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Proposal for a small two-story living room house based on air-quality monitoring

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Abstract

The evolution and innovation in construction is based on extensive testing and validation, best performed on existing buildings, in order to assess their behavior in time. Occupants health and comfort issues are fundamental concerns of the society, which together with economy and environment make up the "sustainability triangle". This becomes even more significant in the case of dwellings with reduced floor areas and built in high-density urban areas. The paper focuses on monitoring air quality parameters in an existing two-story living room house and proposes an architectural solution for improving comfort conditions. The 48 square meters house is a sustainable design, with low-embodied energy, high thermal performance and open-floor flexibility. In order to highlight the benefits of this open-space house, the study was focused on the comparison of two types of dwellings - a two - bedroom apartment with conventional subdivision and a one - bedroom house with double-height living room. In both cases the same indoor comfort parameters were measured: CO_2 levels, humidity and temperature. The study is structured in two stages: the monitoring of the interior air quality of a two-story living room and the proposal of a similar house typology with improved comfort parameters. By analysing the complex monitoring data, the new architectural proposal keeps the environmental qualities of the existing house, with improved comfort benefits.

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Keywords: indoor air quality; interior comfort; natural ventilation; sustainability; two-story living room.

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1. Theoretical background /Research problem

Taking into account that people spend most of the time indoors, ensuring optimal air quality parameters is an essential prerequisite, strictly regulated by European standards, mandatory for contemporary residential buildings[1]. Recent studies in the field of indoor air quality (IAQ), accentuate that CO_2 levels higher than 1000-1100 ppm in the bedrooms have a direct long impact on human health, with the first effects consisting in lack of deep sleep, resulting in a decrease in productivity and degradation of the health status over time [2]. The issue is of most severity if we consider that more than 57% of bedrooms are inadequately ventilated [3]. This worrying statistics is, in part, a direct consequence of sealing the sleeping space by air-tight windows and doors [4].

Romanian legislation stipulates by Order 1659 of 22.06.2011 (Normative for the design, execution and operation of ventilation and air-conditioning installations) the classification criteria of buildings depending on the indoor air quality in relation to the exterior CO_2 levels. Thus, for the IDA 1 standard, high quality indoor medium, the room CO_2 levels must be no higher than 400 ppm over the exterior levels. The qualities of indoor environment and optimal ventilation are also part of the European legislative framework that sets the energy performance criteria for buildings - EPBD, 2010/31 / EU.

Indoor environment problems become acute in densely built urban areas, where often it is opted for flats with minimum net area and reduced air volume. Judicious design can greatly increase in this case the indoor comfort parameters, the overall behavior of the building in time and the degree of satisfaction and health of the occupants.

2. Approach /Research methodology

As a response to increasing urban density and in order to reduce the environmental impact, architects are designing more compact sustainable dwellings, with lower embedded energy. In this context the improvement of indoor environment quality (IEQ) involves two types of actions:

- measurement of indoor microclimate indicators under real conditions of use for existing buildings;
- proposals for improvement of IAQ parameters from the design phase of new buildings.

For the first stage of this research, a small sustainable house, designed and built in the city of Iași by one of the authors is analysed (Fig.1).

Fig. 1. (a) Exterior view; (b) Double-height living room.

The monitored house was build in 2016 and has a total area of 65 square meters, 48 square meters of usable space and a capacity of two occupants. From the architectural point of view, the main element of interest is a double-height living space with natural lighting from three directions - East (major opening), South (main source of light in winter) and West. Coordinating these openings and their size ensures an optimal level of illumination and significantly reduces the time intervals of artificial light usage. All other adjoining rooms open directly to this main space, thus contributing to the general indoor air quality. Fresh air intake is supported by the openings on the