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Comfort-energy nexus in naturally ventilated affordable mass housing with alternative constructions in the developing world

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There is a strong positive correlation between thermal comfort quality experienced inside a building and its energy efficiency. This is more obvious in case of mechanically ventilated spaces where the energy gains are directly related to the thermal load, as compared to free running or naturally ventilated spaces. Current state of arts assess the energy efficiency of building envelops in terms of the cumulative thermal load in the operating phase of the building that are catered by mechanical ventilations. Our study aims at addressing this gap of research in assessing the thermal comfort quality of naturally ventilated residential living spaces. Our study is designed in a warm-humid climate setting and in the context of affordable mass housing in the developing world where mechanical ventilation is unaffordable or affordable only for a definite period of the day and during peak summer seasons; such buildings are said to be operating in temporal mixed mode.

Affordable mass housing constitutes 95% housing demand in the residential sector in India. Various alternative materials and composite roofing and walling envelops have been envisioned in the past decade for such constructions, however, their effectiveness in terms of comfort quality has not been assessed for naturally ventilated envelops. Our study introduces a model to assess the thermal performance of naturally ventilated bedrooms constructed with alternate building envelop configurations. We attempt to review and compare alternative walling technologies and the currently emerging mass housing construction systems in India with the base case housing envelop constructions commonly in practice in India that use ordinary burnt clay brick walls and reinforced concrete roofs. We compare the thermal comfort purveyed in the indoor bedroom spaces using the adaptive thermal comfort model in EN15251 as thermal neutrality temperature. We assess and compare alternative envelop performance using two measuring thermal comfort indices suited for naturally ventilated scenarios - the discomfort hours index and the cooling indoor degree hours index. Discomfort hours measures the number of hours of discomfort experienced during the summer solstice and spring equinox months whereas the cooling indoor degree hours measures the cumulative average temperature elevation from the comfort temperature in the hours marked as discomfort hours. In our study, light gauge steel framed structure with foam concrete filling records the minimum number of discomfort hours, however purveys maximum cooling indoor degree hours.

The above two comfort indices have not been compared in the past to assess the thermal comfort quality in naturally ventilated or temporal mixed mode buildings. Our study frames a thermal comfort assessment model for naturally ventilated envelops and thereby offers a paradigm shift from life cycle cooling load minimization models which are appropriate for mechanically conditioned spaces. Our observations are also important for mass housing envelop selection and in the context of the current policy frameworks in the developing world, aimed at minimizing the projected demand for residential space cooling and future energy footprints in the housing sector.