Abstract

The sensitivity of the human eye varies with the variation in illumination conditions throughout the visible range. The response for photopic vision is characterized by photopic spectral luminous efficiency function and dominated by cone cells. Conversely, the rods dominate the scotopic spectral luminous efficiency function, which is considered for scotopic vision. For the intermediate zone, both types of photoreceptors participate in vision and are defined as mesopic vision. There is no fixed response characteristics for mesopic vision; rather, the response shifts from the scotopic to the photopic zone with an increase in luminance, and vice versa with a fall in luminance. Mesopic photometry is applied to a variety of outdoor and roadway lighting applications. Considering the mesopic vision in outdoor and lighting design along with the photopic vision can help create a balance between visibility and energy efficiency, ensuring optimal performance in varying light conditions. By incorporating mesopic photometry in outdoor lighting design, designers can better understand how the human eye perceives light in real-world scenarios, leading to more effective and sustainable lighting solutions based on adaptation luminance.

In this work experimental analysis of different lamp performances in mesopic zone for area lighting installations has been performed in both simulation and laboratory environments. The photopic luminance due to a light source is computed from its luminous intensity distribution table. Corresponding mesopic and adaptation luminance values are also computed in the presence of two different surrounding lighting conditions with different spectral compositions. All those parameters are measured again in a laboratory environment for the same lamp combinations.

From both the computed and measured data, it has been found that

the lamps with more blue content in their spectrum i.e. the lamps with higher scotopic/photopic (S/P) ratio provide higher mesopic and adaptation luminance as compared to the corresponding photopic luminance.

The mesopic adaptation luminance is estimated in the presence of two different surrounding lighting conditions obtained by two types of light sources of different spectral compositions i.e. yellow-enriched warm white and blue-enriched cool white. Detailed study of experimental results shows that spectral characteristics of surrounding light sources and the location of these luminaires have notable effects on mesopic and adaptation luminance. The blue-enriched cool white LED (CWLED) lamp shows most effective adaptation state of the observer in presence of cool white surrounding ambiance. Therefore, these lamps show better photometric performance and would deliver more energy-efficient performance in the mesopic zone as compared to conventional lamps i.e. high pressure sodium vapour lamp.

The unit power density (UPD) values are calculated for all four types of lamps on a sample area. The number of lamps required for a lighting design is reduced since these cool white lamps are more effective in mesopic vision, which results in lower power and energy consumption for any given application area and it ultimately leads to cost-saving and energy-efficient lighting solutions. Additionally, the reduced power consumption also contributes to a lower carbon footprint and helps to promote sustainability.