Artistic and Architectural Lighting of the Building of the Faculty of Electrical Engineering of Technical University of Sofia, Bulgaria

Iva Petrinska, Dilyan Ivanov
Faculty of Electrical Engineering
Technical University of Sofia
Sofia, Bulgaria
ipetrinska@tu-sofia.bg, dilyanivanov@tu-sofia.bg

***Abstract*—The paper presents the architectural and artistic concept for the lighting of the faculty of Electrical engineering of the Technical University of Sofia – Bulgaria. Except for the simulation model of the architectural lighting of the building, a lot of experiments and preconditions are made. All the surfaces of the building are experimentally tested and their reflective properties are obtained. Test flood lights are chosen according to the reflectance of the surfaces and their color characteristics are experimentally tested. Based on these experimental results, on site experiments are also made and after that the whole idea of the architectural lighting of the twelfth educational building of TU Sofia is simulated. The simulation gives an idea very close to the night look of the building (if the concept is accepted and realized), based on the real characteristics of surfaces and luminaires.**

Keywords—artistic and architectural lighting, reflectance characteristics of surfaces, luminaires color characteristics, feasibility study for artistic lighting

I. INTRODUCTION

The In order to see, people need light and this rule leads to the conclusion that lighting can be estimated based on the viewing conditions that it can assure. Lighting that enhances the luminous contrast of the objects allows correct recognition of small objects and lays the foundation of a lot of standards and recommendations for lighting. The observation of the environment however shows significant variety of ways in which objects can be observed according to their vision [1].

With respect to the fast emergence and improvement of LEDs as light sources and their great flexibility, the entire conception of electrical lighting changes. The LEDs are extremely attractive in the field of architectural and artistic lighting, because of the many advantages that they have as light sources – they are compact, may come in luminaires and lines with different shapes and sizes, electrical power and lighting characteristics. Besides that, the light generation principle of the LEDs itself leads to the opportunity to obtain different color of the emitted light and create attractive night vision of architectural objects and engineering constructions [2].

The aim of the architectural lighting is to ensure recognition of the surfaces of the illuminated objects, simultaneously forming their consistent and complete night vision. Every object, part of the perceived environment is associated with its inherent attributes, some of which are critical for its recognition and other influence the estimation of its properties. The lighting specialists are responsible not only to choose light that make objects visible, but to enhance them in an attractive way. In order to achieve good architectural lighting, attention should be payed not only to the light sources used, but also to the materials used for the different surfaces and their interaction with light. The reflectance and color of the architectural elements are of great importance. Using optimal combination of light spectrum of the source of light and reflective and color characteristics of the surfaces of the architectural elements (in terms of interaction of light and matter) will lead to best lighting results. Based on the effects obtained, the best night vision of the objects becomes reality.

II. PRECONDITIONS FOR PROPER ARCHITECTURAL LIGHTING

A. Necessity of experimental measurements preceding the architectural lighting design process

The object of the current publication is the twelfth educational block of the Technical University of Sofia. In order to design its architectural and artistic lighting properly, some preliminary experiments should be carried out.

The reflective properties of the materials, used for the façade of the building should be investigated in order to obtain their real reflection indices and bidirectional reflectance distribution function (BRDF) [3]. The reflective properties of a surface depend on the angles under which it is illuminated and viewed. Having the BRDF of a surface can help the designers decide the optimal angle at which the luminaire is targeted to it.

Besides the reflective properties of a surface in order to achieve harmonic night vision of an architectural object, the spectral radiation of different LED luminaires should be investigated and experimentally measured. The BDRF itself depends on the spectrum of the emission of the light source and the special orientation of the surface. It is necessary to investigate the color characteristics of the chosen luminaire by means of its particular color rendering indices as well as the color characteristics of the surfaces by means of their color coordinates, thus ensuring the best color match of source and object and enhancement of the night vision of the object.

978-1-7281-2098-0/19/$31.00 ©2019 IEEE

Fig. 1 Façade of the 12th educational block of the TU - Sofia

After that the architectural plan and the façade type should be obtained. A very important stage in the architectural lighting design is the making of high definition night and daytime pictures of the building. The fourth stage is investigation of the possibilities for electrical power supply of the lighting installation. The most important stage of the architectural lighting design is the artistic concept of the lighting. After all the above mentioned design stages are realized, the following steps are taken: choice of lighting parameters that have to be achieved; decision of the position of the luminaires and their direction; choice of light sources and projectors; lighting calculations; visualization of the design.

In order to carry out all the necessary measurements needed before the design itself, three different measuring devices are used. In order to measure the color coordinates of the surfaces and constructive materials of the building, colorStriker measuring device is used. It uses contactless measuring procedure and immediate results. The second device used is for estimation of the light spectrum of the luminaires under consideration as well as its correlated color temperature and color rendering index (The Color Rendering Index (CRI) is a widely used metric to describe color accuracy and fidelity. It is calculated as an average score on 8 color samples (called TCS or test color samples), with an additional 7 supplemental color samples for the extended CRI (e) metric). This device is MK350S LED Meter. It is an especially designed device for measurement of LED light sources. The third and most complicated device is Gonioreflectometer, used for measurement of BRDF [5]. Because of the great volume of the experimental data needed for the design of architectural lighting of the Faculty of Electrical Engineering.

III. Architectural Lighting of the Building of the Faculty of Electrical Engineering – TU Sofia

The reflective characteristics of the different surfaces, that are available on the façade of the building of the faculty of electrical engineering – TU sofia have been measured and the experimental data has been analysed. Based on this information flood lights and LED stripe have been chosen fotr the architectural lighting of the building

A. Spectrum and color coordinates of the light, emmitted by the chosen flood lights.

The spectrum and the color coordinates of the light emitted by the chosen flood lights are given on figures 2 to 6.

The colonnade in front of the building is highlighted by twelve flood lights with green light – Figure 2

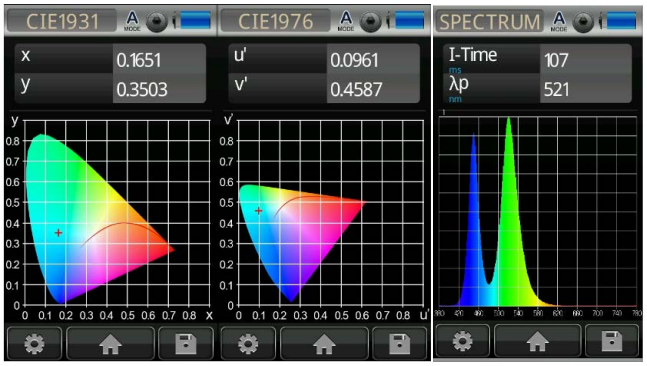

Fig. 2 Spectrum and color coordinates of the green projectors used for the colonnade

The vertical outer edges of the building are green-blue and have been highlighted with eight flood lights, which color coordinates and spectrum are shown on fig. 3.

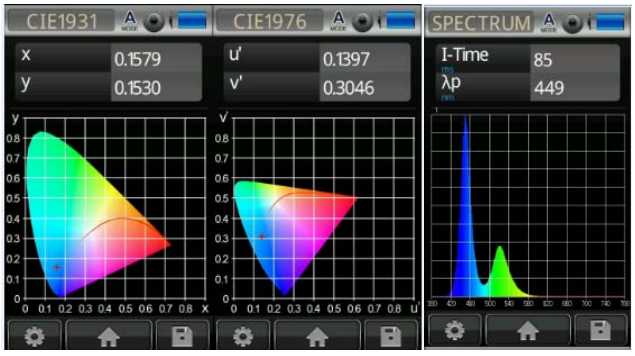

Fig. 3 Spectrum and color coordinates of the projectors used to highlight the vertical outer edges of the building

According to the artistic idea on the right side of the building, the flag of Bulgaria is designed with light. For the purpose eight white flood lights (with spectrum and color coordinates shown on fig 4), eight green (with spectrum and color coordinates shown on fig 5) and eight red (with spectrum and color coordinates shown on fig 6) flood lights are used

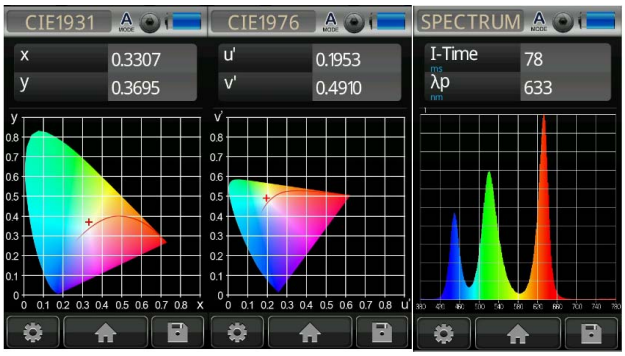

Fig. 4 Spectrum and color coordinates of the flood lights used for the "white" of the Bulgarian flag

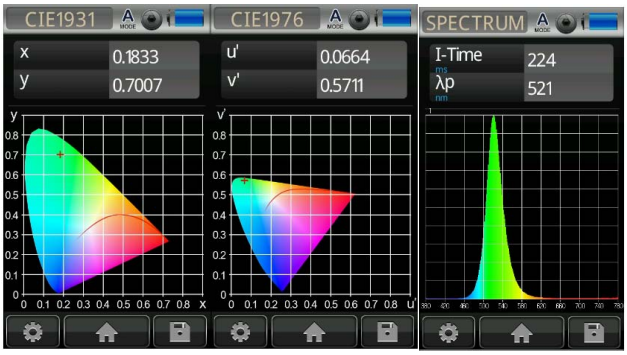

Fig. 5 Spectrum and color coordinates of the flood lights used for the "green" of the Bulgarian flag

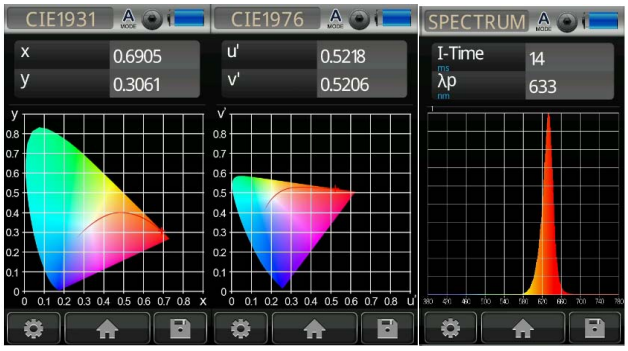

Fig. 6 Spectrum and color coordinates of the flood lights used for the "red" of the Bulgarian flag

In order to highlight the transparent dome at the entrance and the garden in front of the building three projectors are used with spectrum and color coordinates given on fig. 7.

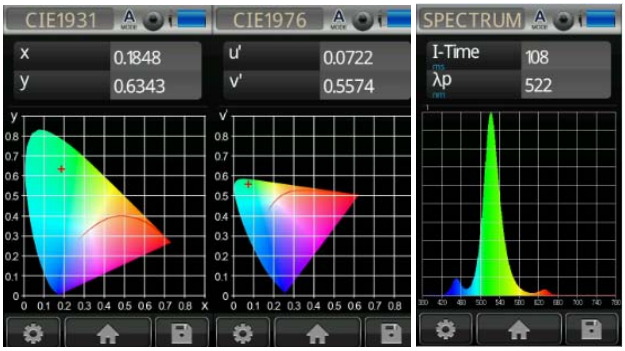

Fig. 7 Spectrum and color coordinates of the flood lights used for the dome and the garden

The horizontal edges and the inner edges are highlighted by means of LED stripes with white light.

B. Simulation results and variations of the façade lighting of the building of the faculty of electrical engineering

The specific architectural elements of the twelfth educational building that have to be highlighted are the colonnade and the transparent dome at the entrance of the building as well as the sign "Technical University, Faculty of Electrical Engineering". Because the building is large with a lot of bends, its contours should be highlighted. In order to choose the best lighting design, several scenarios are simulated and compared. The chosen ones are shown on figures 8 to 16 and figures 11 to 16 actually differ only by the tone of the light – fig. 10, 12, 14 and 16a are with cool light, while figures 11, 13, 15, 16b are with warm light.

Fig. 8 Simulation results for the entrance of the building

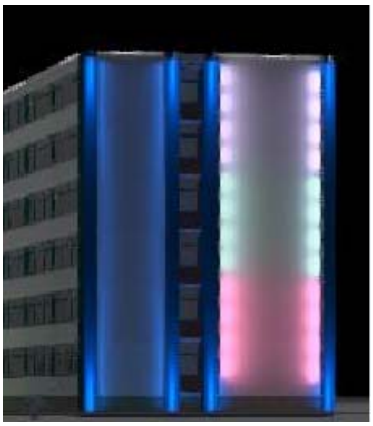

Fig. 9 Simulation results for the Bulgarian flag on the right side of the building

Fig. 10 Simulation results for the night vision of the entire building of the faculty of Electrical Engineering – cool tone

Fig. 11 Simulation results for the night vision of the entire building of the faculty of Electrical Engineering – warm tone

Fig. 12 Simulation results for the side view of the building – cool tone

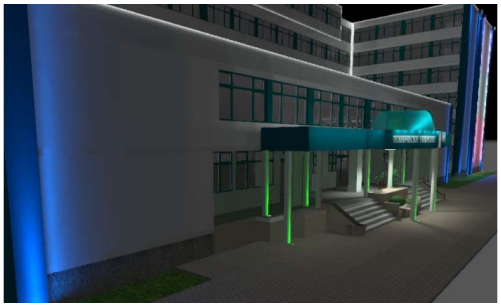

Fig. 13 Simulation results for the side view of the building – warm tone

Fig. 14 Simulation results for the frontal facade of the building – cool tone

Fig. 15 Simulation results for the frontal facade of the building – cool tone

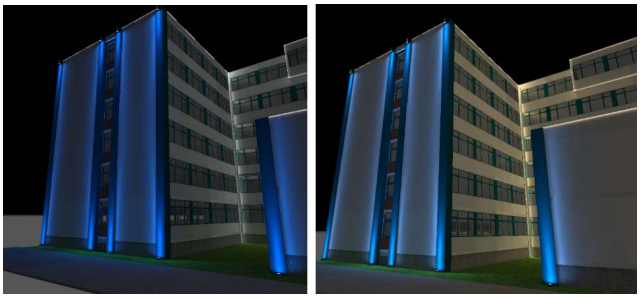

Fig. 16 Simulation results for the left side of the building – a) cool tone; b) warm tone

It is obvious that the warm tone simulations are artistically better than those with the cool tone.

IV. Analysis of the Results and Conclusions

The twelfth educational block of the Technical university of Sofia has an interesting architectural construction and specific elements that allow remarkable architectural and artistic lighting decisions to be realized. In its construction there are metrical elements – colonnades, convex elements, specific glass dome, semi-arc visor with a sign at the entrance and a lot of bends. The aim of the architectural lighting in this specific case is to make the building night vision pleasant and attractive and to create the feeling of coziness and respect in students and workers..

Acknowledgment

The current publication is dedicated to our Teacher and Professor Nikolay Vassilev (In Memoriam).

The paper presents the results from investigation and design carried out according to the program of scientific contract number 191ХТД0002-01, Technical University - Sofia.

References

[1] CIE 094-1993 “Guide to floodlighting”, ISBN: 978 3 900734 31 2, 1993.

[2] N. Krause, P. Bodrogi, and T.Q. Khanh, “Lichtspektren und Farben”, Licht, vol.5, pp.25-30, 2012.

[3] D. Biliouris, W.Vertstraeten, P. Dutre, and J. van Aardt, “A compact laboratory spectro-goniometer (CLabSpeg) to assess the BRDF of materials. Presentation, calibration and Implementation of Fagus sylvatica L. Leaves”, Sensors 2007, vol.7, pp.1846-1870, 2007.

[4] N. Vassilev, and I. Vassileva, Architectural, artistic and advertising lighting, Book, ABC Technika Publishing House, ISBN 954-8873-68, 2007.

[5] I. Petrinska, “Estimation of the reflectance properties of real materials used for buildings’ facades, Proceedings of the Technical University-Sofia, vol.66, book 3, pp. 223-229, 2016.