

293: Sustainable Daylighting Strategy of a Chinese Traditional Building: FaLun Palace of Yonghe Tibet Temple

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Abstract

Investigating 'Daylighting' strategies used in traditional Chinese buildings has revealed sustainable ideas which could be used in today's modern buildings. The 17th century Yonghe Temple's 'daylighting' features were studied to determine how an ancient people could enjoy unobstructed internal vision; and at the same time achieve a religious atmosphere. To establish the source of the interior light, radiance was used to simulate the interior 'daylighting' environment; illumination and luminance in the Falun Palace was evaluated and analysed.

Keywords: daylighting, traditional Chinese building, Illumination, lamination

1. Introduction

Before electric lighting arrived in China at the end of the 19th century, daylight was the most important light source used in buildings; and different strategies were used in different types of historical buildings [1]. Lattice, wooden doors, and folding screens were used to reduce the intensity of bright, direct sunlight. Eaves were also used, not only to direct the flow of rain from the roof, but to control daylight incidence. For religious buildings, daylighting was used to light the interior space, and to help create a spiritual atmosphere. Daylighting in Chinese religious buildings was completely different from that of western buildings [2], because of the specific Chinese lighting culture. Research on traditional religious daylighting strategies is helpful to comprehend Chinese lighting culture, which can be employed in future lighting design of modern buildings.

A typical example is the Yonghe Temple, in Beijing, built in 1694, and used as Tibetan Buddhist temple since 1744. Yonghe Temple is composed of a series of buildings, the most important being the Falun Palace. The Falun Palace, which includes an important reading place for monks, is a wooden building designed on a cross plan, see figure 1. This building is 16.2 meters high, 26.4 meters long, and 26.4 meters wide, see figure 2 and figure 3. Inside the temple, daylighting enables people to see clearly, to study, and at the same time intensifies the religious atmosphere. The center piece of the building is a huge statue of a sitting Buddha.

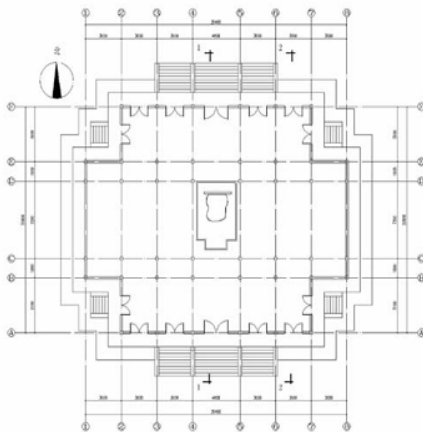


Fig 1. Plan of Falun Place

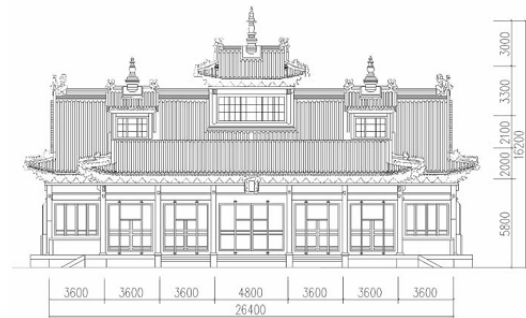


Fig 2. Elevation of Falun Place

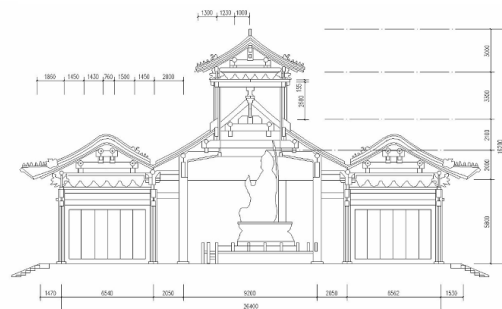


Fig 3. Profile of Falun Place

2. Daylighting Component

Diffused light can always be found in traditional Chinese buildings, which is totally different from the modern buildings. In the traditional building, light in the space is not always designed to be bright and clear; it can be a little dim and lacking high contrast.

In the Falun Palace, diffused light is achieved using a series of components such as a high-standing skylight, huge curved roof, wooden windows and doors, painted beams, light coloured ceiling panels and so on.

2.1 Skylight

In traditional constructions, skylights were used particularly in royal buildings and Buddhist buildings, according to an historical, hierarchical ranking. Although the difficulty of construction increased enormously because of the skylights, they were the most important components for daylighting.

There are five skylights in the roof of the Falun Palace. The largest is located in the centre of the roof, the highest section of the building, with four small skylights symmetrically sited around it, and a little lower than the central one. All the skylights are integrated with the roof and the structure of the building.

In a building with a floor plan exceeding 500 square meters and a substantial, oppressive roof, skylights help to keep the centre of the interior space bright enough to see clearly. Daylight from the central skylight illuminates not only the statue of Buddha itself, but also the floor around, which can be reflected to the space nearby, see figure 4. When kneeling down in front of the statue of Buddha, one can see the light streaming down onto the top of the statue's head, which could be imagined as coming from heaven.



Fig 4. the statue of Buddha under the centre skylight

2.2 Roof

Huge curved roofs and deep eaves are two characteristics of conventional Chinese royal and religious buildings. The huge roof and deep eaves prevent daylight from entering through windows directly, and the light which penetrates has to be reflected into the interior space from the floor, see figure 5. The floor reflects more light than the ceiling, creating a more serious and dignified look on peoples' faces in the Falun

Palace. This is another feature of lighting in Chinese traditional buildings, using daylighting strategies to impose a particular environment, here a religious one.

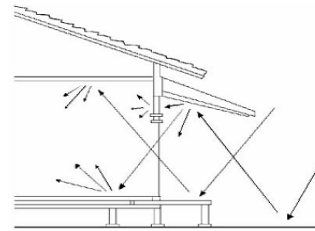


Fig 5. Daylight entering by reflection

2.3 window and door

All the windows and doors in the Falun Palace are wooden, of which the ornate lattice is the most important feature, see figure 6. The latticework diffuses daylight before it enters the interior space. As well as daylight incidence, these windows and doors provide ventilation, defence, curtaining and decoration.



Fig 6. Windows and door with lattice

According to the results obtained using the Radiance simulation, on a clear day in May 2007, it was found that the door is the primary daylighting source. If all the doors are closed for a special activity, the interior space appears very dark, confirming that the windows and the doors are the primary daylighting source.

2.4 Ceiling

All painted the ceiling panels are designed in a checkerboard pattern, see figure 7. With a reflectance of about 0.4, the panelled ceilings help to reflect the daylight entering from the skylight, allowing the paintings on the ceilings and sidewalls to be seen clearly. People can conceive the scale of the space with the bright ceiling.



Fig 7. Ceiling lit by daylight

3. Data acquisition and Illumination distribution

Illumination was measured every hour from 10:00 until 16:00 on a few sunny days in May, 2007,

when the front door was open—this is the only time visitors are allowed to enter the Falun Palace.

3.1 Illumination on the floor

According to the measurement of illumination on the floor at 13:00, there was a sharp decline from under the eave when entering the Palace, illumination varying from 76500 Lux to 900 Lux. This is why people need a few seconds to adapt to the darkness. Once the eyes have adjusted to the dimness, the light on the top of the statue of Buddha will be seen to be the brightest point in the vision field. This imposes, and enhances the religious feeling.

Figure 8 shows the illumination on the floor from south to north. Illumination is greatest near the south door, and decreases as the distance away from the south door increases. In the middle area, illumination varies little during the daytime. Proceeding from south to north, and approaching the north door, the illumination increases, but not nearly as much as that recorded near the south door.

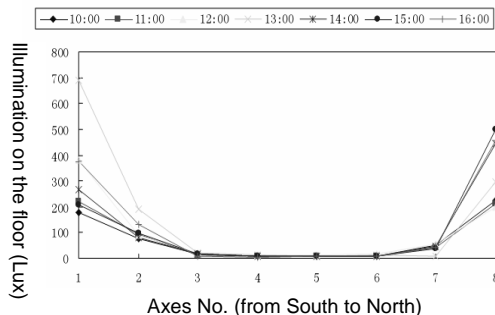


Fig 8. Illumination on the floor from South to North

Figure 9 shows the illumination profile on the floor from west to east. The data are variable in the afternoon, especially at 15:00, when the daylight incidence from west windows sharply increases the illumination nearby.

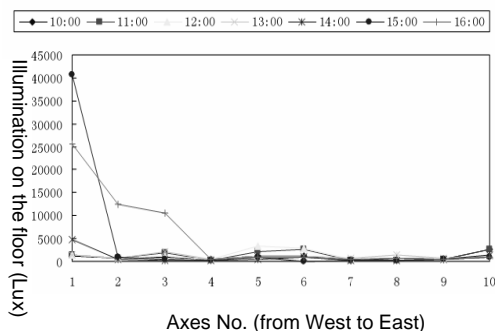


Fig 9. Illumination on the floor from West to East

According to the illumination measurement on the floor, 56% of the interior floor is illuminated and this illumination is maintained, uniformly, during daytime.

3.2 Illumination on the desk

Near the statue of Buddha there are two rows of desks where monks can read and study sacred writings; one row located to the east of the statue,

the other to the west. All the reading desks are located near the centre of the room, far from the

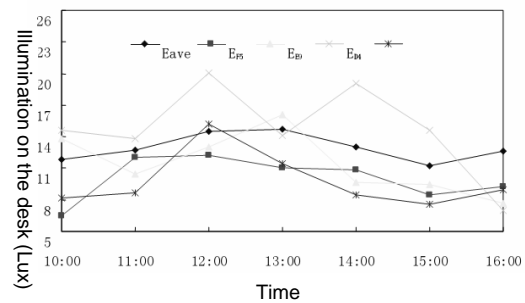


Fig 10. Illumination on the desk during daytime

desk is very low and does not vary during daytime, see figure 10. As the average illumination is about 14 Lux, which is insufficient for reading, candles are used on the desk.

4. Lumination distribution

A Lumination measurement system (SM), developed by Prof. Shen Tianxing, of Tianjin University was used to test lumination in the vision field. From a series of photographs taken with a special digital camera, lumination data can be obtained from special software [3]. The software can output pseudo-colour images, showing the lumination distribution with different colour images.

In order to investigate the lumination distribution in the space, the series included the outside of south door, under the south eave, around the statue of Buddha, the ceiling, the eave, the sidewall, and the skylight, but only three scenes have been selected to present here due to the length limitation imposed for this paper.

All the pseudo-colour photographs presented here were taken at 13:00 on a day in May, with a clear sky.

4.1 From under the south eave

Figure 11 shows that light on the door under the south eave is divided into two parts: 1. on the top of south door in the shadow of the huge roof and eave, lumination is relatively uniform and low. The lumination data is about 4 cd/m². 2. On the remaining part of the south door, lumination increases gradually to about 54 cd/m². Lattice on the wooden door keeps the lumination steady making the south door appear more solid and strong, and leaving a visitor to speculate that something of importance is behind the door.

People can see the statue of Buddha distinctly here. The maximum lumination contrast ratio is about 17.85 in this scene, excluding the guideboards in front of the south door.

4.2 Inside the south door

On entering through the south door, lumination declines sharply, average lumination in the vision field varied from 101.58 cd/m² (when out of the Palace) to 3.25 cd/m², all the spaces being quite different. Beams, ceiling panels and structures are painted with light coloured patterns, and this allows daylight to be adequately diffused in the interior space.

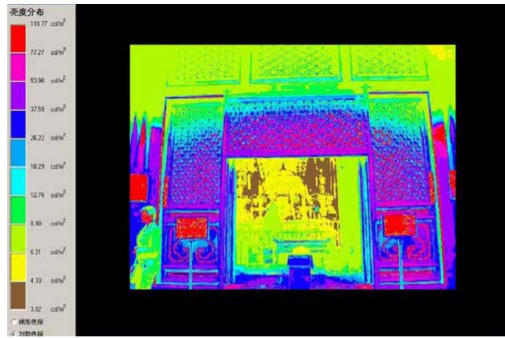


Fig 11. Lumination from under the south eave

Figure 12 was taken using a fish lens in order to show all the directions in vision field. There is no high luminance contrast in this scene, daylight spreads uniformly, excluding two bright points near the east and west door. People feel peaceful and reassured here.

Luminance on the floor is higher than that on the ceiling but light and shadow vary alternately on the ceiling, making appear 3 dimensional, in alternating rhythms of light and dark.

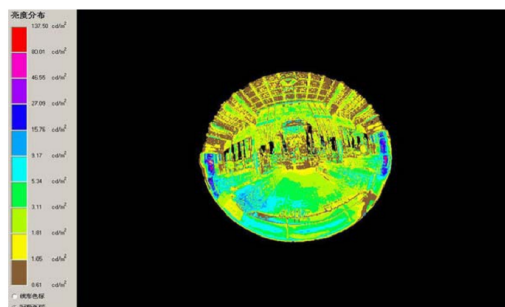


Fig 12. Lumination from south door

4.3 Around the statue of Buddha

In this scene the statue of Buddha is the vision focus. There is a high contrast between the surface, especially on the face of the Buddha, and the background, so this illumination will naturally draw people's eyes from other areas.

Daylight from the skylights always remains focused on the head of the statue. This makes the head, especially above the jaw, extremely bright - about 7.16 cd/m^2 on the top and 1.32 cd/m^2 on the jaw. The maximum luminance contrast between the Statue of Buddha and the ceiling is about 29. The brightly daylight from skylights, the high standing columns, the relatively dark ceiling, all of this creates a feeling of respect and awe.

5. Conclusion

In the Buddhist sutras, there is a saying, "All the world is dark, the only light comes from the Buddha". In the daylighting environment of Falun Palace, this idea is fully expressed. Daylight in this building is used not only to see, but also to create an atmosphere of religiosity.

The strategies used to achieve these two important functions, are firstly, and most importantly, using the building's architectural features to light the interior space.

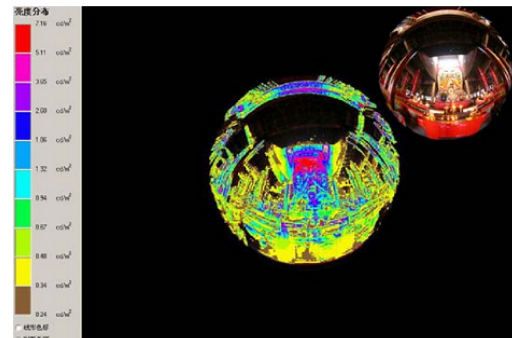


Fig 13. Lumination near the statue of Buddha

The huge roof and deep eaves block the sunlight, preventing it from penetrating directly; while the available sunlight is reflected hundreds of times by the wooden doors, windows, light coloured painted ceilings, beams, and floor. As a result, illumination on 56% of the floor's central area remains low, uniform and with little variation throughout the day. At the same time the luminance on the surface of this space is also constant. The effects is that people feel peaceful in this Palace.

In comparison to modern buildings, most light in this space comes from the floor instead of the ceiling. Luminance on the floor is higher than on the ceiling. This is another feature of the lighting in Falun Palace and some traditional Chinese buildings.

Daylight entering from the skylights lights the central part of the building, falling especially, and deliberately, on the head of the statue of Buddha. The high luminance contrast between the head of the statue and the overhead ceiling enhance the mysterious feeling of religion.

Architectural lighting is functional, detailed. Yet delicate work, reflecting the lighting culture of a nation. This is the first time the daylighting strategy of a Chinese traditional building has been investigated and analysed, and it is hoped that by exploring Chinese traditional lighting culture and the design, this will be helpful to the work of future lighting designers.

6. Acknowledgements

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