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Investigation of the impact of subjective and physical parameters on the indoor comfort of occupants: a case study in central Italy

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Abstract

Indoor comfort perception of buildings occupants depends on several parameters related to physical boundary conditions but also to the adaptation capability of occupants themselves. According to standards, just physical ambient parameters are considered to evaluate comfort so non-measurable factors, such as psychological ones, are not taken into account. The present work aims to identify possible benefits in terms of occupants' comfort perception due to the maintenance of good quality work environment. To this purpose, the environmental multi-physics performance of a mixed industry-office building is investigated through both field microclimate monitoring and questionnaires campaigns. Results obtained are therefore compared and discussed.

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Keywords: indoor comfort, occupants, adaptive model.

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1. Introduction

Occupants' perception of the indoor environmental quality is the object of many studies and can be analyzed by means of different approaches. International standards use to link indoor comfort conditions to specific ranges of physical parameters due to the objectivity of measurable data. ASHRAE 55 [1] and ISO 7730 [2] determine thermal comfort conditions in buildings through the heat balance model for human body by considering the comfort perception as dependent on the following six factors: (1) metabolic rate, (2) clothing insulation, (3) air temperature, (4) mean radiant temperature, (5) air velocity and (6) relative humidity. Furthermore, UNI EN 15251 [3] specifies how to design criteria for dimensioning the building and its systems. Specifically, these criteria are aimed at guaranteeing specific comfort conditions. From the thermal point of view, the standard distinguishes between mechanically conditioned buildings, where the comfort is evaluated by means of PMV and PPD from ISO 7730, and naturally ventilated buildings, where the application of the adaptive method is recommended. Moreover, EN 13779 [4] deals with performance requirements for ventilation to guarantee a good indoor air quality (IAQ). The estimation of IAQ is therefore associated to a maximum concentration limit of CO_2. Finally, the EN 12464-1 establishes lighting standards for indoor work places. Nevertheless, comfort perceptions of buildings occupants are not just related to physical parameters, but are also affected by physiological and psychological aspects. Many studies analyze it by coupling (i) the monitoring of environmental parameters and (ii) the questionnaires submission, and by generally focusing the attention on one environmental parameter at a time. As for the air quality, different works [5-6] detected poor air quality perception among occupants and a positive correlation between job satisfaction and ratings of work area environment quality. A similar method, i.e. parallel monitoring campaign of the ambient parameters and questionnaires submission, was followed by Collins et al. [7] to evaluate the office occupants' satisfaction with the lighting system. In this case, workers' perception resulted to be more related to the patterns of luminance in the space than to the illuminance level of their specific view task. Moreover, many studies dealt with indoor thermal comfort, which is the most important parameter influencing the indoor environment quality perception and therefore the building energy demand according to Frontczak and Wargocki [6]. In a research of Nakano et al. [8], the same workspace was founded differently perceived by groups of different nationality and gender whereas Yamtraipat et al. [9] associated indoor thermal comfort to (i) occupants' education level and on (ii) how much they were accustomed to use of air-conditioner. Many studies aimed at improving the adaptive approach for thermal comfort evaluation. This method considers occupants as agents interacting with their environment with multiple feedback loops and presenting a thermal perception influenced by the complexities of past thermal history, culture and technical practices [10]. To quantify the effects of different adaptation process some studies tried to include some of them within the predicted mean vote (PMV) which, at the moment, is the most common index used and suggested by standards, resting on the steady state heat transfer theory [11-15]. Fanger and Toftum [16] suggested an extension the PMV index to non-air-conditioned buildings in warm climate by introducing an expectancy factor *e* varying between 1 and 0.5 depending on the expectation level (high, moderate or low) and the local climate, i.e. duration of the warm period. Even if these approaches had produced an improvement of thermal comfort numerical evaluation, many others parameters could affect the real perception of buildings occupants, also related to collective influences and social norms [17-18].

Based on the outlined background, this work aims at highlighting how an aesthetically pleasant and comfortable workplace can positively influence occupants' perception of the indoor environment. To this aim, both a microclimate monitoring and surveys campaigns were carried out within a company located in Perugia (Italy) during the autumn and winter seasons. The experimental campaign was carried out by considering thermal, visual comfort, and air quality. The indoor comfort is evaluated according to existing standards and the results are than compared to surveys responses.

2. Methodology

The methodology consists in the comfort assessment carried out by combining (i) the monitoring of the environment physical data and (ii) the submission of questionnaires to the occupants. The monitoring campaign was carried out by an indoor microclimate station collecting physical data of (i) indoor air quality, (ii) illuminance level, (iii) global and (iv) local thermal comfort. The sensors included in the station are: thermal-hygrometer (air temperature (°C) and relative humidity (%)), surface and air temperature sensor (floor and air temperature at ankle level (°C)), black globe radiant temperature sensor (mean radiant temperature (°C)), hot wire anemometer (air speed - m/s, and