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Study of facades with diffuse asymmetrical reflectance to reduce light pollution

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Abstract

The paper continues the study of asymmetrical reflection for facades finishing materials in order to reduce light pollution. Instead to study prismatic profiles, the paper is studying cylindrical profiles, with increased possibilities of optimization. They generate diffuse asymmetrical reflections using perfect diffuse paintings (ie symmetric). Optimization of facades lighting pollution is analyzed in the context of other performance criteria such as energy savings in heating and cooling, indoor visual comfort. The study of asymmetrical reflections was realized using three types of profiles with different heights. Original MATLAB functions are used, developed by author and visualization and interpretation of the results was facilitated by internal MATLAB functions. To validate theoretical results, measurements were performed on a sample test, small (40 cm x 40 cm) but with profile at natural scale. Measurements had confirmed initial assumptions; using diffuse reflection, the micro profiles with asymmetrical reflection could significantly reduce the light pollution.

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1. Introduction

The idea of an asymmetrical reflection of façade material, in order to reduce upward reflection and accordingly light pollution was presented in [1]. The principle of the method is based on a micro profile, witch change the

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proportion of the diffuse light reflected to the sky. The research extends from prismatic profile, simple [1], to cylindrical profiles, more efficient. Due to the complexity of the geometry, details about software simulation and mesh generation are presented, and also measurements on mock-up.

2. The increasing role of the façade paintings and insulation

In recent years, the study of the façade was increasing in importance, due to energy but not only. Comfort was also involved. The radiative balance, important for the heating and cooling, involve new materials and technology [2]. “The purpose of low-e materials is to reduce the radiative heat transfer, either into or out from a building. Near infrared radiation from the sun will be reflected by the low-e material or coating. Long-wave infrared (heat) radiation given off from materials inside the building, either at room temperature or higher (e.g. from heating sources for the latter case) will be reflected back into the room and hence provide to maintain a higher indoor temperature.”

Opaque paints are also discussed, like a solution for the situation when it is hard to use foil products.

The issue of a plaster with different properties in different areas but also in function of time (day - night or summer and winter) seems feasible. Similarly, after the summer when the sun radiation is undesirable, we get this radiation to be considered useful in winter. There are some technologies that tend towards this goal [3]. “Among the chromogenic materials, electrochromic materials (EC) are very interesting. They can shield the solar radiation, particularly the radiation of the visible field and that of infrared field; they also can reversibly change their transparency and coloring due to the presence of a small electric field. They are produced in form of thin films, and inserted into laminated glass panels.”

This property could be applied to areas of dark color profile, fig.1 (with superior vertical orientation, as it will be shown forward) to achieve high reflectivity of solar radiation during the day, when this is not desired.

In this way, accepting the idea of adaptive façade, we will discover immediately the intelligent façade [4]. “With this term we refer to those that respond dynamically to demands posed by outside environment and inside occupancy, following energy-conscious principles and maintaining user comfort. It uses energy and visual comfort strategies abstracted from a prescriptive energy code for hot climates to suggest a range of good starting solutions.

Designers can have energy and visual comfort estimations to these alternatives through an advanced stage energy simulation program, or explore them further”.

The basic idea from [4] is that: there isn’t an optimum, especially when several layers are the performance criteria. And if we accept the user's visual comfort of the building, it is natural that we can enlarge this concept, including the viewer of the façade. For him, visual comfort means acceptable luminance from the illuminated façade, but with minimum luminous flux reflected to the sky.

Another study [5] focuses on the “assessment of cool coloured materials for façade applications, to be used in new constructions and in building renovation. A colour palette of conventional and cool colours was prepared for the experimental characterisation and the comparison of the relevant radiative properties. The impact of the solar reflectance of a cool coloured paints, higher than a conventional paint of equivalent colours is then assessed through a numerical analysis, which implements the energy performance of a reference building under different boundary conditions”.

Obviously, for hot climates, solar radiation must be rejected. Hence a certain contradiction because at night a façade should behave differently, reflecting light, but not upward.