

Passive Methods for Improving the Indoor Thermal Environment for Residential Buildings in a Hot-Humid Region (Indonesia)

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Indonesia has many years of experience in developing modern types of house construction. Unfortunately, these modern houses are often criticized because of their poor indoor thermal conditions when compared with traditional houses. The main reason for this is the behavior of the building materials used and the ventilation system, which can cause heat accumulation inside the house. This results in an uncomfortable living environment for the residents. One effective method to solve this problem is to use an air conditioner. However, this results in increasing energy consumption and, even though the use of residential air conditioners is increasing, there are many people who do not like the high costs and energy consumption involved in their operation. Therefore, a better, passive method of providing improved thermal and ventilation performance for houses is needed if houses are to meet both environmental and economic requirements.

The scope of this research focuses on the Surabaya-Indonesia region, using this as a case study for hot-humid climates. The lifestyle of the residents and their approach to house design is also taken into consideration, especially from a thermal performance perspective.

The main part of this research explores the passive systems already practiced by the residents surveyed. First, the present situation regarding the use of passive strategies is evaluated. Those passive strategies which are very popular in hot-humid regions include the following: ensuring natural ventilation by opening large windows during daytime, nighttime ventilation, and use of the thermal mass effect due to the thickness of the floor and wall. The difference in thermal performance between single and two storey houses is also investigated. Next, we describe experiments conducted in a selected house in order to examine other passive strategies which might be useful for improving indoor thermal comfort, and present measurements of thermal parameters. Finally, several recommendations are proposed, based on the measured results and the evaluation of the residents' opinions.

Based on the results of the above-mentioned survey, natural ventilation by opening windows and doors can be considered the preferred option among

residents. This is regarded as a useful method to obtain comfortable living conditions but fails to take into account the incoming heat from outside that results from opening doors and windows during the hot part of the day. To understand the present situation, it is first necessary to analyze it by developing a numerical calculation program.

Opening windows and doors during daytime is a very popular practice among the residents, not only in traditional, low- and middle-income groups but also in high-income homes. It is regarded as an effective means of restoring thermal comfort by utilizing air flow. However, in practice, the survey results from the 40 houses surveyed show that the living conditions, both during daytime and nighttime, are still regarded as uncomfortable. To solve this problem, electric fans can be used and an experiment was conducted by introducing a low-velocity ceiling fan into a selected house. While this improved the comfort level for the residents during daytime and nighttime, this option needs to be carefully considered since the use of the ceiling fan also increased the heat flow into that living space from neighboring rooms.

Opening doors and windows during daytime, rather than keeping them closed, can result in higher indoor temperatures. When a large exterior surface area is exposed to solar radiation, this also raises the indoor temperature. Thus, it was found that the house with the largest wall surface area exposed to solar radiation also had the highest indoor temperature. If large openings are created in the wall on that side of the house, the indoor temperatures can be much higher still. The larger the surface area connected to the outside, the higher the indoor temperature will be. This is because the outside temperature during daytime also influences the indoor temperature. Therefore, having a large surface area facing the outside, which is very common in hot-humid climates, will actually have an adverse effect on the thermal environment.

Nighttime ventilation can be included as one of the passive methods used. Although there may only be a small temperature decrease during the nighttime, compared with the effect in a hot-arid climate, the cooling effect can be perceived by the residents. The result will be even more effective if the wall and floor are constructed with a high thermal mass. This cooling strategy has to be supported by opening windows during the nighttime, since the air exchange during nighttime can then help remove the reradiated heat from those surfaces with a high thermal capacity, as well as decreasing the indoor temperature by allowing the entry of low-temperature outside air. This form of high thermal mass construction and the use of ventilation during nighttime have long been practiced in traditional houses in Bali. It is an effective method for keeping indoor temperatures down during the hot daylight hours, even though the residents open the door during the daytime. These traditional doors occupy a very small area, and do not adversely affect the indoor thermal environment by allowing a lot of outdoor air into the room.

Keeping the room closed is another way to keep the room temperature down. Roof insulation is also useful in lowering the indoor temperature. However, the effect that any transparent surface, such as a window or door, may have on the room temperature is different (even when their orientation is the same), depending on the opening area which is exposed to the outside and whether the residents open these windows and doors during the daytime.

To ensure a better thermal environment inside the house, the following strategy and construction style is proposed:

Since opening the building up as much as possible during daytime can raise the room temperature, it is recommended that all windows and doors be kept closed during the hot part of the day. It is not recommended that large openings be left during the daytime as this will connect a larger inside area to the outside, resulting in higher temperatures still. This also means that having a large surface area facing the outside is not recommended for buildings in a hot-humid climate. The results of this study therefore contradict many of the ideas currently used when designing buildings for hot-humid climates.

However, having a larger area of the house open to the outside can be useful for buildings in hot-humid climates if the residents understand when they should open or close the windows and doors. They should only be kept open for a very short period during daytime, when the outdoor temperature is lower than that indoors, but should be kept open for as long as possible during nighttime.



Sri Nastiti N. Ekasiwi with husband and supervisor