Analysis of the Moisture Content and Temperature Levels in Different Types of Brick Walls–Case of Tirana, Albania

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ABSTRACT*:* This paper presents information about the moisture content and temperature level of brick walls in Tirana, Albania. The buildings whose walls have been studied, were built in two different eras, throughout the twentieth century, and in more recent times. Given that during the second half of the twentieth century, Albania has been isolated from most of Europe and the West, and consequently the new architectural ideologies of the time, have not had the proper implementation there, the paper focuses on the characteristic types of bricks used in Albania, the functions for which they are used, and their effectiveness in achieving comfort (thermal, moisture content control) during the two time periods mentioned above.

Depending on the functions bricks perform in the walls studied in this paper, the walls are separated in two main groups: Walls in which bricks have structural role (red silicate brick walls, white silicate brick walls); Walls in which bricks do not have structural role (concrete block walls, holed brick walls). For all the types of bricks mentioned above, indoor moisture content and temperature measurements have been performed in all four cardinal directions. For the walls in which the bricks have a structural function, moisture measurements have been performed in all the facades of the buildings, because moisture in the bricks of these types of buildings, being a very important factor, directly affects the structural performance of the elements.

The aim of the paper is to show the differences in moisture and temperature levels of the walls of these buildings, depending on the engineering and architectural techniques used during the building process, the use of insulation, and the masonry composition.

KEYWORDS – *bricks, comfort, insulation, masonry composition, moisture content, temperature level*

I. INTRODUCTION

Typical existing buildings in Albania are traditionally built with retaining walls. In Albania, during the communist period and until its end in the early 1990s, masonry buildings were constructed using standard projects. The typologies of masonry buildings vary in use from public to official. This article focuses on the levels of moisture and temperature of different brick walls, built during the communist period, and in more recent times. [1].

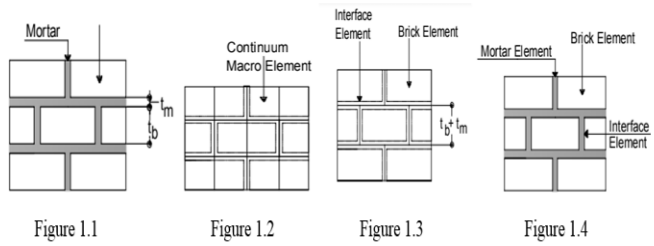


Fig. 1 - Masonry modeling strategies: 1.1) Masonry sample; 1.2) Macro-modeling; 1.3) Simplified micro-modeling; 1.4) Detailed micro-modeling [2]

The main types of bricks that were used during the communist period, together with their binders, are presented in this KTP table:

Table 1 – Brick types and binder classes [3]

Nr.	Wall type	Mortar class (kg/cm^2)			
		100-50	25	4	0
1	Silicate brick walls and concrete block walls	1000	750	500	350
2	Walls with vertically holed bricks	2000	1500	1000	-
3	Walls with horizontally holed bricks	1500	1000	750	-
4	Stone walls	2000	1000	750	-

Depending on the brick function in them, the walls studied in this paper, were separated in two main groups:

- Walls in which bricks have structural role: red silicate brick walls, white silicate brick walls;

- Walls in which bricks do not have structural role: concrete block walls, holed brick walls.

For the walls where the bricks have a structural function, moisture measurements have been performed in all the facades of the buildings. In this case, a white silicate brick building and a red silicate brick building were selected for the measurements to be performed. Moisture in the bricks of these types of buildings is a very important factor, because it directly affects the structural performance of the elements.

For a building to be properly designed in a sustainable way, there are three main components to be taken under consideration: energy performance, environmental impact, and the safety and health of the inhabitants [4]. In order to achieve all of the above, the building interior should be more isolated from the outer environment. Different solutions can be applied in order to improve the humidity levels in the buildings if necessary. The simulation results demonstrate that some improvements to the building's fabric and controls can bring about better performance. Specifically, certain combinations of improvement measures (better windows, better wall/roof construction, natural ventilation) have the potential to significantly improve the thermal performance of the buildings in the climatic context of Tirana, Albania [5].

Most houses have varying levels of humidity up to 50%, so moisture levels in drywall can vary from home to home. While relative humidity can have some effect on moisture levels, drywall is considered to have an appropriate level of moisture if it has a moisture content of between 5 and 12%. Even a reading of up to 17% means that the drywall is salvageable, but any moisture level above 17% tells us that the drywall has been compromised and will need to be replaced, or cannot be used. [6].

If the moisture content in these type of walls does exceed the permissible level [7, 8], it is necessary to undertake measures for its reduction.

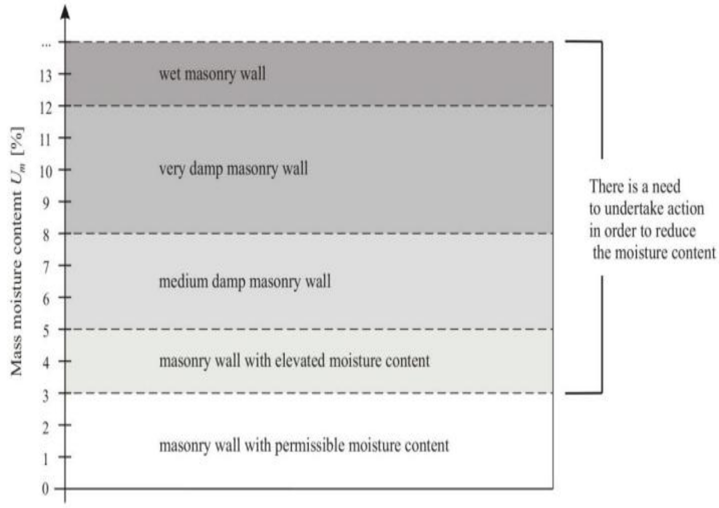


Fig. 2 - Classification of the moisture content of brick walls, based on [7, 9, 10].

II. MEASUREMENTS

For the measurement of the moisture of the bricks in the external and internal walls, the device 'SILVERLINE - Digital Moisture Meter' was used, while for the measurement of the temperature of the walls in the internal walls, the device 'MESTEK - INFRARED THERMOMETER' was used. Measurements were performed on the ground floors in each case, at two different heights, 70 and 90 centimeters from ground level respectively. Measurements are performed every 50 centimeters along the wall surface. These measurements were perfomed on December 15 2021. The time during which the measurements were performed, was between 9 and 12 in the morning, with temperatures of 10-13 Celsius degrees during the measurement time. All the buildings studied for this paper were located in the vicinity of the area known as "Mozaiku i Tiranes". The buildings are found in a range of 1 kilometer from one another.

Fig.3 – The area where the buildings are located, Source: Google Maps

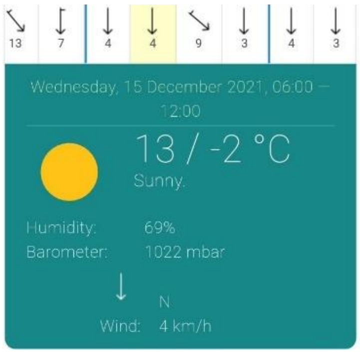


Fig. 4 – Weather report of the day of the measurements, Source: world-weather.info

Fig. 5 – SILVERLINE Digital Moisture Meter

Fig. 6 – MESTEK INFRARED THERMOMETER

III. OUTDOORS MOISTURE LEVELS IN STRUCTURAL BRICK WALLS

Water inside the masonry is always a potential source of damage if it is not properly drained. Pure water does not always cause direct damage to bricks and mortar, while rainwater, which contains dissolved carbon dioxide, acts as a mild acid and dissolves calcium carbonate to form soluble bicarbonates, as in the formula below:

$CO_2 + H_2O \Rightarrow H_2CO_3$(1)

$CaCO_3 + H_2CO_3 \Rightarrow Ca(HCO_3)_2$ (2)

So, elements like ordinary cement lime mortar, porous limestone, porous sandstone, porous concrete blocks and some types of silicate bricks, are degraded by the action of rain, because calcium carbonate is a key component. The process is often accompanied by darkening, due to precipitation of dissolved materials. Bricks lose their surface and can develop pits and degradations, which also affect the structure. [11]

1.1 Moisture content in white silicate brick walls

Fig. 7 – The white silicate brick wall building facades, Source: Authors

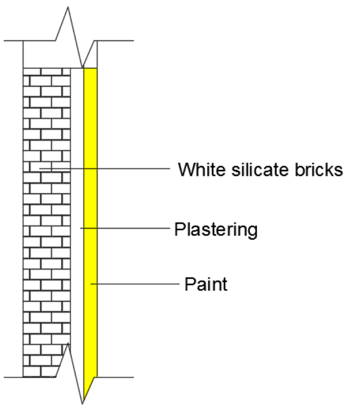


Fig. 8 – White silicate brick wall section cut, Source: Authors

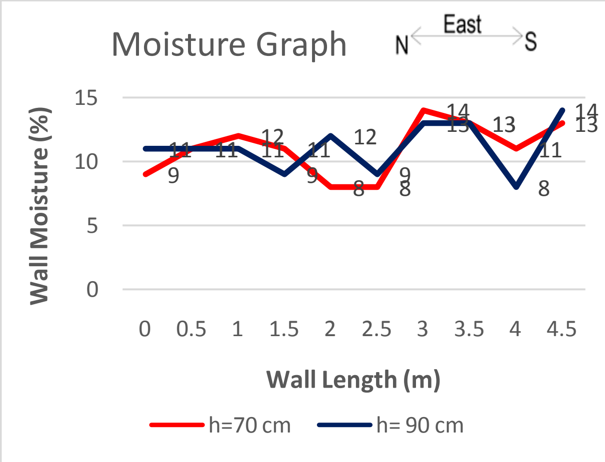


Fig. 9 - Eastern façade moisture graph, Source: Authors

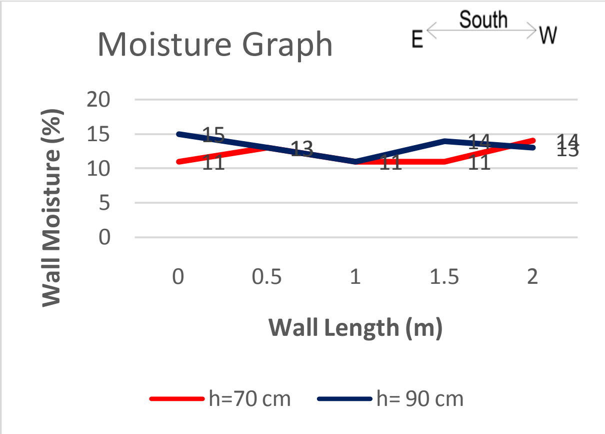


Fig. 10 - Southern façade moisture graph, Source: Authors

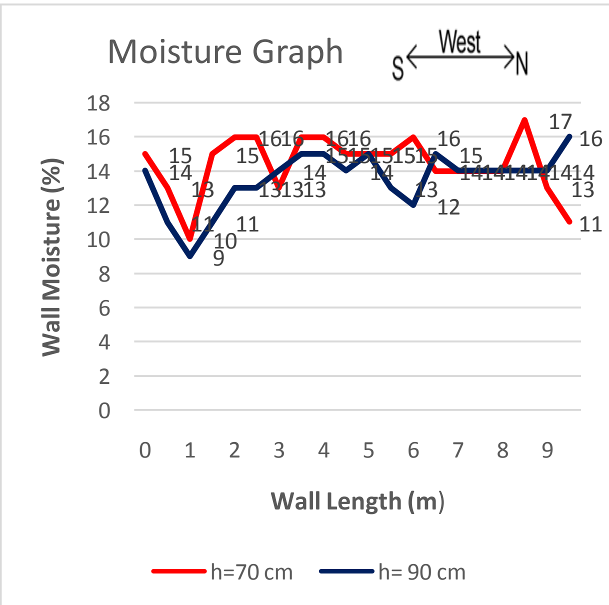


Fig. 11 - Western façade moisture graph, Source: Authors

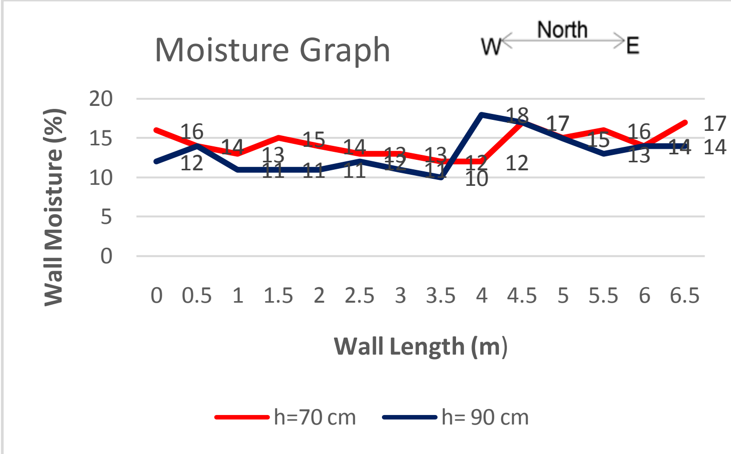


Fig. 12 - Northern façade moisture graph, Source: Authors

1.2 Moisture content in red silicate brick walls

Fig. 13 – Red silicate brick wall façade and mold evidence, Source: Authors.

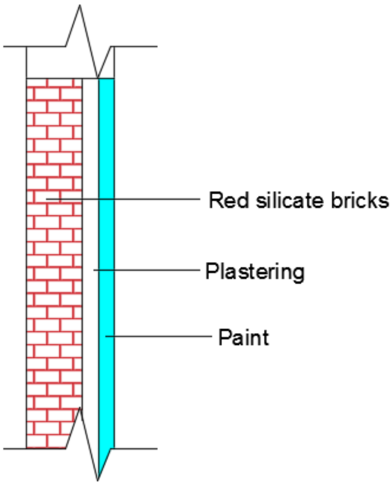


Fig. 14 – Red silicate brick wall section cut, Source: Authors

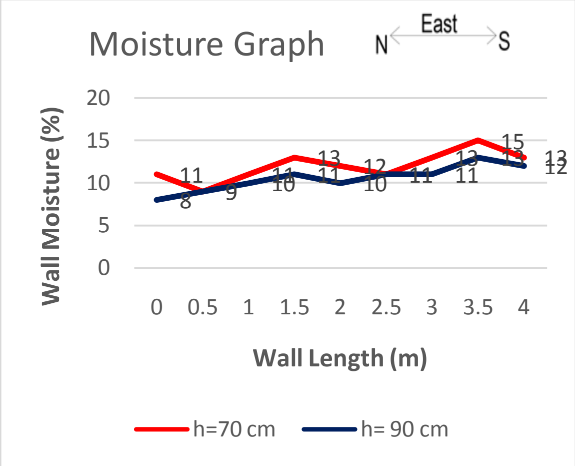


Fig. 15 - Eastern façade moisture graph, Source: Authors

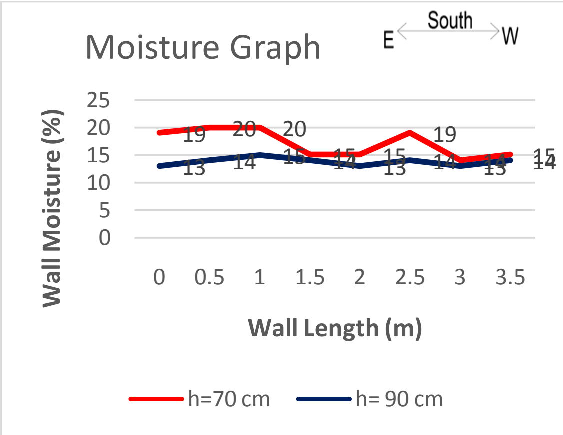


Fig. 16 - Southern façade moisture graph, Source: Authors

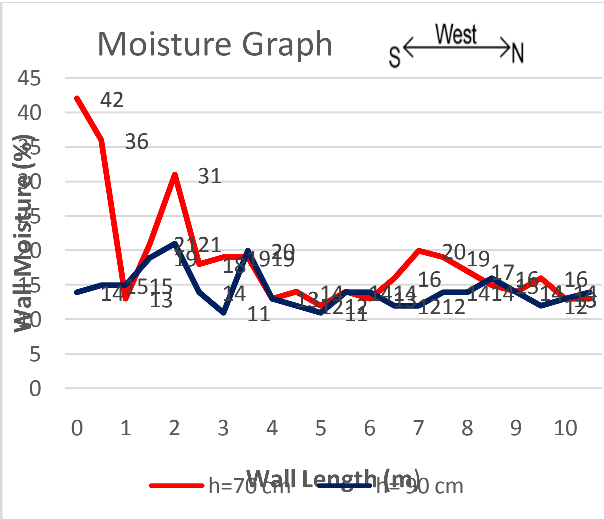


Fig. 17 - Western façade moisture graph, Source: Authors

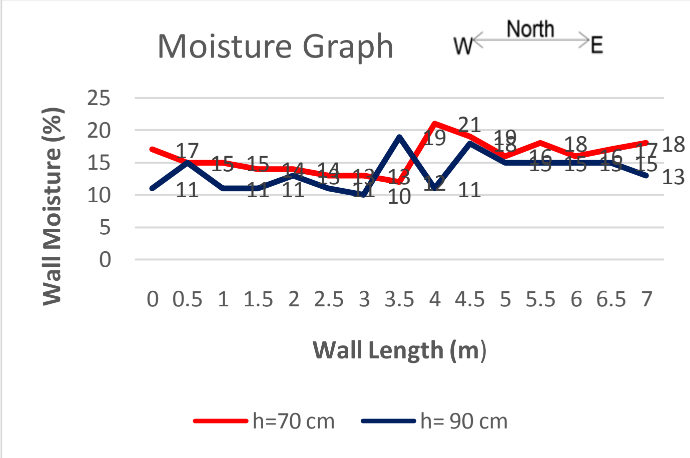


Fig. 18 - Northern façade moisture graph, Source: Authors

1.3 Comparison between white and red silicate brick walls

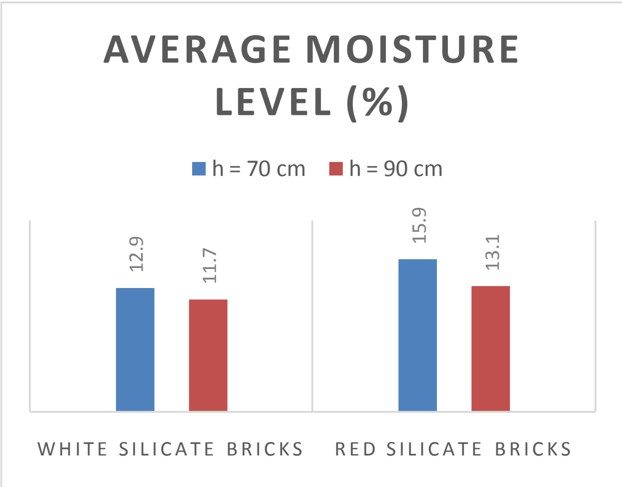
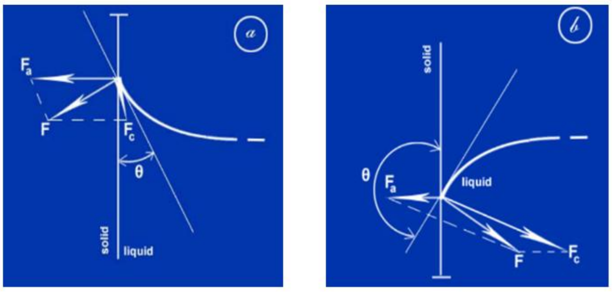


Fig. 19 - Comparative graphs between red and white silicate bricks, Source: Authors

The graph indicates, that the white silicate brick walls perform better than red silicate bricks walls in terms of moisture content, in both 70 centimeters and 90 centimeters heights. The moisture level average of white silicate walls is 12.9 % at 70 centimeters of height, and 11.7% at 90 centimeters, while the red silicate bricks have an average of 15.9 % of moisture at 70 centimeters, and 13.1 % at 90 centimeters. It can be seen by the graph, that as we go higher from the ground, the moisture level in the walls reduces. This happens as a result of the water capillarity phenomenon. The action between a capillary tube and water is called capillary action. If a marginal molecule common to both the liquid surface that is in contact with a solid and the liquid free surface, on this molecule the cohesion and adhesion forces Fc and Fa will exert a resultant force F. At this point the liquid surface tends to get a position such that to become normal to F. When Fa>Fc the liquid is wetting the solid surface; i.e. the liquid free surface becomes concave near the solid plate and the contact angle θ<90o (Figure 20a). When Fa<Fc the liquid does not wet the solid surface (Figure 20b). [12]



a b

Fig. 20 – Water capillarity, Source [12]

IV. INDOOR MOISTURE CONTENT AND TEMPERATURE LEVELSFOR ALL BRICK WALL TYPES

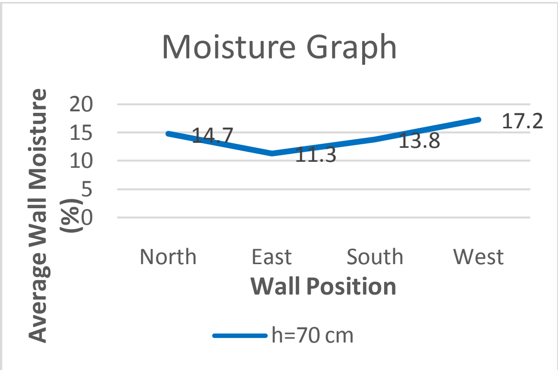


Fig.21 – White silicate brick wall average moisture content graph, Source: Authors

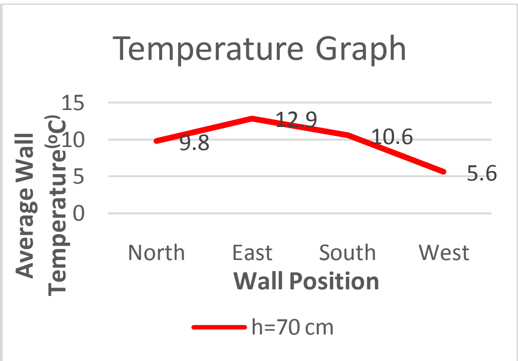


Fig.22 – White silicate brick wall average temperature graph, Source: Authors

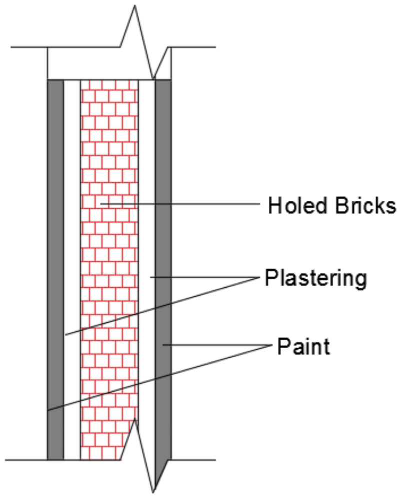


Fig. 23 – Insulated holed brick wall section cut, Source: Authors

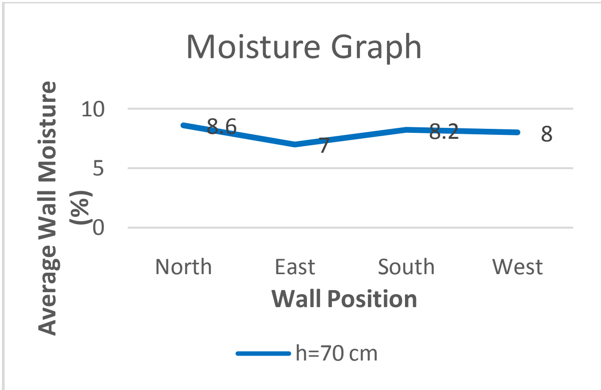


Fig.24 – Insulated holed brick wall average moisture content graph, Source: Authors

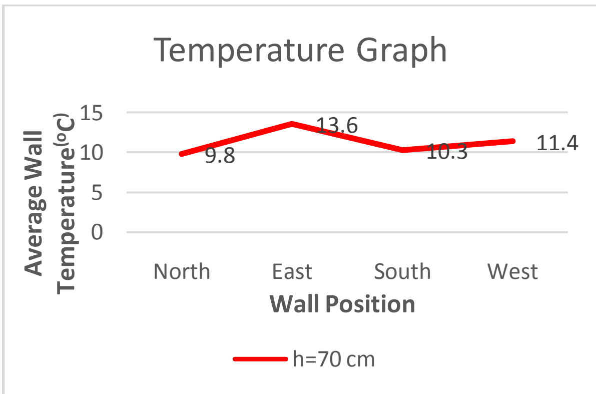


Fig.25– Insulated holed brick wall average temperature graph, Source: Authors

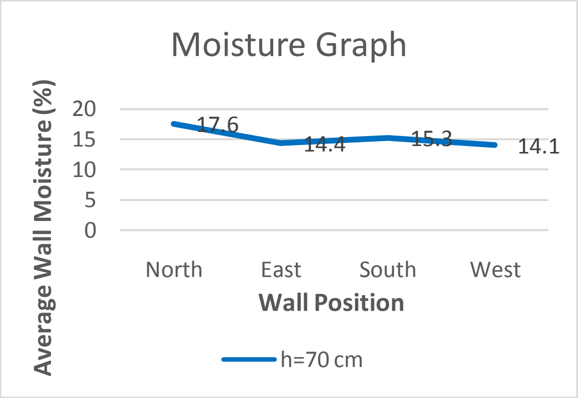


Fig.26– Non-Insulated holed brick wall average moisture content graph, Source: Authors

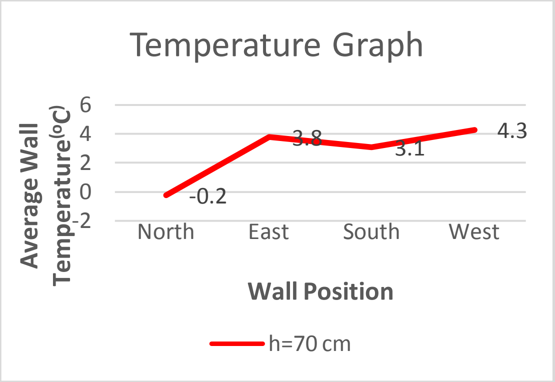


Fig.27– Non-Insulated holed brick wall average temperature graph, Source: Authors

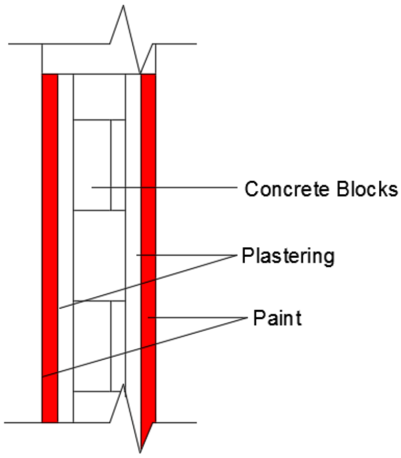


Fig.28– Concrete block wall section cut, Source: Authors

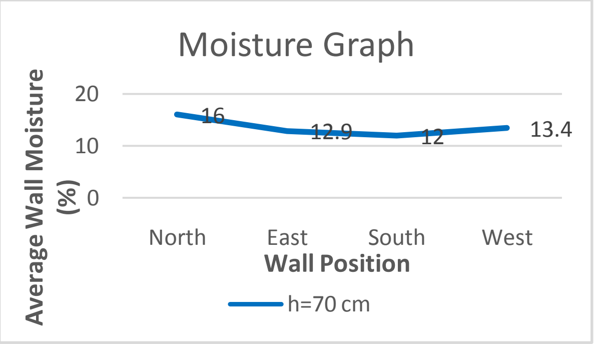


Fig.29– Concrete blocks wall average moisture content graph, Source: Authors

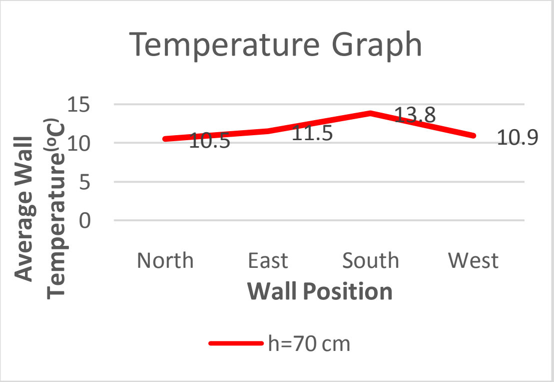


Fig.30– Concrete blocks wall average temperature graph, Source: Authors

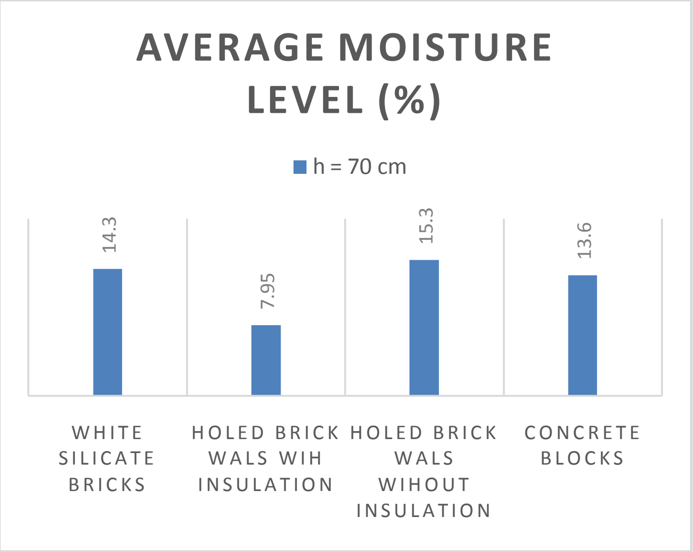


Fig.31– All wall types average indoor moisture content comparison graph, Source: Authors

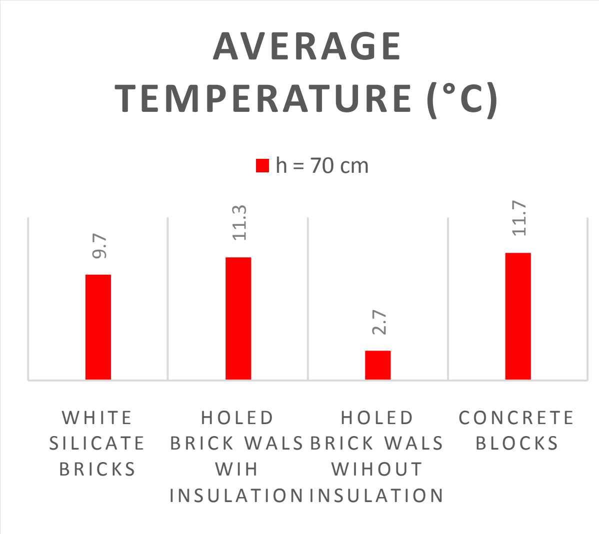


Fig.32– All wall types average indoor temperature comparison graph, Source: Authors

V. CONCLUSIONS

In terms of outer walls moisture content, the white silicate bricks work provide a better protection than the red silicate bricks, in both 70 and 90 centimeters of height from the ground. By observing the average level of moisture, it appears than not any of the walls studied reaches the uppermost limit of 17%, but as noticed in different parts of the walls, some areas of the walls reach moisture percentages as high as 44%, which might cause structural problems. These problems can be noticed by the appearance of mold in these regions of the wall. Judging by the average moisture content in the 70 centimeter height, both red and white silicate brick walls appear to be classified as wet masonry walls. In the 90 centimeter height from the ground, the white silicate walls can be classified as very damp masonry walls, while the red silicate brick walls as wet masonry walls. In both walls studied, the moisture content lowers as the height from the ground increases, due to the water capillarity.

From the inner walls studied, insulated holed brick walls provide the best protection against moisture, this being reflected in temperature absorbing characteristics, while the holed bricks without insulation are the worst provider for temperature absorbance and moisture protection. The white silicate bricks and concrete block walls, despite not being in the same rank as non-insulated brick walls, still do not show very good moisture resistance, because of the poor layering of the insulation. In terms of the highest temperatures, despite the not so good moisture resistance, the concrete block walls offer the best temperature conservation levels.

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