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ScienceDirect

Energy Procedia 132 (2017) 447–453

Energy Procedia

www.elsevier.com/locate/procedia

11th Nordic Symposium on Building Physics, NSB2017, 11-14 June 2017, Trondheim, Norway

Influence of different pigments on the facade surface temperatures

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Abstract

More intensive shades of color are being used with external thermal insulation composite systems (ETICS) on energy-efficient facades. These surfaces heat up extremely and cause damage in ETICS. Based on an analysis of laboratory examinations and practical measurements (test houses) as well as on computations, this paper analyzes commonly used relative luminance (RL) and if this is of an adequate size for the prediction of the surface temperature. Significant issues are: (a) the deviation of the RL limit, (b) the performance capability and temperature advantages of improved pigmentation concepts (infrared reflecting pigments) on ETICS. Additionally, the total solar reflectance (TSR) and its influence on the surface temperature are evaluated.

Peer-review under responsibility of the organizing committee of the 11th Nordic Symposium on Building Physics.

Keywords: Relative Luminance, IR-Color, TSR, Cool Façade,

1. Introduction

The trend toward more intensive shades of color on energy-efficient facades using ETICS, also referred to as Exterior Insulation and Finishing Systems (EIFS), cannot be ignored. Customers increasingly want dark shades. The problem is, these surfaces heat up more than light facades under solar radiation. Even using improved pigment mixtures, high surface temperature cannot be avoided. In addition, ETICS surfaces heat up more intensively than a solid brick façade, so that sometimes its temperature exceeds the temperature stability of the system. The final coating of plaster is therefore exposed to great tensions. The heavy fluctuations in surface temperature can cause cracking and deformation. Special facade colors are also offered, which are equipped with special infrared-reflecting pigment (IR-color) in order to prevent excessive heating of the façade.

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1876-6102
Peer-review under responsibility of the organizing committee of the 11th Nordic Symposium on Building Physics
10.1016/j.egypro.2017.09.662

To avoid the risk of damaging the ETIC system, a standard limitation for the relative luminance (RL) was defined at not less than 20 in Germany [1]. RL corresponds to the tristimulus value Y of the CIE XYZ color space (RL = 0 yields black and RL = 100 indicates diffuse white [2]). If the RL drops below 20, an expert must be aware that the risk of damaging the ETICS increases significantly (fig. 1 a). Further Standard test methods currently don't yet exist.

2. Theoretical background

2.1. Heating up and relative luminance

Relative luminance (RL) describes in principle the solar reflectivity and the resulting heating up of coating. However is it a sufficient parameter to describe the whole solar reflectivity? In the determination of the RL only the part of the visible radiation between 400 nm and 700 nm is considered. Due to the fact that solar radiation is made up of 42 percent UV-Vis and 58 percent invisible NIR, only a fraction from an energy point of view is considered [3]. The Total Solar Reflectance (TSR) is also a parameter to describe this phenomenon. TSR is the percentage of solar radiation reflected from a coating. The TSR takes into consideration the near infrared radiation (NIR) in addition to the ultraviolet and visible radiation (UV-Vis) and therefore covers the whole solar spectrum from 250 to 2,500 nm (fig. 1 b) [3]. This is confirmed also by the results of practical measurements in section 4.2.

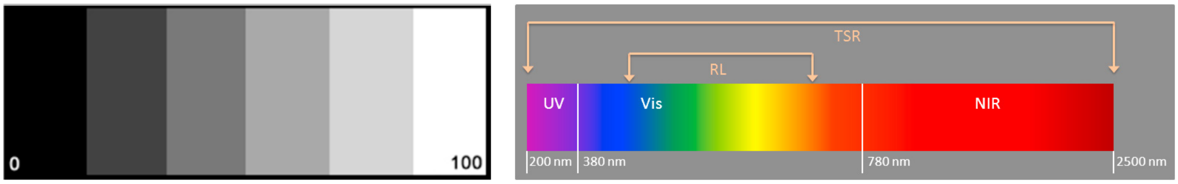

Fig. 1. (a) Definition of relative luminance; (b) Chart (not to scale) of the electromagnetic spectrum of solar radiation relevant to heating, wavelength ranges for the determination of the RL value and the TSR value are marked.

2.2. Solar reflection of pigments

The use of the TSR-value is closely linked with a new technological solution for reducing the solar heating of facades. The technical principle is that special pigments are used in the color shade formulations of facade paints that better reflect the solar radiation. Since color shades are nothing more than pigment mixtures, it is worth having a look at the individual pigments in table 1.

Titanium dioxide is the most important pigment and has the highest TSR-value. As a result, it causes the lowest surface heating. At the other end of the spectrum, carbon black and iron oxide black pigments have the lowest TSR values of about 5 %. These pigments are responsible for intense surface heating. When considering common colored pigments, the TSR-values are considerably higher than those of black pigments, even the special IR-black pigments [4]. Colored pigments, therefore, play a minor role in the heating up, especially in very intensive shades.

Table 1: TSR values of different pigments according to ASTM G173

Pigment	TSR [%]	Pigment	TSR [%]	Pigment	TSR [%]	Pigment	TSR [%]
Phthalocyanine blue	31.7	Dioxazine violet	41.1	Bismuth vanadate	71.1	Carbon black	5.4
Phthalocyanine green	29.1	Iron oxide red	36.3	Cobalt blue	50.9	Iron oxide black	5.4
Diketopyrrolopyrrole red	55.1	Iron oxide yellow	45	Titanium dioxide	83.5	IR-black $_{1, 2}$	14.4 - 22.6