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The Effect of Lighting Intensity on Visual Comfort in The Sacred Space of Buddhist Temple

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Abstract. A Buddhist temple is a sacred Buddhist space where the building users require certain visual comfort conditions. The issue is that the temple's architectural style varies according to the local context and the type of belief it teaches. Implementing certain architectural styles will affect the interior space's artificial lighting design, which eventually affects the visual comfort of building users. Therefore, this study aims to determine the effect of artificial lighting on the building user's visual comfort in two different temple case studies that use dissimilar architectural styles in Medan City, Indonesia. Two data collection methods were used in this study. The first was by measuring the room's illumination level using a handheld lux meter. Secondly, through a survey/ questionnaire to find out user's perception of visual comfort related to the usage of artificial lighting during two activities in the sacred space in the temple: praying and reciting the Sutras. As a result, the two temples were identified using almost the same principle of applying artificial lighting, which aligns with Buddhism's purpose of enlightenment, 'the journey from dark to light.' The data collection results also show similar results. Both have illumination levels below the number stated in the visual comfort standards. While on the contrary, the majority of survey respondents from both cases felt visually comfortable during their activities in the case study. This study proves that the lighting design capable of providing positive visual impacts for users can rely on the technique and method of applying lighting distribution.

Keywords: Artificial Lighting, Temple, Visual Comfort, Level of Illumination

1. Introduction

The city of Medan is the capital city of the North Sumatra Province, Indonesia, which has the second-largest Buddhist population in Indonesia, with the majority Chinese ethnic (Garnesia, 2018). Eventually, this city is filled with Buddhist religious buildings. In 2020, Buddhist temples in Medan City were recorded as much as 212 out of 393 total temples in North Sumatra Province (Badan Pusat Statistik Provinsi Sumatra Utara, 2021). With such a large number, it turns out that the variety of architecture is not homogeneous. The temples applied several different architectural styles, from traditional to modern.

The goal of the Buddhism teaching is to achieve enlightenment. In English, the term enlightenment is highly related to the word "light" (Gojnik, Gojnik, & Šćitaroci, 2015). In Buddhism's sacred space, sacredness is represented by the use of light to symbolize the attainment of Buddha's wisdom in Buddha statues (Gojnik et al., 2015). Buddhist sacred spaces generally use a dark atmosphere with light existing only for illuminating Buddha statues. The lighting design of the Buddhist's sacred space also represents the goal of Buddhism, namely the journey to enlightenment, which is characterized by a gradual increase in the lighting intensity from dark to the brightest point, where the Buddha statue is located at the highest end of enlightenment (Gojnik et al., 2015). In traditional Chinese Buddhist architecture, sacredness is obtained by aligning itself with nature's heights (Wang,

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2021). Wang (2021) stated that this can be seen in the traditional Chinese temple built on mountains to present the perception of contrast between the heights of space and humans. This perception is also supported by DeCastro (2012), which stated that a space that presents sacredness is a space that exceeds human size. This similar concept can also be seen in the existence of indoor and outdoor spaces in the monastery's architecture which is acculturated to Chinese culture (Wang, 2021).

Lighting can be divided into two types based on its source of light, natural and artificial lighting. Integration of both natural and artificial lighting in places of worship, according to DeCastro (2012), will influence the formation of the atmosphere and increases the sensory experience of the sacred space (DeCastro, 2012). Lighting, along with color, is one of the significant factors affecting visual comfort. Visual comfort itself is essential when carrying out religious activities (Mannan, 2021). Lighting in visual comfort supports carrying out activities properly and provides an emotional impact in the form of calm and closeness to the figure worshipped in each religion (Mannan, 2021). In a temple, natural lighting plays a vital role in helping to meet the need for space for prayer and reciting the Sutras (Mannan, 2021). In addition, natural lighting as a form of attachment to nature can also provide comfort to provide stimulation to the five senses and specific emotional impacts (DeCastro, 2012).

In contrast, artificial lighting in Buddhist sacred spaces centered mostly on Buddha statues. Before the advancement of electric lamps, traditional temples generally used candles to light a Buddha statue (Gojnik et al., 2015). But along with the development of technology, artificial lighting in the form of lamps is used in modern temples for many things, such as illuminating prayer areas and Buddha statues by adjusting to a predetermined standard of illumination level.

In lighting, the illumination level is one of the basic standards for presenting an environment that can provide visual comfort for humans (Susanto, Rahayu, & Widyarko, 2018). Based on the Indonesian National Standard (SNI) (Standar Nasional Indonesia, 2000), the level of illumination in the temple is 200 lux for the multipurpose room and 250 lux for the reading room. The International standards are different compared to the Indonesian ones. According to the Society of Light and Lighting (SLL) (Holmes, 2014), the illumination level for the temple is 150 lux for the prayer area and 300 lux for the reading area. Furthermore, according to the standards of the Illuminating Engineering Society of North America (IESNA), the level of illumination for the congregation area (praying and reading) in places of Buddhism worship is 100 - 200 lux (Illuminating Engineering Society of North America, 2000). These international standards also include particular lighting standards for religious objects such as Buddha statues. This specific standard on religious objects is in line with the opinion of Gojnik et al. (2015) that the Buddha statue, which is the main focal point in the Buddhism sacred space, needs to get particular lighting intensity as the endpoint of the Buddhism journey to get enlightenment (Gojnik et al, 2015). According to some standards, lighting on religious objects such as Buddha statues has a lighting intensity standard level between 300 to 600 lux (Holmes 2014 and Illuminating Engineering Society of North America 2000). Focusing the lighting on religious objects will create uneven lighting distribution, which will result in a lighter (foreground) and darker (background) side in the form of contrast. Contrast can be present with one of the lighting schemes by intensity level (Gordon, 2015). An observer can do a contrast calculation by comparing the intensity level between the bright area (foreground) and the darker area (background) and then divided it with the intensity of darker area (background). The more significant difference in value from 0 means the higher the contrast level (Putera, Dewi, & Dugar, 2022). The differences in the standard level of lighting intensity above can be understood very well because the differences in the needs of physiological and cultural aspects significantly affect the visual comfort standards in different countries (RiosVelasco, 2015).

Indirectly, The Buddhism practitioners in Indonesia undoubtedly have a certain visual comfort standard that correlates to lighting design. But unfortunately, until now, there has been no study investigating this matter. Moreover, the diverse architectural styles of temples might have different lighting techniques in their sacred space. Therefore, this study aims to determine the effect of lighting on building users' visual comfort in Buddhist religious buildings or temples specifically in Medan City, Indonesia, which have different architectural styles. As for the standard of visual comfort used in this study is measured by measuring the light intensity and percentage of the questionnaire results. hopefully, this research can contribute to the field of building science by uncovering the relation between lighting strategies, users' visual comfort, and related standards

2. Case Study

Two buildings were used as case studies in this research: Great Maitreya temple and East Mountain Temple, located in Medan City, Indonesia. Great Maitreya is the largest temple in the city that carries a semi contemporary architectural style. At the same time, East Mountain is the largest Confucianism-Taoism-Buddhism temple in Medan with its traditional Chinese architecture. The case studies were chosen because both are well-known Buddhist sacred buildings in the city, and both applied opposite architectural design styles (semi-modern and traditional).

In the case of Great Maitreya Temple, the room used as a case study was the Baktisala room. This space is a sacred space for performing rituals of respect and worship to Shakyamuni Buddha and two other Bodhisattvas, with a room capacity of 1500 people (Akhyar, 2019). The architectural concept used in this building is semi-modern, as seen from the facade, a modern design with non-wood materials but still retains a few traditional features such as reverse angle roofs and traditional joints (see figure 1). The sacred space of the Great Maitreya Temple applies two types of artificial lighting: cove lighting and downlight with armature ceiling light and chandelier. Cove lighting is specifically used for the altar for the statue area while the downlight is applied for the prayer area. All of the lamps use a warm white color temperature. Downlights are placed at a distance of ±2 meters between the armatures. At the same time, the chandelier is positioned in the centre of the room for each 70 m^2 area (see figure 2).

Figure 1. The front view of Great Maitreya Temple (Source: Phinemo, 2017 and Indozone, 2020)

Figure 2. The view of Great Maitreya Temple Baktisala Room (Source: Personal Documentation, 2021 and Virustraveling, 2015)

The East Mountain Temple, on the other hand, is a place of worship, a mixture of Buddhism and the ancient Chinese belief, Confucianism, and Taoism (Napitupulu, 2022). In this case, almost the entire building consists of several but still interconnected rooms for sacred spaces filled with statues of gods and goddesses. The architectural style of this building depicts traditional Chinese religious architecture with a pagoda, two Kirin statues, and a dragon statue located on the roof, which is visible from the front view of the temple (see figure 3.). The characteristics of traditional Chinese architecture are extended eaves, wooden brackets, straight timber joints and rational framing, squareness and symmetry, repetition and reconfiguration of the same motifs, mortise-and-tenon joints. (Tong, 2021). All these characteristics exist in the East Mountain Temple. In the prayer hall, the temple uses downlighting with armature pendant light with a distance of ±1.5 meters between the lamps. Meanwhile, the lighting method for the altar is applied differently, with cove lighting used on the edge of the altar and wall lighting applied inside of the altar. All lights in the building use a warm-white color temperature (see figure 4-right).

Figure 3. The front view of East MountainTemple (Source: Jurnal Asia, 2014)

Figure 4. The view of East Mountain Temple Worship Hall (Source: Personal Documentation, 2021)

3. Methods

This research employed a correlational research method to study the causal relationship between two or more different variables (Groat & Wang, 2013). This study used two data collection methods: field measurements and surveys/questionnaires. Field or on-site measurements were used to measure the lighting conditions or specifically the light intensity in the two case studies. Meanwhile, a questionnaire was used to determine the user's perception of visual comfort related to artificial lighting used in the case study building. The two data will be compared and analyzed using relevant theories or standards to determine their correlation.

3.1 Light intensity measurement method

The method for measuring light intensity was using a hand-held lux meter type UNI-T UT383 to determine the level of illumination at a certain point with a measurement point taken 75 cm above the floor (Supriyadi, 2021). The measurements were taken on three different occasions: morning, noon, and late afternoon. The measurer also collected the data on the Great Maitreya Temple on three separate dates: August 25, August 21, and August 9, 2021. At the same time, the data for the East Mountain Temple was taken on September 12 and August 10, 2021.

In both cases, the space is generally divided into three zones: zone I as the altar area, zone II as the activity area, and zone III as the circulation area. The total spot for Great Maitreya Temple light intensity measurement was 17 spots, and the East Mountain Temple was 19. The sacred hall of the East Mountain Temple has a more complex layout plan and consists of many religious statues compared to the Great Maitreya Temple. Therefore, to standardize the case studies, In East Mountain Temple, the most revered statue in the building, was decided as zone 1 for spot measurement (see figure 5 and 6).

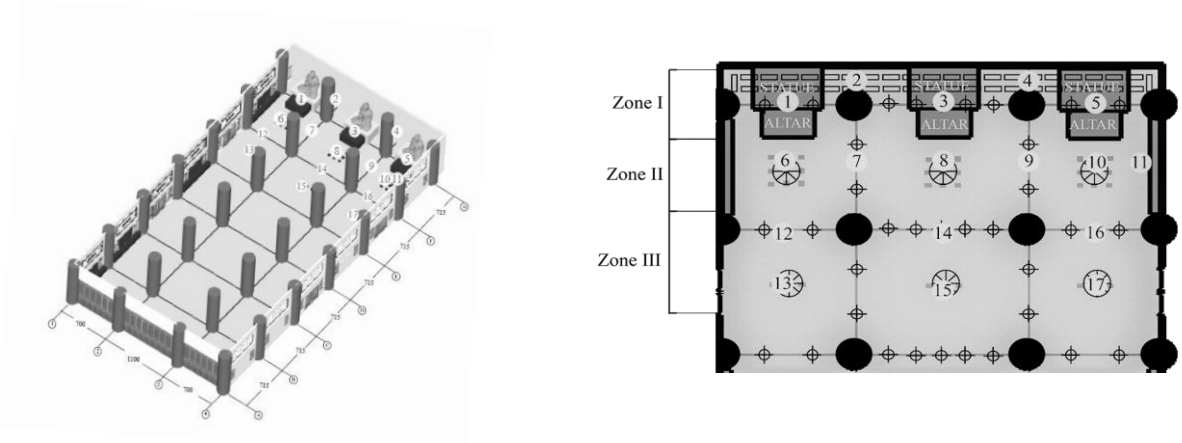

Figure 5. Plan and Isometric Great Maitreya Temple Baktisala Room (Source: Fortuna, 2021)

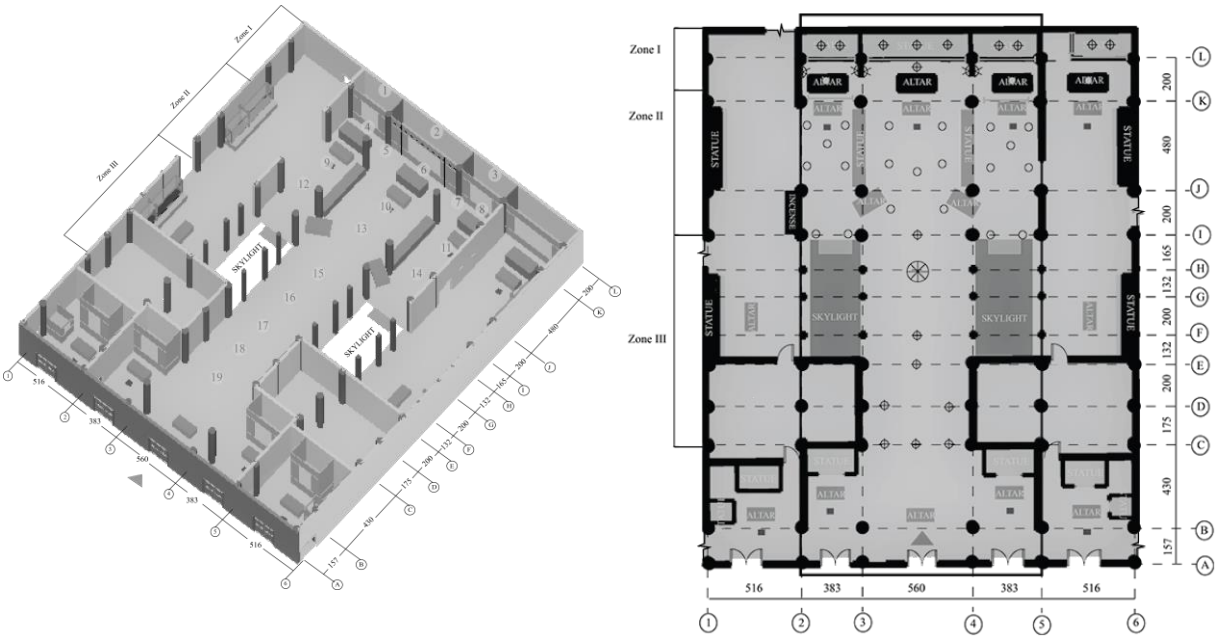

Figure 6. Plan and Isometric East Mountain Temple Worship Hall (Source: Fortuna, 2021)

3.2 Survey/Questionnaire Method

For the questionnaires data collecting method, the questionnaires were distributed using a google form to respondents consisting of temple staff and congregations of building users in each temple. The Questionnaire's questions focused on users' perception of visual comfort during praying and reciting Sutras in the selected room in each case study. This research chose the questionnaire method because visual comfort is a subjective matter. Sometimes the result can be irrelevant to the quantitative research methods. Hence visual comfort is a personal reaction to the quality of light and color schemes in a space, so the response to visual comfort and the perceived psychological impact may differ (RiosVelasco, 2015).

4. Result and Discussion

4.1. Measurement of the Light Intensity

In the first case study, Great Maitreya Temple, there were five measurement spots in Zone I, which is the main focus area of the Buddha-Bodhisattva statue altar. Zone II, an activity area for praying and reciting Sutras, has six measurement points. Zone III, a secondary or circulation space, has six measurement points. The measurement results of the three zones above in the Baktisala Room of Great Maitreya Temple can be seen in table 1.

Table 1. Spot of Measurement Great Maitreya Temple (Source: Fortuna, 2021)

Zone 1				Zone 2				Zone 3			
Spot	Morning (lux)	Afternoon (lux)	Evening (lux)	Spot	Morning (lux)	Afternoon (lux)	Evening (lux)	Spot	Morning (lux)	Afternoon (lux)	Evening (lux)
1	85	60	70	6	94	40	60	12	116*	20	40
2	63	55	60	7	40	33	70	13	113	24	10**
3	80	70	70	8	79	50	62	14	38	35	78
4	48	44	62	9	42	46	70	15	44	25	52
5	44	45	70	10	43	37	60	16	30	23	40

				11	20	37	40	17	20	16	10**
Average	**64.0***	**54.8**	**66.4**	**Average**	**53**	**40.5**	**60.3**	**Average**	**60.2**	**23.8****	**38.3**

*) highest rate **) lowest rate

Table 2. Contrast level on Great Maitreya Temple (Source: Fortuna, 2022)

	Morning	Afternoon	Evening
Contrast	0.2	0.4	0.0

Zone 1 (spots 1 to 5) was the zone with the highest average intensity in the studied space (54.8-66.4 lux). The results may be related to the statue's presence, so the Temple used many artificial lighting points to illuminate this zone (see figure 7-left). Zones II and III are the areas of activity (praying and reciting Sutras) and circulation. The artificial lighting in these zones uses downlighting and consists of two different armatures ceiling light and chandelier (see figure 7-right). The average lighting intensity in Zones II and III was lower than that in Zone I. This result was because fewer artificial lighting points were used in these zones, and some lights were deliberately turned off during the measurements. However, in Zone III, several spots were recorded with the highest and lowest illumination levels. Spot 12 of Zone III has an illumination level of 116 lux in the morning, whereas spots 13 and 17 of Zone III were only recorded at 10 lux in the afternoon. This noteworthy difference may be related to the presence of openings, windows, and vents in this room. Therefore, the illumination level is supported by a natural light penetration during the day (see figure 7-right). But, when the sun goes down, lighting conditions only rely on artificial lighting, decreasing the illumination levels. Overall, the contrast level at Great Maitreya Temple is relatively low due to the integration of natural lighting, which provides diffused light in the morning and afternoon. On the other hand, in the evening, the Temple's sacred space, when it only relies on artificial lighting, shows that the results have no contrast at all (0.0) (see table 2).

Figure 7. Cove light and ceiling light in Zone I (left) and ceiling light and chandelier in Zone II & III (right) (Source: Personal Documentation, 2021 and Phinemo, 2017)

Figure 8. Openings, windows, and vents on wall (Source: Personal Documentation, 2021)

In the second case study, East Mountain Temple, there were eight measurement spots in Zone I, which focuses on the altar of the most revered statue God. Zone II, the praying and reciting Sutras activity area, has six measurement spots. Zone III, which is the circulation area, has five measurement points. The measurement results of the three zones above can be seen in table 3.

Table 3. Spot of Measurement East Mountain Temple (Source: Fortuna, 2021)

Zone 1				Zone 2				Zone 3			
Spot	Morning (lux)	Afternoon (lux)	Evening (lux)	Spot	Morning (lux)	Afternoon (lux)	Evening (lux)	Spot	Morning (lux)	Afternoon (lux)	Evening (lux)
1	78	88	83	9	45	48	44	15	369	470	43
2	128	123	160	10	35	37	32	16	430*	405	66
3	102	103	145	11	39	43	41	17	174	135	42
4	16	16	16	12	23	22	15	18	78	108	70
5	15	21	17	13	37	38	31	19	23	37	70
6	30	34	32	14	22	93	14				
7	12*	14	13								
8	33	23	20								
Av	**51.8**	**52.8**	**60.8**	**Av**	**33.5****	**46.8**	**29.5**	**Av**	**215**	**231***	**58.2**

*) highest rate **) lowest rate

Tabel 4. Contrast level on East Mountain Temple (Source: Fortuna, 2022)

	Morning	Afternoon	Evening
Contrast	0.5	0.1	1.1

Among these three zones, the highest illumination level average was the third zone, between 58.2-231 lux. However, it needs to underline that in this zone, there are skylights that allow natural lighting penetration into the room during the day (see figure 9). It correlates to the measurement results in the afternoon, where the average level of illumination measurement in zone 1 (60.8 lux) was higher than the average level of illumination in Zone III (58.2 lux). In general, artificial lighting in Zone I uses wall light, but especially at spots 1, 2, and 3, it uses downlight and cove light (see figure 10); therefore, the illumination level in these spots was recorded high (between 78-145 lux). The result may be related to the function of artificial lighting at these three spots that aim to illuminate the altar booth to become the room's main focal point (see figure 10).

Zones II and III are activities (praying and reciting Sutras) and circulation areas that use artificial lighting downlighting. But the difference is that it uses a downlight armature with a pendant light on Zone II. Zone II has the lowest average illuminance level. The reason may be the daylighting penetration, which does not point directly into this particular zone. Not only that, the armature used, the pendant light is not entirely exposed, which causes the light intensity to decrease. On the other hand, Zone III has the highest average level of illumination due to the existence of natural lighting from skylights that illuminate the circulation area (see figure 9). As a result, Zones I and II are more dependent on artificial lighting with high-contrast lighting. The over-dependence on artificial lighting was proven with the contrast result showing the high-contrast value of 1.1 (see table 4).

Figure 9. Skylight and The view of Zone III (Source: Personal Documentation, 2021)

Figure 10. downlight (left) and cove light (right) in Zone II (Source: Personal Documentation, 2021)

4.2 Questionnaire Results

Based on the questionnaire's results on Great Maitreya Temple, there were a total of 17 respondents who performed prayer activities and 11 respondents who recited Sutras who filled the questionnaire. The questionnaire results stated that the respondents who agreed that the lighting level of the temple was 'sufficient' and 'very sufficient' turned out to be the most dominant (52.9% and 47.1% for praying and 54.5% and 18.2% for reciting the Sutra). Some respondents did state that they felt uncomfortable while doing activities in this room, but it should be noted that the percentage who expressed discomfort was more in reciting Sutras than praying. 18.2% of respondents feel that the lighting is insufficient during Sutras reciting, unlike the prayer activity, which was only recorded at 0%.

In the second case, the East Mountain Temple, there were recorded 20 respondents doing prayer activities and 13 respondents reciting Sutras who agreed to fill the questionnaire. The results also dominantly stated that respondents felt that the lighting level of the temple was between 'enough' and 'very sufficient' (50% and 30% for praying and 40% and 13.3% for reciting the Sutras). Some respondents did express dissatisfaction with the lighting in this temple. Respondents who stated 'not enough' and 'very not enough' for Sutra reciting

activities were recorded more than the praying activities, 26.7%, and 20%, compared to 5% and 10%, respectively.

Table 5. Questionnaire Result of Great Maitreya Temple and East Mountain Temple (Source: Fortuna, 2021)

Cases		Maha Maitreya Temple		Gunung Timur Temple	
Activities/ Question		Praying	Reciting Sutra	Praying	Reciting Sutra
Does the intensity of lighting is adequate for activities	Very Not Sufficient	0%	0%	5%	0%
	Not Sufficient	0%	18.20%	5%	26.70%
	In between Yes and No (Neutral)	0%	9.10%	10%	20%
	Sufficient	52.90%	54.50%	50%	40%
	Very Sufficient	47.10%	18.20%	30%	13.30%

4.3 Analysis

The standard level of illumination that SNI, SLL, and IESNA have set for a Buddhist temple varies between 100 lux to 300 lux, where the lowest number is for a general space and the highest number is for reading activities (Standar Nasional Indonesia 2000, Holmes 2014, & Illumination Engineering Society of North America 2000). Compared with the measurement results, almost the entire area of both case studies has an illumination level of less than the standard because it only records an illumination level far below 100 lux except Zone III in the East Mountain Temple case. However, the questionnaire results have a different opinion because most respondents still feel comfortable praying and reciting Sutras in both case studies. Indirectly, the standards mentioned above are not in line with the users' visual comfort level of the two temples.

The discrepancy mentioned above is not entirely surprising. According to Wang, Li, and Dac'y (2008), in Buddhist sacred spaces that use traditional architecture, the illumination level can be quite low in the area for praying and reciting Sutras, which can be below 50 lux (Wang et al., 2008). The cause of the low level of illumination in the praying reciting the Sutras areas proves that the lighting in the temple is only focused on the Buddha statue so that when humans enter the dark sacred room, the adapting eyes will immediately focus on the Buddha statue (Wang et al., 2008). Indirectly, the temple's sacred space does not use evenly distributed light because the lighting in traditional buildings tends to be darker and has low contrast levels (Wang et al., 2008). Based on the results, the second case study, which uses a traditional architecture style, tends to have a darker lighting condition. Still, the East Mountain Temple's contrast level was higher than Great Maitreya Temple's, which uses a more modern architectural style. The high contrast level may correlate to less natural lighting penetration on altars and activity areas usually applied in traditional architecture (Wang et al., 2008). Therefore, it also can be stated that the architectural style of the temple also influences the level of contrast.

The temple's lighting from dark to light is indeed in line with the goal of Buddhism teach, namely the journey to enlightenment which can be translated by a gradual increase in the intensity of lighting from darkness to the lightest point is a Buddha statue (Gojnik et al., 2015). It can be stated that the lighting design that can make humans visually comfortable is not entirely based on the average level of illumination throughout the room because the

technique and method of applying lighting distribution can also have a psychological influence that supports these activities (Gordon, 2015). Therefore, this study proves that the standard of illumination level that simplifies the visual comfort of the temple's sacred space into a specific range of number (lux) is not appropriate and needs to be updated, especially if it needs to be implemented in Indonesia. In addition, the presence of a particular contrast level might be determining aspect in influencing visual comfort, especially towards visual activities such as reciting Sutra at the temple. However, it is necessary to understand that physiological and cultural factors will make the standard of visual comfort different in each country. (RiosVelasco, 2015)

The unexplained finding in this research can still be further analysed. Based on observations, the worship performed by Buddhism followers during non-holiday prayer is carried out in a relatively short period, between 15 - 30 minutes. Those short amounts of time to conduct prayer may relate to the respondent's high comfort level even though the level of illumination is far below the standard. However, some respondents did state that they were not comfortable with the activity of reading/reciting Sutra, though it was still considered insignificant compared to the one who stated comfortable. The finding is in line with several standards that articulate that a reading room requires a higher level of illumination because it is related to the physiological aspects of vision (Standar Nasional Indonesia 2000 & Holmes 2014). However, there is a probability that the required illumination level does not need to be as high as the established standard due to the short reading time (recitation of the Sutra).

5. Conclusion

Even though they have different architectural styles, the Temple, as a sacred place of Buddhism, applies the concept of a journey to enlightenment. The room illumination level starts dim at the entrance/beginning until it becomes bright at the end where the Buddha statue is present. This condition of the illumination level is related mainly to the uneven distribution of artificial lighting in the sacred space of Buddhism. This study proves that the activity area (praying and reciting the Sutra) is on the dimmer side of the room, which has an illumination level that is far below the requirements of many visual comfort standards. However, this study also proves that even though it is below the standards, most building users still say they were comfortable with this condition. In other words, the lighting design that can make humans visually comfortable is not entirely based on the average level of illumination throughout the room because the technique and method of applying lighting distribution can also have a psychological effect. There is thing that can be studied further, the short amount of time to conduct non-holiday prayer for Buddhism followers can be a factor in the high level of comfort even though the illumination level is minimal.

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