JOURNAL OF ISLAMIC ARCHITECTURE
P-ISSN: 2086-2636 E-ISSN: 2356-4644
Journal Home Page: http://ejournal.uin-malang.ac.id/index.php/JIA

DESIGNING DAYLIGHTING FRAMEWORK FOR NORTHERN HEMISPHERE CLIMATE: STUDY OF ANALYSIS & RECOMMENDATIONS FOR ADAPTIVE EXPANSION APPROACH FOR LONDON CENTRAL MOSQUE, UNITED KINGDOM

| Received August 7th 2023 | Accepted Oct 10th 2023 | Available online Dec 30th 2023 |
| DOI http://dx.doi.org/10.18860/jia.v7i4.21233 |

Nur Amalina Hanapi*
Architecture
Department, Faculty of
Civil Engineering and Built
Environment,
Universiti Tun Hussein
Onn
Malaysia

Corresponding Author:
amalina@uthm.edu.my

ABSTRACT

Any religious building's holistic and ceremonial performance is profoundly and dramatically impacted by lighting research. In this study, the current situation is examined via the lens of analysis, and a performance - based preamble design proposal analysis for the study of adaptive expansion approach for London Central Mosque. Numerous studies have been done on the significance of the ornamentation of mosques and its acoustics impacts on the congregational activities. However, few exceptions are given on the importance of daylighting effect in the mosques. Looking at the massive and widely compacted end-users in London Central Mosques especially during peak season given that the numbers of devotees is increasing each year, the objective is to understand the analysis and recommendations needed for the adaptive expansion approach in designing a daylighting framework for the northern hemisphere climate. The performance of the lighting design for London Central Mosque was the subject to few case studies referred that focused on the evolution and morphology of daylighting in religious and historical areas. Thus, this research will then conduct an observation and analysis studies as the method to materialize the findings. This study was also anticipating recommendations that suggest both passive and active design implications towards the idea of adaptive expansion. As a result, the outcome discussions demonstrate numerous implementation criteria ranging from design stages of site analysis, climate aspects to the electrical fittings and external shading devices well recommended for the best proposal assisting and improving the mosque's current circumstances. The study's findings also indicate that minimal glare and efficient lighting distribution help to reduce energy consumption, enhance reading quality, and properly illuminate public and private religion events and other activities carried out in the situation of optimum brightness of London Central Mosque.

KEYWORDS:
Daylighting; Adaptive; Expansion; Mosque; Architecture; Assessment

INTRODUCTION

Such a luminance relationship inside the typical visual field should be regulated where visual work is involved to allow the retina to adjust to the ambient brightness in line with the task's own brightness[1]. By doing so, it is possible to lessen the requirement for constant readoption and the "shock" of extreme contrast when doing a task. Learning that lighting is important in daily life activities including spiritual aspect, daylight is widely used in any primary spiritual or congregational area[2]. Those buildings or structures that representing religion are also typically well-equipped with conference and discussion spaces where we need optimum lighting to prompt our visual assistance in carrying out congregational routine.[3]

To avoid uncomfortable visual situations caused by high contrast, this research demonstrated the need for suitable daylighting for both the interior and exterior of structures. Additionally, the rhythm of lighting in religious buildings denotes a unique function and highlights the hierarchy of space layout and its importance in religious activities[4]. Usage of light not only has symbolic and spiritual significance, but also contributes to the enhancement of the adornment and beauty of mosque interiors. Muslims use several techniques to bring light into the inside of mosques to highlight simplicity, clarity, and purity. The mosque's lighting structure and illumination within are seen as designs, mystical and spiritual representations.[5]

PROBLEM STATEMENT AND ISSUE

Figure 1 Entrance lawn to lobby area of London Central Mosque in Regent's Park London, United Kingdom (Source: Authors)

The development of the London Central Mosque (also known as the Regent's Park Mosque) has widely known for its representation of worldly and spiritual integrations of people and culture. Situated along the Park Road in Regent's Park, London principal prayer hall and a conference room are located on the ground floor whilst female worshipping area is located on the first floor of the London Central Mosque as per Figure 1, 2 and 3. It was built in 1977, with a noticeable golden dome, and was designed by Sir Frederick Gibberd. Over 5,000 male worshipers may fit in the main hall and women can pray on the balcony above the hall. The mosque has only a large carpet and a chandelier as furniture. Islamic sacred geometry is used to design the interior of the dome, which also features small stained-glass windows around the base that feature turquoise 16-pointed stars as indicated in Figure 11, where it's adorned with a chandelier at the center of the main prayer hall highlighting decorated fragment-shaped dome with symbolizing Islamic geometry.

Figure 2. Site plan location of London Central Mosque in 146 Park Rd, London NW8 7RG, UK (Source: Google Maps)

The mosque holds on-site amenities include a small bookstore and halal café as per floor plan indicated in Figure 3. The Islamic Cultural Center, which was formally inaugurated by King George VI in 1944, is connected to the mosque [6]. George VI gave the property to the Muslim community in Britain in exchange for King Farouk of Egyptian and the Sudan giving land in Cairo for the construction of an Anglican cathedral. Mosques in the United Kingdom predominantly serve as one initiation of renewed interfaith deliberation among locals. A strong, cohesive society depends on the contributions made by mosques and Islamic institutions around the nation [7]. For instance, the mosque continues to organize an open-to-all COVID-19 immunization clinic. They also operate a food bank to assist the most vulnerable members of our communities, particularly during these trying times [1].

COMPACT LIVING ON PEAK CONGREGATIONAL

The second-largest religious community in the UK now is British Muslims. According to the 2021 census, there are now approximately 4 million Muslims living in England and Wales, making up about 6.5 percent of the country's total population and a growth of 1.2 million ever since 2011 count. This has significantly altered Britain's demographics and subsequently escalates the occupancy capacity in the central mosque during peak seasons [2] [3] [4]. The mosque serves as a gathering space for Muslims to engage in religious observances and group prayers. Given its diversity and multiculturalism, London has a sizable Muslim community, and the city is home to many mosques[8]. It could be used to describe the process of constructing a new mosque or enlarging an existing one when referring to mosque construction or expansion. To meet the expanding demands of the Muslim community, many mosques worldwide either undergo repairs or are built from scratch [4][6].

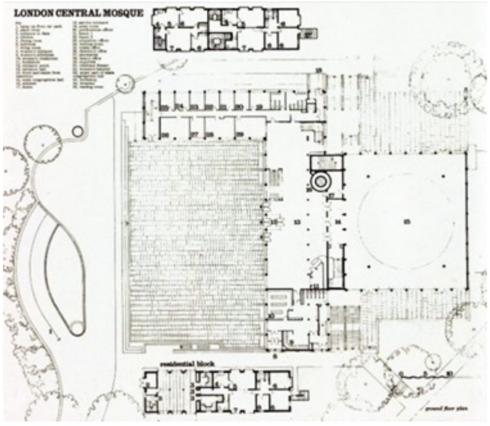


Figure 3. Ground floor plan of London Central Mosque. (Source: https://www.architectural-review.com/buildings/gibberds-london-central-mosque)

LACK OPTIMIZATION OF MOSQUE DAYLIGHTING IN VARIOUS SEASONS FOR THE CLIMATE

Additionally, lighting enhances Islamic ornamentation and decorating in mosques in both active and passive design ways, giving them life and spirit. However, this were seen to be a direct reference to the middle eastern without fully inculcating the cultural characteristic of the actual region [5]. Following several factors may prevent mosque daylighting from being optimized for diverse climates and seasons:

1. Traditional Architecture: Traditional architectural designs are used to construct many mosques, giving aesthetic appeal and cultural significance precedence above scientific optimization. Its specific requirements for natural lighting optimization in various seasons and climates may not be considered in these designs.
2. Insufficient Data and Study References: On mosque's natural lighting optimization in various climates, there may be little research and data accessible. This can be because there's not enough funding or research being done on this area of mosque architecture.
3. Value Added Concerning to Culture and Religion: Mosques have significant cultural and religious value; thus, any alterations or design changes should be done cautiously. The investigation of optimization methods could be constrained by a preference for keeping conventional architectural characteristics and design components.

4. Cost Constraints: Implementing daylighting optimization ideas into practice may require additional funding for things like the installation of high-tech glass systems, shading equipment, or automatic monitoring systems. Mosques with limited funding may give other building or maintenance needs priority over daylighting optimization.
5. Insufficient Knowledge and Experts' Skills: Mosque architects and designers could not be sufficiently knowledgeable or skilled in maximizing daylighting for periods and regions [6]. This may lead to a lack of awareness or comprehension of the possible advantages and approaches for maximizing mosque daylighting.

Daylighting performance for an acceptable level of comfort in mosques are important even though daylight hours may be significantly different depending on the climate and geographical situation [7]. Hence, this research will then focus on the daylighting analysis distribution in the main area of the London Central Mosque for each season and suggesting the best possible mitigation plan for the mosque in preserving its post-critical context with consideration of its climate setting [8].

METHODS

The methodologies used to accomplish this recommendation study are site observation and pre-assessment software. According to the preliminary site survey, the main prayer hall area was too dark for night worshipping activity in autumn and winter as indicated in Figure 4. The following research suggests the expansion detailing preamble thoughts on the design criteria that needed to be inculcated to cater the upgrowing Muslim community in London [10]. Predesign software was used to test proposals based on all the data and graphic evidence gathered to determine the practical design options for the mosque. The study that was undertaken was quantitative research, and the data that were obtained were the primary type of data. To provide a workable plan for repurposing religious structures, the proposed proposal layout will be injected and imparted into the architecture of the mosque.

RECOMMENDATION FOR A CLIMATIC BASED PRE-ASSESSMENT INCULCATION FOR LONDON CENTRAL MOSQUE ADAPTIVE EXPANSION

REACCESSING SITE ANALYSIS

Start by performing a comprehensive site analysis to comprehend the mosque's location, orientations, nearby structures, and any relevant limitations that might have an impact on daylighting [9]. Surrounding structures or tree elements will have to be taken into consideration. Based on climate-based daylight simulation shown in Figures 5 and 6, the main entrance shall be given priority to assess and allow visible way findings to the visitor since it is adjacent to the main road and facing the location of frequent beneficial sun, slightly south which is opposite to countries like Australia in the Southern Hemisphere [10].

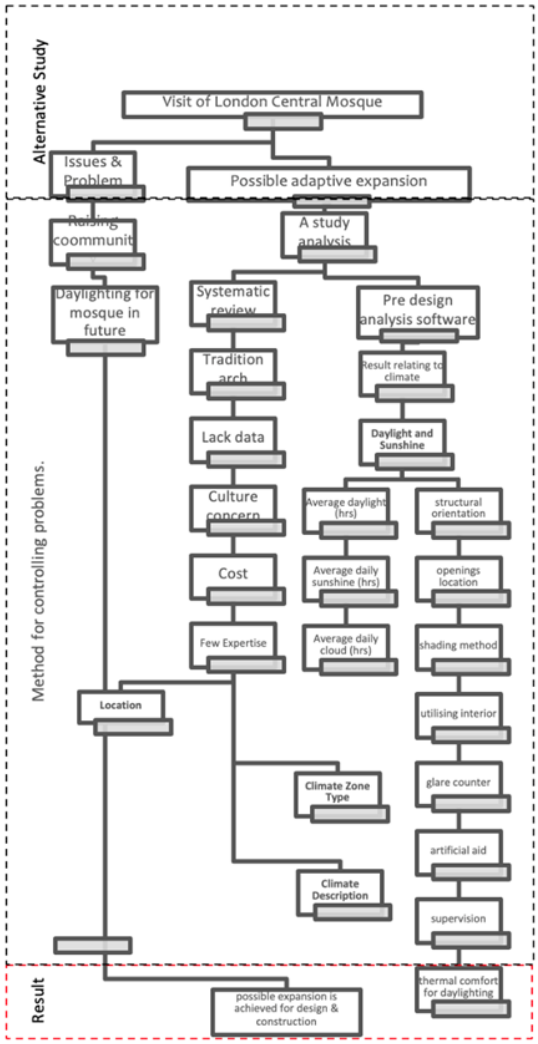


Figure 4 Methodology for daylighting analysis and recommendation for the study of adaptive expansion in London Central Mosque

Figure 5 (left) Main entrance of the mosque from the Park Rd (right) View from internal courtyard area (Source: Authors)

The analysis portrays the finding on the daylight percentage are most during summer with the 15 hours daylight hours as per Figure 6. Thus, the best time for maximizing work activity for the mosque is during this time of the year when Muslim may experience longer prayer time for Asar to Isya' in the most favorable time as compared to winter seasons which we have shorter daylight hours. In Muslim religious practice and according to the Islamic Hijr calendar, Ramadhan is one of the holiest months where lots of religious activities such as fasting, congregational tarawih prayer, massive gathering for breaking fast and *sahor* are being performed. Muslims across the world commemorate Ramadan, which is the ninth month of said Islamic lunisolar calendar, as a time for fasting, prayer, introspection, and community. The months of the Islamic calendar, which is based on the moon, advance by 10–12 days annually in comparison to the Gregorian calendar, which would be based on the sun. Within the Gregorian calendar, Ramadan's start and end dates change every year. On a contrary, it can happen at any time of year, even in the cold. Ramadan in the wintertime affects the architectural space planning activities and how Muslims religiously celebrate this holy month in different ways than when it falls in other seasons [10].

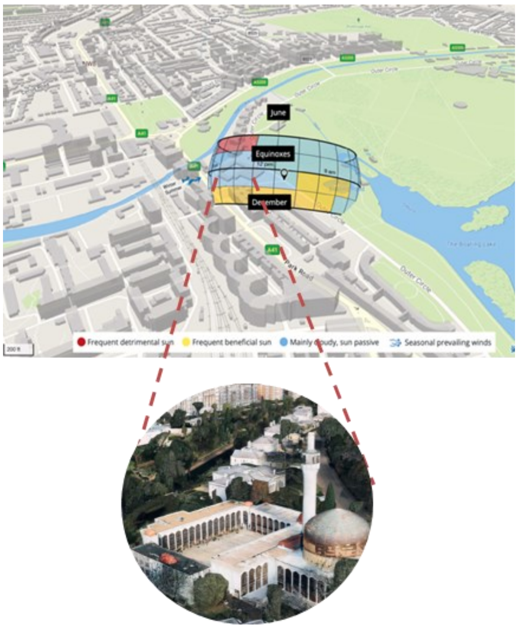


Figure 6. A site analysis study for the location on how the sun and wind affecting the site at different times of the year.

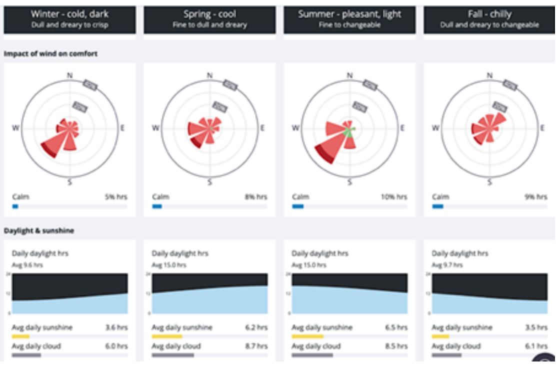


Figure 7. Daylight hours analysis based on the location of the London Central Mosque according to seasons.

The findings indicate that London Central Mosque do have very low exposure to daily sunshine in winter and fall which the end user in the mosque is more likely to be around the plaza area close to the courtyard where full openings of the windows can be found. This plaza is normally used for breaking fast during Ramadhan. Thus, this area will need a slight treatment for heating purpose if the Ramadhan fall during those seasons [4]. From the analysis in Figure 7 as well, it is shown that the radial distribution mapping shown the biggest circumference ($C=2\pi r$) facing the south-west in summer which is close to 40 %.

CURRENT GLOBAL CLIMATE ON PRE-DESIGN

Learning from the predesign assessment of London Central Mosque location has quite seasonal with winters with cold, short days and summers with mild-warm long days as per Figure 8, Northern Hemisphere's Mosque may propose various religious activities to be done in from Jun 21 to Sep 20. This indicates the proposition site in the Central London has a temperate oceanic climate. Daylighting conditions of space does appear differently for this site as highlighted previously in Figure 8. Thus, identification variations in the amount of natural light that is available at various times by analyzing data on sunshine patterns across the seasons is crucial for erecting buildings and structures [11][12]. In fact, an article published by F. Leccese et al in 2020 restating the same concern of climate-based data and dynamic towards spaces, events, and the end-user performance [2].

The predesign climatic analysis was done as per Figure 9 for site representing the percentage frequency of the site' occupied hours. This was being segregated into 4 categories: i) too cold to be outside, ii) ok outside if sheltered, iii) want to be outside and iv) too hot to be outside. All categories are indicated with the 1st part of the result showing the 68% percent frequency, the 2nd part presenting 24%, 3rd indicating 7% and 0% in the 4th category. The categories describe the ambience of surrounding environment with the human interactions to it. These elements will help and aid the architectural concept and design process in future for the said location of the Central London [13]. With that being highlighted, Muslims worldwide especially those in the Northern Hemisphere will have to adapt to the seasonal changes and continue to observe the rituals and traditions associated in mosque especially during Ramadan with devotion and reverence, regardless of whether it falls in winter or any other season [14]. Thus, it is important to note as well that the experience of Ramadan can vary significantly depending on geographical location and cultural practices.

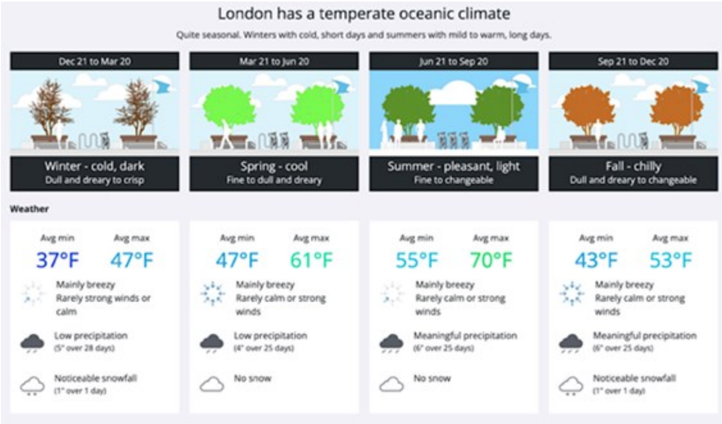


Figure 8 Result indicates that the site has temperate oceanic climate where it renders quite seasonal weathers.

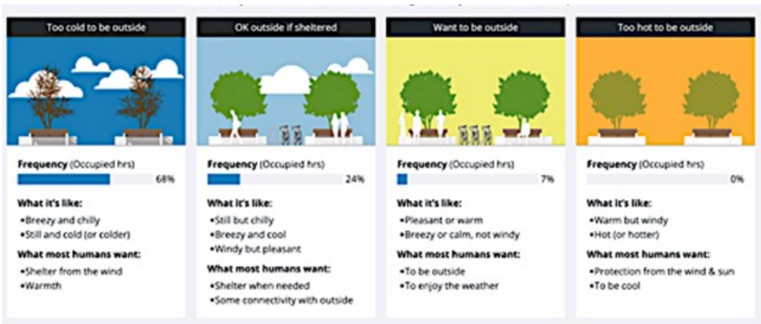


Figure 9 Analysis result impact on architectural response on London Central Mosque adaptive expansion study

STRUCTURAL ORIENTATION WITH SUNBREAK

Based on the pre examine assessment done for the location of the mosque as per Figure 10 shown, it suggests relative counters to its location for better positioning facade to obtain as much natural light as possible. Hence, this mosque’s future adaptive expansion project may rely on the quality suggested during the stages of design or renovation for optimum adjustments to be made to achieve and maintain the same spiritual inside the building [15].

Results indicate considering shading, especially during the middle of the year where the summer season hits where detrimental direct exposure to sun could happened for the site. This is however significantly different towards end of year and early of the year where according to graphic analysis shown beneficial amount of sun to be let in for the surrounding site[14]. One building will reject most of the direct sunlight if it is incorrectly planned for daylight. They also acknowledge that there is a plentiful supply of beneficial ones and that there are numerous strategies to manage the sun's radiant heat accordingly for the next expansion project [16].

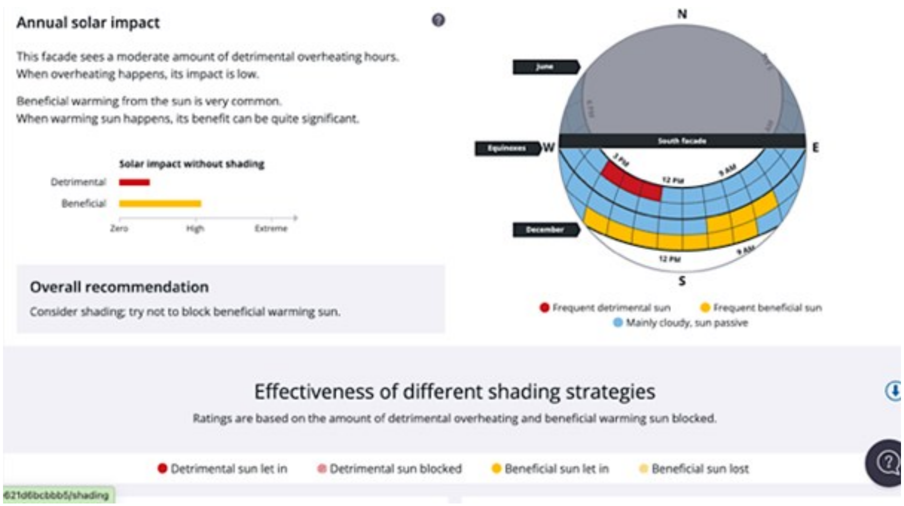


Figure 10 The results show the best shading strategies by facade based on annual solar impact.

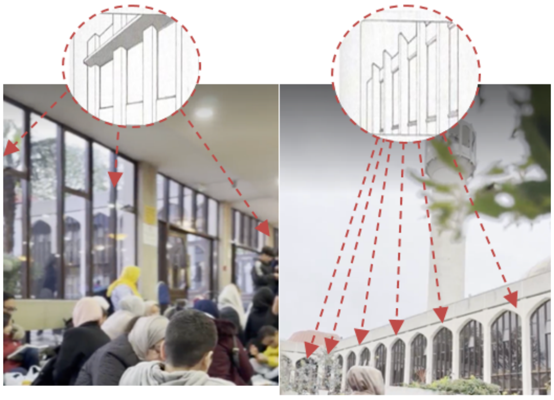


Figure 11 shows London Central Mosque internal plaza used as sheltered gathering places that elongated with commercial mini bookstores and suggestions for integrations with main columns improvements. (Source: Authors)

The greatest approach to avoid the sweltering evening sun at the London Central Mosque during summer would be to have a sunbreak around the internal plaza area of the mosque, as shown in figure 12. Establishing through vertical or horizontal hooked sunbreak will include suggestions of verandas, projecting eaves, and other fixed horizontal architectural elements that offer shade for the walls and windows as per Figure 11 previously [13], [14]. Fixed vertical sunbreak should typically not exceed 150 percent V due to their impact on daylight and structural considerations. Additionally, certain laws could restrict how far they can project onto street frontages [13]. Using inclined blades like fixed blind should ideally not be turned more than 30 degrees from normal to reduce the amount of daylight lost. The sunbreak that is added should allow windows to open all the way, and the window must be constructed to make it simple to clean the outside of the glass. Additionally, the blade gap during production should be adequate for cleaning or painting the mosque future adaptive expansion.

INCORPORATE METHODS FOR SHADING

Create efficient shading plans that can be adapted to this London Central Mosque adaptive expansion project's environment and strike a compromise between reducing solar heat gain and maintaining easy access to sunlight inside the mosque rooms [17]. This can entail the use of external shading tools like overhangs, hoods, fins, louvres, or movable blinds suggested by the predesign assessment software in Figure 12 that will let inhabitants regulate incoming sunlight. The most suitable mechanism is the double overhang where it will reduce the mosque's dramatic contrast between internal and outdoor luminance. With the indication of rating implementation in the Figure 12, it exemplifies the highest percentage of beneficial sunlight absorption and lowest detrimental solar impact among others in the pre-assessment software done for the site. Among the five automated design results in the pre-assessment test, the least option listed is external blinds or offset panels are also quite effective and appropriate in many instances, while not being as long-lasting as sunbreak in Figure 11. Part types of curtains and internal blinds or panels can reduce glare especially during hot summertime, and if their exterior surfaces are light-colored and placed close to the glass, some of the solar energy that reaches them is reflected outwards through the glass [9].

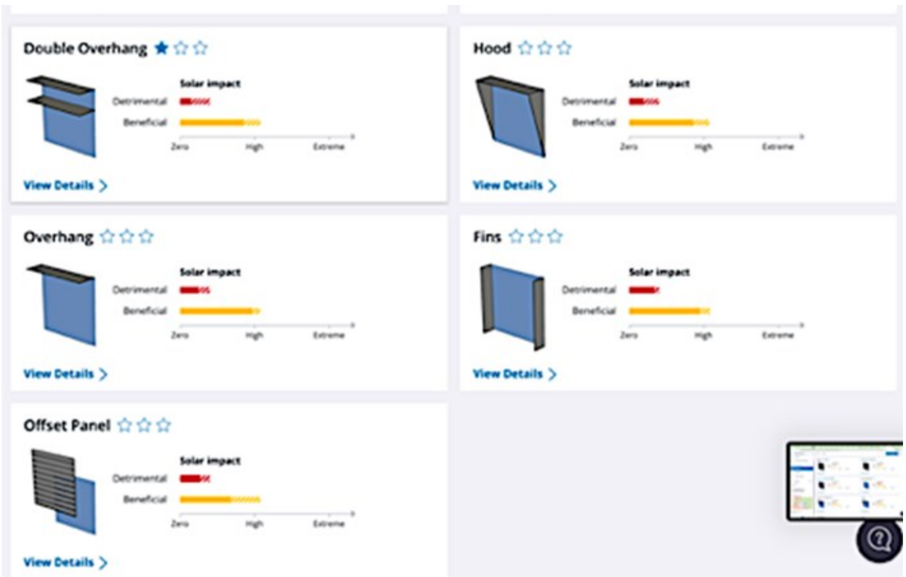


Figure 12. Shies the different options result of shading design for the area with the indication of the degree effect in beneficial and detrimental.

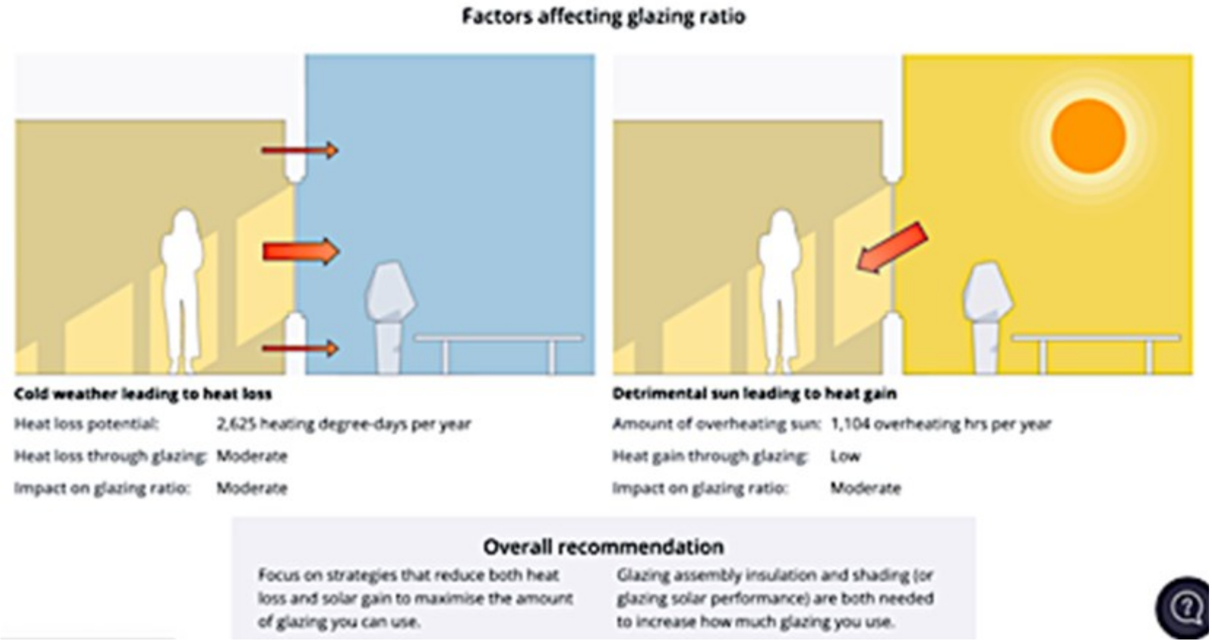


Figure 13 The pre-assessment result for design solutions showed suggestions for maximum glazing ratio for this London Central Mosque site.

WINDOW LOCATION AND SIZING

Evaluation done based on the pre-assessment design expansion project shown Figure 13 where the mosque's openings should be situated to maximize sunshine while minimizing glare and heating gain or loss using data about solar angles year-round. Glazing assembly insulation and shading are both needed for better performance as suggested by the predesign analysis. Where more natural light is required, the future expansion project should consider installing larger windows or skylights with guidance as per assessment done further in Table 1.

Insertion of special window glazing in the mosque can be used to partially regulate the amount of sunlight that enters[18]. However, there is still a noticeable disparity between areas in the sun and those in the shadow. Consequently, curtain spaces are also necessary. Hectic lighting environment of the future praying room for women, meeting room and plaza or assembly point should be avoided with correct distribution lighting. The amount of light in the room should be adequate for the task or activities that will be carried out there[18] The current general lighting with a high luminance was used to distribute an equal amount of intensity around a room. However, a lot of the light was not used effectively. In achieving optimum thermal comfort, the quantity and quality of mosque's task lighting needed to complete each duty varies from one activity to another, such as reading the Quran, delivering lectures to people, and holding meetings among Muslims [9].

REFLECTIVE SURFACES FOR EXTRA LUMINATION

In conjunction to window sizing and location, designing interior spaces of the mosques, extra care usage in reflective surfaces like bright walls, panels, ceilings, or flooring does give significant impact inculcating focus and mood in religious activity [11]. Based on the assessment done through the predesign software, it gives optimal and typical strategies in handling the glazing specifications. There are various adaptable provisions of windows, glazing and glass options which are tabulated in Table 1 with its detailing characteristics and impact percentages.

From the result shown in Table 1, it indicates that the optimal strategy for glazing properties is triple glazed low-e, non-metal with no shading where the percentage of maximum glazing achieved is 58% compared to typical glazing of double glazed low-e, metal broken with no shading properties where on 34% maximum glazing is achieved. Additionally, these factors can also help direct available light farther into spaces like what Marina Tabassum did for her extraordinary simple and daylighting focus through skylight and louvers for the mosque design in Dhaka as shown in Figure 15. Although a mosque that receives appropriate full sunshine, the design pays close attention to thermal comfort and brightness control [2].

Table 1 Glazing selection results based on insulation and solar control properties for location of London Central Mosque.

Percentage of glazing			
55-59%	50-54%	45-49%	40-44%
Triple glazed low-E, non-metal, no shading, good glazing. Insulation Solar control Maximum glazing 58%	Triple glazed low-E, non-metal, no shading, basic glazing. Insulation Solar control Maximum glazing 50%	Triple glazed argon, non-metal, no shading, great glazing. Insulation Solar control Maximum glazing 45%	Triple glazed low-E, metal-broken, no shading, basic glazing. Insulation Solar control Maximum glazing 43%
Triple glazed low-E, non-metal, non-shading, great glazing. Insulation Solar control Maximum glazing 58%	Double glazed low-E, non-metal, no shading, good glazing. Insulation Solar control Maximum glazing 48%	Triple glazed argon, non-metal, partial shading, good glazing. Insulation Solar control Maximum glazing 45%	Triple glazed low-E, metal-broken, no shading, good glazing. Insulation Solar control Maximum glazing 43%
Triple glazed low-E, non-metal, substantial shading, basic glazing. 58%	Double glazed low-E, non-metal, no shading, great glazing. 48%	Triple glazed argon, non-metal, partial shading, great glazing. 45%	Triple glazed low-E, metal-broken, no shading, great glazing. 43%
Triple glazed low-E, non-metal, partial shading, great glazing. 58%	Double glazed low-E, non-metal, partial shading, basic glazing. 48%	Triple glazed argon, non-metal, substantial shading, basic glazing. 45%	Triple glazed low-E, metal-broken, partial shading, basic glazing. 43%
Triple glazed low-E, non-metal, substantial shading, good glazing. 58%	Double glazed low-E, non-metal, partial shading, good glazing. 48%	Triple glazed argon, non-metal, substantial shading, good glazing. 45%	Triple glazed low-E, metal-broken, partial shading, good glazing. 43%
Triple glazed low-E, non-metal, substantial shading, great glazing. 58%	Double glazed low-E, non-metal, partial shading, great glazing. 48%	Triple glazed argon, non-metal, substantial shading, great glazing. 45%	Triple glazed low-E, metal-broken, partial shading, great glazing. 43%
Triple glazed low-E, non-metal, extensive shading, great glazing. 58%	Double glazed low-E, non-metal, substantial shading, basic glazing. 48%	Triple glazed argon, non-metal, extensive shading, basic glazing. 45%	Triple glazed low-E, metal-broken, substantial shading, basic glazing. 43%
Triple glazed low-E, non-metal, extensive shading, basic glazing. 58%	Double glazed low-E, non-metal, substantial shading, good glazing. 48%	Triple glazed argon, non-metal, extensive shading, good glazing. 45%	Triple glazed low-E, metal-broken, substantial shading, good glazing. 43%
Triple glazed low-E, non-metal, extensive shading, good glazing. 58%	Double glazed low-E, non-metal, substantial shading, great glazing. 48%	Triple glazed argon, non-metal, extensive shading, great glazing. 45%	Triple glazed low-E, metal-broken, substantial shading, great glazing. 43%
-	-	-	Triple glazed low-E, metal-broken, extensive shading, basic glazing. 43%
-	-	-	Triple glazed low-E, metal-broken, extensive shading, good glazing. 43%
-	-	-	Triple glazed low-E, metal-broken, extensive shading, great glazing. 43%

Figure 14 Glazing ratio result of optimal and typical strategy.

Figure 15 Marina Tabassum used daylight as the primary source of nature in the Bait Rouf Mosque which is in Dhaka, Bangladesh (Source: Asad Hossen)

The possibilities of the female praying area for London Central Mosque's sloping roof makes installing a skylight in the structure the ideal solution to this issue. It will benefit more using a skylight in the prayer to take advantage of the building's natural illumination since the current situation is only relying on artificial lighting in enclosed space as shown in Figure 15. Usage of heat-reflecting glass for future skylight with a metallic covering and its infrared reflectivity, should be sufficiently dense to restrict the entry of solar heat[2], [17]. However, it is quite transparent to let in enough light and offering partial view of the outside mosque from the female praying area. Thus, suggestion of plastisol film can be used to "heat reflect" clear glass [2]. By using heat-absorbing glass, more of the infrared spectrum is absorbed by heat-absorbing glass while less light is lost. However, a large portion of this absorbed radiation is heated and reflected into the space. When the heat-absorbing glass is the outer pane of a sealed double-glazed system, which is not suitable to be advised for London Central Mosque, this effect is diminished [15]. Glare-reducing glass, such as "natural grey" and "bronze," can assist in reducing glare from the sky and light surroundings, making it appropriate for use in the female praying area of London Central Mosque.

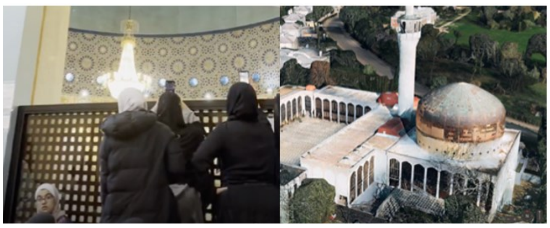


Figure 16 Verandah in 1st floor of the most main praying area is the only female praying area which is quite congested during peak hours. (Source; Authors)

DESIGN INTEGRATION WITH ARTIFICIAL LIGHTING

Integrating artificial lighting solutions that can be dynamically adjusted to ensure consistent illuminance while consuming the least amount of energy [19]. Artificial light is typically created by turning electrical energy into light energy and using lamps. The design of the light fixture (luminaries) housing the lamp and the reflectivity of the walls and ceiling are additional variables that affect the quality of artificial light on the work area[20]. Fixtures should be made to provide as much useful light to a work surface as possible. They ought to be positioned to reduce shadows and glare. Reflective walls and ceilings can reduce the amount of lighting needed in a place [9]. Based on the predesign analysis done for the London Central Mosque and the suggested implementation of the skylight in women praying area's expansion, the simulation result indicates various percentage frequencies of occupied hours under different daylight ambiences as per Figure 17. 26% frequency reached under sunny spells which suggests 5% roof glazing may be enough for good light where it bounces or diffuses direct sum to control glare and spread light evenly. However, this is totally different scenario experienced under low daylight ambient. During this situation, other sources of light are needed for illumination and the interior glazing will act like a mirror [1]. In fact, the privacy of human occupants will be slightly poor without the usage of blinds in the mosque area. Thus, this low daylighting situation for the mosque were further explored onto another assessment analysis for the possibilities of different skylight design as per Table 2. The listed solutions to counter the low daylighting problem are implementation of the sawtooth-clerestory window facing north of the mosque and cushions lighting. Both solutions limit glare by diffusing direct sun heating the mosque and warming the lighting condition during sunny and making it a bit cooler when cloudy apart from providing partial view to the end-user

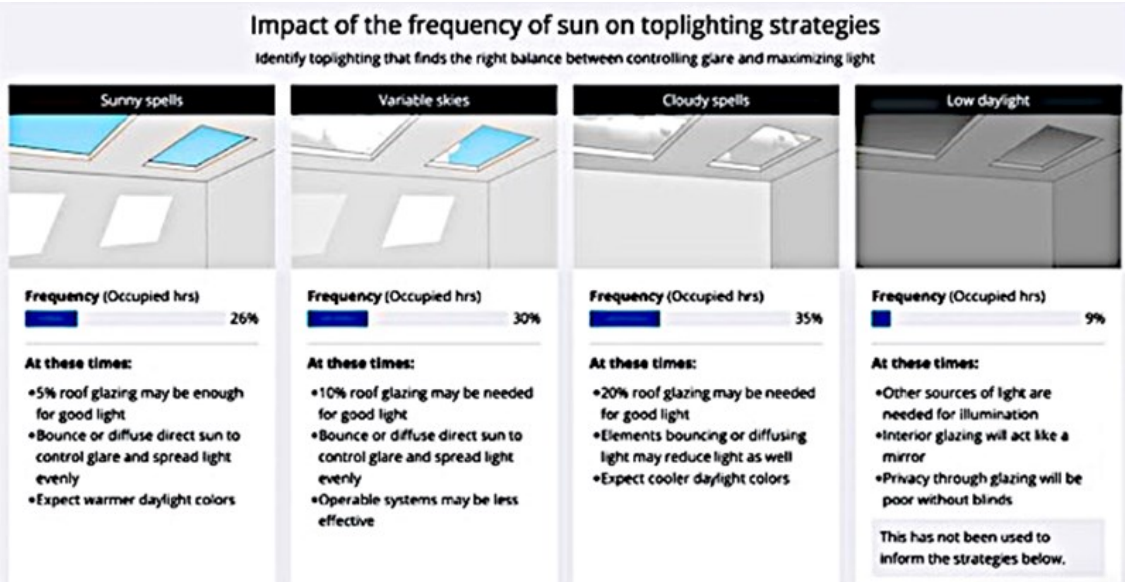
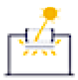
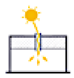
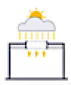
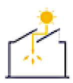
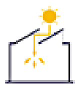


Figure 17 Impact results on top lighting on London Central Mosque

Table 2 Assessment analysis for the possibilities of different skylight design under lower level of daylighting projection

Design styling & Star rating		Design characteristics
Sawtooth facing north ★★★		limit glare by facing away from direct sun. cooler daylight from northern sky great view of northern sky decent sense of time passing
Cushions ★★★		limit glare by diffusing direct sun. warm light when sunny, cooler light when cloudy great view of the sky when cloudy decent sense of time passing
Baffle ★★☆		low angle sun may cause glare. warmer daylight from diffused sunlight obstructed view of sky light levels change with time of day.
Reflector ★★☆		high angle sun may cause glare. warmer daylight from bounced sunlight mostly obstructed view of sky reflected light communicates time passing
Light pipe ★★☆		limits glare by bouncing direct sun. warm daylight mixed duller, cooled light. Virtually no view of sky Light levels change gradually with time of day.
Sky Light ★★☆		Diffusing material may be hard to get right. Cooler daylight mixed with bright, warmer light. Diffused view of the sky Light levels change with time of day.
Sawtooth facing south ★★☆		Frequent direct sun likely to cause glare. Harsher daylight due to direct sun. Great view of southern sky Decent sense of time passing
Clerestory ★★☆		Frequent direct sun likely to cause glare. Cooler daylight mixed with harsher direct sun Great view of sky if blinds not in use Good sense of time passing
Roof light ★☆☆		High risk of glare from direct sun. Extremely bright sunlight very common Excellent view of the sly and clouds Enhances sense of time passing during cloudy spells.

LAYOUT UTILIZATION

Analyzation of the mosque's interior and exterior spaces or spatial distribution are laid out. Future designers are encouraged to think of ways to improve daylight distribution while yet upholding the need for privacy for worshipers in each section.[4] The result as per Figure 18 from the predesign analysis software highlighted the section of expected the outdoor spaces intervention usability where it indicates hours of space and material used which are breakdown into 13% hours of outdoor lighting, 13% of rain cover, 1% of sunshade, 86% of windbreaks and 58% of heating. Without these intervention strategy on the outside area the mosque outdoor compound area will only have limited habitable or seating usage which can only cater for around 20 minutes. Thus, the overall recommendation needed a combined windbreaks with heating and extra lighting outside of the mosque which shall then increase the percentage hours by 66%.

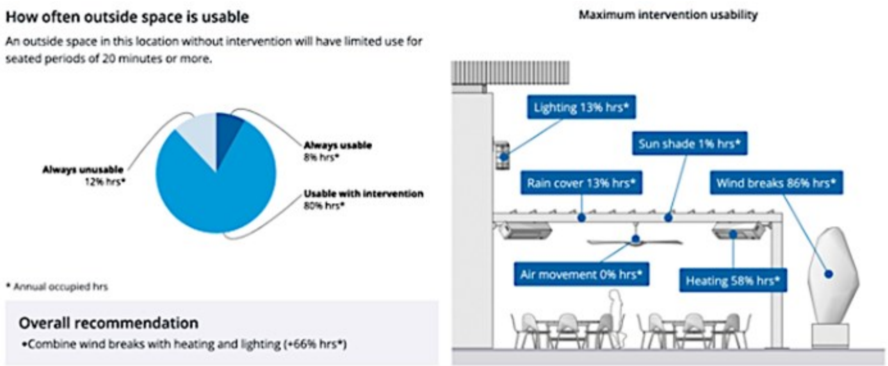


Figure 18 Overall recommendation of maximizing the usability of mosque's outside spaces to compare combinations of intervention anticipating best result to achieve goal in the adaptive expansion.

Figure 19 Suggests the best architectural layout for London Central Mosque

High ceiling conditions in the London Central Mosque main prayer hall and its relatively compacted situation during peak hour seasons, urged more light required in the inner spaces and surfaces. As diagnosed in the predesign software based on the mosque climate as per Figure 19, the result illustrated and clarified the best ways for architectural response is providing shelter from the cold that include well-insulated glazing envelope for the indoor, good control of infiltration, layout massing with limited articulation, efficient and comfortable heating system for the central mosque's expansion project [17].

Figure 20 Interior lighting for the main prayer hall of London Central Mosque

By introducing the intensity and homogeneity of the room perimeter, the suggested type of lighting may enhance the atmosphere of the prayer hall and even give the feeling of space [21]. The difference in the amount of horizontal brightness from the proposed overhead system has very little of an impact on feelings of comfort. The suggested new lighting scenario condition fosters new potential visual contact and unifies individuals in places of worship[2]. Because facial emotions and movements are more easily discernible in the mosque, increasing the intensities can lessen anonymity and bring people together[17]. Thus, choosing multidirectional distributional concentrating lighting for the main praying hall as per Figure 20 allowing extreme contrasts in the space to be mitigated to a sufficient extent by the upward component as per Figure 20. It produced efficient operation, which led to an evaluation of the lighting, and built a new framework to make the activities in the prayer room more convenient (Figure 18-20). An architect and builder should understand and implement modern building technology to reflect the essence of lighting principles and indirectly help with various end-user activities through design [10]. relationship between integral lighting system and architectural form allow reflex control of brightness function and light management like the dome of the mosque. Visually subordinate lighting used for both indirect and concentrated direct lighting systems established the relative importance of various mosque space planning [17]. For instance, the primary prayer hall, which houses the congregational prayers located on the highest point of the London Central Mosque's space planning whilst the kiosk, class, and meeting rooms encircling the semi-private spaces and some insertion of dim lighting in the visual landscape for the outdoor plaza area for the mosque [10].

CONCLUSION

The result answers the methodology and objective drafted for the study. Creating a schedule for monitoring time limit and frequency for data collecting through this predesign assessment software, observation studies and literature reviews done prepare developers with then set of frameworks in daylighting needed. Thus, considering changes in the length of the day throughout the year, monitoring could take place continuously, irregularly (like once per hour), or seasonally like the predesign assessment done based on the climate change for the next expansion project for the mosque [22]. Hence, it is known that the illumination levels as well as any additional pertinent information, such as the weather, the placement of the shading devices, the direction of the building, and all key points rendered in the suggestion analysis and the intervention strategies drafted will produce about 88% hours in terms of improvements as per Figure 21, are excellent move for the adaptive future expansion project for the London Central Mosque.

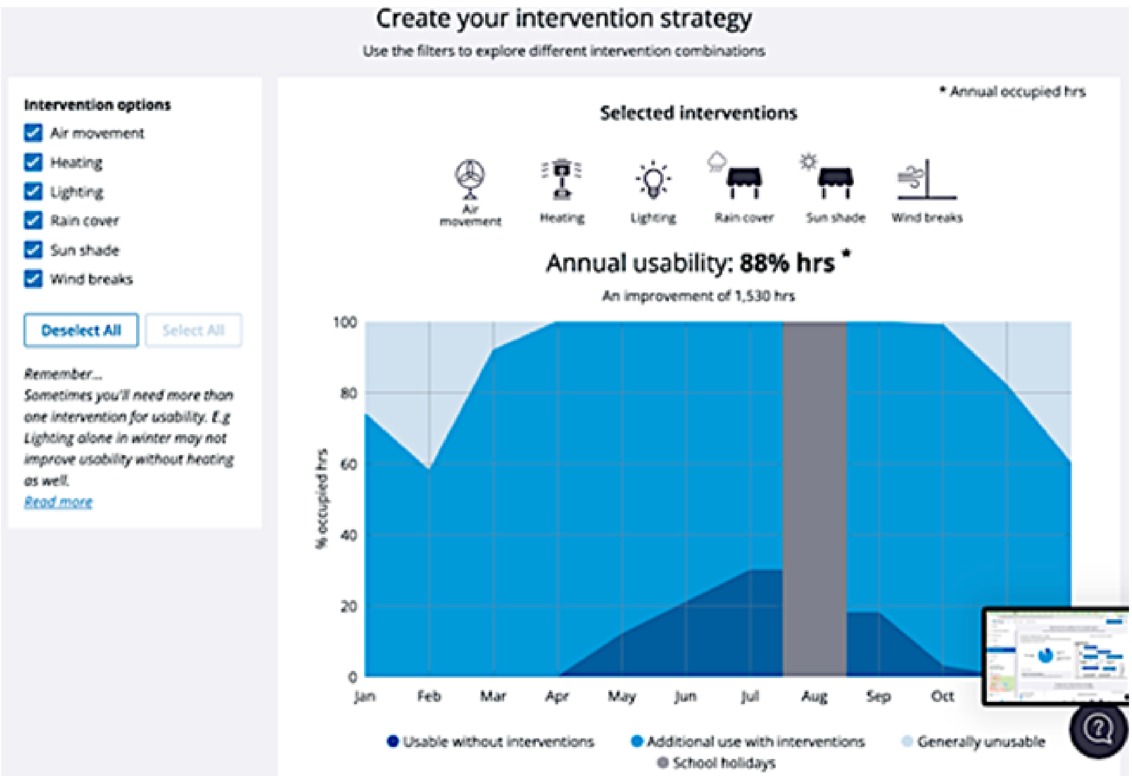


Figure 21 Intervention of mosque project improvement in terms of saving hours

REFERENCE

[1] F. Leccese, G. Salvadori, G. Tambellini, and Z. T. Kazanasmaz, "Assessing museums' daylighting adequacy without annual measurement campaign: Dataset of a confrontation between measured and simulated illuminance values inside the Cetacean Gallery of the Charterhouse of Calci," *Data Brief*, vol. 32, p. 106065, Oct. 2020, doi: 10.1016/J.DIB.2020.106065.

[2] F. Leccese, G. Salvadori, G. Tambellini, and Z. T. Kazanasmaz, "Application of climate-based daylight simulation to assess lighting conditions of space and artworks in historical buildings: the case study of cetacean gallery of the Monumental Charterhouse of Calci," *J Cult Herit*, vol. 46, pp. 193–206, Nov. 2020, doi: 10.1016/J.CULHER.2020.06.010.

[3] M. Ayoub, "A review on machine learning algorithms to predict daylighting inside buildings," *Solar Energy*, vol. 202, pp. 249–275, May 2020, doi: 10.1016/j.solener.2020.03.104.

[4] P. Matracchi and A. Sadeghi habibabad, "Prioritizing the effect of 'Light' in the religious places and environments with an emphasis on the sense of spirituality," *Ain Shams Engineering Journal*, vol. 13, no. 1, p. 101514, Jan. 2022, doi: 10.1016/J.ASEJ.2021.05.028.

[5] H. Alkhatib, P. Lemarchand, B. Norton, and D. T. J. O'Sullivan, "Deployment and control of adaptive building facades for energy generation, thermal insulation, ventilation and daylighting: A review," *Appl Therm Eng*, vol. 185, Feb. 2021, doi: 10.1016/j.applthermaleng.2020.116331.

[6] Chris Doyle, "UK's Muslim community becoming genuinely Britis," *Arab News*, Jan. 23, 2023.

[7] Zaynab Khojji, "UK mosques' open-door interfaith initiative returns," *Arab News*, London, Sep. 07, 2022.

[8] Jawad Iqbal, "The diverse origins of Britain's Muslims," *BBC News*, London, Jan. 18, 2016.

[9] N. A. Hanapi and K. A. M. Rodzi, "LIGHTING DESIGN FRAMEWORK; RECOMMENDATION STUDY FOR NEWCASTLE MOSQUE NEW SOUTH WALES," *Journal of Islamic Architecture*, vol. 7, no. 1, pp. 111–119, Jun. 2022, doi: 10.18860/jia.v7i1.13093.

[10] M. Sudan and G. N. Tiwari, "Daylighting and energy performance of a building for composite climate: An experimental study," *Alexandria Engineering Journal*, vol. 55, no. 4, pp. 3091–3100, Dec. 2016, doi: 10.1016/J.AEJ.2016.08.014.

[11] S. M. Hosseini, M. Mohammadi, T. Schröder, and O. Guerra-Santin, "Integrating interactive kinetic façade design with colored glass to improve daylight performance based on occupants' position," *Journal of Building Engineering*, vol. 31, p. 101404, Sep. 2020, doi: 10.1016/J.JOBE.2020.101404.

[12] S. Mayorga Pinilla *et al.*, "Advanced daylighting evaluation applied to cultural heritage buildings and museums: Application to the cloister of Santa Maria El Paular," *Renew Energy*, vol. 85, pp. 1362–1370, Jan. 2016, doi: 10.1016/J.RENENE.2015.07.011.

[13] S. Al-Maiyah and H. Elkadi, "The role of daylight in preserving identities in heritage context," *Renewable and Sustainable Energy Reviews*, vol. 11, no. 7, pp. 1544–1557, Sep. 2007, doi: 10.1016/J.RSER.2005.11.004.

[14] A. S. Hassan and Y. Arab, "Analysis of Lighting Performance between Single Dome and Pyramid Roof Mosque in Mostar, Bosnia Herzegovina," *Procedia Soc Behav Sci*, vol. 91, pp. 1–12, Oct. 2013, doi: 10.1016/J.SBSPRO.2013.08.395.

[15] P. Matracchi and A. Sadeghi habibabad, "Explaining and evaluating the quality of 'light' in religious environments and its effect on spirituality," *Frontiers of Architectural Research*, vol. 10, no. 4, pp. 803–820, Dec. 2021, doi: 10.1016/J.FOAR.2021.06.001.

[16] R. Suárez, A. Alonso, and J. J. Sendra, "Virtual acoustic environment reconstruction of the hypostyle mosque of Cordoba," *Applied Acoustics*, vol. 140, pp. 214–224, Nov. 2018, doi: 10.1016/J.APACOUST.2018.06.006.

[17] I. I. El-Darwish and R. A. El-Gendy, "The role of fenestration in promoting daylight performance. The mosques of Alexandria since the 19th century," *Alexandria Engineering Journal*, vol. 55, no. 4, pp. 3185–3193, Dec. 2016, doi: 10.1016/J.AEJ.2016.08.006.

[18] N. A. Azmi and S. H. Ibrahim, "A comprehensive review on thermal performance and envelope thermal design of mosque buildings," *Build Environ*, vol. 185, p. 107305, Nov. 2020, doi: 10.1016/J.BUILDENV.2020.107305.

[19] V. Cimino, M. Frascarolo, M. Mucciante, and U. Santamaria, "Interaction between daylighting and artificial lighting in relation to conservation and perception, according to new illumination system of Sistine Chapel," *J Cult Herit*, vol. 58, pp. 256–265, Nov. 2022, doi: 10.1016/J.CULHER.2022.10.004.

[20] K. Tarabieh, K. Nassar, M. Abdelrahman, and I. Mashaly, "Statics of space syntax: Analysis of daylighting," *Frontiers of Architectural Research*, vol. 8, no. 3, pp. 311–318, Sep. 2019, doi: 10.1016/J.FOAR.2019.05.004.

[21] A. Taufan, S. A. Zaki, N. W. Tuck, M. K. Singh, and H. B. Rijal, "Energy-efficient retrofitting strategies in mosque buildings: A review," *Renewable and Sustainable Energy Reviews*, vol. 183, p. 113479, Sep. 2023, doi: 10.1016/j.rser.2023.113479.

[22] S. Shaik *et al.*, "Space-age energy saving, carbon emission mitigation and color rendering perspective of architectural antique stained glass windows," *Energy*, vol. 259, p. 124898, Nov. 2022, doi: 10.1016/J.ENERGY.2022.124898.