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Comparative Analysis of Day lighting and Artificial Lighting in Library Building; Analyzing the Energy Usage of the Library

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ABSTRACT: Day lighting has often been recognized as a useful source of energy savings and visual comforts in educational spaces. Occupant in building needs a very good lighting in their work environment. Natural lighting helps students and other workers to be more comfortable and productive. Effective use of natural Day lighting in library buildings has the potential to maximize the benefits of visual comfort, reduce energy usage, and achieve a qualitative building environment in terms of thermal comfort for the building users. Even though the number of possible alternatives that can be generated for integrating day lighting in buildings architecturally is challenging.
Allowing direct day light into building space will also affect the thermal comfort of the space. Buildings with big window opening of glazed surfaces also affect the thermal and visual discomfort, because of the large income of solar radiation into the building.
This paper study the use of day lighting design to improve visual comfort, energy efficiency and thermal comfort of Library located at Eastern Mediterranean University, Famagusta. North Cyprus (OZAY ORAL LIBRARY-EMU). The natural day lighting performance of this base case study was evaluated in terms of daylight factor, illuminance, room depth and glare index. It has been found that the day lighting performance for library buildings is quite effective in order to achieve a qualitative and comfortable building. In order to gain more ideas about this study, data analysis and computer simulation are taken into consideration in order to make the comparative result of the study. The use of computer package simulation namely RELUX was used for the study.

KEYWORDS: Day lighting, Artificial Lighting, Energy Saving, Visual comfort, Thermal comfort.

I.INTRODUCTION

Day lighting is used by occupant or building users for the comfort of their lifetime living in the building. As humans, our visual comfort and phycology is adjusted by developing to natural day light and therefore we need it as a basic alternative in our building during the day hours [1]. Its dynamical change is stimulus for our day and night cycle and it can control our mood and health respectively. Minimum lighting requirements for visual performance described earlier refer to artificial lighting and day lighting as well. improved lighting conditions for higher visual comfort and performance can be reached by integrating the design of day lighting without increase of energy use consumption and CO2 emission of the built environment. The view from the indoor to the outdoor is an important and significant requirement for natural day lighting design as well.
It is significantly important to consider lighting while designing indoor spaces. In educational spaces, it is even more significant to pay considerations to light, especially natural day light, due to high level of visual activities [2]. Activities in dark environment cause psychological, physical and visual problems for users in educational spaces. Also, artificial lighting is one of the highest electricity energy consumption. Therefore, reducing the use of artificial lighting in an area in which it is saving energy consumption is very important [2].
There has been much discussion regarding the metrics used to specify, measure and calculate lighting levels in building [1]. Effective use of Day lighting in buildings has the potential to maximize the benefits of natural day lighting and visual comfort, reduce energy usage, and achieve a qualitative building environment in terms of thermal comfort for the building users. Even though the number of possible alternatives that can be generated for architecturally integrating day lighting in buildings is challenging. To acquire a good energy efficient performance in buildings, it is necessary to assure the environmental comfort for users, without the comfort of users the solutions are not useful.

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In this research paper the aims and objectives of the study is to improve the visual and thermal comfort of library and educational environment, reducing energy uses of artificial lighting in this environment and Integrating the use of day lighting and artificial lighting system.

Making full use of daylight, and decreasing the energy consumption while maintaining an adequate illuminance environment and achieving the occupant needs at the same time when designing a building is a constant challenge for building researchers and architects. There are various strategies for include day lighting and artificial lighting integration through lighting dimming controls, and the integration of shading devices to improve the overall energy performance and enhance the illuminance levels for visually comfortable environments.

A. **daylight factor** (DF) is the ratio of the day light level in an indoor environment to the light level of the outdoor environment [4]. It is mathematically defined as:

DF = (Ei / Eo) x 100%

- Ei = illuminance due to daylight at a point on the indoors working plane,
- Eo = simultaneous outdoor illuminance on a horizontal plane from an unobstructed hemisphere of overcast sky.

To calculate the illuminance due to daylight at a point (*Ei)*, requires knowing the amount of outdoor light received inside of a building [4]. Light can reach indoor space through a translucent window, roof light, or other open building element (doors) via three paths:

- Direct light from a patch of sky visible at the point considered, known as the sky component (*SC*),
- Light reflected from an exterior surface and then reaching the point considered, known as the externally reflected component (*ERC*),
- Light entering through the window but reaching the point only after reflection from an internal surface, known as the internally reflected component (*IRC*).

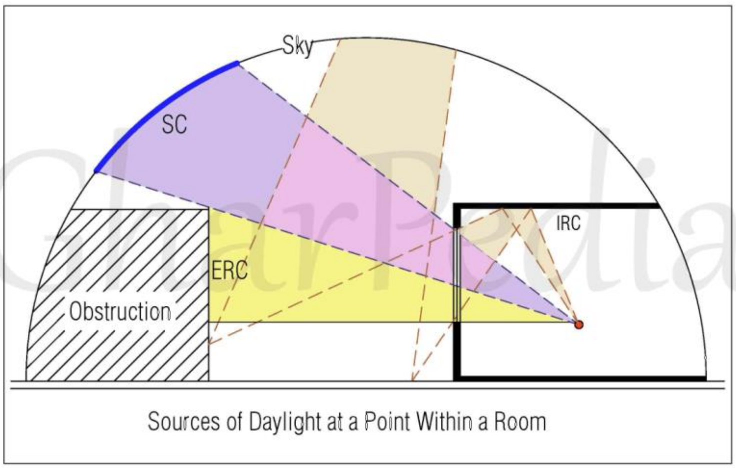

Figure: Source of Daylight into a building space.

Source: https://gharpedia.com/wp-content/uploads/2018/08/010215010016-01-SC-IRC-ERC-Daylight-Factor.jpg

The sum of the three components gives the illuminance level (typically measured in lux) at the point considered:

Illuminance = SC + ERC + *IRC*

The daylight factor (DF) can be enhanced by improving and increasing the direct Skylight SC (placing a glazed window to see direct sky than adjacent buildings), increasing and improving the Exterior Reflected Surfaces ERC (by painting surrounding buildings surfaces white), and also increasing and improving the internal surfaces IRC (for example by using light colours for the internal surfaces). In most indoor spaces, the ceiling and floor always have fixed colour, and much of the walls are covered by furnishings materials [4]. This gives less variability in changing the

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design of the daylight factor by using different wall colours than might be expected meaning changing SC is often the key to good daylight design [4].
Architects and engineers use daylight factors (DF) in architecture and building design to integrate the internal natural lighting levels as perceived on working planes or surfaces. They use this information to determine if light is sufficient for occupants to carry out normal activities [4].
Illuminance is 'The level of light on a surface; measured in lux (lx). Previously called the illumination value [5]. It can be used as a reference measurement of the performance of a lighting system as related to the activity.' [5]. It is measured in lux (lx), the '...SI unit (the International System of Units) of illuminance or amount of light on a surface. One lux is equal to one lumen per square metre (lm/m^2)' where a lumen (lm) is the '...SI unit of luminous flux, describing the quantity of light emitted by a lamp or received at a surface.' [6]. Average illuminance is 'The illuminance averaged over a specific area. In practice, this may be derived either from an average of the illuminances at a representative number for points on the surface, or from the total luminous flux falling on the surface divided by the total area of the surface'[6]. Maintained illuminance is 'Illuminance at the time when maintenance is expected to take place. Most values of illuminance that are quoted as applicable to a store, e.g 500-1000lx, refer to this value. The time taken to reach the maintained illuminance level would depend on the lamp types and application' [5].
Table 1:Common outdoor light levels at day and night:

Condition	Illumination	
	(lm/m^2)	(lux)
Sunlight	10000	107527
Full daylight	1000	10752
Overcast day	100	1075
Very dark Day	10	107
Twilight	1	10.8
Deep twilight	0.1	1.08
Full moon	0.01	0.108
Quarter moon	0.001	0.0108
Star light	0.0001	0.0011
Overcast night	0.00001	0.0001

Source: www.engineeringtoolbox.com/light-level-rooms

The outdoor light level is approximately 10000lux on a clear day. In a building in the area closest to the windows the light level may be reduced to approximately 1000lux. In the middle area it may be as low as 25 - 50lux. Additional lighting is often necessary to compensate low levels. Earlier it was common with light levels in the range 100 - 300lux for normal activities. Today the light level is more common in the range 500 - 1000lux - depending on activity. For precision and detailed works, the light level may even approach 1500 - 2000lux.

II. LITERATURE REVIEW

Stemming from the first times of the eighteenth century, artificial light-weights have forever competed a supporting role to natural light. However, once this period, there appeared to be a reversal within the roles of artificial and natural lights in buildings when advancements in technology created it possible to make an unlimited majority of artificial lights like fluorescents and electrical bulbs. Now, because of the exposure of designers to ideas of sustainability and green design, natural lights are taking the lead role in modern styles and constructions. To further aid the conception of sustainability, in line with [3], a retrofit strategy that involves the combination of photovoltaic panels into the shape of a structure has been utilized in numerous variations of the star tube daylighting device.
Daylight is incredibly necessary in building spaces because it has been connected to high levels of productivity, higher moods, reduced absence, higher job satisfaction, improved assimilation ability for college students and improved aesthetic values of buildings [3]. the results of daylight on people are numerous and human responses to daylight ought

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to not be neglected as a result of architectural styles aim at creating the occupants of a space comfortable thermally as well as visually [3]. Represented the advantages that are derived from daylighting by people. Daylighting provides people with a “favourable perception of colour”. In different words, daylighting provides users of an area with communicatory and engaging visual qualities.
The performance of staff is increased because of enough daylighting in a workplace house, allowing staff to experience visual comfort. Cooling loads are reduced considerably through the utilization of effective daylighting ways. using large windows in a building space helps to bring in most daylight however most of the time, this may prove to be a large disadvantage due to the excessive heat losses or gains by the building [3].

A. IMPACT OF DAYLIGHT ON HUMAN PERFORMANCE IN LIBRARY BUILDING

Students' performance is considerably related with satisfaction with educational environment. one of the foremost important environmental factors in library building is lighting. Daylight controls the body's biological time by touching the retina, impacting the neural structure organ and controlling hormone secretion. endocrine (as sleep hormone) levels are reduced within the light and it's secreted in the dark [1]. One study has shown that there's not enough daylight in library building and blood hormone levels of students in these library are most beyond those in areas with sensible lighting. This issue causes drowsiness among students and undermines their performance [1]. On the other analysis, studies have demonstrated that hormone suppression values calculated for the electrical light compared with natural light are the lower and so this lighting system doesn't appear to supply enough information to the circadian system [1]. during this research, the obtained results showed that not only the luminance but additionally light spectral power distribution of {the light the sunshine} received by eyes played a major role in circadian response and spectral characteristics of internal and external surfaces influenced light spectral power distribution [1]. Incidence of sleepiness conditions in library and ateliers caused by low-light was reported within the measured areas of this text [1].

B. APPROPRIATE DAYLIGHT CONDITIONS AND ITS EFFECTIVE FACTORS IN LIBRARY

Daylight is the combination of sunlight, skylight and reflected light from the ground [1]. Factors affecting the amount of daylight in buildings include latitude and longitude, building form, building location, landscaping, building orientation, building usage, joinery construction materials of interior walls and exterior facades, window size and position and window components (such as glass ratio, glazing materials and shading devices) [16]. The amount of daylight in interior spaces can be measured by calculating method of daylight illuminance of space (in Lux and Foot Candle units) and daylight factor (DF).
Daylight factor is the ratio of indoor illuminance and outdoor illuminance, which can be measured for a specific point or for an average of a space [18]. In more accurate definition, Daylight factor is the "ratio of the illuminance at a point on a given plane due to the light received directly or indirectly from a sky of assumed or known luminance distribution, to the illuminance on a horizontal plane due to an unobstructed hemisphere of this sky, excluding the contribution of direct sunlight to both illuminance" [19]. Unlike the illuminance of daylight, this percentage is constant on different days during the year. The glazed area of the window, diffuse transmittance of the glazing material, vertical angle subtended by the sky that is visible from the centre of the window, total area of room surfaces including floors, ceilings, walls and windows, area-weighted average reflectance of the interior surfaces (including glazing) are known as effective factors in daylight [20]. With regard to the amounts of reflectance of the interior surfaces, to minimize influence of thermal energy and also take advantage of natural light, it is recommended to use joinery materials with high maximum reflection coefficient [21].
In the measured spaces of this article, dark coloured ceilings were used in many places. Also, depth of rooms (deeper rooms have a poorer daylight factor at the back of the room compared with the front), height of window head (depth and amount of daylight increase with increasing height of windows. Also, the higher the window head, the deeper the penetration of day lighting would be), shading devices (interior and exterior shading devices and solar control glazing) and glazing type are the factors affecting the amount of daylight [22].
The standard amount of daylight factor is not the same for all building types and each building has its own value [1]. Overall, if rate of daylight factors is below 2%, the space appears to be dark and depressing and often requires use of electric lighting during daytime and electric lighting dominates daytime appearance. If value of daylight factor is between 2% and 5%, windows have provided considerable daylight, but sometimes supplementary electric lighting is still needed; if daylight factor is 5% or more, there would be enough light into the room and daytime electric lighting is rarely needed [23, 24]. Also, there are standard criteria for the amount of daylight factor based on empirical and

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mathematical studies. Table 2 shows the appropriate amount of daylight factor for education spaces. Also, appropriate illuminance for learning spaces is demonstrated in terms of Lux in Table 3.

Table 2: Proper daylight factor in educational spaces

SPACE TYPE	AVERAGE DAY LIGHT FACTOR (%)	MINIMUM DAY LIGHT FACTOR (%)	MEASUREMENT HEIGHT
Classroom	5	2	Desk
Libraries	5	2	Desk
Assembly hall	1	0.3	Working plane
Corridor & stairs	2	0.6	Floor and tread
Art room	5	2	Desk & Easels

Table 3: Proper Illuminance in educational spaces.

Standard maintained illuminance (lux)	**Space type**
300	Classrooms
500	Library
500	Lecture hall
500	Black board
500	Art room
750	Technical drawing room
200	Entrance hall
100	Circulation area, corridor
150	Stairs
200	Student common room, assembly hall

In addition to the good amount of natural light, direct sunlight should be controlled to stop glare, overheating and disturbing thermal comfort in spaces, especially during the summer. Also, providing good visual contact with the outside and reflection coefficient of interior surfaces are important [25]. Figure 3 shows appropriate reflection factors for educational spaces. The appropriate amount is 70 to 90 percent for ceilings, 30 to 50 percent for floor, 40 to 60 percent for walls and over 20 percent for educational boards [15].

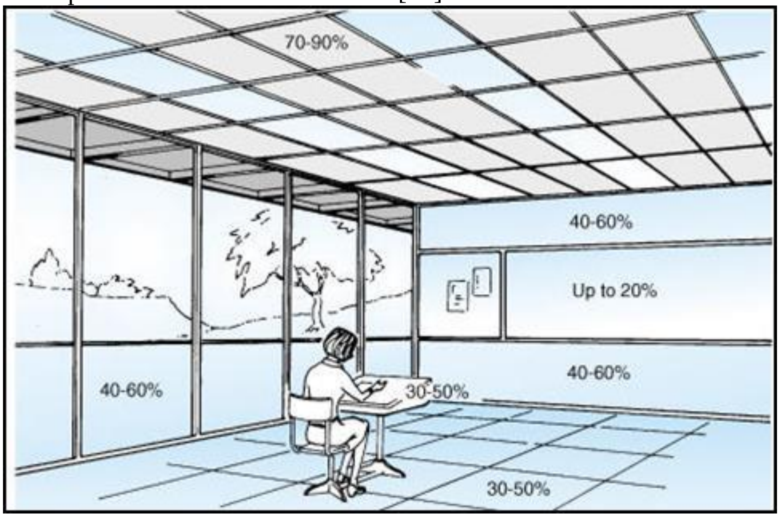

Figure: Appropriate reflection factors for educational spaces [1]

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III. METHODOLOGY

In this study, conditions and characteristics of good daylight in educational facilities were briefly studied relying on library resources and documents. In order to evaluate student performance, besides investigating the factors such as feeling drowsiness, fatigue and weary in the library. Then, quality of daylight was evaluated in the library building in measured spaces of this article by computer simulations using RELUXDESKTOP software (A high performing application for simulation of day light and artificial light. It also gives you efficient support on the research). Finally, strategies were provided for improving quality of daylight in this Library building. So, the research method of this article is descriptive-analytic and computer simulations were used in the case study (0ZAY ORAL LIBRARY – EMU). Moreover, objective observations were conducted to confirm some results of the survey (for example, the signs of drowsiness states, fatigue and weary among staff and students) and find the tendency of students and staff members to use the library with natural or artificial lighting.

A. CASE STUDY; EASTERN MEDITERRANEAN UNIVERSITY LIBRARY (OZAY ORAL LIBRARY)

This work shows the EMU library study at EMU Campus located in Famagusta, North Cyprus.Eastern Mediterranean University Library supports the education and research activities of the university with its materials and information services [13]. The Library houses a collection of more than 150,000 books, thousands of audio-visuals and around 300 periodical subscriptions.The library has 6,600 m² of space. The place has a sitting capacity of 900 seats. In addition to this, in the library there is a multi-purpose auditorium with 240 seats; an audio-visual room with a 60-seat capacity; and a special exhibition hall for different kind of exhibitions [13].

Figure: Ozay Oral Library EMU
Source: Google Map

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Figure: EMU library
Source: https://library.emu.edu.tr/PhotoGalleries/library/library-02.jpg?RenditionID=7

B. GEOGRAPHICAL DESCRIBTION OF THE SELECTED SITE

The selected building of this study (OZAY ORAL LIBRARY EMU) is located in North Cyprus(35^{o} Latitude, 33^{o} Longitude). North Cyprus features a hot and humid climate. It can be generally described as mild in the spring and autumn, hot and dry in the summer, and cold in the winter. Figures below shows cloud cover types of Famagusta.

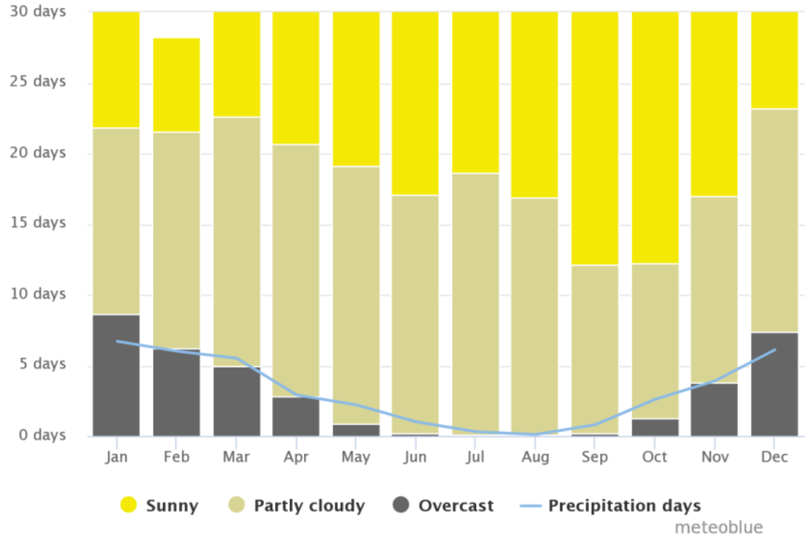

figure: sunny and cloudy day graph of Famagusta
source: https://www.meteoblue.com

The graph shows the monthly number of sunny, partly cloudy, overcast and precipitation days. Days with less than 20% cloud cover are considered as sunny, with 20-80% cloud cover as partly cloudy and with more than 80% as overcast.

Considering the expressed content, appropriate lighting levels must be provided for libraries and other educational buildings and spaces. For this purpose, natural lighting (which is more appropriate) and artificial lighting can be used during the darker day hours. On the other hand, using daylight in space types that are used during the day (such as reading spaces) could save energy by reducing use of electric light sources. In the case study of this article, electric lighting along with daylight sources was used in the library all day long, which showed that daylight was not sufficient in those spaces (reading Spaces).

According to these points in this article, the case study (OZAY ORAL LIBRARY EMU) spaces were investigated, examined and modelled to answered the following questions:

1. What's the difference between student performance in library with artificial lighting with their performance in library and other educational spaces with appropriate daylight?
2. What factors have caused favourable or unfavourable daylight quality in these spaces?
3. Which architectural approaches could reform unfavourable factors of daylight quality?
4. How much daylight illuminance is sufficient for student’s tasks in library building and other educational spaces?

The results could be useful for physical reformation of the implementation examples and also in new designs.

Figure: Ozay Oray Library interior pictures showing the skylight, window parameters, and the use of artificial lighting.
Source: By Author

The measured spaces of this study were classified into two groups in terms of their location, lighting orientation and common characteristics (space facing the north and the spaces the south). In Table 4 and figure below, variety of the library, spaces are classified based on their location and average spatial dimensions and window areas are demonstrated. In order for more accurate simulation of the library space, in addition to the area and height of windows, distance of bottom of windows from the floor was considered. Daylighting measurements and simulations indicated that, at the same height of the window, the windows near the ceiling had better performance in daylighting because of the reflected daylight from the ceiling (bright coloured ceiling). These dimensions will be used in computer modelling as well.

Table 4: Average spatial dimensions, window size (by the authors).

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Space Types	Average floor area of space (m^2)	Height of room (m^2)	Average window area (m^2)	Window Height (m^2)	Window height from floor (m)
North/west facing spaces	200	4.0	2	2	0.9
South/east facing space	200	4.0	2	2	0.9

C. COMPUTER SIMULATION PARAMETERS

Computer simulation modelling was done to check quality of the natural day lighting based on daylight factor and illuminance of the spaces, (in terms of Lux) on 10 days of year randomly (1, 12 and 17 days of every month of the year) in RELUX simulation software based to the parameters presented in Table 4 above, orientation of the spaces, geographical location of city of Famagusta (35^o Latitude, 33^o Longitude), joinery materials of interior space surfaces and glazing type (approximately 70% transparency), existing skylight in the middle of the library building, surrounding structures and obstacles around the library building are all used for the simulation calculation. Illuminance analysis and calculations are done at 10:30 am of the days (this time was the default of the RELUX Simulation software. In addition, the library is in use at this time of the all days except holidays and weekend. In addition, there was a natural day lighting in the space at this time on all the days of the year except during the cloudy and dusty days of the year and this time was not part of critical times in terms of the solar radiation). In addition, effect of influential factors in daylight was evaluated and finally causes of necessary or undesirable daylight were investigated.

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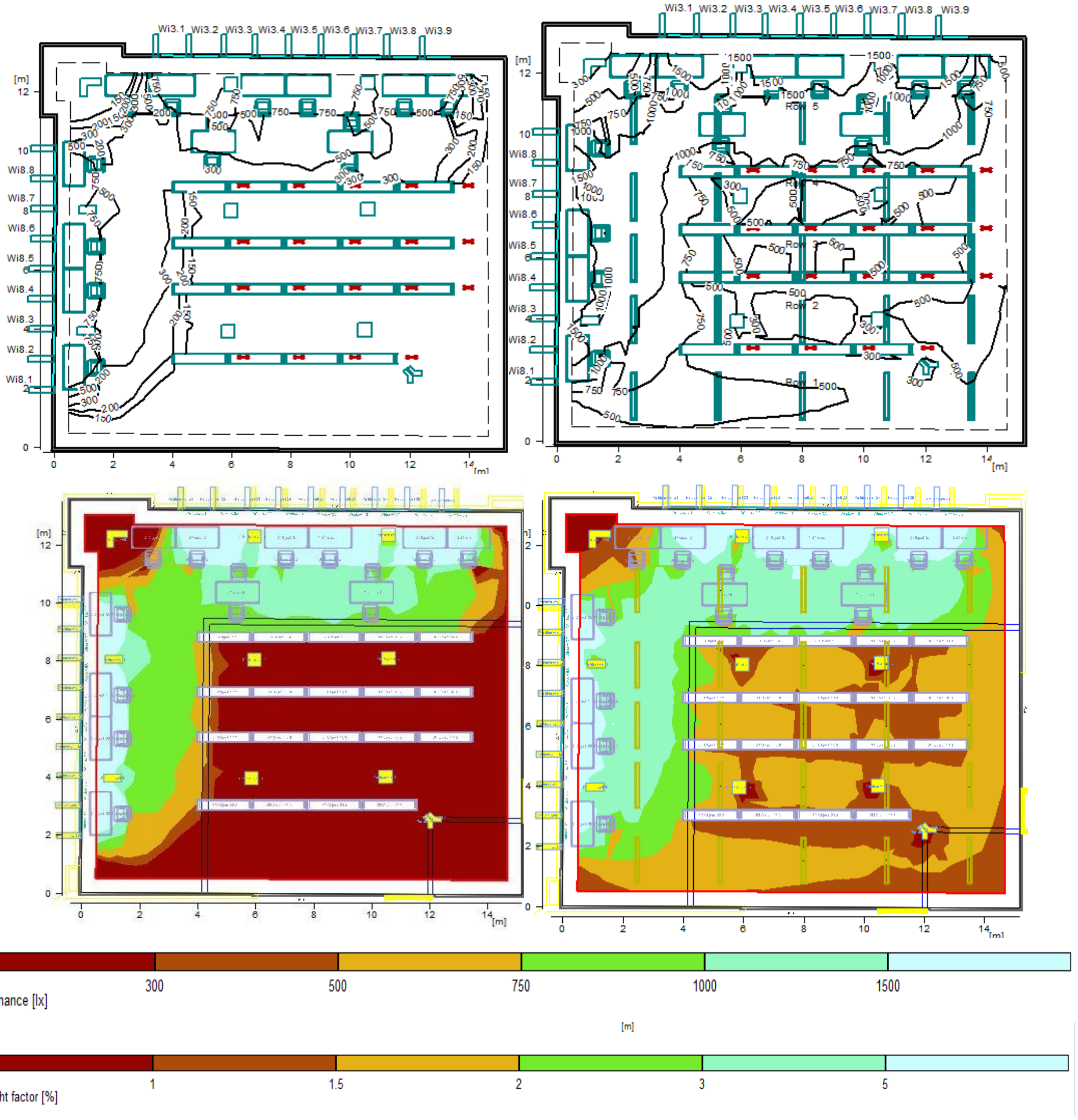
D. RESULT AND DISCUSSION

The simulation of the Northwest Space of the library is shown below; compiaring the space with natural daylight and the combination of the dalight and the artificial lighting and showing the difference of the illumance and energy use of the space.



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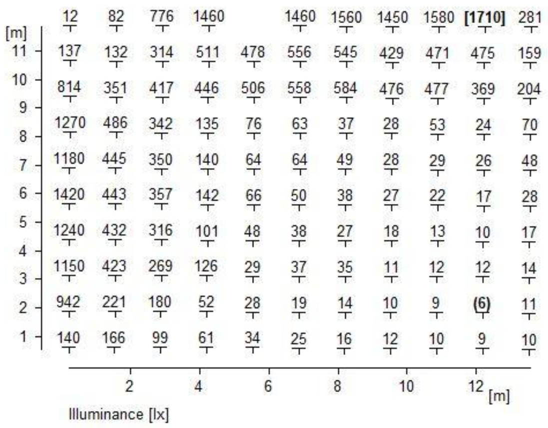

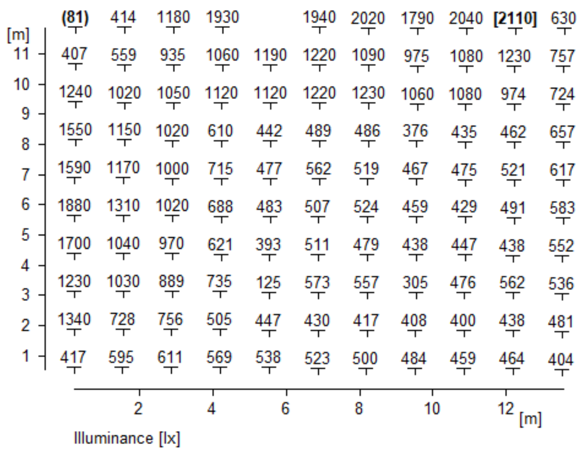

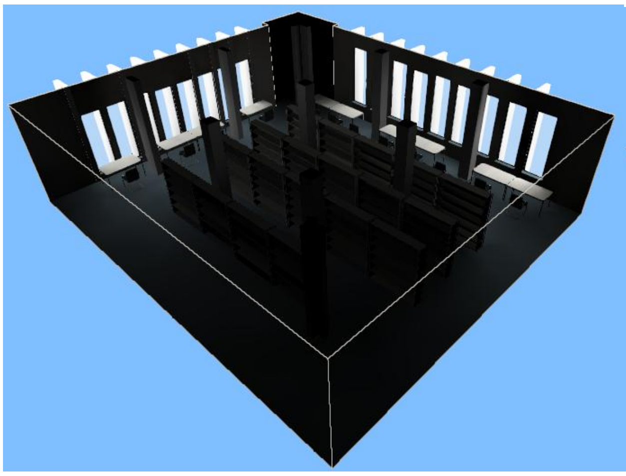

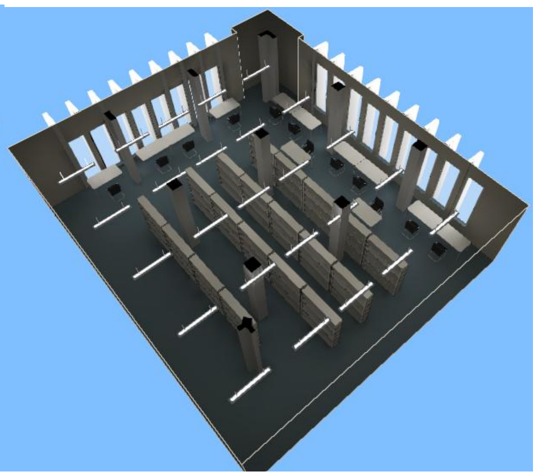

GENERAL

S/No	PARAMETER	ONLY DAYLIGHT	DAYLIGHT AND ARTIFICIAL LIGHT
	Calculation Algorism used	Average indirect fraction	High indirect fraction
	Evaluation Height	0.8m	0.8m
	Height of luminaire plane	-	3.50m
	Calculation mode used	Clear sky	Artificial and daylight calculation

DAYLIGHT FACTOR OF THE SPACE

S/No	PARAMETER	
	Average daylight ratio	1.9
	Minimum daylight ratio	0
	Maximum daylight ratio	10.5

ILLUMINANCE OF THE SPACE

S/No	PARAMETER	ONLY DAYLIGHT	DAYLIGHT AND ARTIFICIAL LIGHT
	Average illuminance	311lx	800lx
	Minimum illuminance	6lx	80.6lx
	Maximum illuminance	1710lx	2110lx
	Uniformity (min/ave)	1:47.84(0.02)	1:9.92(0.1)

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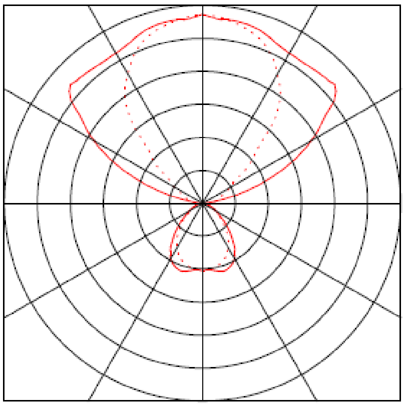
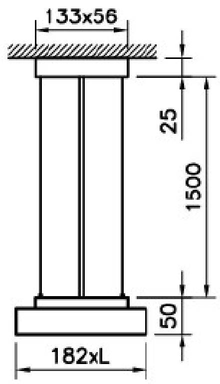
	Diversity (min/max)	1:262.98(0.00)	1:26.2(0.04)

LUMINIARE DATA

Absolute Photometry		
Luminaire efficacy	:	112.86 lm/W
Classification	:	D53 ↓22.7% ↑77.3%
CIE Flux Codes	:	60 86 96 23 100
UGR 4H 8H	:	11.8 / 11.3
Power	:	70 W
Luminous flux	:	7900 lm
Dimensions	:	1560 mm x 182 mm x 50 mm





S/No	PARAMETER	AMOUNT
	Total number of luminaire	25
	Total luminous flux of all lamp	197500 lm
	Total power	1750W
	Total power per area (200m^2)	8.69 W/m² (1.09 W/m²/100lx)

SOUTHEAST SPACE

The simulation of the Southeast Space of the library is shown below; compiaring the space with natural daylight and the combination of the dalight and the artificial lighting and showing the difference of the illumance and energy use of the space.

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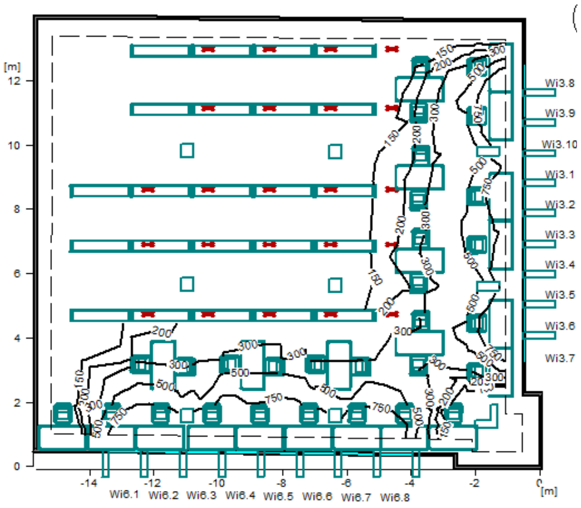

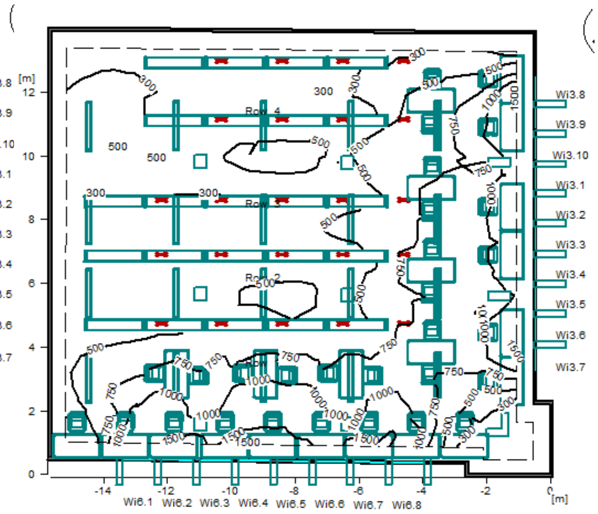

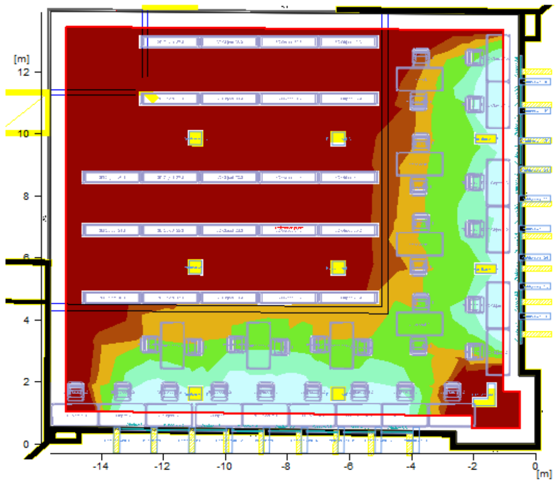

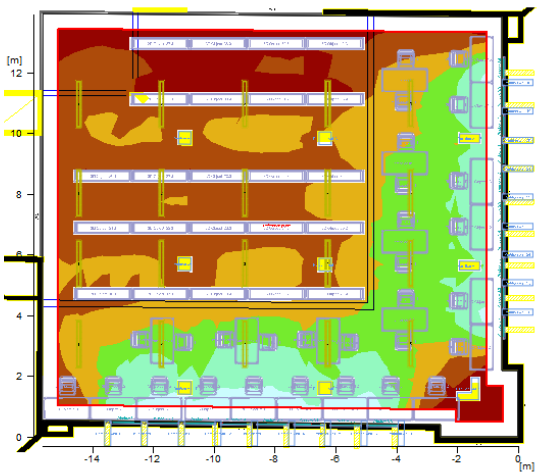

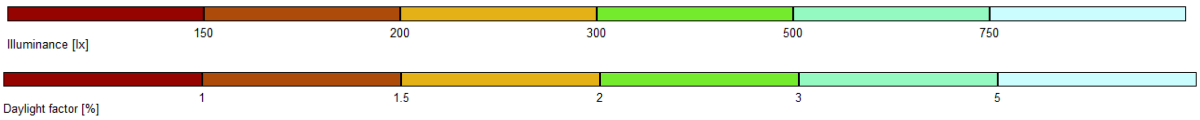

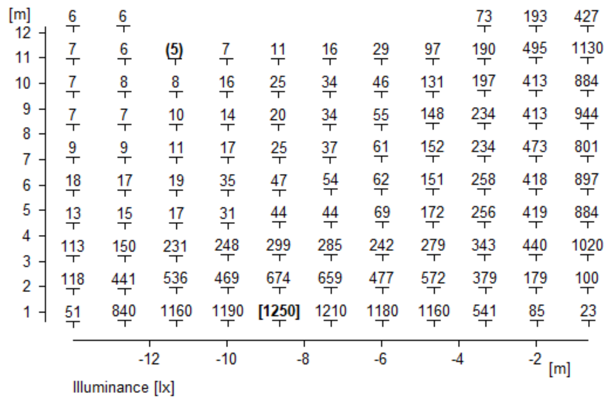

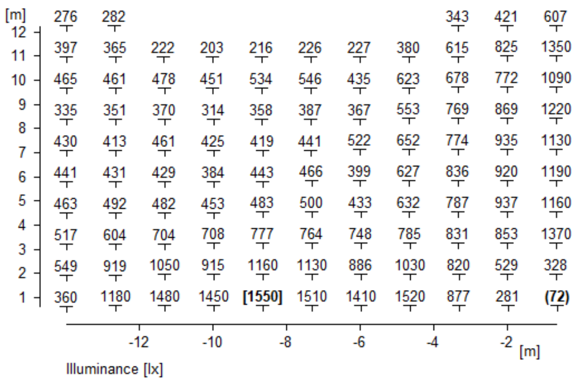

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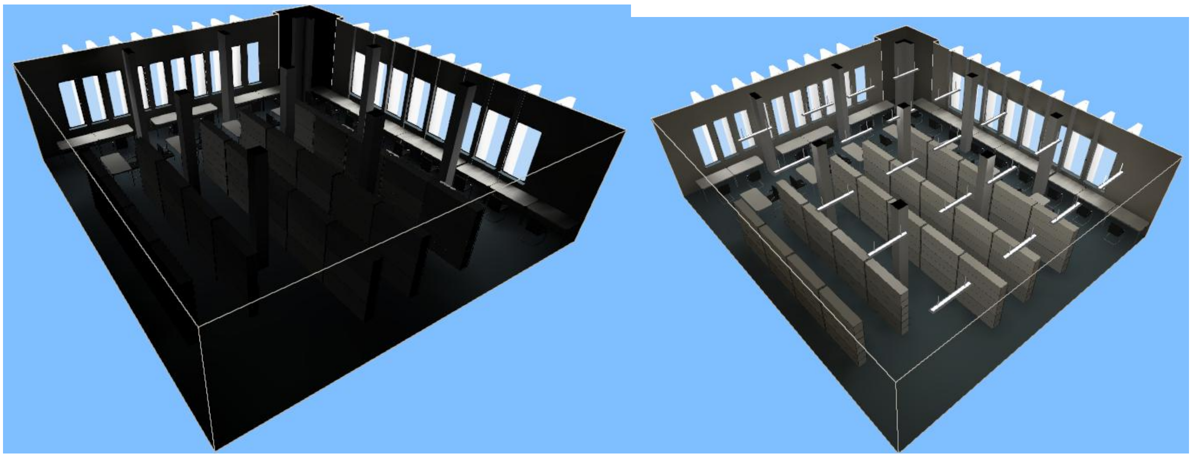

GENERAL

S/No	PARAMETER	ONLY DAYLIGHT	DAYLIGHT AND ARTIFICIAL LIGHT
	Calculation Algorism used	Average indirect fraction	High indirect fraction
	Evaluation Height	0.8m	0.8m
	Height of luminaire plane	-	3.50m
	Calculation mode used	Clear sky	Artificial and daylight calculation

DAYLIGHT FACTOR OF THE SPACE

S/No	PARAMETER	
	Average daylight ratio	2.08
	Minimum daylight ratio	0.04
	Maximum daylight ratio	9.28

ILLUMINANCE OF THE SPACE

S/No	PARAMETER	ONLY DAYLIGHT	DAYLIGHT AND ARTIFICIAL LIGHT
	Average illuminance	280lx	664lx
	Minimum illuminance	5lx	72lx
	Maximum illuminance	1250lx	1550lx
	Uniformity (min/ave)	1:52.88 (0.02)	1:9.22(0.11)
	Diversity (min/max)	1:236.23(0.00)	1:2405(0.05)

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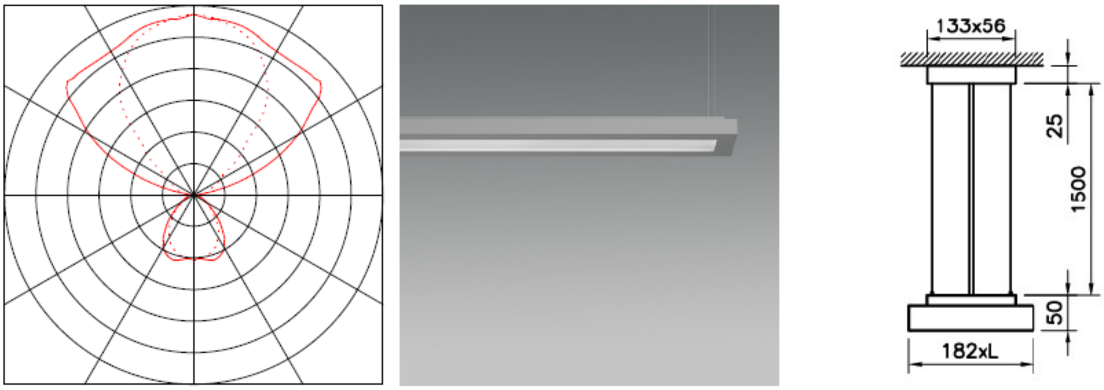
LUMINIARE DATA

Absolute Photometry
Luminaire efficacy : 112.86 lm/W
Classification : D53 ↓22.7% ↑77.3%
CIE Flux Codes : 60 86 96 23 100
UGR 4H 8H : 11.8 / 11.3
Power : 70 W
Luminous flux : 7900 lm

Dimensions : 1560 mm x 182 mm x 50 mm



S/No	PARAMETER	AMOUNT
	Total number of luminaire	25
	Total luminous flux of all lamp	197500 lm
	Total power	1750W
	Total power per area (200m^2)	8.69 W/m² (1.09 W/m²/100lx)

IV.CONCLUSION AND RECOMMENDATION

The results of this study indicated very high use of artificial light and high use of electricity energy in the library building with less natural lighting used in the space. In these spaces the use of the artificial light was higher than the natural daylight which cause to the consumption of high energy in the building and the satisfaction of students using the space is high in terms of sleepiness and tiredness of the student were higher as well. In addition, the student and staff performance were not comfortable in these spaces and many of them tended to have natural daylight in library building than more of artificial light according to an oral interview done with some staff and student in library building. In relative to the illuminance value and daylight factor, the simulation done in this research displayed that daylight factor was lesser than its ideal least in an educational related spaces (library) and daylight illuminance in these library was also lower than the suitable average for educational study space like library shown in table 3 (500 Lux) on several days. This circumstance in the library was lower than the satisfying illuminance in both side on the of the building which is the northwest and southeast space that is simulated (with daylight illuminance between 200lx and 350lx). In these spaces, artificial light was used all the time and this lead to high energy consumption and will put the student and the staff which are using the library to be tedious and drowsy modes among them.
The calculations and simulation model of daylight illuminance and daylight factor were also done in the southeast and northwest space of the library and the results indicated appropriate window size and utility of rearrangement of the book shelfs in the spaces. Moreover, illuminance and daylight factor of these spaces reduced significantly on the overcast days and they necessary use artificial lighting for the spaces to be brighter. Daylight factor in these spaces supposed to be above 2% and the average illuminance of sunlight in the space should be 500 Lux or even more on most days.

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In overall, the most significant design complications and other attained results of this case study (Ozay Oral Library) include:

- Optimal area of windows in the spaces. In this study, optimal area of windows in the library spaces was estimated to be about 4.5% of the total interior surface area. In this situation to improve the daylight factor and illuminance, the increase of window high is significant. Moreover, in this regard, to avoid heat loss during the winter seasons, double glazed window or triple glazed windows must be used as well.
- From the simulation result, the arrangement of the book shelfs in the library building was arranged in a way that they are blocking the flow of the natural daylight coming into the interior space.
- Suitable daylight illuminance. The results of computer model simulations and indicated that in the educational related spaces (library, Classroom) in which the reports of sleepiness and tiredness are fewer and student's happiness is greater, daylight illuminance was between 400lux and 750lux on different days of the year. And in this space of the case study, the illuminance is lesser than the appropriate as needed

The modelling results showed that the amount of natural light in these spaces on most days could be appropriate by shift installation channels and double increase in the windows height on the library building (there was a need to four-fold increase size of the windows in both side of the library).

REFERENCES

1. Amin alah Ahadi, Mohammadali KHanmohammadi, Mostafa Masoudinejad, Babak Alirezaie. (2015). Improving student performance by proper utilization of daylight in educational environments (Case study: IUST1 School of Architecture). Acta Technica Napocensis: *Civil Engineering & Architecture* Vol. 59, No. 1.
2. Ahmad, R. and Reffat, R. (2018). A comparative study of various daylighting systems in office buildings for improving energy efficiency in Egypt. *Journal of Building Engineering*, 18, pp.360-376.
3. Toluwalogo David Babarinde, Halil Zafer Alibaba. (2018). Achieving Visual Comfort through Solatube Daylighting Devices in Residential Buildings in Nigeria. International Journal of Scientific & Engineering Research Volume 9, Issue 1, January-2018 ISSN 2229-5518
4. En.wikipedia.org. (2018). *Daylight factor*. [online] Available at: https://en.wikipedia.org/wiki/Daylight_factor [Accessed 25 Nov. 2018].
5. Designingbuildings.co.uk. (2018). *Illuminance - Designing Buildings Wiki*. [online] Available at: https://www.designingbuildings.co.uk/wiki/Illuminance [Accessed 21 Nov. 2018].
6. En.wikipedia.org. (2018). *Illuminance*. [online] Available at: https://en.wikipedia.org/wiki/Illuminance [Accessed 21 Nov. 2018].
7. Engineeringtoolbox.com. (2018). *Illuminance - Recommended Light Level*. [online] Available at: https://www.engineeringtoolbox.com/light-level-rooms-d_708.html [Accessed 21 Nov. 2018].
8. Giarma, C., Tsikaloudaki, K. and Aravantinos, D. (2017). Daylighting and Visual Comfort in Buildings' Environmental Performance Assessment Tools: A Critical Review. *Procedia Environmental Sciences*, 38, pp.522-529.
9. Maximumyield.com. (2018). *What is Artificial Light? - Definition from MaximumYield*. [online] Available at: https://www.maximumyield.com/definition/2126/artificial-light [Accessed 21 Nov. 2018].
10. Moazzeni, M. and Ghiabaklou, Z. (2016). Investigating the Influence of Light Shelf Geometry Parameters on Daylight Performance and Visual Comfort, a Case Study of Educational Space in Tehran, Iran. *Buildings*, 6(3), p.26.
11. Library.emu.edu.tr. (2018). *Floors, Virtual Tour and Photos | Özay Oral Library - EMU*. [online] Available at: https://library.emu.edu.tr/en/about-us/floors-virtual-tour-and-photos [Accessed 26 Nov. 2018].
12. CIBSE (Chartered Institution of Building Services Engineers). *Daylighting and window design*. London: CIBSE; 1999.
13. The website of Meteorological Organization Tehran Province. http://www.tehranmet.ir / [last date accessed: September 2013].
14. Baker N, Steemers k. *Daylight Design of Buildings*. London: James and James (Science Publishers), 2002.
15. BS EN (British Standards Institution). *Light and lighting. Basic terms and criteria for specifying lighting requirements*. UK: British Standards Institution; 2011.
16. CIBSE (Chartered Institution of Building Services Engineers). *Environmental Design*. London: CIBSE; 2006.
17. Simm S, Coley D. "The relationship between wall reflectance and daylight factor in real rooms." *Architectural Science Review,* **Vol.54 (4)**, PP. 329-334, 2011.
18. ICAEN (Institut Català d'Energia). *Sustainable Building- Design Manual: sustainable building design practices*. New Delhi: The Energy and Resources Institute; 2004.