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An investigation of the potential for natural ventilation and building orientation to achieve thermal comfort in warm and humid climates

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Abstract

The aim of this study was to analyze the most important factor, the climatic conditions with respect to thermal comfort in buildings. The impact of building location and climate and orientation on thermal comfort were investigated.

With the help of dynamic computer simulations the different hourly weather data were analyzed. First of all the climate determines the amount of solar radiation and mean outside temperature that a building is exposed to. The climate also influences the amount of energy that is used for heating and cooling but also the amount of energy that is used for lighting. There is solar excess which determines the amount of solar energy that is unwanted in the building. With growing amounts of glass and a glazing system that allows large solar heat gains,the impact of orientation is substantial. A detailed analysis was conducted to evaluate the potentials for improving thermal comfort. Detailed results are given in sample graphics and tables in the study. In a tropical climate the improvement in comfort by NV range between 9% and 41% (Kuala Lumpur in April). For a subtropical climate the improvements vary between 3% and 14%. In a temperate climate the improvements vary between 8% and 56%. The results showed that NV has a good potential in tropical and temperate climates but not in subtropical climates. Especially in Hong Kong it seems to be very difficult to apply NV. The results showed that in particular in the hottest period (summer) the potential for comfort improvements is rather small. The design of climate responsive building envelopes should take this into consideration.

Keywords: Climatic design; Degree days; Hot and humid climate; Natural ventilation; Thermal comfort

1. The façade as an integrated building system

The energy consumption of buildings in Hong Kong is growing and currently accounts for 53% of the primary energy consumption (Ko, 1991). Fig. 1 shows that office and commercial buildings were using 35% of total energy consumption in Hong Kong in 2003. These data show that built environment in Hong Kong has a great potential for improving its energy consumption (Hui, 2000). The improvements can be reached by taking an energy responsible approach to design buildings that have a reduced impact on the environment (Goulding et al., 1992; Krishan et al., 2001; Lee et al., 1998).

One of the most significant technologies for energy savings in a building is the façade. Innovations that were already made apply recent advances in the fields of materials, manufacturing and thermo sciences to the construction of new buildings, to the retrofit or rehabilitation of existing buildings and to the efficient operation of buildings (Compagno, 2002).

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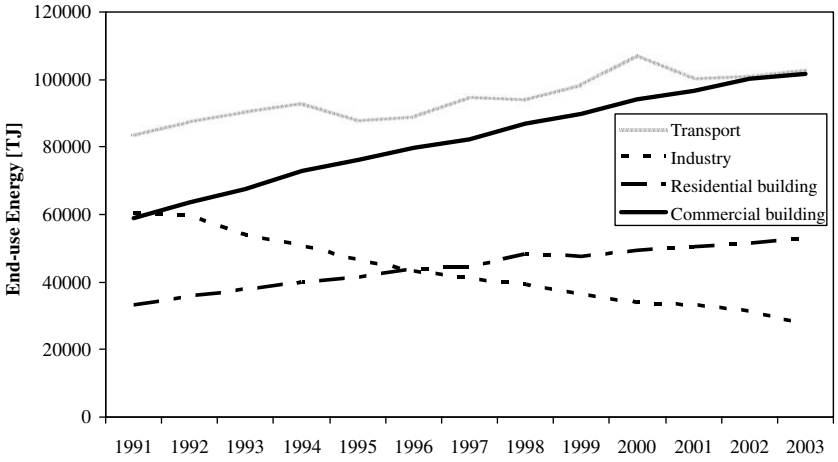

Fig. 1. Energy consumption in buildings (Ko, 1991).

Architects working in collaboration with engineers started to take an energy-responsible approach to the design of building façades. The façade contributes to both the embodied energy as well as operating energy of a building (Amato, 1996). Especially in temperate to cold climate like Europe new concepts were tested. They took into account the outdoor conditions and tried to create a climatic responsive building. Especially for the top-end market sector of office buildings advanced façade technologies were developed (Wigginton, 1996). They tried to integrate more and more functions like sun shading systems or solar energy devices into the façade system. One promising technology is double-skin facade systems. Here, the ventilation of the building is enhanced by making use of the cavity airflow. This has the advantage of reducing the space needed inside the building and reducing initial overall costs (Allard et al., 1998; Wigginton, 2002).

However, little work has been done on the behavior of double-skin facades in hot and humid climates. It is not sufficient to adopt the new concepts to a different environment. The seasonal and daily climate in respect to mean temperature, humidity and wind speed distribution in Hong Kong is different to the temperate climate in Europe. A new approach has to take the climatic factors into account to find out if a double-skin façade can help to reduce the energy consumption in buildings in a hot and humid climate. An analysis of the building energy consumption in Hong Kong gives peak cooling load which is shown in Fig. 2 (Lam and Li, 1999). It can be seen that the building envelope design accounts for 36% of the peak cooling load. The daylight design can help to reduce the amount of cooling load from artificial lighting. This means that potentially (or up to) 55% of the peak cooling load is influenced by the building envelope design.

2. Objective

Before a decision is made to adopt a design strategy from other climates into hot humid climates (such as double-skin facades), one must understand the climatic conditions of the site and their impact on the building. The study reported in this paper was aimed to analyze the most important factor, the climatic conditions with respect to thermal comfort in buildings. The impact of building location and climate and orientation on thermal comfort were investigated. The potential thermal comfort improvements of energy conservation building design strategies in hot and humid climate were then evaluated. Special focus was put on the analysis of the potential of natural ventilation (NV) in these climates. Natural ventilation in this work is

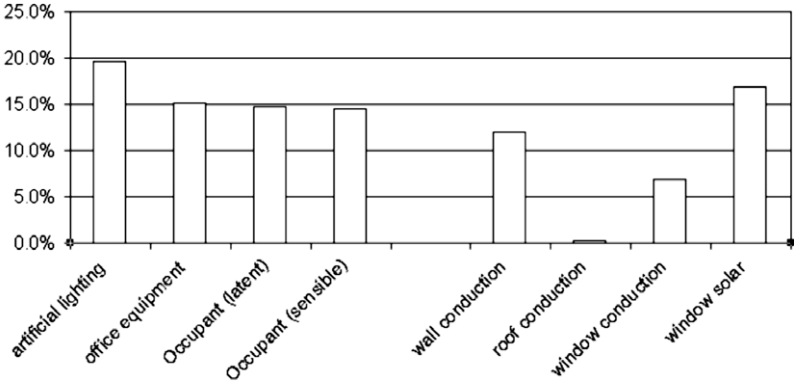

Fig. 2. Peak cooling load in Hong Kong office buildings (Lam and Li, 1999).