On-Site Measurements of Reflection Characteristics of a Dry Asphalt Road

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On-site measurements of luminance images as well as illuminance distribution for the studies of reflected properties of a LED lighted dry asphalt road have been performed. The relatively more practical luminance coefficient of this old curved road was obtianed from high observation angles. The luminance coefficient can be simply fitted with quadratic equation of angle between the incident and the observation directions.

1. INTRODUCTION

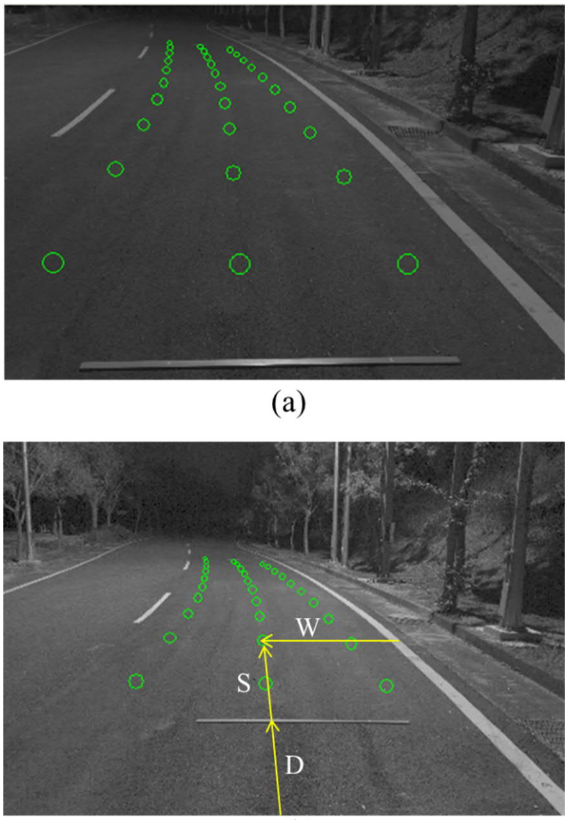
The luminance (*L*) from a road surface is a function of the illuminance (*E*) on the road and the reflection characteristics, which depend on the nature of the surface and physical state. Luminance on a point depends on the illuminance incidence angle (ε), deviation angle (β), and observation angle (α). The reduced luminance coefficients (*r*-table) and average luminance coefficient are standardised into different classes for dry and wet conditions [1]. It is convenient for an engineer to simulate the performance of a lighted road.

However, the use of *r*-tables are limited to some constraint such as low observation angle ($0.5^o < \alpha < 2^o$), straight road, known material and physical state. The reflection characteristics for an in-service road may not so ideally for the visual experience of a driver. To improve this disadvantage, this work demonstrates on-site measurements of reflected luminance images of a curved road at various observation distance. These luminance images as well as illuminance distribution were analysed and converted to luminance coefficient ($q = L/E$), which is functions of β, ε, and α. These results and procedures would get relatively more physical properties for safety road lighting design.

2. EXPERIMENTS

The measurements were carried out on a 2-lane dry asphalt road at southern Taiwan. A LED luminaire was mounted on a lighting pole at roadside. The height of the luminaire and width of lane are 10 m and 3.8 m, respectively. The luminance images of road was measured with a calibrated image luminance measuring device (ILMD) with 10-22 mm focal length. The distribution of horizontal illuminance was automatically measured with commercial lux-meters on a cart [2-4].

The ILMD was placed at distance of D+10 m (D = 2, 4, 6, 8 and 10 m) from the lighting pole, and the height of the ILMD is 1.5 m. Typical luminance images are shown in Fig. 1, where the region of interest (ROI, green circles) are selected according to CIE-140 [5]. The notations *W* and *S* are the transverse and longitudinal distances of a ROI, respectively.



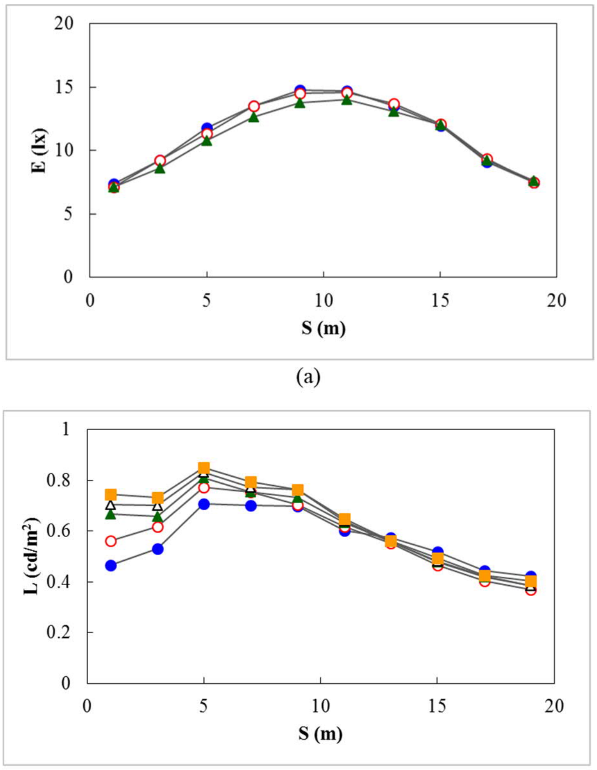
(a)

(b)

Figure 1. Luminance Images at D = (a) 2 m, and (b) 4 m. The green circles are the ROI for analyzation.

3. RESULTS AND DISCUSSIONS

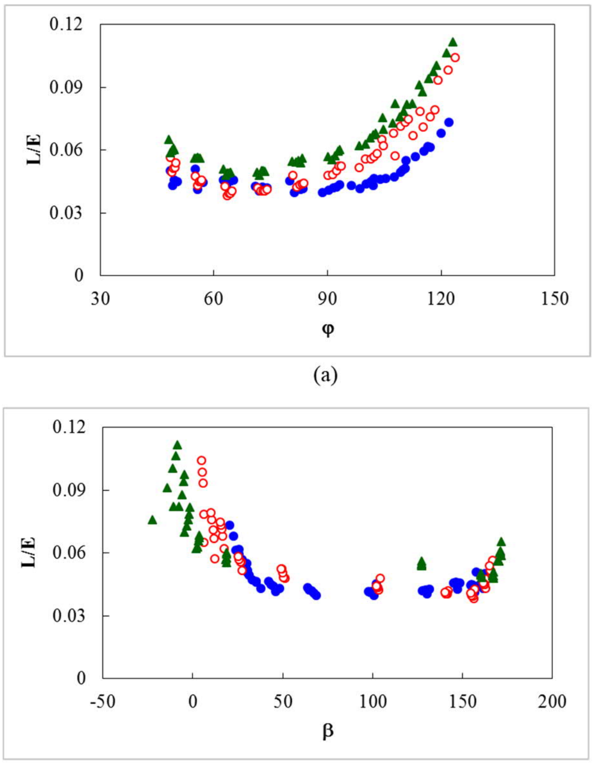
The horizontal illuminance as a function of *S* is shown in Fig. 2(a), where the filled circles, empty circles, and filled triangles are corresponding to *W* = 0.62, 1.88, and 3.13 m, respectively. The luminance at *W* = 1.88 m as a function of *D* is shown in Fig. 2(b), where the filled circles, empty circles, filled triangles, empty triangles, and filled squares are corresponding to D = 2, 4, 6, 8, and 10 m, respectively.



(a)

(b)

Figure 2. (a) Horizontal illuminance as a function of S; (b) luminance at W = 1.88 m as a function of D.



(a)

(b)

Figure 3. Luminance coefficient q as functions of φ (a), and β (b).

The above data were used to calculate the luminance coefficient q. Furthermore, the angles β, ε, and α can be calculated form D, S, and W with the angular relationships for luminaire, observer and point of observation [5]. The measured angles ε and α are ranged between 2° to 27°, and 10° to 43°, respectively. The angle (φ) between the incident and the observation directions was calculated with the following equation:

$$\cos\varphi = \cos\varepsilon \cdot \sin\alpha - \cos\beta \cdot \sin\varepsilon \cdot \cos\alpha \qquad (1)$$

The luminance coefficient q as a function of φ and β is shown in Fig. 3, where the filled circles, empty circles, and filled triangles are corresponding to W = 0.62, 1.88, and 3.13 m, respectively. These data can be fitted with the following equation:

$$q = a(\varphi - \varphi_0)^2 + b(\beta - \beta_0)^2 + q_0 \qquad (2)$$

Corresponding parameters are listed in Table 1. It is observed that these parameters is dependent on W, and may be originated from the long-time and uneven wearing by vehicles on this old curved road.

Table 1. Fitted parameters between q and φ, β.

W(m)	a(x10^{-5})	b(x10^{-6})	φ_0	β_0	q_0
0.62	1.59	-1.08	59.3	214.1	0.0482
1.88	2.58	-1.16	74.0	91.1	0.0429
3.13	2.43	-0.44	71.3	111.6	0.0507

It is expected that this on-site measuring and analysing method can be applied to other roads with various pavements, physical properties, luminaires, and observation directions. Practical luminance coefficient would be obtained for further design or improvement of illumination of an existing road.

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