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The Impact of External Façade Shading on the Thermal Comfort of Public Rental Housing under Near-extreme Weather Conditions in Hong Kong

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ABSTRACT: The comfort and health of building occupants are significantly affected by the indoor thermal environment, which can be improved by building envelopes with a good façade design. This study aims to explore the impact of façade shading on the indoor thermal comfort by adding external shading panels on a typical public rental housing building in Hong Kong. Potential improvements on thermal comfort, in terms of indoor operative temperatures (T_{op}), were evaluated for vertical and horizontal shading panels that were tilted at different angles to the façade. Simulation results on DesignBuilder reveal that horizontal shading panels (with a T_{op} reduction up to 0.91˚C) can achieve a better thermal performance than those oriented vertically (with a maximum T_{op} reduction of 0.57˚C). Moreover, shading panels tilted at 90˚ to 45˚ for horizontal panels and at 75˚ to 0˚ for vertical panels were preferred for better thermal performances. This strategy can be readily implemented to procure more sustainable public housing without causing obstructions to the window view of occupants.
KEYWORDS: Façade shading, Indoor thermal comfort, Operative temperature, Public rental housing

1. INTRODUCTION

In recent years, buildings face increasing risks of overheating in summer due to more frequent heatwave weather conditions and the dense urban morphology. Occupants thus suffer from thermal discomfort, higher energy costs, and even heat-related illnesses. The elderly and low-income families living in public rental housing (PRH) estates in Hong Kong are particularly vulnerable to prolonged overheating during the hot and humid summers. Hence, the use of appropriate passive design strategies for PRH is crucial for maintaining the indoor thermal comfort of occupants [1].

Building performance can be significantly improved by applying passive design strategies (e.g. providing shading, adding insulation, improving airtightness) during building retrofits. Adding external shading panels to existing buildings is potentially a popular strategy for local governments because of its ease in implementation. However, window shading designs may be restricted by various considerations on view obstruction, natural ventilation, and indoor lighting. Therefore, the application of shading panels on opaque building façades is explored in this study. Also assessed are the impacts of different shading panel designs on the indoor thermal comfort of a typical PRH building in Hong Kong.

2. METHODOLOGY

2.1 Building model and weather data settings

Building simulations were performed using the EnergyPlus software v8.5 within DesignBuilder. Standard component blocks were added onto a typical PRH building as shading devices on external walls facing the east and the west (Figure 1). Buildings were simulated under free-running conditions for the design summer week. In order to take into account the more frequent occurrences of near-extreme summer conditions due to climate change, the Hong Kong summer reference year (SRY) weather data [2] was used as input for building simulations in this study.

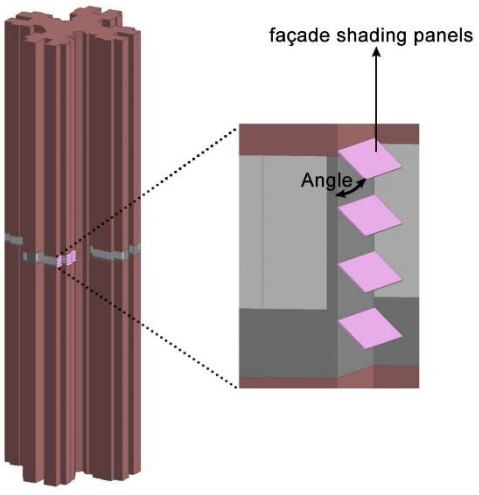

Figure 1: The simulation model with shading panels applied on the opaque façades of a typical PRH building.

2.2 Shading types

Two types of façade shading devices, namely vertical and horizontal shading panels, were added onto the eastward- and westward-facing external walls of the PRH building model. The length of shading panels (measured perpendicularly from the wall) was set to 700mm such that it is within the recommended limit in the Hong Kong Practice Note APP-156 [3] and will not be regarded as causing obstructions. The impact on indoor thermal comfort for different designs was then examined by changing the angle between the shading panel and external wall.

3. RESULTS

Operative temperature (T_{op}) is used as a measure of the occupants' thermal comfort in this study. Though seldom investigated in previous studies, external shading on opaque façades is found to have a considerable cooling effect on the indoor thermal environment. Results show that the horizontal type of shading panels have a better performance than the vertical type, and adding horizonal shading panels can yield a reduction in maximum T_{op} up to 0.57˚C and 0.91˚C for eastward- and westward-facing flats, respectively (Figure 2). Furthermore, shading panels parallel (at a small angle) to the façade are able to achieve a greater reduction in indoor T_{op}. For horizontal shading panels, changing their angles of tilt from 90˚ to 45˚ can achieve a larger T_{op} reduction, but any changes after 45˚ do not cause further improvements in indoor thermal comfort. On the other hand, vertical panels at large angles from the wall (90˚ and 75˚) perform the worst and are only able to reduce the maximum T_{op} by 0.10-0.15˚C. Whereas, the potential in T_{op} reduction is almost inversely proportional to the angle of tilt from 75˚ to 0˚.

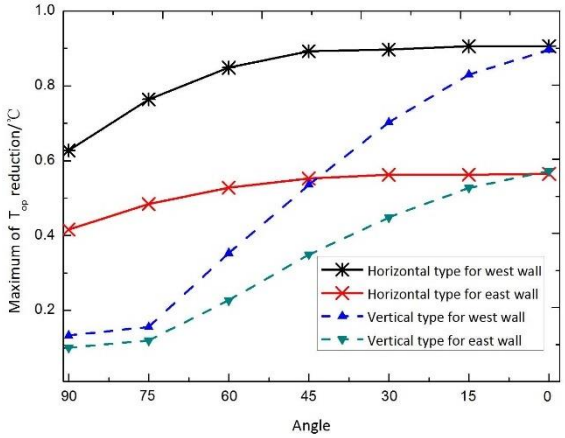

Figure 2: Impact of shading panels at different angles on maximum of T_{op} for west and east facing façade.

The maximum shading effect by adding horizontal shading panels for flats facing the west is almost double of that for flats facing the east (Figure 3). The simulated reduction in T_{op} is the most significant during midday (1:00 p.m.) for eastward-facing flats and in the late afternoon (7:00 p.m.) for westward-facing flats. Those times have a half to one hour delay after the period of façades exposed to the beam radiation.

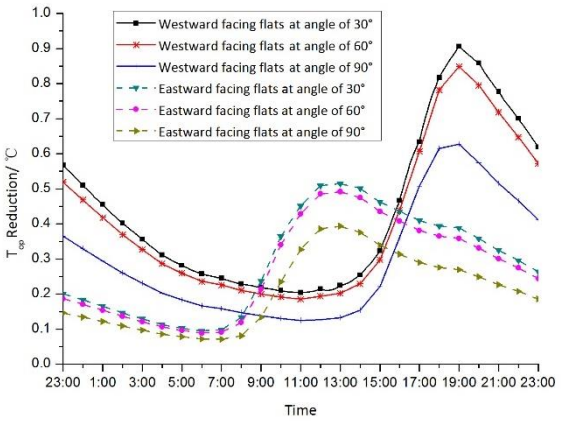

Figure 3: Diurnal variation of T_{op} reduction by horizontal shading panels at different angles on a typical hot day.

4. CONCLUSION

In this study, simulations were performed to evaluate the effects of opaque façade shading devices on the indoor thermal comfort of a typical PRH building in Hong Kong. It can be concluded that shading panels oriented horizontally and at a small angle to the wall are generally more effective in reducing indoor T_{op}. It should also be noted that changes in angles of tilt are more sensitive between 90˚ and 45˚ for horizontal panels and between 75˚ and 0˚ for vertical panels.

This initial study on external façade shading can provide some useful references for the local government and architects regarding building retrofits using passive design strategies, which can be readily implemented to procure more sustainable public housing. Further work is needed for a more detailed investigation on other parameters, such as panel size, distance between shadings and walls, and separation between panels etc.

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