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HYBRID WHITE LED STREET LIGHT FOR MESOPIC VISION

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Abstract

In the night time, Street lights are used to illuminate for drivers or pedestrian. The main purposes have improved visibility in night vision and safety. LED Street light was used instead traditional luminaires. The range of colour temperature is starting at 2700K from now on. Light sources with high colour temperature are appearing brighter due to the high scotopic lumen. Cause of short wavelength is more affect eye sensitivity in the mesopic vision. The proportion of scotopic luminous flux and photopic luminous flux were used to indicate and call that s/p ratio. However, light sources with high colour temperature are generating more blue light. While the brightness of low colour temperature is less effective in the mesopic range. This paper present 4000K LED streetlight with high s/p ratio.

Keywords: Light Emitting Diodes, Mesopic Vision, Streetlight, S/P ratio

1 Introduction

Visual performance in the night time is an important factor for developing in outdoor lighting design. Lighting in night time is most effect to be approve traffic safety and reduce the accidents. In many studies and researches was found that the number of serious injuries and fatalities during nighttime are increasing, when street lighting are absent (Wanvik, 2009) and (Yannis et al., 2013).

Several years after the LED were widely used in daily life. With the advantages that less power consumption and easy to control light colour. Hence, there are used in a variety of applications such as monitor, automotive, traffic light or even roadway lighting.

Traditional lamps and luminaires as MH or HPS were instead by LED luminaires cause of more energy saving, and can control the colour temperature. In 2012, LED roadway lighting was demonstrated and assessment. (Pacific Northwest National Laboratory, 2012). HPS and 4000K to 5000K LED were installed and compared. The result found that the LED is better colour quality, and participant was rated LED more than HPS. Consistent with guidelines for road lighting design that recommended appropriate colour temperature (CCT) is 4000K (NZ Transport Agency, 2014). Cause the high colour above was generated more blue light, and harmful to the eyes.

However, the luminance of road lighting was required between 0.3 to 2 cd/m2. It was recommended by the international standard (Commiss. Int. l'Éclairage, CIE 41:1978), (Commiss. Int. l'Éclairage, CIE 115:2010) and (Illuminating Eng. Soc. of North America, RP-8-2000). Which the luminance that required is in the mesopic region. In the mesopic region, human eyes sensitivity both of photopic and scotopic respond. But, when use a standard illuminance meter to measure which in lux unit, the spectral power of light was only adjusted by photopic sensitivity. Then the CIE 2010 system uses scotopic/photopic (S/P) ratio to rank Spectral Power Distributions (SPDs) in term of visual performance at equal light levels in the mesopic range (Commission Internationale de l'Éclairage, CIE 191:2010). Brightness perception under the scene of outdoor lighting was affected by the light with short wavelength (Bullough et al., 2014).

The relationship between colour temperature and s/p ratio was shown that light sources with high colour temperature have more s/p factor (Berman, 1992). Although the LED light with high colour temperature are give high s/p ratio, but they also emit more blue light (U.S. Dept of Energy, 2013). The blue light hazard weighting function has peak around 435 nm. to 440 nm.

This paper presents the Hybrid White LED Street Light that was made by mixing colours of neutral white 4000K combined with cyan and red LED. The cyan LED were used in order to increase the S/P ratio where the red LED were used to compensate for the colour temperature of light. This paper used the photopic and scotopic luminosity function according to CIE standards to find optimum S/P values, meanwhile the colour temperature is in the range of 4000K based on standard (American National Standard, C.78.377-2015).

2 Light Mixing Colour

LED chips products of Nichia were used in this experimentation. There are three light mixing colour consist of NVSL119CT neutral white 4000K, NCSE119T-V1 Bluish-green, and NCSR119BT-V1 Red. LED chips each colour was tested for spectral power distribution result. Dominant wavelength of each colour has shown in table 1.

Table 1 – Dominant Wavelength of each LED chips

LED Colour	Model	Dominant Wavelength
Neutral White 4000K	NVSL119CT	442nm
Bluish-green	NCSE119BT-V1	505nm
Red	NCSR119BT-V1	631nm

Present model was combined with each spectral power distribution. Then the result use to design and calculate chromaticity coordinates as Eq. (1) and (2). After combination, coordinates are x_c and y_c.

$$x_c = S_c(\lambda)\bar{x}(\lambda) / S_c(\bar{x}(\lambda)+\bar{y}(\lambda)+\bar{z}(\lambda)) \tag{1}$$

$$y_c = S_c(\lambda)\bar{y}(\lambda) / S_c(\bar{x}(\lambda)+\bar{y}(\lambda)+\bar{z}(\lambda)) \tag{2}$$

This streetlight luminaire was designed at power consumption 80W, and target of colour temperature is 4000K. Then the main colour is neutral white and bluish-green additional for improving that scotopic lumen. The colour temperature are not within 4000K range of only two colours. Therefore, red LED were used and mixing to generate white light. The SPD of each light colour have shown in Figure 1.

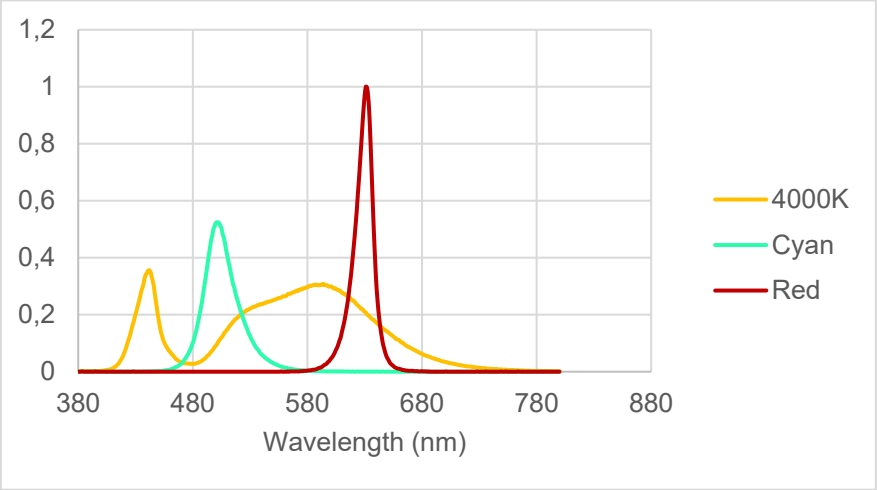

Figure 1 – Spectral power distribution of each LED chip

3 Results

Figure 2 shows that Spectral power distribution of this streetlight luminaire. Testing result from Integrating sphere was show spectrum have three peak wavelengths. The result from testing found that S/P ratio is 2.28 and Photopic luminous flux is 6677.45lm. Luminous efficacy is 86.22lm/W. Colour temperature and chromaticity coordinates from testing was show in Figure 3. The coordinates are x 0,3955 y 0.3989 and temperature colour is 3786K. The colour rendering of this luminaire is 55.8.

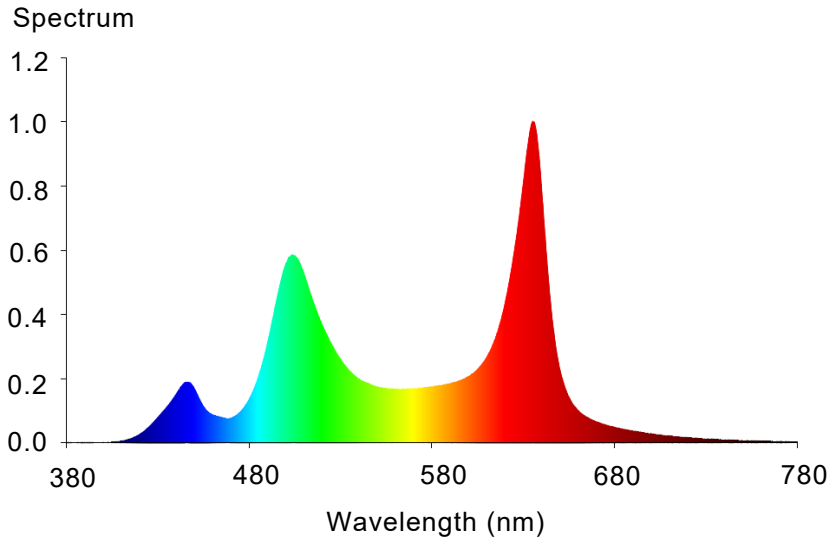

Figure 2 – Spectral power distribution from testing

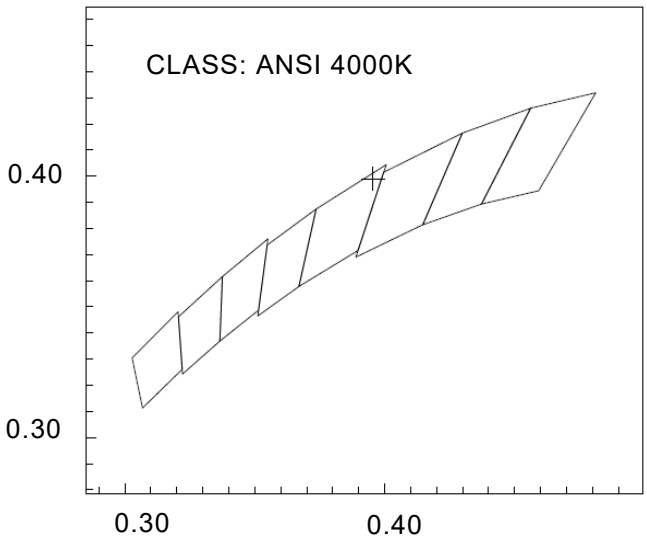

Figure 3 – Chromaticity coordinates according to ANSI C78.377

NOTE Spectral Power Distribution and Colour temperature were test by Integrating sphere. Total luminous flux and luminous efficacy are test results from Goniophotometer.

4 Discussion

From Integrating sphere test result, we found that spectral power distribution curve has three peaks dominant wavelength. First peak is around 440-450nm which is blue colour from neutral white 4000K. Next, the peak wavelength is around 507nm from cyan colour. Last peak is red colour and the wavelength is around 630nm. Colour temperature from testing is 3786K, and chromaticity coordinates is x 0,3955 y 0.3989.

This luminaire has nominal CCT at 4000K follow by ANSI C78.377, but s/p ratio is increase to 2.28. The cyan colour LED has improved scotopic lumen, because the peak wavelength is close to scotopic human eyes sensitivity at wavelength 505nm. Photopic values are calculations by photopic human eyes sensitivity. Efficacy and colour rendering are higher than normal RGB white light luminaires.

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