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Winter and summer analysis of daylight characteristics in offices

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ABSTRACT

This paper reports a comparison of the results of daylight measurements carried out in summer and winter in three offices, with different exposures and characteristics, located in Naples (Italy).

The aim was to extend and enrich the findings of a previous study which reported the results of summer measurements about desk illuminances and circadian impact. The research project includes measurements carried out in other seasons and a comparison between measured and software simulated values with the final goal of developing design guidelines.

This research confirmed that the spectral distributions and CCTs of the light reaching the eye of a person seated at the desk in these offices are similar, irrespective of the different sky's conditions and season and of the rooms' different characteristics (dimensions, surfaces' spectral reflectances, external obstructions, etc.). It was also confirmed that eye level irradiances and thence their circadian impact are similar to those of D50 and D55 CIE standard illuminants.

1. Introduction

The importance of daylight availability in indoor environments has been highlighted by numerous studies, especially in recent years [1–5]; however allowing an adequate amount of daylight in built environments is also a complex problem for several reasons. For example, maximizing daylight access can lead to a reduction in electric light use, thus decreasing energy consumptions [4] but, at the same time, it may also cause glare and overheating if not correctly controlled, thus neutralizing every benefit.

Moreover, to maximize energy saving, electric light should be designed according to daylight availability and, to do so, designers need daylight performance indicators and software that allow to easily predict an environment's performance from this point of view. Nowadays the design practice is still heavily based on the daylight factor (DF) as a daylight performance indicator of a built space [6], however recent studies highlighted its weaknesses [7–9].

Therefore other performance indicators were proposed such as Useful Daylight Illuminance (UDI) [8,9], Daylight Autonomy (DA) [10], Continuous Daylight Autonomy (DAcon) [11], but they are still not so common among the designers' community and so far only RADIANCE based software allow to easily calculate them [12,13]. Recently the US Illuminating Engineering Society published the LM-83-12 document "Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)", which introduces two new daylight performance indicators [14].

Another issue connected to the problem of daylight access is its effects on the circadian system. The circadian system is a biological clock, found in all living creatures, that regulates a series of biological functions, such as hormones secretion and sleep wake cycle. Those processes, called circadian rhythms, repeat themselves with a period which length is controlled by this system; for human beings is about 24 h and is maintained by the daily exposure to light [15].

Depending on light's characteristics and time of exposure a light stimulus can help maintain this 24 h period or may disrupt it causing health diseases [16,17]. Moreover daylight can also influence people's mood and performance [18].

The current knowledge of the circadian system's working does not allow to predict its exact response to a light stimulus; it has been demonstrated that melatonin's levels variations in humans' body is one of the most important circadian rhythms and it gives input for the regulation of the other circadian rhythms [19]. It was also reported that blue light (460 nm) has the power to suppress melatonin levels [20], therefore the variation of this hormone's levels is used as an indicator of the circadian impact of a light stimulus.

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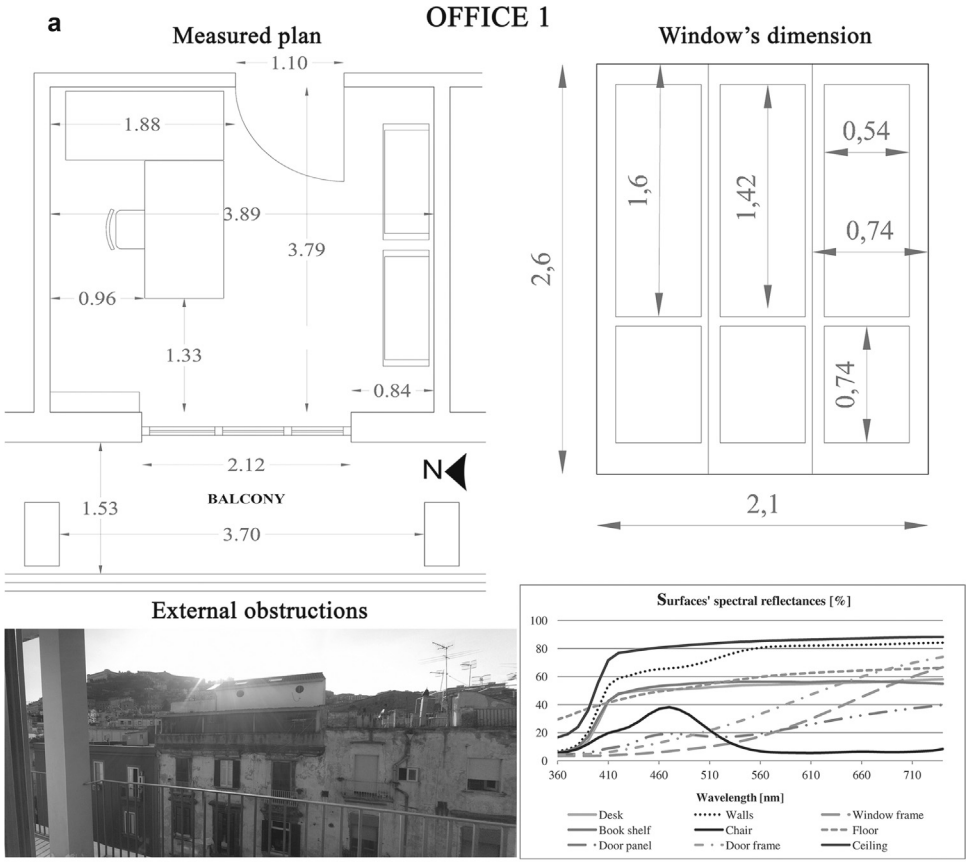

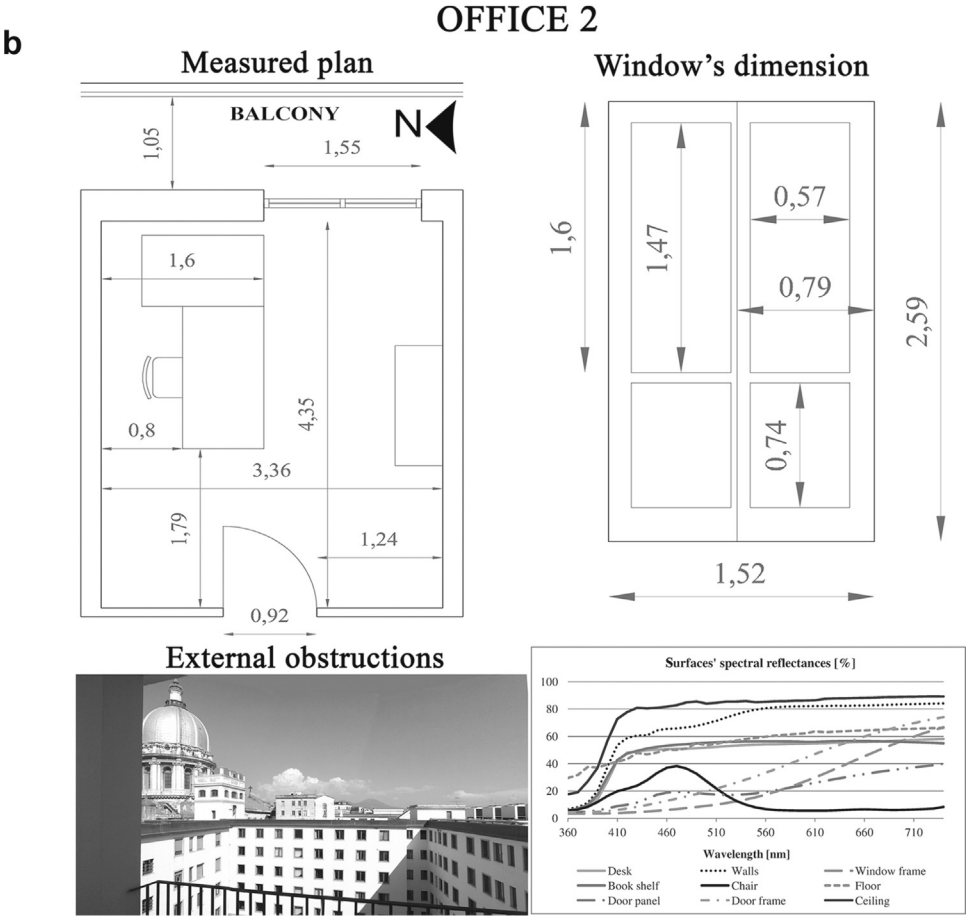

Fig. 1. a,b,c: Offices' measured plans, external obstructions, windows dimensions and surfaces' spectral reflectances.