ASPECTS OF VISUAL TASK COMFORT IN AN URBAN ENVIRONMENT

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SUMMARY

In urban environments, intrinsic non-functional criteria as decorative and aesthetical elements; comfort and well-being aspects are very well on their way to be converted into functional criteria. Lighting has indeed proven to be a definite actor in upgrading the urban scene.
In city and residential area lighting, performance and comfort parameters are including the horizontal and vertical component of the lighting, the uniformity of illuminances, glare control and the background brightness distribution. The problem of photopic, mesopic and scotopic vision is touched.
A case study has then been chosen to illustrate this system approach.

Keywords : urban lighting design, visual comfort, residential area lighting, city beautification, urban environment.

1. INTRODUCTION

Within the frame of Environmental and Urban Planning some functions are to be examined like embellishment and decoration of the open; mobility and traffic; and social safety.
The **visual task** and the **visual task comfort** is an *integrated* part of urban lighting design and city beautification and of the so-called lighting master plan for these outdoor applications.
The visual task within residential area lighting concerns recognition of persons and assimilation of the visual scene. **Semi-cylindrical illuminance** appears to be the appropriate describing lighttechnical parameter for recognition, as revealed by a set of experiments carried out under real outdoor conditions. The minimum level is used as a basic design criterion [1].
Public lighting design, as based upon car-driver oriented concepts, does require changes in perspective, especially within zones with a considerable presence of slow moving observers (viz. pedestrians, bike-drivers and mopeds).
Criteria to be applied are a.o. : detection of obstacles; visual orientation; recognition and identification of objects and of the intentions of people's faces; modelling; glare control; legibility of the lit urban scenery. Briefly, the fundamental criteria within residential areas are in a first step, the ability of recognition of a human's face and other patterns; and in a second step, the estimation of a person's intentions.
Urban areas too, deal a lot with the psychology of man in such a way, an adequate lighting does contribute substantially to a comfortable ambient atmosphere for residents moving outside their premises; and for non-residents entering a non-familiar surrounding after dark.
In order to fully understand the visual task one needs to learn about people's sociological behaviour as pedestrian and how the mechanism of meeting one another works (body language, eye contact, scanning the environment, search for identification with familiar patterns); in brief, how the visual impression and image of a complex background is built up.
Let's remark the distinction between facial recognition and identification (as a purely matching of patterns).

2. LIGHT AND LIGHTING IN THE URBAN SCENE

In urban environment, accent is clearly put on safety, comfort and performance.
The whole city is presenting itself as an architecture with the outer building façades as essential components, likely to bring about symmetrical and asymmetrical rhythms. Light

and lighting is able to play a fundamental role here by interfering with these rhythms or by integrating in the outer wall architecture. Innovating urban architecture can thus be applied to overcome occasionally boring perfect symmetry. The P&V building in Hasselt (Belgium - designed by Aldo Rossi) is an outstanding example of this so-called **architecture in the city** [2] and of **"the city in the city"**. See Figure 1.
A dialectic is existing likewise between the interior (inner) and the exterior (outer) city. This dialectic can be developed by assigning to each detail its proper form, its proper signature.

The light master plan for the urban environment is grounded on photometrical criteria but is often exceeding these. The light master plan is functionally and aesthetically integrating within an organic entity.
The districts, the residential areas, the monuments, the art works, the public domain, vegetation and parks, the premises, the roads and waterways; typical elements are marked and identified in view of their relevance, hierarchy and modelling potential in the urban image. The silhouette of the urban site and the scenographic capacity by night are in this way sketched. Sites are then being linked with their environment.
One of the objectives of the light master plan is to illuminate the urban environment (public and private-but with public impact) in relation to the historical, touristical, commercial; utilities and services qualities. The colour of the lighting (in terms of the colour temperature of the light source and the colour attributes of reflecting or transmitting surfaces) is a crucial option.

Briefly, six scripts can be considered in stimulating the urban environment around the basic elements "city", "people" and "light" :

- Assigning the city a personal and historical identity in time and space;
- Bringing together (the city as a socio-dynamic actor);
- Searching for more (attractive and animating lighting and magic pulses are inviting people to discover the city);
- Connecting the elements (efficient city transport systems);
- Balancing the elements (towards harmony in the urban chaos);
- Fear and hope (concern and excitement).

3. LIGHTING CRITERIA : PERFORMANCE AND COMFORT ASPECTS

Fundamentally, within the visual task, the major problem consists of the more or less counteracting elements of illumination on vertical surfaces (like the human's face and the building façades); of illumination on horizontal surfaces (like the ground pavement); and controlling of light emittance producing glare or some degree of visual discomfort, eventually visual disability.
Fulfilling these requirements is very hard to attain with any type of luminaire and luminaire configuration (installation height, spacing); they tend to realise predominantly the **horizontal** component or the **vertical component of the lighting**. As the basic criterion consists of person's recognition, the semi-cylindrical illuminance (as describing parameter) can be used to overcome the conflict of horizontal with vertical illuminances.

The impact of the uniformity of illuminances is to be sorted out as well as the influence of background lighting.
It has been found on the basis of preliminary *in situ* experiments, the **uniformity of the illuminances** (horizontal, vertical) has an effect on facial recognition. Semi-cylindrical illuminance implies however an asymmetrical lighting system which, on the other hand, ought to be uniformly distributed over the area !

In road lighting too, criteria on uniformity and lighting level are not independent to a certain degree. One could argue for lowering absolute lighting levels (illuminances) at high uniformities; although this is less the case in residential area lighting with the minimum semi-cylindrical illuminance as design concept and less stringent conditions on uniformity.

Observation of the background is corresponding to a vision determined by a complex brightness distribution which could eventually be represented by the concept of veiling luminance.

A comfort indexing system could be introduced for city and residential area lighting and should incorporate the lighting level (in terms of horizontal, vertical, hemi-spherical and/or semi-cylindrical illuminance); uniformities (of the illuminances); background luminance (in terms of veiling luminance within the field of view) and the glare control mark (cfr. the luminaire glare restriction formula [3], [4]). But, the impact (weight) of each element on the global figure has to be pointed out by now. Moreover, each element is treated separately; eventually poorer uniformity could yield better recognition (at higher semi-cylindrical illuminance) while better uniformity does not imply better recognition (at lower lighting levels), on the contrary.

Veiling luminance is expressed according to Stiles/Holladay (viewing angle $1° < \theta < 10°$; θ being the angle between the viewing direction and the incident beam) or preferably to the JJ. Vos formulation ($0° < \theta < 100°$) which covers a wider range of viewing angles θ , clearly present in residential area lighting.

A fifth element is **modelling** of three-dimensional objects, *in casu* the human's face (i.e. the directional nature of incident light on the object and from there the object's restauration) and is indeed most important. By the way, semi-cylindrical illuminance is an integrated parameter : a certain value is sometimes corresponding with differing directional character. Therefore, the vector to scalar ratio or the visible hemisphere concept can eventually be applied. In this context, predominantly two-sided light incidence (eventually with self-contrast on the face) is resulting in a higher degree of recognition than uniformly diffused lighting does (at the same lighting level). Research is actually on the way.

Discomfort glare from pedestrian's point of view is described by a parameter of type $\mathbf{L.A^n}$ where L is representing the nominal value of the luminance of the glaring source and A the vertically projected area of the emitting luminaire or source surface. This parameter is entitled *Luminaire Glare Restriction Formula*; the value of "n" has been set to 0,5 [3], [4]. Conflicts do arise when illuminating the face of the "object person" while the "object person" is at the same time obstructed in his own vision.

Finally, the **legibility of the scene** is an important criterion recently introduced in urban planning. It translates the visual impression of the global urban environment with regard to the dynamism of brightness and colour.
A balance in brightness and colour patches is effectively crucial in creating a degree of legibility within this complex background.

Light pollution is a generic term describing the impact of light and lighting on the environment. "Spill light" or "stray light" is that part of the light entering the zone outside the area to be illuminated. "Obtrusive light" is that part of the spill light that is the cause, in terms of quantity, direction or spectral content of distraction, discomfort or reduction of the vision performance; and this in a given context (cfr. the CIE Technical Committee TC 5-12 *Obtrusive Light*). "Sky glow" is defined as the effect of the brightness of the sky by night,

originating from the scattered radiation of the particles present in the atmosphere, in the viewing direction. A distinction is made between the natural sky glow (i.e. by the celestial sources and the luminescence of the upper atmosphere) and the artificial sky glow (i.e. by the direct or indirect contribution of artificial light sources).
To quantify light pollution, the *Upward Light Output Ratio*-ULOR is defined as the fraction of the light source flux emitted above the horizontal plane through the luminaire; and the *Upward Waste Light Ratio*-UWLR as the fraction of the luminaire output light flux emitted above horizontal.

To restrict sky glow, the upward contribution of the lighting installation (beit direct or indirect by reflection of road pavement, roadside or other surfaces) has to be limited.
In public road lighting installations, the artificial sky glow is merely determined by the on the road pavement reflected component [5]. When applying adequate luminaires with slightly curved bowls, optimum light distributions and minimum light pollution can be realised.
In city and residential area lighting, from slow moving observer's point of view, sky glow and other obtrusive light is part of the background brightness distribution, eventually to be weighed by means of the veiling luminance concept.

There is also the problem of **photopic**, **mesopic** and **scotopic vision** to mention. Indeed, in urban lighting, there are some applications wherein all of these observer systems can occur. Dark, twilight and nighttime vision is more complicated because part of the vision is foveal (with for the most *cone*-type receptors and active under photopic conditions) and another part is extra-foveal i.e. peripheral (with for the most *rod*-type receptors and active under scotopic conditions). Mesopic vision implies both cone and rod receptors to be active. The relative spectral sensitivity curve for scotopic vision $V'(\lambda)$ is bringing higher sensitivity for the shorter wavelenghts. As a matter of course, white light sources yield stronger brightness impressions than f.i. Sodium low pressure lamps do. Doing so will however result in a higher visual impression of the white light source (in the periphery) and in a reduction of the visibility of the objects within the field of view. This so-called paradox of Fechner entails an intermediate adaptation level of the eye leading to widening of the pupil opening, meaning an increase of sensation for one (peripheral) part and a decrease for the other (foveal) part.
Moreover, the atmospheric Rayleigh scattering is inversely proportional to λ^4 and from there there is a more important scattering from "white" light sources compared to Sodium low pressure lamps for instance. This scattering is then contributing to the visual image in the periphery.

4. CASE STUDY

Projects regarding cities like Veurne and Tienen (BE) will be discussed while photographs are presented.

Figure 1 : The P&V building in Hasselt, Belgium (architect Aldo Rossi)

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