Ain Shams University
Faculty of Engineering
Department of Architectural Engineering

تكامل أنظمة التظليل مع الواجهات المزدوجة المهواة طبيعياً لتحسين الأداء الحراري في المباني الفندقية بالقاهرة الكبرى

Integrating Shading Systems with Naturally Ventilated Double Skin Facades for Enhancing Thermal Performance in Hotel Buildings of Greater Cairo.

A Thesis Presented in Partial Fulfillment of the Requirements for Master of Science Degree in Architecture

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Statement

This thesis is submitted to Ain Shams University for the M.Sc. degree in Architecture.

The work included in this thesis was carried out by the researcher at the Department of Architecture, Faculty of Engineering, Ain Shams University, and During the Period from December July 2016 to July 2019.

No Part of this thesis has been submitted for a degree of a qualification at any other university or institute.

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Abstract

The research aimed at evaluating the efficiency of integrating shading devices with naturally ventilated walls on thermal performance and indoor ventilation rates of a generic five stars hotel double room in Greater Cairo. This research is composed of 4 chapters. Chapter 1 and 2 studied theoretically and analytically naturally ventilated walls and shading devices' working principle, types and how they work in hot arid climates. Also, the parameters of shading devices and naturally ventilated walls were discussed and some parameters were determined to be used in the comparative analysis which took place in chapters 3 and 4. In chapter 3, Cairo's weather was analyzed and moreover a reference case was modeled and tested using Computational Fluid Dynamics simulations. In chapter 4 the results of three more cases were introduced and compared analytically. Those cases are: naturally ventilated wall case, and two cases of integration of shading devices with naturally ventilated wall one with shading devices near the outer skin and one near the inner skin.

The research focused on the extreme conditions of Cairo's climate and the study was made in the day with the highest temperature in summer in South orientation and the hours of the study were the hours which had the highest operative temperature at day and night. Three floors were chosen for the study which were decided to be at the beginning of the building (5^{th} floor), at the middle of the building (20^{th} floor) and the last floor (35^{th} floor). The study was done on South, West, East and North orientations and the research revealed that naturally ventilated walls which depend on stack effect, as a working principle, could achieve reasonable ventilation rates and could lower down operative temperature of the room both at day at night.

The research revealed also that integrating shading devices with naturally ventilated walls could affect cavity's overheating problem positively especially when placing shading devices near the outer skin. The techniques were compared to a single skin façade reference case using the outputs of EnegryPlus as a Computation Fluid Dynamics (CFD) simulation engine to study the efficiency of all techniques on thermal comfort and flow rate using only convective cooling strategy. CFD simulations showed that integrating shading devices with naturally ventilated walls while placing shading devices near the outer skin could enhance thermal comfort and ventilation rates in South, West and East orientations. This technique could lower down the room's operative temperature (OT) by 1.85 Celsius degrees in West façade when compared to ambient temperature. Also, air velocity (AV) values could

reach an average of 0.041 m/s in all orientations which is close to comfort zone. The results also showed that placing shading devices near the inner skin could lead to higher operative temperatures at West orientation only at day and night while the difference in other orientations was not significant but gave advantage to the case where shading devices are placed near outer skin over this case because at higher floors the operative temperature were higher with a difference that could reach 1.57 Celsius degrees. Regarding ventilation rates, the case where shading devices were placed near the outer skin always showed better performance than when shading devices were near the inner skin. Average age of air[1] was significantly lower also in this case.

On the other hand, using naturally ventilated walls alone could enhance thermal performance and ventilation rates in North where an operative temperature difference between the room and ambient air could reach 1.79 Celsius degrees and a maximum value of air velocity could reach 0.041 m/s.

The results give promising indication that although the room couldn't reach comfort zone, it still could have a lower operative temperature than single skin façade case by 2.85 Celsius degrees at South which is considered a significant result gathered with the significant result regarding age of air which was enhanced. More studies on the parameters of shading devices coupled with the introduction of a forced air flow in the cavity need to be investigated.

[1] Definition in table 3-4 – Page 87.

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