Study for the Lighting of Four Medieval Castles in Cyprus

Pafos, Kolossi, Limassol, Larnaka

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Abstract: To design the lighting study for four medieval castles in Cyprus, the impact of natural light on the castles' facades was observed and recorded. It is essential to highlight the architectural features of each castle in isolation by means of the application of differing concepts and methodology. The areas surrounding the castles are an important parameter to take into consideration when focusing on lighting enhancements: artificial light, as well as quantity and color of fixtures can be adjusted on certain days (RGB) of the year according to the schedule of the Department of Antiquities of Cyprus.

***Keywords**: Night Lighting—Monuments—Exhibition rooms—Medieval Castles—3D Design—Cultural Heritage*

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Introduction

This project (VC/2015/0836) was funded by the European Commission DG Employment, Social Affairs and Inclusion Investment EGF, Shared Management Commission and was supervised by the Department of Antiquities of Cyprus[4].

The lighting study was carried out, after tender, by 'EON, Design and Manufacturing of Architectural and High-Quality Lighting Systems' in collaboration with the 'Ergo Culture Human Traces' cooperative.

Within the project's framework, an interim report was submitted in which lighting proposals for the castles were included. Different lighting solutions, as well as their advantages and disadvantages, were presented analytically.

Together with officials from the Department of Antiquities of Cyprus, the project team visited the medieval castles whereupon the proposed solutions were analyzed in situ. During these visits,

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solutions were also discussed as to the interior lighting of the each castle site, given that permanent and temporary exhibitions are often hosted within the castles' interior spaces.

The fundamental parameters of lighting design are: luminance (cd/m^2), illuminance (lux), reflectance on building materials, the color temperature of light, the compatibility of the aesthetics to the nature of the site, a comfortable optics area (reduced glare to enhance visual comfort), the protection of flora and fauna within the castle's surroundings and, finally, dimming control and low energy consumption. Led luminaires have been proposed for the illumination of interior areas as well as for the lighting of exhibition spaces.

Methodology

The principles adhered to regarding the recording and evaluation of the parameters for the photorealistic process of the exterior facades of the castles are as follows:

1) The archaeological data for each castle and its surrounding area.
2) A description of the construction phases of the facades.
3) The environmental context surrounding each monument.
4) The current lighting conditions of the castles, their surrounding area and how each reflect on the overall image of the monument and on the visitors' perception of the monument.
5) Data collection of the color of building materials using mobile equipment and calculation of light reflectance in specific sets for specific building materials.
6) Recording of the impact of natural light on the facades and its alterations during the day through detailed descriptive comparison between shady and illuminated areas.
7) How architectural details are enhanced by means of natural light.
8) Current electricity circuits.
9) Digitalization of the ground plans and each façade separately (as provided in printed form by the Cyprus Department of Antiquities) and design of 3D models, including all the details of each façade.
10) 3D modeling of each facade according to the technical specifications of various luminaires sourced from different companies.
11) Alternative lighting solutions had been proposed until the final one was accepted by the Cyprus Department of Antiquities.
12) Re-design of electricity circuits to provide different operating modes for the luminaires.

The impact and recording of natural light on the facades is essential for the later design of artificial lighting for each castle, because in this way architectural features can be enhanced and highlighted in the way that the medieval architect had originally conceived them.

The Castle of Pafos

The castle of Pafos stands on the ancient mole in the western part of the town's port. Its characteristics today are the result of various modifications throughout its history (Fig. 1). The Frankish rulers of the island built the castle in the middle of the 13th century to replace the Byzantine fort destroyed in the earthquake of 1222 A.D. When the Genoese captured the towers in 1373 A.D. they made certain modifications and also reshaped the moat.

What survives today is the 1780 Ottoman restoration of the western Frankish keep with its Venetian additions. An inscription above the sole entrance of the castle bears witness to this restoration.

On the upper level of the castle there is a battlement indented with twelve crenels, which housed a corresponding number of cannons. The Ottomans removed the cannons in 1878 when they handed over the administration of the island to the British.

From the beginning of British rule the castle was used as a salt store until 1935 when, under the Cypriot Law of Antiquities, the castle was declared an Ancient Monument. Since then, the castle has been restored and is protected by the Department of Antiquities.

Lighting Of Exterior Façades – Photorealistic Study.

Luminance is an important photometric parameter in our calculations, so in order to determine this feature, the lighting of the castle's surroundings and the visitors' viewing distance, as well as the architectural features of the construction need to be analyzed. Reflectance on the materials of each façade will also be taken into account.

In terms of the lighting of the surroundings, the waterfront of Pafos Castle is illuminated by fixtures mounted on poles and fitted with low pressure Na lamps. The visitors' viewing distance to the castle is considered to be somewhat close.

On the main NE façade there is a bridge connecting the waterfront to the castle's main entrance. Sea water surrounds the other two facades from 0.5 m to 1 m in height. Masonry stones are aligned in rows of both larger and smaller blocks. The main color of the stones is brownish on both the rougher and smoother surfaces while the reflectance is estimated at between 20–25 %.

According to our results, luminance and illuminance for each façade is determined as:

North eastern (main) façade: 2 cd/m^{2}and 25lux, RGB (3500 K) floodlights to be installed in the four contoured niches located along the waterfront, to the right and left of the bridge (Fig. 1a, 2):

Fl.b (two floodlights 1820 lm, beam angle 40^o, power consumption 54W)

Fl.c (two floodlights 1820 lm, beam angle 40^o & 20^o, power consumption 54W)

Fl.d (two floodlights 1820 lm, beam angle 20^o & 40^o, power consumption 54W)

Fl.e (two floodlights 1820 lm, beam angle 20^o, power consumption 54W)

North western façade: 1.7 cd/m^2 and 26 lux, three RGB (3500 K) floodlights, 1820 lm, beam angle 40^o and 20^o, power consumption 54W.

Southeastern façade: 1.8 cd/m^2 and 24 lux, two RGB (3500 K) floodlights, 1820 lm, beam angle 60^o and 40^o, power consumption 54W.

Keep. Tower: The installation of four RGB (3500 K) floodlights at each corner of the terrace has been proposed to achieve lighting uniformity and consistency, while linear luminaires will also be installed at the center of the NE façade. We suggest that the lighting of the main tower be of lower intensity than the lighting of the rest of the façades (Fig. 1b, 2).

Specifications: Four RGB (3500 K) floodlights, 1820 lm, beam angle 40° and two linear led luminaires RGB (3500 K), 634 lm, beam angle 60 × 30°.

a b

Fig. 1. Castle of Pafos from the north. Location of floodlights a) Ground plan b) The keep (© Department of Antiquities of Cyprus)

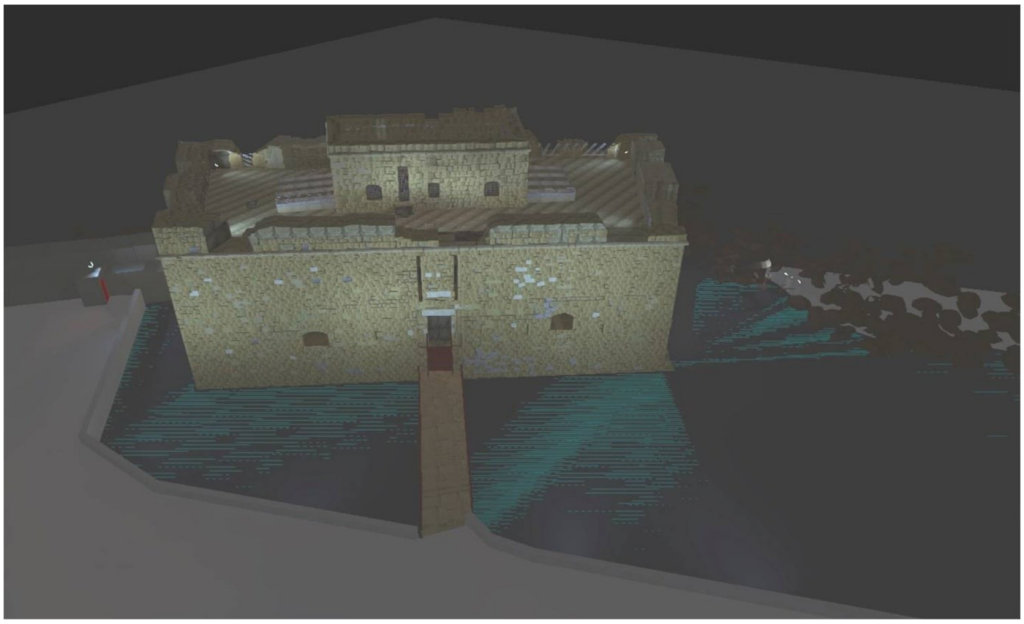

Fig. 2. The Medieva lCastle of Pafos. Main façade and tower, 3D model (© Department of Antiquities of Cyprus)

Interior lighting

Entrance and five halls on the ground floor.

Six floor standing Led luminaires will be placed on the left and right-hand sides of the entrance and the halls. Indicative type LED luminaire with angle beam 40°, 3000 K, 18 W power, 1758 lm, IP67 protection degree, featuring dimmer have been proposed. The luminaire is to be mounted at the top of a 2 m-high pole.

Lighting of the halls on the ground floor.

During winter, storms can generate waves that occasionally reach the skylights, while sea spray can enter the area under the skylights. The opening in the upper part of the frame is covered with a semi-circular cover which abuts with flanges onto the frame to prevent water infiltration.

Two stainless steel frames (channels) can be installed 50 cm below the skylights. Such frames would be rectangular in shape. Twelve Led luminaires of 18 W and 3000 K each are to be placed in each frame. Ten luminaires will be adjusted at a 40° beam angle and two at a 17° beam angle (Fig. 3).

a *b*

Fig. 3. Medieval Castle of Pafos. a) Interior areas under the skylight b) Metallic frame with luminaires under the skylight, schematic display (© Department of Antiquities of Cyprus)

The Castle of Kolossi

The castle of Kolossi is one of the most important extant fortifications of the island's Frankish period and is located at the southern edge of the village of Kolossi, about 11 km west of Limassol (Fig. 4a). The castle was built in 1210 by the Order of St. John of Jerusalem (Knights Hospitaller). In 1306 it briefly came into the possession of the Knights Templar, who were supporters of Amalrique of Tyre, the usurper to the throne. After the abolition of the Knights Templar in 1313, the castle of Kolossi returned to the stewardship of the Knights Hospitaller, but was destroyed during the Mameluke raids in 1525–26. The Great Commander Louis de Magnac built the existing castle upon the ruins of the 13th century castle. Magnac's coat of arms can be seen alongside the emblems of Jerusalem, Cyprus

and Armenia, as well as the old Lusignan coat of arms, carved into the outside of the eastern wall of the castle and on a fresco on the interior wall of the second floor.

Lighting of exterior façades – Photorealistic study

There are similarities between the façades in terms of stone color, roughness, joints and apertures. All the façades were constructed using polished grey stones, except for the upper sections of the western and northern façade, where weathering has turned the color to graphite.

An important architectural feature in the eastern façade is Louis de Magnac's coat of arms along with that of the Kingdom of Cyprus. Five 'murder holes' (meurtrières) are located at the top of the southern façade just above the castle entrance.

a *b*

Fig. 4. a) Medieval castle at Kolossi, view from SE, b) ground plan and location of floodlights (© Department of Antiquities of Cyprus)

The current electricity network can be used and further improved in the new lighting study (Fig. 4b). However, new floodlights will need to be installed closer to the monument to allow for: a) improved visibility and enhancement of the building, b) a selection of floodlights with low energy consumption, c) the protection of flora and fauna.

The illumination of the castle's surroundings, including pathways for visitors, the ruins and the old acacia tree can be enhanced by means of softer lighting options.

Eastern façade: A 3–4 m high wall segment, which probably dates to the castle's initial phases of construction, is located at the eastern edge of the façade. Visitors pass along a pathway, located between the wall and the façade, to the castle's eastern areas (Fig. 4b, 5a), thus limiting the use of floodlights along the pathway. However, a series of linear ground luminaries would provide a solution, illuminating the façade's lower sections as far as the coat of arms. Consequently, supplementary lighting will be needed for the upper sections of the façade, for which we propose the installation

of pole-mounted floodlights at a distance from the façade, to effect both the enhancement of architectural features and to minimize visual impact on visitors.

The average reflection coefficient ≅ 35 %, luminance ≅ 2 cd/m^2, illuminance ≅ 20 lux.

Lighting of the lower section using linear RGB luminaires.

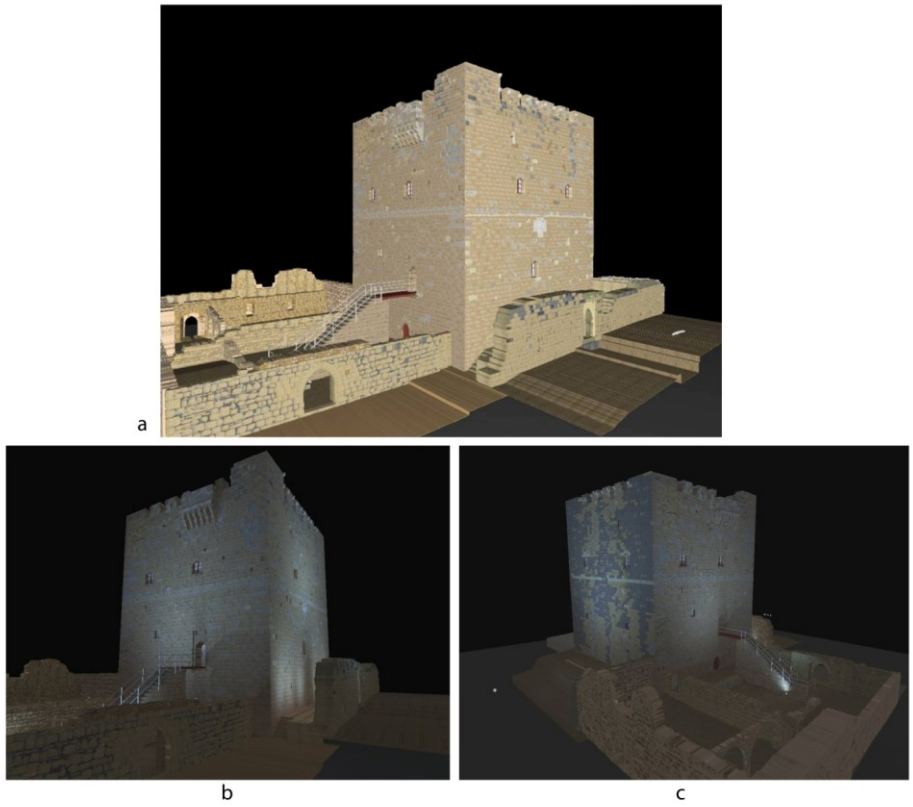

Fig. 5. a) Medieval castle at Kolossi, 3D model, view from SE b) View from SE, photo realistic model, c) View from SW, photo realistic model (© Department of Antiquities of Cyprus)

The eastern façade will be partially illuminated as far as the coat of arms by means of linear luminaires. These luminaires will be fixed with brackets onto metallic bases (ground installation) and can be rotated through their horizontal axes.

To achieve optimal results in lighting distribution and uniformity, remotely controlled luminaires featuring a wide beam angle and dimming capability have been recommended.

3D computer software lighting tests were conducted and luminaires with the following technical specifications have been recommended: five linear with 12 leds, 4000 K, beam angle 12 × 44°, 628 lm.

Lighting of upper section of the façade using RGB floodlights.

The middle section of the façade extending to the battlements will be illuminated by floodlights mounted along a horizontal arm on a 3 m high pole positioned 15 m from the castle. This pole will be erected closer to the surrounding shrubs.

Eastern façade location a: Four RGBW- three floodlights1820 lm at 40° and one 1846 lm at 20° Power consumption 54 W (Fig. 4b, 5b).

Southern façade: Potential location for floodlights: a) on the left and right wing of the entrance landing and b) in the masonry cornices located opposite the façade and which date to the castle's initial phases of construction.

Average reflectance ≅ 35 %, luminance ≅ 2 cd/m^2, illuminance ≅ 20 lux.

The floodlights will be installed on grounded metallic bases to avoid visual interference. Specifically:

Location b: single RGBW floodlight, 1846 lm, beam angle 20°, power consumption 54 W.

Location c: single RGBW floodlight, 1819 lm, beam angle 40°, power consumption 54 W.

Location d and e: two single RGBW floodlights, 1819 lm and 1846 lm respectively, power consumption 54W.

Western façade: The only potential location is the area along the stone enclosure where the existing floodlights are installed. These cannot be installed closer to the monument due to ongoing excavation (Fig. 4b, 5c).

Average reflectance ≅ 25 %, luminance ≅ 1.8 cd/m^2, illuminance ≅ 23 lux.

Location f: Four RGBW floodlights—1819 lm, beam angle 40°, Power consumption 54 W.

Northern façade**:** floodlights will be mounted on a metallic 'Π' shaped frame 10 m from the façade.

Average reflectance ≅ 25 %, luminance ≅ 1.8 cd/m^2, illuminance ≅ 23lux.

Location g: four RGBW floodlights—1819 lm -beam angle 40°-Power consumption 54 W.

Lighting of the interior halls

To light the interior of the castle, floor standing luminaries have been recommended (base, square sectioned pole, led lamp, 2 m high). Three luminaries are to be installed in each hall, apart from the ground floor, where a single luminaire in each hall will suffice. The floor standing luminaries are to remain switched on until later in the day. Given the fact that the night lighting will gradually decrease in intensity towards the upper sections and battlements, the visitor will be able to see the illuminated windows in addition to the illuminated façades. These luminaries can be switched off using a timer. Indicative type LED luminaries with wide beam angle 40°, 3000 K, 18 W, 1758 lm, IP67 protection degree.

LIGHTING OF pathways and surrounding area

Despite ample illumination of the castle façades, their reflective capability will not be sufficient to illuminate the surrounding area. Furthermore, the ongoing archaeological excavation area must be illuminated for health and safety reasons when the monument is open to the public at night. For this reason, our lighting solutions will provide an adequate lighting environment for visitors without having a negative impact on the overall lighting of the castle (Fig. 4b). Indicative oval light brass wall turtle with metal wire guard: Socket E27 where Led lamp is affixed, spherical matte color lamp, power 5 W, 3000 K, diffused light without causing glare, installation of constructed niches in walls with dimensions of at least twice the size of each luminaire.

The Castle of Larnaka

According to written sources the castle of Larnaka was built during the reign of King James I (1382–1398). These sources mention that the Castle was constructed to protect the town's harbor, which, after the capture of Famagusta, was used as the island's main port. In its present state of conservation the castle consists of a complex of buildings constructed over different historical periods. The two-storey building on the north side was constructed during the Ottoman occupation, evidenced by its architectural style and a Turkish inscription above the entrance, while the eastern and southern wings date from earlier phases of the castle's construction. The British Administration used the western chamber in the eastern section of the ground floor for the execution of convicts. The gallows, which must have been located in the room, were in use until 1948. Today the Castle houses a small museum consisting of three rooms situated on the upper floor of the main building (Fig. 6a).

Lighting of exterior façades – Photorealistic study

Due to the overlapping construction phases of the castle, each façade features different architectural details.

As a result, the reflection coefficients vary. Very few stones share similar levels of reflectance. Consequently, different coefficients have been calculated for each façade: 31 % for the northern façade, 40 % for the western, 34 % for the southern and 25 % for the eastern.

According to our results, RGB (3500 K) remote control operated luminaires have been suggested.

To estimate luminance levels, the lighting of the castle's surroundings, as well as the visitor viewing distance were considered. The area located opposite the northern and southern façade is illuminated by street lighting luminaires, whereas the area around the western and eastern façade is totally unlit.

The luminance and illuminance for each façade was estimated as:

Northern façade: 1.8 cd/m^{2}and 20 lux.

Western façade: 1.7 cd/m^{2}and 17 lux.

Southern façade: 2 cd/m^2 and 22 lux.

Eastern façade: 2 cd/m^2 and 22 lux in the higher sections and 17 lux in the lower sections.

Northern façade.

Mounted RGB (3500 K) floodlights on poles will be installed at fixed positions along the sidewalk opposite the façade (Fig. 6b). This solution can only be implemented in a specific area from the main entrance up to the northwestern corner, owing to the fact that a section of the sidewalk is located opposite the street junction and the palm-lined patio. The only place where the poles can be installed is in the section of the sidewalk located opposite the entrance extending to the castle's northwestern corner. There is already an installed pole in this section. The floodlights are to be located between 15 m and 23 m from the northern façade.

Technical floodlight specifications: four RGB (3500 K) floodlights, 1820 lm and 1791 lm, power consumption 54W, beam angle three at 20º and one at 40º.

Fig. 6. a) Medieval Castle at Larnaka, view from NE, b) View from SE, photo realistic model (© Department of Antiquities of Cyprus)

Western façade.

Three poles can be installed with three floodlights on each. The poles should not be the same shape as the existing ones on the northern façade and should not be higher than 3.5 m. If the floodlights are installed above 3.5 m, their light beam might enter the interior yard and cause interference for visitors.

Technical floodlight specifications: a total of six RGB (3500 K), two floodlights on each pole, 1820 lm, beam angle 40°, power consumption 54W.

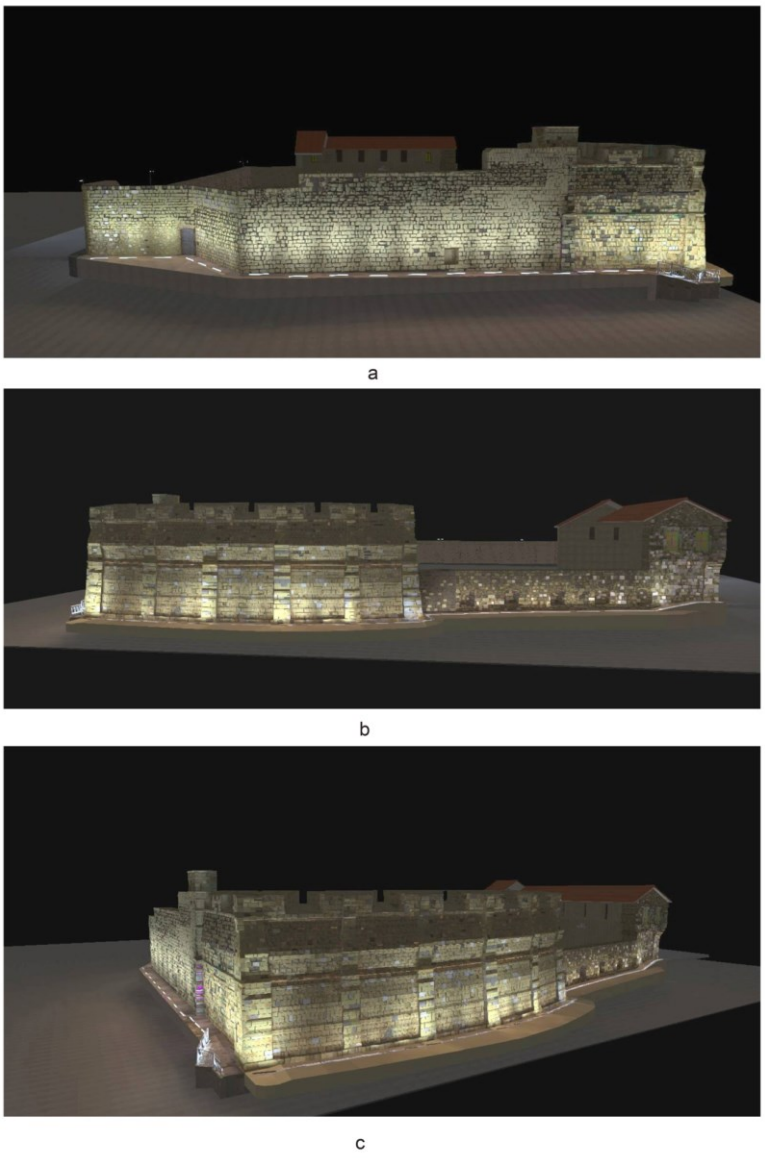

Fig. 7. Medieval Castle at Larnaka, 3D photo realistic model a) View from south, b) View from east, c) View from SE (© Department of Antiquities of Cyprus)

Southern façade.

Installation of linear luminaires for the lighting of the southern façade:

A continuous concrete channel 0.40 m wide and 0.30 m deep will have to be constructed along the façade. The concrete channel should be waterproofed and covered with transparent anti-slip glass (Fig. 7a-c).

If the proposed luminaires are installed on the metal ramp located at the SE corner of the sidewalk, then light will be directed sideways and away from the fortification. The railing could be positioned on the front side of the ramp and the concrete channel could either be constructed horizontally to the edge of the ramp or at the edge of the ramp below the railing.

Total number of asymmetric beam linear luminaries: 19 luminaries of 1230cm, 48leds of 2236 lm, 57W power and three of 930 mm, 36leds, 1677 lm, 44W power, IP67, IK08.

Eastern façade.

A continuous concrete channel 0.40 m wide and 0.30 m deep will need to be constructed along the façade. This concrete channel should be waterproofed and covered by transparent anti-slip glass. In the event of water running along the channel, plastic tubes can be used for drainage. In addition, Φ100 tubes can also be fitted to provide proper ventilation within the channel and prevent condensation on the underside of the glass. A third tube (Φ60) can be also placed in the middle of each concrete channel to improve air circulation.

A small ramp is located at the NE corner of the sidewalk. Luminaires are currently installed in the middle of the ramp. If the same inclination to the luminaries is maintained, (i.e. that of the ramp) then both the fortification and the façade will only be partially illuminated. For this reason, the width of the ramp should be increased to 0.50 m with the concrete channel constructed along its edge on two or three horizontal levels, although the glass cover to the channel can be inclined at the same angle as the ramp.

The linear luminaires on the eastern façade facing the sea are separated into two groups. The first group are those which will illuminate the lower section up to the midpoint of the facade, while the second group are those which will illuminate the upper section, including the buttress (Fig. 7b–c).

Group A.

Three RGBW linear luminaires with asymmetrical beam (length 930cm, 1700 lm) will be installed in the ramp section and twelve asymmetrical beams (length630cm, 1100 lm) will be installed between the end of the ramp and the end of the section.

Group B.

RGBW linear luminaires with asymmetrical beam have been suggested. One (length 1250cm, 2250 lm) will be installed in front of each of the six buttresses and two (length 930cm, 700 lm) along the space formed between the buttresses.

It has been also recommended that the luminaires should feature dimming control and that they should be able to be rotated relative to their longitudinal axes.

The Castle of Limassol

The medieval castle is located near the old harbor in the historical center of the city and houses the Medieval Collection of Cyprus Museum.

Archaeological research has revealed that the castle was built over an Early Christian basilica and a Middle Byzantine structure. Other finds beneath the Castle bear witness to the existence of an important church, possibly the city's first cathedral. According to Etienne Lusignan, the original castle was erected by Guy de Lusignian in 1193.

From the 1950s the castle of Limassol was ceded to the Department of Antiquities and used as the District Museum (Fig. 8).

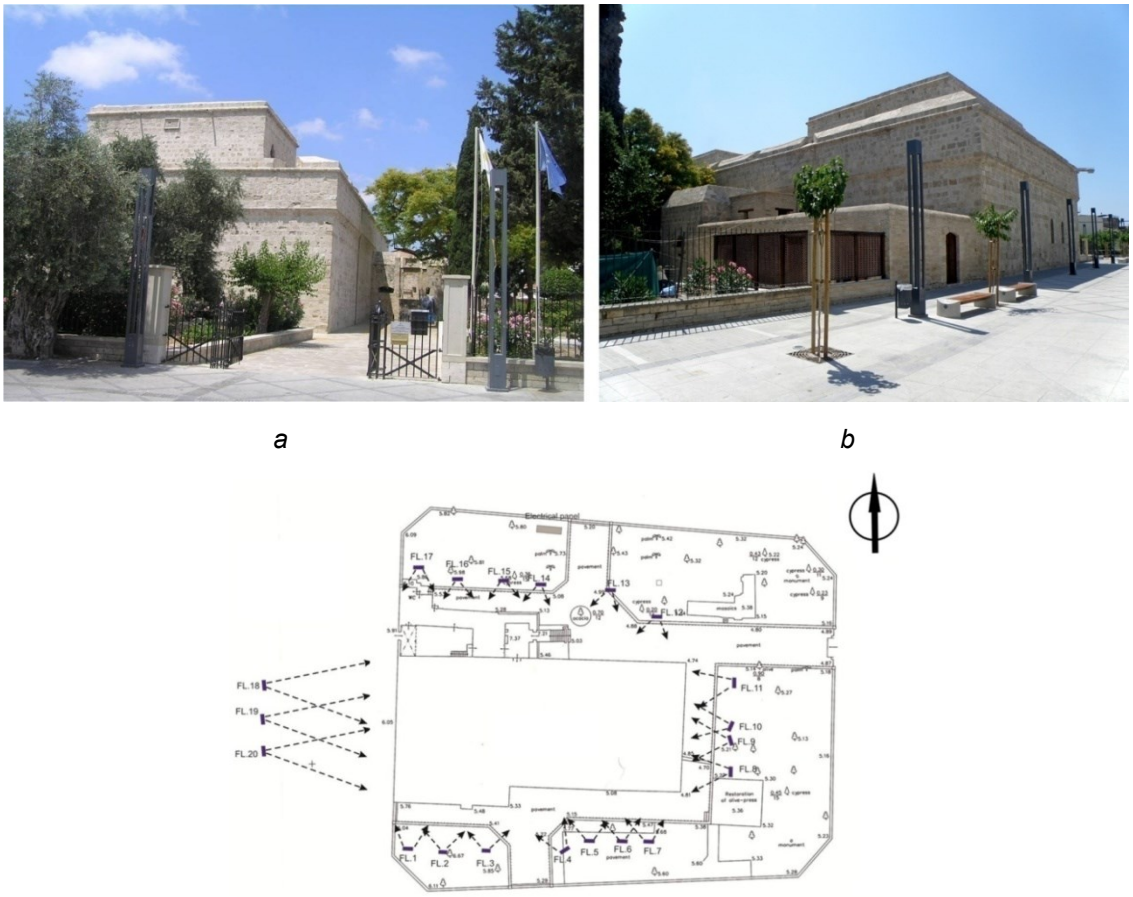

Fig. 8. Medieval Castle of Limassol, a) View from east, b) View from NW c) Ground plan, position of floodlights (© Department of Antiquities of Cyprus)

LIGHTING DISTRIBUTION, PHOTOREALISTIC STUDY.

To estimate the luminance, the lighting of the castle's surrounding area as well as the visitor viewing distance was considered and measured. The surrounding area is heavily illuminated. The visitor viewing distance is considered to be somewhat close.

Luminance and illuminance for each façade is as follows:

Eastern façade: Average reflectance 35 %, luminance 1.8 cd/m^2, illuminance 20lux.

Southern façade: Average reflectance 35 %, luminance 1.8 cd/m^2, illuminance 20lux.

Northern façade: Average reflectance 35 %, luminance 1.8 cd/m^2, illuminance 20lux.

Western façade: Average reflectance 35 %, luminance 1.8 cd/m^2, illuminance 20lux.

Eastern façade.

RGBW floodlights will be installed 8 m away from the eastern façade (Fig. 8):

- Three floodlights 1791 lm, beam angle 60^o, power consumption 54W.
- One floodlight1819 lm, beam angle 40^o, power consumption 54W.

Southern façade.

RGBW floodlights will be installed 8 m away from the southern façade:

- Seven RGBW, 1791 lm, beam angle 60º, power consumption 54W.

Western façade.

On the western façade, the existing luminaires around the pedestrian zone should be removed (especially the three that are closest to the façade). The western façade can be illuminated by means of monochromatic floodlights installed in the upper section of the 'Charoupomilos' building located opposite the façade.

- Three RGBW floodlights, 2141 lm, beam angle 21º, power consumption 50W.

Northern façade.

The northern façade is not a unified surface. Stone stairs leading up to the entrance as well as the entrance area, the ticket office and the utility room/public conveniences are all located in the middle of the façade. Under night lighting, these buildings cast shadows on the façade and, as a result, distort its architectural features. Therefore (Fig. 9):

a) lighting of the section between the NE corner and the entrance will require RGBW(4000 K) floodlights (positioned 8 m from the façade); b) installation of linear RGBW luminaires on the ticket office terrace to illuminate the section above the ticket office; c) installation of two floor standing monochromatic light led luminaires to the left and right of the entrance; d) installation of two linear RGBW luminaires on the wall behind the public convenience (the wall along the length of the utility room), e) lighting of the buildings (stairs, entrance area, utility area, public convenience) using low intensity RGBW floodlights installed close to the existing floodlights' positions.

NE section and buildings.

RGBW floodlights can be installed in the current floodlights' positions as required:

Five floodlights,1791 lm, beam angle 60º, power consumption 53W and one floodlight 1819 lm, beam angle 40°,power consumption 54W.

Section above the buildings.

Very small linear luminaires would have to be used due to limited space. The luminaires are to be fixed on bases and can be rotated on their horizontal axes. The following luminaires have been proposed in the study, taking into consideration the limitations noted above:

Two Led RGBW (432cm) to be installed on the ticket office roof and two along the utility room wall (behind the ticket office). Type of luminaires: linear with 12Leds, beam angle 12X44°, 628 lm, power consumption 17W.

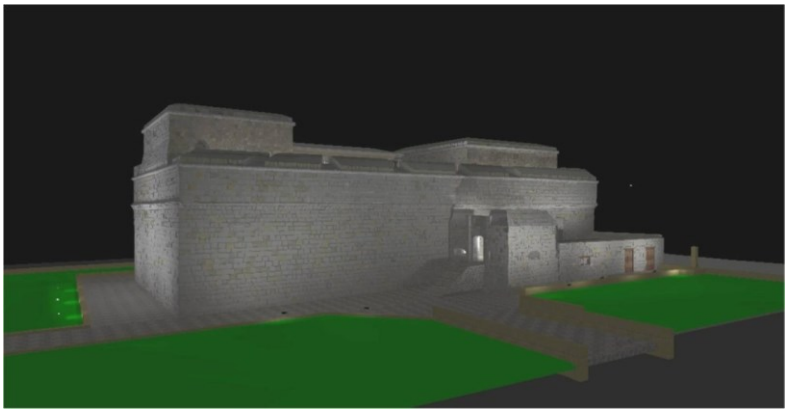

Fig. 9. Medieval Castle at Limassol. 3D photo realistic model, view from north (© Department of Antiquities of Cyprus)

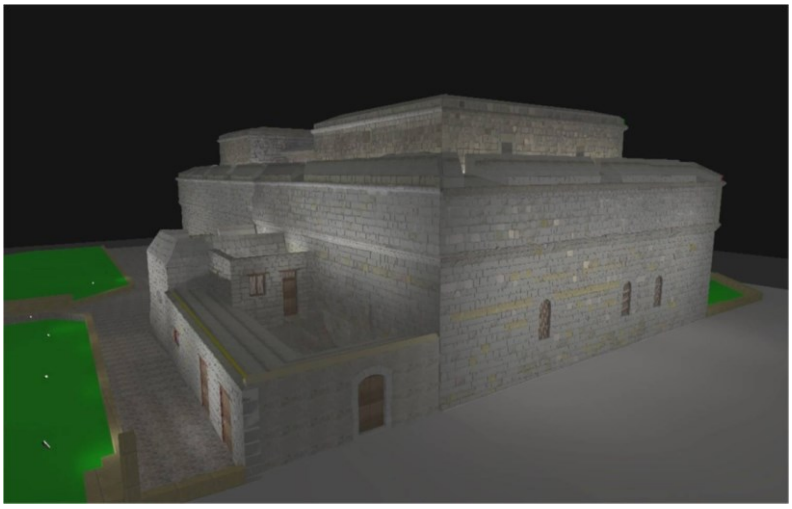

Fig. 10. Medieval Castle at Limassol. 3D photo realistic model, view from NW (© Department of Antiquities of Cyprus)

Lighting of the terrace

Lighting of the towers and battlements.

Both of the tower's façades and the terrace will be illuminated using linear monochromatic luminaires 3000 K (Fig. 9, 10). These luminaires are to be installed in the base of the skylight (northern and southern side) and around the corner between the terrace floor and the parapet. The luminaires are to be fixed on 20cm-high metallic bases and will feature a pivotal arm support on their horizontal axis. Power cables are to be fitted within protective tubing fixed to the corners of the terrace.

a. Northern and southern sides, along the skylight

Four linear luminaires with 48leds, 3000 K, 3425 lm, beam angle 32°, power consumption 52W.

b. Circumferentially at the corners of the towers and the battlements. Eighteen linear luminaires with 12Leds, 3000 K, 56 lm, beam angle 32º, power consumption 15W.

Lighting of rooms and interior halls

a. Lighting of the interior section of the entrance.

Currently, the interior section of the entrance is illuminated by means of a wheel-shaped fixture featuring mignon type lamps. The lighting of the area can be improved with the installation of a square

metallic frame. The frame is 1 × 1 and can be mounted on the ceiling a wire rope and pulley system for easy maintenance. To light the hall, rail spot led luminaires can be used. These luminaires will feature barn door framing and dimmers and a light color of 4000 K neutral white. Both the frames and the luminaires will be colored matte grey. Eight luminaires will be installed, three with narrow beam (12º) and five with medium beam (25º).

b. Lighting of the large western hall**.**

There are museum exhibits both inside and outside the showcases in this hall. The existing luminaires are mounted on masonry and feature energy saving fluorescent lamps. This solution causes serious glare issues.

We have suggested that all fluorescent lamps should be removed while three 3000 K floor standing led luminaires should be installed on 2 m poles in the corners of the hall.

Description: small led floodlights with medium beam angle 30°, 3000 K, power consumption 50W-3960 lm, protection degree IP67. Antiglare mask to be fitted on the luminaires, which will also feature pivotal arm supports on their horizontal and vertical axes.

Supplementary notes and Conclusion.

The project for the night lighting of four medieval castles in Cyprus was an initiative of the Cyprus Department of Antiquities and was funded by the European Commission. The design of the final proposal was shaped after several meetings and field visits with officials of the Department of Antiquities and after full evaluation of all the parameters of the study. Upon completion of the first phase of the project, a meeting between the relevant parties was held, during which all possible night lighting solutions were examined and analyzed in line with international standards on illumination. Afterwards, the interim report was submitted and upon the project's completion the final proposals were presented to officials of the ministries and municipalities concerned during a public presentation in Nicosia. The current paper was based on the final report which was accepted and approved by European Commission and the Cyprus Department of Antiquities. The framework of the paper's publication focused on the analysis and description of all the elements concerned with the topic of the lighting of the sites, and any problems which arose therefrom, on the final presentation of photo technical results and the 3D models, in order to provide a clear picture of the results.

In conclusion the dynamic of the lighting proposal is focused on the following factors:

a) since archaeological museums are housed within the castles, the possibility of multiple remote controlled lighting choices depending on the theme of events planned by the Cyprus Department of Antiquities,

b) option for dimming control depending on the time of day and time of year,

c) new underground electrical installations and electrical wiring,

d) the final lighting proposal was based on the latest technology in contemporary luminaires and their accessible operation manuals,

e) easy and low cost maintenance of luminaires. The innovation in the current lighting study relies on the fact that the architectural features of the medieval castles are not distorted by artificial, a

common issue when night lighting solutions are applied to such historical sites. The visitor, who is the final end user and judge of the results, is presented with an almost identical image of the monument during the night as they are during the day.

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