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Studying the usage of Double Skin Facades in utilizing Manjil wind in building ventilation

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Abstract

The environmental crisis has induced experts to develop renewable energy alternatives. Given the application of Double Skin Façade as an alternative in renewable energy usage, the current study aims to investigate an optimized procedure for utilizing wind energy in the natural ventilation of a building in Manjil city. The velocity and pressure of the wind are impossible to control and suppress its force. This study is intended to inquire into the relationship between physical components of the double-skin façade as well as the structure of the openings, and the velocity and pressure of wind within the internal environment of mid-rise buildings to achieve a method through which the wind affects the building is controlled by double-skin façade. The parameters' values are determined and assigned to the variables in the Design-Builder simulation software, version 6.1.0.6. It is revealed that the use of two skins leads to a decrease in the velocity and pressure of the wind within the internal space of the building concerning the velocity and pressure in the external space. The extent of reduction in wind velocity and pressure is directly related to the distance between layers of skins.

Keywords: Double Skin Facades, Natural wind ventilation, Manjil city

1. Introduction

Double-skinned facades minimize energy consumption and enable external environmental forces to create interior comfort and tranquility, and provide thermal and aesthetic comfort in the structure. The double-skinned façade offers a double barrier and protection for the structure by using the energy of sunshine and wind pressure to ventilate, heat, and cool it [1,2]. Despite its wind and hydropower installations, the city of Manjil is considered one of the country's renewable energy hotspots. Wind speed in this location is greater than the numerical rate in other cities in the province, according to data from the Guilan Meteorological Department's winter quarterly quarter, with an average value of 35 meters per second and a frequency of 18 percent. It has made controlling the wind almost difficult. The possibility of using balconies and the space inside the openings has been reduced as a result of the entry of this volume of uncontrolled air, and by preventing the wind from entering the building, the architectural structure and, as a result, its residents have been deprived of natural ventilation[3]. This research aims to determine how to minimize Manjil city's average speed and wind pressure on buildings by adopting double-skinned facades.

1.1. Research background

In the construction of the Brussels Industrial Museum, the first documented research tests on the pattern of double-skinned facades, which led to ventilation in the layers between the glass facades of the building, were reported. This type was utilized in Germany in the following years to take advantage of additional sunshine while avoiding the region's cold and strong winds.

Oestrle et al. investigated the categorization of two-Skin facades according to the geometry between the two Skins in their research in 2001 (Partitioning: width of openings, height, and depth of space between the two Skins, etc.).

In a comprehensive study published in 2017, Gang et al. used a wind tunnel implementation and laboratory method to investigate the behavior of high-rise towers with and without exterior openings in favorable and unfavorable winds and discovered that the two-Skin façade outperformed the single-Skin façade. Winds that are not open do not influence lessening the effects of the wind. While there is an aperture in the double-skin facade, it has a powerful lowering impact.

Hasanli et al., in 2018, studied the function of double skin facades in energy generation in 4 cities of Australia. They realized corridors in the north-south direction are the best orientation to energy generation [5].

In 1396, Keshavarz et al. conducted a full assessment using Builder Design[1] software to

[1] Design Builder

accomplish correct airflow distribution in the interior and the suitable depth of the middle space of two-quarter Skin width to improve natural ventilation in the two-Skin corridor facade. The double-Skin image was acquired at a rate of 5 meters per second, and the depth of the inner space was assumed to be the same to match the two Skins' center space. It moves through the area at the specified rate [4].

As a result, most of the study focuses on the thermal behavior and energy efficiency of double-skinned facades, with just a small amount of effective ventilation research. On the other hand, no cohesive study has been undertaken to date in comparing the performance of double-skinned facades in windy places in Iran to exploit wind at the size of buildings, and this research vacuum exists.

2. Methodology

The thermal behavior of double-skinned facades was investigated using a simulation approach in this study. In 1399, climatic data for Manjil city was obtained from Gilan province's summer, autumn, and winter quarterly meteorological journals and imported into the software for modeling. According to the wind rose of Manjil diagram, the prevailing wind direction is west and northwest, with a wind speed of 18 meters per second and an average pressure of 189.36 Pa. Information about the structure of the building in order to consider geometric criteria and levels of the building (including exterior walls, floors, ceilings, and windows), as well as site information and orientation of the building, building facade, material specifications, and other factors based on common design standards, as reflected in general design guidelines in architecture and urban planning rules and regulations included in Manjil's Comprehensive Plan, which was authorized in 2016, were gathered.

2.1. Calculation conditions

The test model is a two-story structure on a pilot with a flat roof and a fixed space in various designs. The fundamental model's size and model are based on the common area of the residential plan model, which is based on the frequency of occupancy levels of licenses granted in 2010, which was collected from the Statistics Center's data for single-unit residential structures in the region. The building is situated on the site such that its sides are exposed to the wind, and it has a square layout with dimensions of 10 * 10 on the ground and 20 * 10 on the upper levels (one pilot floor without a two-skin view and two-story residential floor with a two-skin view) Is. The pilot, with a height of 2.40 meters above the ground and a total cubic capacity of 10 * 10 * 10, is fitted with a two-Skin façade on the west side, which faces the strong wind of Manjil. It is a double-skinned corridor facade with a height and width of 10 meters and internal divisions of 3 * 3 meters.

3. Simulation

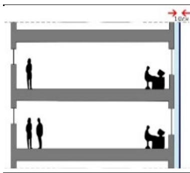
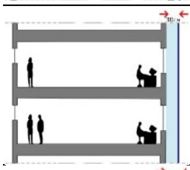
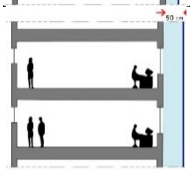
The simulation was conducted in two phases. The first stage's goal was to establish the ideal distance between the Skin and the building's main façade in order to obtain the least speed and pressure so that the openings are only on the first facade's surface (Skin). The modeling of other relevant characteristics - apertures, dimensions, and position - was carried out in the second stage to obtain the lowest speed and pressure.

3.1. Step one

A separate corridor area was formed between the two facades on each story, and the apertures were positioned on the facade surface. Air inlet openings were made near the floor in the lower part of the second facade surface, and air outlet openings were produced near the ceiling in the upper part of the second facade surface; all three were adjusted to a width of 3 m with an average distance of 10 cm, 30 cm, and 50 cm. The protrusion on the facade is restricted to 10 to 50 cm, according to the quality norms and regulations of the province's urban landscape, which were authorized in 1393.

Regardless of the cross-sectional width of the Skin, the wind speed near the façade decreases from 18 m / s to 16.32 m/s; the air pressure at this position is 189.36 pa. At a distance of 50 cm, the biggest drop in velocity and pressure occurred. The wind speed dropped from 6.53 m/s to 5.66 m/s, while the wind pressure dropped from 89.73 to 59.73 Pascals. As a result, this cross-sectional width, or dichotomous distance, was chosen and fixed to imitate the next phases. (Table 1)

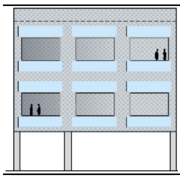
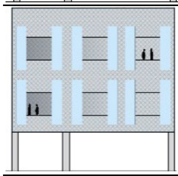
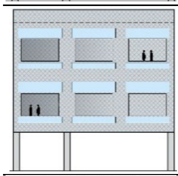
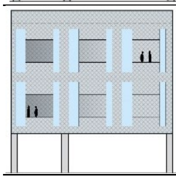
Table 1. Details of double-skin in step one

3d model section	The cavity (cm)	Encountering to Skin		Entering to Skin	
		speed (m/s)	pressure (pa)	speed (m/s)	pressure (pa)
	10	16.32	189	6.53	89.7
	30	16.32	189	6.31	64.8
	50	16.32	189	5.66	59.7

3.1. Step two

A table of sizes with varied ratios was developed and applied fully and individually in the program to reach appropriate values in the dimensions of the shutters. It performs well. For the remainder of the studies, two sizes of 25 and 50 cm with a length about equivalent to the length of the Skin panel were chosen. At this point in the simulation, the size and placement of the apertures were calculated based on the four options presented. (Table 2)

Table 2. Details of double-skin in step two

Model type	**Model ID**	**Opening dimension**	**Encountering to Skin**		**Entering to Skin**	
			(m/s) speed	(pa) pressure	(m/s) speed	(pa) pressure
	DSF 01	2.5*0.5	16.3	189	5.43	88.7
	DSF 02	0.5*2.5	16.3	189	6.52	64.5
	DSF 03	2.5*0.5 2.5*0.25	16.3	189	4.07	76.8
	DSF 04	0.5*2.5 0.25*2.5	16.3	189	6.25	125

The fluctuates according to the apertures, with the biggest drop in speed occurring in the second, third, fourth, and ultimately the first model. Similarly, the process of lowering air pressure within the Skin with the fourth model, with vertical apertures of double dimensions 2.5 * 0.5 and 2.5 * 0.25, second; it has vertical openings of 2.5 x 0.5, and the third and first models have horizontal openings. (Figure 1)

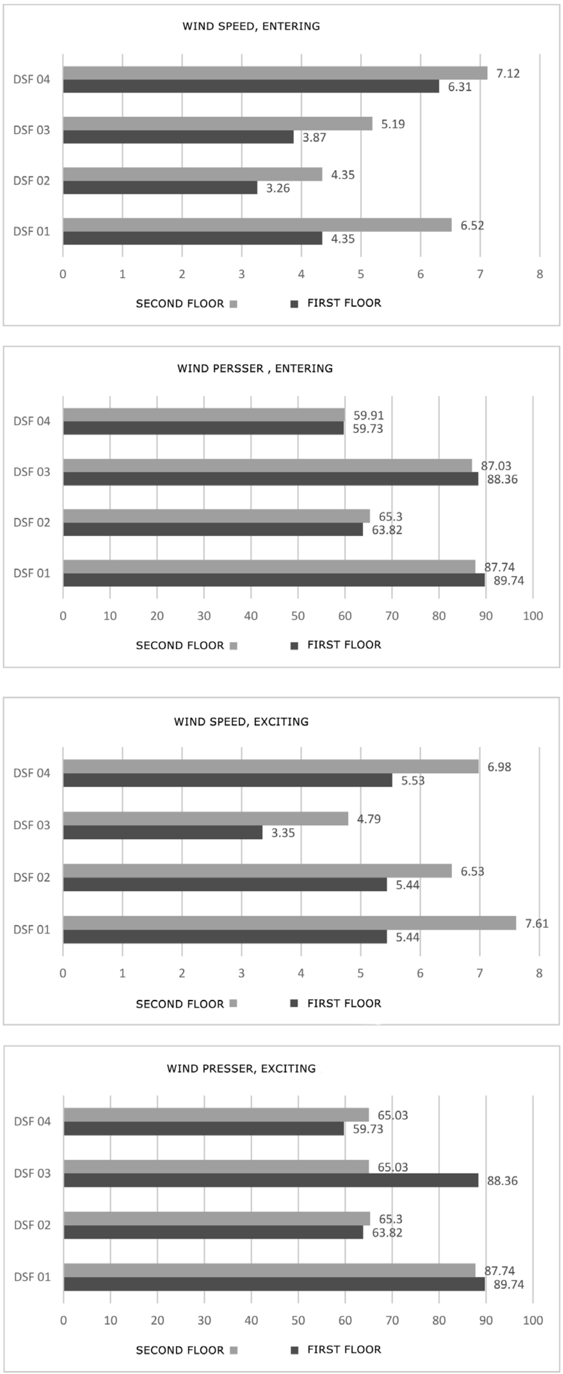


Figure 1. Diagram of wind speed and pressure during Skin entry and exit

4. Conclusions

Following are the rules that may be generalized and utilized in other residential buildings after reviewing the many alternatives by altering factors such as the size of the cavity, modifying the dimensions and placement of the proposed openings in the outside of the residential building in question;

The wind pressure within the Skin is a function of the air pressure outside the building, which stays constant with a substantial drop, and duplicity's duty is to lower the speed and air pressure outside the structure to a minimum usable level.

Furthermore, the distance between the two Skins is proportional to the rate of wind speed decline. Therefore the shorter the distance between the outer and inner Skin, the slower the rate of wind speed decrease. It was discovered that vertical apertures perform better than horizontal openings when compared to the suggested outside openings.

Furthermore, compared to openings of the same size and homogeneity, the function of openings with a ratio of 1/2 with each other, for example, with sizes of 2.5 * 0.5 and 2.5 * 0.25, is better at managing pressure and wind speed. These findings support the study's predictions that the physical components of the outer Skin, such as the number, size, ratio, and placement of openings, were prioritized.

In general, using dualism as a solution to minimize pressure and wind speed on the building's facade in Manjil may be advised, as it can balance the speed and pressure of the wind and land and ventilation of the space and residential unit.

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