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Pilot Study on Underground Air Temperature for Interior Thermal Comfort of Building in Malaysia

A H A Sulong[1], A Baharun[1], R N S R M Yazit[1*], R A Bakar[1] and T Muyandy[2]

[1]Faculty of Built Environment, Department of Architecture, Universiti Malaysia Sarawak, Jln Datuk Mohammad Musa, 94300 Kota Samarahan, Sarawak
[2]Faculty of Engineering, Department of Civil Engineering, Universiti Malaysia Sarawak, Jln Datuk Mohammad Musa, 94300 Kota Samarahan, Sarawak

*rmysyaheeza@unimas.my

Abstract. The purpose of this study is to assess the methods for achieving thermal comfort by utilising underground or subsurface air temperature. The goal of the research is to identify the efficiency of basement design as interior thermal comfort strategy in Malaysia. Two methodologies were employed, including computer modelling simulation and field data collection. The modelling simulation uses Energy Plus software to mimic and test the building' thermal comfort, while the field data collection method employs a 1m x 1m x 1m physical model in an open space and the temperature was recorded using a globe thermometer. The temperature of underground at various depths was measured to establish the optimal temperature at which the earth may be used as a heat sink. The results from the physical model were then analysed to validate the results of the computer simulation. The result from the physical model and computer simulation shows that the underground temperature manages to decrease the indoor temperature. As a result, the presence of a basement that utilizes the temperature of the earth has significantly reduced the temperature of a specific room.

Keywords: thermal comfort, underground air temperature, soil temperature, heat sink

1. Introduction

According to research, houses in Malaysia are not designed to accommodate the climatic conditions. Malaysia, which is located on the equator, has warm and humid climate all year [1], yet study has revealed that houses designed are not in accordance with Malaysia's climatic conditions. As a result, the thermal condition of Malaysian homes would decrease. This study arose from the necessity to give comfort to residents as global temperatures rose. The greater the temperature, the more effort is taken to keep the inside temperature of houses within an acceptable range. Thermal comfort is defined as the state in which the mind displays comfortless with their thermal surroundings [2].

While the factors that impact thermal comfort have been recognized, initiatives can be performed to increase occupant comfort, including the search for innovative methods to improve occupant comfort. Ground cooling is one way that may be utilized to promote thermal comfort by applying passive design knowledge (direct earth contact method), which can be defined as the partial or entire positioning of the building surface in direct touch with the surface of the ground. With knowledge of soil temperature, it is possible to apply the ground cooling method to provide air ventilation to boost the energy efficiency of Malaysian houses.

The modelling simulation employs Energy Plus software to simulate and assess the thermal comfort of the building, whereas the field data collecting approach uses a 1m x 1m x 1m physical model in an outdoor area and a globe thermometer to record the temperature. Each method collects the same unit of data, which is the internal temperature of the tested model. Both results will be compared to identify the efficiency of utilizing underground or subsurface air temperature for thermal comfort in a space, specifically for housing typology.

2. Literature Review

This section describes the literatures than has been referred for this research. The content of the literature review focuses on buildings' thermal comfort, ground cooling method, earth-sheltered walls, basements and many more.

2.1. Thermal Comfort

Environmental factors, for example, might have an impact on thermal comfort. Among the climatic factors, the key variables that were generally employed in the consideration for environmentally friendly building designs include solar energy, the radiation reflected from the ground, air temperature, air velocity, humidity, and rainfall [2]. According to MS1525 [3], the range for thermal comfort and neutral temperature for air-conditioned buildings of a non-residential building varies from 23 °C to 26 °C and 24.5 °C, respectively, and this coincides with the recommended ASHRAE [4].

2.2. Ground Cooling

The ground cooling method concept is dependent on two variables, one of which is the earth's accessibility to operate as a heat sink, where the temperature is lower than the air within and promotes heat transfer to the earth that serves as an environmental heat sink. This indicates that the building envelope conducts heat to the earth. Second, the use and application of this technology is also affected by soil temperature. This component concerns the depth to which it may specify optimal temperature, hence improving occupant comfort. The ground can give enhanced thermal inertia in which around 46% of the energy gained from the Sun is subsequently absorbed by the Earth, generating temperature changes on the ground surface, particularly deeper in the ground.

The concept of terrain cooling has been based on the dissipation of excessive heat from the building to the ground. This dissipation might be performed by direct connectivity between a component of the building's' envelope with the ground, or by introducing air underground into the structure via an earth-to-air heat temperature exchanger [5]. Research have clarified that earth contact structures have advantages related not only to their energy efficiency, but also to the visual effect aesthetics, upkeep of surface open areas, environmental advantages, noise vibration management, and safety [6].

During the summer, the temperature of the ground at a specific depth is lower than the ambient temperature, and during the winter, when there is significant humidity, the temperature of the earth rises. This is due to the difference in regular and periodic temperature, which decreases with increasing depth until the temperature of the soil is constant throughout the year [7]. Underground buildings typically become wetter than aboveground buildings in the summer due to difference of temperature and high humidity content. High relative humidity, which can reduce indoor thermal comfort dramatically, is thus a major problem for underground constructions.

Some studies have demonstrated that suitable air exchange rates and earth coverings (e.g., plastic sheets or insulating materials) are essential to minimize moisture infiltration into underground spaces to avoid high relative humidity [8]. Another research has investigated multiple mathematical models to study the flow and thermal properties of the heat transfer solution, which was dispersed using a heat exchanger from earth to air [9]. Similar results shown in Figure 1 below.