
HVAC Sizing for Insulated Concrete Homes

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ABSTRACT

Insulated concrete walls are increasingly chosen as an alternative to wood-frame walls in residential construction. Insulated concrete walls can be built with insulating concrete forms, cast-in-place concrete, precast concrete panels, autoclaved aerated concrete, and concrete masonry. Houses built with these walls are disaster resistant (wind, hurricane, fire, and flood) and energy efficient. Their energy efficiency is imparted by the walls' thermal mass and high levels of insulation. In addition, solid concrete walls have very low air infiltration.

Concrete and wood-frame homes do not have the same energy use even when walls have similar R-values. Techniques and rules-of-thumb for estimating energy use of wood-frame homes do not always work well for concrete homes. Considerable work has been performed by a variety of researchers to compare the energy performance of concrete homes to that of wood-framed alternatives. They have shown that, in addition to being more energy efficient than wood frame for the same R-value in many climates, the inherent energy-saving properties of insulated concrete walls can result in heating, ventilating, and air-conditioning (HVAC) equipment being downsized by as much as 15% to 40%.

Unfortunately, widely used HVAC sizing methods such as Manuals J and S and the ASHRAE Handbook—Fundamentals are either cumbersome or do not account for the thermal mass, high levels of insulation, and/or low air infiltration of the insulated concrete walls. Even worse, many builders and HVAC contractors size HVAC equipment based on a "rule-of-thumb" developed for wood-framed homes that equates equipment size with square footage of living space. The net result is an inefficient HVAC system that is typically oversized. An oversized HVAC system will have a higher initial cost than a correctly sized system, and it will consume more energy than necessary to maintain thermostat setpoints. Additionally, an oversized system will have a shortened "on" time, which can lead to larger temperature swings and reduced thermal comfort. Air-conditioning systems with short "on" times do not remove enough moisture from the indoor environment, which can promote moisture problems and increase the probability of occupant respiratory problems. This is especially important for homes that are tightly constructed.

The objective of this project was to compile available information regarding energy use in insulated concrete homes, develop additional information as needed, and use this information to develop a methodology to properly size HVAC equipment for insulated concrete homes in the U.S. and Canada.

The authors prepared a literature review on thermal performance of insulated concrete walls and on sizing HVAC equipment in residential construction. The literature review identifies and summarizes published information on (1) thermophysical properties of concrete and concrete walls, (2) thermal behavior of concrete walls, including work performed to support the development of energy codes, (3) general information on sizing HVAC equipment independent of construction type, and (4) sizing HVAC equipment for insulated concrete homes.

The authors also developed software intended for use by residential contractors to estimate the required heating and cooling system capacity for single-family concrete homes. The capacity is based on a user-defined thermostat setpoint, the house dimensions, construction materials, and location (U.S. and Canada). The software uses the DOE2.1E program modules to determine

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energy loads for equipment sizing. The modules calculate the heating and cooling loads of the space for each hour of a year and simulate operation and response of the equipment and systems that control temperature and humidity and distribute heating, cooling, and ventilation to the building. A user's manual for the software is also available.

Comments from 13 peer reviewers were received and applicable comments were incorporated into the software and user manual. Several reviewers compared the results to those of other software, and most compared favorably.

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