Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 22 (2018) 358–363

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

11th International Conference Interdisciplinarity in Engineering, INTER-ENG 2017, 5-6 October 2017, Tirgu-Mures, Romania

Determination of optimal dimensions of fixed shadowing systems (pergolas) to reduce energy consumption in buildings in Romania

Florin Babota[a,]*, Daniela Lucia Manea[a], Claudiu Aciu[a], Constantin Munteanu[a], Nicoleta Cobîrzan[a], Daniela Roxana Tămaș-Gavrea[a]

[a]*Technical University of Cluj-Napoca, 28 Memorandumului Street, 400114, Cluj-Napoca, Romania*

Abstract

Depending on the season, the sun light entering a building has a varying impact upon the energy consumption of the building. Thus, during winter, the sunlight reaching the façade of a south-oriented building can provide passive solar heating, hence reducing the energy consumption required to heat the building. Contrary to this, during summer, the sun rays penetrating the building mainly through windows oriented towards the south lead to excessive accumulation of heat. To diminish the thermal lack of comfort, it is necessary to increase energy consumption required to cool the building. The fixed shadowing devices such as pergolas, when well designed, are able to significantly reduce the energy consumption required to cool the building during summer and also to allow for the energy contribution from the solar beams, during winter. Shadowing has always been recommended as a passive way to diminish solar heat input in constructions. In order to reach this aim, i.e. of reducing energy consumption in buildings in Romania, the present paper presents the optimal dimensions of fixed shadowing devices, namely of pergolas.

Peer-review under responsibility of the scientific committee of the 11th International Conference Interdisciplinarity in Engineering.

Keywords: optimal dimensions of fixed shadowing systems; pergolas; passive shadowing; reduction of energy consumption.

* Corresponding author. Tel.: +40-744-599-663; fax: +40-264-550-518.
E-mail address: florin.babota@ccm.utcluj.ro

2351-9789 © 2018 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the scientific committee of the 11th International Conference Interdisciplinarity in Engineering.
10.1016/j.promfg.2018.03.054

1. Introduction

Passive design is the key to sustainable building, it responds to local climate and site conditions to maximise building users' comfort and health, while minimising energy use [5]. Using passive design can reduce temperature fluctuations, improve indoor air quality and make a home drier and more enjoyable to live in. It can also reduce energy use and environmental impacts such as greenhouse gas emissions [5].

Shading of house and outdoor spaces reduces summer temperatures, improves comfort and saves energy. Effective shading (which can include eaves, window awnings, shutters, pergolas and plantings) can block up to 90% of this heat [3]. Shading of glass to reduce unwanted heat gain is critical, as unprotected glass is often the greatest source of heat gain in a house. However, poorly designed fixed shading can block winter sun. By calculating sun angles and considering climate and house orientation, it can be used shading to maximise thermal comfort [6].

2. 1. Computation methodology

Passive design is the key to sustainable building, it responds to local climate and site conditions to maximise building users' comfort and health, while minimising energy use. Using passive design can reduce temperature fluctuations, improve indoor air quality and make a home drier and more enjoyable to live in. It can also reduce energy use and environmental impacts such as greenhouse gas emissions [4].

2.1. Determination of the position of the sun in the sky

The angle of the solar altitude γ_S [°] and the angle of solar azimuth α_S [°] represent the polar or angular coordinates defining the position of the sun in the sky relative to a reference point (observer) on the earth surface (Fig. 1) [2].

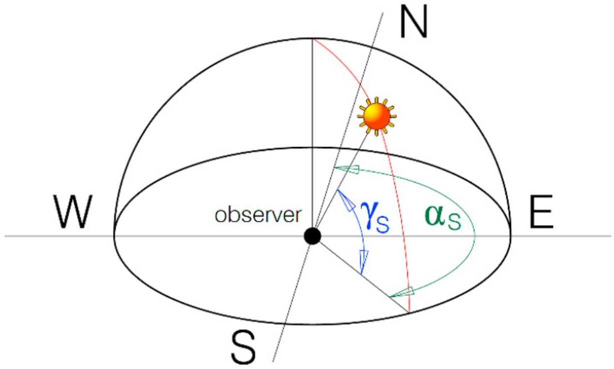

Fig. 1 The angle of the solar altitude γ_S and the angle of solar azimuth α_S [2].

The two angles are calculated with [2]:

$$\gamma_S = \arcsin(\cos(\omega)\cdot\cos(\varphi)\cdot\cos(\delta) + \sin(\varphi)\cdot\sin(\delta))$$
$$\alpha_S = 180° \pm \arccos((\sin(\gamma_S)\cdot\sin(\varphi) - \sin(\delta))/(\cos(\gamma_S)\cdot\cos(\varphi)))$$
$\pm$ = "+" when the solar time ST > 12:00 and "-" when the solar time ST < 12:00

With the two angles (or polar coordinates), one can draw the diagrams of the positions of the sun in the sky. The diagrams of the positions of the sun in the sky can be found for any location relative to the geographical coordinates, either with the algorithm shown here or with other calculation devices, among which a software Of the University of Oregon USA, Laboratory for monitoring solar radiation, software that can be found in the Internet [7].