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Original Article

Revitalizing college building corridors with skylights

Reham Eldessuky Hamed

Architecture Department, Faculty of Engineering, Beni Suef University, Beni suef, Egypt

Keywords:
College corridors, energy performance, indoors environment, passive skylights, users comfort.

Corresponding Author:

Reham Eldessuky Hamed, Architecture Department, Faculty of Engineering, Beni Suef University, Beni suef, Egypt, **Tel:** 01005096011, **Email:** reham011299@eng.bsu.edu.eg

Abstract
Convertible corridors in university buildings through creating skylights to meet the environmental and architectural requirements of providing thermal, daylight, ventilation, and visual comfort. Besides achieving aesthetics, economics, and durability to improve interior–exterior visual connection, Built-environment energy efficiency and long-term sustainability.Bringing natural light and natural ventilation into indoor spaces has been a critical and necessary feature of architecture throughout history. But nowadays, Architects have become increasingly reliant on artificial lighting and ventilation, claiming that daylight and natural ventilation were a luxury that could be ignored. This response is because artificial lighting and air conditioning can be used to provide sufficient light and ventilation, especially in the corridors of university buildings in Egypt. However, due to contemporary initiatives that promote green building and passive design, natural daylight and ventilation have regained popular attention. The research study on the newly designed last level of the college of Literature- Beni Suef University, which is used recently as classrooms. Simulations reviews a concept to understand the passive behavior of creating skylights to revitalize college buildings corridors. The results reached the advantages of using skylights towards raising the efficiency of the college corridors in terms of thermal, lighting, ventilation, and energy consumption.

I. INTRODUCTION

Transformable building envelope design is a concept applied in the architectural retrofit approach to improve morphology, function, and performance. Roof skylights are a type of design that allows natural light from the sun to penetrate through rooftops or horizontal surfaces of buildings with few wall openings[1]. A passive skylight system is a key component of a building envelope when compared to other construction elements such as windows, walls, and roofs because it is in contact with the majority of external environmental variables. The presence of daylight in educational buildings has been strongly associated with occupants' performance and productivity, whereas the effectiveness and duration of light exposure throughout the day influence students' comfort, health, activities, and learning.

Roof skylights are commonly used in temperate and cold climates to absorb heat from the sun during cold weather and thus minimize heating energy demands. As a result, in hot regions, the influence of solar radiation on roof skylights may be considered to have a great negative impact on the quality of building energy consumption. On the contrary, it refers to the development of architectural concepts with the use of skylights to revitalize the interiors, particularly in educational buildings[2].

There are numerous architectural options for bringing natural light into an interior space, but each has its own set of limitations.When suitable lighting cannot be obtained through the use of windows due to their size, orientation, or complete lack of them in some interior areas and corridors, skylights are one of the techniques where passive systems allow natural light to flow through the roof and into interior spaces.

Accordingly, the corridors in buildings, especially universities, need to be revived with skylights to provide daylight and natural ventilation and reduce the use of artificial lighting and energy consumption.

II. RESEARCH METHODOLOGY

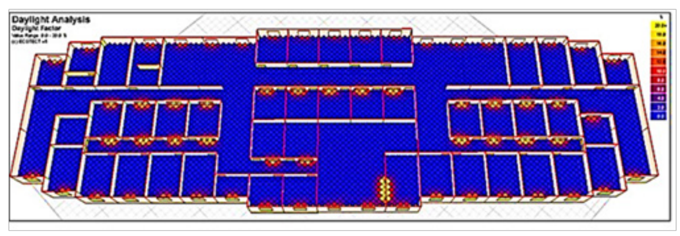
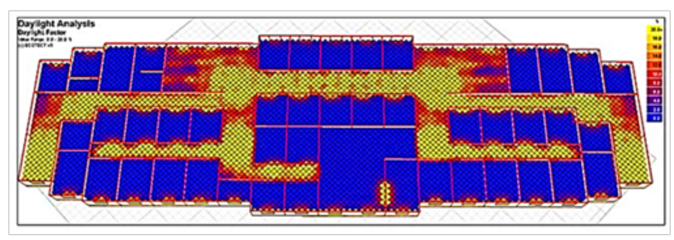
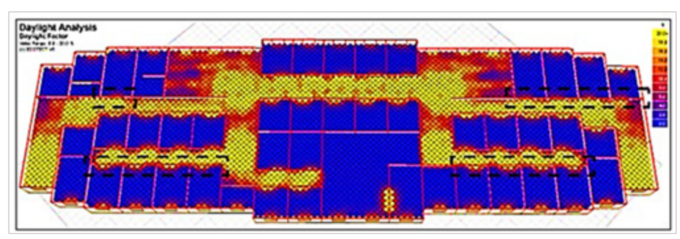
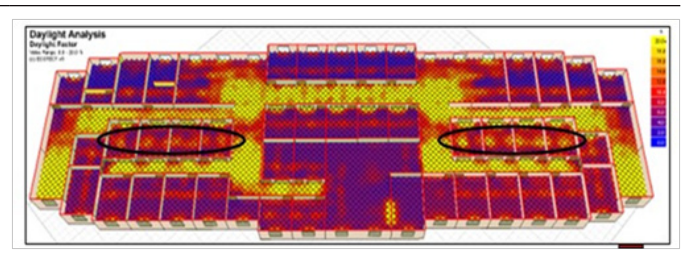
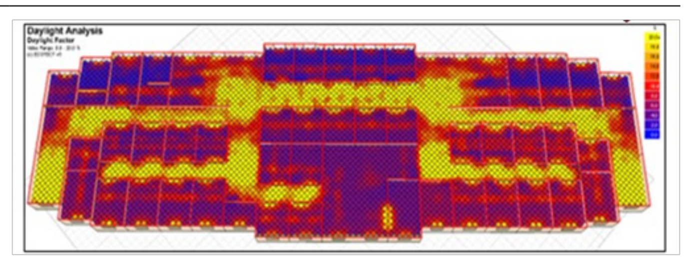
The research study is on the newly designed last level of the college of Literature at Beni Suef University, which has recently been used as a listening room. Simulations review a concept to understand the behavior of creating skylights to revitalize corridors. The purpose of the research is to improve the thermal and daylighting conditions where solar lighting and skylights have the effect of saving energy and providing comfort while also enhancing the indoor environmental quality (IEQ). It is worth noting that the proposals to change the type of glass and the solutions for automatic control are difficult to implement due to the peculiarities of government university buildings.

To satisfy occupants' comfort, enhance IEQ performance, and improve energy efficiency with the selected case study, the analysis methodology is based on daylight, thermal, and ventilation simulations.A comparative study was conducted for all proposed solutions, which included a study of the corridors in their current condition, skylights and false ceilings covering the classrooms, skylights with extra upper windows opening into the corridors, skylights without a false ceiling covering the classrooms, as well as skylights, by including a ceiling tile covering part of the classes and additional upper windows opening onto the hallways.

III. RESULTS AND DISCUSSION

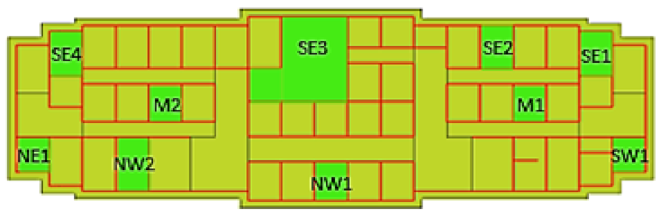
A. Daylight Simulation: The sun is at its maximum level within the space on August, a it is almost perpendicular to the building's front, and therefore it enters inside classes at its highest level that has the most sunlight. Table 1 shows the daylight simulations of the proposed solutions.

Table 1: Daylight simulations of proposed solutions

Case	Simulation Results
Daylight factor inside spaces with no designed skylights and an artificial roof covering the classes	
The daylight factor inside places is increased by designed skylights and an artificial ceiling covering the classrooms.	
Daylighting inside is achieved by the designed skylights, false ceilings in classrooms, and additional upper windows in hallways.	
Daylight factor inside space, due to the strategically placed skylights and the absence of false ceilings in the classes.	
Daylight factor in interior rooms: Customized skylights, a created artificial ceiling over some classrooms, and additional top windows opening at hallways.	
Analysis: The corridors without skylights are completely darkened, not commensurate with the requirements of university buildings, which require adding skylights. Considering that the marked locations have high glare and unsuitable lighting in classrooms.	

B. Thermal Simulation: The Material Properties of the Building Envelope cross section: In the Designed Case, the U-value values of the building envelope cross section are all within the CODE rates.On the warmest and coldest days, temperature were examined in the hallways represented in table 2.Although there are perpendicular skylights on the rooftop, the sections reached their peak temperature of 35.5°C and their minimum temperature around 11.6°C when a skylight was added on the corridor roof.Because there were no skylights, the zones attained their peak temperature of 35.5°C and the minimum temperature around 9.1°C when compared to the alternative case.

Table 2: Table of Temperature Assessment: (Naturally Ventilated case)

Calculated Zones		Calculated Zones		Calculated Zones	
					
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
South-East	SE1	When the outside temperature is 36.1 degrees, the highest temperature inside is 35.5 degrees at 17:00.	When the exterior temperature is 3degree, the lowest temperature inside is 14.7 at 6:00.	When the exterior temperature is 35.5 degrees, the highest temperatureinside is 34.9 degrees at 19:00.	When the exterior temperature is 6, the lowest temperature inside is 9.6 at 7:00.
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
	SE2	At 17:00, the temperature range inside was 32.8°C, while the outside temperature was 38.3°C.	When the exterior temperature is 3, the inside temperature is 13.1 at 6:00.	At 13:00, while the exterior temperature is 38.2, the greatest temperature inside is 35.0.	When the exterior temperature is 6, the lowest temperatureinside is 9.4 at 7:00.
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
	SE3	At 17:00, the peak temperature inside was 35.3°, while the outside temperature was 38.3°.	When the exterior temperature is6, the inside temperature is 13.1 at 7:00.	At 19:00, while the exterior temperature is 35.5, the inside temperature is 36.2.	When the exterior temperature is 3, the lowest temperatureinside is 9.3 at 8:00.
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
	SE4	At 17:00, the peak temperature was 35.5°C, while the outside temperature was 38.3°C.	When the outside temperature is 3, the lowest temperature inside is 13.3 at 6:00.	At 19:00, the highest temperature inside was 34.6°C, while the outer temperature was 35.5°C.	When the exterior temperature is 6, the lowest temperature is 10.0 at 7:00.
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
South-West	SW1	At 14:00, the highest temperature inside was 32.5°, while the outside temperature was 39.6°C.	When the exterior temperature is 3, the lowest temperature inside is 11.6 at 6:00.	At 14:00, the highest temperature inside was 35.5°C, while the outer temperature was 39.6°C	When the exterior temperature is 6, the lowest temperature inside is 9.1 at 7:00.
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
North-East	NE1	At 17:00, the peak temperature inside was 32.5°C, while the outside temperature was 38.3°C.	When the exterior temperature is 3 degrees, the lowest temperature inside is 12.8 degrees at 6:00.	At 19:00, the highest temperature insidewas 34.6°C, while the outer temperature was 35.5°C.	When the exterior temperature is 6, the lowest temperature inside is 9.7 at 7:00.

North-West		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
	NW1	The highest temperature inside At 17:00, the outside temperature was 32.7°C.is 38.3°	When the exterior temperature is 3 degrees, the lowest temperature inside is 13.3 degrees.	At 19:00, while the exterior temperature is 35.5, the greatest insidetemperature is 35.0.	When the exterior temperature is 6, the insidelowest temperature is 9.7 at 7:00.
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
	NW2	At 14:00, the highest temperature inside was 32.1°C, while the outside temperature was 39.6°C.	When the exterior temperature is 3 degrees, the lowest temperature insideis 13.0 degrees.	At 14:00, the highest temperature insidewas 34.9°C, while the outside temperature was 39.6°C.	When the exterior temperature is 6 degrees, the lowest temperature inside is 10.1 degrees.
Middle Spaces		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
	M1	At 17:00, the peak temperature inside was 34.1°C, while the outside temperature was 38.3°C.	At 22:00, the lowest temperature inside was 12.1°C, while the outer temperature was 10.3°C.	At 19:00, while the exterior temperature is 35.5, the highest insidetemperature is 35.5.	When the exterior temperature is 6, the lowest temperature inside is 9.4 at 7:00.
		Hottest Day 1st Aug.	Coldest Day 24th Jan.	Hottest Day 1st Aug.	Coldest Day 24th Jan.
	M2	At 17:00, the peak temperature was 34.3°C, insidewhile the outside temperature was 38.3°C	At 23:00, the lowest temperature inside was 12.2, while the outer temperature was 9.1.	At 19:00, while the exterior temperature is 35.5, the greatest insidetemperature is 35.0.	When the exterior temperature is 6, the lowest temperature insideis 9.8 at 7:00.

The appropriate outcome was to combine skylights with pergolas over the roof, according to the findings of all the proposals. Fig.1,These panels may block unwanted direct direct sunlight, which would increase the amount of heat gained, while permitting in desired indirect sunlight, which would increase the amount of natural light inside the areas without increasing the temperature. The presence of such pergolas somehow doesn't prevent the desired solar rays from improving the inside lighting in the early morning or late afternoon. While hourly heat gains/losses from the building for the best proposal as table 3

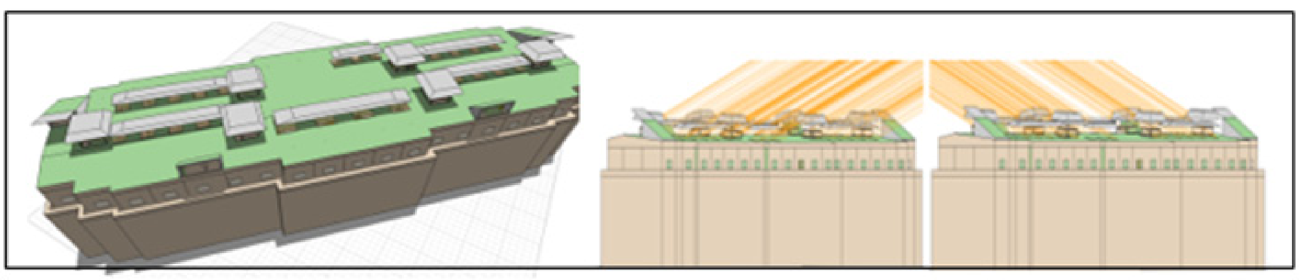
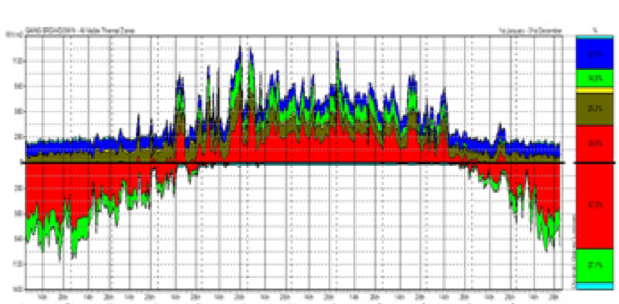
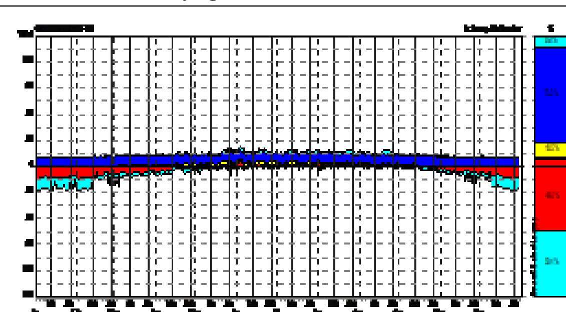


Fig. 1: Combine skylights with pergolas over the roof

Table 3: Heat Gain and Loss

Corridors With Skylights	Corridors Without Skylights
	

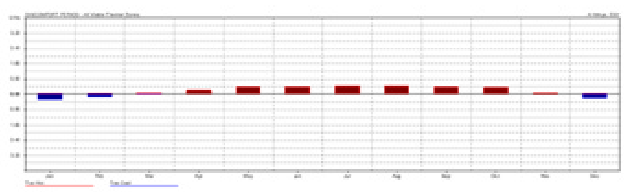
Conduction Solar-Air Direct Solar Ventilation Internal Internal-Zonal

Results of Hourly Heat Gains/Losses Analysis

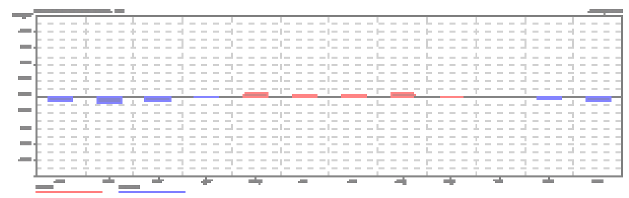
CATEGORY	LOSSES	GAINS
FABRIC	67.5%	29.8%
SOL-AIR	0.0%	25.2%
SOLAR	0.0%	4.4%
VENTILATION	27.1%	14.5%
INTERNAL	0.0%	23.9%
INTER-ZONAL	5.4%	2.3%

CATEGORY	LOSSES	GAINS
FABRIC	49.6%	5.4%
SOL-AIR	0.0%	1.9%
SOLAR	0.0%	10.5%
VENTILATION	0.0%	0.0%
INTERNAL	0.0%	73.3%
INTER-ZONAL	50.4%	8.9%

Discomfort Hours Graph ------ cold ------- hot



3446.3 hours outside of the building thermal comfort, comparable to 39.3 percent of the year's hours.Nearly 80% of them are for Hot hours, while the rest are for Cool hours.

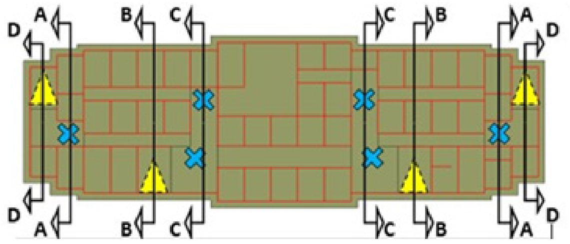


1. 875 hours outside of thermal comfort during the year, comparable to 10% of the year hours. Almost 37% are for Hot hours, while 63% are for Cool hours.

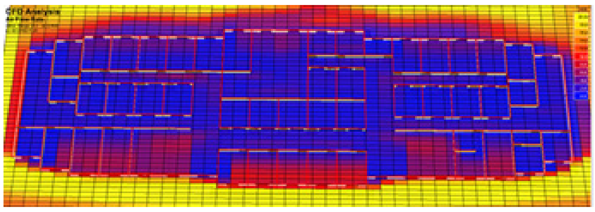
Analysis: According to the Hourly Heat Gains/Losses, the amount of Hourly Heat Gain and Loss is dramatically reduced to very small amounts, lower than 140 Whm2, as compared to the existing case, which reaches higher than 1120 Whm2.

C. Ventilation Simulation: On the hottest day in this temperature zone, horizontal and vertical sections of the ventilation were taken to indicate the effectiveness of skylights acting as wind catchers and movable skylight windows in boosting the airflow rate inside the building.

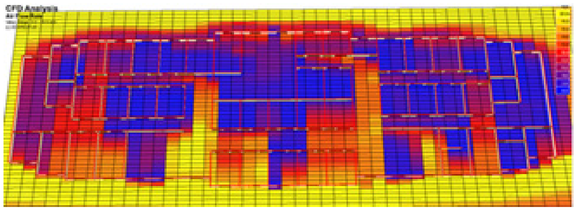
Table 4: Ventilation Simulation



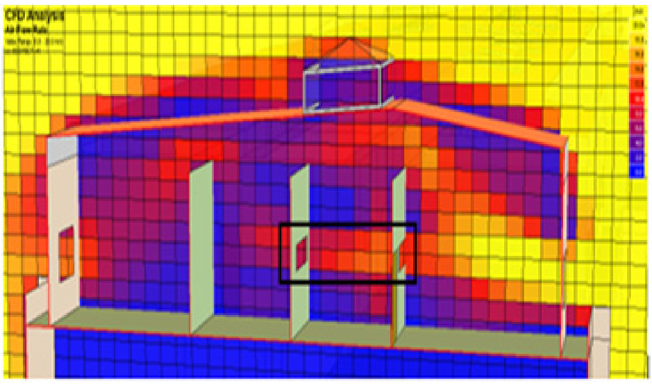
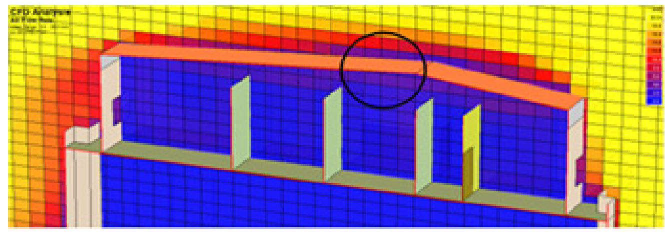
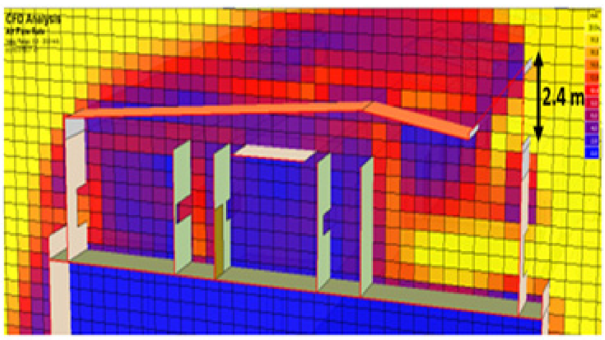
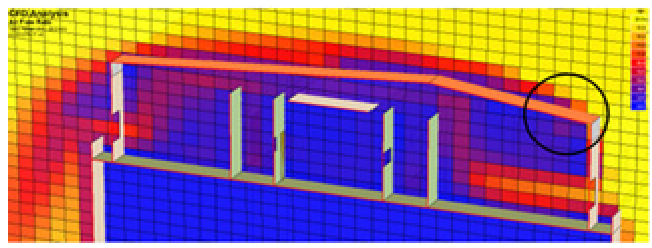
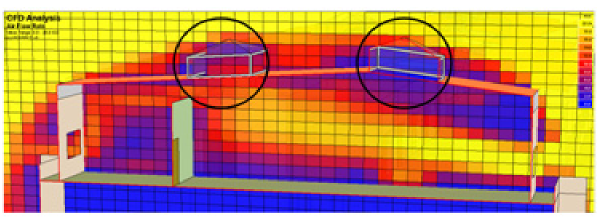
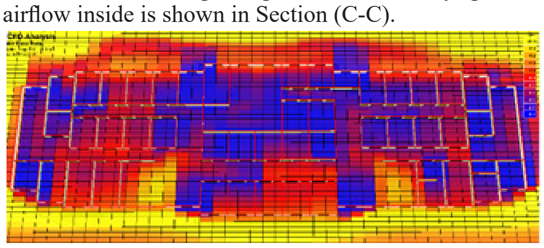
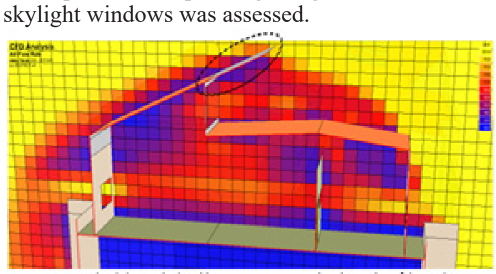
The Taken Key Plan
Locations of Vertical Sides



Without the designed wind catchers and operable skylights, the airflow within the spaces is insufficient.



The impact of integrating Designed Wind Catchers and Moveable Skylight Windows into interior spaces is optimizing airflow levels

	Section (A-A) illustrates the internal airflow without the skylight window. Additionally, adding top windows to the inner classes improves the airflow efficiency within spaces. 
	The airflow rate inside is shown in Section (B-B) without the designed wind catchers. Furthermore, installing a larger wind-catcher has a significant impact on improving airflow within spaces. 
	Section (D-D) depicts the air-flow level inside the space without open skylights. Enhance airflow rates inside while implementing skylights as wind-catchers. In addition, installing a Long Hangover in the wind-catcher input window has the effect of increasing air flow into those regions.
The effect of adding designed moveable skylights on increasing airflow inside is shown in Section (C-C). 	After achieving a final improvement in improving air flow inside, the impact of incorporating designed wind-catchers and moveable skylight windows was assessed. 
Analysis: The effectiveness of activating skylights as wind-catchers and movable skylight panels after reaching the final improvements depends upon improving airflow inside.	

C. Cost of Light Lamps and Electricity:

Electricity consumption before adding skylights:

MONTH	HEATING (Wh)	COOLING (Wh)	ELECTRIC (Wh)	GAS (Wh)	FOSSIL FUEL (Wh)
Jan	0	0	7535456	0	0
Feb	0	0	14348192	0	0
Mar	0	0	21853538	0	0
Apr	0	0	29099618	0	0
May	0	0	36587236	0	0
Jun	0	0	43833316	0	0
Jul	0	0	51320932	0	0
Aug	0	0	58808548	0	0
Sep	0	0	66054628	0	0
Oct	0	0	73542248	0	0
Nov	0	0	80788328	0	0
Dec	0	0	88275944	0	0
TOTAL	0	0	88275944	0	0

Electricity consumption after adding skylights:

MONTH	HEATING (Wh)	COOLING (Wh)	ELECTRIC (Wh)	GAS (Wh)	FOSSIL FUEL (Wh)
Jan	0	0	3767728	0	0
Feb	0	0	7174096	0	0
Mar	0	0	10926769	0	0
Apr	0	0	14549809	0	0
May	0	0	18293618	0	0
Jun	0	0	21916658	0	0
Jul	0	0	25660466	0	0
Aug	0	0	29404274	0	0
Sep	0	0	33027314	0	0
Oct	0	0	36771124	0	0
Nov	0	0	40394164	0	0
Dec	0	0	44137972	0	0
TOTAL	0	0	44137972	0	0

Based on natural light from the designed skylights, the use of artificial light was reduced by 50% from 8:00 a.m. to 6:00 p.m.

Case 1: creating an artificial ceiling to cover the entire space without skylights in the rooftop.	Case 2: skylights in the rooftop and a created artificial ceiling covering several classrooms.
- Period of light usage :8:00 a.m. to 21:00 p.m. = 13 hours per day = 3640 hours every year. - Electricity consumption = 235,872 EGP per year	- Period of light usage :16:00 to 21:00 = 5 h\day = 1400 h\year - Electricity consumption= 90,720 EGP per year

IV. CONCLUSION

The following are the main outcomes: Sometimes appropriate daylight cannot be provided through windows due to size, position, or total absence of them in some interiors and hallways. Skylights are one of the approaches where passive systems encourage natural sunlight to pass through the rooftop and into interiors.

- The creation of design features that use skylights to invigorate the indoor environment, notably in educational facilities,

- Without skylights, the corridors are totally dark, which is incompatible with the requirements of campus buildings that require skylights.

- Simulations investigate a concept for clarifying the passive behaviour of skylights in college pathways.

- The benefits of employing skylights to improve the efficiency of college hallways in terms of thermal, lighting, ventilation, and energy consumption were discovered.

- The impact of operating skylights as wind-catchers and movable skylights on increasing airflow indoors

- As a result, the total amount of hourly heat gain and loss is dramatically reduced to very small amounts, less than 140 Whm2, as a result of the improvements made in the existing corridors, as opposed to the current situation, which reaches more than 1120 Whm2.

- Electricity was cut in half by placing skylights on the rooftop, which reduced the use of artificial light from 8:00 a.m. to 16:00 p.m. and replaced it with sunlight from the skylights.

V. REFERENCES

[1] Matheou, M., Couvelas, A., and Phocas, M. C. (2020). Transformable building envelope design in architectural education. Procedia Manufacturing, 44, 116-123.

[2] Eiz, H. M., Mushtaha, E., Janbih, L., and El Rifai, R. (2021). The Visual and Thermal Impact of Skylight Design on the Interior Space of an Educational Building in a Hot Climate. Engineering Journal, 25(1), 187-198.

[3] K. Alshaibani, (2015), "Planning for daylight in sunny regions," in International Conference on Environment and Civil Engineering 2015, Pattaya.

[4] Mushtaha, E., Eiz, H., Janbih, L. and Rifai, R.E., 2019, November. Analyzing and Improving Natural Daylight in Educational Buildings Using Skylights, Victoria International School of Sharjah as a Case Study. In IOP Conference Series: Earth and Environmental Science (Vol. 385, No. 1, p. 012013). IOP Publishing.

[5] Hara, A.H. and Pereira, F.O., 2020. Lighting In Corridors Influencing The Switching On Of Electric Lighting In Classrooms: Need For Educational Actions. Eco-Architecture Viii: Harmonisation Between Architecture And Nature, 195, P.103.