Chapter 2
Basic Lighting Quantities

Abstract The first thing to determine is which are the lighting parameters that positively influence the visual performance and comfort of the users of road lighting. For this it is necessary to define those basic lighting quantities that play a dominant role in the seeing process of motorists, pedestrians and residents, namely: illuminance or luminance. For motorized traffic it is the luminance of the road surface that forms the background to possible objects on the road. For the normal directions of view of motorists, the reflection properties of road surfaces, needed for the determination of road-surface luminance, can be photometrically characterized. Therefore, road surface luminance can and is indeed used as the basic lighting quantity for road lighting for motorized traffic. Since the directions of view of slow-moving traffic such as pedestrians and cyclists are more varied and the reflection properties of surfaces of interest are widely different, we have to fall back on illuminance as the basic lighting parameter for road lighting specifically meant for non-motorized road users. The basic measure here for the lighting of the road and pavement is the horizontal illuminance; for the lighting of facades it is the vertical illuminance and for the lighting of faces of persons in the street it is the semicylindrical illuminance.

2.1 Road-Surface Luminance for Motorized Traffic

A surface is made visible by virtue of light being reflected from it and entering the eye of the observer: the greater the amount of light entering the eye, the stronger will be the visual sensation experienced. Thus, the illuminance on a road surface, which refers only to the amount of light reaching that surface, gives no indication of how strong the visual sensation will be; or in other words, how bright the surface will appear. The brightness of the road surface will depend on the amount of light reflected from it in the direction of the observer (Fig. 2.1).

The photometric measure for this is the luminance (L) of the surface. That it is the luminance and not the illuminance that determines the brightness is illustrated by way of the four photographs of one and the same road-lighting installation shown in Fig. 2.2.

The illuminance pattern on the road is the same in each photograph because the road-lighting luminaires and their configuration are the same—it is the changes in the reflection properties of the road surface which results in changes in the luminance

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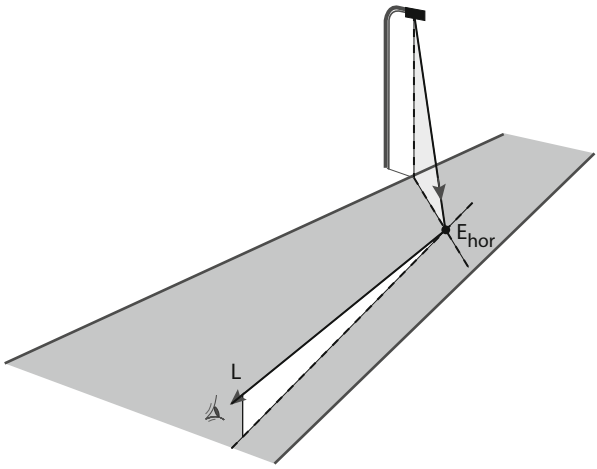

Fig. 2.1 Light incident towards the road results in the horizontal illuminance, E_{hor} on the road, while the light reflected from the road surface results in the road-surface luminance, L

pattern and, in turn, in differences in brightness. Since brightness is finally determined not by illuminance but by luminance, the visual performance and visual comfort of a road user are directly influenced by the complex pattern of luminances existing in his view of the road ahead. The refection properties of cars, bicycles, pedestrians, obstacles and other objects in the field of view vary widely. Dry road surfaces, on the other hand, have relatively similar reflection properties for the normal viewing directions of a motorist towards the road area some 50–150 m in front of him. The road-surface luminance, as achieved from a particular road-lighting installation, can therefore be accurately predicted. The road surface often forms the background to objects on or close to the road. This is why the road-surface luminance concept is usually better suited than the (horizontal) illuminance concept for use in defining the visual performance and comfort of the motorized road user.

2.2 Illuminance for Pedestrians, Cyclists and Residents

The viewing directions of pedestrians and cyclists are far more varied than those of a motorist. The surface of interest to the former is not only the surface of the road but also that of the pavement (sidewalk in America), the facades, and the faces of other people in the street. For these two reasons it is not possible to work with standard reflection properties for this category of road users. For road lighting specifically meant for non-motorized road users we therefore fall back on the illuminance as the basic lighting parameter.

Fig. 2.2 The influence of road-surface reflectance on perceived brightness, with illuminances constant: **a** smooth dry surface; **b** smooth wet surface; **c** rough dry surface; **d** rough wet surface. (Van Bommel and De Boer 1980)

2.2.1 Horizontal and Hemi-spherical Illuminance

It is important for pedestrians and cyclists that the lighting reveals potentially dangerous obstacles lying in their path and any irregularities in this. The horizontal illuminance is therefore usually used as the basic lighting parameter (Fig. 2.3). Since most objects are not flat but three dimensional, some road lighting standards specify the strength of the lighting at ground level in terms of the hemispherical illuminance rather than the horizontal illuminance (see again Fig. 2.3). Appendix A gives the calculation formulas for horizontal and hemi-spherical illuminance.

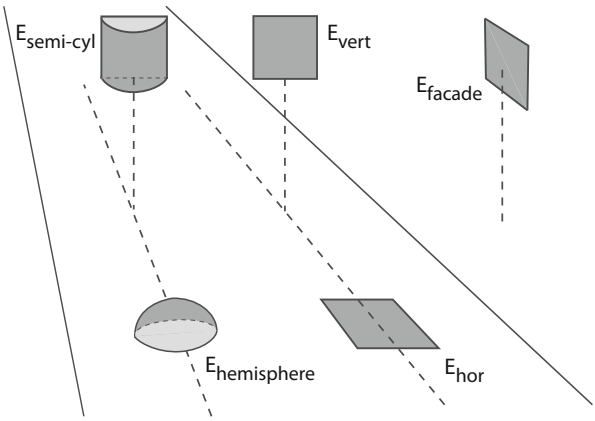

Fig. 2.3 The terms horizontal illuminance (E_{hor}), hemispherical illuminance ($E_{hemisphere}$), vertical illuminance (E_{vert}), façade illuminance (E_{facade}) and semi-cylindrical illuminance ($E_{semi\text{-}cyl}$) refer to the illuminances on an (infinitely small) body of the shape illustrated

2.2.2 Vertical and Semi-cylindrical Illuminance

For security reasons, it is important to be able to identify one another on meeting in the street. It is for this reason that the vertical illuminance at face height is sometimes used as the basic lighting parameter. It has been shown, however, that the semi-cylindrical illuminance at face height is an even better basic parameter for this purpose (see again Fig. 2.3). This is, as will be discussed in more detail in Chap. 5, because the human face is not flat, and light incident on the sides of the face contributes to its visibility. It is the vertical illuminances on the facades bordering the street that actually determine how well these facades can be seen. Appendix A gives the calculation formulas for vertical and semi-cylindrical illuminance.

Reference

Van Bommel WJM, De Boer JB (1980) Road lighting. Kluwer Technische Boeken, Deventer

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