International Journal of
Civil Engineering (IJCE)
ISSN(P): 2278–9987; ISSN(E): 2278–9995
Vol. 10, Issue 2, Jul–Dec 2021; 1–12


International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

# THE WALL AS ARCHITECTURE SPACE ENHANCING THERMAL AND LIGHTING EFFICIENCY FROM TRADITIONAL TO MODERN BUILDING

***Dr. Abdulfattah Yahya***

*Department of Architecture, Cairo University, Yemen*

## *ABSTRACT*

*The architectural wall is a space, rather than a separation between two spaces or a separator between the inside and the external environment. The buildings with the bearing walls, which are based on natural building materials such as clay and stone, use walls as extremely thick of one and a half meters and are even used in multi-story buildings as the mud buildings of Shibam Hadramout and the stone buildings of the city of Yafi in Yemen, So the objective of the research is to take full advantage of the traditional buildings by the process of design in spaces of the traditional buildings and the emergence of economic and environmental importance in order to return to the building styles while taking advantage of modern technology, The researcher assumes that the design treatments for the interior spaces of the traditional buildings achieve maximum benefit in terms of the thermal and lighting environment Thus, the problem is the lack of full awareness of the environmental benefits of the walls, especially in the traditional buildings (clay, stone, wood). The architectural wall in these buildings is important. Can we deal with it as a space? And exploitation of internal loads in order to deal with the horizontal projection as a block and can unload it as need Secondly, neglecting the design treatments for the internal space, The comparative analysis between the architectural wall of a space in a stone building for the city of Yafi and the other in a modern building with the same size and dimensions were studied. The effect of light and heat was studied on the Design builder and the deluxe programs. The efficiency of the old buildings was calculated in thermally and the lighting was not appropriate in contrast to the modern buildings, the thermal beaver of the wall as an architectural space in bearing buildings is important architecturally, functionally, environmentally and constructively taking into account the improvement of lighting.*

***KEYWORDS:*** *Wall-Space-Bearing Buildings-Thermal Efficiency-Lighting Efficiency*

***Article History***

***Received:*** *14 Aug 2021* **|** ***Revised:*** *20 Sep 2021* **|** ***Accepted:*** *24 Sep 2021*

## INTRODUCTION

### Walls

The Wall is an element of a flat surface structure that is determined by three dimensions: height, length, and thickness. The wall can is a non-structural element, that is, it carries only its own weight. It is generally in the vertical plane or, a structural element it carries loads and weight other than its own weight, As in Figure 1.

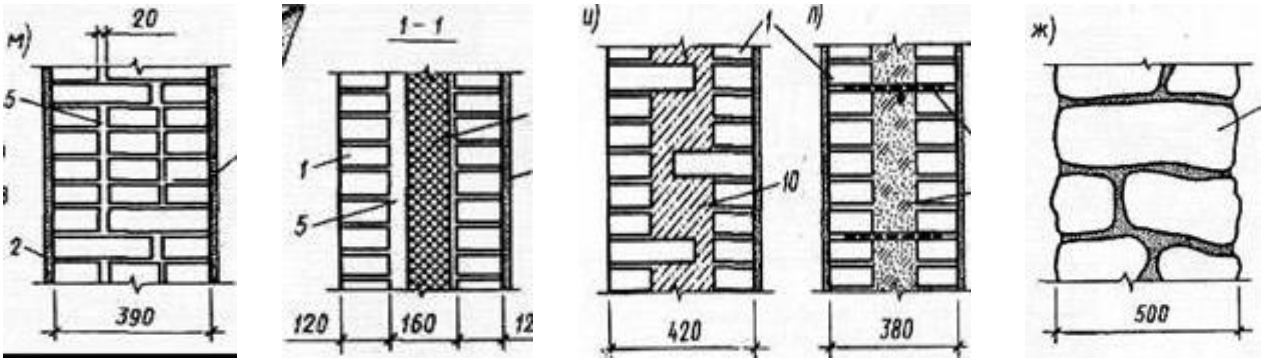


**Figure 1: Brick Is One of the Most Technologically Advanced Construction Materials. Due to Its Excellent Performance and Technical Characteristics, it Has Long Been Used By Humans for the Construction of Small One-Story Buildings and the Construction of Large Multi-Story Buildings.**

## Wall Definition

The approved document, Fire Safety in Dwelling houses, suggests that for the purpose of the performance of wall linings, a wall includes:

- The surface of glazing (except glazing indoors).
- Any part of a ceiling which slopes at an angle of more than 70º to the horizontal.

However, the Approved document, Site preparation, and resistance to moisture, suggests the kind of wall.as in the Table 1.

**Table 1: The Type of Wall**

| | |
|---|---|
| Buttressing wall | Partition wall |
| Cavity wall | Party wall |
| Compartment wall | Pile wall |
| Curtain wall | Rain screen |
| Dwarf wall | Separating wall |
| Green wall | Solid wall |
| Internal load-bearing wall | Supported wall |
| Parapet wall | Trombe wall |

## The Manufacture

Bricks are most typically made from clay, although they are also usually made from calcium-silicate and cement. Other than the standard rectangular block, a number of special shapes exist for special conditions that may be found when building with bricks. These include: Radial, reduced or arch bricks—Angle and can't brick that form returns and rooms—Bull nose bricks with rounded edges—capping and coping bricks. Cell bricks—Plinth bricks—Brick slips. Soldier bricks, —Bricks can also be cut to size.

## Typical Values

U-values are measured in watts per square meter per Kelvin (W/m²K). For example, a double-glazed window with a U-value of 2.9, for every degree difference in temperature between the inside and outside of the window, 2.9 watts will be transmitted every square meter.

A range of U-values are indicated below for the ideas of illustration only:

- õ Solid brick wall: 2 W/m²K.

- Cavity wall with no insulation: 1.5 W/m²K.
- Insulated wall: 0.18 W/m²K.
- Solid timber door: 3 W/m²K.
- Single glazing: 4.8 to 5.8 W/m²K.
- Double glazing: 1.2 to 3.7 W/m²K, depending on the type.
- Triple glazing below: 1 W/m²K.

It should be noted though that these are maximum approved values, the term for the general residential building included in Part L1A has considerably lower rates, for example:

- External wall: 0.18 W/m²K.
- Floor: 0.13 W/m²K.
- Roofs: 0.13 W/m²K.
- Roof windows, glazed roof lights, and glazed doors: 1.4 W/m²K.

Wall Ties are a necessary element in the force and confidence of cavity walls, but by joining the cavity they work as a thermal bridge between the internal and external skins. Usually, the deeper the insulated cavity, the more important the Wall Tie is required to be, and the higher the impact the tie will then have on the U-value of the wall.

### The Cavity Walls

It is a wall made by an internal skin and an external skin of masonry, joined by ties, but divided by a cavity. The masonry is made by units such as brick, stone, or block. Very regularly, if the outer walls of a building are less than 30 cm thick, then they are incredible to cover a cavity. A Cavity wall survived in Greek and Roman times, but only formed as an element of more recent build in the 18th and 19th centuries. The use of metal ties to join the two skins only developed in the second half of the 19th century and then became more general towards the start of the 20th century.

## ENERGY EFFICIENCY IN HISTORIC BUILDINGS Ancient CAVITY WALLS

Thermal mass in outside walls can take up the heat while the day from the inside and then re-release it at night, thus balancing out the need for artificial heat and reducing overall energy use. This impact will be significantly decreased by the extension of internal insulation but can be very improved by external insulation**.**

### Clay in Construction

Clay is a finely-grained natural rock or soil element that, forward with extra materials such as stone and wood, has been used for construction for thousands of years. It is made of one or more clay crystals (such as kaolinites or smectites), sometimes with small numbers of quartz, metal oxides, and original matter. Clay is made very slowly as a result of the weathering and erosion of rocks including the crystal collection known as feldspar.

Due to the particle volume (typically, a grain size of fewer than 4 micrometers (μm), and water content, clays have high flexibility until they are dried or shot, at which point they become strong and inelastic. As Figure2.

Figure 2 shows presence of water in the soil is one of the most important factors affecting the transfer of pollutants and their interaction and clay soil. Recently, the science of geology has emerged, which deals with the interaction, transfer, and treatment of organic, inorganic, and organic pollutants.

**Figure 2: Quaternaryclay in Estonia -Magnification 23,500.**
**http://www.austsaw.com.au/cutting/clay-and-mud**

## Stone in Shape

Is it a kind of construction that has been managed for thousands of years? The first stone walls were built by farmers and old people; later, mortar and plaster were used, particularly in the shape of city walls, palaces, and other castles during the Middle Ages. These stone walls are developed all over the world. It is normally made of different local materials from limestone and granite to sandstone. However, the condition of the building stone ranges considerably, both in the stability of the weather factors, and the resistance to water entrance, and in its strength to be managed in normal shapes before construction. Granite is highly resistant to weathering, while some limestone is very low. Is Portland stone, is more climate resistant? Dimensions Huge structures are normally composed of very thick walls, so castles and cathedrals control walls that may have a thickness of up to 3.6 meters. It is normally composed of layers of stone and rubble. We view the old city of Sana'a, for example, the stone building and its wall, which continues for 6200 meters as in Figure3

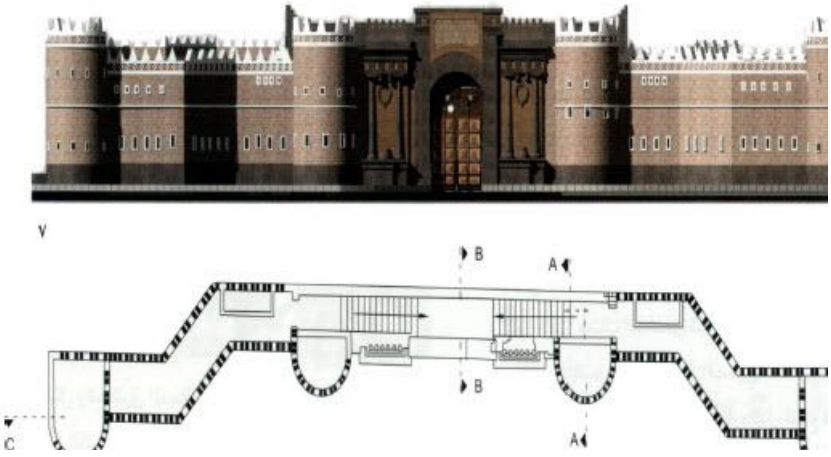


**Figure 3: The Door of Yemen in the City of Sanaa Stone Building up to 3.6 Meters Back to the Fifth Century BC.**
**https://ar.wikipedia.org/wiki/old Sanaa**

## The Foundations of the Evaluation of the Walls in the Colloquial Architecture

(Respect for site characteristics—Reduce energy consumption—Twins with climate environment—Economical resource use—Minimizing waste and polluting—the use of local building materials). As in Figure 4&5.

**Figure 4: Architectural Space for the House of Aini in Sanaa and Explained the Amount of Exploitation of the Walls, Where More Than 10 Slots Using Different Uses.**

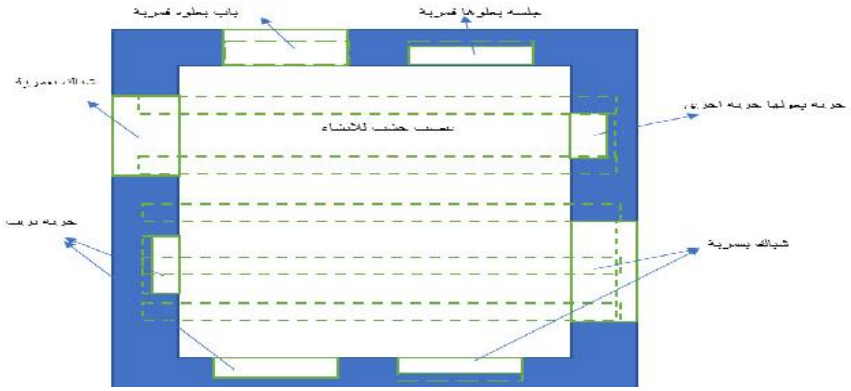

**Figure 5: Horizontal Projection Imagine the Use of Space in the Mud Wall with Different Functions.**

## Classified As a Fine Soil, Clay Has the Following Properties

Dry lumps can be crushed but not powdered between pointers. It is soft to the touch. It shrinks on drying which normally leaves cracks. Its particles have average to high flexibility. It has a sand or gravel content of less than 35%. Its compactness is fine.

Clay is also a critical element in composite materials such as adobe, cob, rammed earth, wattle and daub, clay plaster, clay mortar, ceramics, and so on.

Clay has high-grade robustness, stability, and durability. It is fire-resistant and intelligent in resisting seismic activity, giving it an inherent lifespan of 100 years or more.

## The Goal for the Least of Spaces Innovative Side-Folding Design

Vertical room space Furniture fitted above bed In addition to your available and compact wall bed, Strachan can also design bespoke storage features within the same unit. From full height furniture to shelving and indeed exhibit areas, complete with glass shelving and LED downlighting, your specialist designer can help design the specific furniture designs you are looking for. As Figures 6

Figure 6 shows the use of vacuum or double walls gives good results to reduce the penetration of heat into the interior as the air trapped between its inner and outer parts acts as a thermal insulator, but this air must be moved by

leaving some openings in the lower part of the outer wall and the upper part of it as a number and pressure can be reduced Thermal walls and openings are shaded during the daytime hours, especially during the afternoon period, where the thermal energy in its power reaches its maximum extent. This shading is done using the appropriate sun blocks and since the angle of inclination of the large solar radiation during this time period of the day Will be required to use the sun arresters horizontal and in particular, the Bishop of South the destinations extended abroad and other horizontal units above the high-profile openings are useful in this case, the form number.

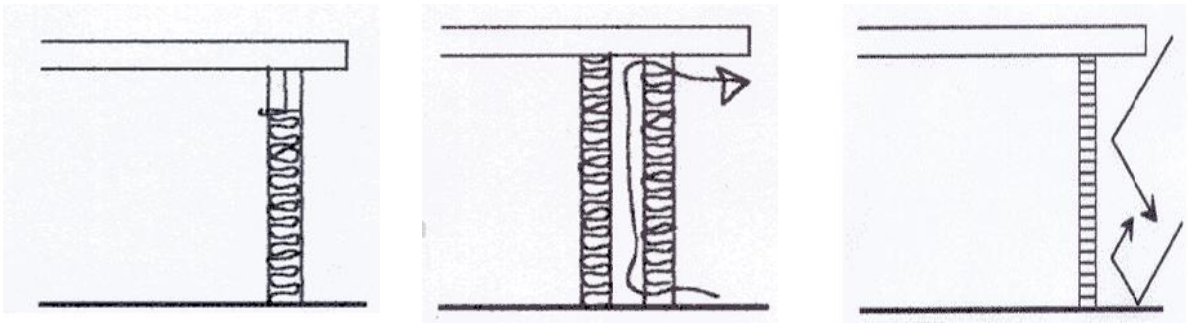

**Figure6: Use Small and High Openings, Double Walls, or Make an External Covering with a Reflective Material.**

## Case Study

Residential building in Yafi city, Lahj province Lahj is located in the south-west of the Republic of Yemen between latitudes (46-43) east of Greenwich, between latitudes (15-12) north of the equator and away from the capital Sana'a (320 km), Located in Lahj province northeast of Aden in Yemen. It had a population of 75,014 in 2004. The area of the province is about (12648) km 2. The climate of Lahj is moderate in the winter and hot in the summer. Rainfall also occurs on the coastal plain in the winter and autumn in a few quantities, while rainfall at the mountainous highlands falls in the summer and spring in large quantities. The building is constructed using the same building stones, but with larger dimensions, noting that the nature of the rocky terrain of the area does not require foundations, but the difference in height and height necessitated the recount architecture in using foundations.

The stones are cut off from the mountains and sculpted evenly and accurately. Approximately 6 cm to remove the pressure exerted on it from the top. Each of the floors is built with a row of white-painted stones, forming a white belt called "Noura", one of the most important features of Yafa's building. These buildings can last from 400 to 600 years and maybe up to 800 years. The architects who visited Yafa'a and saw the tall buildings in it said that the method of overlapping the stones with each other horizontally and vertically, as in figure (7).

## Reasons for the Vertical Height of These Buildings

- Narrow geographical area.
- The increase in the number and density of the population, the convergence and convergence of families in one building during tribal wars.
- Participation in the ownership of the land as inherited inheritance between brothers and cousins.
- High income of some immigrants and the need for vertical expansion. The extreme need for housing led to a vertical direction.

They concluded by saying this unique architectural style that they should realize that the architecture of concrete buildings is not a good solution architecturally and environmentally, so we need to raise awareness of the importance of preserving our unique and distinctive architectural identity in the world. As in Figure 8.

**Figure 7: Fibonacci Buildings and Tiling in the Structure. https://ar.wikipedia.org/wiki/yafi**

**Figure 8: Residential Building 5 Houses in Yafa'a Area.**

## Heat Calculation

The Design-Builder program was used to calculate the heat quantity of the brick and stone wall, and the effect of wall thickness on the building's energy use, in terms of thermal wall acquisition, heating and heat loss for all elements of the space.

For the brick wall, The highest temperature was 26.57° C, in April with the highest radiation in the same month the amount of 28.10° C, and the highest temperature in the shade 27.34° C, and from the observation that the climate helps in Yemen effectively in the impact of the heat of the presence of rain and buildings on the heights of the mountain have a large amount of ventilation and also after the buildings.

## Lighting Analysis of Different Conditions of Wall Use as Space and the Difference between A Solid Wall and a Full and Partial Discharge

The case study of two spaces with the same total area is 4.2 m width and 4.8 m length at a rate of 20.1 m2, but the function and use and internal spaces differ as well as the wall area of the ordinary brick vacuum and the clay or stone vacuum where

in the case of vacuum stone or clay the net vacuum area is 8.3 m2 and the wall space is 11.8 m2 In contrast, the other case for the structural building is a brick wall, a net area of 15.9 m2, and a wall area of 4.2 m2.as Figure 9.

Figure 9 shows it is clear that the stone or clay space with thick walls is good thermally, but weak in terms of lighting and function, and vice versa in terms of structural space is good in terms of lighting and function, but it is thermally weak so we need to reach a suitable temperature thermally and functionally and in terms of lighting also by making solutions for traditional buildings built From the clay or stone walls, and emphasizing the importance of lighting and lighting in order to achieve thermal and environmental comfort.

Figure 10 shows Various times were selected (9 am - 12 pm - 3 pm) to study the direct lighting and its impact on the two spaces with an area of 0.8 square meters in the stone building (0.6meter * 0.6 meter depth 0.8 meter) and an area of 0.288 square meters.

The amount of natural light on the space as in the forms (10-12-14) was not comfortable for the stone wall, and the amount of light entering the space is very small. As for the space of the ordinary traditional solutions building, so that the result is satisfactory for the two spaces as in Figs 11, 13&15.

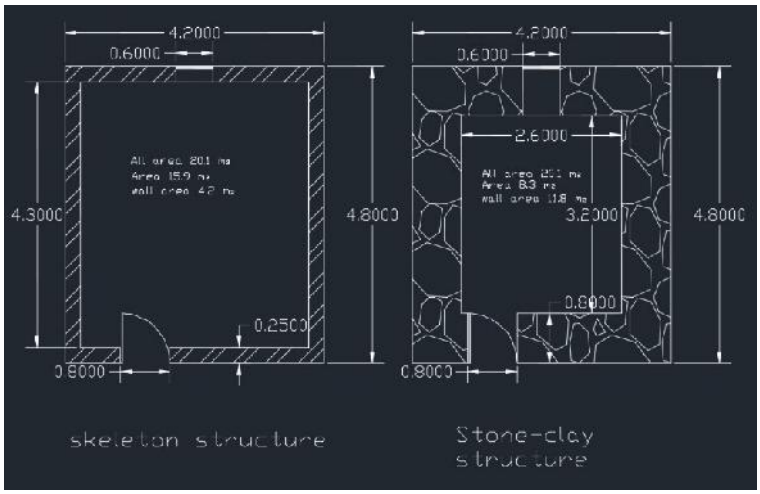


**Figure 9: Space with a Clay or Stone Wall and Structural Brick.**

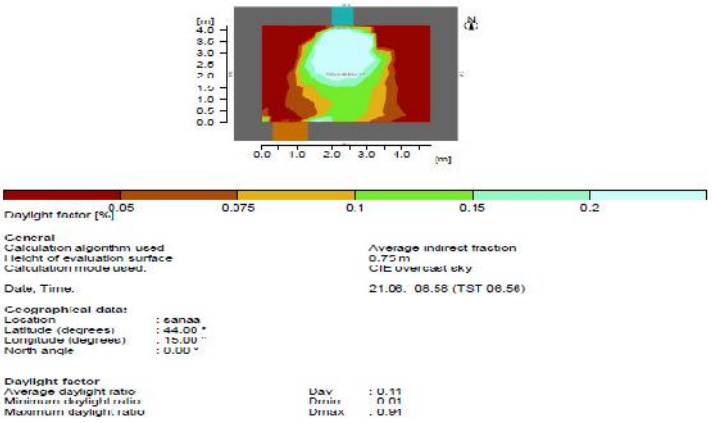


**Figure 10: The Amount of Lighting for the Space in the Walls (Stone) at 9 Am.**

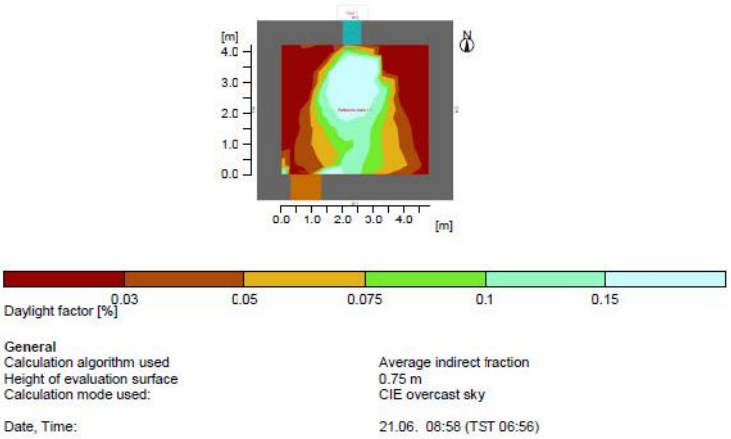


**Figure 11: The Amount of Lighting for the Walls (Stone) at 9 Am after the Modification of the Solar Crusher.**

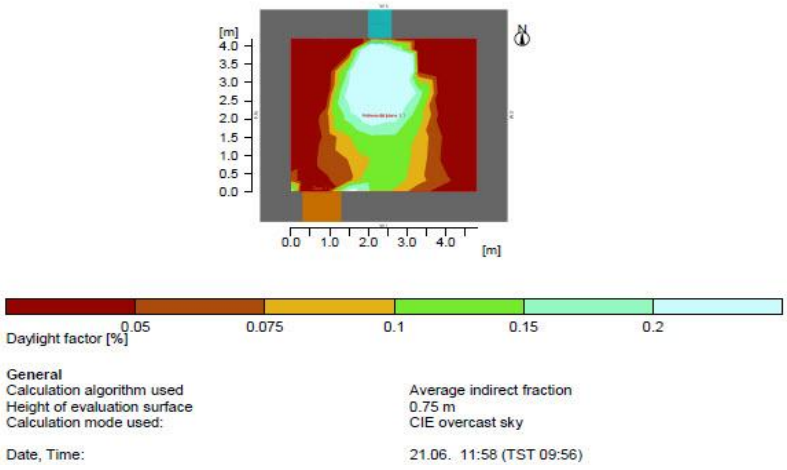


**Figure 12: The Amount of Lighting for the Space in the Walls (Stone) at 12 Noon.**

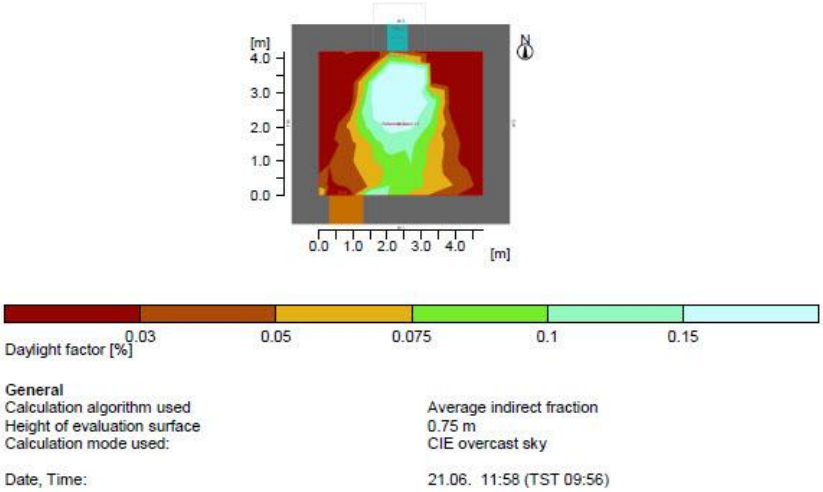


**Figure 13: Quantity of Lighting for the Walls (Stone) at 12 Noon after the Modification of the Solar Crusher.**

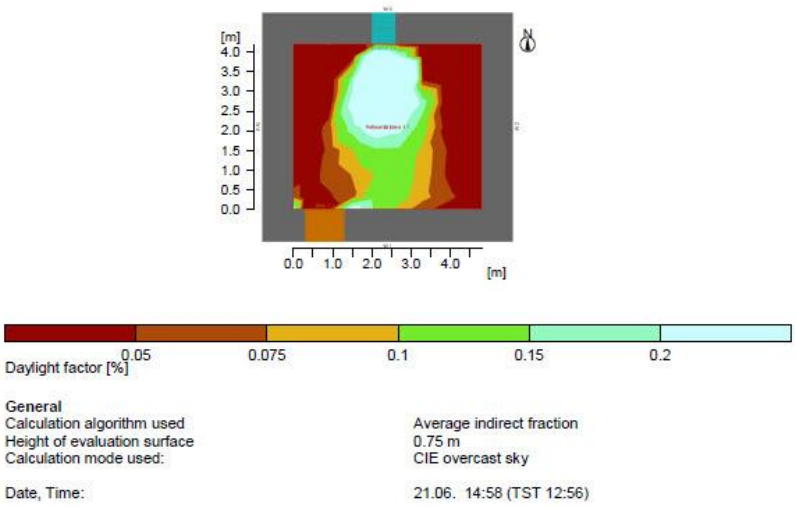


**Figure 14: The Amount of Lighting for the Space in the Walls (Stone) at 15 Pm**

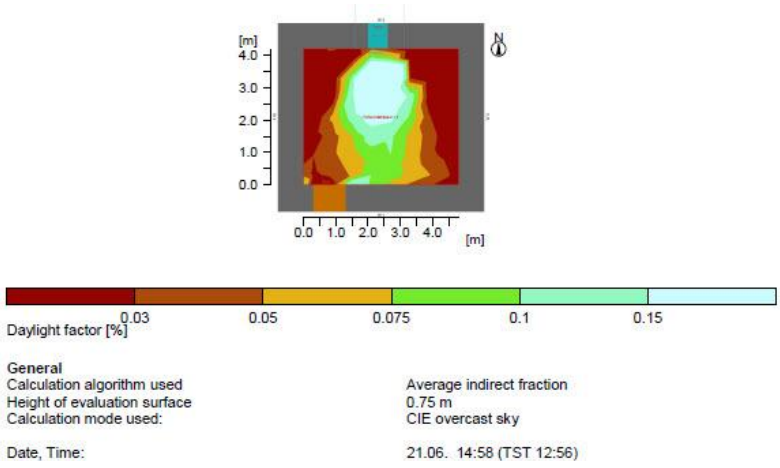


**Figure 15: The Amount of Lighting for the Walls (Stone) at 15 Pm after the Amendment of the Solar Crusher.**

## REFERENCES

1. *Mohammed Abdullah,* ***Building Construction - Building Technology****, Cairo University Press and University Writers, Cairo, (1983) p71.*
2. *Ahmed Ibrahim Hanshour,* ***Traditional Architecture in Yafea****, Second Engineering Conference, Faculty of Engineering, University of Aden, 30-31 March 2009.*
3. *A.W. Hendry, B.P. Sinha, S.R. Davies****, DESIGN OF MASONRY STRUCTURES, Third edition of Load Bearing Brickwork Design****, Department of Civil Engineering University of Edinburgh, UK,2004, p231.*
4. *Lstiburek, J.W.,* ***Moisture Control for Buildings****, ASHRAE Journal, February 2002.*
5. *Samuelson, I. and Samuelson, R.,* ***Conditions for Growth of Mold on Wood Products****, Swedish Testing Institute, Boras, Sweden, 1990.*
6. *Lstiburek, J.W.,* ***Understanding Air Barriers****, ASHRAE Journal, July 2005.*

7. *Building Air Quality—**A Guide for Building Owners and Facility Managers**, DHHS (NIOSH) publication No 91-114, Environmental Protection Agency, Washington, DC, December 1991.*
8. *Wilson, A. G., **Condensation in Insulated Masonry Walls in Summer**, RILEM/CIB Symposium on Moisture Problems in Buildings, NRC 9130, Helsinki, 1965.*
9. *ASHRAE Standard 62.2, **Ventilation for Acceptable Indoor Air Quality in Low Rise Residential Buildings**, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., Atlanta, 2002.*
10. *Rinella, J., Kohli, G., and Timusk, J., "**Impact of Residential Air Supply and Demand on Ventilation of Gas Appliances**," Proceedings, 1986 International Gas Research Conference, Toronto, Ontario, 1986.*
11. *Handegord, G. O., **Prediction of the Moisture Performance of Walls**, ASHRAE Transactions, Vol. 91, 1985.*
12. *Fundamentals Volume—ASHRAE Handbook, **American Society of Heating, Refrigerating, and Air Conditioning Engineers**, Inc., Atlanta, 2005.*
13. *Brunskill, R.W & Clifton-Taylor, A: 1977, **English Brickwork**, Hyperion Hollis, M; 2005 Surveying Buildings (Fifth Edition); RICS Books; Coventry.*
14. *Lynch, G, 1994; **Brickwork History, Technology and Practice**, Volume 2; Donhead, London.*
15. *Melville, I.A & Gordon I.A; 1997, **The Repair and Maintenance of Houses***
16. *Energy Saving Trust. 2004. **Energy efficient refurbishment of existing housing**. Energy Efficiency Best Practice in Housing. GPG155. EST.*
17. *http://whc.unesco.org/en/list/385*
18. *https://www.designingbuildings.co.uk/wiki/Brick*