Interior Lighting Design for the Holy Rosary Church, Bangkok

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ABSTRACT

 ighting design is an important element in spirituality in architecture from the past to the present. Places of worship have existed long before electric lighting and were designed for meaningful daylight orientation and the controlled use of fire and candlelight.

Currently there are new activities held in churches, such as concerts and wedding ceremonies that need different types of atmospheric lighting. Modern application of lighting design and spirituality are explored in a case study of the Holy Rosary Church in Bangkok. A design concept of various lighting scenes was introduced to provide maximum effect and flexibility while still performing its primary function in a place of worship.

Interior lighting in churches, both daylight and electric light, is a crucial element that can considerably enhance the atmosphere within the building during various ceremonies. It offers tranquility and reinforces the faith leading Christians towards God.

Since the reign of King Rama V, the Holy Rosary Church possesses both historical and architectural significance. It is one of the historic churches in Thailand of which original architectural elements remain largely intact. With its setting on the bank of Chao Phraya River, the Church is frequently visited by both local and foreign visitors throughout the year.

As the Church has undergone many restorations throughout the one hundred and twenty years of its history, its lighting system has changed extensively from the original. At present, the activities of the church are more diversified, and there is a rise in the frequency of usage for events in addition to the Holy Mass and other religious ceremonies. There have been various requirements and methods of lighting over time. The purpose of this research and the project to design the interior lighting for the Holy Rosary Church addresses the existing worn-out light systems and the lack of suitable, up to date controlling systems.

The following process was used for this research: generating a study of the church's history, making a survey of the existing building, assessing existing light fixtures and conditions, measuring lighting performance, the studying lighting design guidelines and concepts, and designing and installing light systems, light controls and equipment as well as evaluating users' satisfaction levels.

Keywords: *interior lighting design, Catholic churches, lighting assessment, users' satisfaction, electric lighting, energy conservation*

Figure 1:
Existing condition

Figure 2:
Rendered image of the proposed design

INTRODUCTION

Background

The Holy Rosary Church symbolizes the resettlement of the Portuguese Catholics in Bangkok after the fall of Ayutthaya. It is one of the Catholic churches in Thailand that has successfully retained most of its original architectural elements. The Church, built around the time Bangkok was established as the new capital, became one of the first Catholic churches in the Rattanakosin dynasty. It is considered among the earliest churches in Thailand.

A group of Portuguese missionaries established settlements in the Ayutthaya territory. They were the first group of foreign missionaries and lay Christians to arrive in the kingdom of Siam and founded the first Catholic churches in Thailand.

Following the designation of a French missionary from the Vatican as the new Christian leader in Siam, the Portuguese communities of Ayutthaya divided. Some followed the new leadership sending their children to school or working as volunteers at seminaries such as the St. Joseph Seminary, the first seminary of Siam founded in Ayutthaya period. Others refused to accept the new authority and the French Mission and remained loyal only to their Portugal priests.

In 1767, when Burmese soldiers attacked the city of Ayutthaya, the Portugal priests surrendered, French priests were captured and the Saint Joseph church was destroyed with all valuables confiscated. Some Portuguese Catholics and Vietnamese escaped and traveled by vessels on the Chao Phraya River to the area known as present-day Bangkok. These Portuguese took treasures from the old church in Ayutthaya. Amongst the treasures were two holy figures; the statue of Our Lady of the Rosary and the statue of Jesus Christ's corpse, which are still kept at the Holy Rosary Church. (100th Anniversary, Holy Rosary Church, 1997).

The Holy Rosary Church is the official name, acquired on October 1, 1839 as a consecration to Our Lady of the Rosary. Before the official name, it was locally known as "Calvary Church," which was derived from the word *Calvario—or Calvaire in French* - the name of the mount on which Jesus Christ was crucified.

Located in Samphanthawong District, on the eastern bank of Chao Phraya River, the first church building originally adopted a stilted wooden structure, and it existed during ca. 1787-1837. Later, it was replaced with the second church building (ca. 1838-1890), which was a wooden-framed structure on a masonry base. The current church, built in the Gothic Revival style, is the third church building. It was first constructed in ca. 1890 (2433 B.E.) and consecrated in 1897 (2440 CE). This historic building received the Association of Siamese architects' Architectural Conservation Award in 1987. At present it houses various ceremonies of the Roman Catholic tradition, including daily Mass and other festive religious events. Its 120th anniversary will be celebrated in 2017.

This historic church has played an important role in accommodating community activities for a long time. Even though some of the earlier local Christians relocated to new areas, most of them still come to the Church for the Holy Mass as they did in the past.

After meeting Paul Arpichart Kittimethaveenan at the School of Architecture, the author of this research, a lighting designer and lecturer, became a part of the project to redesign the interior lighting for the Holy Rosary Church. Arpichart is a regular worshiper at the Church and has been an active community member of the Church since his childhood. At the time of meeting, he was a landscape architecture student at the school. His attachment to Holy Rosary Church motivated him to seek assistance in redesigning the church's interior lighting. The author agreed to the project and has been working on the study and design since 2014. It is noted that when a building user has an awareness of architectural aesthetics and spaces, the person will recognize the importance of the building, its lighting design in enhancing interior functional spaces, and creating characteristic atmospheres.

METHODS OF STUDY

The aim of this study was to design interior lighting for the Holy Rosary Church to meet the functional requirements and the need to be economically energy-efficient. The project takes into consideration limitations of building conservation work because the church is an important architectural heritage of the Rattanakosin era. Budget constraints were also considered. As part of the research the selection of lamps and luminaires as well as and methods of installation was made in order to achieve the economic goal.

The study process was as follows: 1) Literature review of architectural characteristics and values of the Holy Rosary Church and of lighting guidelines for the interior of a church building; 2) Building surveys of functional space organization and existing building conditions, usage in various ceremonies, and existing lighting conditions and performance 3) Design concept framework 4) Lighting design, installation and measurement 5) Assessment of users' levels of satisfaction and 6) Alterations to installation based on assessment results.

LITERATURE REVIEW

Architectural characteristics and values of the Holy Rosary Church

An important characteristic of the Holy Rosary church lies in its employment of the Gothic Revival style. The building utilizes a load-bearing wall structure with a timber framed roof truss system. Decorated with stencil painting, the interior curved ceiling is of wooden boards placed longitudinally along the length of the main roof, in between the tie beams and in between the braces. One of the key decorative features of the building is its beautiful stained glass windows and openings of the church. Gothic-style buildings make use of tall narrow openings to provide daylight for interior spaces. The large openings allow natural light to shine through stained-glass windows, under the concept that light represents the manifest presence of God. This representation is present in the design of Holy Rosary Church. Since its construction, lighting during the day has been achieved via the use of large stained-glass openings depicting some selected stories of the Old and New Testaments. Its glasswork is renowned for its artistic and historical values. The light filtered through the stained glass windows leaves colourful reflections on the interior surfaces that allow for a variety of atmospheres throughout the day.

Apart from daylight, an electric lighting system might have been introduced into the building during the reign of King Rama V. From the historical and photographic evidence, there had been several relocations of luminaires from their original positions and some alterations of the type of lamps and the method of lighting employed. It has also been noted that, at present, the interior lighting in the Holy Rosary Church has not successfully complimented its architectural style. Meanwhile, the current lighting system including wires and switches has begun to wear-out. As current light bulb technology has improved greatly in terms of energy-efficiency, it is possible to replace the conventional lamps with more energy-saving lamps and to introduce lighting control systems for providing appropriate lit scenes for different usages.

In *Design Guidelines for the Catholic Church in Thailand* (2005), the term "lighting system" has been described as follows:

Interior lighting of a church, apart from the need to offer sufficient lighting for the priests and worshipers to appreciate the ceremony, the hymn and chant, is one of the major elements that help capturing the attention of the worshipers during religious process. It plays a part in enhancing the church's atmosphere on the dimension of faith and serenity of mourning, as well as reflection and elevation of the mind. Both of the lighting system and the control system inside a church should then be carefully designed and should be adjustable to cater for the need of different events in order to enhance the value of religious ceremonies.

Taken into consideration the meaning of lighting mentioned above, in conjunction with the historical background and significance of the Church, it is unquestionable that interior lighting is one of the important atmosphere considerations in this building.

Church Lighting Design Guidelines

According to the literature review of *Catholic Church Lighting Design Guidelines, after LG13: Lighting for Places of Worship* (SLL, 2014) that addresses interior lighting of Catholic churches and of *Design Guidelines for the Catholic Church in Thailand* (2005), the details related to the main functional space of the Holy Rosary Church are as follows: (Table 1)

Lighting design concept

The generally accepted method of lighting the interior of a church is to take the three areas of nave, chancel and sanctuary into account and to then provide increasing levels of illuminance for the three areas respectively, starting from a lower level of luminance to a higher level of illuminance. Doing so will help direct the view of the congregation towards the altar and the person or persons leading the ceremony. This scenario is similar to that of a theatre when considering the lighting design.

The nave / congregation area

An illuminance level of 150 lux at a height of 1 m above floor level in the nave is a good starting point from which the lighting design can be developed. This level is sufficient to allow the congregation to read hymn books and prayer books for relatively short periods of time during evening ceremonies. Due to

Table 1: Catholic Churches Lighting Design Guidelines (SLL, 2014)

Application	Maintained illuminance (lux)	UGR limit	Minimum uniformity (U_0)	R_a	Remarks
Nave/congregation	150	25	0.4	60	
Chancel/choir-stalls	300	22	0.6	80	E_{hav} measured at hymn book, 1 m AFFL*
lectern	300	19	0.6	80	E_{hav} on book stand and E_{vav} at speaker height
Sanctuary/altar	500	19	0.6	90	E_{hav} at altar height, 1 m AFFL
Vestry/robing	200	25	0.4	80	
Choir practice room	300	19	0.6	80	

*AFFL = above fixed floor level

the size of most churches and the difficulty in providing high ambient temperatures, it is usual for the nave to be illuminated with warm colour temperature lamps. Lamps with a correlated colour temperature of 2700 K or 3000 K will make the congregation feel psychologically warmer.

Luminaires can be ceiling mounted or suspended, depending on the height or structure involved. In certain circumstances, existing chandeliers can be converted to use low-energy light sources. Exact positions, if any, may be compromised by regulations if the church is a listed building. Under certain circumstances it may be necessary to mount the fixtures onto vertical stone pillars. From a lighting perspective this method is not encouraged due to the glare caused by luminaires at lower mounting heights. However, it is possible to use pillar-mounted luminaires to supplement the main lighting provided care is taken in their use. Luminaires with "high bay" type aluminium reflectors, although more efficient, should be avoided where there is a high ceiling to avert a "tunnel" effect.

Lectern

Lectern is a reading desk where either a member of clergy or a member of the public addresses the congregation by reciting a portion of the Bible or giving a sermon. It is important that this person is highlighted. This can be achieved by the use of either narrow beam spotlight or floodlights with a controller to minimize stray light.

The luminaires themselves can be suspended from the ceiling, or more conveniently, mounted on stone pillars. The illuminance level on the bookstand should be 300 lux to enable the person to read for what can be a lengthy amount of time. In addition, the vertical illuminance on the speaker needs to also be the order of 300 lux, in order to stand out against the background. The colour temperature of this light source should be of cooler type of 4000-6000 K. This will create a colour contrast between the subject and the surrounding background, allowing them to stand out visually.

The chancel

Chancel area refers to the place where the choristers and organ are situated. While the organ may have its own lighting built into the fascia or music stand, it may be necessary to provide localized lighting for the organist. The choristers need to be able to read script and music throughout the ceremony, therefore the required illuminance in this area should be raised to a level of 300 lux at 1 m above floor level. It is important to ensure that glare is at a minimum level and in positions that are not readily seen by the congregation. The colour temperature in this area should be around 4000 K with a colour rendering index (R_a) > 80 to ensure good colour contrast as well as good colour rendition. In this area the maintained mean cylindrical illuminance should be at least 100 lux with $U_o \geq 0.6$. Occasionally, individual chorister is provided a music stand with personalized local lighting. In this particular case it may be possible to use low-energy lamps in the existing luminaires with a warm colour temperature.

In the Holy Rosary Church, however, there is an absence of a designated chancel area hence the choir and musicians play music on the mezzanine above the front entrance. Nevertheless, same guidelines can still be applied for other functions similar to those stated in the guideline.

Music and festivals

Some churches hold festivals and music evenings. These events generally occupy the space at the front end of the nave, by the steps leading up to the chancel. Wherever the location might be, they will require dedicated lighting by some means. If the lighting is temporary, lighting frames used in theatres can be brought in to perform this function. However, it is possible to make the lighting effect permanent by adding adjustable spotlights, either fastened to cross trusses or fixed to vertical stone pillars. Where white lighting is used, colour temperatures should be approximately 6000 K. If coloured effects are required, a set of LED floodlights with DMX control is recommended as a suitable option.

Dimmers should be also considered for these luminaires.

The sanctuary

The sanctuary should be the visual focus when viewed from the nave. Therefore, the average illuminance at floor level should be within the region of 500-600 lux with uniformity > 0.4 and a maintained mean cylindrical illuminance of at least 150 lux. The common method of illuminating this altar area is by the use of wide beam floodlights mounted on the side walls approximately 8 m above floor level. It is important to have some beam control, however, so that a reredos, if present, is illuminated fully. Care should be taken to ensure that glare is not caused by high intensity luminaires reflecting on parts of the iconography on the reredos screen.

Some information concerning the lighting design aspects for churches drawn from The Art of Illuminating Art (1997) is as follows:

Places of worship make up a large percentage of an artistic heritage because of their architectural worth and because of the numerous works of art found in them.

Concerning lighting of frescoes, paintings, furnishings and all precious art objects inside the building and the building itself, the criteria followed for museums are still conceptually valid.

However, there is another aspect to keep in mind in any church lighting project: the needs dictated by the celebration of worship functions.

The designer must consequently provide artificial light that can:

1. *Present analogies with characteristics of natural lighting;*

2. *Ensure the basic lighting conditions to:*
   a. *light the rostrum (podium) and lectern for reading of Sacred Scripture;*
   b. *light the presiding seat to facilitate reading of the missal; and*
   c. *light the assembly to allow reading;*

3. *Respond to those needs connected to Eucharistic liturgical celebrations and others: weekday Mass, Sunday Mass, Easter, Christmas;*

4. *Meet needs connected to extra-ordinary events, such as weddings, confirmations, prayer vigils; and*

5. *Promote the following, even in the absence of any celebration:*
   a. *the identification of the altar as the central, pivotal element of the church; and*
   b. *the creation of an atmosphere that is both welcoming and conductive to individual prayer.*

Modelling and cylindrical illuminance

Modelling is a good yardstick for 3D perception of persons and objects in a room. It expresses the balance between diffuse and directional light and is determined by the ratio of cylindrical illuminance to horizontal illuminance at a given point.

As a rough guide, a value between 0.30 and 0.60 is an indicator of good modelling: faces and bodies are not too dramatically or sharply illuminated, nor are they cast in a flat, dull light.

A high cylindrical illuminance is important for the perception of vertical planes and objects. It is enhancing particularly the recognition of faces. Maintained illuminance must be no lower than 50 lx. In places where good visual communication is crucial, e.g. in an office, meeting room or classroom, maintained illuminance should be raised to 150 lx. This requirement needs to be met at 1.2 m above floor level for seated persons and 1.6 m above floor level for persons standing in activity and interior areas.

Apart from the literature reviewed, a student advisee under the author's supervision, Promtida Miliang, previously conducted a pilot research to study the

contrast between the luminance value of the sacred image and the luminance value of its background to identify the difference in luminance contrast values that influence Catholics' composure in the church. The study has found that the level of contrast has an evident impact on the feeling of the Catholics. There should be minimal contrast between the luminance on the set of the sacred image and the luminance of the background. Compared to the luminance level on the set of the sacred image, a lower level of luminance on the background has more positive impact on participants' composures than a higher level of luminance on the background, as shown in the figure 3.

BUILDING SURVEY

Layout plan

The orientation of the Church is on an east-west axis. The church faces Chao Phraya River, with the main entrance on the west. An outdoor multi-purpose outdoor area extends to the bank of the river and serves as a parking lot, sport courts, and an outdoor activity plaza, The Church is flanked by the Abbot's house and also a monastery office on the north and a building of the Kularbwittaya School on the south. To the east of the Church is Soi Wanich 2 as shown in figure 4-5.

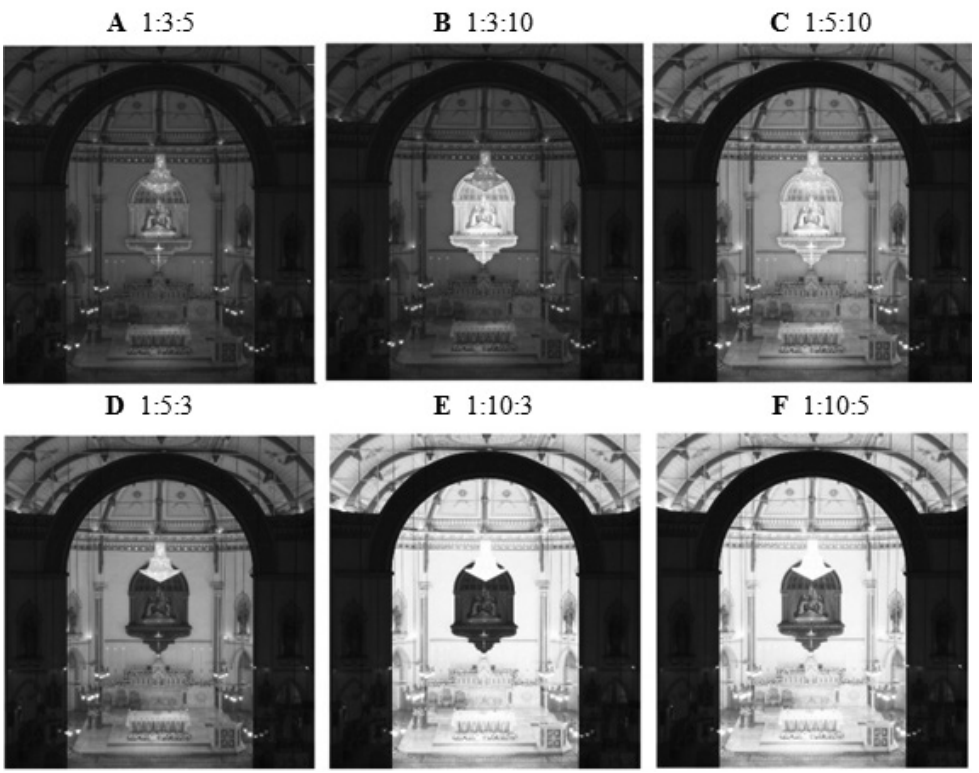

Figure 3:
The six different ratios of foreground: background: the set of the sacred image luminance (A-F) of the test images

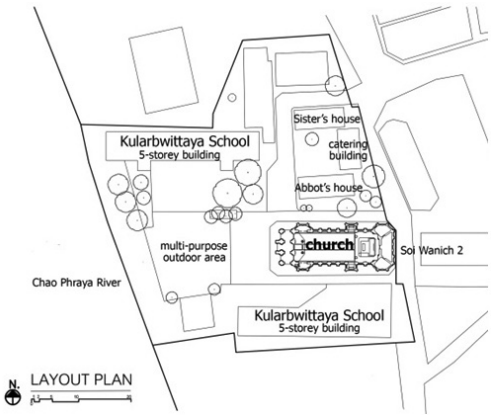

Figure 4:
Lay-out Plan

Figure 5:
The church and its surroundings

The Church's functional space organization and existing condition

The building's functional space organization

Built in the Gothic Revival style, the Holy Rosary Church features a symmetric cruciform plan. The building's space is divided into four main sections including: the front porch; the nave flanked by the baptistery; the confessional and the north and south chapels; the sanctuary; and the sacristy (Latin called sacristia). The front part is the entrance porch or *portico* that occupies the space directly below the bell tower. The area adjacent to the entry is covered by a mezzanine for the choir and musicians with the bell tower directly above. Next is the nave or congregational area with wooden pews for worshipers. Between the nave and the sanctuary is a Roman arch flanked by two symmetrical wings that house the north and south chapels each containing altars: the north altar of St. Joseph and the south altar of the Sacred Heart. The sanctuary is located behind the Roman arch and consists of: a tabernacle, a high

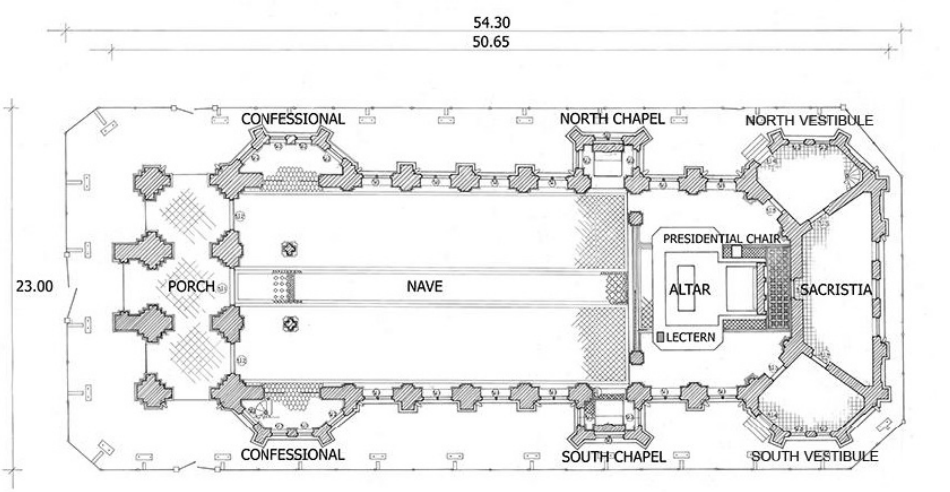

Figure 6:
The Holy Rosary Church plan

altar or *Altare Maius* on the altar steps; a lectern; and presidential chairs. As viewed from the front entrance, the tabernacle is located on the wall behind the high altar. The marble lectern, on the southwest corner of the altar steps, is an ambo for the ritual proclamation of the Word of God.

Above the tabernacle is a niche holding the holy image of Our Lady of the Rosary. Behind the sanctuary is a hall called the vestry or sacristy for storing vestments, sacred vessels and other church items. The sacristy is adjoined by vestibules on the north and the south. The north vestibule might have originally been a wash room, and the south one might have served as a chapel for a particular period of time.

The building's condition and the work of arts inside the church

Due to over a hundred years of operation, the Church's interior is rather run-down despite several major restorations. There is the problem of humidity found on the upper part of the walls, which is probably due to the clogged drainage system of the roof drains, gutters, and downspouts. This problem has caused the deterioration of the grapevine stucco relief on the decorative crown moulding at the top of the walls, especially on the south side of the church. There are also stained areas on the walls found about 1 m above floor level, which might have been caused by the moisture from the ground beneath the masonry load bearing walls. In fact, the moisture problem has been partially solved. The survey found that there is a row of holes drilled near the base of some interior walls, about a foot above the skirting as evidence of an attempt to alleviate the rising damp problem. Some parts of the marble floor have changed in colour due to moisture evaporating from the ground. On the south wall of the sanctuary, in the niche behind the Saint's statue, there are traces of damage from the moisture. The surfaces of the wooden doors and windows are cracked and worn off because of weathering.

The intact decorative elements include curved wooden ceiling arches decorated by stencil paintings and the large stained glass openings that are still in relatively decent condition.

The Church features several historic, holy sculptures. Among them are two remarkable polychrome wood sculptures in the Spanish Baroque style. One of them is the statue of the Corpse of the Christ that is kept in the vestibule south of the sacristy. The other sculpture is of the Immaculate Conception Madonna and Child that is now located in front of the sanctuary. As viewed from the entrance, it is under the pointed arch of the wall which supports the right leg of the Roman arch. The principle holy image, which is the symbol of the church, includes the statue of Our Lady of the Rosary offering the holy rosary to Saint Domenico and Saint Catharina of Siena. The other historic sculptures seen around the church's interior are eight statues of the Saints situated along the walls and relief sculptures of the fourteen Stations of the Cross on the pilasters. Next to the main entrance is the Holy Water Font used for the making of the Sign of the Cross. Besides the holy statues, another distinctive piece of art is the high altar. It was isolated at the back wall near where the tabernacle is situated, but moved to its current location closer to the congregation. After being relocated there were some alterations made to the altar. However, its original pieces of marble, including the marble slab with a crucifix, and the front stone relief depicting five virgin-martyrs, are still in good condition.

The condition of the electrical wiring cables inside the church is complex and disorganized due to the many restorations that took place in different eras. It is difficult and troublesome to locate the circuits and the switches for the lights . Some of the luminaires still use the traditional, short-life incandescent bulbs in the chandelier suspended above the high altar, and compact fluorescent bulbs above the grapevine crown moulding. These electrical features are hard to maintain and repair because of their poor accessibility. They are located above and behind the crown moulding, which is approximately 10 m above the floor level.

Ceremonial practices

Today, the Holy Rosary Church functions mainly to host religious ceremonies and daily Holy Mass for Catholics. The functional space can be divided into four parts: 1) the outer entrance hall or the porch, as a welcoming space to accommodate the crowd before and after a ceremony and is considered to be on the exterior of the church 2) the inner entrance hall, in which the visitors make the Sign of the Cross 3) the congregational area, as the seating area for the Mass and 4) the sanctuary, where the priest perform a ritual ceremony.

The church hosts all religious ceremonies ranging from regular Mass, matrimonies, funerals and annual festivals. On some occasions it is also used to conduct religion lessons for young people.

Its mezzanine functions as the space for choirs and music during religious ceremonies and also as a rehearsal area for the chorus. The sacristy is a dressing and preparation room for priests and acolytes and a room to store sacred objects and valuables, such as sacred vessels, ritual vestments, and the statue of the Corpse of the Christ.

According to the study, the Holy Rosary Church functions both during the day and at night, mainly for praying and regular Mass. The Mass is sub-divided into morning and evening sessions with larger crowd attending the evening Mass. The church can accommodate up to two hundred and seventy (270) participants. Occasionally, it is necessary to extend the inside activity area to the outside, for instance, the Mass on Good Friday could be attended by over 800 people. Apart from ceremonies, there are other events such as weddings, confirmations, and prayer vigils that vary in attendance.

Surveys of Interior lighting conditions

Survey on Daylight Fenestration

Similar to other Christian churches, the Holy Rosary Church was designed to allow early morning light to be received from the east, with south light flooding into the nave and the southern aisle during the day. In the evening, light from the west would enter from behind the congregation. However, today, the five - storey school building on the south side of the Church blocks the late afternoon light.

The Gothic stained glass windows are fairly intact. The damaged parts have already been restored. The two sets of double casement windows on the lower half of the glass openings and the main entrance door allows daylight admission and ventilation throughout the church operating hours.

In the morning at approximately 8 a.m., the building caretaker opens windows and doors to allow daylight and ventilation. The church is closed daily after the evening Mass at around 9 p.m. Therefore, electric light is hardly used during the days except during Mass and other ceremonies.

Survey on lighting methods, lamps and luminaires

The author found that lighting is used regularly during the ceremonies in the major functional spaces, such as the sanctuary, and the congregational area. In the sanctuary, the lighting is focused on the statue of Our Lady of the Rosary, Saint Domenico and Saint Catharina of Siena. The statues' niches represent blue sky with golden little stars. The colour temperature of the 4000K fluorescent lamps selected to light the niche as a backdrop for the statues, while the statues were highlighted with PAR38 lamps. However, the face of Our Lady of the Rosary did not stand out as well as it should.

Statues of saints are found in the niches in the walls around the Church. Silhouette lighting technique was used to up-light the backdrop of the statues, using 2x14W compact fluorescent lamps for each niche.

The large chandelier (72x40W candle incandescent lamps) hanging above the high altar caused light to sparkle on the ceiling and wall surfaces around the sanctuary. The chandelier shone brightly towards the congregation. Moreover, floodlights of 4000K of metal halide lamps also illuminated the sanctuary, and PAR56 lamps were focused on the altar.

Twelve pendants were installed in the nave at a level of four meters above the nave's floor. However, their glass bulbs were so thick that light sources with high lumen output were needed to be able to illuminate the congregational area. 6x8 W Compact fluorescent lamps were selected for each luminaire. However, these light fittings are not the original pendants as they were installed in 2005. Mounted on the interior walls and pilasters, luminaire (1x15W compact fluorescent) were also used to highlight the fourteen Stations of the Cross and to illuminate the areas close to the walls. However, these lamps were not well concealed and as a result, from a normal point of view they were glary.

On the ceiling of the church, cove lighting was used to up-light the ceiling surface around the roof's wooden braces on both sides by 11W compact fluorescent lamps. These lamps delivered such a diffused light effect that the ceiling could not be well illuminated and caused glares that were discomfort due to the unconcealed light sources.

Measurement of illuminance of daylight and electric lighting

Under overcast sky conditions the measurement of illuminance at approximately 12 p.m.-1 p.m. in May 2016, over the working plane across the nave and the sanctuary was found to be daylight factor was of 0.3. The average illuminance at the nave was 125 lux while at the altar was 45 lux.

In addition, another measurement of illuminance under clear sky condition in April 2015 at around 12:00 p.m. (12 noon) has shown that the average illuminance for nave area was 100 lux and 110 lux at the high altar.

In the evening after the Mass, the average illuminance, when turning on the electric lighting, was only 57 lux, while on the high altar, the average illuminance was 66 lux.

From the Guidelines (SLL, 2014), the nave should have an illuminance level of 150 lux while the altar should have about 500 lux or 3 times the value at the nave.

From the measurement of illuminance conducted, it can be concluded that the daylight illuminance at the nave has a value close to the guidelines. While for the altar; the value was much lower than the guidelines' value. Meanwhile, the illuminance value from the electric lighting at night was much lower than the guidelines on both areas. Therefore, a new lighting design and lighting systems should be proposed to increase the illuminance level and to improve the Church's lighting and atmosphere.

DESIGN FRAMEWORK

According to the literature reviews and the findings at the actual site the basis of the interior lighting design takes into account following considerations:

1. Lighting to enhance the atmosphere (peace, holy and ceremony or special activities)
2. Lighting for regular usage
3. The conservation of architectural elements and the work of arts inside the building
4. Electric lighting energy conservation

From the four factors mentioned above, the project was divided into two phases. Phase I focused on enhancing the atmosphere of the sanctuary and putting an accent on the statue of Our Lady of the Rosary by considering contrast ratio of the luminance levels on the statues, backgrounds and the high altar. The tasks for this first phase included changing light bulbs, installing dimming systems, and setting scenes to suit ceremonies and activities.

Later, after the building conservation work is started Phase II will take place. This phase will include installing new wiring systems plus surface restoration and finishing.

Most of the previous artificial lighting had been installed since 1995. In 1999 spotlights were added to highlight the statue of Our Lady of the Rosary and the pilasters. Wall lights were to illuminate the periphery of the nave. In 2005, the original pendants hanging in the center line of the nave were removed, new pendants were hung in two rows, and the ceiling was up-lit. Furthermore, a huge chandelier was installed above the altar in 2006. Many light sources caused a strong glare due to unintentional errors in previous light design. The beauty of interior architecture was also not revealed. So the idea for the redesign was as follows:

- to improve the general lighting for the nave to provide sufficient light for the congregation, while eliminating glare
- to accentuate the statue of Our Lady of the Rosary and the high altar
- to highlight certain architectural features, such as the pilasters and the wooden roof truss braces and tie beams appeared as part of the ceiling
- to highlight the important work of religious artworks, including the fourteen Stations of the Cross and all sculptures of saints in the niches

LIGHTING DESIGN AND INSTALLATION

The design and methods of lighting

In designing the method of lighting, the designer's decisions were based on an analysis of the visually outstanding architectural elements as well as on the reviewed lighting guidelines. Also, taking into consideration the pilot study (Miliang, 2015), the designer used various techniques to light the four areas listed above. As for the niche where the statue of Our Lady of the Rosary is situated, the previous spotlights were replaced with a smaller model for a better viewing perspective, putting an accent on the facial expression of the Lady. All light bulbs were replaced with LED light bulbs with high CRI value of more than 80 for better colour rendition.

As the result of work from Phase I, there are different scene-sets in response to the varying ceremonies and church activities. The interior of the church consists of six scenes and is regulated by the automatic control system installed in the sacristy. These lighting scenes are;

1) **Holy Mass Scene** to direct the view of the congregation towards the high altar with low but sufficient light level, and reduce high brightness from the chandelier
2) **Chinese Prayers Scene** to save energy while early evening daylight can still be integrated
3) **The Fourteen Stations of the Cross Scene** to highlight the depicted story of Jesus Christ on the relief sculptures
4) **Concert Scene** to accent the sanctuary and the Our Lady of the Rosary statue
5) **Daytime Visit Scene** to create both welcoming and conductive environment to individual prayer
6) **Fully Lit Scene** for special events, such as Easter vigil and Christmas, to reveal the interior architecture. (Figure 7)

During phase I, most of the light bulbs were successfully replaced with LED light bulbs for energy efficiency, especially for those of the pendants. More of an accent has been put on the statue of Our Lady via the use of LED spotlights. The vertical lines from the rows of pilasters and the fourteen Stations of the Cross have also been accented via the use of up-downlight wall mounted luminaires. Different beam angles of LED spotlights were selected as seen in figure 8-9. The sanctuary is highlighted using wide-beam spotlights with colour temperature of 4000 K to create a colour contrast between the subject and the surrounding background of 2700-3000 K and to make the architectural features stand out to achieve the proposed general impression.

Phase II will take place after the construction work for conservation process starts, and all light cables are to be changed. Compact fluorescent lamps on the ceiling will be replaced by LED spotlights to highlight the ceiling's wooden truss frames or tie beams. The compact fluorescent lamps inside the niches behind the Saint statues will be replaced with LED strip lights to complete the installation design.

Lamps replacement and the newly designed luminaires

The lamps in phase I are mostly conventional types with LED bulbs. Different beam angles of LED spotlights were selected as seen in figure 7-8.

Measurement of illuminance

The average illuminance measured in the holy Mass scene for the sanctuary has a value of 146 lux and 383 lux at the high altar, with an average of 73 lux in the nave. When fully turned on for special ceremony the average illuminance is around 168 lux, with 383 lux at the high altar and 98 lux in the nave.

If compared to the SLL guidelines (2014) these illuminance levels are lower than what was recommended. However, the illuminance at the high altar is around 3-5 times higher than the average illuminance in the nave so that while the priest is standing at the altar he would be clearly seen by the audience. The mean semi-cylindrical illuminance of 150 lux measured and the ratio of mean semi-cylindrical and horizontal illuminance at the lectern of 0.58 indicate that it particularly enhances the face of the person presenting at the lectern. (Table 2)

1) Holy Mass Scene

2) Chinese Prayers Scene (5:30-6:30 p.m.)

3) The 14 Stations of the Cross Scene

4) Concert Scene

5) Daytime Visit Scene

6) Fully Lit for Special Ceremony Scene

Figure 7:
six lighting scenes after phase I has been done

Measurement of luminance contrast at the niche of the Lady of the Rosary

From the worshiper's visual perception, the view from the congregation area to the sanctuary is similar to a view through an arched door opening into another room containing sacred images. Therefore, worshipers would be seeing mainly the wall in the front, the holy images and their respective background.

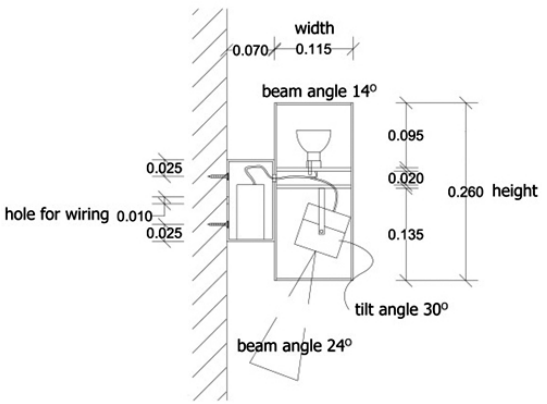

Figure 8:
A rough drawing of an up-downlight wall mounted luminaire

From a research conducted by Michel (1996) which proposed that people felt psychologically more connected within a space when the luminance of the wall in front of them has been lowered, the wall in front has then been set with the lowest luminance. This also follows the pilot study conducted by Miliang (2015) which concluded that luminance contrast has an impact on congregants' composure and that there should be minimal difference in the luminance contrast or similar luminance levels between the sacred image and its background.

The luminance of the area was measured using a luminance meter for Holy Mass scene, and the ratio of luminance between the wall in front: the background: the sacred image is 2: 3: 6, similar to the pilot study where the majority of the sampling group felt composed at the contrast ratio of 1: 3: 5, the level whereby the congregation is supposed to feel the peacefulness within space.

Figure 9:
up-downlight wall mounted luminaires

Table 2: The measurement of illuminance after phase I lighting improvement

Application	Altar	nave	E_{hav} at altar to E_{hav} at nave	lectern			$E_{cylindrical}$ to E_{hav}
	E_{hav} at altar height, 1 m AFFL (lux)	E_{hav} (lux)		E_{hav} on book stand (lux)	E_{vav} at speaker height (lux)	mean $E_{cylindrical}$ (lux)	
SLL Guideline	500	150	3:1	300	300	150	0.3-0.6
holy mass scene	380	73	**5.2:1**	252	188	147*	**0.58****
fully turn on scene	380	98	**3.8:1**	257	190	150*	**0.58****

*mean semi-cylindrical illuminance measurement (semi-cylindrical illuminance is the amount of vertical illuminance in lux that falls on a semi-cylindrical surface.)

** $E_{semi\text{-}cylindrical}$ to E_{hav}

ASSESSMENT OF USERS' SATISFACTION

Since the tasks in phase I were completed in March 2016 a questionnaire was designed to assess the levels of satisfaction among the attendants of the church. The survey was conducted during a regular ceremony. The observers were given a list of questions intended to help describe different perceptions of the newly lit interior spaces, especially the sanctuary and the congregation area.

The survey included thirty five (35) participants composed of five (5) congregates (priests and acolytes) and thirty (30) Catholics; of which 60% are female and 40% are male. Of the participants 34% of them were 20-29 years old, which was the majority of the sample, and 3% were 50-59 years old, which was the smallest sampling group. 80% of the participants completed the survey during the evening Mass between 7 – 9 pm.

The majority, 83%, of surveyed participants had attended the Holy Mass before the redesign of the Church's lighting, of which 90% agreed that there was a visible change in the lighting. The most observable change was at the altar, 80% of the thirty five (35) participants noticed the change. The second most perceptible changed element was at the fourteen Stations of the Cross which were noticed by 57% of the participants. The following changes were also noticed: the colour of the light by 51%; the statue of Our Lady of the Rosary and the pilasters by 40%; and the congregational area by 37%.

The survey indicated that 71% of all participants were satisfied with the lighting at the altar and that 63% participants were satisfied with the 14 Stations of the Cross. While forty five (45), thirty seven (37), twenty nine (29), and twenty three (23) percent of them were satisfied with the Statue of Our Lady of the Rosary and the church pilasters, the seating area for worshipers, and the colour of lights, respectively. Moreover, there were no lighting conditions in which the participants were "very dissatisfied."

Different impressions of the light in two different areas of the Church can be explained by the number of the observers who share the same response and are as follows:

- In the congregational area 50% of the observers agreed that the light was "moderately bright"; twenty nine (29), twenty (20), and twenty three (23) percent of them found that the light was: "comfortable", "uniform", and "moderately yellow coloured", respectively.

- In the sanctuary, forty five (45), fourteen (14), and thirty one (31) percent of the observers felt that the light was "moderately bright"; "comfortable"; and "overall stands out" respectively. Whereas eleven (11) percent of the observers remarked that the statue of Our Lady and the two Saints, Saint Domenico and Saint Catharina of Siena "stood out" while 14% of them felt that the sanctuary is "visibly white".

The majority (83%) of the observers felt that the lighting condition is "suitable" for the Holy Mass. 54% of that majority felt that the interior had a "slightly peaceful" atmosphere, and 34% of them found the setting of the Holy Mass "peaceful" while 11% found it "neutral".

STUDY AND DESIGN CONCLUSION

After completing the design process, the author realized that the most crucial part of the research lies in understanding the significance of the Holy Rosary Church. Studying the historical background and understanding the church goers' participation experiences were essential to the project. Through working on the project for two years, the author gradually became part of the church community. That community, in return, became more understanding of the author's work. Despite financial limitation, the project has successfully carried out the process and found that most of the church's congregation was satisfied with the redesigned lighting during the regular Mass.

Moreover, the study found that for a relatively small-size church community it is not necessary to increase the illuminance level to be equal to the level indicated in the SLL guidelines for the users to be satisfied. Furthermore, for any church compact enough for the congregation to view the ceremony clearly, it is important to take into consideration the mean cylindrical or semi-mean cylindrical illuminance at the lectern (ambo) and altar area. Similarly, the difference in colour temperature between the light in high altar area and the light in the nave helps direct the congregation's focus towards the altar.

Appealing to the users' satisfaction concerning the atmosphere of the church helps promote the community's sense of pride as well as the community's sense of belonging to the church. It is a means to keep the audience's attention during church ceremonies.

SUGGESTIONS

By observing the church activities it has been found that additional areas need better illumination, especially those areas used for the choir, concerts, and events that frequently take place in the space at the front end of the nave. Likewise, it is recommended that on the mezzanine the illuminance level be increased suitably for reading music.

REFERENCES

"Cylindrical Illuminance." Retrieved March 20, 2016. http://glamox.com/gsx/mean-cylindrical-illumination.

"Holy Rosary Church (Thailand)." Retrieved May 20, 2016. https://en.wikipedia.org/wiki/Kalawar_Church.

"In Sacred Spaces—The Meaning of Light." Retrieved May 20, 2016. http://www.designerpub.com/education/in-sacred-spaces-the-meaning-of light.

Major, M., Speirs, J. and Tischhauser, A. (2005). Made of Light: The Art of Light and Architecture. Berlin: Birkhäuser.

Michel, L. (1996). Light: The Shape of Space. New York: Van Nostrand Reinhold.

100th Anniversary: Holy Rosary Church. (1997). Bangkok: Assumption Press.

Phillips, D. (1997). Lighting Historic Buildings. Oxford: Architectural Press.

Promtida Miliang. (2015). "The Impact of Luminance Contrast at the Sanctuary on Catholic's Composure: Case Study of the Holy Rosary Church, Bangkok.", (A Report in Methodology in Architectural Research).

The Society of Light and Lighting. (2014). Lighting for the Built Environment LG13: Lighting for places of worship. London: CIBSE.

"Semi-cylindrical illuminance." Retrieved March 20, 2016. http://en.licht.de/en/lighting-know-how/compact-knowledge/glossary/details-lichtlexikon/semi-cylindrical-illuminance/.

Shook, R. and White, M. "Churches let their light shine for effective services." Retrieved Feb 27, 2016. http://churchexecutive.com/archives/churches-let-their-light-shine-for-effective-services.

Subcommittee on Arts and Rite. (2005). The Catholic Church Design Guidelines in Thailand. J. Smile Design: Bangkok.

Vipawan Sanglimsuwan. (1999). "The Catholic Church in the Central Region and Eastern Region of Thailand from Ayutthaya Period (1893 B.E.-2310 B.E.) to 2475 B.E." Master of Arts Thesis, Department of Architecture and Related Arts, Graduate School, Silpakorn University.