Effect of Insulation Position in Concrete Residential Buildings on Cooling Equipment Energy Consumption

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Residential buildings in hot climate regions usually require heavy air conditioning usage with its associated high electricity consumption and costs. In order to maintain comfortable indoor conditions and help reduce cooling costs, it is recommended that residential buildings be insulated in order to decrease heat gains through the envelope. For the case of concrete-block and brick buildings, commonly used in developing countries, buildings are normally insulated by adding rigid polystyrene insulation to the roof and outside walls, and covering the insulation with an appropriate material, like stucco or gypsum board. Insulation can be added to the outside or to the inside of the building, and it is generally assumed that both installations methods will provide the same savings in cooling energy. Therefore, the insulation installation method chosen depends on considerations other than thermal performance. For example, in some developing countries, homes are sold un-insulated, and the owner installs insulation to the outside after moving in.

In addition to installing insulation to the building, occupants normally try to decrease their electricity consumption by shutting-off the air conditioning equipment when the building is unoccupied, usually during daytime; or when the outdoor temperature drops to more comfortable levels. As a consequence of shutting off the a/c during the daytime, indoor temperature increases due to solar effects and varying outdoor temperatures. This causes a cooling pickup load for the air conditioning equipment when the equipment is restarted. The indoor temperature variation, and corresponding cooling pickup load depends on the thermal storage of the building, and the position of the insulation with respect to this thermal storage (e.g. the brick or concrete-block walls and roof).

Most cooling energy consumption calculations for residential construction in hot climates are based on steady-state or near steady-state heat transfer conditions, with an indoor temperature maintained by the air-conditioning equipment during the day at a constant level, or at least, constant over determined daytime periods. Under steady-state conditions, position of the insulation has no effect on energy calculations as thermal storage effects vanish. While steady-state methods of energy calculation are simple and relatively accurate for most residential application, they are not capable of dealing with transitory effects, or accurately describing the thermal behavior of buildings with significant thermal mass storage, or with uncontrolled indoor temperatures.

State-space simulations with lumped parameter modeling of building components are being used to compare the thermal performance and cooling equipment energy use of three model concrete-block buildings: un-insulated buildings, buildings with outside insulation, and buildings with inside insulation. A state-space model allows a simplified description of the thermal behavior of the buildings, including transient effects due to thermal storage, and air conditioning equipment operation based on occupancy patterns.

The purpose of this research is to determine whether the difference in cooling pickup load, as well as the indoor temperature changes when the air conditioning equipment is off, between the building with inside placed insulation, and the building with outside insulation, are significant enough to favor one insulation installation method over the other.

Key Words: insulation methods, energy modeling, construction methods, energy use simulation.