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Visual comfort assessment using high dynamic range images under daylight condition in the Main Library Building of Institut Teknologi Bandung

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Abstract

The use of daylight in buildings should consider the aspect of visual comfort, since productivity of building occupants is affected by visual comfort. This research focuses on studying visual comfort under daylight condition in a reading hall of the Main Library Building of Institut Teknologi Bandung. An assessment was conducted with measuring daylight physical variables and glare indices and comparing the results with earlier experiments on daylighting visual comfort. Data were collected with applying High Dynamic Range (HDR) image technique, which concept is to combine various exposures of photograph images to obtain an image that has accurate and sufficient information of scene luminance. The HDR images were employed as input for *Evalglare* software to obtain luminance value from each pixel of the image. The obtained value was then used to calculate the daylight physical variables and glare indices, such as Daylight Glare Probability (DGP) and Daylight Glare Index (DGI).

There were 81 measuring points on this assessment, each representing a sitting point of the occupants. Based on criteria proposed by Wienold, the daylighting glare situation the reading hall can be categorised into the comfortable range, since all obtained DGP values were under 0.35, which is the upper threshold of imperceptible range. Meanwhile, based on comparison of measured data to result of research by Hirning et al., it is found that based on DGP, there are 27 points (33%) categorised into comfortable range and 14 points (17%) into uncomfortable range. Based on DGI, 4 (5%) and 63 (78%) points are categorised into comfortable and uncomfortable ranges, respectively. Based on mean luminance of the scenes, 5 (6%) and 63 (78%) points fall into comfortable and uncomfortable ranges, respectively. The remaining points of each group of data fall into a neutral area between comfortable and uncomfortable ranges, since their values are between the upper threshold of the former and the lower threshold of the latter.

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Keywords: visual comfort, daylight, glare, high dynamic range image, luminance

1. Introduction

The use of daylight in a room is a common way to save electrical energy in buildings, since it has the potential to reduce the use of artificial lighting that requires electrical energy. However, the implementation of daylighting concept in buildings should always take the aspect of occupants' visual comfort into consideration. Visual comfort is mostly related to the present of discomfort and/or disability glare within the field of view of an observer. Glare is a kind of physical discomfort that arises because of the large amount of light contrast. Even though assessments of glare are often subjective, glare can be quantified by glare indices.

For the specific context of glare from daylighting in buildings, the Daylight Glare Probability (DGP) index was proposed and developed by Wienold and Christoffersen in 2006 [1], and has been widely used and contested by other researchers ever since. In 2013, Hirning et al. [2] conducted a study with 63 occupants who worked under daylight condition in several open-plan office buildings in Australia. The result showed that the average occupants felt visually comfortable when the value of DGP and DGI are respectively 0.21 and 8.8, and felt visually uncomfortable when DGP and DGI are respectively 0.23 and 13.

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In addition, the average of luminance in the work plane and field of view when occupants feel visually comfortable and uncomfortable are respectively 224 cd/m^2 and 329 cd/m^2.

Most studies on visual comfort and/or discomfort glare from daylight are however conducted in developed countries, most particularly Europe, North America, and Australia. These regions are located in high latitudes (north or south), and demographically are dominated by Caucasian population. Meanwhile, most of the world population live in developing countries, which regions are closer to the Equator (i.e. tropics) and have non-Caucasian population. These differences may lead to different environment, physiological, as well as psychological conditions.

It is therefore of general interest, to perform studies on visual comfort from daylight in the tropics, taking Indonesia as a sample. The aim of the study in this article is to assess visual comfort on daylight in the reading hall of the Main Library Building of Institut Teknologi Bandung (ITB), which is described in Section 2. The method used is High Dynamic Range (HDR) image technique, in order to obtain daylight physical variables and visual comfort indicators at the measuring points, which are all described in Section 3. The results are then compared with the experiment results of previous studies conducted, which is discussed in Section 4. Section 5 concludes the article.

2. Object of the Study

This study was conducted at the reading hall on the 3rdfloor of the Main Library Building of ITB, Bandung, Indonesia (Fig. 1). This building was chosen since the northern and southern sides of the building has a reading hall with relatively large glass façades, utilising daylight as the primary light source throughout the day. The building occupants are mostly the Library employees and visitors, mostly students. The building has a main function to support students' activities by providing books, journals, magazines, and other reading materials, to provide common spaces for reading, self-studying, and other academic-related working activities. Additionally, some rooms at the building can be used for various training or seminar activities.

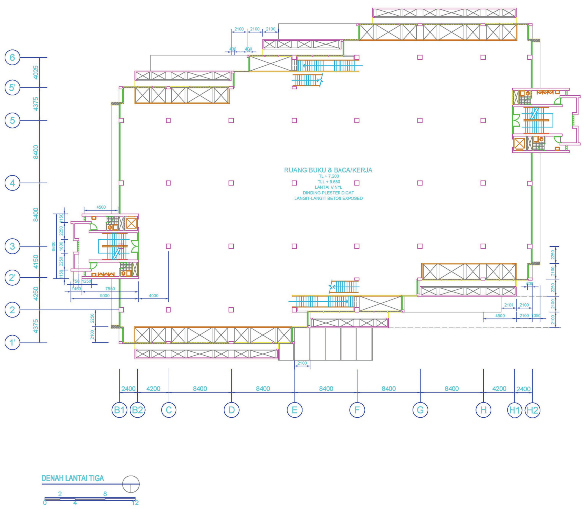

Fig. 1. Floor plan of the reading hall of the Main Library Building of ITB

3. Methods

3.1. Glare Indices

Various studies quantified indoor glare in the room using the concept of glare index. Glare index is a quantitative measure that represents the amount of glare perceived by the observer in the field of view. In general, glare index can be formulated by the following equation:

$$\text{Glare} = \sum_{i=1}^{n} \frac{L_{s,i}^{f}\,\omega_{s,i}}{L_b^{g} P_i^{h}} \tag{1}$$

where $L_{s,i}$ is the luminance of the i-th glare source (cd/m^2), $\omega_{s,i}$ is the solid angle of the i-th glare source (sr), L_b is the luminance of the background (cd/m^2), P_i is the position index of the i-th glare source based on the viewing position of the observer, and f,