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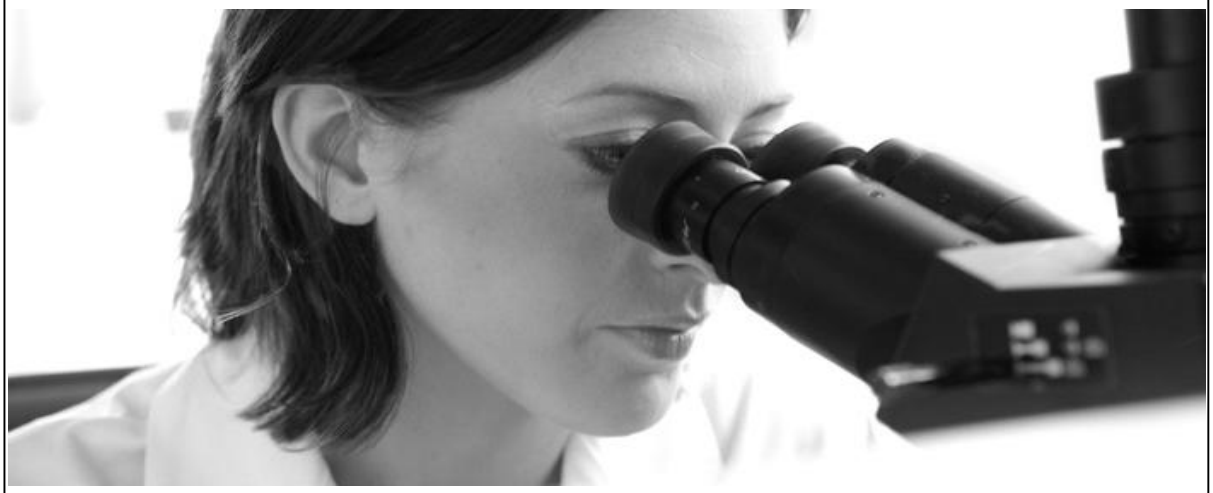

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RESEARCH ARTICLE

IMPROVING NATURAL LIGHTING FOR KING HUSSEIN MOSQUE AT AMMAN, JORDAN, USING SUNPORTAL SYSTEM

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ABSTRACT

This research is studying the possibility of improving natural lightining inside king Hussien mosque, that is depending mainly on artificial lighting despite the fact that Jordan is enjoying with 300 sunny days with more than 600000 lux of the direct sun and in considering that the sky illuminance is measured to be more than 10000 lux in 90% of the whole year.

Passive sunportal system refers to technology used to improve naturallighting, include outside mirrors, inside lenses, pipes and other similar devices. These devices have been studied by many researchers, while our study uses a scale model of sunportal system which is applied in the prayer hall in AlHussien mosque as a case study.

The research will base on three stages, descriptive stage will review the literature about natural lighting and mosque, analytical stage will analyze passive system units, especially Sun Portal system, and applied stage will analyze the measurements of natural lighting before and after adding the passive units. Based on the analysis of the data received from the three stages, the experiment revealed significant findings including that the illuminance of the mosque raised up to400 lux by using passive sunportal system, the initial reading is promising and improves the quality and quantity of lighting inside the mosque.

INTRODUCTION

Natural light and architecture are two strongly connected concepts on many different levels whether on function, esthetic, or environmental level.

Before the 1940s, daylight was the primary light source in buildings: artificial lights supplemented the natural light. In the short span of 20 years, electric lighting had transformed the workplace by meeting most or all of the occupants lighting requirements. Recently, energy and environmental concerns have made daylighting a rediscovered aspect of building lighting design. The buildings which are designed using daylight system are considered as having excellent passive design. Daylight is lighting that is obtained from indirect sunlight source, it provides the best source which comfortably matches with human visual response. The amount of daylight's penetration inside the building is mainly through sunlit areas from windows and doors openings which provide the dual function not only of admitting natural light to the indoor environment but also allowing the occupants to have visual contact with the outdoor environment (Chel, Tiwari, & Chandra, 2009; Chel, Tiwari & Singh, 2009)[1].

The absence of natural light role in the function of prayer hall for reading holy Quran in the mosque was the reason for this study. The Mosque is the place in which Muslims come together for corporate prayers, the floor of the praying hall is always covered by carpets because Muslims perform their prayers on the floor and they perform reading Quran and other, as well, while sitting on the floor. Therefore, sufficient illumination level is required for the reading task.

Taking into consideration of daylighting must be related to the time of day. Therefore, daylighting coming to the reading work plane level (six inches) should be evenly distributed during the day time prayers (12:00 p.m., and 3:00 p.m.). Sources of daylighting are the roof (skylights or dormer windows) and the walls (windows or full walls). Such lighting must be used with care so that glare does not reduce its usefulness by creating visual competition during the religious service (IES, 1993).[2]

Daylighting Systems Overview

A daylighting system combines simple glazing with some other elements that enhance the reaching or control of light into a space. Whilst ordinary windows deal adequately with some of

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the daylight needs of a space, there are two categories for new technologies and solutions that extend the performance beyond that of the conventional solutions:

The first one Daylight systems with shading and another system without shading, the second system is our study field.

Daylight system without shading

Daylighting systems without shading are designed primarily to redirect daylight to the area away from a window or skylight opening. They may or may not block direct sunlight. These systems can be divided into four categories:

Diffuse light –guiding systems

Direct daylight from specific area of the sky vault to the interior of the room. under overcast sky conditions, the area around the sky zenith is much brighter (around three times) than the area close to the horizon .for site with tall external obstructions (typical in dense urban environments), the upper portion of the sky may be the only source of daylight .light-guiding systems can improve daylight utilization in these situations.

Direct light – guiding systems

Send Direct Sunlight to the Interior of the Room Without the Secondary Effects of Glare and Overheating.

- **Light –scattering or diffusing systems** are used in skylit or toplit apertures to produce even daylight distribution .if these systems are used in the vertical window apertures, a serious glare will result.
- **Light transport systems** collect and transport sunlight over long distances to the core of a building via fiber-optics, light pipes and sunportal system.[3]

Sunportal Daylight System

Sunportal technology allows the best natural daylight to reach and illuminate any indoor environment, including deep plan building spaces that no other conventional daylighting systems can deliver.

It actively captures and effectively transports maximum sunlight from a heliostat with a unique parabolic dish concentrator to a luminaire via a series of special optical relay lenses, providing the highest transmission rates over any long distances and in any directions.

And because it also uses the latest IR-cut coating technology, there is no heat loss or gain associated with the transmitted daylight so the cost of heating or air-conditioning and its greenhouse impact is also reduced.This technology is the next generation of building integrated daylighting solutions delivering a whole new level of flexibility in residential and commercial environments, and can be used in single and multi-story residential properties through to commercial, industrial, mining and hazardous environments.[4]

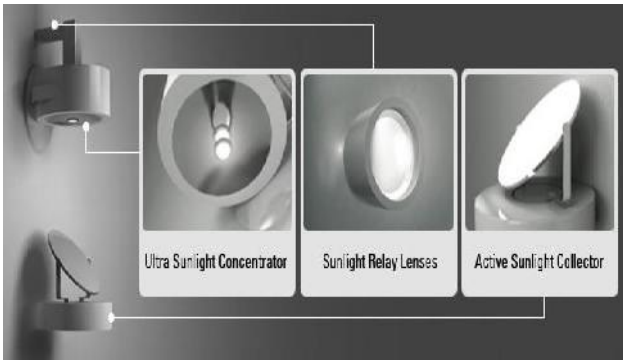


Figure 1 Components of sunportal system

The Benefits of this technology

Better Quality Light, Positive Impacts On Climate Changes, More Sustainable Future, Numerous Health Effects, Significant Productivity Improvement Great Energy And Cost Savings

Figure 2 The problem with other daylighting system

How sunportal system works

1. The Active Sunlight Collector captures the maximum amount of sunlight and redirects it into the Ultra Sunlight Concentrator by tracking the sun throughout the day and even in a cloudy day.
2. The Ultra Sunlight Concentrator collects and focuses the reflected daylight into the small light pipe aperture.

Figure 3 How sunportal system works

3. The highly concentrated sunlight then travels through a series of Sunlight Relay Lenses, over any distance and in any direction.
4. The best natural daylight reaches and illuminates evenly throughout the desired areas of your building by the Sunportal Tube Diffuser.
5. Creating a brighter, healthier and more pleasant indoor environment for everyone.

Al Hussien Mosque

King Hussein mosques located in West Amman, surrounded by a huge public park and accommodate 5000 prayers inside the hall and 10000 prayers in the court outside the main hall. It is a new mosque to commemorate King Hussain, the builder of new Jordan. Mosque usually is used for Friday services, praying 5 times a day, religious lecturing during religion occasions and reading Quran before and after praying.[6]

The mosque is depending mainly on artificial lighting instead of natural light despite the significant location in the highest point from surrounding that allows it to receive large amount of natural light without any shading, Jordan is enjoying some 300 sunny days with more than 600000 lux for the direct sun and the sky illuminance is measured to be more than 10000 lux in 90% of the whole year.

Natural Lighting Measurements in Mosque

There are two measuring stages, the first stage; measured the illuminance by using lux meter before adding sunportal system. Several reference points were carefully chosen and distributed in different locations in a grid pattern which drawn on the ground floor plan of the mosque. Some of them were located in the prayer hall, as shown:

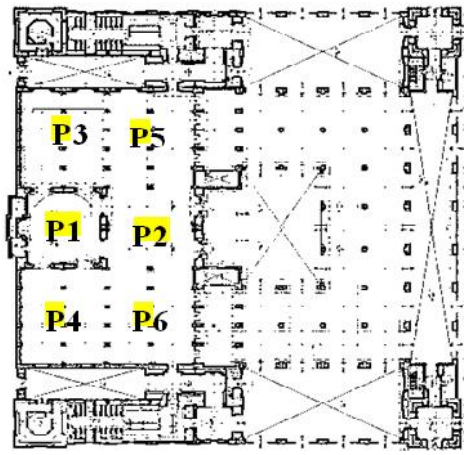


Figure 4 The grid pattern on the ground floor plan of the Mosque

P1- The center of the Mosque; P2- The center of the central dome; P3- South West corner of the prayer hall; P4- South east corner of the prayer hall; P5- North West corner of the prayer hall; P6 - North East corner of the prayer hall.

As a result of The measurement performed of these points ,the average reading inside the prayer hall was less than 100 lux as shown in the fig(5). While the average readings within the recommended illuminance for crustal reading should be at least 300 lux.

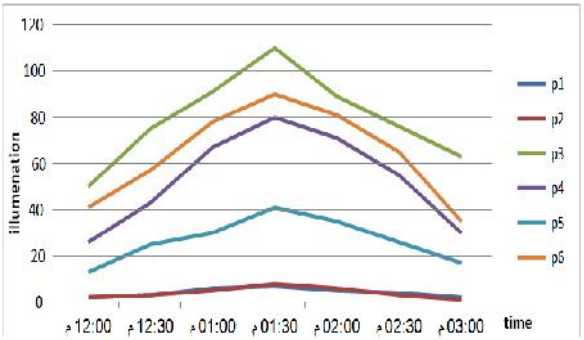


Figure 5 graphs showing illumination within the prayer hall before adding sunportal system.

The second stage; A physical model of a scale of 1:20 was used to simulate the daylight distribution inside the prayer hall after added sunportal system. The physical model was built of thick foam to represent the thick walls with (5*5*5cm) size. The foam was covered with black sheets to avoid any light leak.

The model was measured under clear sky conditions similar to the conditions of the original location of the mosque.

The applied one unit of sunportal system which consists of one mirror reflector, one concentrator and three lenses fixed with glass pipes gives a reading for more than 300 lux within the space of rough model fig (6); each lens gives around 130 lux.

Figure 6 The physical model used for testing.

DISCUSSION AND RESULT

The study is able to identify the sufficient illumination level provided when the applied sunportal system design for two lenses in each one defused in the prayer hall according to the experimental model. The findings from the results of analysis/calculations are as follows:
The illumination from each lens was calculated from every measured point, each point consists two lenses.

Illumination for each point = 2 lens * illumination to each lens
(2) Lens * (150) lux = 300 lux.

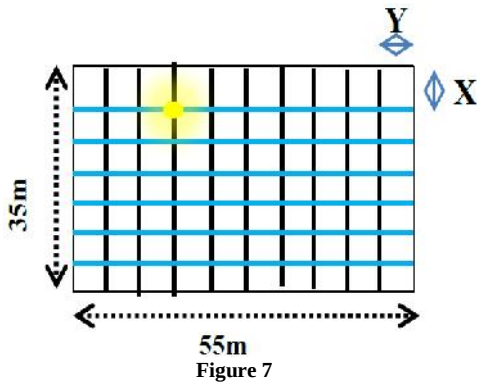


Figure 7
X=5 35/5=7 units Y=5 55/5=10 units Z=5 the high for each diffuse point. Each unit contains 2 lenses, 54 units for prayer hall.

Data indicated that the primary variation of illumination for every reference point inside the prayer hall occurred due to the change in time and month.; for instance, the point in center of the central dome before adding the lens or the system the reading was (8) lux while the reading in the same point gave (308) lux after adding (2) lenses. The distributed system in the plan as following fig (7).

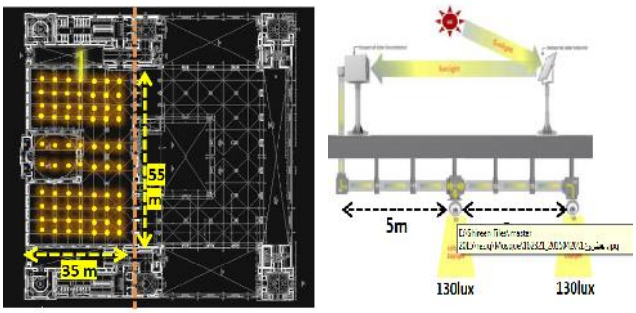


Figure 7 The distributed system in the plan

All the output data were plotted in graphs showing the geometry of the prayer hall using DPlot program as shown in fig (8) shows illumination before and after add sunportal system.

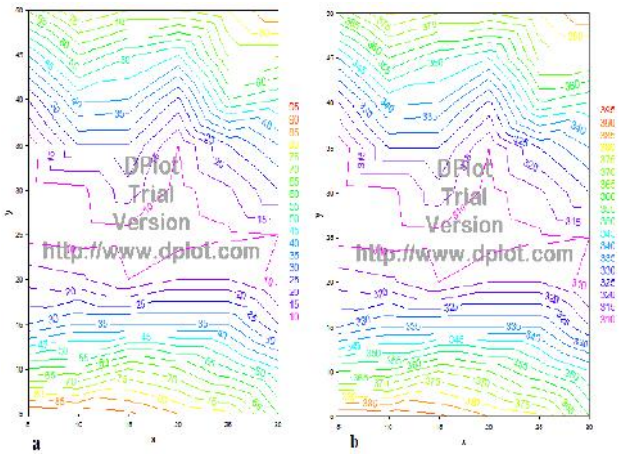
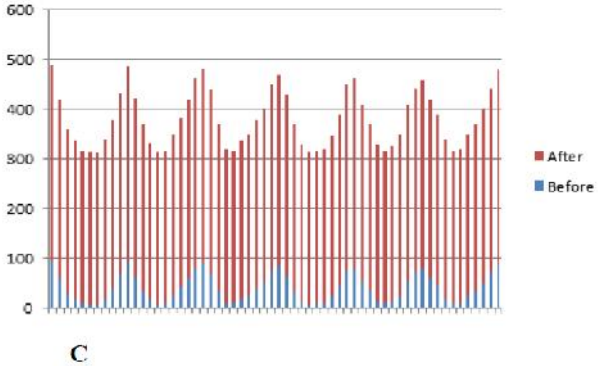


Figure 8 a - Showing the contour line of illuminance inside the Mosque before added sunportal system b - Showing the contour line of illuminance inside the Mosque after added a sunportal system



c -The graphs showing the increase in the illumination when using sunportal system. From 100lux Up to 500lux

CONCLUSION

This study concludes that AlHussien Mosque receives less quality and a non-sufficient quantity of light along all the year at the hours 12:00 and 3:00 p.m. Most of the light is basically comes from the windows of the courtyard.

The research findings show that adding the sunportal system in the prayer hall in Alhussien Mosque provides additional daylight especially in the center of the prayer hall at point P1 and P2.

As a result, the extra high ratio to the illumination from sunportal system helps to provide a good illuminance levels in Mosque even without the windows openings.

However applying the sunportal system in prayer hall offers illuminance level distributed at all locations inside the mosque which gives a better illuminance level in all locations inside the mosque.

Applying this system form gives inspiration to the master builders to design a mosque with a perfect lighting performance with sacred sense of worshipping activities in the mosques and helps creating vast interior space plan layout without obstruction by walls and columns.

These offers the master builders to explore daylighting design as a source of scared expression a place of worship with a presence of divinity inside prayer hall.

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