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Properties and Design of Double Skin Facade in the Tropics

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Abstract

On average, a person spends more than 70% of their life inside buildings Thus, a comfortable indoor environment has a vital role as not only can it improves the people's working efficiency, but also sustain their health. The building envelope or skin is the most critical aspect to be considered in designing a comfortable indoor environment for occupation. Theoretically, the application of Double Skin Façade (DSF) system is said to be an attempt towards sustainable design as it creates a controlled ventilated buffer area between the outside environment and the indoor climate of the building. However, several research shows that it might be the opposite for DSF applied in the tropics, especially since previous studies are mostly done in temperate climate countries. This research aims to study the properties and identify design consideration of DSF application in hot and humid climate. Three case study buildings in Malaysia with Double Skin Facade (DSF) are selected and analyse through comparative study based on similarity of characteristics, difference approach and design considerations. In this paper, it will also be discussed how the design considerations of DSF might affect the Indoor Environment Quality (IEQ). Design considerations for building envelope is needed to increase the awareness towards quality of indoor environment and its influence on occupant's comfort.

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1 Introduction

Studies have shown that a lot of comfort and health related effects are connected to characteristics of building as people spend more than 70% of their lives indoor according to ASHRAE guidelines 2010 (Al horr et al., 2016; Huang & Niu, 2016). Therefore, a comfortable indoor environment is an essential quality as not only can it improves the occupants' productivity, but additionally sustains their health too. In order to design a sustainable building that particularly emphasised on climate integrated design, the building skin or building envelope is the most critical aspect to be considered (Van Timmeren, 2009).

Building envelope is the building's skin which provides a suitable barrier between the interior space and exterior environments. The envelope system's purpose is to protect against thermal, solar, aerodynamic, acoustic and other forces that are generally invisible to direct observation but are significant for human occupation (Bachman, 2004). Double skin facade is a method using the buildings skin to assure indoor environmental quality in buildings as it provides natural ventilation and daylighting, noise isolation and also for heat and solar control.

However, several research shows that it might be the opposite for DSF applied in the tropics (Alibaba & Ozdeniz, 2016; Barbosa & Ip, 2014; Safamanesh & Byrd, 2011), especially since previous studies are mostly done in temperate climate countries (Halil & Mesut, 2011; Kim, Schaefer, & Kim, 2013; Pomponi, Piroozfar, Southall, Ashton, & Farr, 2016). This study aim is to study the relationship between double skin facade applications in office buildings that affect indoor environment quality through understanding DSF properties and design considerations in tropical climate.

2 Understanding the General Principles of Double Skin Facade

Oesterle et.al define DSF is built with two layers of envelope which consists of an external and internal layer that contains an air gap used to control movement of air and protection against solar heat. In summary, DSF styles can be combined with both natural and mechanical ventilation styles and airflow principles (Haase & Amato, 2011). As a result different design of DSF can be produced as shown in Fig 1.

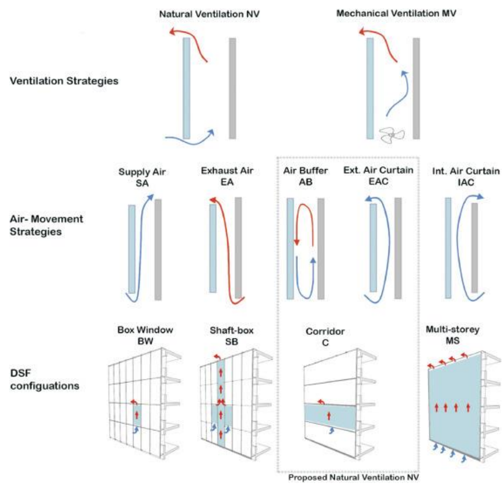

Figure 1: summary of all the DSF types that is possible for a combination.
(Retrieved from Google Image)

3 Methodology

The research methodology used for this research are mostly qualitative analysis by content analysis and case study buildings through previous research done.

3.1 Content Analysis

Firstly, the field of study is defined by reading materials such as journals and other resources. Data are collected through journal articles, books and other paper media from year 2009 to 2019 through various means such as Scopus, Google Scholar and etc. The keywords use in the searches are “Building Envelope”, “Indoor Environmental Quality”, and “Double Skin Facade”. Criteria related to double skin façade in terms of indoor environment quality are identified in literature review.

3.2 Case Study

This research is conducted through case study method, allowing the author to examine based on the results of previous research done by other authors. Buildings are identified according to similar characteristics such as typology, building height category (medium rise buildings), orientation of facade and etc. The findings are tabulated according to the parameters of DSF design, which will be analyse and discussed. The case study is evaluated by comparison of similarities and differences whether if fits the design consideration for the tropics. The parameters for DSF design are based on Barbosa & Ip, (2014). Three (3) case study building located in Malaysia (mainly in Kuala Lumpur and Putrajaya) are identified as follow:

- **Case Study A: The Securities of Commissions Malaysia Building (SCB), Bukit Kiara, Kuala Lumpur.**
- **Case Study B: PjH Tower, Putrajaya.**
- **Case Study C: Suasana PjH, Putrajaya.**

4 Findings

In this section, the findings obtained from the three case study will be tabulated and analysed by comparative study according to the design parameters of DSF.

Table 1 shows the summarized description of each case study building and data obtained from the methodology above. The type of DSF are identified based on observation and also description of each DSF and will further be justified in the discussion later.

Table 1: Summarized description of case study buildings.

Characteristic	Case Study		
	A	B	C
Typology	Office Building	Commercial + Office Building	Commercial + Office Building
Location	Bukit Kiara, Kuala Lumpur, Malaysia	Putrajaya, Malaysia	Putrajaya, Malaysia
Orientation of Facade	West Facing Facade	West Facing Facade	West Facing Facade
DSF Materials	Two layers of glass with 1.2m cavity. -External: 12mm Low-E green tinted glass -Internal: 8mm thick green glass	Double Glazing with vertical fin -External: Aluminium fritted glass fins (tower) -Internal: High performance glass with	Double glazing with a pattern shading device -External: Fritted glass with ceramic pattern -Internal: Clear glass

		aluminium spandrel framed	
External Additional Sun Shading Devices/ Solar Control	Horizontal louvres and vertical blinds are installed within the cavity.	Aluminium louvres and aluminium vertical fin (podium)	Cantilevered vegetative balconies
Ventilation System	Natural	Natural	Natural
Air- Movement Stratergy	External Air Curtain + Internal Air Curtain + Extract Air	External Air Curtain	External Air Curtain
DSF Type (By Construction)	Buffer system	Buffer system	Twin face system
DSF Type (By Form)	Multi-storey	Shaft-box	Box-window

5 Discussion

The three case study will be discussed into detail by going through each parameter of designing a DSF and how it contributes towards achieving the indoor environmental quality needed for the tropics.

5.1 Cavity depth

Cavity depth has a direct effect on whether the DSF will achieved its function. Out of the three case study, depth of cavity for Case Study B would make the DSF work better. Narrower cavity gaps shall result in increased of ventilation rate (Barbosa & Ip, 2014). This means the stronger air movement penetrates through the cavity, the more effective extraction of warm air through the cavity. Thus, lessen the heat transfer from the cavity into indoor spaces. And so able to provide a better IEQ for its occupant. Case study A will caused uncomfortable indoor temperature as larger cavity depth (especially more than 1m) will reduce the stack effect in the cavity area. So, will the heat transfer towards the interior room rises or remain the same throughout the day. Lastly, it will result in occupants depending on air-conditioning and indirectly increase usage of energy in the building. Hence, a poorly designed cavity depth can result in uncomfortable indoor temperatures and additional energy consumptions too.

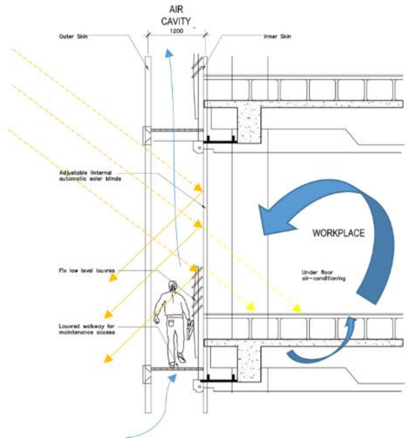

Figure 2: Detailed section of DSF Design in Case Study A

(Redrawn by Author)

5.2 Shading devices

Next, the installation of shading device also helps to boost the functionality of DSF in the tropics. The scorching sun in a tropical climate can be extreme throughout the years and a DSF without a shading devices might not necessarily work in the tropics. In all the three case studies, all buildings have additional shading devices especially in east-west façade. However, in order to choose which one works best is all depending on the building orientation and placement of shading devices. In a research done by Gratia and De Herde, the shading device positioned closed to the inner glass will cause the temperature in the inner glass to rise. However, when the shading device is positioned in the middle of the cavity, the temperature balance as air flow as both sides of the blind. So, in this case, building A is better since it has both fixed louvres and solar controlled blinds. In summary, whether the shading device is made up of passive or active design, it should be appropriate as a solar control. Thus, reduces the heat and glare penetration into interior spaces.

5.3 Outer skin glazing property

The material of outer skin determines the amount of heat absorption to the façade that could cause a heat transfer to the internal skin and interior spaces. Even the amount of heat absorb by the material used for shading device contributes to occupant's thermal comfort indoor. Glazing property will also determine the visual comfort and also the amount of heat transfer through the glass curtainwall. For example, too reflective glass will reflect the heat well, but it could cause blindness towards pedestrian and drivers as they causes glare. Case study B would be lead in this category since glazing property for its external façade is less reflective and minimal surface area exposed to direct sunlight, as it is designed in long vertical fins.

5.4 Structure

The structure of case study C would be better in the sense it is constructed in box-window type of DSF. The type of box window that has the cavity between the two layers divided horizontally and vertically along the constructional axes. This type of construction allows penetration of air in many directions.

5.5 Cavity openings

Cavity openings couldn't be compared because two of the case study has a fixed curtainwall as the internal skin. So this only applicable to Case study C since case study C has an opening towards a cantilevered balcony.

6 Conclusion

Based on the data obtained, analyse and discussed, it can be concluded that certain Double Skin Façade (DSF) properties can function in tropical settings while some design considerations needs to be address. The parameters for DSF design is determine by the depth of cavity, shading devices, outer skin (materials), Glazing property, Structure and openings of cavity.

Hopefully, this research paper might help in an area where local designers have limited resources with the design consideration for DSF in the tropics and it still remains a challenge for most projects during design stage. Hence, design considerations for building envelope is needed to increase the awareness on it affect towards quality of indoor environment and its influence on occupant's comfort.

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