

PAPER • OPEN ACCESS

The impact of an external obstacle daylight in deep office spaces at hot arid zone

To cite this article: Doha Mohamed Saeed 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **974** 012029

View the [article online](#) for updates and enhancements.

You may also like

- [Asymmetric and symmetric light couplers of daylighting systems for direct indoor lighting](#)
Wei-Feng Hsu, Yi-Ta Shen and I-Lin Chu
- [Assessment of Daylighting Designs in the Selected Museums of South-West Nigeria: A Focus on The Integrated Relevant Energy Efficiency Features](#)
P Aderonmu, A Adesipo, E Erebor et al.
- [Determining Proper Daylighting Design Solution for Visual Comfort and Lighting Energy Efficiency: A Case Study for High-Rise Residential Building](#)
Z A Kiliç and A Köknel Yener



245th ECS Meeting
San Francisco, CA
May 26–30, 2024

PRiME 2024
Honolulu, Hawaii
October 6–11, 2024

Bringing together industry, researchers, and government across 50 symposia in electrochemistry and solid state science and technology

Learn more about ECS Meetings at
<http://www.electrochem.org/upcoming-meetings>

ECS Save the Dates for future ECS Meetings!

**Military Technical College
Kobry El-Kobbah,
Cairo, Egypt**



**13th International Conference
on Civil and Architecture
Engineering
ICCAE-13-2020**

The impact of an external obstacle daylight in deep office spaces at hot arid zone

Doha Mohamed Saeed

*Teacher – Architectural Engineering Department – Faculty of Engineering and Technology,
Badr University in Cairo (BUC), Egypt*

Abstract. The use of effective daylighting systems is one of the main factors that influences energy consumption in buildings especially in deep office spaces. Therefore, the need for innovative daylighting systems with optimum overall daylighting performance - especially in term of saving energy performance - is an essential design element for such spaces. Light shelf systems are the most major potential lighting systems that can be used to provide such innovative daylighting systems.

The parametric approach was implemented where all possible combinations of the various design parameters for the main two design elements of the light shelf system (light shelf and room specifications) were computed through Diva-for-Rhino (Grasshopper). The study of optimized light shelf systems in deep office spaces has been carried out in case of an external obstacle (neighbor) and without it – according to the Egyptian building codes - in order to identify the impact of such design elements on the performance of the optimized light shelf system in the main four directions in hot arid zone climate.

Keywords: Light shelf systems – obstacle - deep office spaces - Diva-for-Rhino (Grasshopper)

1. Introduction

Light shelf is a daylight-redirecting system intended to bounce daylight to the deepest side of a room. This function suits well to all climates [1]. Light shelf was developed to create uniform indoor illuminance. However, in hot climates the unshaded clerestory above the shelf transmits high solar heat gain. In dense urban context, these advantages and disadvantages might vary regarding the context and position of the fenestration [2]. This confirms the necessity of studying the effect of the presence of a neighbor integrated with the reflectors system. employed scaled physical models and computational simulation methods to examine the daylighting performance of lightshelves under several tropical sky conditions in Subang, Malaysia, i.e., intermediate sky with direct sunlight, intermediate sky without direct sunlight and overcast sky. Under clear sky conditions, daylighting performance of light shelf depends on the dynamic movement of solar position. Franco [3] proposed tilted and automatic lightshelves to solve daylighting problems in hot tropics by adjusting the elevation of the internal shelf to the dynamic movement of solar position. Previous studies on light shelf were limited in building context. Recently, studies on urban environment have widely emerged following the awareness of the impacts on the urban climatology. Shafaghat et al. [4] established a taxonomy body of knowledge in urban climatology studies and mentioned urban street canyon, which



consists of aspect ratio and street orientation, as the most important urban features. The impacts of urban height to width ratio aspect and spacing distance to length ratio on the building energy demand had been studied by Kesten et al. [5]. Additionally, canyon surfaces have been understood to be vital in determining the thermal performance of the urban canyon [4], that affected on the surrounding building energy consumption. Akbari et al. [6] found that the surrounding's surface albedo or emissivity could modify the energy balance of the buildings. High albedo materials reduce the amount of solar radiation absorbed by the building envelope. In multi-story buildings, the urban geometry and texture effects on the indoor illuminance and radiation fluxes may vary for each floor level. Therefore, it could be interesting to relate these factors to the light shelf planning in multi-story buildings in terms of building energy performance. In order to measure the effectiveness of light shelf.

2. Methodology

This study comes as a part of the completion of the study of the development of the performance of the light shelf systems. This study, based on the benefit of the outcome of what has been concluded in a previous study phase, especially the identification of design indicators and key design elements to develop the performance of light shelf systems. Based on this conclusion, The results were studied from a different perspective, which is the effect of integrating the neighbor's presence with the light shelf system in four orientations. this various cases experimental tests by using parametric design approach by using Diva for Rhino- Grasshopper program, in order to define The impact of an external obstacle (neighbor) or its absence on the performance of optimized light shelf system in deep office spaces in the main four orientation in hot arid zone climate. (Ahmed,Reham,Doha, 2017&2018) [7,8]& [9].based on CIE Standard.

2.1. Light Shelf Models

Light shelf is a parametric panel installed at a height below the clerestory and above the view window for The hypothetical office is 6x12x3.3 m, which represents a large deep space in a multi-story Building Which properties as follows. Figure (1) & Table (1)

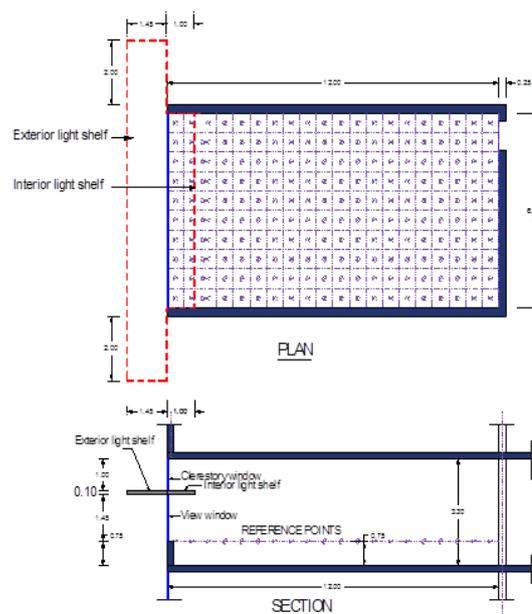


Fig. (1) Hypothetical office building room plan and section is 300 lux (daylight autonomy)

Table 1. Dimensions and properties of the tested office space

Materials and Dimensions		
Level of Floor	One level	
dimensions (m)	6m x 12m x 3.30 m	
Walls	Reflecting	50%
	Material	Internal-walls Off-White (Medium Colored)
Ceiling	Reflecting	80%
	Material	Ceiling in white Color
	Rotation angle	10 from half ceiling
	Curvature angle	10 from half ceiling
Floor	Reflecting	20%
	Material	generic floor
Window (1) Dimensions and Materials		
Width (m)	6 m	
Sill (m)	.75 m	
Lintel (m)	2.20 m	
Glazing	Double glazing, clear (VT=80%)	
Clear story (2) Dimensions and Materials		
Width (m)	6m	
Sill (m)	2.30 m	
Lintel (m)	3.30 m	
Glazing	Double glazing, clear (VT=80%)	
Light Shelf Dimensions, angle, curvature and Materials		
Light shelf orientation	South, north, east and west	
Light shelf position	External, Internal, External and Internal together	
External light shelf depth	1.45 m	
Internal light shelf depth	1 m	
Internal light shelf height from finish floor level	2.20	
External light shelf height from ground level	5.90	
External and Internal light shelf width	6 m	
External and Internal light shelf thickness	.10 m	
External light shelf rotation angle	0, 15, 35	
Internal light shelf rotation angle	0, -10	
External light shelf curvature angle	0, 15, 35	
Internal light shelf curvature angle	0, -10	
Light shelf obstruction angel	49° (the neighbor distance = 18m.)	
External and Internal light shelf Material	Generic ceiling 80, Silver mirror, Transparent glass and Translucent Panel	
Reflecting& Material	High-Refl_80%	

2.2. Light shelf obstruction angel:

The light shelf obstruction angle is measured as the degree (α) which is the angle located in between the extension line of the external light shelf's upper surface plan (a) and the line of light shelf beginning point and neighbor end point (b) fig. (2).

The obstruction angle depends mainly on the distance from the neighbor which has defined for the exploring test phase in this study, up to the Egyptian construction law in new cities (building heights = 1.5 street width), which ensure the constancy of the impact of the neighbor distance whatever changed, because it is directly proportional to the height, which mean the constancy of the obstruction angle. Science 18 meters (49° obstruction angel) is more commonly use in planning office building zone areas (building height = 27 m = 6 level), thus this study has define a distance of 18 meter away from the neighbor which make an obstruction angel of (49°) for the further developed study cases in the case of neighbor Figure (2)

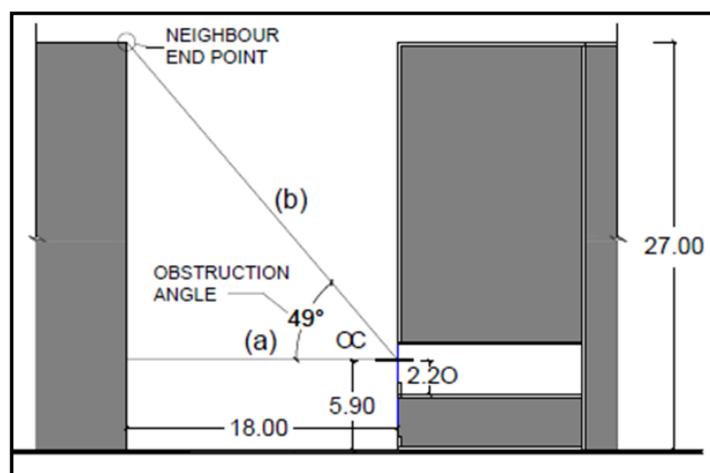


Fig. (2) This figure has define a distance of 18 meter away from the neighbour which make an obstruction angel of (49°)

2.3. Daylighting and Energy Simulations

The calculation of energy use for lighting was based on the daylighting performance computed using Diva for Rhino- Grasshopper program based on IES/ LEED v4/ASHRAE Standard, two metrics in LEED v4 are codified for evaluating daylight autonomy design, which allow a daylight space to be evaluated for a one-year period using two different performance parameters: sufficiency of daylight luminance and the potential risk of excessive sunlight penetration [10]. These two metrics are Spatial Daylight Autonomy (sDA) and Annual Sun Exposure (ASE) metrics, which together form a clear picture of daylight performance. sDA describes how much space receives sufficient daylight, which, for office building spaces, must achieve (sDA 300 lux / 50% of the annual occupied hours) for at least 55-75% of the floor area. sDA has no upper limit on luminance levels, and, therefore, ASE is used to describe how much space receives too much direct sunlight which can cause visual discomfort (glare) or increase the cooling loads. ASE measures the percentage of floor area that receives at least 1000 lux for at least 250 occupied hours per year that must not exceed 10% of floor area [11].

3. Results and Discussions

3.1. Data Analysis Methods

6552 cases were investigated for a hypothetical deep office room for 4 orientations with 819 combinations of light shelf system parameters in two cases (with no obstructions and with obstruction angle); figure (3). Total tested cases in the four orientation= $819 \times 2 \times 4 = 6552$ cases.

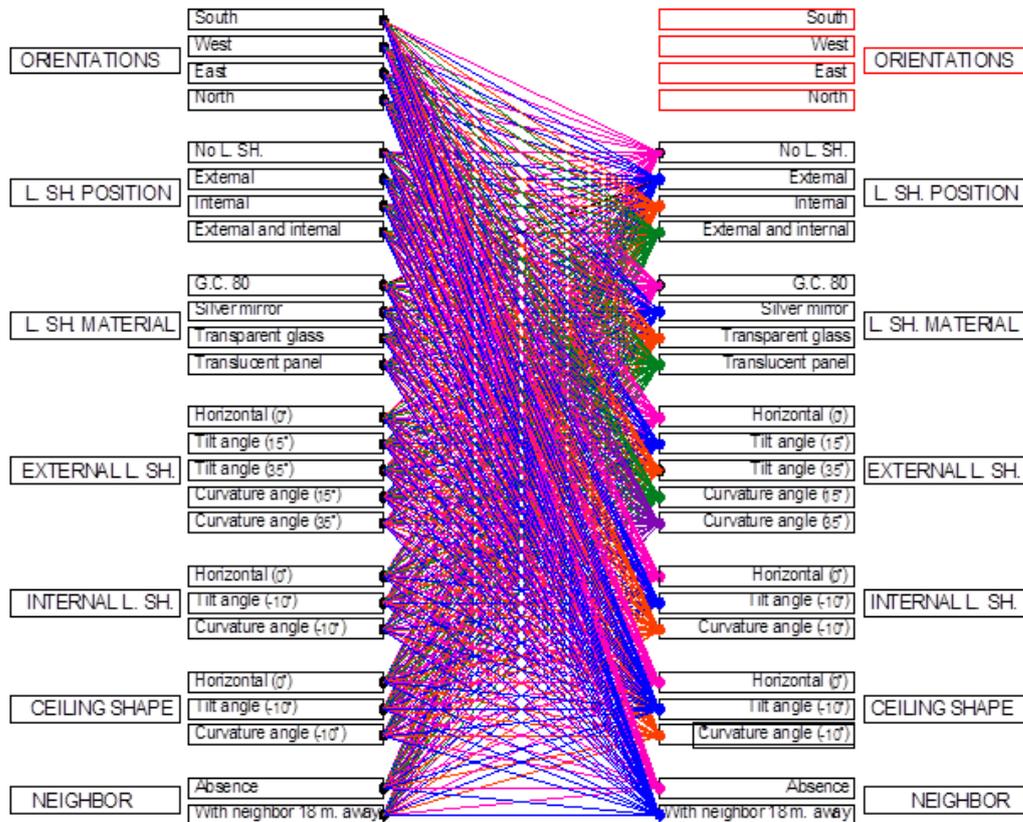


Fig. (3) Modifications parameters for the study modelling

Algorithm is inspired by natural selection to generate high-quality optimization by depending mutation, cross-reference and selection. It is based on the concept of Darwin’s theory that was extended to GA in 1989. figure (4)

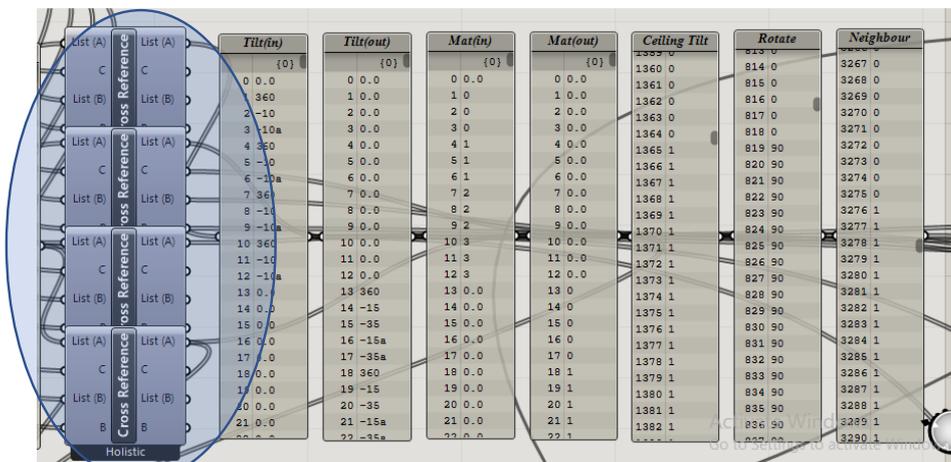


Fig. (4) Modifications parameters for the study modelling which are applied by cross-reference component in Rhino grasshopper.

After conducting the simulation experiments, the focus in analyzing the results was in four stages in the four orientations, which are as follows: Table (2)

Table 2. The results was in four stages in the four orientations

n. The Stages	Stage one		Stage two		Stage three		Stage four	
	Light shelf	neighbour						
Yes/No	No	No	Yes	No	No	Yes	Yes	Yes

3.2. Define Selected Cases and Result Analysis:

Table 3. Digital results for Daylighting and Energy consumption in four orientations

Case No.	the case situation	Orientaion	Neighbor	Outer LS. Material	Outer LS. Angle	Inner LS. Material	Inner LS. Angle	Ceiling	sDA	ASE	Daylit	P.Daylit	Overlit	T.AEC	A.H.L	A.C.L	A.E.E.E	A.L.E.E
0	Stage 1	South	N/A	N/A	N/A	N/A	N/A	Horizontal	80.5	27.5	44	20	36	161.1351	5.503875	149.9614	31.974	5.669833
321	stage 2	South	N/A	Generic cd	Horizontal	Silver min	Horizontal	Tilted	76.5	7	53	24	24	168.0951	5.206064	153.5096	31.974	9.379438
3276	stage 3	South	18 m	N/A	N/A	N/A	N/A	Horizontal	43	10	30	57	14	200.2854	5.187073	168.5752	31.974	26.52313
3842	stage 4	South	18 m	Silver min	35	N/A	N/A	Curved	53	5	39	47	14	189.9325	5.167231	163.8131	31.974	20.95214
2457	Stage 1	West	N/A	N/A	N/A	N/A	N/A	Horizontal	75	39.5	30	25	44	156.765	6.547382	142.4243	31.974	7.793364
2778	stage 2	West	N/A	Generic cd	Horizontal	Silver min	Horizontal	Tilted	72	18.5	45	28	27	161.0629	6.148321	144.6088	31.974	10.30584
5733	stage 3	West	18 m	N/A	N/A	N/A	N/A	Horizontal	53	12	34	47	19	164.0778	6.523888	145.9362	31.974	11.61767
6021	stage 4	West	18 m	Generic cd	35	N/A	N/A	Tilted	64.5	6	46	36	18	160.9599	6.287348	144.6418	31.974	10.03077
819	Stage 1	East	N/A	N/A	N/A	N/A	N/A	Horizontal	72	39.5	26	28	46	146.4902	5.02029	136.089	31.974	5.380912
1140	stage 2	East	N/A	Generic cd	Horizontal	Sheet Mir	Horizontal	Tilted	72	16	43	28	29	149.3177	4.777921	137.7194	31.974	6.820353
4095	stage 3	East	18 m	N/A	N/A	N/A	N/A	Horizontal	53	12	34	47	19	181.4815	4.733934	152.6352	31.974	24.11232
4383	stage 4	East	18 m	Generic cd	35	N/A	N/A	Tilted	64	6	46	36	18	175.0902	4.563516	149.853	31.974	20.67367
1638	Stage 1	North	N/A	N/A	N/A	N/A	N/A	Horizontal	68	0	49	32	19	91.60071	7.257533	74.15991	31.974	10.18328
1972	stage 2	North	N/A	Generic cd	+35 Curve	Silver min	-10	Tilted	75.5	0	56	24	19	90.01158	6.823174	73.50326	31.974	9.685148
4914	stage 3	North	18 m	N/A	N/A	N/A	N/A	Horizontal	60.5	0	42	40	19	101.8132	7.185491	79.03686	31.974	15.59084
5249	stage 4	North	18 m	Generic cd	+35 Curve	Silver min	-10	Tilted	74	0	55	26	19	90.52819	7.048315	73.81528	31.974	9.664603

3.2.1 Result analysis for Daylighting and Energy Simulations in four orientation:

Table (3) & Figure (5 and 6)

The first stage:

The basic case (without any obstruction & light shelf system) in south, west, east and north orientations achieved (80.5%, 75%, 72% and 86% sDA 300, 50%) Respectively and (27.5%, 39.5%, 39.5% and 0% ASE1000, 250h) Respectively . We find that the amount of sunlight entering is acceptable, but the amount of direct light is higher than acceptable.

The second stage:

This case (without obstruction & with light shelf system) in south orientation achieved (76.5 % , 72%, 72% and 75.5% sDA 300, 50%) Respectively and (7% , 18.5% , 16% and 0% ASE1000, 250h) Respectively . We find that the amount of sunlight entering is minimal, but the amount of direct light is minimal also the reason for existence Light shelf.

The third stage:

This case (with obstruction & without light shelf system) in south orientation achieved (43%, 53% ,53% and 60.5% sDA 300, 50%) Respectively and (10%, 12%, 12% and 0% ASE1000, 250h) Respectively. We find that the amount of sunlight entering is minimal, but the amount of direct light is minimal also the reason for existence neighbor.

The fourth stage:

This case (with obstruction & without light shelf system) in south orientation achieved (53% , 64.5% , 64% and 74% sDA 300, 50%) Respectively and (5%, 6% ,6% and 0% ASE1000, 250h) Respectively. We find that the neighbor integrated with light shelf system caused amount of sunlight entering more about the third case and the amount of direct light is minimal. Table (4,5,6 and 7)

Table 4. Visual results for Daylighting performance in West orientations

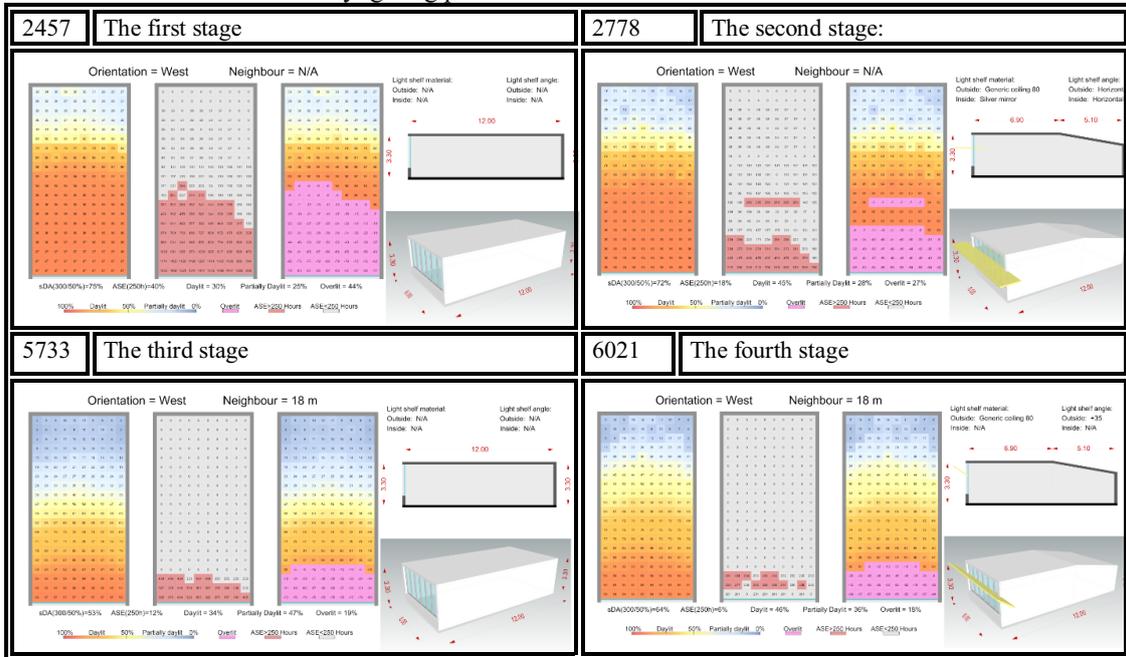


Table 5. Visual results for Daylighting performance in East orientations

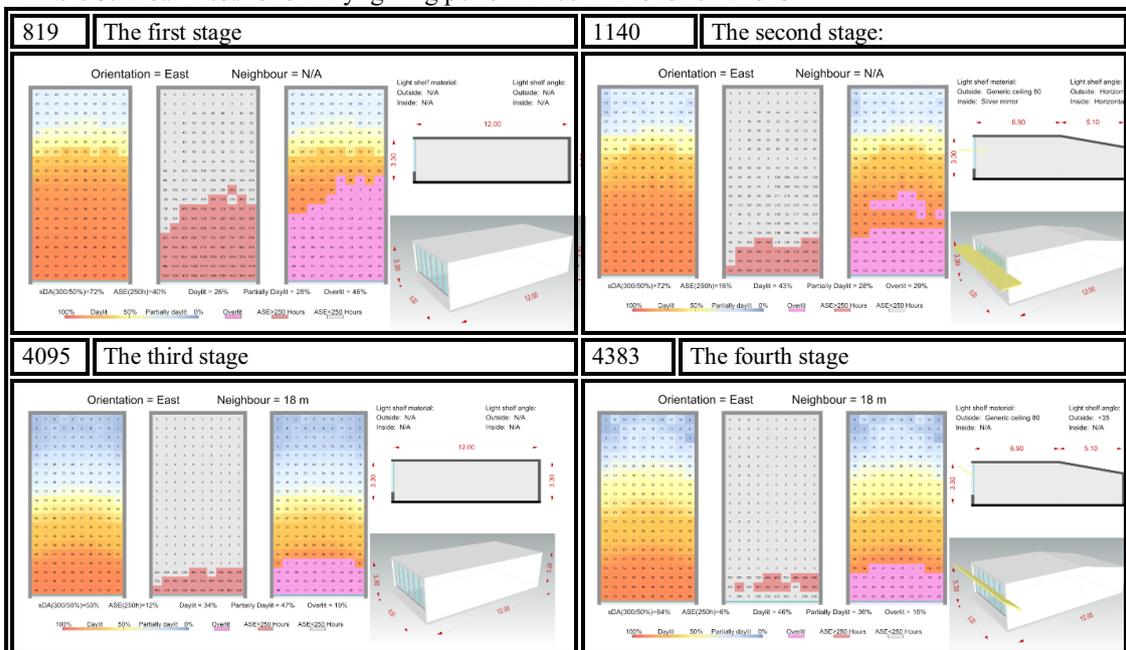
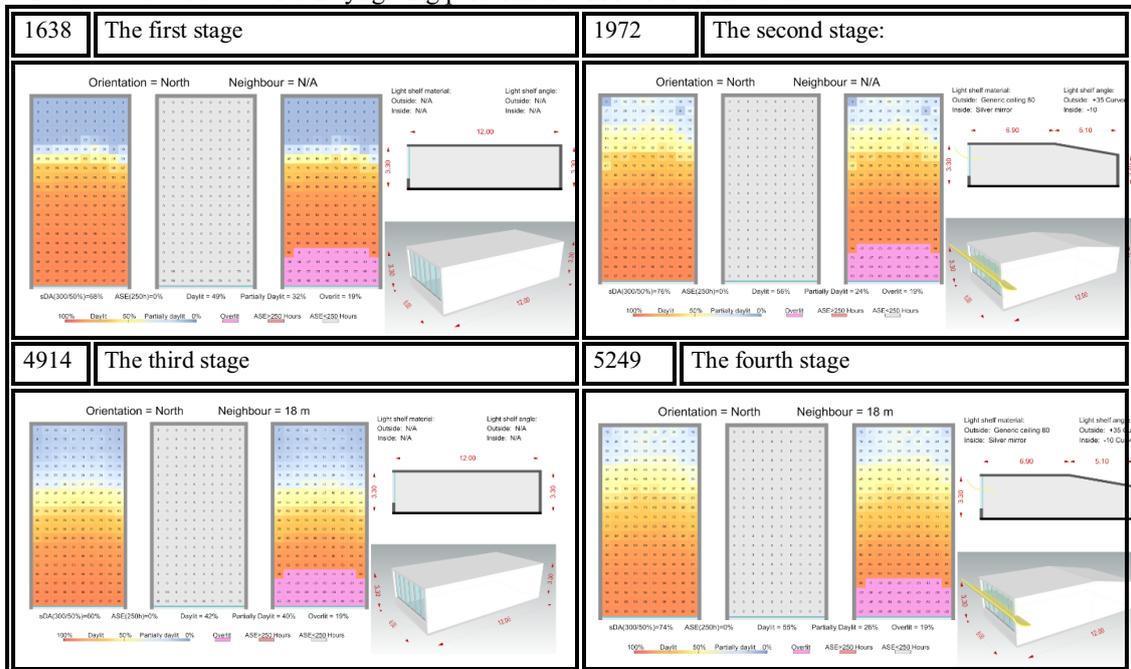


Table 6. Visual results for Daylighting performance in North orientations

2. Summary and conclusion

In the total study of the four stages of four orientations, we find that the best results in terms of Daylight performance and energy consumption were in the presence of the light shelf only without the presence of the neighbour (the second stage), but if the neighbour is found, it is better to integrate with the light shelf (the fourth stage)

As for the effect of the presence of the neighbour with the light shelf system on the total energy consumption, it is a result of energy consumption in the electric lighting loads that we resort to as an alternative to the lack of quality of the available daylight and the reason was not the change in cooling or heating loads.

We find that the arrangement of the positive effect of the presence of the neighbour is integrated with the light shelf system in the four directions as follows, firstly the northern direction, because it collects light from the south and sends it to the north, then the eastern and western direction, then the southern direction, where light is collected from the north, it is weaker.

In the end, the study determined the effect of the presence of the neighbour integrated with the presence of the light shelf system, but it is recommended that the design of the light shelf needs further development in the all orientations of achieving balance between the amount of daylight entering and blocked to reach the harmony of daylight and prevent the glare and thus reduce dependence on electric lighting during the day and thus reduce energy consumption with Achieving daylight efficiency and this is the optimum goal.

3. References

- [1] International Energy Agency. Energy Conservation in Building Community Systems (IEA-ECBCS). Annex 29/Solar Heating and Cooling Programmes Task 21, 2010.
- [2] The Effectiveness of Light Shelf in Tropical Urban Context, 2016 Floriberta Binarti, Sintia Dewi. This is an open access article licensed under the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), in the manner agreed with De Gruyter Open.

- [3] Franco I. M. Efficacy of light shelves: passive, dynamic and automatic devices related to light and thermal behavior. Presented at Thermal Performance of Exterior Envelopes of Whole Buildings, 2007
- [4] Shafaghat A., Manteghi G., Keyvanfar A., Bin Lamit H., Saito K., Ossen D.H. Street Geometry Factors Influence Urban Microclimate in Tropical Coastal Cities: A Review. *Environmental and Climate Technologies* 2016:17:61–75. doi:10.1515/rtuect-2016-0006
- [5] Kesten D., Kereci A., Strzalka A., Eicker U. A method to quantify the energy performance in urban quarters. *Indoor Air Quality, Ventilation* 2012:18(1–2):100–111. doi: 10.1080/10789669.2011.583307
- [6] Akbari H., Menon S., Rosenfeld A. Global cooling increasing world-wide urban albedo to offset CO₂. *Climate Change* 2009:95(3–4). doi:10.1007/s10584-008-9515-9
- [7] Ahmed f., Reham D., Doha m., Investigating of the light shelf system performance in the main four geographical direction in hot arid zone. *Egyption Engenering magazen* 2017.
- [8] Ahmed f., Reham D., Doha m., Aparamtric study of light shelf system performance for south orientation in hot arid zone. *Egyption Engenering magazen* 2017.
- [9] Ahmed f., Reham D., Doha m., Sophisticated Light Shelf System in South Orientation in Hot Arid Zone. *Proceedings of Science and Technolgy* , Print ISSN: 2357-0849,2018, <http://www.ierek.com/press>
- [10] IES. Spatial daylight autonomy (sDA) and annual sunlight exposure (ASE). New York (NY): IES. LM-83-12. Lighting Measurement # 83, 2012.
- [11] USGBC. LEED Reference Guide for Building Design and Construction v4. USGBC. Washington DC 2013.