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A study on different natural ventilation approaches at a residential college building with the internal courtyard arrangement

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ABSTRACT

Dayasari RC is an old low-rise multi residential building which was established in the year 1966 and is located in the University of Malaya (UM) campus in the capital city of Kuala Lumpur. This building was designed with the internal courtyard that allows numerous implementations of bioclimatic design strategies, especially in regard of natural ventilation. Eight unoccupied student rooms were selected to represent ten different scenarios, where two from eight selected rooms had been chosen to represent two different scenarios. The scenarios are concerned with the level of radiation and penetration of sunlight that influence the values of temperature and relative humidity. Different natural ventilation approaches were introduced simultaneously in all selected rooms for four weeks. Initially, the effectiveness of different ventilation approaches is obviously influenced by the position/floor level rather than the orientation of the selected rooms. The night ventilation is the most effective approach due to the lower mean temperature and higher relative humidity values. The recorded mean temperature values were below than 30 °C with the relative humidity values exceeding 70%. Other ventilation approaches namely; daytime, full-day, and no ventilation, were more than 30 °C and had exceeded 32 °C at certain rooms. The ranking of the effectiveness of the ventilation approaches was in the following order; night ventilation>daytime ventilation>full-day ventilation>no ventilation.

1. Introduction

The majority of people spend approximately 90% of their lives indoors, and indoor air pollution is one of the top four environmental risks to public health where the sources originate from combustion sources [1]. The indoor pollution is consistently reported to be around 2 to 5 times higher than outdoor pollutions [2]. This situation becomes more serious when there is inadequate ventilation in the house, either due to the design of the building itself or due to the actions taken by the occupants [3]. The lack of good indoor air quality has a strong bearing on the sick building syndrome (SBS) where the main symptoms prevailing in SBS are headache, lethargy, and dryness in body mucus; mostly contributed by the concentration of CO_2 [4]. The effects of the SBS will be more apparent with an increased CO_2 concentration.

The heat, ventilation, and air conditioning (HVAC) systems are not the ultimate solution to these problems. These mechanical systems which are commonly used to control the temperature, humidity, circulation, ventilation, and purification of the air in the building are not entirely the aspects which provide comfort to the building occupants. As reported by Yau [5], the majority of the occupants had been feeling uncomfortable from unpleasant odour resulting from the returning air circulation inside the building itself. This situation is a consequence of the design failure in HVAC systems in fulfilling the requirement of our distinctive hot and humid climates. Hence, natural ventilation is perceived to be the best approach in providing comfort to occupants [6–10]. The fluctuations of natural wind can make people more comfortable and closer to nature, while the prolonged low speed helps to reduce the feeling of tiredness, and intensifies the heat convection between people and the environment through the larger turbulence and intensity of natural wind [9]. The simulation predictions show that utilizing natural ventilation could help reduce air-conditioning energy use in the flats by about 24%, compared to the contrary [11]. The natural ventilation has a good potential in tropical and temperate climates but not in subtropical climate when the potential for comfort improvements in the hottest period (summer), is rather small [12].

Basically, shallow buildings with optimal orientation and a maximum of five floors is more applicable for exploiting wind for

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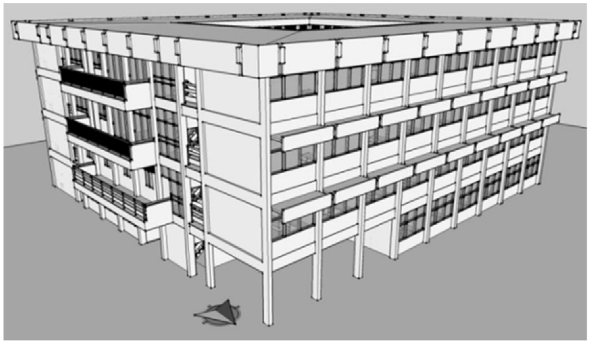

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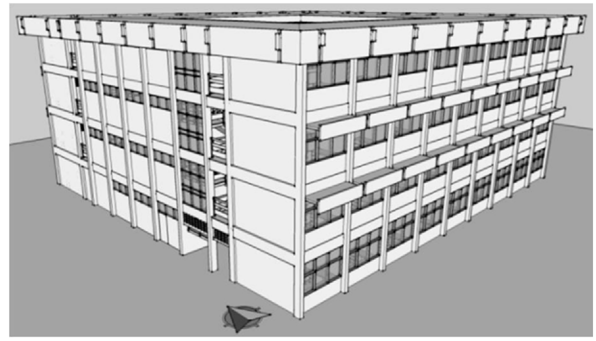

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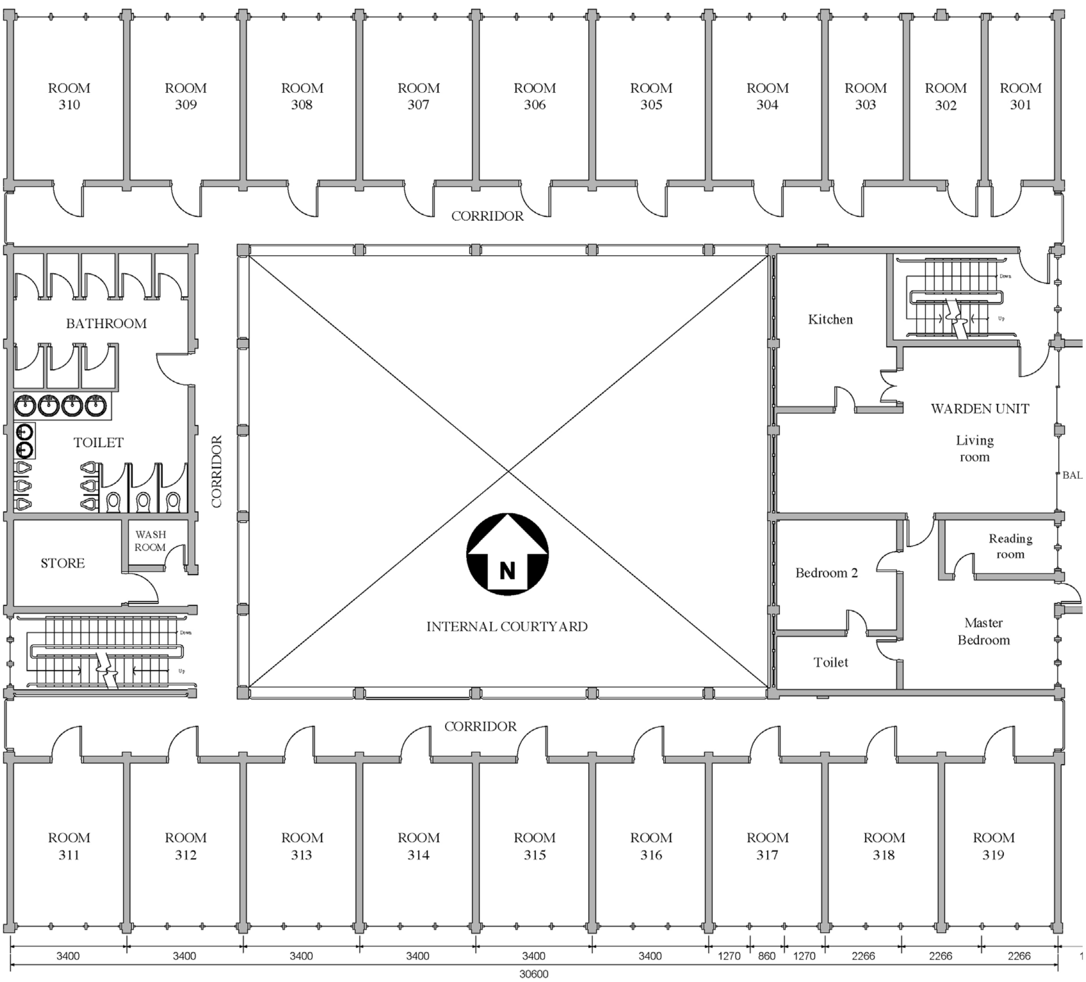

Floorplan

Fig. 1. Typical elevation and floor plan of the Dayasari RC building.

natural ventilation [13]. The inconsistent average wind speed and high air temperature that leads to stack effects become a major issue for natural ventilation in high rise buildings, especially an office building in a hot and humid country [14]. Hence, natural ventilation in modern buildings is most common in residential buildings, schools and small office units [15].

Natural ventilation is highly variable and dynamic despite the fact that this approach is reliant on three principal factors, namely; the site and local landscaping features, the building form and building envelope, and the internal planning, and room design [15]. In enhancing the convection and evaporative heat transfer between the occupants and the room air, five aspects should be considered to ensure the effectiveness of natural ventilation [8]. They are;

- Spatial planning to allow air to move through from the windward side to the leeward side to create cross-ventilation.
- Position of windows where at least two windows are placed on different external walls.
- Ceiling height approximately 3 m to allow air to flow vertically through the bottom of the window and it can diffuse through the room and out through the top of the window.