ABSTRACT

Thermal, visual, and acoustic comfort are among the major parameters of overall occupant comfort and indoor environmental quality in buildings. Early-stage design and selection of building envelope parameters require due consideration to all these three aspects of comfort to enhance envelope performance, productivity, and wellbeing of occupants. Several methodologies have been proposed by researchers for optimization of thermal and visual performance of the envelope, both individually and simultaneously, but the acoustic performance, i.e. mainly noise insulation, has remained largely disregarded or left to be dealt with at a later stage. The lack of a proper methodology for simultaneous optimization of thermal and visual performance of building envelope with acoustic performance has led to degradation of the acoustic environment inside green buildings. The present study proposes a methodology for simultaneous optimization of the thermal, daylight insertion, and noise insulation performance of building envelope to minimize operational energy consumption and enhance thermal, visual, and acoustic comfort for the occupants. The proposed methodology makes the use of a multi-objective optimization algorithm, Non-Dominated Sorting Genetic Algorithm-II (Deb, Pratap, Agarwal, and Meyarivan 2002a), combined with thermal, daylight, and sound energy transfer models to arrive at a set of optimized building envelope parameters for early-stage design. The admittance method proposed by Milbank and Harrington-Lynn (Milbank and Harrington-Lynn, 1974) is used to assess the thermal performance of the building envelope. The daylight insertion through the windows is estimated making the use of the Perez sky model (Perez, Seals and Michalsky 1993) and inverse square law (Koenigsberger, 1984). The noise insulation property of the envelope construction and glazing is estimated through the transfer matrix method (Brouard, 1995) and the performance is assessed using the OITC rating (ASTM,

2016). The efficacy of the proposed methodology is assessed by using it for the early-stage design of a hypothetical case study building and studying the set of optimal design solutions thus obtained. An adequate sky luminance prediction model for Indian tropical climatic conditions is proposed through comparative between measured sky luminance data and widely used sky luminance prediction models (Perez and CIE sky model (Darula and Kittler, 2002)).

As an end-user or a decision-maker, every person is not skilled enough to carry out whole building simulation optimization himself for the selection of building envelope parameters for the desired objectives. For global and mass adoption of such green building solutions, a set of climate-specific ready-to-use guidelines are required that can be readily used by the architects or decision-makers in the design stage of building for the reduction in energy consumption and enhancement of comfort levels inside the building. Therefore a set of guidelines are also proposed using the developed methodology for low rise commercial buildings which when implemented in design will enhance thermal, visual, and noise insulation performance for the building envelope leading to minimum energy consumption while ensuring thermal, visual, and noise insulation comfort for the occupants in different climatic zones of tropical climate.

The proposed methodology was also used to develop design guidelines for envelopes in multi-unit residential buildings. A modified form of the proposed methodology was used to develop design guidelines for multi-unit residential building envelopes in major climatic zones of the Indian tropical climate.