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Influence of Wind Catcher on Thermal Performance of the Central Zone of a Heritage Building in a Moderate Climate: A Case Study

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Abstract

The wind catcher is one of the passive design strategies that can have a clear impact on the thermal comfort of the central zone of a heritage building (the case study of this research). This building is deserted and unknown, and its current condition may lead to destruction. Therefore, one of the challenges was to document it architecturally using various methods that will help define its orientation, design and attributes, and visualizing the final model was achieved using AutoCAD, Photoshop, surveys, and photos. The final building model helped in simulations through the use of the Tas EDSL software which is used for building simulations. This was used to assess the indoor air temperature for the case study in both days 180 and 225. The simulation result for both days shows that the internal temperature was decreased after applying a wind catcher by 1.50^0. This strategy has openings which help the movement of air inside and outside the building, and this exchange reflects positively on the internal temperature. The wind catcher can help to mitigate internal pollution. This indicates that the use of this environmental method increases the efficiency of the place and helps to achieve thermal comfort for the end user, thus converting the space from a place of distribution to a place of use.

Keywords: wind catchers, thermal comfort, heritage building and simulation

I. INTRODUCTION

The issue of energy consumption has become more prevalent in recent decades, especially with the industrial revolution and increasing human activities [1]. This was reflected in the philosophy of the built environment through creation and development of various environmental concepts, factors, solutions and strategies such as Solatube, chamber wall and courtyard. All these measurements are applied in buildings to reduce the internal temperature and enhance the energy efficiency as referred to in [2], [3], [4] and [5].

The wind catcher is a passive cooling strategy which enhances reducing the internal temperature of the building through catching the air flow to enhance the interior thermal comfort. In addition to that, it is one of the traditional methods that supports the ecosystem of the building to be more sustainable and reliable for climate change issues.

There are several types of wind catcher, which are classified based on the window openings, such as cross two sides and four sides [6]. Even though wind catchers have been used on modern buildings in recent decades, in terms of heritage buildings, the wind catcher can be included in their development, improvement, or rehabilitation. This inclusion needs to take into account the positive, aesthetic and environmental impact.

This paper will study the impact of including a wind catcher on an existing heritage building, through a simulation that assesses the effect of natural ventilation through using a wind catcher on internal temperature. This work is the first work that studies and documents a case study of this research as well as simulating it.

II. CASE STUDY OF THIS RESEARCH

Taif city has several heritage buildings, such as mosques, palaces, homes and schools [7]-[8]. Alkateb home was later known as the Palace of the Prosecution, where King Faisal lived when he was the King's Viceroy in the Western Region. This palace was built in the year 1315 AH and abandoned in the year 1388 AH. Among the distinguishing features of this house are Roman artistic and architectural influences. As for the design, it consists of two separate zones for men and women for privacy; in addition to that, the palace includes a marble staircase and a large grove [7]. Another example is Alkaaki home; this palace consists of three floors and was designed in the Roman style and built in 1358 AH. This house is distinguished by its trumpet decorations and ceilings, taking into account in its design the presence of two sections for men and women in what was known in Islamic houses and palaces as the Haramlek and the Salamlek [8]. These terms mean the observance of privacy according to the culture of the society.

In this paper, an old heritage home in Taif was chosen as a case study. This is due to several factors, including its vital location near the historic downtown area, its distinguishing architecture style, building materials, and finally the internal distribution of the building. In terms of the design, it consists of one floor which includes four rooms and four toilets. In addition to that, its design is symmetrical. In the first stage, the researcher tried to find any data that referred to this place in terms of history, survey, architectural planning and drawing. For this reason, it was an inevitable requirement to begin documenting the building, architecturally and spatially, and its survey points are shown in Table 1. In terms of architectural documentation, it was at three levels which are documenting the building architecture though visiting the building, drawing the building and analyzing the building environmentally.

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Table 1: Survey Points

Points	E	N
1	646169.39	2353530.45
2	646152.15	2353536.65
3	646144.15	2353514.28
4	646161.59	2353508.33

II.I Site observation

Through visiting the building site, the aesthetics of the building were observed and monitored, as well as the internal arches as construction and aesthetic solutions for large spans, as shown in Figures 1 and 2. It was observed that the building was very dilapidated and also deserted.

Figure 1: The arches and ornament

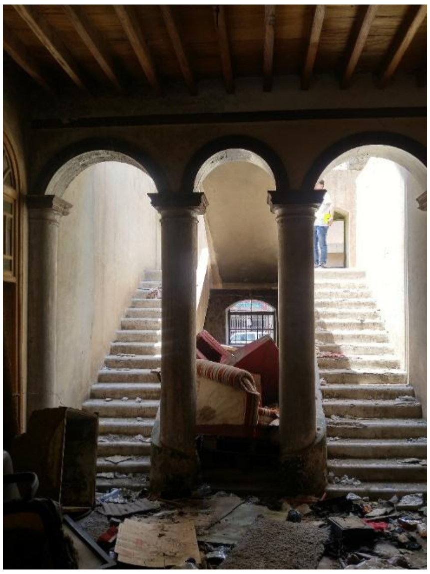

Figure 2: The distribution area for building rooms

II.II Architecture building description

The building is of a regular shape and contains four wings, in the middle of which is a distribution area that ends with stairs, as shown in Figure 2 and the drawing in Figure 3. The central area as highlighted in Figure 3 is a traditional roofed area, which is a research study zone. This zone is distinguished from all building rooms surrounding it. Its area is 4.5 * 6.46m. and the building dimensions are 18.1 * 14.1m. The ground floor is designed and drawn using AutoCAD software. The documentation included the elevations using Photoshop, as appeared in Figures 4 to 7.

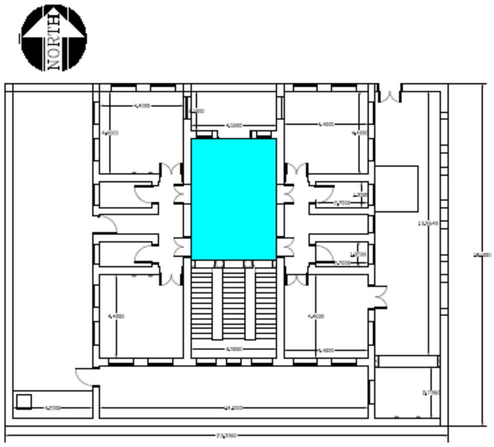

Figure 3: Ground floor

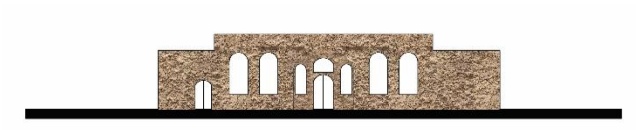

Figure 4: The north elevation

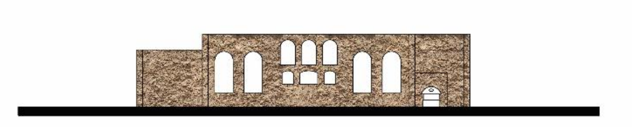

Figure 5: The south elevation

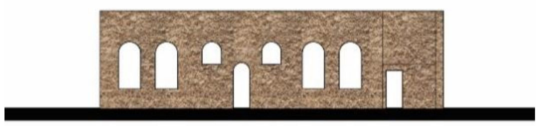

Figure 6: The east elevation

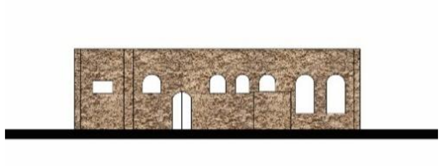

Figure 7: The west elevation

II. III Environmental components of the building

The building assessment and analysis showed that its material is green material such as mud, stones and woods, like other traditional buildings in Taif during that era, such as Almadhoon mosque [8]. In terms of building openings, all rooms are distinguished by window availability on two sides, which can enhance passive lighting and ventilation, enhancing the internal temperature for more thermal comfort for the end user. It is said that the heritage building philosophy can be modified through enhancing energy efficiency. Also, the end user is inclined to save energy and be optimistic with environmental solutions leading to this [9]. For this reason, it has been proposed to modify the roof of the main area to be a wind catcher and then compare that with the current situation. Further explanation in the following section will show the methodology that has been used for this research.

III. METHODOLOGY

The heritage building of this research has a main zone which is surrounded by the building rooms. The ground floor and building elevations have been designed and drawn using AutoCAD and Photoshop. The 3D of the building model is developed using Tas software, which is simulation software used worldwide [10], as shown in Figures 8 and 9. Then building material has been set in the model through the software as illustrated in Table 2. The file of the weather for Taif city has been imported to the programme before building the simulation for set environmental conditions. After that, the day was identified and measured hourly, as will be explained in the result of the simulation in the following sections.

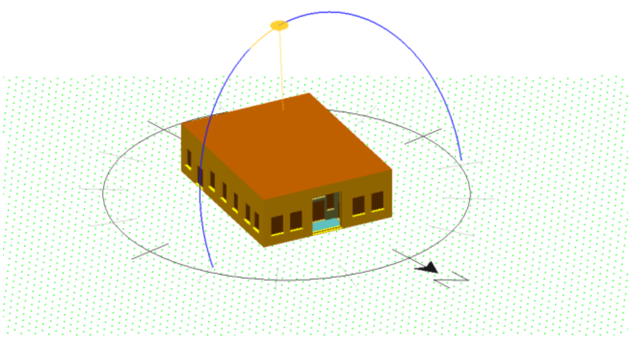

Figure 8: The current model

Table 2: Building materials

	Layer	Width (mm)	U value (W/m².°C)
External and internal walls	Rock	400	3.247
Ground	Sand dry - Crushed aggregate - Concrete	1250	0.286
Roof	Concrete - Wood	200	3.876
Doors and windows	Timber	35	2.381

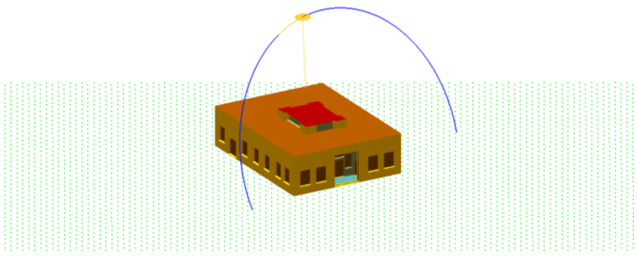

Figure 9: The proposed model

IV. RESULTS AND DISCUSSION

Even though the heritage building includes several attributes that enhance energy efficiency, such as building materials and design, the central area can lead to decreasing the internal temperature through remodeling the building, such as applying a wind catcher. As introduced in the early part of this research, a wind catcher can lead to reducing the internal temperature. For that, the current building simulation can give us a clear vision about its internal temperature before applying the wind catcher strategy. The internal temperature for the central zone is illustrated in Figure 10 and Figure 11 for different days, namely days 180 and 225. The highest external temperatures in degrees for day 180 were at 2.00pm and 3.00pm, which were 35.6^0 and 36^0 respectively, as illustrated in Table 3. In terms of the central zone, the temperatures for the current building case were higher than the external temperature which were 37.03^0 at 2.00pm and 37.49^0 at 3.00pm. The proposed model (as shown in Figure 9), which included a wind catcher, has a clear impact. The result was decreased to nearly 1.50^0 for both hours 2.00 pm and 3.00pm, which were 33.93^0 and 34.29^0 compared to the external temperature.

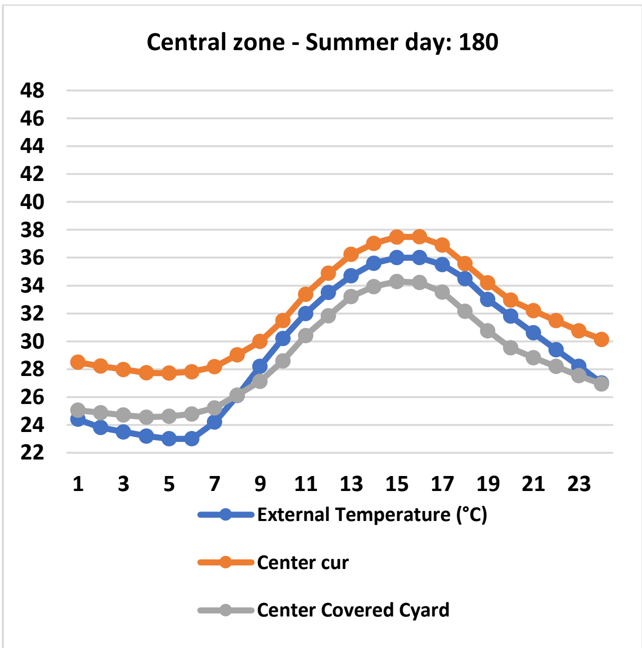

Figure 10: External temperature and central zone comparison

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Table 3: The result for day 180

Hour	External temperature (°C)	Center current case	Center covered cyard
180, 14	35.6	37.03	33.93
180, 15	36	37.49	34.29

The highest external temperatures in degrees for day 225 were at 2.00pm, 3.00pm and 4.00pm, which were 35.5^0, 35.90^0 and 36^0 respectively, as illustrated in Table 4. In terms of the central zone, temperatures for the current building case were higher than the external temperature, which were 36.72^0 at 2.00pm, 37.26^0 at 3.00pm and 37.25^0 at 4.00pm. The proposed model (as shown in Figure 9) which included a wind catcher has a clear impact. The result was decreased to nearly 1.50^0 for 2.00pm, 3.00pm and 4.00pm, which were 34.02^0, 34.27^0 and 34.14^0 compared to the external temperature.

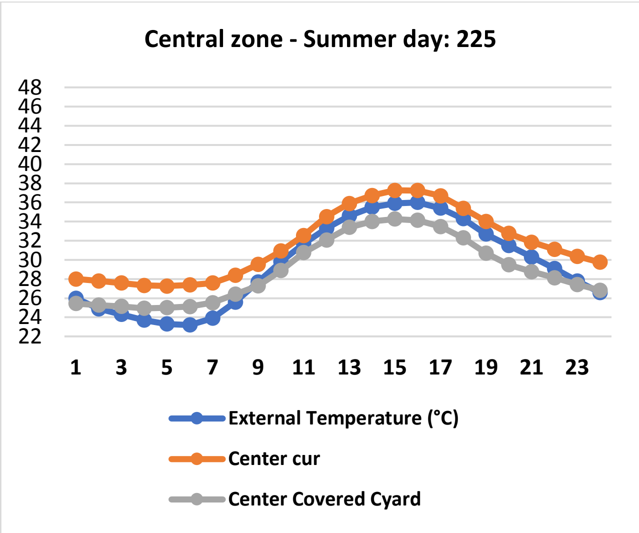

Figure 11: External temperature and central zone comparison

Table 4: The result for day 225

Hour	External temperature (°C)	Center current case	Center covered cyard
225, 14	35.5	36.72	34.02
225, 15	35.9	37.26	34.27
225, 16	36	37.25	34.14

V. CONCLUSION

This research used the passive ventilation strategy (wind catcher) to assess its impact on the thermal comfort of the central zone of the heritage building through using Tas EDSL software. The external and internal temperature was measured for both days 180 and 225, and the measurement was for the 24 hours. The result shows that applying a wind catcher in the central zone has a clear impact on decreasing the internal temperature. Even though it is almost 1.50^0**,** this result in a moderate climate is considered a positive and appreciated result. Additionally, it achieves thermal comfort for the ultimate user by employing the optimum vacuum via environmental practices. Natural ventilation helps reduce the indoor air temperature, makes the vacuum usable, and helps reduce pollution from various sources through the entry and exit of air.

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