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Energy in Historic Buildings: A review of hygrothermal transfer models through the building envelope

BENCHEKROUN Marwa[*1], BABA SLIMANE Nour El Houda[2]

[1]*Department of Architecture and Urban Planning/ETAP Laboratory, University Saad Dahleb of Blida 1, Algiers*
[2] *Polytechnic School of Architecture and Urban Planning " EPAU", City, Urbanism and Sustainable Development Laboratory "VUDD"*

[*]*(Marwa.benchekroun1991@outlook.fr) Email of the corresponding author*

Abstract – Algiers is a city that has a rich built heritage with a great historical value and a strong identity, where different solutions meet the environmental requirements and more specifically the needs of current comfort. The aim of the work is to fit into the framework of comfort and energy aspect. This work is done in a logic of continuity by punctual and more thorough aspects that the various transformations and modifications made on the interior comfort could have, more precisely on the hygrothermal comfort of the residential building.

The idea developed in this research is that the old design offers practical and sustainable solutions to the problems related to the quality of the environment and the comfort of the habitat, in order to correlate the impact of the transformations undergone during the colonial and post-colonial period on the residential buildings of the old city of Algiers. The results obtained are intended to identify the impact of these modifications on the indoor comfort.

In this work, we evaluate the microclimatic conditions and the level of comfort in these traditional houses, in their old and current state. We specify that the objective of this work is to build a thorough knowledge of the functioning of these houses to meet the requirements of current comfort. In this paper, we identify the nature of colonial and post-colonial transformations in order to determine their impact on the hygrothermal comfort and indoor microclimate conditions of Ottoman residential architecture.

Numerical simulation, in situ measurements and the study of many parameters were the tools that allowed us to evaluate some houses that have kept favorable living conditions and to ensure a lesser transformation, in order to maintain a comfortable and healthy indoor environment.

Keywords – Indoor microclimate, Energy Building, thermal comfort, Modeling and Simulation,Energy efficiency rehabilitation

1. INTRODUCTION

Algiers is a city that has a rich building heritage with high historical value and strong identity, where the different solutions meet the environmental requirements and more precisely the needs of current comfort

Fig 1. View of the Casbah of

2. TYPOLOGIES OF CASBAH HOUSES IN ALGIERS

The different typologies of houses presented in this study are located in Algiers and exactly in the Casbah.
We define two main typologies:

Fig 2. Figures representing houses with

A. ***The house with wast al-dâr «courtyard» contains two variants:***

1.A- HOUSE WITH PATIO:

With wast al-dâr discovered (the courtyard)

2.A- HOUSE WITH CHEBAK:

The sescond one is partially covered with a chebâk which is in the form of a well of light and ventilation.

Fig 3. Figures representing houses with chebek

B. ***House with Ulwi:***

The house without wast al-dâr called al-ulwî: which is a small house, organized in height and developed around a staircase.

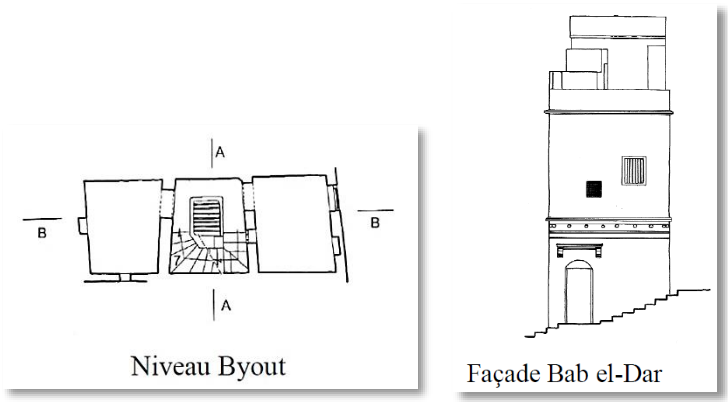


Fig 4. Figures representing houses with ulwi

3. PHENOMENON OF TRANSFORMATION / MODIFICATION

During the colonial and post-colonial period, the houses of the Casbah of Algiers, are seized by the process of transformation / modification.

The inhabitants expressing the desire to rise to the norms of modernity and representing the result of the superposition of two architectural models, showing two ways of life (ancestral and contemporary).

The transformations have generated disturbances that are sometimes small and sometimes enormous. We can divide these transformations into two types:

a) THE INTERNAL TRANSFORMATIONS

- the installation of washrooms
- the new openings piercing a window
- introducing bathrooms in an unthinking way
- the obstruction of *djebs* and wells which transforms them into sanitary voids

b) EXTERNAL TRANSFORMATIONS

Adding new windows or closing others due to alignments that there were in the colonial period.

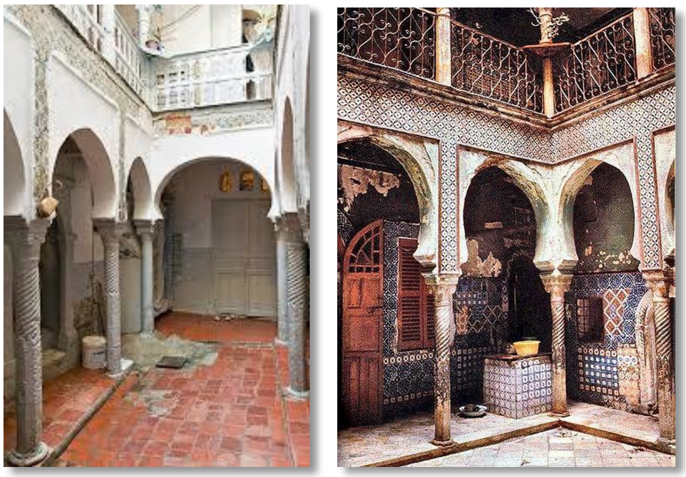


Fig 5. Phenomenon of transformation

Fig 6. The Internal and external transformation

4. METHODOLOGY

<u>4.1. PRESENTATION OF CASE STUDIES</u>

It is located in Algiers, in the upper Casbah. The two cases of houses belong to the same typology and seem to have a positive transformation and negative transformation

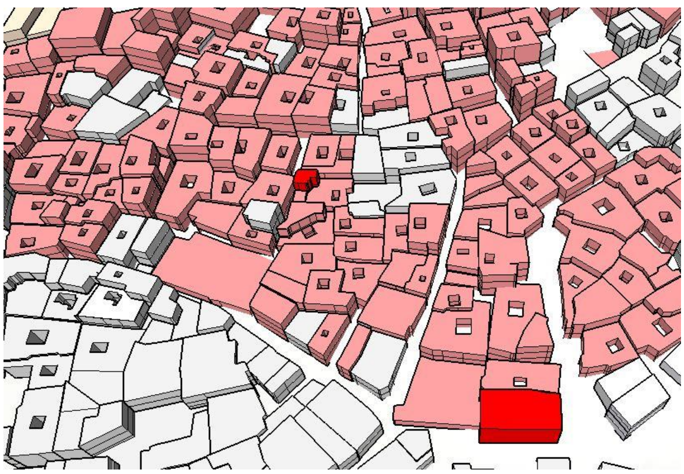


Fig 7. Figure representing the two case studies

4.2. ARCHIVES AND MEASURES

In order to identify the transformations and to study their impact on interior comfort, we have used:

primary source the archive from OGEBC (Organisme de Gestion des Biens Culturels). It is a cultural property management agency located in Algiers, it is the graphic archive of the ottoman house plans. This tool enabled us to establish the old state of the house studied.

MEASURES:

We have been able to carry out In-Situ measurements for the summer season for the validation of the results obtained by simulation.

We use 3 instruments, including two automatic and a manual one:

The first one is a recorder and a data acquisition system: a Fluke Hydra 2635A series.

The second one is a Testo 174H, internal temperature and humidity mini-recorder.

The third one is manual TMA5 Anemometer.

These tools were used in order to measure 3 parameters: temperature, humidity and air velocity.

4.3. SIMULATION METHODOLOGY

Thermal dynamic simulations were performed using the Design Builder v.4.8 software.

its purpose is to provide an analysis to assess the building's behavior in terms of energy efficiency and user comfort.

The idea is to compare the difference between the house transformed in a positive way and the negative one, in its original state and the different Transformations that have been made over the years and to see if there is an impact on the interior comfort

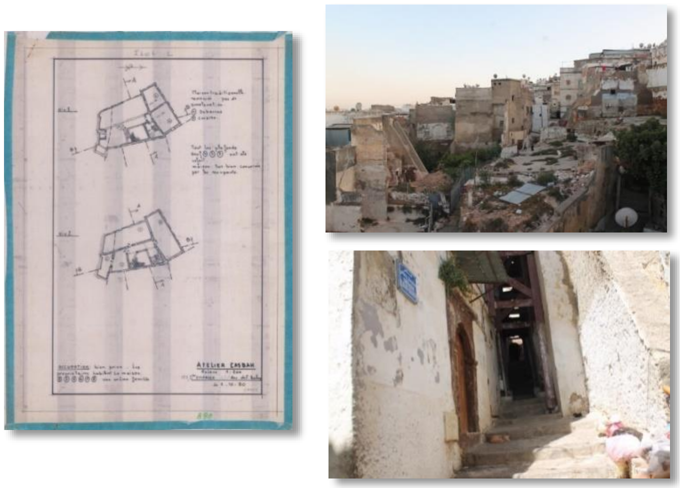


Fig 8. Investigation on sit and archives.

Fig 9. The instrument of measures

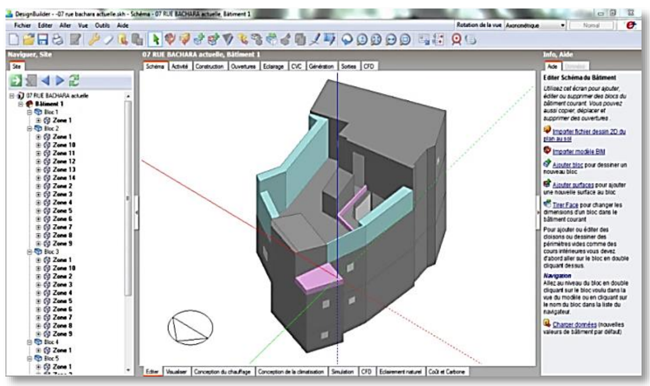


Fig 10. Design Builder Software interface.

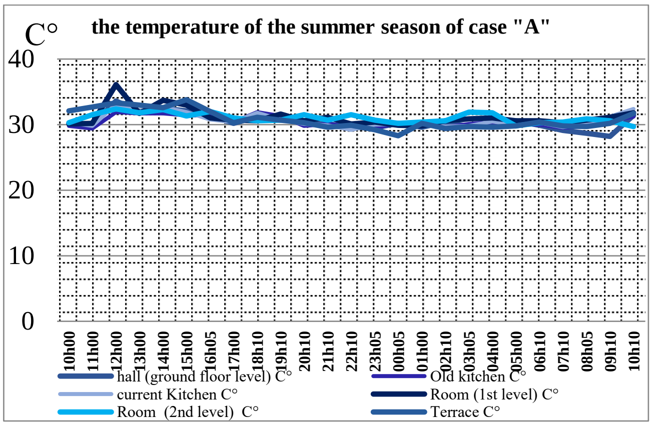
5. RESULTS AND DISCUSSION

Measures:

For the in situ measurement, as shown in the graphs of cases "A" and "B" for the summer period, the temperatures vary between 25 C° and 30 C ° for the case "A" and between 30 C° and 35 ° C for the case "B".

Regarding the rate humidity, it varies between 40% and 70% for the case "A" and 40% and 80% for the case "B". The houses of the Casbah suffer from high humidity in summer due to the use of new materials, such as concrete, which prevent the old walls from breathing, causing high humidity.

For ventilation, the flow of air for case "A" is quite important and evolves between 1m/s and 3.5 m / s which show that the house "A" is airy in summer. The case "B" shows low and inconsistent ventilation, modulated between 0.5m/s and 2.5 m/s.



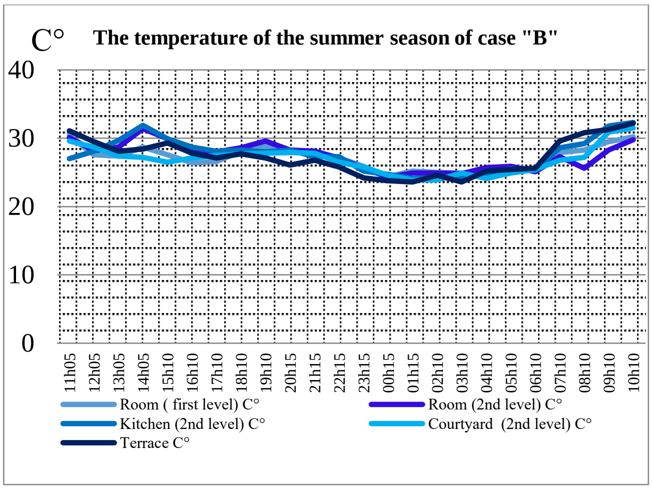
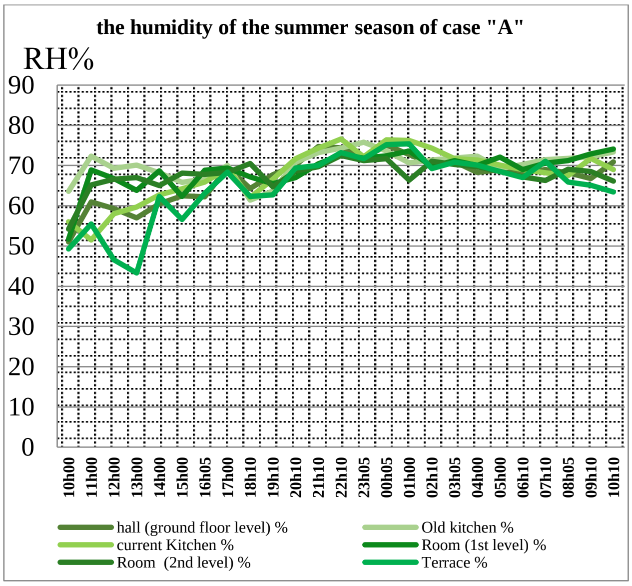


Fig 11. Figures representing the results of humidity obtained by the measurement campaign for the summer period



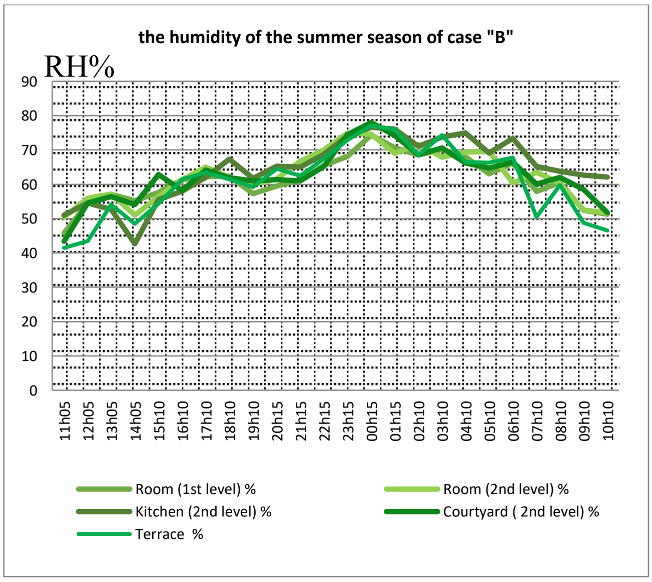


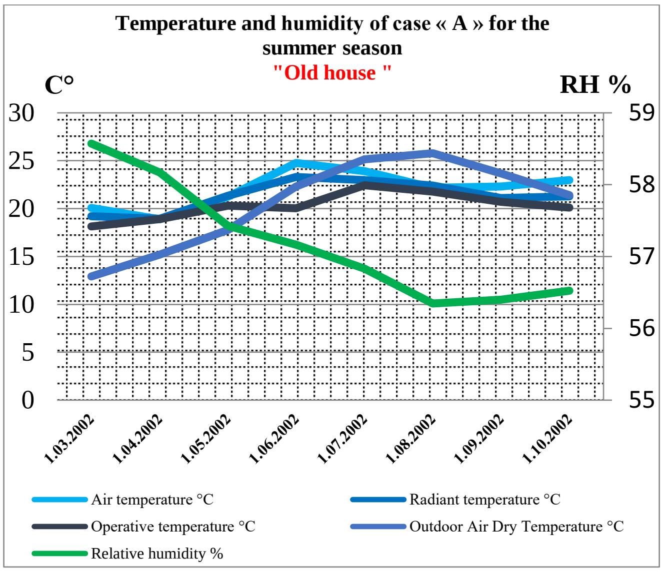
Fig 12. Figures representing the results of humidity obtained by the measurement campaign for the summer period

Thermal dynamic simulation:

For Case A, The average maximum temperature in both cases is 25 ° C due to thermal inertia, which reduces fluctuations and serves as a temperature stabilizer. However, the disturbances are significant, which confirms the destabilization of the air circulation.

In both cases, the humidity is estimated between 50% and 60%, which can be explained by the different thermal gradient associated with the thermal inertia of the walls.

In the original case, the air distribution is natural, while for the transformed case, it is mechanical and the value vary between 0 and 2 vol /h, coinciding with the increase or the decrease of the temperature.



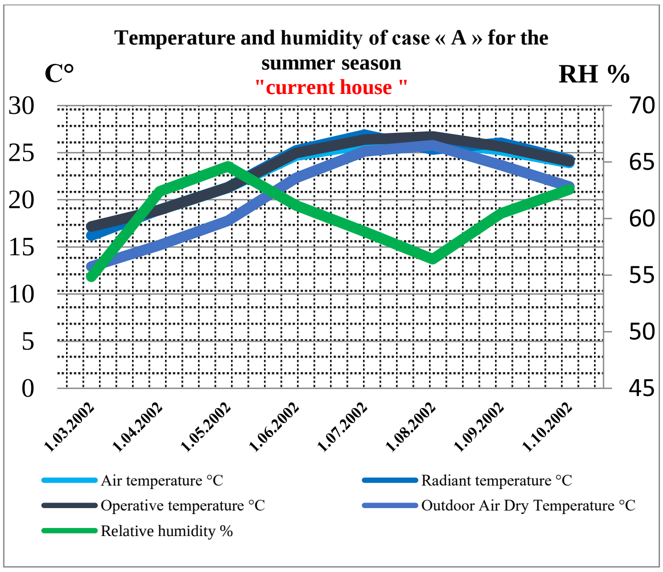
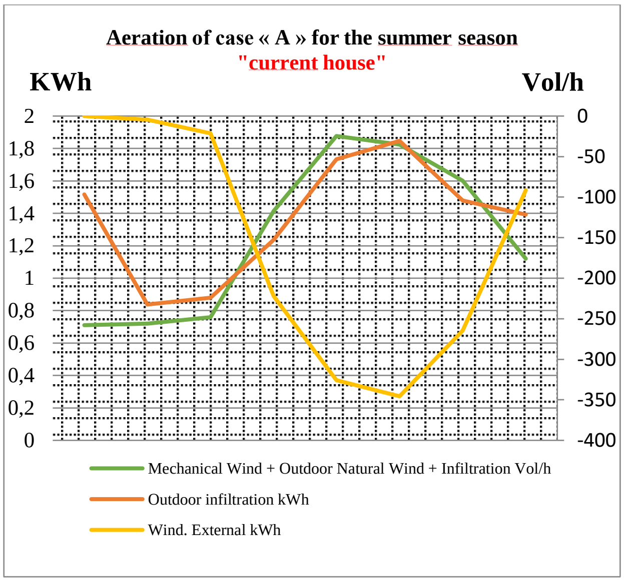


Fig 13. The results obtained by simulation of case "A" for the summer period



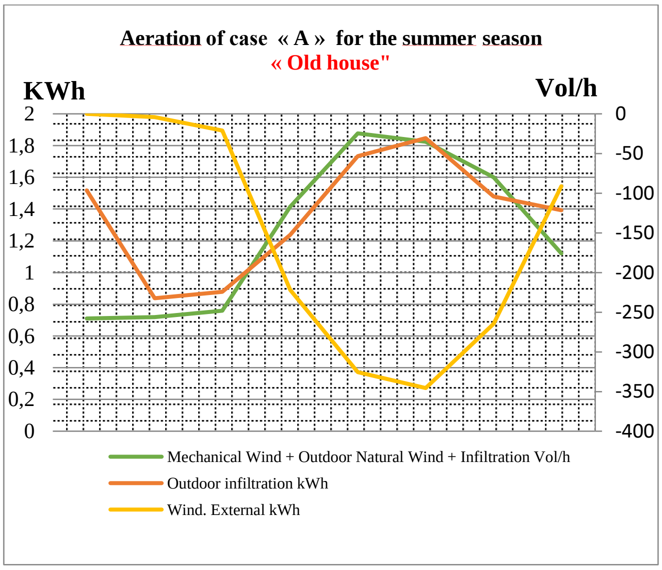


Fig 14. The results obtained by simulation of case "A" for the summer period

For case “B”, the house in its current state shows no difference between interior and exterior temperatures, indicating insufficient transmission created by the architectural changes.

With regard to humidity levels, significant differences between the two house states can clearly be seen, ranging from 50% to 62% for the house in its original condition, and from 60% to 70% for the house in its current state, during the summer season. For the former case, ventilation is natural and air transmission inside the house is constant, with no disturbance. For the latter, peaks of 2,5 vol/h can be observed.

These results can be explained by the phenomena of thermal inertia, humidity, due to the presence of heating and cooling appliances (air conditioning) which affect the temperature.

6. CONCLUSION

The methodology developed has shown that the reconstruction of the historic climate of a house is possible and may determine optimal changes that could meet the demands of current comfort.

The results obtained by simulation and in situ measurements, show that house B suffers from overheating. This is due to the different alterations that have been carried out by the residents without expert advice. It is, therefore, case of negative transformation on the indoor climate of the house.

The house A shows a positive transformation in terms of indoor climatic conditions. The minimal and well-established alterations have not affected the indoor comfort of the house.

The aim on this work is to build a detailed knowledge of the functioning of these traditional houses representing this rich residential heritage and taking into account its degradation according to the conditions of the indoor microclimate.

We propose a series of renovation solutions and recommendations likely to improve the conditions of the current comfort in the houses of the Casbah;

- The **natural ventilation** of the house can be improved by avoiding the obstruction of apertures or the opening of new ones.
- The installation of **modern ventilation** devices should be undertaken in a calculated way (**need**, **functionality**, **position**).
- **Traditional construction techniques** should be adopted and **local materials** used in order to improve the **durability** of the building.
- **Toilets**, **bathroom** and **water points** should be installed along the **same axis** as waste water evacuation.
- The installation of **kitchen appliances**, **computers**, **air conditioning** and **heating** equipment must be done, not only according to need but also in consideration of their strategic position so as to avoid overheating which inevitably leads to discomfort

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