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Effect of wall construction materials over indoor air quality in humid and hot climate

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A B S T R A C T

In the present research work, a mix of 15 modern and old office buildings were sampled and classified in accordance with their building construction materials, along with the indoor ambience conditions. From this hourly study, it was found that the season was not the more important parameter, despite there being a tendency towards a similar kind of ambience during the rainy season. On the other hand, it showed a clear difference between modern and old buildings with plaster coating, during the period of occupation. Specifically, a better indoor ambience prevailed in the old buildings. At the same time, when marble and plaster coatings were analysed in the old buildings, a clear difference in indoor ambience was felt at the time of opening the office. This shows that a better indoor ambience prevailed during the dry period in the old buildings when marble coatings were used. Finally, the same effect, but not as pronounced, seen in the indoor ambience during the opening of the office, was obtained in new buildings that had marble coating.

Finally, the procedure obtained could be the much sought-after solution to the problem stated by researchers in the past and future research works relating to this new methodology could help us define the optimal improvement in real buildings to reduce energy consumption, and its related carbon dioxide emissions, at minimal economical cost.

Contents

1. Introduction

Passive methods are an interesting design parameter that allows us to improve indoor ambiences by means of an adequate understanding of the processes and physics of building construction. Notable

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developments were achieved in the past few years to define building thermal processes, but its hygroscopic effects have not been clearly defined. Different international research projects of the International Energy Agency have tried to define these effects and to develop building design guides based on this concept.

Despite the fact that different research works have developed building simulation tools, employing actual sampled data to validate them is required. In previous research works [1], the effect of permeable covering in a humid region of Spain was shown based on real sampled data and statistical studies. The main results showed a clear improvement of indoor ambiences of buildings with permeable internal coverings, like wood and plaster, in contrast with the other ambiences under impermeable internal coverings, like paint and plastic [2,3]. This same effect could be related, at the same time, with an average and immediate improvement in local thermal comfort [4–9] and energy saving [10]. Results show how permeable coverings allow construction materials in building walls to absorb very high humidity in the indoor air and release it when the humidity is very low. This effect showed a clear working behaviour during the unoccupied hours of the office buildings. During this period, the number of air exchanges is reduced, and the infiltrations by doors and windows are nearly null. Consequently, indoor ambience during the first hour of occupation was modified towards favourable conditions, thus reducing peak energy consumption during that period.

In sub-Saharan Africa, very few studies have been conducted to analyse the influence that different types of buildings have on indoor air quality. In accordance with previous research works, the thermal and hygroscopic effects of local materials used in new and old buildings can be of interest for engineers. The types of bricks employed in wall construction will also be analysed. Two types of brick materials are employed in Cameroon: parpen and earthen bricks. Owing to the different levels of permeability, they are expected to have some different kinds of effects over the indoor ambience. Other parameters, like permeability level of the wall's external coating were also analysed. To achieve these objectives, 15 office buildings located in the humid and hot region of the capital city of Cameroon were studied during two seasons, in accordance with the procedure developed by Toftum et al. [11].

2. Materials and methods

2.1. Buildings description

In the present research work, 15 types of office buildings were sampled and classified in accordance with their building construction materials. It must be clarified here, that old buildings were considered as those that were more than 25 years old. In particular, these old buildings are named B2, B6, B9, B11, B12, and B14 in the tables and figures, since they were built with earthen bricks.

On the other hand, the new buildings are named B1, B3, B4, B5, B7, B8, B10, B13 and B15, since they used parpen bricks, as we can see in Table 1. Finally, for favourable comparison, all buildings present the same wall structures and orientation. Some, have an internal coating that mostly consists of marble, which is often dressed in fabric wool. The outer layer of the wall is made of mud bricks and plaster in old buildings. In new buildings, bricks of parpen, plaster and paint are employed. An example of a wall segment is given in Fig. 1. The structure and characteristics of the buildings studied are reported in previous table. In some buildings, large windows occupied more than half the wall areas, and are covered by curtains, thus preventing light rays from entering indoors and doors are mostly made of wood. In accordance with previous research works, selected offices were naturally ventilated, and the cooling and heating systems were interrupted during the experimental studies. In these offices, we could found some computers and sometime TV as electrical equipments. There were still less than 8 employees during study period in the office. These workers were estimated having a sedentary occupation, which corresponds with a metabolic rate around of 1 met, in accordance with thermal comfort standards.

2.2. Materials

In this study different indoor air variables were sampled. Between others, variables like indoor air speed, indoor relative humidity, CO_2 concentration and indoor air temperature were measured using a thermo-anemometer (model C.A 1226) and a CO_2 Monitor (model CO200).

On the other hand, outdoor weather variables were sampled to consider the effect of weather and indoor conditions. In this sense, data relating to outdoor temperature, wind speed and relative humidity were collected from the national weather stations. It must be explained that all these equipments were calibrated before use, to ensure reliability and accuracy during the sampling processes. Furthermore, the sampling accuracy of each device is shown in Table 2.

2.3. Sampling period

In the present research work, a sampling process with frequencies of 10–20 min was carried out during the working hours from 08:00 to 17:00, and during the unoccupied period from 17:30

Table 1
Some characteristic of offices studied in the buildings.

Buildings	Altitude (m)	Floor area (m^2)	Volume (m^3)	Height (m)	External coating	Type of brick	Type of building	Age (years)	Window area (m^2)	Door area (m^2)
B_7	782 ± 2	71.5	299.1	4.2	Plaster	Parpen	New building	2	0.18	1.46
B_{15}	730 ± 7	47.5	137.7	2.9	Marble	Parpen	New building	7	0.50	1.90
B_{10}	731 ± 7	36.0	126.0	3.5	Plaster	Parpen	New building	15	0.35	2.26
B_{13}	763 ± 2	55.2	209.8	3.8	Paint	Parpen	New building	5	0.40	1.95
B_3	784 ± 5	59.5	220.1	3.7	Plaster	Parpen	New building	18	0.66	3.75
B_4	763 ± 4	96.0	288.0	3.0	Plaster	Parpen	New building	11	0.36	1.80
B_5	762 ± 8	49.0	186.2	3.8	Plaster	Parpen	New building	5	0.75	1.71
B_8	748 ± 7	32.0	121.6	3.8	Paint	Parpen	New building	22	1.20	3.00
B_1	750 ± 8	80.0	280.0	3.5	Plaster	Parpen	New building	16	0.42	1.90
B_9	696 ± 5	66.0	270.6	4.1	Paint	Earth	Old building	45	0.58	1.62
B_{11}	734 ± 5	45.0	180.0	4.0	Marble	Earth	Old building	39	0.84	2.10
B_{12}	717 ± 3	76.5	306.0	4.0	Paint	Earth	Old building	28	1.02	1.93
B_2	762 ± 3	84.0	336.0	4.0	Plaster	Earth	Old building	31	0.70	2.28
B_{14}	747 ± 4	35.7	149.9	4.2	Plaster	Earth	Old building	51	1.45	1.35
B_6	761 ± 3	54.0	210.6	3.9	Plaster	Earth	Old building	32	088	2.20