



Improved Window Design in Buildings Light Shelf System to Improve Window Design in Bed Room, Residential Building , Overcast Condition in Sinai

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Abstract :

Daylighting represents an important factor in human's life , well-being and caused more productivity in space. In recent studies , advanced daylighting systems together with innovation of materials could improve illuminate level in interior space and healthy indoor environment. The aim of the current study is to improve window design in buildings according to daylighting requirements and design recommendations to enhance daylighting performance of the indoor environment , reduce energy consumption of using artificial lighting in a day , and enhance human health .

In the same context, the study focuses on using light shelf system as advanced daylighting systems. In this daylighting case study, the performance of the Illumination Engineering Society (IES) metric to Spatial Daylight Autonomy is 300/50% (SDA) , daylight availability as well as annual daylight glare probability (DGP%) not exceed 17% in winter ,were analyzed to improve daylighting distribution in bed room space in residential area. The same result has been verified by simulation . The room is 4m x 4 m area , 3 m height . A window has a minimum area opening to external wall (WWR 15%) .The room has been finished with material's reflectivity to floor is 15%, walls are 50% , ceiling 70%, door is 35% and window is 15% . Diva- plug-in For Rhinoceros was used to interface radiance and Dayism to analyze and evaluate 432 configurations to optimize cases.

This paper aims to reach healthy distributed curve of indoor environmental daylighting , (1 : 0.30: 0.10) to achieve visual comfort and task performance to man's life .The enhanced daylighting performance depends on the best position of light shelf according to overcast sky condition in Sinai.

KEYWORDS: Daylighting - Overcast sky- Advanced Daylighting Systems- Light shelf- Innovative Materials -In residential area .

1- INTRODUCTION :

Many problems in daylighting arise from its special nature ,because the window have to perform the function not only of admitting light ,but also of providing the view outside of nature scene and the desired visual contact with outside world [1] . The Function of window design to let daylight to illuminate interior building, ventilation, Protection against weather., Insulation against surrounding noise, Visual contact to outside, Safety, Privacy , perception objects of interior space [2]

Vitruvius who described the relation between window position and visual effects in the interior [3] . Mankind need their eyes to see the whole and external world for livability and adaptation in ambient nature.

Eye is like a socket ,open and close to visual performance to improve human health. The same case is found in buildings ,whose windows is also like a socket to building's spaces Which provide them with the light so that people can see interior spaces , and which provide a good ventilation for the human health requirements .

A windows are strongly favored in work places to provide daylight ,view out , ventilation , privacy , thermal protection , and improve in mood. Environmental surroundings are monitored though the window during the different times of day.

The previous studies showed the tight connection between the mood which is affected by daylight and productive work [4] .

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1-1 SIGNIFICANCE OF THE RESEARCH:

A window is decorated and functional tool in building's facade in architecture profession. It is a main important element in design process to reduce energy consumption.

A window will produce an improvement in mood seems to depend on priority of occupants , which is enhanced human health for physiologically and psychologically [5] .

Determine how our houses can help us to live in the healthy pattern of light and dark. We use windows as tools to control privacy, glare and temperature, as well as light exposures and view.

Daylighting is an important factor to enhance human health ,visual comfort and performance the illuminate of indoor environment . Daylighting availability of natural light , which is determined by latitude of building's location in Sinai as a case study , in overcast sky condition and precisely in winter season is low illuminated value. The dilemma we needs to increase daylight in quantity , quality and good distribution pattern in the rear area of room by using advanced daylighting systems (Illumination Engineering Society [IES] about task 21) [6] .

Light Shelf is effective system to reflective bright light from upper sky dome to darkness area of test room in residential area, analyze daylighting performance's (DIVA for RHINO) simulation and evaluate the output results by excel sheet to achieve optimum daylighting performance [Figure 1].

From this literature review , a research agenda is developed .

1- 2 RESEARCH OBJECTIVES:-

This paper aims at:

- 1- Used advanced daylighting systems and technology of daylighting tools to improve indoor daylight environment.
- 2- Maximize and optimization of used light shelf system with different position and materials to high reflected light rays to the rear area .
- 3- Described the light shelf's system design ,as well as, experimental assessments of performance the illuminance to quality and quantity of illuminance value in work plane.
- 4- Improved visual comfort by international ratio of daylight's distribution indoor (1 :0.30: 0.10) in near window area, middle area and the rear area in the back of room's space.
- 5- Approved the positive effective of light shelf system in daylighting performance and environmentally friendly design in residential building's design .
- 6- Improved window design by light shelf system to enhance daylighting requirements in overcast sky condition, because daylight level is low in winter season, according this result make a decision .

1- 3 PROBLEM IDENTIFICATION:-

To define the problem, we need to know North Sinai location and weather in Egypt region , thus know the main problem on it decrease lighting distribution levels in winter as low luminance condition in overcast.

In this study used technology of daylighting systems such as light shelf and changed some factors (width, structured materials, material's color, cross section, position, shape and thickness). Assumed all calculations related to improve window design, related minimum area of window area (15%) to external wall area (WWR) [7] , take into account in hot humid region and consideration of opening energy to electrical consumption.

1- 4 HYPOTHESIS:-

In residential area , This study assumed daylight in room space (4 X 4) m² in very low distribution light level in overcast sky in 21 Dec, 2016, 10:00 AM, as all calculations related to El Arish conditions. All variants of the window position in external wall (centre, aspect left and aspect right) and all variants of light shelf to window (materials, color reflection factor, width, thickness and height from window's lintel) .

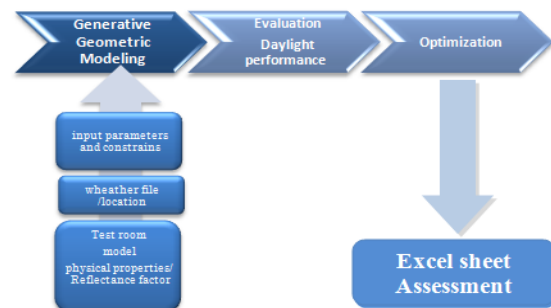


Figure 1. Diagram show the process for simulation program & assessment results

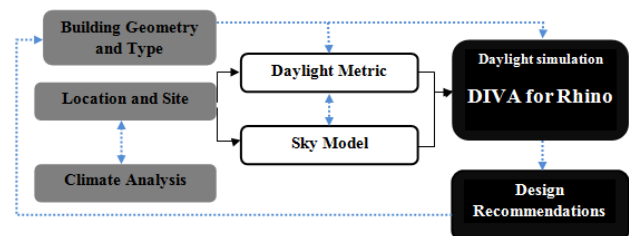


Figure 2. Diagram show the process for simulation program & design recommendations

2- METHODOLOGY AND RESEARCH TOOLS:

To practical study , light shelf system and Measurements of light shelf 's factor in bed room design (4.0x4.0) m² area by using daylighting simulation programs (Grasshopper model + Rhinoceros Generative modeler + DIVA for Rhino) from whether file and location to El Arish .

The optimum benefit of daylighting distribution to visual comfort curve with some changes to physical and architectural properties (rendered and visualization) , Thus all studies from bed room to 432 cases about left, centre and right window's position to external wall . Then choose all best case studies shown visualization and pattern

distribution of illuminated space, Then using excel sheet to results and recommendations [Figure 2].

Bed room specifications , is 4 x 4 m² area and 3.00 m height ,which is a reference room .

south facing elevation should not exceed 15% (WWR) of total area to external wall [8] .

The codes of different Illumination Engineering Societies (IES) , living room /bed room in a home is 100-300 lux (taken from code for interior lighting ,CIBSE UK ,1994) as a recommendation in daylight design needed [9] .

To improve visual indoor space , these six visual principles of light will facilitate the dialogue regarding the visual relationship between light and space such as illuminance , luminance, color , temperature , height, density, direction and distribution are empirical by nature ,but their quantifiable measure embody only a portion of their working potential together [10].

Illuminance plays critical role in our emotional response to a space (we fear of dark spaces and safety , reassurance of light spaces and faith), which is describes quantity of light or energy that when administrated at appropriate levels , which provide us visibility, safety, and emotional satisfaction [11].

A window in a previous room will admit daylight , change in quality and quantity . Un shaded window in

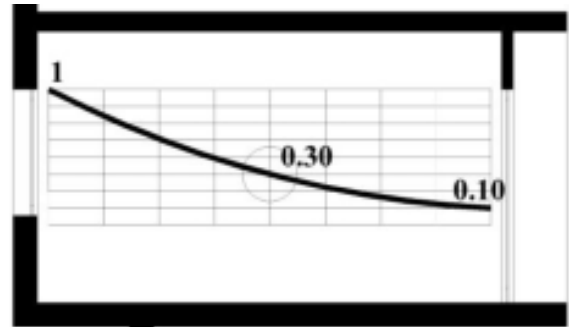


Figure 3. Shown Healthy distributed curve indoor space to comfort vision .

Daylight levels distribution measured in the indoor space depends on Lux unit in the SI unit .

Daylight regulations, daylight intensity reduced into deep area of the room ,which is out of window position [12] [Figure 3] .The human's eye adapted to visual comfort in a space to following proportion (1: 0.3: 0.1) [Figure 3] 100% in near of window , 30% in the middle and 10% in the end area of space, which didn't cause a glare in quality[13] .

Building type	Residential area	Bed room
Room components	Reflectance factor(p)	Parameters of room
Floor	15%	White tiles
Walls	50%	White matte paint
ceiling	70%	White finish paint
door	35%	Brown color related to (p)
Window	15%	White frame + clear glass
Position of window		In the Right , centre and Left of wall
Floor level		Zero level (ground floor)
Room dimensions		4.0 x4.0x 3.0 m ³
Window orientation		North (all directions)
Window to wall ratio (WWR)		15% (1.80m ²)
Width of window		1.00 m
Sill height		0.90 m
Lintel height		2.70 m
Glazing		Single clear glass 6mm
Visual transmittance VT		88%
U-Value (W/m ² K)		6.121
Light shelf system	Variable Width - depth -Height - Materials - Cross section - Micro structure additions	Out exterior wall positions
Work plane height (m)		0.60 m
Daylight grid spacing calculations		0.50 m
Sky condition		Overcast sky
Time of calculation	Winter	10:00 AM(21/12/2016)

Table 1. The main parameter of bed room space and window opening , input data for modeling and simulation.

All parameters of daylighting calculations have been written in below shape from **Grasshopper & Diva for Rhino** Simulation [Figure 4] (**computer program**) and base to follow methodology [Figure 5] to get results .

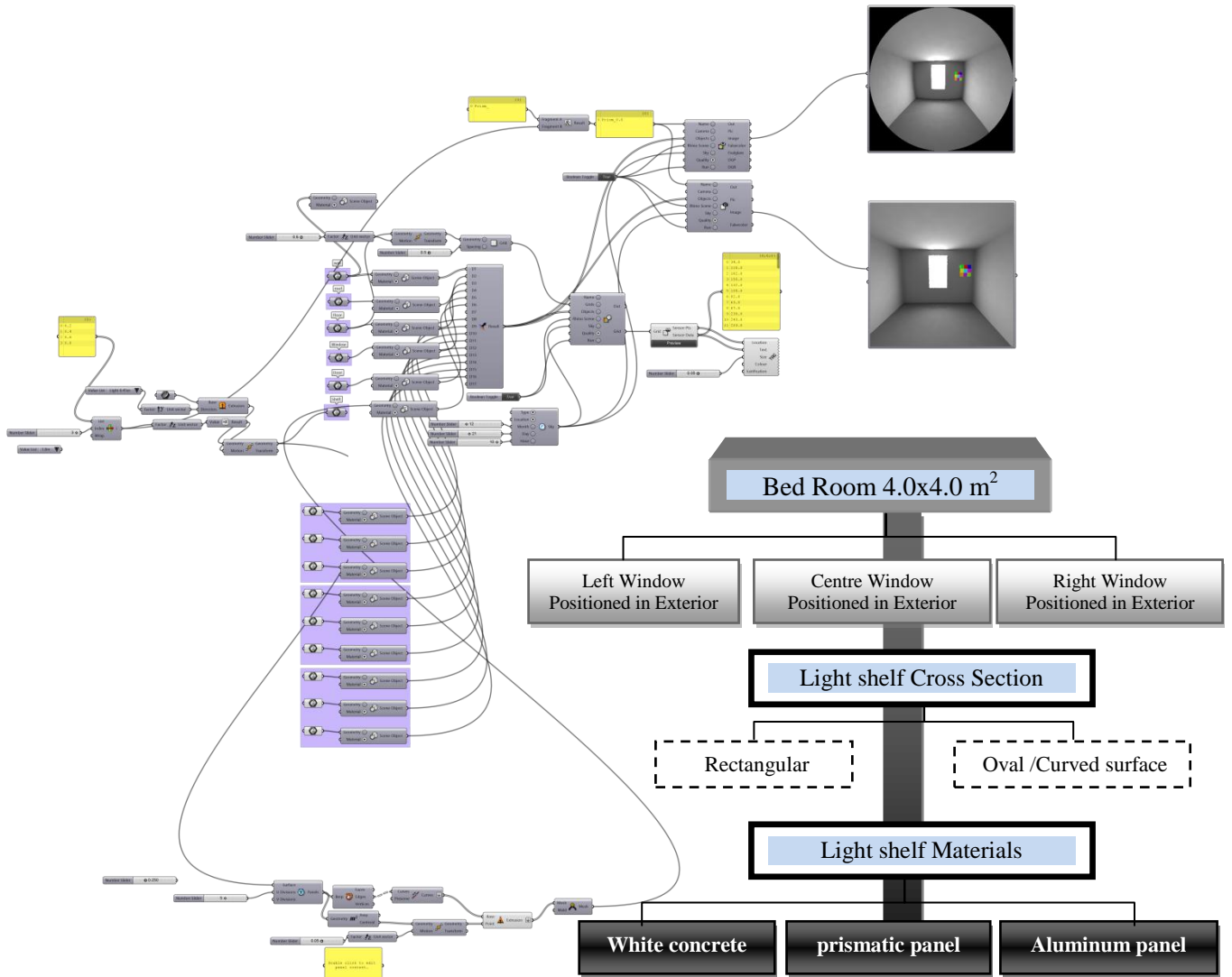
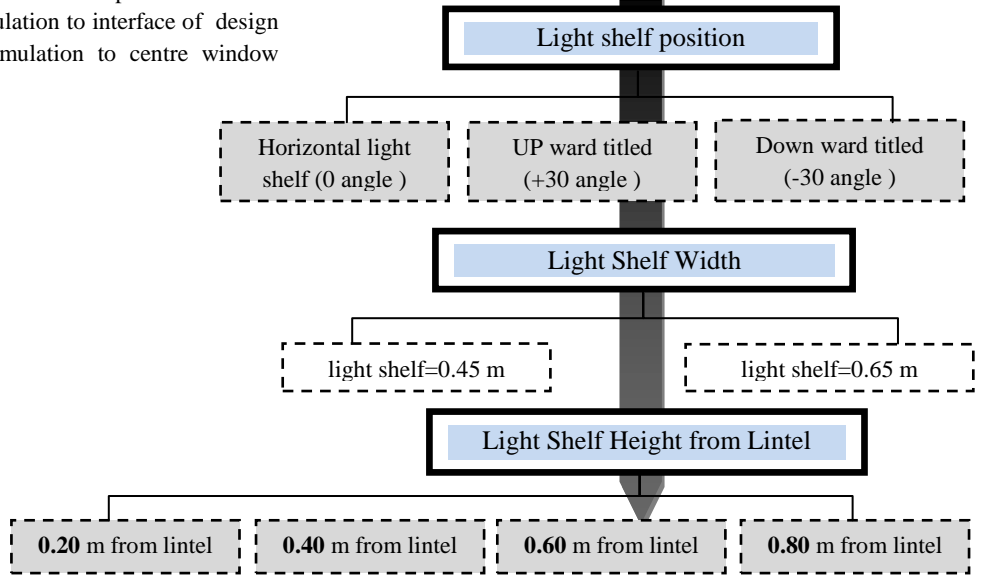


Figure 4. The main parameter for Material components and the DIVA Daylight component to run a simulation to interface of design process to get a result of daylight simulation to centre window position

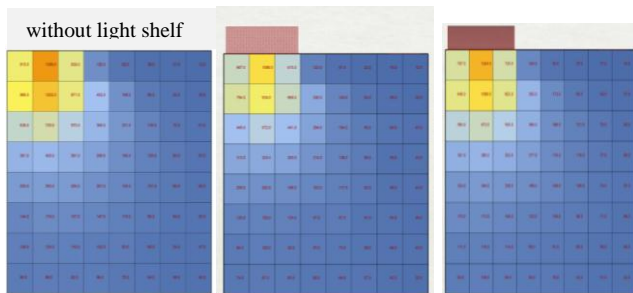
Figure 5. Diagram of methodology study of main content of variable factors affected in light shelf to room



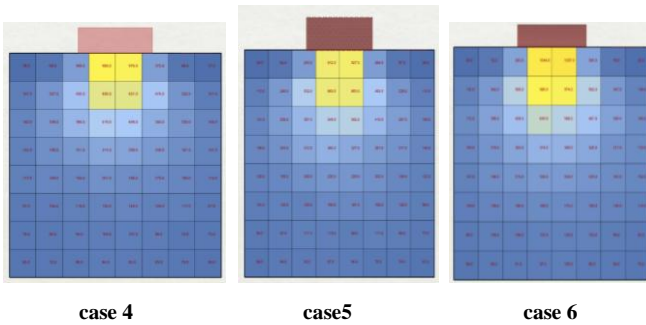
3-The Research Result :

In this stage , evaluated of light shelf system results which is extracted by DIVA simulation to achieve optimum case to improve and enhance daylight performance and visual comfort in bed room 4.0 x4.0 m² , According to variable parameters to research tools and assessments [Figure 6].

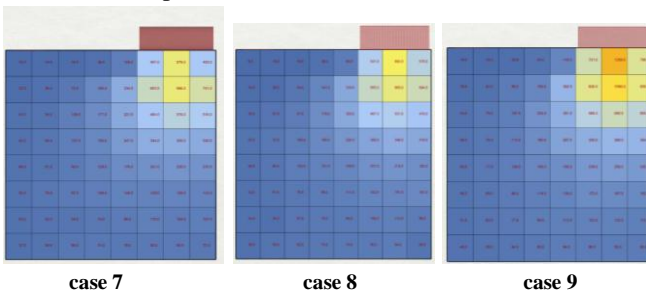
3-1 Illuminance value and daylighting distributions:



A- Illuminance levels distribution in indoor room space of aspect left window position.



B- Illuminance levels distribution in indoor room space of centre window position



C- Illuminance levels distribution in indoor room space of aspect right window position.

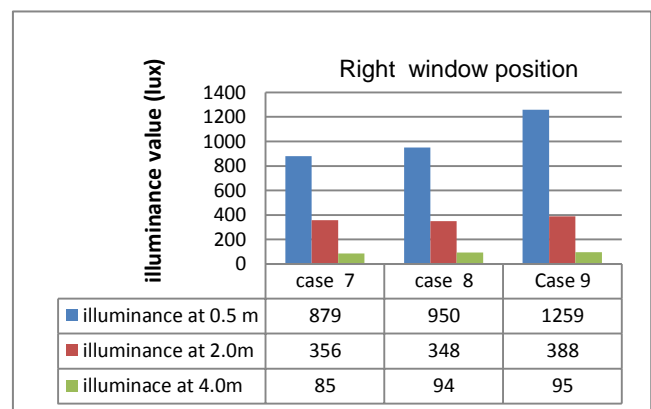
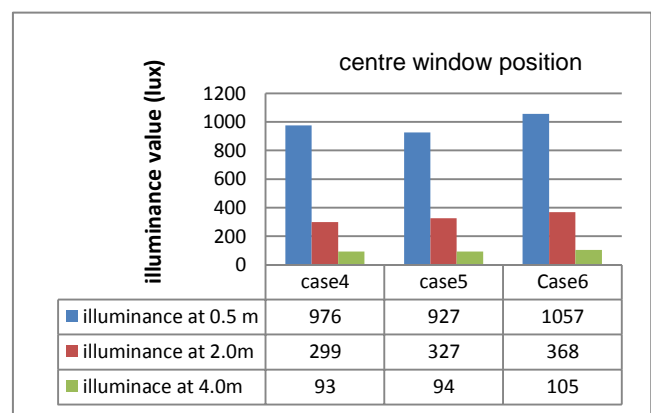
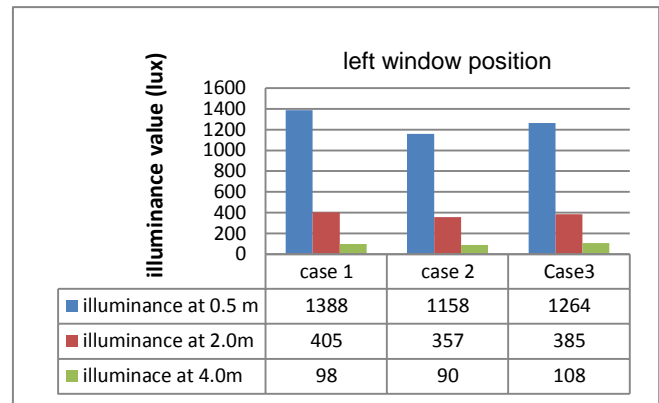


Figure 6. Shown daylight analysis - daylight illuminance map in work plane at 0.60 m height from floor in bed room plan

3-2 Daylight Glare Probability (DGP%):

According to Daylight Glare Probability (DGP) is intolerable category larger than .45, perceptible category .35 to .40 , and imperceptible category less .35 ,which is evaluation method suggested , according to user assessment [14] [15] .

Analytical imperceptible Glare at Fish- Eye camera's view for a sitting positioned at 2.0 m distance from the window, which is standard Daylight Glare Probability

(DGP) not excesses to 17% ,when exceed over ratio is a problem need to redesign .

Glare considered an enemy and dilemma to lighting designer , which is a vital issue for building's occupants due to visual discomfort and user acceptance of luminous indoor environment and caused eye fatigue .

Optimizing performance of light shelf by computer assessment of daylight performance, which remind it-

in next[Figure 7] with final findings and recommendations .

All results are approved imperceptible glare not exceed 17% , which is a bright area of upper sky dome in zenith three time from horizon [16] .

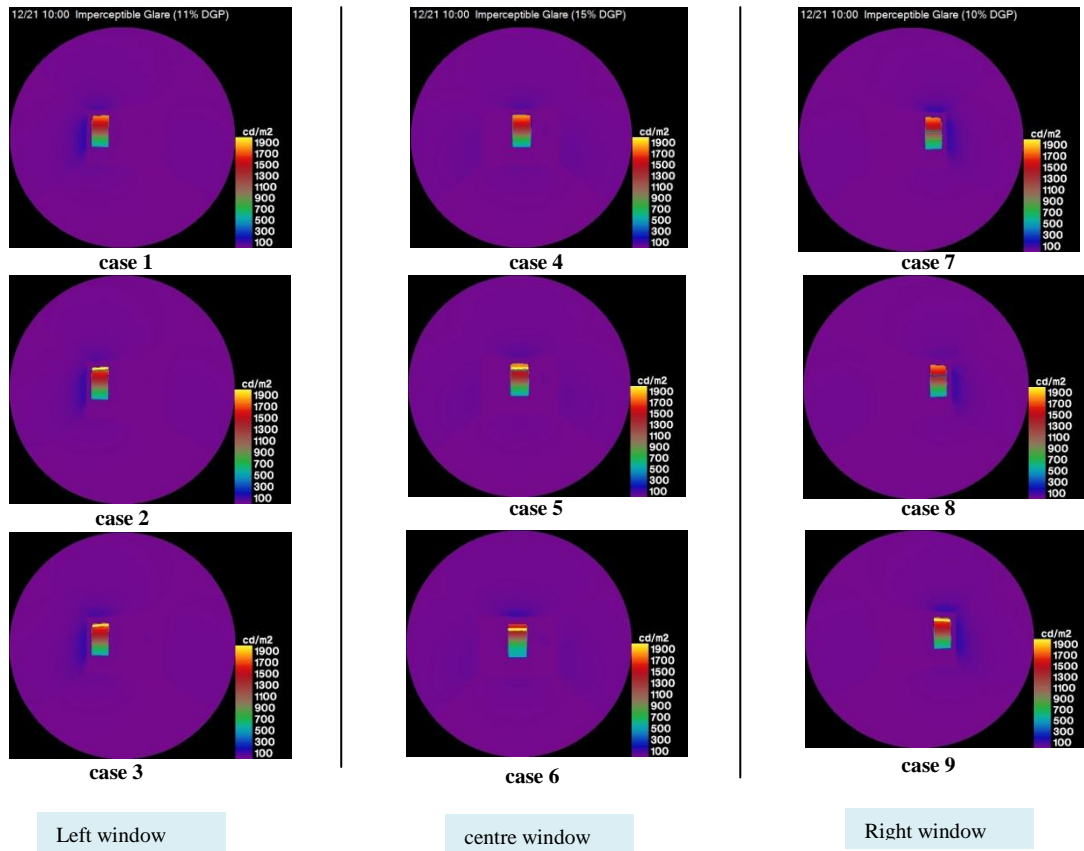


Figure 7. Analytical imperceptible Glare at Fish- Eye camera views for a sitting position at 2 m distance from the window.

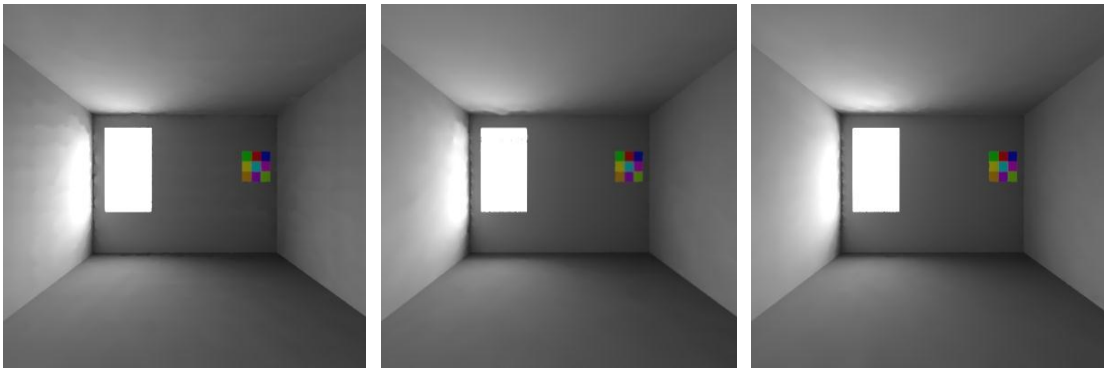
Case NO.	Position of window			Light shelf material			Light shelf position angle	Light shelf position from lintel distance	Light shelf width	Light shelf thickness	Light shelf cross section		Day light values			Day/light Ratio evaluated	DGP%
	Left	Centre	Right	White concrete	Prismatic	Aluminum					Rectangular	Oval	0.5m	2.0m	4.0m		
Case 1							without light shelf						1388	405	98	1: 0.29 :0.10	11
Case2							Upward+30°	0.2	0.65	0.02			1158	357	90	1: 0.31 :0.10	16
Case3							Upward+30°	0.2	0.45	0.02			1264	385	108	1: 0.30 :0.18	17
Case4							Horizontal 0°	0.2	0.45	0.10			976	299	93	1: 0.31 :0.10	15
Case5							Upward+30°	0.4	0.65	0.02			927	327	94	1: 0.35 :0.10	13
Case6							Upward+30°	0.4	0.45	0.02			1057	368	105	1: 0.35 :0.10	17
Case7							Horizontal 0°	0.8	0.45	0.10			879	356	85	1: 0.41 :0.10	10
Case8							Horizontal 0°	0.6	0.45	0.02			950	348	94	1: 0.37 :0.10	14
Case9							Upward+30°	0.2	0.45	0.02			1259	388	95	1: 0.31 :0.19	17

Table 2. Shown the results of best cases using light shelf system and its parameters.

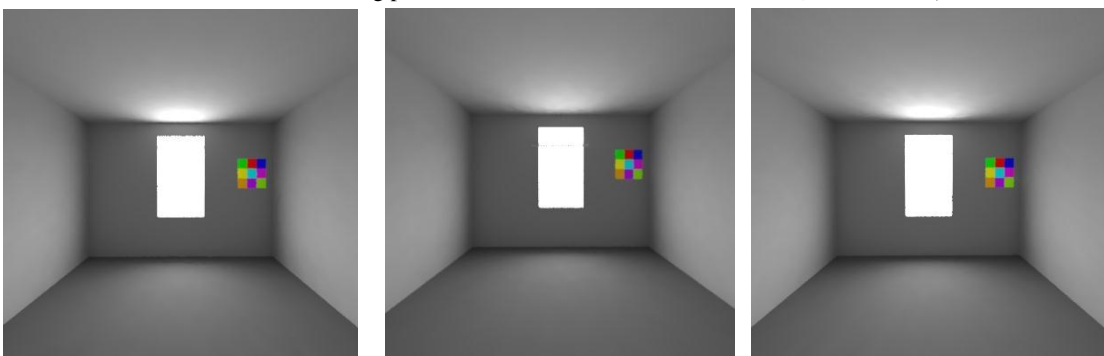
Case2 The best position of light shelf

It used visual tricks in colored picture in front wall ,which is a man entered the interior space as following [Figure 8]

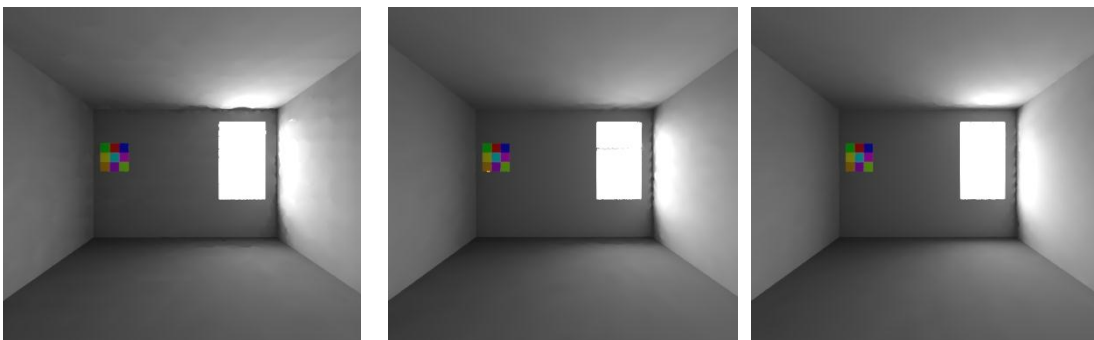
3- 3 Render and visualization:



A- Rendered camera views for a sitting position at 2 m distance from the window (winter season) in left window



B- Rendered camera views for a sitting position at 2 m distance from the window (winter season) in centre window



C- Rendered camera views for a sitting position at 2 m distance from the window (winter season) in right window

Figure 8. Diva for rhino rendered camera views for a sitting position at a 2 m distance from the window at north (winter)

Daylighting design Combines art and science, which internally images tend to bluish rendering in overcast sky ,whatever used a visual trick to catch entered person to bed room by nameplate by small colors , according to (Danish research) "A film about light, architecture and health" [17] .

Color evokes personal emotional reactions, which are highly individual and need special treatment to enhance daylight according to the internally reflected components and the requirements of the brightness pattern of visual field [18] .



Figure 9. Rendered views of light illuminance distribution A- Equinox. in 12:00 Pm B- winter solstice, which is a film about light, architecture and health.

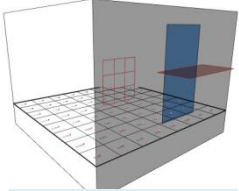
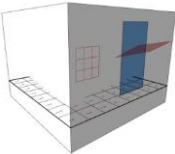
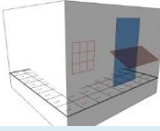
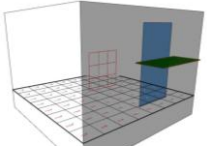
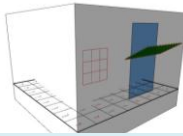
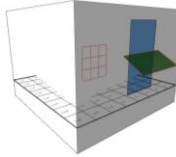
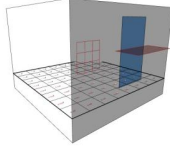
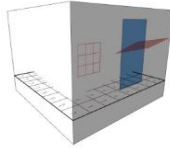
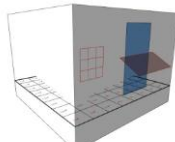
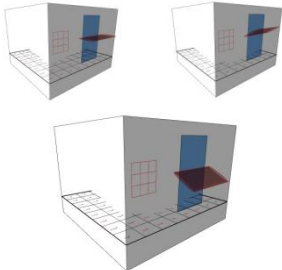
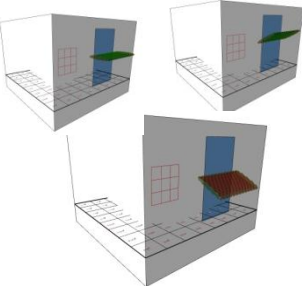
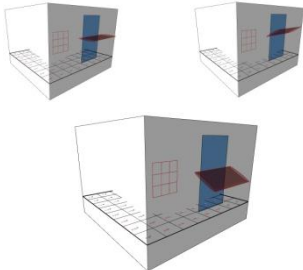
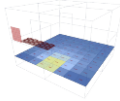
Light shelf properties :		
White concrete	Prismatic panel	Aluminum sheet/panel
Color : white Reflection : 90% purely diffuse reflector with a standard ceiling reflectivity of 90%	Color : no color - mirror sheet Reflection : 95%	Color : silver - metal Sheet Reflection : 95%
Straight cross section		
 <p>Horizontal position</p>  <p>Upward position</p>  <p>Down ward position</p>	 <p>Horizontal position</p>  <p>Upward position</p>  <p>Down ward position</p>	 <p>Horizontal position</p>  <p>Upward position</p>  <p>Down ward position</p>
Oval cross section		
		
Illuminance level /work plane		

Table 3. light shelf properties

4-The Research Conclusion:

- 1- Daylighting is important in life of human and well-being in environmentally healthy indoor spaces .
- 2- Window design with variable position in external wall has been various solution of daylighting system to enhance daylight performance .
- 3- know the best position of vertical window at minimum area (WWR%) with suitable light shelf system by using computer assessment of application (DIVA plug-in for Rhinoceros program) simulation according to daylighting performance [Table 3].
- 4- The best solution of bed room area (4x4) m² according to test performance simulation from 432 cases by using excel sheet evaluation is a left window position , prismatic light shelf material, put Upward+30° position, fix at 0.20 m from lintel, oval cross section's light shelf, and 0.65 m width (case 2) [Table 2] .
- 5- When we change the color of the room painted, that affected on reflectance factor is changed , thus we need to choose a suitable of light shelf systems.
- 6- Lighting designer has seen architectural spaces with his artistic attitude by experience of scientific attitude, methodology of lighting specifications and good rendered image of space
- 7- Each architect should know software programs to simulate a daylighting performance by DIVA plug-in for Rhinoceros program , and to learn code of daylight and good illuminance ratio (1.0 :0.30 : 0.10) indoor spaces.
- 9- Light shelf has two cross section which rectangular cross section and oval /curved surface ,there are three type of material input to simulation program as a parameters to analysis (white concrete ,prismatic panels, and Aluminum sheet) with various thickness to improve daylight performance .
- 10- Light shelf is Influential factor to increase internally reflectance components, especially in the rear area at the room and decreased lights in near area of window.
- 11- Light shelf near window's lintel height was reflected daylights to ceiling surface then the rear area of back wall such as .20m more than .80m .
- 12- The designer had a three chooses to select a material's of light shelf according to his requirements of design process, which technologies of daylight system permitted to use innovative materials and structure properties to be fixed in window (Prisms , Aluminum and Acrylicetc)
- 13- Light shelf should to be clean and not dusted to reflect more light to room depth and need small holes to Rain water drainage.

5- Acknowledgement:

This work used to scientific research in under heading " **Improved Window Design In Buildings**" at port said university , and using advanced program to daylighting simulation "**DIVA-Plug in for RHINO &Grasshopper**" as all rights reserved .

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