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Application of passive cooling techniques in vernacular houses to modern urban houses: A case study of Malaysia

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Abstract

The main purpose of this paper is to determine potential vernacular passive cooling strategies for improving thermal comfort of modern urban houses in hot-humid climate of Malaysia. Field measurements were carried out in two traditional timber Malay houses and two traditional masonry Chinese shophouses to investigate their indoor thermal environments and passive cooling techniques. The results of the former showed that the indoor air temperatures were higher than the outdoor air temperatures by 1 °C during daytime under open window conditions and 2 °C at night under closed window conditions on average. The results of the latter revealed that indoor air temperatures adjacent to small courtyards were lower than immediate outdoors by up to 5-6 °C during daytime; at night, the indoor air temperatures maintained values similar to the outdoors. The small courtyards were effective to enhance night ventilation and nocturnal radiant cooling in the high mass shophouses. When assessed using an adaptive thermal comfort equation for hot-humid climates, the periods of indoor operative temperatures exceeding the 80% comfort upper limit in the Malay houses, Chinese shophouses, daytime ventilated and night ventilated terraced houses were 47%, 7-8%, 91% and 42%, respectively on fair weather days. By comparing these evaluations and relationships between indoor and outdoor thermal conditions of all houses, potential passive cooling strategies for the existing terraced houses including night ventilation, roof/ceiling insulation, window/wall shading, courtyard/forced ventilation, and microclimate and urban heat island mitigation were discussed.

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1. Introduction

It is generally believed that vernacular buildings have withstood time and are subtly crafted over generations in response to experience of conditions and use including the local climate and human comfort needs using passive systems (Oliver, 2006). Therefore, recent researchers were devoted to analyze the performance of traditional techniques adopted in and around vernacular buildings in order to derive principles for the use in modern urban houses (Rapoport, 2006). Traditional cooling techniques are considered to be particularly important because energy consumption by air conditioning has been rapidly increasing over the last few decades in the hot-humid climates like Indonesia.

This study aims to determine potential vernacular passive cooling strategies for improving indoor thermal comfort of modern urban houses in Malaysia by learning the traditional wisdoms seen in and around their vernacular buildings. Two fine examples of Malaysian vernacular architecture include the traditional Malay house and the traditional Chinese shophouse. The traditional Malay house is known as a well-ventilated detached building of timber structure usually seen in rural villages while the traditional Chinese shophouse is a narrow, deep-plan brick building situated in rows in relatively dense urban areas. The primary objectives of this study are dual, which include:

1. To investigate indoor thermal environments of the above-mentioned vernacular houses (traditional Malay house and traditional Chinese shophouse) and their passive cooling techniques;
2. To discuss potential application of the vernacular passive cooling techniques to modern urban houses for improving indoor thermal comfort in naturally ventilated condition.

The target modern houses are brick terraced houses, which form majority of the existing urban housing stock in Malaysia; the percentage of terraced houses in 2010 was 42% (DSM, 2012). Due to year-round uniformity of climatic conditions of lowland cities in Malaysia, it is assumed that there was little seasonal variation among the different measurement months and the results on fair weather days are comparable.

2. Field measurement in traditional Malay houses

2.1. Case study houses and measurement methods

The first field measurement was conducted in two selected traditional Malay houses (MH 1 and MH 2) in Pontian, Malaysia consecutively from March to April 2011 (Figure 1). Pontian is located about 40 km to the west of the city of Johor Bahru in Peninsular Malaysia. Both houses were considered typical traditional Malay houses and shared the typical Malaysian rural village setting with many trees in their surroundings. Thus, the average outdoor air temperature is basically a few degrees lower than that of urban areas.



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