Quantification of Energy Efficiency though Simulation Software for Exploration of Passive Solar Architecture features and Materials in Building Envelope in the United States

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Reducing building energy demand is a pressing need. Most energy supply utility companies provide incentives for shifting cooling and heating load demands from peak to non-peak hours. The purpose of this study is to understand and minimize the energy consumption of a building through the use of energy modeling software tools. Primary focus is given to energy efficiency techniques through the use of passive solar architecture (PSA) features. The study explores the various PSA alternatives for the building envelope in terms of design and location of windows, glazing types, thermal insulation, and roofing and wall types. The research investigates the different options of materials for building envelopes that are available in the market and performs a comparative analysis of these materials by fitting them into building's purpose as well as the local climate. Energy Simulation Modeling is performed for buildings of similar size and function in various climate zones across United States. The primary simulation software used in this project is Design Builder and Ret screen. A base model is first developed and compared with the proposed models incorporating passive solar architecture features. Design and material alternatives are chosen and tabulated based on the ability of the alternative to reduce the energy consumption while maintaining indoor thermal comfort condition for building occupants. The results are quantified using simulation software and utility bills. Previous studies indicate that passive solar architecture helps reduce overall energy consumption of a building. This paper assesses various PSA techniques in a quantifiable manner and proposes innovative alternatives. Factors such as thickness and number of layers, materials and so on are experimented in the model to study energy performances through the envelope. Findings are discovered and presented at the end. This study thus helps in realizing the energy savings by computing energy demand for various insulation alternatives, materials, options, etc. Computational Fluid Dynamics (CFD) analysis is performed to understand the three dimensional perspective of the temperature and velocity properties inside the building due to building envelope conditions and shape and to ascertain the comfort levels attained through the natural ventilation of these passive solar features that were incorporated into the model. This research uses simulation software extensively towards studying building energy consumption through the envelope to come up with quantifiable results in terms of percentage of energy reduction and overall cost savings and payback period for the expenses incurred while incorporating passive features into the design.

KEY WORDS: Energy Efficiency, Design Builder, Passive Solar Architecture, Building Envelope, Building Energy Simulation