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ScienceDirect

Procedia Engineering 170 (2017) 226 – 233

Procedia Engineering

www.elsevier.com/locate/procedia

Engineering Physics International Conference, EPIC 2016

Photometric and colorimetric measurements of luminaires using goniometer and spectrophotometer in a dark chamber

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Abstract

This article reports the actual performance of a newly-renovated dark chamber in the Engineering Physics Program, Institut Teknologi Bandung, by measuring the photometric and colorimetric characteristics of a high-bay and a street luminaire. Both luminaires had light-emitting diodes (LED) as their light sources. The dark chamber has dimensions of 11.8 m × 5.8 m × 3.5 m; its interior surfaces are painted matte black or covered with black fabric curtains. Using the installed goniometer at a fixed distance of 10 m, the photometric characteristic of the luminaires could be accurately measured at approximately 15 minutes per luminaire. The measurements were conducted for four *C*-planes and γ-angles ranging from –90° to 90° at 1° resolution. Using a portable spectrophotometer at distances of 10, 8, 7, 6, and 4 m, the colorimetric characteristic of the luminaires, including correlated colour temperature, peak wavelength, colour rendering index, and standard deviation colour matching, could be accurately measured. Variation of distance has a very small influence (coefficient of variance < 2%) on the colorimetric results of the high-bay luminaire; however, it has some influence on those of the street luminaire. Since the tested street luminaire had asymmetrical luminous distribution, it is therefore recommended to conduct the colorimetric measurement at smaller distances of less than 6 m.

Peer-review under responsibility of the organizing committee of the Engineering Physics International Conference 2016

Keywords: photometry; colorimetry; dark chamber; goniometer; spectrophotometer

1. Introduction

Performance characteristics of a luminaire are one of the specifications that have to be tested and evaluated before the product being launched to the commercial market. These characteristics in general consist of photometric and colorimetric performance, which should be objectively measured according to internationally recognised standard, e.g. the IES LM-79-08 [1]. Photometric characteristics are described in terms of, among others, luminous intensity values and distribution, and light output or total luminous flux of the luminaire; while colorimetric characteristics are described in various parameters such as correlated colour temperature, peak wavelength, dominant wavelength, colour rendering index, red-green-blue ratio, and standard deviation colour matching. A certain luminaire normally has a certain luminous intensity distribution, which largely depends on the geometrical shape of the armature and its optical properties. Meanwhile, the choice of lamps largely affects the light output or total luminous flux of the luminaire and its colorimetric characteristics.

To perform such measurements, a dark chamber, i.e. a room with near-zero interior reflectance, is commonly used, with a goniometer and spectrophotometer as the main instruments. In Indonesia, these facilities are available only in a few institutions, mostly research laboratories or institutes. Meanwhile, demands for lamps and luminaires are constantly increasing, particularly after the establishment of ASEAN Economic Community in 2015 [2]. In higher education institution or university level, a dark chamber facility is available in the Engineering Physics Program, Faculty of Industrial Technology, Institut Teknologi Bandung, Indonesia. The chamber has undergone a major renovation in 2015, and since that has been housing a goniometer system for

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Peer-review under responsibility of the organizing committee of the Engineering Physics International Conference 2016
doi:10.1016/j.proeng.2017.03.054

photometric measurement. This article reports the actual performance of this newly-renovated dark chamber, by taking two luminaire samples which are described in Section 2. The measurement methods are described in Section 3. The results are given and are discussed in Section 4, whereas Section 5 concludes the article.

2. Object of the study

This article reports the actual performance of a newly-renovated dark chamber in the Engineering Physics Program, Faculty of Industrial Technology, Institut Teknologi Bandung, by measuring the photometric and colorimetric characteristics of two luminaires. The dark chamber has a rectangular shape with dimensions of 11.8 m × 5.8 m × 3.5 m, as illustrated in Fig. 1. The interior floor, ceiling, and part of the wall surfaces are painted matte black. Interior glazing of the chamber's windows (on the short side of the chamber) are covered with matte black sticker, and are enclosed with black fabric curtains. The partition wall on the west side of the chamber is also enclosed with black fabric curtains. The chamber houses a goniometer system dedicated for photometric measurement, which was installed in fixed positions. The main feature is a rotating table that holds the tested luminaire sample (maximum weight: 50 kg), at a distance of exactly 10 m from a dedicated photometer sensor, which in turn send the reading to the data acquisition system. The data acquisition system itself control the switching and the entire movement of the rotating table, performed with a dedicated software installed in a personal computer connected to it. The reading, post-processing, and reporting of the obtained data are also performed with the software.

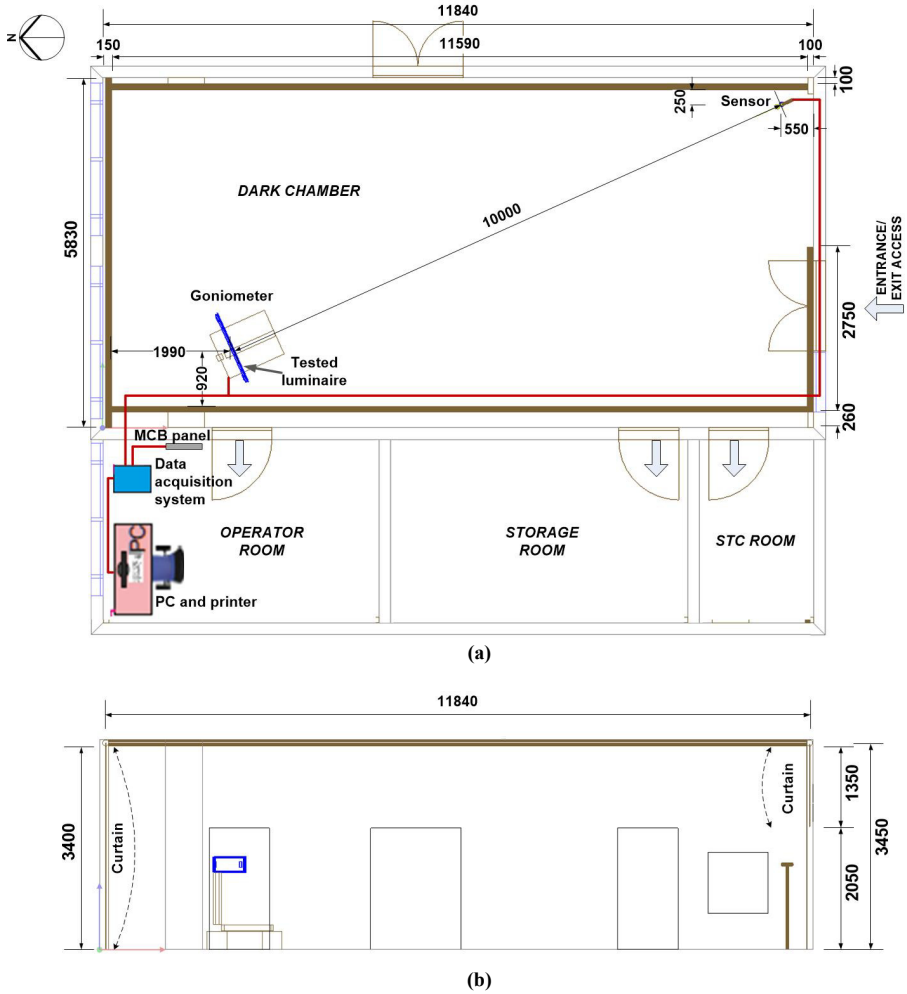

Fig. 1. (a) Floor plan and (b) section plan of the dark chamber