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A Low Order Thermal Envelope Model for Heat Transfer Characteristics of Low-Rise Residential Buildings

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Abstract : A simplistic model is introduced for determining the thermal characteristics of a Low-rise Residential (LRR) building and then predicts the energy usage by its Heating Ventilation & Air Conditioning (HVAC) system according to changes in weather conditions which are reflected in the Ambient Temperature (Outside Air Temperature). The LRR buildings are treated as a simple lump for solving the heat transfer problem and the model is derived using the lumped capacitance model of transient conduction heat transfer from bodies. Since most contemporary HVAC systems have a thermostat control which will have an offset temperature and user defined set point temperatures which define when the HVAC system will switch on and off. The aim is to predict without any error the Body Temperature (i.e. the Inside Air Temperature) which will estimate the switching on and off of the HVAC system. To validate the mathematical model derived from lumped capacitance we have used EnergyPlus simulation engine, which simulates Buildings with considerable accuracy. We have predicted through the low order model the Inside Air Temperature of a single house kept in three different climate zones (Detroit, Raleigh & Austin) and different orientations for summer and winter seasons. The prediction error from the model for the same day as that of model parameter calculation has showed an error of < 10% in winter for almost all the orientations and climate zones. Whereas the prediction error is only <10% for all the orientations in the summer season for climate zone at higher latitudes (Raleigh & Detroit). Possible factors responsible for the large variations are also noted in the work, paving way for future research.

Keywords : building energy, energy consumption, energy+, HVAC, low order model, lumped capacitance
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