building design.

In conclusion, the outcomes offer practical recommendations for selecting appropriate building design parameters based on specific objectives. Overall, this research advances the knowledge and understanding of BESO and fine-tuning of algorithm parameters. The study contributes to the development of more efficient building designs in tropical regions of India, offering innovative strategies for algorithm parameter optimization in both fixed and adaptive approaches.