Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 126 (201709) 163–170

Energy Procedia

www.elsevier.com/locate/procedia

72nd Conference of the Italian Thermal Machines Engineering Association, ATI2017, 6-8 September 2017, Lecce, Italy

Opaque construction materials solar loads calculation: Dependence on directional reflectance

Luca Mauri[a]*, Emiliano Carnielo[a]

[a]*Roma Tre University, Engineering Department, Via della Vasca Navale 79/81, Rome 00146, Italy*

Abstract

Generally the solar reflectance associated to construction material surfaces is considered perfectly diffuse, namely they reflect in every direction the incident irradiance. Therefore reflectance and absorptance are assumed to be constant and independent on the incidence angles. This assumption, generally used in the most of energy analysis simulation tools, has to be considered not valid for materials characterized by a regular reflection, like glass or polished surfaces, where an angular dependence of their optical–radiative properties is observed. However, many opaque construction materials often show a mixed behavior, which includes regular and diffuse (or scattering) reflectance components. Moreover, the apparent roughness of the materials surface changes according to the angle of incidence of the solar irradiance. This issue is relevant for some cool materials, which are polished or treated with other methods to offer a very smooth surface, to increase the solar reflectance. In this work the dependence of opaque materials on the directional properties of their surfaces are investigated to assess the impact on solar loads and energy performances of the building envelope. The reflectance shape and the hemispherical values of two materials used for roofing are measured by means of a goniophotometer to characterize the directional reflectance. A numerical analysis was carried out to compute the differences in solar loads during cold and hot seasons between a reflectance angular dependent model and a constant reflectance model. Sensible discrepancies between the two models put in evidence that solar reflectance angular dependence should be included in the calculation tools to achieve more accurate results.

© 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 72nd Conference of the Italian Thermal Machines Engineering Association

Keywords: Solar Loads; Goniophotometer; Lambertian; Directional Reflectance;

* Corresponding author. Tel.:+39-328-06-90417
E-mail address: luca.mauri@uniroma3.it

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 72nd Conference of the Italian Thermal Machines Engineering Association
10.1016/j.egypro.2017.08.136

1. Introduction

Buildings are responsible of 40% of the total national and Europe energy consumption. The European Directive 31 [1] establishes the need to adopt criteria for assessing building energy performances aimed at reaching low energy consumption standards for new and existing structures. Several studies on UHI mitigation techniques [2,3] and on the influence of urban climate on the building energy demand have been performed by means of BES [4-9] and CFD tools [10-13]. Several methods were proposed during the last years for improving building energy performance through envelope retrofit [14], passive ventilation [15], innovative glazed components [16], shading systems [17,18]. Talking about technical systems, innovative cooling technology has been studied [19-21].

Solar reflectance is a construction materials surface property concerning the assess of the selective capability to reflect the irradiance as a function of the wavelength. Aside from the spectral properties the assessment of the reflectance variation with the beam irradiance incidence angle is investigated. Reflectance ranges between a minimum value corresponding to a normal light beam incidence to a maximum one corresponding to a 90° incidence angle with a trend depending on surface roughness. Smooth surfaces present a regular (or specular) component with a magnitude dependent on incidence angle while rough surfaces present a reflectance value less affected by the incidence variation. Solar irradiance depends on latitude and change in intensity during the day. It can be divided into two components: diffuse and direct. While the first one hits a surface uniformly in every direction, the second one changes with the incidence angle. The energy and geometrical distribution of solar irradiance is typically taken into account in the thermo-physical tools while they assume as lambertian the reflectance of materials surfaces (perfectly diffusive with a constant distribution of hemispherical radiance and thus incidence angle independent). This assumption may not be valid for some actual materials that present a mixed behavior. This issue induces an overestimation of solar gains in the calculation of energy performances of buildings.

Cool materials are a particular category of materials that have high reflectance in the solar spectrum. They are able to reduce the absorption of solar irradiance limiting the surface temperature. These property keep building cool during hot season improving thermal comfort and energy savings. Moreover a massive use of this solutions in urban scale may induce a mitigation of the urban heat island effect [22,23]. This technology is now well-established especially with regard of coatings for roof applications. The latter generally present smooth surfaces with a reflection that has a not negligible regular component. In this perspective the study of reflectance solar dependence on incidence angle increase in importance for a correct estimation of energy gains in buildings.

Nomenclature

G	Solar Irradiance	$[W\cdot m^{-2}]$
Q	Solar Load	$[W\cdot m^{-2}]$
ρ	Reflectance	[-]
θ	Incidence Angle	[°]

Superscript

b	Beam
diff	Diffuse
hem	Hemispherical

Subscript

b	Beam
d	Diffuse
e	Solar
g	Global
v	Light (in the visible spectrum)

Download English Version:

https://daneshyari.com/en/article/5444450

Download Persian Version:

https://daneshyari.com/article/5444450

Daneshyari.com