Abstract

Addressing the global agenda of sustainable development goals, India has mandated Energy Conservation Building Code (ECBC2017) for commercial buildings. Envelope (wall, roof and fenestration) is its most critical system. Referring to the modest capability of the Indian professionals in design and operation of green building (GB), this research aimed to develop a decision support system (DSS) for GB envelope design to achieve short-term goal of ECBC-compliance and long-term performance considering maintainability and site microclimate. Extensive surveys, interviews and case-studies showed that sluggish adoption of building information modelling (BIM) and ignoring maintainability greatly hinder Indian GB scenario.

The proposed BIM framework can derive maintainability performance factor (MPF); energy efficiency and holistically rank envelope options by integrating both. Field studies noted 92 major design-related defects where 32.6% were found critical. Accordingly, a list of 74 maintainability attributes was drafted for defect prediction and MPF calculation. For energy-efficiency, a customizable BIM library of common green materials and passive features was designed for early energy simulation and generation of envelope performance factor ratio (EPFR) as per ECBC norms. However, by reflecting the effect of site microclimate through shadow from adjacent buildings, peak total cooling load (PCTL) was established as a better indicator of energy performance. Best-Worst method (BWM) was chosen to develop a multi-criteria DSS to combine energy-efficiency and MPF, With benefits of the analytic hierarchy process, BWM is simpler and more flexible. The DSS can handle project-specific additional criteria to derive overall score in BIM setup with programmable spreadsheets at backend.

Operational validity was adopted to gauge the accuracy and reliability of the developed framework with an existing GB of LEED-Gold status. Calculated MPF of only 63% vs 73% match of predicted and actual defects verified the maintainability aspect. From 180 simulated cases, the as-built case and other top five envelope combinations had the same ranking for EPFR and PCTL–proving agreement of both. For BWM based holistic ranking, project team added third criteria of material availability. The as-built case topped in energy performance but came third in holistic rating. There was rank reversal for every case, but the stakeholders' subjective opinion logically ratified the BWM ranks. Hence the model was validated.

The novelty of the work lies in (a) integration of energy efficiency and maintainability; (b) new formula for window projection-factor; (c) optimal design utilising the effect of site microclimate to minimise redundant green materials or features and (d) scientific short-listing of alternatives in early design. These are vital to make GB mainstream in resource-constrained Indian scenario. The proposed framework augments the industry's competency, and modularity makes it flexible to use. Extending the same BIM model to other lifecycle phases is a value addition. This generic framework equally applicable to conventional buildings contributes towards the global goal of sustainable development.

Keywords: Best-Worst method; BIM; Early design phase; ECBC 2017; Green building envelope; Maintainability.