

Landscape Luminaire Design for Part of the Conservation of Chudhadhuj Royal Residence, Sichang Island

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ABSTRACT

Chudhadhuj Royal Residence is a historically significant place, located on Si Chang island where a vast landscape area covers both coastal and mountainous areas. Its context connects natural landscape and culture which can be termed a cultural landscape in a holistic. The researcher would like to describe the link between the design criteria and the concepts of the cultural heritage conservation and some identities of the place to meet the function of each area in designing luminaires. The objective of this article is to demonstrate the design process of landscape luminaires for walkway. The design of prototype luminaires consists of a lamppost, a bollard, and a bollard with perforated patterns. Visual design elements and principles with the design concepts were applied to these luminaires. The image of luminaires and the effect of light of each prototype were designed, developed, and tested on-site both day and night-time. The questionnaires displaying computer- simulated images in the actual context were used for an assessment by experts from various design and architectural conservation fields. The results show that these luminaires respond to architectural conservation and identities of the place both day and night-time. The prototype luminaires were improved according to the comments of the experts. Consequently, these luminaires were granted three design patents. Ultimately, the designed luminaires and the lighting master plan were applied to the landscape improvement project of the Chudhadhuj Royal Residence, operated by the Fine Arts Department. This project can be an example of architectural conservation for a cultural heritage site in the future.

Keywords: architectural conservation, Chudhadhuj Royal Residence, Sichang Island, cultural landscape, visual design elements and principles, landscape luminaire design, cultural heritage

INTRODUCTION

Chudhadhuj Royal Residence is a former royal palace of King Rama V, located on Sichang Island, Sriracha District, Chonburi Province. As a result of its fresh and clean air throughout the year and its beautiful scenery, the residence was once most frequently used for convalescence by the Thai Royal family (Chulasai, 2006). Unfortunately, due to Western colonization, the royal family was forced to leave the island. The palace was left vacant, and some mansions under construction in the compound were left unfinished. Nonetheless, it has been listed as a National Historic Site by the Fine Arts Department since 1990. The royal residence has undergone several renovations, the latest of which was carried out in 2004 by a team of researchers from Chulalongkorn University in cooperation with the Fine Arts Department. Mansions were turned into exhibition halls, while other historic buildings and landscape features were restored and conserved as they had been in the past. The residence compound was renamed Phra Chudhadhuj Ratchathan Palace Museum (พิพิธภัณฑ์พระจุฬาราชวัง) in 2014 (Suriyothin, 2019). Since that time, the royal residence has become a popular tourist attraction, hosting approximately 250,000 visitors each year (Office of Art and Culture Chulalongkorn University, 2020). For this reason, a landscape luminaire design and lighting master plan has been proposed for cultural heritage conservation to promote the value of the palace site as a cultural landscape and its identities, as well as to fulfill the lighting function within the royal residence area both during the day and at night.

BACKGROUND

Sichang Island is one of the most significant Islands in the Gulf of Thailand in Chonburi Province. In the past, it was well-known as a busy port and a gateway to Siam for ships from China, Vietnam, and the East Indies. The island was once a significant landmark for immigrants arriving to Siam. Nowadays, it still attracts children of Chinese immigrants visiting shrines and religious artifacts. In addition, the island features a beautiful environment, scenic landscape, and interesting topography. During the 19th century, it became a popular place for health rehabilitation for King Rama IV, who admired the island for its fresh and clean air, which brought him to the island for vacation several times (Chulasai, 2005).

Survey and design for developing Chudhadhuj Royal Residence, Sichang island, Chon Buri province (Arayanimitskul, 2005) explains that Chudhadhuj Royal Residence has different types of terrain as the site is situated at the foot of the mountain, with a plateau sloping down the foothills by the sea. Some parts of the area are very steep, and the highest part is the western plateau, which is approximately 50-60 meters above sea level. The height gradually descends to the east along the coastline and the plains headlands as shown in Figure 1.

Chudhadhuj Royal Residence was built in 1888 as a place for the rehabilitation of King Rama V and his royal family. King Rama V conferred the name of the royal palace in honor of His Royal Highness Prince Chudhadhuj Dharadilok (สมเด็จพระเจ้าบรมวงศ์เธอ เจ้าฟ้าจุฑาธุชธราดิลก กรมขุนเพ็ชรบูรณ์อินทราไชย) who was born there. The royal residence is located in the southeast part of Sichang Island, and is set in an area of approximately 237 Rai (37.92 hectares). Both the palace (buildings) and the royal park (landscape architecture), located in a mountainous seaside area, comprise a place of historical value enhanced by the beautiful landscape features, including gardens, walkways, stairs, ponds, fountains, waterways, and waterfalls, all of which have names bestowed by the King (Arayanimitskul, 2005).

Chudhadhuj Royal Residence underwent great physical development when it was first built, especially in 1892, when King Chulalongkorn went on a vacation to the royal palace for several months. However, the construction of the palace was never completed as the crisis of the Franco-Siamese War in 1893 resulted in a sudden halt to palace construction.

After the abandonment of the palace, the responsibility for upkeep first fell to the Thai Navy. Later, it was taken over by the Provincial Police.

Over the past eight decades, the palace has served several different functions. During World War II, the palace area was designated as a logistical supply depot. In subsequent months and years, it was used as a juvenile detention centre, a wartime logistical rice transportation centre by the Japanese, a public school, a district office, and a research laboratory for vaccine production, and more. The heavy usage of the physical facilities and lack of regular maintenance resulted in the deterioration and the disappearance of the royal palace and the royal park (Chulasai, 2005).

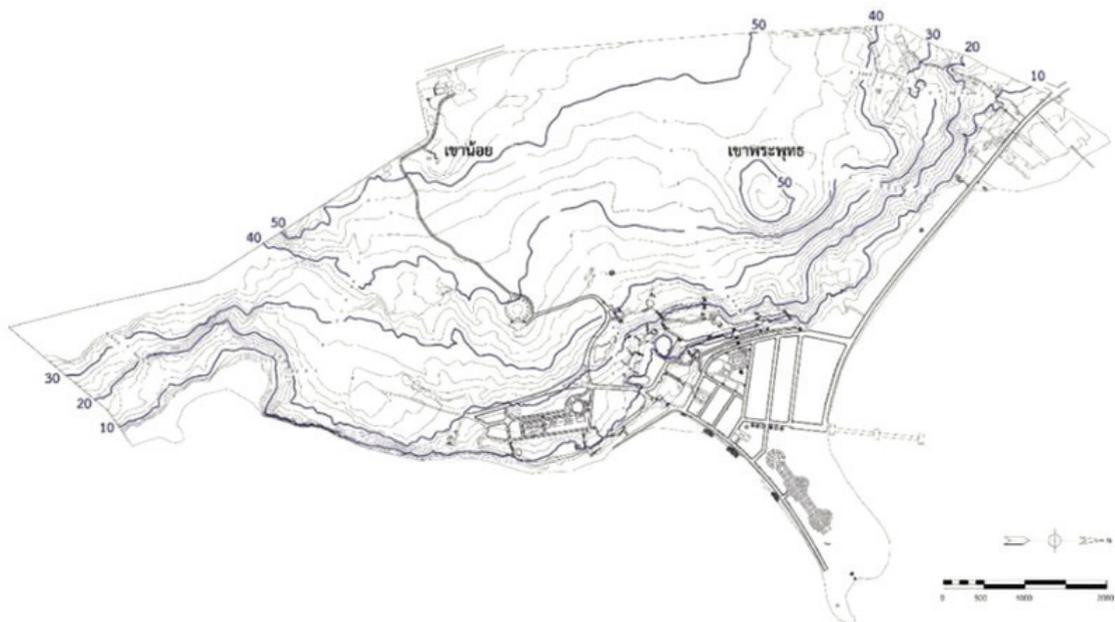
After World War II, the royal residence area was mostly dilapidated. Only a few suggestions of the historical architecture of the royal palace were left as a reminder of its past, and they were mostly in poor condition. Four main buildings remain, namely Wattana Building (ตึกวัฒนา), Phongsri Building (ตึกผ่องศรี), Apirom building (ตึกอภิรมย์), and Green Wooden House by the Sea (เรือนเขียว หรือ เรือนไม้ริมทะเล) (Arayanimitskul & Povatong, 2006). Moreover, the remains of the foundation of the Manthat Rattanakot Throne Hall, located by the sea, and Assadang Nimit Temple (วัดอัญญาางศนีมิตร) located on the top of the hill, can still be found.

The design of Assadang Nimit Temple is a significant departure from traditional Thai and Buddhist Architecture. It is a remarkable design which combines the function and shape of the Ubosot and Chedi (Stupa) in the same building. Joachim

Grassi was the renowned foreign craftsman responsible for the design of this temple (Chulasai & Povatong, 2010). The building incorporates western architectural structure with a Thai-style stupa. It is clearly seen that the wall thickness of the building is very thin compared to that of traditional load-bearing walls. The building looks like a temple with a bell-shaped stupa on top.

Inside the temple is a circular hall with a vaulted ceiling under the form of a stupa. There are two doors and many windows around the circular-shaped hall. These features provide natural light and good ventilation to the building. The doors and windows were built in Gothic style with coloured-glass patterns. The walls of the temple are made of bricks, and the interior walls are decorated with stucco in various motifs and patterns (Khwanmueang, 2013) as shown in Figure 2-4.

Figure 1
The area of Chudhadhuj Royal Residence and its contour lines



Note: Adapted from Khrōngkān samrūat læ 'ōk bāep phūa phatthanā phra chūthā thut rāтчathān ko sī chang čhangwat Chon Burī: rāingān chabap sombūn [Survey and design for developing Chudhadhuj Royal Residence, Sichang island, Chon Buri province], by C. Arayanimitskul, 2005. Copyright 2005 by Chamaree Arayanimitskul.

Figure 2

Architectural elements and patterns of the circular hall of Assadang Nimit Temple



Note: An image of architectural elements of Assadang Nimit Temple, by N. Propateep, 2017. Copyright 2017 by Nattapol Propateep.

Figure 3

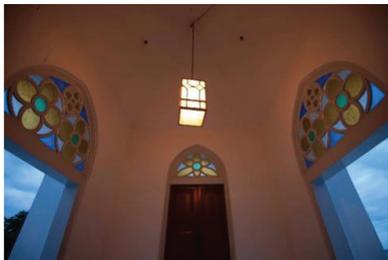
Motifs of stucco and a pattern of coloured glass of Assadang Nimit Temple



Note: An image of motifs of stucco and a pattern of Assadang Nimit Temple, by N. Propateep, 2017. Copyright 2017 by Nattapol Propateep.

Figure 4

Pattern of coloured glass of Assadang Nimit Temple



Note: An image of coloured patterned glass of Assadang Nimit Temple, by N. Propateep, 2017. Copyright 2017 by Nattapol Propateep.

In 1979, the Marine Science Research Station and Training Centre (SMaRT) was developed by Chulalongkorn University at Sichang Island, providing facilities for teaching students in the university's Department of Marine Science, Faculty of Science. Later, in 1991, the SMaRT was converted to the Aquatic Resources Research Institute (ARRI) to provide well- equipped facilities and laboratories for aquatic research, and accommodation for the university staff and students.

The construction of the SMaRT Centre led to the re-discovery of the abandoned palace and royal park. Despite its poor condition, the architectural and historical value of Chudhadhuj Royal Residence was apparent. A study of the history and a survey of the palace was undertaken by the Chulalongkorn University research team.

In 1989, when the Eastern Seaboard Development Project was launched, the government identified Sichang Island as a natural resource that should be conserved. One of the most dangerous environmental threats at that time was the stone quarry industry. During the construction of the deep- water seaport for the project, the quarry caused landslides, air, and noise pollution. Moreover, the geological vibrations from the quarry operations endangered the natural and architectural heritage of the island, which led to the controversial closing down of the quarry. A study and development plan of the royal residence was developed, leading to the announcement of its registration as an historic site in 1990, and the launch of a conservation and rehabilitation project by the Fine Arts Department that was completed in 1996 (Arayanimitskul, 2006).

At around this same time, the tourism industry in Chonburi province began to develop, and funds started to spill into the conservation of architecture and landscape of the royal residence. Under the royal patronage of H.R.H. Princes Maha Chakri Sirindhorn, the conservation projects have been kindly welcomed by the island residents, who directly benefit from tourism, which has replaced the fishing and stone mining industries that were environmentally destructive. The conservation of Chudhadhuj Royal Residence has been carried out in conjunction with community developments that balance conservation, tourism development, and sustainability (Chulasai, 2005).

Since 2002 Chulalongkorn University has been responsible for the financial support of the building

and landscape architecture restoration as part of the new usage as a museum, presenting the history of the royal residence and its beautiful natural landscape, especially the seaside area that serves as a public park where both residents and visitors can relax and exercise. The museum was officially opened to the public in 2004. At present, Phra Chudhadhuj Ratchathan Palace Museum is under the supervision of the Office of Art and Culture Management, Chulalongkorn University.

One important element of the conservation and development plan that is still in progress is the design of luminaires for the historical architecture, which is intended to promote the ambiance of the royal residence. There are two main concepts: preserving the historical atmosphere from the time of King Chulalongkorn, and fulfilling the goals of sustainable use and maintenance (Suriyothin, 2006).

The process began with lighting design for historic buildings that had not yet been illuminated, such as Phongsri Building, Apirom Building, Wattana Building, Green Wooden House, Assadang Nimit Temple, and the rebuilt Assadang Bridge, to recreate the ambiance as it had been in the past. The decorative architectural elements of the Green Wooden House were employed as a pattern for the luminaire, and adapted into various types of luminaires to suit the use of each building. However, the luminaires for the main routes in the landscape area have not yet been designed. Hence, the landscape luminaires for walkways and lighting master plan still need to be provided to Phra Chudhadhuj Ratchathan Palace Museum and its cultural landscape area.

The purpose of this study is to design these landscape luminaires by employing design elements and principles in accordance with the concept of conservation and the identities of the former palace to connect the past and the present as well as to create a sense of place by reestablishing the emotive bonds and attachments to this particular site.

LITERATURE REVIEW

Cultural Value and Sense of Place

The International Council on Monuments and Sites Thailand [ICOMOS Thailand] (2007) states that heritage is not confined to the past; it is made up of those things that are inherited or that can be inherited whether they are natural in origin or man-made. Heritage includes not only those things that come from the past in general, but also those that we inherit from other people, whether they are living or dead. Heritage also includes that which is passed on to others who are alive now or yet to be born. Heritage is divided into Natural Heritage and Cultural Heritage. This difference between the natural and the man-made is useful, but it has its limitations. Usually, environments are a combination of the two, having both a natural and a cultural dimension at the same time, and there are usually interrelationships between them. The relative proportion of the natural to the cultural dimension will vary from one environment to another. To preserve cultural heritage, it is important to consider what values the historic site has, such as aesthetics, archaeology, history, academic, social affairs, etc. in order to plan and preserve the most remarkable values.

Harrison (2012) stated that heritage is not simply a collection of 'things', but, instead, constitutes the social 'work' that individuals and societies undertake to produce the past in the present. This process is not one that occurs only in the minds of humans, or one that functions solely a discursive manner, but one that evolves from a range of material beings who co-produce heritage as a result of their own affordances or material capabilities. He also suggested that the interconnectedness of people, things, and their environments should be considered more comprehensively in relation to heritage.

A cultural heritage site refers to a place, locality, natural landscape, settlement area, architectural complex, archeological site, or standing structure that is reorganized and often legally protected as a place of historical and cultural significance (The ICOMOS International Scientific Committee on Interpretation and Presentation, 2008).

Cultural values are a series of principles and values passed on, generation after generation, from our ancestors. Based on values, the entire cultural community decides their way of life. Those ideas

influence how individuals of that culture will behave and how they will lead their lives. Cultural value is also a product that results from the invention, selection, improvement, and creativity of ancestors; it continues to be learned or inherited until the public can access and be aware of it in as a part of contemporary life. It consists of tangible heritage, such as historic buildings, and intangible heritage, such as beliefs, values, customs, traditions, memories, or identity, as well as dress, food, arts, and crafts (Harrison, 2012).

Cultural values connect people together, making them strong and united. It helps people learn tolerance and understand friendship, which paves the path of social harmony, economic improvement, and physical well-being of the community and others.

The definitions above indicate that Chudhadhuj Royal Residence qualifies as a cultural heritage site since it has a long history that is integrated with its setting, 'Sichang Island', which has drastically changed through time, as has the royal residence. The creation of a development plan for the abandoned palace led to the announcement of its registration as an historic site. The conservation of the palace has not only revived a valuable part of Thai national heritage, but has also raised the pride of the Sichang people and increased awareness of their heritage, together with the environmental issues. Moreover, it initiated many improvements on the island, including improvements to the residents' quality of life, economy, culture, and natural preservation (Chulasai, 2005).

Fritz (1981) stated that sense of place is the particular experience of a person in a particular setting (feeling stimulated, excited, joyous, expansive, and so forth) while the word "Topophilia" seems to have similar meaning as that which Tuan

(1974) indicated -- that topophilia is the effective bond between people and place or setting. It can be defined broadly to include all human beings' affective ties with the material environment. The response to environment may be primarily aesthetic: it may then vary from the fleeting pleasure one gets from a view to the equally fleeting but far more intense sense of beauty that is suddenly revealed. The response may also be tactile, such as taking delight in the feel of air, water, or earth. This rather poetic explanation is offered in hopes of more fully explaining the rather beautiful concept known as a sense of place.

When a visitor arrives for the first time at Chudhadhuj Royal Residence, the history of the royal palace, the historic buildings, the royal park situated by the sea and the mountainous area kindle the sense of place, which is further enhanced by the beautiful pathways and great views that are an integral part of the experience. Regular visitors to the royal residence can, for example, delight in the changes of Frangipani trees in different seasons of the year. It is a place of rejuvenation and renewal; a place of excitement. The local Sichang residents can come to the seaside or the public park area of the royal residence regularly for exercise or leisure; it is a place for solitary relaxation, or a place to share loved ones. Everyone from locals to tourists, and individuals to families can enjoy the value of the site.

The sense of place may be different for each person even though they each experience the same place. Anyone can depict his sense of place from his or her personal point of view, depending on the experience, particularly in a place that offers the wonderful setting and long history found at Chudhadhuj Royal Residence. There should be no doubt that good design for the environment of this site would enhance its sense of place.

Luminaires in the Past

Types and styles of past luminaires in Chudhadhuj Royal Residence

Historical evidence from photographs of the Chudhadhuj Royal Palace taken in 1896 and kept at the National Library of France (Bibliothèque nationale de France) as shown in figure 5-6, along with the construction inspection reports at Sichang Island, show that the landscape luminaires of the royal palace in the early days consisted of two main types: 1) permanently installed on the walkways and the rail of Assadang Bridge and believed to have

comprised a pole with an oil lamp (Arayanimitskul & Povatong, 2006) and 2) temporary luminaires, used for the celebration by hanging decorative Japanese lanterns at the entrance gate and festive light along the walkways and bridge railing. Further, on the day of Visakha, a royal charity tradition, paper lanterns in various images were hung around Assadang Nimit Temple (Suriyothin, 2006). Since 2004, Chudhadhuj Ratchathan Museum has revived the Visakha Day activity in May every year. In fact, a Visakha lantern contest has been established. These temporary lanterns are used to decorate the main walkway to Assadang Nimit Temple.

Figure 5

Oil lamp next to the Daat-thongbai walkway (ทางดาตทองใบ)



Note: From “Phračhuthāthutrāčhathān ra sō nưngrōisipsōng khōmūn mai čhāk hōsamut hāeng chāt Farangsēt [Chudhadhuj Royal Residence RS. 112 new information from the National Library of France],” by C. Arayanimitskul and P. Povatong, 2006, *Academic Journal of Architecture* (03), p. 54. Copyright 2006 by Chamaree Arayanimitskul and Pirasri Povatong.

Figure 6

Oil lamps along the Don-thong-plad walkway (ทางดอนทองพลัด)



Note: From “Phračhuthāthutrāčhathān ra sō nưngrōisipsōng khōmūn mai čhāk hōsamut hāng čhāt Farangset [Chudhadhuj Royal Residence RS. 112 new information from the National Library of France],” by C. Arayanimitskul and P. Povatong, 2006, *Academic Journal of Architecture* (03), p. 56. Copyright 2006 by Chamaree Arayanimitskul and Pirasri Povatong.

Luminaires in the same period

Photographs were also found of the same type of luminaire, a pole with an oil lamp installed at Bang Pa-In Palace. King Rama IV graciously ordered the renovation of the Bang Pa-In Palace in 1872. It was built at about the same time as Chudhadhuj Royal Palace, when gas or oil lamps were popular (Suriyothin, 2018).

Nowadays, similar heritage-style lamppost luminaires with LED light sources are found on the streets in European countries such as the Netherlands and England, as shown in figure 7-8, and are typically found in outdoor luminaire catalogues.

Figure 7

A heritage style lamppost in England



Figure 8

A heritage style lamppost in England



Outdoor Lighting

The objectives of outdoor lighting

The common objective of outdoor area lighting is to help people to circulate and identify intersections, landmark, and locations where activities are taking place. It also helps increase safety and the perceived sense of security for passers-by. Furthermore, good illumination can enhance and reveal the distinctive appearance of the area where it is needed (Boonkham, n.d.). Lighting can also extend activities or area use well into the evening and enhance the nighttime experience for visitors and residents of the area, as well as create a sense of place, especially focal points and nodes of activities, while making positive connections between the various elements of development and its locale (Society of Light and Lighting [SLL], 2016).

Factors related to night vision

Vision is an important sense for humans. In low light levels, moving around becomes more difficult for humans and other diurnal species (Gaston et al., 2013) because visual performance is obstructed by low luminance level, insufficient contrast, scattered luminance distribution, and glare (Boyce, 2014).

Therefore, lighting designers have to consider these factors when designing outdoor lighting that serves the desired objectives. The design of outdoor lighting for effective visibility, therefore, depends on the control of illuminance, luminance, uniformity, contrast, glare, and eye adaptation (Colorado Department of Transportation, 2019).

Task visibility for pedestrians includes seeing obstacles in the walkway or reading signage. Visibility depends on the size, brightness, illuminance, and contrast of the objects in an area. However, the object's brightness has to be balanced with its surroundings to prevent glare. The lighting system should also provide wayfinding by establishing consistent patterns and visual cues.

Horizontal illuminance refers to the amount of light falling on a horizontal surface such as pavement, while vertical illuminance is the amount of light falling on vertical surface such as a person or foliage. Both should be used for pedestrian areas.

Luminance is reflected light or the brightness of a surface or an object in an individual's field of view. More reflective or light-coloured surfaces reflect more light than darker, less reflective surfaces.

Uniformity is defined as the evenness of light. Human eyes continually adapt to bright object in the visual field. However, too much uniformity in surfaces may minimize the surface contrast of an object, which can cause some objects to blend into the background, making them harder to detect. A balance is required between uniformity and contrast.

Contrast is the difference between the luminance values of two adjacent surfaces. High contrast is necessary for good visibility. However, if the contrast is excessively high, the brighter surface can become a source of glare.

Direct glare is caused by excessive light entering the eye from a bright light source. The eye has a harder time seeing contrast and details with direct glare. Indirect glare or reflected glare is caused by reflected light, such as light reflecting from wet pavement. Both types of glare can be minimized with the use of appropriate luminaire type and design.

Eye adaptation refers to the eye's ability to quickly adjust between changes in luminance and intensity. Human eyes automatically adjust to the brightest object in the field of view.

Human night vision can work outdoors because it's rarely completely dark. There is always a little light from the moon, stars, or streetlamps. Nevertheless, the smallest amount of light can give human eyes enough to work with. Moving around the royal residence from the afternoon until dusk, visitors will experience photopic (daytime vision) and mesopic (a combination of night and day vision). If the visit lasts until dark, visitors will experience scotopic (night vision) as the eyes have the natural ability to see in the dark. Since human eyes respond to varying colours of light differently, white light sources are recommended for optimal visibility.

Mitigating the Adverse Effects of Lighting

Since Chudhadhuj Royal Palace comprises a cultural landscape that reflects the relationship between humanity and nature, the effects of lighting should be carefully considered due to its key role in the presentation of this national heritage venue because of its environmental and cultural values. The adverse impacts of artificial lighting on different habitats can be reduced in five ways: 1) avoiding the use of lighting that is not needed, 2) controlling the colour spectrum, 3) limiting light intensity, 4) managing the direction of light emissions, and 5) limiting the duration of light output (Longcore & Rich, 2016).

TYPES OF LUMINAIRES AND LUMINAIRE CHARACTERISTICS

Type of luminaires

Luminaire types which are commonly used in landscape illumination, especially for walkways, are lampposts, lanterns as found in the past, and bollards as often seen today.

The luminaires used in the past, as mentioned earlier, were lampposts with oil lamps and temporary lanterns. At present, luminaires emit, distribute, and control the light originating from one or several lamps, and LED has become the most popular of many forms of light sources. The Outdoor Lighting Guide (Institution of Lighting Engineering, 2005; The Illuminating Engineering Society of North America [IESNA], 2000) describes the characteristics of these luminaires as follows:

Lampposts illuminate a relatively large area. They can thus be spaced relatively widely apart, which also makes them less dominating. Heritage-style luminaires should be considered as they can improve daytime aesthetics. However, styles and size of the luminaire should be considered to suit the scale of the application. Glazing varies from opal to patterned to clear depending on the appearance and performance required. Generally, the mounting height is typically 4-6 meters using LED module rated between 36-60 W.

A lantern is a lamp with a transparent case protecting the flame or electric bulb, and typically having a handle by which it can be carried or hung (Oxford Dictionary, n.d.). Today's lanterns include many styles of traditional fixtures to recall the outdoor lights of earlier times in history. The wattage of LED lamps has to be kept low (around 3-15 watts) to avoid too much brightness.

Bollard luminaires are mainly used for lighting of walkways and grounds, for boundary and entrance marking, and to illuminate shrubbery. A typical illuminated bollard comprises a luminaire on a base unit, typically up to 1 meter in height, housing a lamp, which now becomes an LED. They are often fitted with optical controllers that throw the light directly onto the path, eliminating the risk of glare. The lower the mounting height, the closer the spacing required for uniform illumination. The heritage-style lantern can also be coupled with the bollard.

Luminaire Characteristics

Key attributes and certain basic requirements of luminaires should be met, such as durability in the external environment and resistance to water ingress. In addition, the appropriate use of energy, ease of maintenance, managing the threat of vandalism, and harmonizing the appearance of lighting equipment with its surroundings should be considered as well (SLL, 2016).

LED is the most widely used light source today. It offers better performance and saving benefits over previous conventional lighting technology. Its benefits include 1) long lifetime up to 100,000 hours; however, as the LED light source ages the amount of light emitted will decrease until it ceases

to emit enough light to be functionally effective (SLL, 2016), 2) instant switch-on, 3) ability to withstand vibration and impacts, 4) ability for the light output to be directed where it is needed, not thrown into the night sky, and 5) lower energy consumption.

The characteristics that most significantly affect human perception are correlated colour temperature (CCT) and colour rendering index (CRI). It was found that low color temperature (around 3000 K) phosphor-coated LEDs are more suitable for street lighting (Jin et al., 2015). As CCT increases, dark adaption time increases. A high CCT LED light source that has relatively high amount of blue light components has the longest dark adaption time. On the other hand, warm white LEDs have relatively low CCT and a high amount of long wavelength components, and they have short dark adaption times. Similarly, as road illuminance increases, dark adaption time increases as well. The IESNA Lighting Handbooks (IESNA, 2000) mention, however, that within the landscape, cool colours work well on some foliage, but typically warmer tones work best on most foliage, flowering plants, people, and hardscapes.

Nowadays the CRI of LEDs is not less than 80. A CRI of 90 or more is considered high, while below 90 is considered mid-range to low. CRI of more than 90 should only be seriously considered if colour quality is important; thus, a high value of CRI is not significant for walkway lighting in the landscape.

Glare can be magnified by the improper colour temperature of the LED, such as blue-rich LED lighting. LEDs are very intense point sources that cause visual discomfort when viewed by the human eye. This effect is increased by higher colour temperature LEDs because blue light scatters more within the human eye, leading to increased disability glare (Kraus, 2016). This means that the CCT of light sources on the walkways should be warm.

RESEARCH METHODS (RESEARCH-BASED DESIGN PROCESS)

To establish the landscape luminaire requirements for walkways in the cultural landscape areas of Chudhadhuj Royal Residence, a number of steps were followed:

Survey of the main circulation routes of the site and an **interview** with the museum's manager were conducted in order to understand the luminaire requirements.

Types of the luminaires and their characteristics were determined from the luminaire requirements and luminaire design criteria.

Design concepts of architectural conservation of cultural landscape, and identity of the place, together with Thai identity, were reviewed.

Luminaire prototype design with the concepts of cultural landscape conservation and identities were applied employing the design elements and principles onto each type of luminaire. The alternative designs of the luminaires were explored. Then, the prototype luminaires were finally decided.

Questionnaires with open-ended questions were assessed by thirteen selected experts on architectural design and conservation who offered suggestions for the development of luminaire design (Suriyothin, 2019). The prototype luminaires were built and tested on-site. The findings and the recommendations of the assessment and the appearance of prototype luminaires from the mock-up testing, both day and nighttime, were summarized for further luminaire development.

Final luminaire design documents were divided into 2 parts: the design patents and the construction drawings of the landscape improvement project of the Chudhadhuj Royal Residence.

This paper aims to elaborate on the design process and design concepts, and how visual design elements and principles were applied in the design of the luminaires.

LUMINAIRE REQUIREMENTS

The Survey of the Site

The physical characteristics of the royal residence can be divided into 3 zones according to the historical importance, physical terrain, and connection between natural and cultural landscape as follows:

Zone A, from the entrance on Chakrabongse Road (ถนนจ๊ก รพงษ์) through the Phlang-thong-hum walkway (ทางแฝงทองหุ้ม) near the Square-Shaped Pagoda (เจดีย์เหลี่ยม), this zone covers the outer area of the palace and the royal park. It is a natural landscape area located on a high hill which can be classified as the least important area.

Zone B, from the Phlang-thong-hum walkway further down to Wattana building, covers a significant area of the palace, on a hill which is less steeply sloped than zone A as some historic buildings and the royal park are located in this zone.

The last, is zone C, from the Kuad-thong-kon walkway (ทางกวดทองก้อน) along Assadang Road (ถนนอัษฎางค์) and the Roey-thong-rai walkway (ทางรอยทองราย) to the Om-thong-lor walkway (ทางอ้อมทองหล่อ), adjacent to the base of Manthat Rattanakom Throne Hall (ฐานพระที่นั่งมณเฑียรรัตนโกสินทร์), this comprises the flat area of the seaside with a beautiful natural scenery. It is also of great importance zone as shown in figure 9.

The results from the physical survey of the main circulation route of each zone are as follows:

The main route in Zone A starts from the main entrance at the hillside on Charkrabongse Road.

This concrete-pavement walkway runs through Assadang pond (บ่ออัษฎางค์), an important water source of the royal residence to Assadang Nimit Temple; some Frangipani trees cover both sides of this walkway. Most of them were planted during the restoration period in 2004. From Assadang Nimit Temple to the Square-Shaped Pagoda, some indigenous trees cover on both sides of the walkway, interspersed with an open area of the natural stone yard.

The route in Zone B begins with the Phlang-thong-hum walkway, which is covered with the old Frangipani trees; hence, it is shadier than Zone A, especially in the rainy season when all the trees are covered with leaves. The pavement was made of natural stone with cement mortar, just as it was when first built. This route is important because it connects to the secondary routes leading to the historic buildings: Pongsri Building and Apirom Building. There is also natural landscaping and man-made ponds along the route. Pid-thong-phan (ทางปิดทองแผ่น) is also the main walkway that leads to Maha Anodard Pool (สระมหาอนาดัด) where there is a steep walkway without handrails; consequently, it is quite dangerous for nighttime passers-by.

Zone C is a continuous route from Zone B down to the flat area near the beach. It is the area where the Wattana Building, Green Wooden House, the base of Manthat Rattanakom Throne Hall, and Assadang Bridge are situated. Since this area includes another main entrance from Assadang Road, most of the tourists and Sichang Island people also use this area as a public park to relax and exercise in the evening. Some landscape luminaires were already installed to illuminate the walkways during the first renovation by the Fine Arts Department in 1989; however, the installation has not been yet included the areas that are regularly used at night.

Figure 9
The 3 zones of Chudhadhuj Royal Residence



Note: From *Khrōngkān samrūt læ 'ōk bæp phra phatthanā phra chuthā thut rāthathān kə sī chang chāngwat Chon Buri: rāngān chabap sombūn* [Survey and design for developing Chudhadhuj Royal Residence, Sichang Island, Chon Buri province], by C. Arayanimitskul, 2005. Copyright 2005 by Chamaree Arayanimitskul.

The Interview for Lighting Requirements

The manager of Chudhadhuj Ratchathan Museum was interviewed in order to gain greater understanding of the needs for lighting on the main walkway. The result of that interview indicates that luminaires are required for the main walkway of Zone A because this area covers a vast natural landscape and currently lacks illumination. Although

Charkrabongse Road gate is one of the main entrances, not many visitors start their journey from this entrance gate. However, large vehicles such as cars and pickup trucks can be parked at the front area of this entrance to accommodate a large group of visitors. As it is quite a long and straight route covering a large natural landscape, lighting for safety and security is needed at night. Moreover, lighting should enhance the visibility of the surroundings for tourists and night-time staff.

Zone B used to be a royal park located in the hilly area, so it has many manmade landscape elements, and the old Frangipani trees are very attractive. Some of the visitors and local people like to walk or exercise along the walkway until evening. For safety and security reasons, lighting should illuminate the sloped pathway and enhance the beauty of the Frangipani trees in different seasons.

On the main routes of Zone C, some cast concrete luminaires and some bollard lanterns have already been installed. It is an area where local people and tourists often visit as it acts as the second main entrance along the coastline. However, the numbers of luminaires currently installed are not sufficient to guide the way. Furthermore, the existing bollard lanterns are of the type typically found in the local market, and not of the grade or quality that can resist the effects of seawater. In addition, these kinds of luminaires lack identity or characteristics for such a significant historical site.

It can be concluded that 1) the routes in Zone A, Zone B, and some parts of Zone C lack illumination because most of the terrain is rock, making installation of electrical wiring and luminaires quite difficult; however, current technology can be used to deal with these issues, 2) good visibility lighting for safety and security is needed for all zones, 3) lighting for enhancing the beauty of the landscaped surroundings has to be considered, and 4) the newly designed luminaires should have a rich identity to create a sense of place, and should have the robust characteristics needed to withstand the harsh environment.

DESIGN CRITERIA

Lighting Design for Main Walkway in The Royal Residence

Located on Sichang island, Chudhadhuj Royal Residence is a cultural landscape site, consisting of hills, plains and indigenous vegetation, the royal palace, and the royal parks, as well as a beautiful beach. The building and grounds are used as a museum during working hours and as a public park until dusk. The overall area of the site, the surroundings, and the sea are rather dark at nighttime. For this reason, the lighting design along

the main walkways of the royal residence should take into account the safety and security of the users, and the mitigation of problems that may be caused by excessive lighting, as mentioned earlier.

At night, the overall environment of the royal residence is rather dark, and does not need to be illuminated with a high-intensity light source. Luminance and contrast are important to the design of walkway lighting design since they are related to the reflectivity of the surface. Problems caused by adaptation of the eyes can be reduced by employing low luminance ranges at night. Lighting distribution that provides horizontal illuminance onto the walkway and vertical illuminance onto the vegetation or immediate surroundings would help to increase visibility. The color of light that is suitable for illumination is a warm white light source; colored lights should not be used.

Luminaire Characteristics

In Zone A, lampposts should be designed to provide the main pedestrian walkway and the vast area in the vicinity of the walkway with broad light distribution for a sense of safety and security. Wänström Lindh (2011) tested different types of outdoor luminaires in a park near a church in Alingsås, Sweden, to examine how light distribution in a public space is experienced. The results showed that, in this context, street luminaires at a height of 4.5 meters contribute more to creating a pleasant, delimited, and legible experience that gives a feeling of safety than does a height of 6 meters. However, given that the site is a cultural landscape area and a type of protected land, certain adverse effects of artificial night lighting should be avoided.

In Zone B, the luminaires should be a bollard type to illuminate the walkway as well as the hedges, leaves, and tree branches, especially in the intimate area near the row of the old Frangipani trees, which have very beautiful trunk structures.

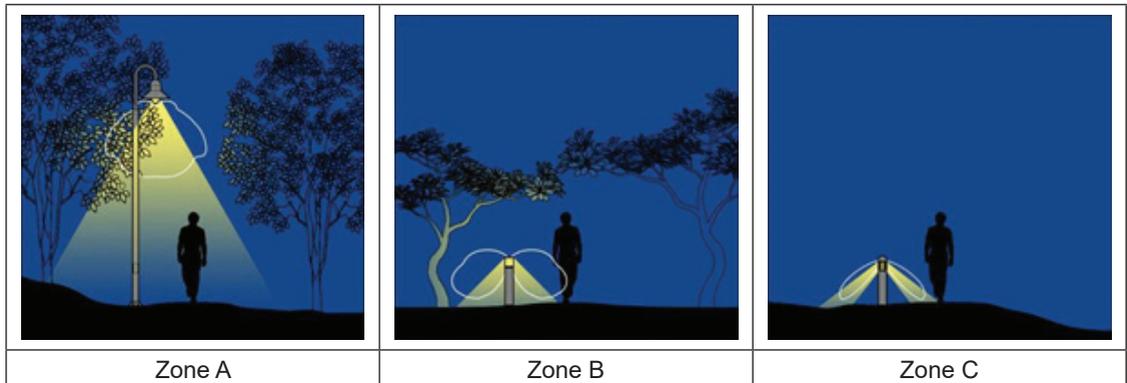
Finally, Zone C should have bollard type luminaires with a downward glow aimed at the ground to catch and to guide the eyes to the walkway by the sea with minimal intensity as the beach is an open environment with low vegetation (Longcore & Rich, 2016). The lighting distribution patterns are shown in Figure 10.

All the luminaire supports should respond to different constraints such as the effect of wind, normal shock, storms, and corrosion (Narboni, 2004) and the luminaires should be accessible for

cleaning and component replacement (Tregenza & Loe, 2014). Moreover, the lighting installations should be resistant to salty vapor as the site is on an Island.

Figure 10

Proposed lighting distribution patterns of the 3 zones of Chudhadhuj Royal Residence



THE DESIGN CONCEPTS

Architectural Conservation of Cultural Heritage

Because of the historical buildings and landscapes in Chudhadhuj Royal Residence, the palace is an important part of Thailand's cultural heritage, and the historic site is worth preserving. Hence, the importance of the site and the surrounding conditions has been taken into account. Principles and concepts of the conservation of architectural and cultural landscapes from Act on Ancient Monuments, Antiques, Objects of Art and the National Museum 1961, important conservation charters such as Venice Charter 1964 (International Council on Monuments and Site, 1965), The Florence Charter 1981 (International Council on Monuments and

Site, 1982), The Burra Charter (The Burra Charter: The Australia ICOMOS charter for place of cultural significance, 2013), Thailand Charter on Cultural Heritage Management (2011), and other various books and documents (Chulasai, 2006; Feilden, 1988; Feilden, 2003; Kanjanasthti, 2009) were reviewed, summarized, and used in the development of design concepts that take into account the conservation of the cultural landscape of the site. Several key issues were identified as being important to the design, as follows: 1) the importance and the value of the historical site and its aesthetics are maintained, 2) the difference between the old and the new parts is distinguishable, and 3) new parts should be in harmony with the environment while maintaining the value of the cultural heritage as described in a paper entitled "Development of Luminaire Design Prototype for the Landscape of Chudhadhuj Royal Residence" (Suriyothin, 2019).

As previously discussed, heritage luminaires similar in style to those from the period of the royal residence are still used these days and can be found in the market. However, these lack the specific identity of the place, so it was determined that new luminaires for the walkway in the landscape of the royal residence should be designed.

The intent is to apply the concept of cultural heritage conservation in order to integrate this concept into the luminaire design, and to promote the past atmosphere in the present time without devaluing the cultural landscape. The luminaire design should call to mind the atmosphere of the royal residence in the past.

Identity of the Place

Finding the identity of Chudhadhuj Royal Residence is an important step in the process of identifying the appropriate style, design, form, and decorative patterns of the luminaire. The outstanding architecture of Assadang Nimit Temple, in the area of Chudhadhuj Royal Residence, which has rich

elements and design details, offers one model for understanding these issues. In addition, His Royal Highness Prince Chudadhuj Dharadilok's flag was also studied as part of the effort to create the identity of the luminaires.

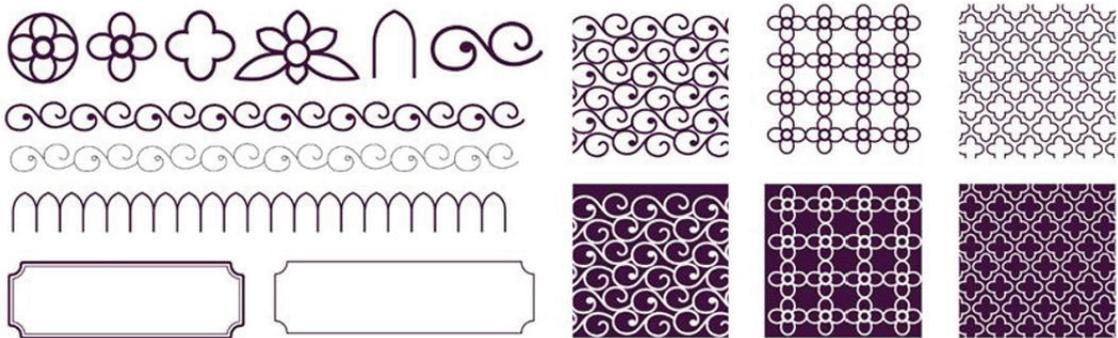
The intent was to use the concept of the identities of the place by integrating the motifs, patterns, colours, and Traditional Thai mouldings that were found into the luminaire design to enhance the importance of the cultural heritage as well as to create a sense of place.

Applied motifs and patterns

The motifs and patterns were taken from research entitled "Development of Identity Design, Promotional Items and Souvenirs Design for Sustainable Community Tourism Promotion: Chudhadhuj Rajathan Palace, Sichang Island" (Siangarom, 2018) as shown in Figure 11. The stucco motifs and patterns on the walls inside Assadang Nimit Temple and patterns of coloured-glass windows were selected for the luminaire decoration.

Figure 11

Pattern reproduced from the decorative elements of Assadang Nimit Temple



Note: From *Rāingān wičhai chabap sombūn kānphatthanā kān'ōkbæp 'attalak sub prachāsamphan læ tonbæp khōng thīraluk phu a songsōe m kānthōngthīeo yāng yangyun samrap phra chuthā thut rāthathān ko sī chang* [Development of identity design, promotional items and souvenir design for sustainable community tourism promotion: Chudhadhuj Rajathan Palace, Sichang Island], by S. Siangarom, 2018. Copyright 2018 by Saranya Siangarom.

Thai tone colours

The colours were selected from the emblem of the royal ornament of His Royal Highness Prince Chudadhuj Dharadilok. A flag pin in deep purple colour with the abbreviation of His Royal Highness Prince's name (Dithanon, 1992) shown in Figure 12 was reviewed. It provided inspiration, along with a wrapping cloth for the teacher's day for artisans and artisan textbooks, Prince Chudadhuj Dharadilok Edition, decorated with purple flags and a gold border crossed in harmony with the abbreviation of his name in deep purple colour. The Office of Arts and Culture of Chulalongkorn University simplified this flag, and it is used as a symbol of the Phra Chudhadhuj Rachathan museum.

These colours were compared to the Thai tone colour system (Pittayamethi, 2016) which names colours after natural materials. It was found that deep purple was close to the color of Jambolan (Lukwa), and that the gold or deep yellow was close to the color of pyrite as shown in Figure 13.

Figure12

A flag pin with the abbreviation of His Royal Highness Prince's name



*Note: From *Nvngroṅ i pī somdet čhaofā čhuthā thut* [Commemorative Book Subcommittee in the steering committee of the 100th Anniversary Celebration Project of Prince Chudadhuj] (p. 164), by C. Dithanon (Ed.), 1992. Copyright 1992 by committee of the 100th Anniversary Celebration Project of Prince Chudadhuj.*

Figure 13

Main color tones selected from the Thai tone color system: deep purple and deep yellow



*Note: From *Rāingān wičhai chabap sombūn kānphatthanā kān'ōkbæp 'attalak sūb prachāsamphan læ tonbæp khōng thīralūk phūa songsoēm kānthōngthīeo yāng yangyūn samrap phra čhuthā thut rātchathān ko sī chang* [Development of identity design, promotional items and souvenir design for sustainable community tourism promotion: Chudhadhuj Rajathan Palace, Sichang Island], by S. Siangarom, 2018. Copyright 2018 by Saranya Siangarom.*

Traditional Thai mouldings, motifs, and patterns

Thai moulding (ลวดบัว) is decorative ornamentation applied in Thai architecture. It is used to cover and decorate the edges of the floor, as well as the bottom and top part of the wall in order to coordinate horizontal and vertical spaces, such as a ceiling and a wall. The moulding is a sheet or strip that is appropriate in width to the area, but which extends along an angle or edge of that surface. Various profiles and patterns can be made of stucco or carved wood. Furthermore, these traditional Thai mouldings, motifs, and patterns can be applied to the luminaires.

THE LUMINAIRE DESIGN PROTOTYPES

Alternative Design for Luminaire Prototypes

Various designs for luminaires have been sketched and drafted to scale according to the design requirements, criteria, and concepts. The lampposts and the bollards should be designed in the same styles since Zones A and B are connected. The design process began with the lamppost, followed

by a bollard with perforated patterns. Different forms of the luminaire bases and design elements taken from different motifs were explored in the alternative designs. A team of graduate and undergraduate students, including a few students from the field of Thai architecture, made the 3D models. Furthermore, Traditional Thai mouldings were added to these luminaires. Selected colours were applied to the luminaires in different ways. The bollard was designed after the style and patterns of the lamppost, and the bollard with perforated patterns satisfactorily linked the two types of luminaires. Examples of the alternative designs are as shown in Figures 14-19.

Figure 14
Lamppost and base alternative design



Figure 15
Sketch of the base of lamppost and the colour applied alternative design



Figure 16
The base details with colour applied alternative design

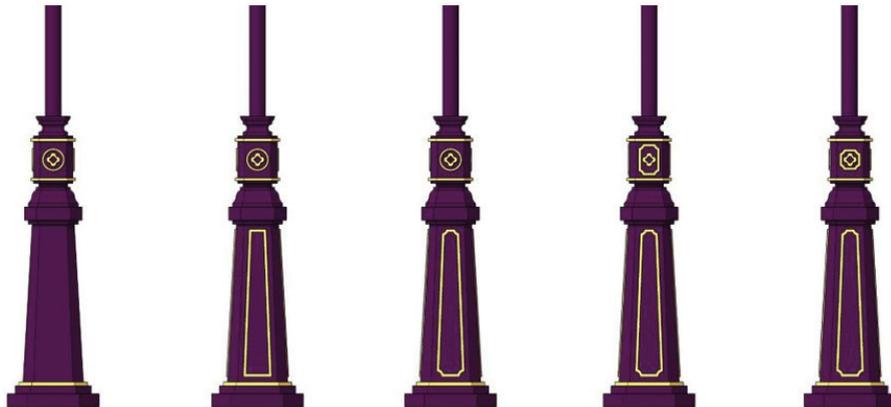


Figure 17
Bollard with perforated patterns and the colour applied alternative design

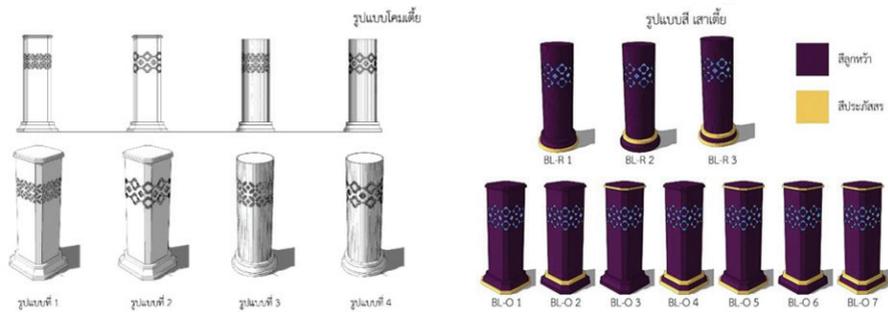
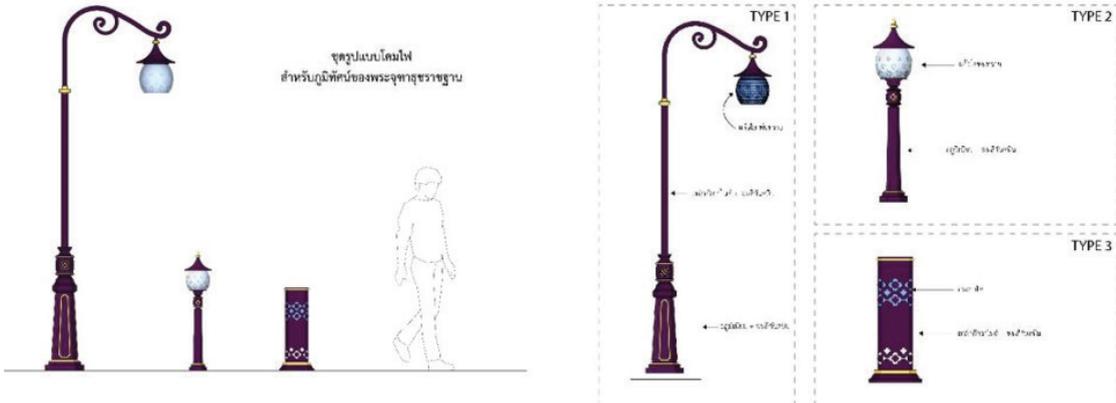


Figure 18
Bollard with perforated patterns and the shadow alternative design



Figure 19
A draft of 3 types of luminaires



The Design Elements and Principles Applied to the Luminaires

After satisfactorily customizing the forms, patterns, and proportions of the luminaires, the details were then fine-tuned. The design elements that were considered for the design of the luminaires were colour, line, shape, and mass, while the design principles included contrast, pattern, scale, and proportion. These design elements can be applied to the whole body of the luminaires to respond to the design of landscape luminaires as well as to the criteria established for both cultural heritage conservation and the identity of the place in daytime and nighttime. The design elements and principles applied to the luminaires are as follows:

Colour can accentuate the form and surface of the luminaire materials. The deep purple colour of the luminaires derives from the emblem of the royal ornament of His Royal Highness Prince Chudadhuja Dharadilok, and can be applied onto the body housing of luminaires, contrasting with the deep yellow used to accentuate the decorative flower motif elements. The deep purple colour can be perceived in the daytime. Moreover, this colour is cool and calm, so it can blend comfortably into the natural environment. At nighttime, the colored surface of the luminaires will not be well perceived as the dark surface has low reflectance property so that the luminaire itself will not disturb the view of the passers-by.

Contrast is the difference between two or more elements in the composition, particularly adjacent elements. It enables us to distinguish the qualities of one object by comparing differences with another. Contrasting colour is applied to the lamppost and bollard luminaires design. The deep yellow colour of floral motifs at the joint between the base and the column of the lamppost, and at the joint between the base and the glass cover of the bollard will provide a striking contrast to the purple. Another form of contrast generated by the light sources is the contrast of light and shadow from the bollard with perforated patterns.

Lines define the shape, form, and volume of luminaires. Curved line shapes of the extending arm derive from the motifs of the decorative elements of Assadang Nimit Temple. Curved lines that appear to flow are perceived to be more in line with natural elements such as the curves of tree branches, for example. Shape is the two-dimensional representation of form. The lamppost and bollard luminaires are designed in a curved form combined with the abstract shape of Traditional Thai mouldings to keep a soft-natural look in unity with the surroundings. Form refers to the three-dimensional aspect of the shapes. The bollard with perforated pattern is designed in the shape of a rectangular box, which is a more modern style. However, the perforated abstract floral motif patterns applied on the surfaces of the luminaires will diminish the bulky look during the day.

Texture relates to the surface appearance of the material used. As the finished material of the body and the pole of these luminaires is painted, the texture should be quite smooth. Moreover, the glass covers of the lamppost and the bollard are also designed with embossed floral motif patterns that can be distinguished from common glazing and provide strong identities.

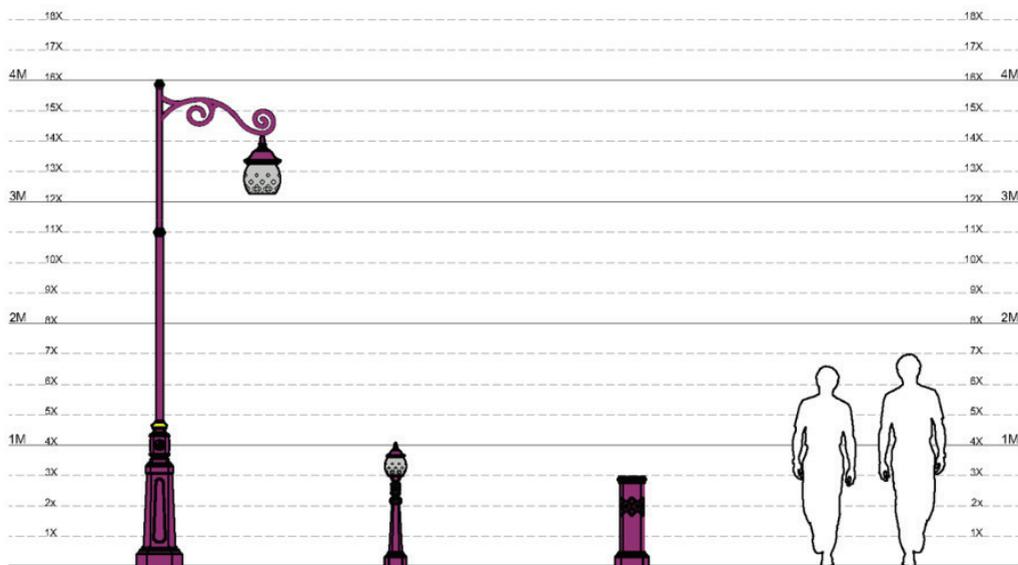
Pattern is an arrangement of repeated images or decorative motifs. The floral motifs from the coloured glass of Assadang Nimit Temple are arranged as a pattern on the body housing of the bollard with perforated patterns. At nighttime, these patterns can create unique shadow patterns on the ground.

Harmony involves the design of elements that share a common trait. The three types of luminaires share

the same color, motif patterns, and Traditional Thai mouldings on their body housings. However, these visual elements are applied to each part of the luminaires in different ways. Furthermore, the main colour of these luminaires is also harmonious with the natural surrounding environment.

Scale relates to proportion. Scale is the size of the element, while proportion is the ratio between two or more elements. The scale of all types of luminaires relates to their surroundings and to the activities of the main users. The proportion relationship of the luminaires is used to establish the light distribution in terms of function and lighting effects desired. The proportion of each luminaire is in relation to the installation location of the routes, and the proportions of these luminaires are designed to be related to each other as shown in Figure 20.

Figure 20
Proportion of the luminaires



Luminaire Prototype Design

Lamppost

As shown in Figure 21, the design intention is to evoke the atmosphere of the royal residence of the past. This type of luminaire is installed in Zone A, which is a natural landscape area. The pole is 4 meters in height.

The lamppost consists of a rectangular base, chamfered and tapered to the top of the base with a round shape column. A luminaire glass bowl is decorated with floral motifs. The overall body of the luminaire is deep purple. The joints between the base and the column are designed in a square shape with a floral motif within a circle, embossed in deep yellow, in contrast to the deep purple background. The extending arm for hanging

the glass luminaire is designed with a graceful curvature. The lamppost not only gives a wide distribution of light over the walkways and the surrounding landscape, but CCTV cameras and

broadcasting equipment can also be installed. This type of luminaire can be specified not only in Zone A, which is less important, but also in other areas which need such functionality.

Figure 21
Lamppost



Note. From *Development of the solar energy-operated luminaire design prototype for the landscape of Chudhadhuj Royal residence*, by P. Suriyothin, 2018. Copyright 2018 by Phanchalath Suriyothin.

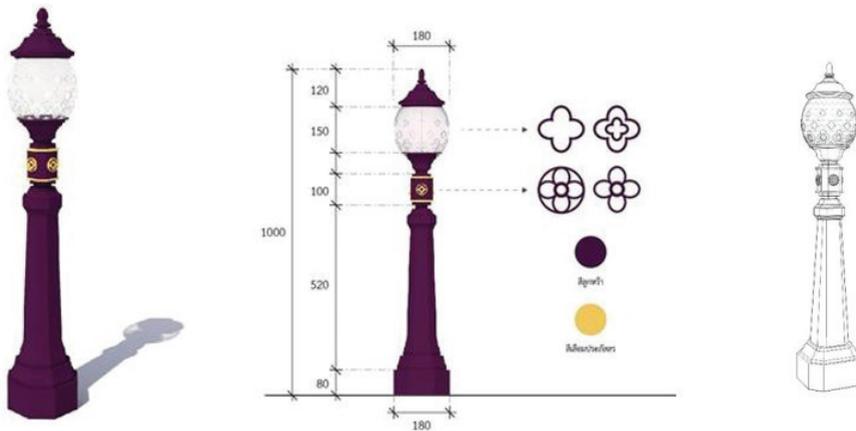
Bollard

The design intention of the bollard luminaire is as same as that of the lamppost, as shown in Figure 22. This type of luminaire is installed in zone B, where the historical buildings and the royal parks are located. The bollard is 1 meter in height.

The bollard consists of a rectangular base, chamfered and tapered to the top of the base. A lantern on the top is designed as a glass bowl

decorated with floral motifs. The overall body of the luminaire is deep purple. The joint between the base and the glass cover luminaire is designed in a square shape with a floral motif in a circle, embossed in light yellow, contrasting with the deep purple background. The styles and appearance of this bollard are similar to those of the lamppost. The bollard not only provides light distribution to the walkways, but it also illuminates the shrubs and branches, especially the historical Frangipani trees in this area.

Figure 22
Bollard



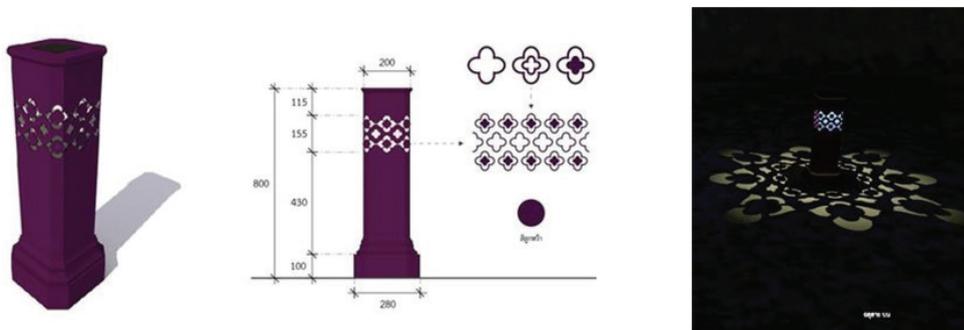
Note: From *Development of the solar energy-operated luminaire design prototype for the landscape of Chudhadhuj Royal residence*, by P. Suriyothin, 2018. Copyright 2018 by Phanchalath Suriyothin.

Bollard with perforated patterns

The design intention of bollards with perforated patterns is different from the other two types as it takes into account the light and shadow on the ground from the perforated patterns. The unique perforated patterns of the floral motifs achieve a romantic and relaxing atmosphere that recalls the past, especially from light and shadow as shown in Figure 23. This type of bollard is installed in Zone C, where the seaside area and some historic buildings continuing from Zone B are situated. The luminaire

is 80 centimeters in height. The luminaire consists of a rectangular base with perforated patterns on the upper part of the body modified from the floral motifs. The shadow of the patterns on the ground looks like Traditional Thai motifs. The top cover is equipped with an LED lamp to emit light through the perforated patterns, resulting in intricate and attractive light and shadow. The overall body of the luminaire is deep purple. The floral motifs are as shown in Figure 12. The patterns from light and shadow on the ground can guide the eyes along the walkway.

Figure 23
Bollard with perforated patterns



Note: From *Development of the solar energy-operated luminaire design prototype for the landscape of Chudhadhuj Royal residence*, by P. Suriyothin, 2018. Copyright 2018 by Phanchalath Suriyothin.

The designs for the three types of luminaires were redeveloped several times in an effort to achieve the best effect. Then, the luminaire design was assessed in terms of styles and architectural conservation by thirteen experts, including architects, landscape architects, product designers, and two staff of the royal residence in order to determine whether the 3 types of luminaires are suitable for the royal palace (Suriyothin, 2019).

The assessment results indicate that the 3 luminaires are suitable for the royal residence in terms of conservation, according to the criteria: 1) the importance and the value of the historical site and its aesthetics are maintained, 2) the difference between the old and the new parts is distinguishable, and 3) new parts should be in harmony with the environment while maintaining the value of the cultural heritage, though, during the daytime, the three types of luminaires are slightly less visually appealing in terms of architectural conservation than they are at night.

The key opinion of the experts that increased confidence in the luminaire design is the concept of luminaire type installation location and luminaire styles. Considering the historical importance of the royal residence, it was found that the expert's opinions are consistent with the analysis of the physical environment, and that is one of the main considerations in the design of the luminaires.

The results from the questionnaire show that all the experts were of the same opinion that the luminaires are not very distinguishable from the historical environment. It can also be seen that these luminaires are new and different from the luminaires in evidence in the past. In addition, in the less important historical areas such as Zone A, in which the landscape characteristics are not particularly striking, the newly designed luminaire enhances the importance of the area, but it does not create any conflict with the history of the site.

After the assessment of experts, the luminaire design was further. Moreover, the additional comments gained from the experts helped in improving the detailed design of the luminaires with respect to such issues as durability and maintenance.

An application for patent registration was made, and the luminaire design was patented within 2 years. In 2020, the Office of Architecture, Fine Arts Department implemented the lighting design master

plan and installation of the luminaires described in this study in the landscape area of Chudhadhuj Royal Residence.

Once all these luminaires are installed, the visitors who come to visit the museum, to enjoy the cultural landscape, and to relax or exercise in the park will doubtless be impressed by the new atmosphere created by the well-thought-out luminaires both during the day and at night in the beautiful surroundings. This enhancement to the grounds should help inspire them to visit the royal palace again because of its sense of place and of deep meanings.

DISCUSSION

The beautiful setting of Sichang Island inspired King Rama V to choose it as the location of Chudhadhuj Royal Residence, and the presence of the palace on the island enhances the value of the location. Following the renewal and conservation of the buildings and grounds, and the establishment of the Chudhadhuj Rachasathan museum, the cultural value of the site was enhanced, and remains to this day. Because of its historical value, the palace and royal park have become a popular tourist attraction. The design and installation of the luminaries will help visitors to enjoy the deep cultural value and offer a sense of place to the visitors as well. The luminaire design prototypes show that all the design elements, motifs, patterns, and colours which comprise tangible heritage applied to the luminaires help create a sense of place to the landscape, and transform the patterns of light and shadow intangibly so as to enhance the cultural value of the palace and the royal park.

CONCLUSION

This paper shows that the landscape luminaire design for Chudhadhuj Royal Residence is an example of a luminaire design project for a cultural landscape site. The luminaire design process of the cultural landscape was studied. The history, architecture, and landscape of the site are the key sources of information that should be reviewed in order to find the elements of design. Visual design elements such as line, shape, form, colour, and

design principles such as scale and proportion were applied to the luminaire design.

The research-based design helped the researcher to understand the cultural value of the place and how to apply the identities of it to the design as a part of the conservation of the cultural heritage. The concept of cultural heritage is central to the integration of the luminaire design into the existing space, and to bringing the past atmosphere alive in the present time without devaluing the cultural landscape. The luminaires add functionality, but also call to mind the atmosphere of the royal residence of the past.

The designed luminaires reflect the identity of the palace and park, and create a sense of place as a primary focus of the design intent. Finally, this project can provide an example of effective architectural conservation work for a cultural heritage site that can be used as a roadmap for future similar endeavours.

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