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### DEVELOPMENT OF LUMINAIRE DESIGN PROTOTYPE FOR THE LANDSCAPE OF CHUDHADHUJ ROYAL RESIDENCE

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#### *Abstract*

The main contribution of this research is to demonstrate the design process and development of the luminaire design prototype for the landscape of Chudhadhuj Royal Residence. The historical importance of the context, as the former royal residence of King Rama V of Thailand, is the main focus of the study to establish the design criteria. Three luminaire prototypes including: lamp post; bollard; and bollard with perforated patterns are developed based on extensive reviews of literature on history, and architectural conservation as well as on the identity of the context, and luminaire design guidelines and site surveys for luminaire installation. The evaluation of conservation aspects based on expertise is collected through questionnaires showing computer-simulated images in the real environment. The assessment by the experts from design and/or conservation fields reveals that the luminaire design prototypes can be further developed especially in terms of architectural and landscape conservation aspects for the cultural landscape. It also shows the possibility of utilizing the solar energy-operated hybrid system as an alternative energy source to improve landscape lighting and enhance safety around the premises. Therefore, the researcher could lead the luminaire prototypes to be patented.

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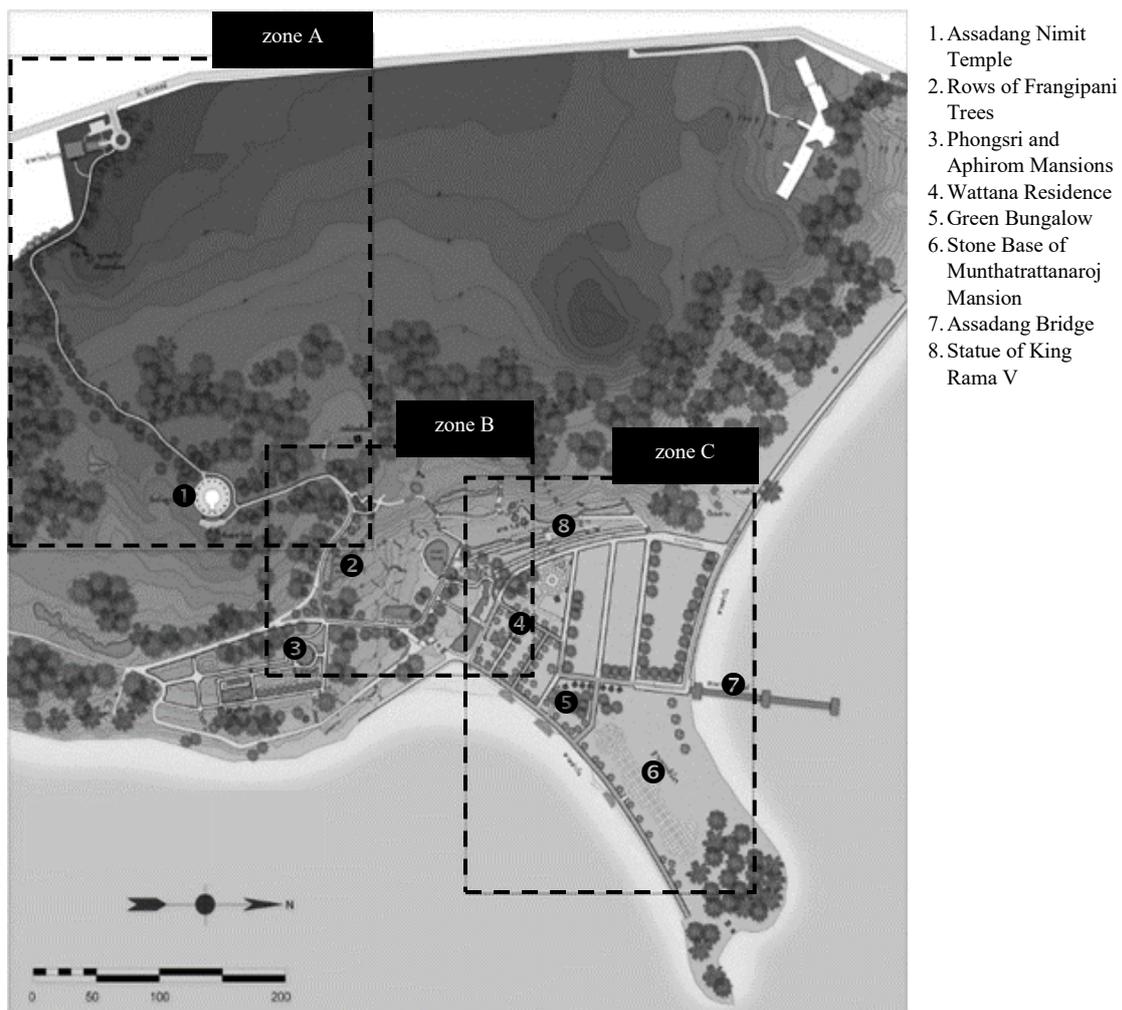
**Keywords:** Luminaire design, Chudhadhuj Royal Residence, Solar cell System, historic area, cultural landscape.



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## 1. Introduction

Constructed in 1888-1892 on the southeast of Sichang Island in the Gulf of Thailand, Chudhadhuj Royal Residence was the first seaside resort for the Thai royal family. It was a residence of King Rama V, named after his son, Prince Chudhadhuj Dhardilok, who was born there. The residence had become the most popular place for rehabilitation for the Thai Royal family because of its fresh and clean air throughout the year and its beautiful scenery (Chulasai, 2005). Unfortunately, the Royal family was forced to leave the Island due to the rise of Western colonialism. The palace was left vacant and some mansions under construction in the compound were left unfinished. Now in the supervision of Chulalongkorn University, the residence has been renovated several times, the latest of which was done in 2004 by a team of researchers from Chulalongkorn University in cooperation with the Fine Arts Department to develop plans for renovating historic buildings and improving landscape features on the site, including lighting design. Mansions were turned into exhibition areas while other historic buildings, as well as landscape features, were conserved as they were in the past. Subsequently, the royal residence was listed as a National Historic Site by the Fine Arts Department and was named Chudhadhuj Rajthan Palace Museum.



**Figure 01.** The three zones of Chudhadhuj Royal Residence based on terrain and historical significance

### **1.1. Physical Conditions**

The site of the royal residence can be divided into three zones based on terrain and historical significance as shown in Figure 1. “Zone A” is a natural hilly landscape with the Assadang Nimit Temple standing at the top of the hill which is the outer part of the palace. “Zone B” sited on the hill accommodating some residence buildings. It is a significant area embracing the palace and the royal park with a beautiful pathway flanked by rows of Frangipani trees. “Zone C” is the seaside area holding the Green Bungalow, the Wattana Residence, the stone base of the Munthatrattanaraj Mansion, and the Assadang Bridge (Saphan Assadang). In Zone C, apart from these historic buildings, there is also the 1993 statue of King Rama V standing in front of a cliff. The compound also consists of many ponds, brooks, cliffs, caves and beautiful trees as illustrated in Figure 1.

### **1.2. Lighting Design: Past to Present**

From a few photographs of Chudhadhuj Royal Residence in 1894 and some of the building construction inspection reports, it was found that some oil-lamp posts were permanently installed on the roadways and the handrails of the bridge. Some temporary lanterns were used for special celebrations, such as Japanese hanging lamps at the main gate, and some supplementary lanterns on the roadway and the bridge (Arayanimitskul, 2005). Hanging paper lanterns have been used to decorate the pagoda-church of the Assadang Nimit Temple on Vesak Day annually until today.

The main idea of the royal residence restoration including the lighting design for buildings and surroundings is to conserve the atmosphere of the place as it was during the reign of King Rama V. As for the design factors—regarding of functions and of maintenance sustainability— besides the architectural style, landscape, climate, and environment, the surrounding contexts and the use of space, according to cultural traditions of local people, have been taken into account (Suriyothin, 2006).

Most of the buildings in the royal residence are simple, with hints of Western styles. The designer used some architectural pattern details from a green wooden bungalow by the seaside as a lattice panel design of luminaire for each building. However, without the complete network of electrical wiring installation at that time, and due to the bedrocks features of the site, it was not easy for electrical installation. Nevertheless, the designer has prepared the route for the lighting master plan to allow the residence’s staff to monitor the area at night for the safety and the security of the visitors in the future.

## **2. Problem Statement**

Today, Chudhadhuj Royal Residence has become the main tourist attraction of the Sichang Island with the increasing number of visitors each year (Rakchat, 2018). It is also used as a public park giving locals opportunities for leisure and exercise. The premises’ staff, then, had an idea to extend the landscape lighting design stage and, therefore, consulted the designer (the author) to design the luminaires on the main route—as presented in the lighting master plan, to meet the new activities and the safety requirements of the visitors and the staff. However, the landscape area of the royal residence has not been thoroughly analysed in terms of its historical importance as well as the design identity of the place, which is needed to be studied for the design of luminaire on this specific site.

At present, the electrical wiring is almost completed all over the area of the royal residence. However, the operation cost of energy consumption is rather high compared to the budget, and some existing landscape luminaires do not have any characteristic or identity. Moreover, the onsite workforce is limited both during the day and at night; therefore, the designer comes up with an idea for energy saving using solar power system by installing photovoltaics for supplying electrical energy to the museum buildings and some infrastructures during the day and to illuminate buildings and traffic routes at night. If such design concept of new luminaires provides a unique feature in harmony with the cultural landscape during the day and improves safety at night, it can be developed as a design prototype for other similar historical sites.

### **3. Research Questions**

The author stated two questions regarding the landscape luminaire design on the main pathways of The Chudhadhuj Royal Residence as follows:

- What are the design guidelines for the luminaires in a cultural heritage site?
- How to develop the luminaire prototypes for the cultural landscape of the royal residence?

### **4. Purpose of the Study**

This paper aims for the design process and development of the luminaire design prototype for the landscape of the Chudhadhuj Royal Residence. The historical importance of the context, as the former royal residence of King Rama V of Thailand, is the main focus of the study to establish the design criteria.

The purposes of the study for the design of the landscape luminaires for the main pathways of the Chudhadhuj Royal Residence are as follow: 1) to develop a draft of luminaire prototype from the selective students' luminaire design as a part of an Architectural Lighting Design course on this specific site; 2) to establish the design guidelines for the landscape luminaire prototype; 3) to study the possibility of utilizing the solar power system for landscape lighting in the royal residence; and 4) the luminaire prototypes can be patented when the research is completed.

### **5. Research Methods**

This qualitative research was conducted in the form of questionnaires and open-ended questions to the experts as they can give relevant information and suggestions for the luminaire design of the Chudhadhuj Royal Residence's cultural landscape.

The research started with the study of relevant information including: the general information of the Sichang Island and the Chudhadhuj Royal Residence; the styles, types and the development process of the luminaires in the royal residence; landscape lighting design (Moyer, 2013; The Society of Light and Lighting, 2016; Wänström, 2012) and the theory and principles of the conservation of historic buildings and cultural landscapes (Act on Ancient Monuments, Antiques, Objects of Art and the National Museums, 1961; The Venice Charter, 1964; ICOMOS, 1982; The Australia ICOMOS, 2013; ICOMOS Thailand, 2011; Feilden, 2003; Khanjanusthiti, 2009). A related research on the identity of the Chudhadhuj Royal Residence was conducted at the same time (Siangarom, 2018), and the students' luminaire design works

are shown in Figure 2. Furthermore, the survey and study of the site's topography provided the understanding of the location and the installation of luminaires and the photovoltaic system (Panyakaew, 2015).



**Figure 02.** Samples of students' luminaire design work

The information above was analysed to determine the luminaire design guidelines starting from defining areas and routes that need to be illuminated. The work of students selected from the criteria of aesthetics, functions, and the use of appropriate materials was developed as a prototype design. Different types of luminaires were designed to be in harmony with the cultural landscape of the royal residence and in according to the architectural conservation perception.

After the design was made, thirteen selected experts with an experience of 10-35 years in the fields of design and/or conservation, such as architects, landscape architects, industrial designers and conservator, which include Dr. Pinraj Kanjanastiti, Chamree Arayanimitsakul, Dr. Pirasri Povatong, Dr. Pim Sutthikam, Dr. Wimonrart Issarathumnoon, Saranya Siangarom, Ronarit Dhanakoses, Chaiboon Sirithanawat, Suphichaya Suppipat, Dr. Vasu Poshyanandana, Surayoot Wiriyadamrong, Saowalux Poshyanandana, Saowalak Nurumitpancharuen, together with Chudhadhuj Royal Residence museum's director and manager, which include Kunchit Jitratan, and Wandee Rakchat, were asked to evaluate the three types of luminaire design in three different zones using computer-simulated images in the real location, presenting both day and night conditions as shown in figure 3. The questionnaires of 5-point Likert Scale consisted of three statements; 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 are distinguishable; and 3( the harmonization of the new parts with the environment, while maintaining the value of the cultural heritage, were assessed for their opinion along with open-ended questions for additional suggestions. On the other hand, questionnaire results were summarized. Finally, the luminaire prototypes of the full-scale model were tested at the actual location and minor adjustments were carried out so that the luminaire design would be more comprehensive.

The possible location for the installation of the solar power system was decided after the site survey, and electrical loads from photovoltaic panels were calculated to find the possibility to save electric energy.



Zone A



Zone B



Zone C

**Figure 03.** Samples of the computer-simulated images of the luminaire prototype on the designated site.

## 6. Findings

The luminaire in figure 2a was selected from the criteria of aesthetics, functions, and the use of appropriate materials. Moreover, its inspiring shadow pattern design, along with the residence's characteristic patterns and colours, can be integrated into the luminaire prototypes.

After reviewing the relevant literature, the author summarized the guidelines for the landscape luminaire design of the Chudhadhuj Royal Residence as follows: 1( its style should be in harmony with the route in each zone; 2( the luminaire lighting distribution should be as required function; 3( it should respond to the concept of architectural and landscape conservation; 4( it should reflect the patterns and colours which are the identity of the royal residence; and 5( its materials should be resistant in the severe environment affected by the sea.

The preliminary design of the luminaire prototypes derived from the above-mentioned guidelines. The route of the visitors of each zone gave the author the idea of the height and the type of luminaire. Zone A is a natural landscape of the hilly area, and it is the outer part of the palace. A lamp post should be suitable for this area as the routes are lined up with new Frangipani trees and some open spaces. The lighting from

above would help good visibility in a wide area. In Zone B the residential area on the hill, which is a significant sector occupied by the palace and the royal park with a row of more than 100-year Frangipani trees along the pathway, a bollard with the same style as the lamp post was developed to link the adjacent zones. Also, the leaves and/or the branch of the trees need to be illuminated to express their aesthetics in each season. Zone C which is the area at the seaside where some mansions are located, a different kind of bollard was designed to give a shadow effect on the ground as this area became popular as a public park for both locals and tourists because of its beautiful scenery.

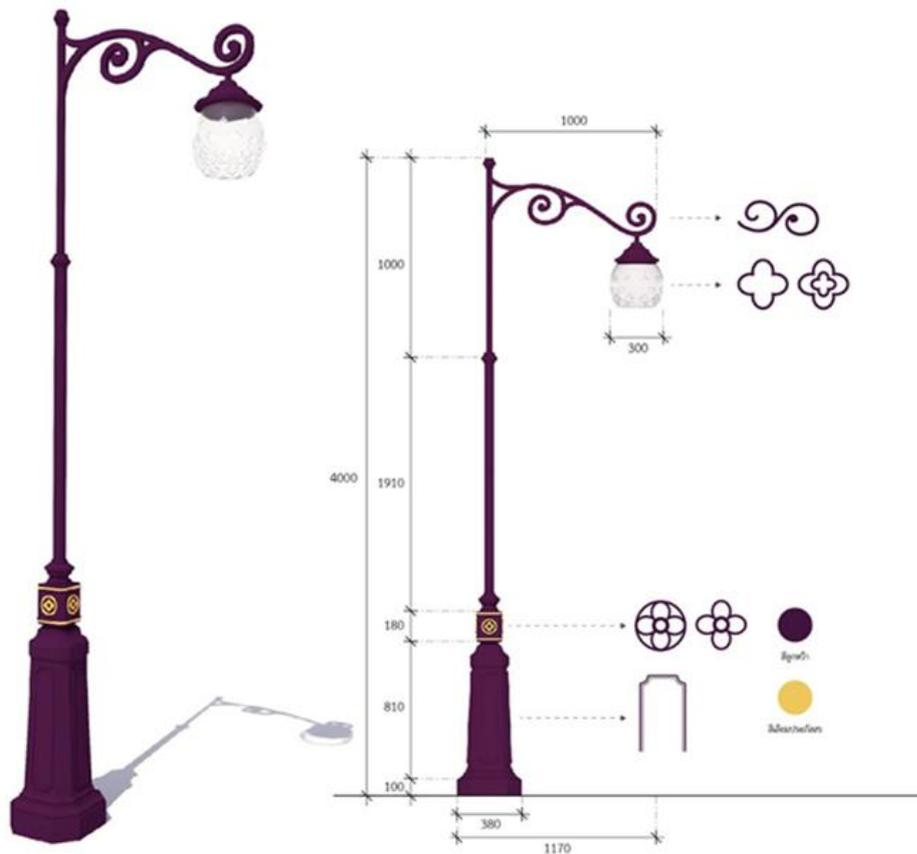
The principles of architectural conservation from several Acts and Charters for Conservation and some related books were reviewed. Therefore, the author decided to design three new luminaires rather than reproduce the old ones as evidences in some photographs.

Not only the luminaires' styles, patterns, colours but also their proportions to one another were to be considered. The selected patterns were inspired by architectural elements of the historic buildings on site while the selected colours were derived from the Thai-colour tone, which is in harmony with the surroundings. However, these luminaires have been developed several times in order to get the best result before the evaluation of their design in terms of styles and architectural conservation by the thirteen experts and the staff of the royal residence. The data from questionnaires are analysed using basic statistics in Table 1.

**Table 01.** Mean of expert opinions in the statements was derived from the conservation basis concerning the luminaire styles of each zone from 5-point Likert Scale

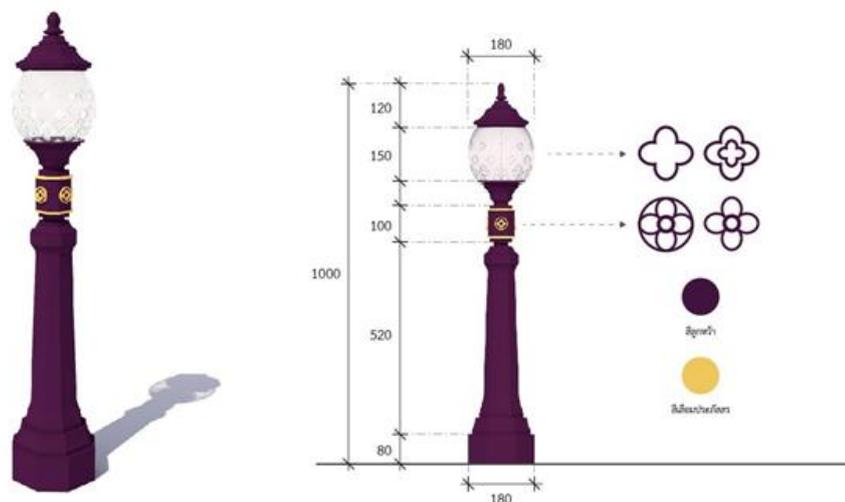
Statements	Luminaire in zone	Daytime		Nighttime	
		Mean	SD	Mean	SD
1) The importance and the value of the historical site and its aesthetics are maintained;	A	3.80	0.68	4.07	0.59
	B	4.00	0.76	4.13	0.83
	C	3.87	0.64	4.13	0.74
2) The difference between the old and the new parts is distinguishable.	A	4.00	0.85	3.93	0.80
	B	4.07	0.80	4.07	0.59
	C	4.27	0.70	4.27	0.80
3) The harmonization of the new parts with the environment, while maintaining the value of the cultural heritage.	A	3.67	0.62	4.13	0.64
	B	3.93	0.80	4.20	0.94
	C	3.80	0.77	4.20	0.68

It is found that the lamp post in Zone A, shown in Figure 4, was more harmonized with the environment at night than it was during the day. At night it could maintain the aesthetics, significance and values of the place more than it could during the daytime. The experts also agree that at night the difference between the old and the new parts are sufficiently distinguishable while they are slightly more different during the day time.



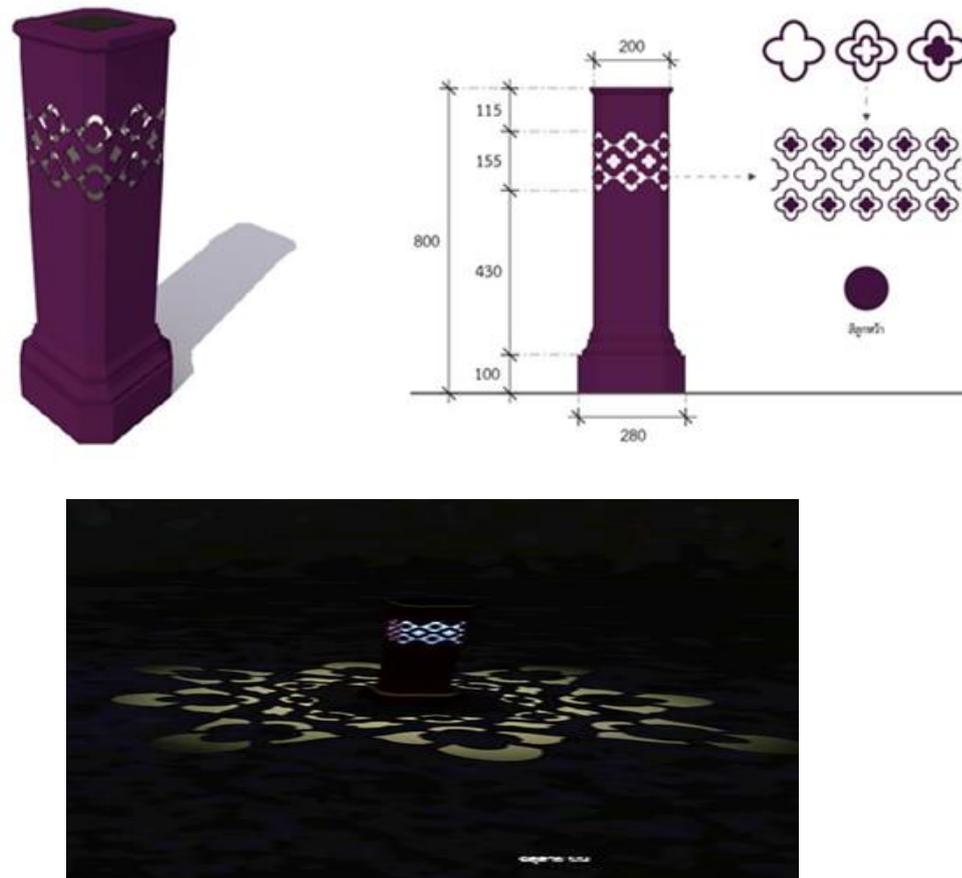
**Figure 04.** The lamp post in zone A

As for the bollard in Zone B, as shown in figure 5, it was more harmonized with the environment at night than it is during the day. At night it could maintain the aesthetic, significance and value of the place slightly more than it could during the daytime. The experts agree that, with the selected bollard, the difference between the old and the new parts in Zone B was sufficiently distinguishable and that it was achieved to the same degree both during the day at night.



**Figure 05.** The bollard in zone B

In Zone C, the bollard with perforated pattern, as shown in figure 6, was more harmonized with the environment at night than it is during the day. At night it could maintain the aesthetic, significance and value of the place slightly more than it could during daytime. The experts agree that with the bollard with perforated pattern, the difference between the old and the new parts was sufficiently distinguishable in Zone C and that it was achieved to the same degree both during the day at night.



**Figure 06.** The perforated bollard in zone C

The additional suggestions from the open-ended questions can be categorized into six issues: 1( the design concept and the importance of the royal residence; 2( the styles, patterns and colors of the luminaires in details both strengths and weaknesses; 3( the lighting distribution and the lighting patterns; 4( the installation of the luminaires; 5( the materials of the luminaires; and 6( the energy consumption.

The installation of the solar power system should consider a suitable location, direction of photovoltaic panels, all related electrical wiring and equipment should be provided for best performance. The author decided to install photovoltaic panels on a service building's roof in Zone C near the seaside as it is an open area. It was planned that the electrical loads—for all the luminaires, CCTV, and videos to be installed on the site—be calculated for landscape lighting and security system on the pathways.

## 7. Conclusion

The study concluded that all of the three luminaire types are compliant with the conservation guidelines, as follows: 1( they can maintain the importance and values of the place; 2( they are satisfactory in terms of distinguishability of the difference between the old and the new parts; and 3( the new parts do not devalue )are in harmony with( the cultural heritage site. However, during the daytime, all three luminaires types are slightly less visually appealing than they are at night. The group of experts also have further comments related to the development of luminaires and suitable materials for their production.

The findings show that the assessment of experts from the field of design and/or conservation ensures that the luminaire design prototypes can be further developed, especially in terms of cultural landscape conservation aspects. Furthermore, additional suggestions gained from the experts help improving the detailed design of the luminaires, such as the luminaires' durability and maintenance, the installation and location of the luminaires in each zone depending on its main function and on design criteria. The most important opinion is that the luminaire prototypes do not compete with the historic environment, and their appearances are clearly new parts. Whereas in zone A which is a less significant zone, the new lamp post luminaire can add more value but does not have any conflict with the site's historical appearance. This method of study can then be applied for similar cases.

There is also a possibility of utilizing the solar energy-operated hybrid system as an alternative energy source. Although the roof area of the service building that the photovoltaic panels was installed is quite small, it can produce electricity almost eight units per day or around 2,500 units per month. This figure shows that the system can save about 10 percent of the electric energy used per month. However, in the future, if the landscape luminaires are fully installed and featured with a security system in the royal residence, the cost of energy may not be decreased but the landscape routes will be well-illuminated and safer.

The designer has to take into consideration both the architectural and landscape lighting, and the part of the overall landscape was shown on as the proposed master plan. When combined with the main routes, the illumination area will be completed. This case study can be a design prototype for other similar cultural landscapes. Furthermore, design patent applications for individual luminaires can be made.

## Acknowledgments

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