

Article

Impact of Building Envelope Materials on Energy Usage and Performance of Evaporative Cooling System in Residential Building

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Abstract: A large proportion of building energy consumption in tropical countries like Thailand primarily comes from air conditioning systems used to maintain the comfort level of building occupants. This paper aims to evaluate the performance of an alternative cooling system based on the evaporative principle in terms of thermal characteristics and energy consumption. A simulation model using computational fluid dynamics (CFD) software ANSYS version 16.0 and an actual experimental setup at the laboratory level were built to verify the results of the proposed cooling system. Additionally, factors that influence performance, such as components of the building envelope and the building's orientation, are considered. This research aims to demonstrate the impact of building envelope material and building characteristics on the energy usage in air conditioning systems and to propose an energy-efficient cooling system. The results demonstrate that the proposed cooling system can reduce the temperature inside the building. However, the characteristics of the building also affect the energy performance. Thus, the proposed cooling system, in combination with an efficient envelope material, can achieve energy savings of around 35–43%. Therefore, a combination of the proposed cooling system and optimal building design can ensure comfort for building occupants while saving energy.

Keywords: building envelope; evaporative cooling system; energy usage

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1. Introduction

The global demand for electricity keeps increasing. With economic expansion and industrial development, electric power has become an indispensable factor in ensuring the efficient operation of businesses and industries. Electric power production primarily requires fuel. Currently, limited resources such as coal, natural gas, and oil are predominantly used for energy generation, with renewable energy also being utilized to a certain extent [1]. As shown in Figure 1, the average temperature in Thailand from 2017 to 2020 tended to be higher, approximately 38 °C, making the weather generally sultry. Thailand has a tropical climate and is located in Southeast Asia. Due to the high temperatures, there is an increasing demand for electricity for air conditioners. Generally, the demand for electricity is highest from March to May and lowest from November to December. In other words, these months correspond to the summer and winter seasons, respectively.

When considering household electricity consumption, air conditioning has become a crucial component in households due to the high temperatures. Figure 2 shows the