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Editorial: Healthy and energy efficient buildings

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Editorial on the Research Topic
Healthy and energy efficient buildings

The built environment has a significant impact on human health. The extent of the impact of buildings on human health and the environment depends on different environmental factors. The extent of the impact of buildings on human health and the environment depends on the design, materials and methods used for construction and operation (Altomonte, 2019; Awada et al., 2022; López et al., 2023). It is increasingly important to design healthy buildings in the pursuit of sustainable development, where not only the occupants play an important role in ensuring indoor air quality through their habits, but also current developments related to interior finishes with low chemical emissions and good fungal resistance (Rupp et al., 2015; Loftness et al., 2007).

Recent research has shown that people contract COVID-19 through airborne transmission indoors, especially in poorly ventilated environments (Domínguez-amarillo et al., 2020). It is therefore necessary to maintain optimal air quality to eradicate the virus spread. This requires innovative changes to existing indoor and outdoor infrastructure to positively influence occupants even in the most densely populated spaces (Karagulian et al., 2015). This is also a challenge to traditional residential and public building construction in the aftermath of the COVID-19 pandemic (López et al., 2023).

Because as previously stated, people spend most of their time inside buildings and, therefore, a healthy and comfortable indoor environment is essential for human beings. Indoor environmental quality encompasses the four environmental conditions (thermal, air quality, visual and acoustic) within the building (Serrano-Jiménez et al., 2020; González-Lezcano, 2023). Humans have strived to control their built environments in which they can feel comfortable. The use of adaptive actions by occupants, such as opening windows or doors, using blinds, and using fans, substantially influences the indoor environment. Naturally ventilated or free-running buildings provide many adaptive opportunities for occupants to improve their built environment by utilizing natural airflows (Kumar et al., 2016). Opening windows helps in comfortable ventilation of air, distribution of fresh air and extracts overheated and polluted air from the interior space (Kaasalainen et al., 2020). Recently developed research (Sansaniwal et al., 2021a) showed that the adaptive actions of the occupant were governed primarily by the search for comfort and were based primarily on the change in the indoor rather than the outdoor environment and that the behavioral patterns of the occupants can be used to simulate the environment built in buildings with natural ventilation.

The healthy building concept focuses primarily on the creation of a desirable environment, which is measured in terms of indoor environmental quality (IEQ) (Jain et al., 2020; Sansaniwal et al., 2022). A healthy IEQ is expected to positively impact the occupants of most densely populated buildings in terms of physical, mental and social wellbeing. The level of indoor environmental quality depends on several parameters, such as thermal, visual, acoustic and chemical variables (Altomonte, 2019). The parameters, which should be assessed individually and/or collectively, include indoor air quality (Agarwal et al., 2021), thermal comfort (Tartarini et al., 2020), ventilation (Dhahri and Aouinet, 2020), acoustic performance (Baeza Moyano and González Lezcano, 2022; Moyano et al., 2022), lighting (Moyano et al., 2020) and spatial layout (Ribeiro et al., 2020).

Particularly in the workplaces, the satisfaction of building occupants with the qualities of their indoor environment has been associated with their health and wellbeing, self-assessed job performance (Veith et al., 2002; Hormigos-Jimenez et al., 2017), and behavior (Bordass and Leaman, 2005). Some of these can also have a significant influence on buildings' energy requirements due to the adaptive actions (e.g., on thermostats, blinds, lights, etc.) that users exercise in response to changes in environmental conditions (Haldi and Robinson, 2011). In this context, an awareness that people spend almost 90% of their time indoors (Delzendeh et al., 2017), and that salary costs in commercial buildings largely exceed investment and operational expenses, has triggered substantial interest in the potential contribution of green rating systems towards improved workplace experience (Fernandez-Antolin et al., 2021; Soharu et al., 2021).

Therefore, it is necessary to set up a building with a high level of IEQ to promote the health and wellbeing of its occupants (Toyinbo, 2019). Air quality is one of the factors that play a major role in providing a healthy IEQ (Hormigos-Jimenez et al., 2019; López et al., 2023). Indoor air quality can be compromised by both outdoor and indoor sources of pollutants related to building materials, equipment, animals and humans (Van Tran et al., 2020). Recent research has demonstrated new implementation methodologies for quantifying IEQ elements (i.e., thermal comfort, indoor air quality, visual comfort, and acoustic comfort) in real buildings (Sansaniwal et al., 2021b). Below is a summary of the main findings of the articles included in this Research Topic.

McLeod et al. propose a novel indoor air quality testing methodology in the context of post-occupancy performance assessment of a newly renovated architectural studio building at Loughborough University, UK. Additional scenario based testing was incorporated to isolate the presence and source of harmful volatile organic compounds, which were measured using diffuse sampling methods involving analysis using thermal desorption, gas chromatography, and mass spectrometry techniques. The results indicate that existing standards, designed to protect the health and wellbeing of students, are likely to mask potentially serious indoor air quality problems.

Mimura et al. presented a discussion on the prediction ability of three numerical models using the finite element method to predict the sound reduction index (SRI) of fixed windows having different dimensions in a laboratory environment. The results highlighted the importance of including a niche in a numerical model used to accurately predict the sound reduction rate below 1 kHz for smaller windows.

Khaledi et al. evaluated the impact of green spaces and their benefits during COVID-19 on mental health and generalized anxiety disorder. The authors demonstrated that the use of personal green spaces has a negative correlation and significant impact on general mental health and generalized anxiety disorder. It also plays a bigger role in reducing depression than reducing anxiety among individuals. Therefore, maximum land use policies should be reviewed. They further conclude that more attention should be paid to green spaces in post-COVID designs from a macro to small scale.

Okuzono and Yoshida describes the significantly higher efficiency of 3D-FEM (finite element method) against a frequency-domain FEM (FD-FEM) via acoustics simulation in a small cubic room and a small meeting room, including two porous-type sound absorbers and a resonant-type sound absorber. The authors modeled with local-reaction frequency-dependent impedance boundary conditions and an extended-reaction model. Results demonstrated the high potential and computational benefit of time-domain FEM as a 3D small room acoustics prediction tool.

Chen et al. presents the evaluation of a hybrid indirect evaporative cooling-mechanical vapor compression (IEC-MVC) cycle for cooling applications in Saudi Arabia. Over the whole year, IEC contributes 50% of the total cooling capacity and reduces energy consumption by 40% in dry cities, while the saving is lower at 15%–25% in humid cities like Mecca and Jeddah. The average water consumption of the IEC is in the range of 4–12 L/hr. The authors explained that the water consumption can be replenished by the condensate collected from the MVC evaporator if the ambient humidity is high. Based on the annual performance, the cost of the IEC-MVC process is calculated, and it is 15%–35% lower than the standalone MVC.

Yan et al. analyzed the characteristics of the subway environment and sort out six environmental elements that affect passengers' comfort, including thermal environment, vibration, noise, lighting, air quality, and air pressure. In addition, the measurement scheme, calculation model, and evaluation method of each element are outlined based on relevant norms and literature. The authors explained Measures to improve comfort, especially the exploitation of energy-saving air conditioning systems, will provide strong support for the sustainable and sound growth of the rail transit industry.

Kim et al. presents an advanced borehole heat exchanger that has been developed in order to apply a ground source heat pump to a volcanic island where the existing borehole heat exchangers are inapplicable by local ordinance. The proposed heat exchanger was also compared with the conventional heat exchanger that was made of high-density polyethylene (HDPE) heat exchanger. The authors revealed that the maximum heat capacity for the developed heat exchanger was measured at 63.9 kW, which is 160% higher than that of the high-density polyethylene heat exchanger (39.9 kW).

Rahman et al. explore the repertory grid technique (RGT) as a research method and advance its use in the built environment field. Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, this study conducted a systematic review to identify studies on Scopus that have used RGT before 2021. These studies were investigated according to subject area, location, year of publication, aim, and research design. The authors indicated the validity of RGT to the built environment by exploring different ways it may be employed. This review strongly recommends advancing the use of RGT in the built environment and taking advantage of its potential.

Ndou and Aigbavboa investigate the extent to which the indoor air quality (IAQ) management of higher educational institutions (HEIs) in South Africa could be improved through the appropriate implementation of environmental policy adoption enablers. According to the authors, an alternative to the management of IAQ is possible through environmental behavioral change. The inferential statistical evaluation using exploratory factor analysis revealed three crucial environmental policy adoption metrical approaches (stakeholder dialogue, institutional commitment, and policy composition) to the management of IAQ in HEIs.

Fowler et al. analyzed if a native American shelter (wigwam) can create comfort and if while doing so can provide healthy indoor air quality (IAQ) levels as defined by current standards. Concurrent to this research a technique to digitally model the outcomes of comfort created within the shelter was developed. It was found that comfort can be achieved to modern standards in this native shelter; as temperature, relative humidity, and rainfall exposure can all be controlled to acceptable levels. Indoor air quality is always at an acceptable level when a fire is not active. When an open fire is introduced, the particulates and VOC released into the interior of the wigwam are at dangerous levels.

González-Lezcano et al. focuses on the characterization of the residential building stock in the Madrid area. Despite the fact that no evidence was found to justify that climate is a significant variable in terms of airtightness, it seems clear that there are different aspects associated with the region where the building is located such as differences in construction quality, dwelling design or materials, or due to differences in the building size or age. The authors delved into the main causes of the lack of airtightness in multi-family homes through 151 tests of blower doors in the Community of Madrid.

Maciá-Torregrosa et al. presents a comprehensive refurbishment project undertaken in the Lagos Park residential building in Madrid. The authors offers a detailed analysis of common building Research Topic related to excessive humidity in the surrounding areas and deficiencies in the energy performance of the building envelope, including facades and roofs. Precise measures for achieving compliance with the Spanish Technical Building Code, as well as enhancing energy efficiency and functionality, are explained through the renovation of the building envelopes. The study also encompasses improvements made to the domestic hot water supply systems and the air-conditioning system, which contribute to the building's attainment of an optimal energy rating

This Research Topic aims to address issues concerning Indoor Environmental Quality (IEQ), which are described more simply as the conditions inside the building. It includes air quality, but also access to daylight and views, pleasant acoustic conditions and occupant control over lighting and thermal comfort. They will also include the functional aspects of the space, such as whether the layout provides easy access to tools and people when needed and whether there is sufficient space for the occupants. Building managers and operators can increase building occupant satisfaction by considering all aspects of IEQ rather than focusing on temperature or air quality alone.

Author contributions

RG-L: Conceptualization, Formal Analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing–original draft, Writing–review and editing. SS: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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