Formulation of Design Criteria for Lighting of Shopping Centers

A thorough survey of shopping centers in Pakistan

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Abstract: The lighting design is an essential element in the planning and construction of retail and recreational spaces like shopping centers, cinemas, restaurants, etc. It affects people's mood, energy, and perception of the space. For shopping centers, in particular, lighting design greatly impacts purchasing behavior and customer satisfaction. The lighting design is a tradeoff between aesthetics and science. Choice of illuminance level, arrangement of the luminaire, luminaire type, and color temperature, etc. are important factors to be considered. For shopping centers, however, there aren't any dedicated standards to define the design criteria. In the absence of standards, it is apt to study the practices. This research focuses on the center culture in Pakistan. This survey-based research investigates the illuminance levels and color temperatures at thirteen centers in Pakistan with respect to different general and specialized areas of the center. Based on the gathered data the authors have proposed ideal design criteria. This exercise shall facilitate the designers and enable them to bring their design in close compliance with the targeted ambiance.

Keywords: Shopping center, Lighting, illuminance, Color temperatures, Standard practices

I. INTRODUCTION

Interior lighting quality has a great impact on a person's visual comfort and contentment with public spaces, the most frequently visited among them being shopping centers. Upon research, it becomes evident that standards such as EN12464 and SLL Lighting Guide, are deliberately silent regarding shopping center illuminance levels.

The criteria for design greatly depends on the ambiance targeted. A low lighting level based warm and cozy environment can be an equally good design as an overly bright one. Therefore, the aim of this research is to identify general lighting practices in a number of famous shopping centers in the cities of Karachi, Islamabad, and Lahore and identify any correlation between them, consequently recommended most suited values as design targets.

In addition to the illuminance level, there are a number of factors that define a good lighting scheme. For instance, uniform distribution of illuminance over the floor space, called uniformity. Uniformity [1] is defined as the ratio of the minimum lux to the average lux level of space and it helps to quantify the overall spread of light in an area. Differences in light levels go visually unnoticed in working planes with a uniformity ratio of 0.60. To achieve better distribution the ratio can be further raised to 0.65 to facilitate people with weaker eyesight. Illuminance uniformity has a significant impact on the visual satisfaction of occupants.

Another metric that plays an important role in visitors' perspective is CCT [2]. CCT is the light color emitted by a black body radiator if it is heated up to a certain temperature. Lower values of CCT create a warm and relaxing mood while higher values improve alertness and provide an energy boost.

This research focuses on illuminance levels and CCT, the measurements of which have been taken with careful consideration towards uniformity of illuminance.

[3-5] presents a similar approach for streamlining the design requirements.

S. Zakaria, N. Rou, H. En, and T. Iyian [3] surveyed a Malaysian shopping center with respect to correlated color temperature (CCT) of the installed lights. The authors recommended warmer and fewer lights to reduce glare and create a comforting atmosphere.

A. Kusumowidagdo [4] compared the importance of social and physical factors and their effects on the perception of visitors in the food courts of two famous shopping centers in Indonesia.

H. Jin, X. Li, J. Kang, and Z. Kong [5] investigated the most suitable metric to evaluate the visitors' degree of satisfaction with shopping center lighting. The findings indicated a good correlation between luminance uniformity and the average occupant satisfaction under a natural and artificial lighting environment.

The absence of case studies of shopping centers in Pakistan sets the foreground for our study.

II. METHODOLOGY

This research targeted thirteen shopping centers in Pakistan which included ten shopping centers of Karachi, one of Lahore, and two of Islamabad.

Average illuminance and correlated color temperatures were measured. The measurements were performed using Opple Light Master Generation-II.

General areas like elevators, lobbies, toilets and parking areas were surveyed in addition to the dedicated shopping center facilities like corridors, food courts, event spaces, prayer rooms, etc.

It has to be noted that in shopping centers, the corridors contribute the highest to the total area excluding the shopping outlets. Lighting levels of corridors are majorly impacted by the presence of shops. The spill light factor, however, is impossible to be made part of the lighting design as the outlets may change over time. For this purpose, three types of corridors were studied,

- ➤ Corridors with no shops
- ➤ Corridors with shops on one side
- ➤ Corridors with shops on both sides

In order to record average illuminance, the illuminance measurement was performed at several locations and averaged. Fig. 1 depicts a typical corridor simulated on DIALux 4.13.
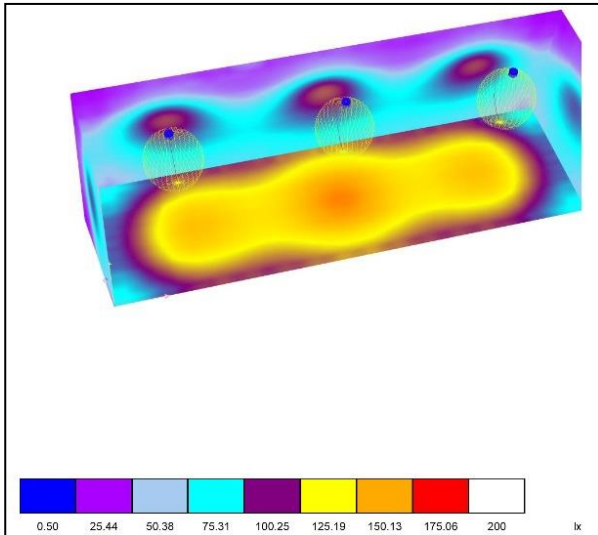

Fig. 1 Lux Levels in a Typical Corridor

It can be observed that the red area which is present right below the luminaires represents the highest lux levels. Blue and yellow regions represent the farther end and the area between two luminaires respectively. Smaller lux levels are observed in these regions. Therefore for the calculation of average illuminance,

readings for all of the above areas were recorded and averaged.

An important factor affecting the measured results is space cleanliness and luminaire maintenance. Cleaner surfaces reflect more, improving the light utilization factor. Fig. 2 depicts the impact of maintenance on illuminance.
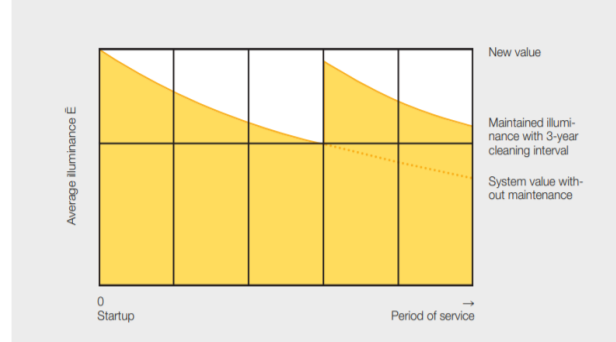

Fig. 2 Maintenance Affecting Illuminance [6]

Maintenance schedules, light replacements, and cleanliness schedules were therefore discussed with the staff members of the shopping centers surveyed. It was learned that in most of the centers at every 6 months and additionally before events, thorough preventive maintenance is done.

Other parameters like daylight, crowd, events, weather, etc. may have affected the results, however, it was tried to take all the readings at the same time and same day to minimize the effect of the environment on the readings.

III. RESULTS & DISCUSSION

Table 1 summarizes the average illuminance values measured for all the shopping centers. Various conclusions can be drawn from the observed values. An effective way to analyze a set of data is to evaluate its mean. However, the mean is prone to be affected by outliers. Therefore, the median is also calculated to provide the positional mean of the set of data. Table 2 shows the mean and median calculated.

For corridors, it can be observed that that the contribution of spill light from the shops is significant. Table 3 quantifies the contribution of spill light for shops on one side and both sides. The spill light contribution triples with the shops being located on both sides of the corridor instead of one. The mean and median hint a design target of 150 Lux for corridors. However, the likelihood of shops being located on either or both sides cannot always be predicted at design stage.

Table 1. Measured values of average illuminances

Areas	Packages Mall Lahore	Millennium Mall	Ocean Mall	Lucky One Mall	Dolmen Mall Clifton	Dolmen Mall Tariq road	Atrium Mall	Lavish Mall	RJ Mall	Saima Square	Safa Mall Islamabad	Centaurus Mall Islamabad	Saima Mall
Corridor without shops	-	121	147	123	225	236	140	97	71	102	244	115	-
Corridor with shops on one side	-	231	224	159	325	252	-	132	84	80	323	126	102
Corridor with shops on both sides	850	247	520	-	550	260	360	-	266	160	415	152	142
Food court	1000	-	546	136	533	186	140	-	356	-	525	135	53
Prayer Area	-	-	-	98	750	171	500	-	-	-	69	123	13
Event space	-	-	-	201	-	-	-	-	-	149	-	-	133
Elevator Compartment	-	-	362	-	45	806	-	236	538	117	113	63	102
Elevator Lobby	-	-	271	72	-	417	118	70	-	66	-	-	84
Toilet cubicle	-	35	115	211	325	204	310	43	11	106	125	20	105
Toilet vanity	-	91	551	142	288	364	-	49	124	117	170	70	135
Basement Parking	-	-	99	37	-	51	-	-	-	-	11	7	-

Table 2. Summary/Analysis on the measured values of illuminance

Areas	Average	Median	Author's /standard recommendation for design targets
Corridor without shops	147	123	200-300
Corridor with shops on one side	199	191	-
Corridor with shops on both sides	356	266	-
Food court	361	271	300
Prayer Area	246	123	200-300
Event space	161	149	200-300
Elevator Compartment	265	117	100*
Elevator Lobby	157	83.5	200**
Toilet cubicle	134	110.5	200*
Toilet vanity	191	135	200
Basement Parking	41	37	75*

*EN12464-1 **SLL Lighting guide

Table 3. Spill light in corridors

Corridor type	Average Spill Light	Percentage
Corridor with shops on one side	68	55%
Corridor with shops on both sides	143	116%

Table 4. Measured values of CCT

Areas	Millennium Mall	Ocean Mall	LuckyOne Mall	Dolmen Mall Tariq road	Lavish Mall	RJ Mall	Saima Square	Saima Mall
Corridor	5300	3000	4000	3500	3000	5500	5000	5000
Elevator Compartment	3500	4000	-	3800	5300	6600	5800	5000
Elevator Lobby	4800	3000	4200	4000	-	-	6000	4600
Food court	-	4000	4000	3200	-	4000	-	5200
Washroom cubicle	4500	4000	4000	2800	3400	5800	5800	5800
Washroom vanity	6000	4000	4200	2800	5700	6700	6000	5800
Basement Parking	-	4000	4700	3800	-	-	-	-
Prayer Area	-	-	3700	3500	-	-	-	5000

Additionally, the depreciation of lumen output of the luminaire and lack of frequent maintenance of the facility are important to be considered. Authors, therefore, recommend a slightly higher design target of 200-300 lux.

For food courts the readings average at 300 lux, also EN12464-1 recommends 300 lux for various eating and dining applications. A design target of 300, therefore, seems apt.

Prayer areas present a difficult case. The data set varies greatly. The deviation is also evident from the significant difference between mean and median. From an application perspective, the prayer room is used for offering prayers as well as recitation of the Holy Book. EN 12464-1 recommends 300 Lux for reading tasks. Authors, therefore, recommend a design target of 200-300 Lux.

Event spaces are usually supplemented with additional lights to be used during events and festival decorations. General illuminance, however, needs to be maintained without consideration of the additional luminaire. The measured values indicated a design target of 150 Lux. considering the lumen depreciation and infrequent maintenance, a design target of 200-300 Lux is recommended.

General areas of the shopping center have already been discussed in various standards such as EN12464-1 and SLL Lighting guide in different contexts. Table 2 shows the recommended values as per standards for these areas.

Table-4 gives the recorded values for the correlated color temperatures in various areas of the shopping centers. The data set provides a fairly divided opinion between warmer and cooler colors i.e. CCT in the range 3000-4000K and 5000-6000K are both observable equally. To devise a recommendation, the authors have resorted to rely on their own experience of using the facilities at different shopping centers.

The color temperature (CCT) in toilets is recommended to be high (5000K) to create a sense of cleanliness and allow safe use of the amenities. For all other areas like corridors, food courts, prayer rooms, lobbies, etc. warm white to neutral white light (3000K-4000K) is recommended. Owing to limited options for family recreational activities, shopping centers in Pakistan play many roles in addition to being a market space. Warmer colors shall provide a relaxing environment, encouraging a longer stay and a peaceful shopping experience.

IV. CONCLUSION

Lighting design is an important planning aspect, more specifically for public spaces like shopping centers. Commonly used lighting standards are silent on recommendations for shopping centers. To combat the case, various shopping centers in Pakistan were surveyed and their lighting practices recorded. The major focus was laid on illuminance levels and correlated color temperatures. In addition to surveyed results, various recommendations have been put forward. The scope of the survey can be extended with the inclusion of other metrics like CRI, Lumainaure types, and UGR. Similarly, in addition to quantitative analysis empirical analysis maybe considered.

Similar surveys can be conducted for other facilities like mosques, to streamline the design requirements.

ACKNOWLEDGEMENT

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