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The Rehabilitation of A Public Square Through The Improvement of Its Microclimate Case of “la Brèche” Square in Contantine (Algeria)

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Abstract*— Rapid urbanization often changes the naturally vegetated surfaces with hard non-porous surfaces such as concrete asphalt, etc…, affecting the microclimate in cities. The most apparent effect of urbanization on climate parameters is the increase in air temperature within a city, referred to as the urban heat island (UHI). This paper focuses on the microclimatic features of open spaces, in the center of urban blocks of the city of Constantine (Algeria) characterized by semi-arid climate where summer temperatures exceed 40 ° C making her urban areas very uncomfortable during the warm season. In order to re-establish and sustain life outdoors it is important that we try to make urban spaces comfortable as far as the ambient climate permits. This paper presents findings on outdoor comfort based on field investigations conducted in “La Brèche” plaza, located in down town of Constantine. A series of measurements in situ (Temperature and Wind) and simulations were used for this research. Microclimatic measurements, simulations together with solar access studies were performed to investigate possible environmental improvements. The paper summarizes the triple approach (mapping, adaptive skins, and potentialities of the site) which allows designers and planners, to staff their urban design by natural ventilation and solar control radiation. through the use of digital resources such as Townscope Software and Autodesk Flow Design Software to create zones in relation to the intensity of solar radiation and air movement on our site, Photoshop CS4 has allowed us to do a mapping by superimposing the previously created zones, ComFa which is an index of thermal comfort in outdoor spaces allows us to assess the level of comfort on the site before and after improvements.

***Keywords*— adaptive skins, bioclimatic device, mapping, microclimate, outdoor, shelter, thermal comfort, ventilation.**

I. Introduction

The climatology of the building was far more interested in interior spaces for the well-being of the occupants, forgetting by this is the fact that it is essentially concerned by all urban surfaces and by the effects more or less complex on the lower atmosphere[1]. This has, of course, involved an excessive use of fossil energies (air conditioners especially) with very important emissions of CO2 thus aggravating the problem of the UHI in the cities. Improving comfort in outdoor spaces would encourage the inhabitants of the city to do more activities in these spaces, which will reduce their dependence towards the air conditioning and the heating of houses. "The landscapes creating positive microclimates have a tendency to persist, while the negative microclimates tend to be deleted or replaced" [2]. The objective is therefore to find a method of rehabilitation of these places for the improvement of their microclimate in general, while taking benefit of their passive potentialities. This rehabilitation was conducted as follows: investigation in situ (measurement of temperatures and wind, weather data, observation etc ...), simulation of solar radiation with Townscope, wind simulation (in real time) with Autodesk Flow Design, use of phtoshop to create different thermal mappings and evaluation of comfort level after and before rehabilitation with ComFa index.

II. Methodology

Comfort is mainly affected by exposure to solar radiation [1] [3] and the effect of wind speed on thermal comfort was proved to be the second important parameter for thermal sensation after shading [3]. From this point we conducted our study on how to rehabilitate our public spaces improving their microclimate. Thus, we used two methods: mapping and “adaptive skins”. Mapping was used to define the type of intervention related to each area. It permits to specify, at an uncomfortable area, the sub-areas in which the factors that make them uncomfortable are different. These small areas are just small microclimates [4]. In the "adaptive skins" method, S. Yannas affirms that "The most significant climate variations are commonly created by the differences of sun and wind patterns" [5]. These differences immediately affect the thermal comfort feeling that people express when sitting, standing or moving. But they also affect the temperature, the degree of humidification of the soil, the plant growth, etc. These, in turn, contribute to the differentiation of microclimate by compiling a microclimate profile [5]. This profile takes into account: both duration and intensity of sunshine, and velocity and direction of the wind. The ComFa program, based on a formula that evaluate comfort level in outdoor spaces allowed us to compare comfort conditions before and after the rehabilitation of the plaza.

III. Investigation

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A. . Presentation of The Case Study

«La Brèche» plaza is located in the center city of Constantine. It marked the point of junction between the traditional tissue and the colonial tissue of the city. Despite of that, the rate of frequentation of this place is in decline and doesn't drain the flow of visitors as it should be (figure1 & 2).

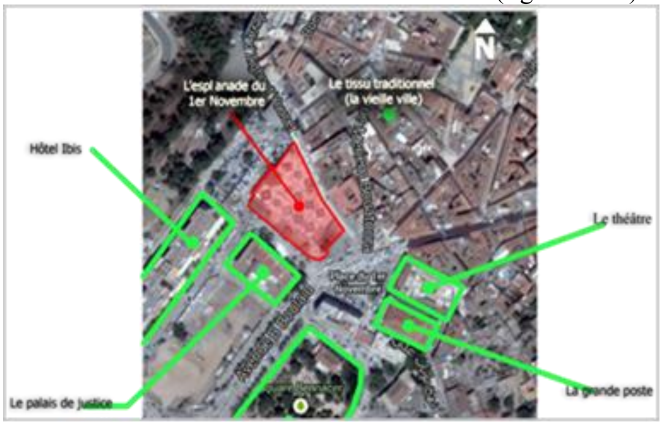


Fig. 1 Situation of the plaza "la Brèche" (in red)

Fig. 2 View of "la Brèche"

B. Microclimatic Data

The area of the plaza was divided into fifteen stations, temperature measurements showed a difference of about 5°C between them (figue 3 & 4).

Fig. 3 Stations of measurements in-situ

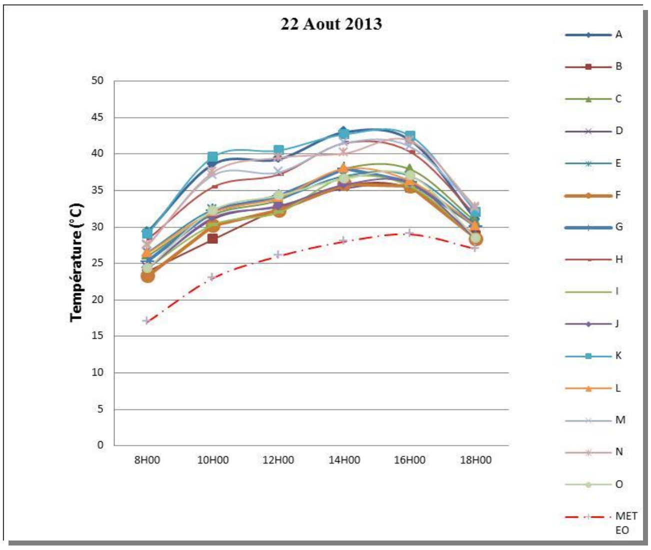


Fig. 4 Temperatures at each station on the plaza (22/08/2013)

C. Observations In-Situ

The flow of visitors begins after 11h30 on the plaza (about twenty men). The plaza reached 180 visitors at 13h30. But only around 70 people of them stayed from 11h30 until 16h. The flow remains very low because the surface of this plaza (about 4800m²) could contain more than 1200 people.

D. Conclusion

The intense solar radiation of small lengths of waves creates the overheating and the sensation of discomfort. Also, reflected terrestrial radiation is sequestered under the plastic covers shelters and umbrellas. This is aggravated by the absence of air movement. «la Brèche» plaza imprisons the hot air and needs to be ventilated. The animation shakes the place from 13h30 to 16h (figure 5).

Fig. 5 Radiation is sequestered under short plastic canopies

IV. Comfort Modelling

A. . First Scenario: Investigation of The Existing Conditions

1) Solar Radiation: We used Townscope software to simulate Solar radiation (figure 6). The critical areas that are very exposed to the solar radiation during more than 12 hours are: A, H, K, N and M, followed, with less time of Sunshine by C, D, E, G and L. And areas that seem cooler are B, I, J and O.

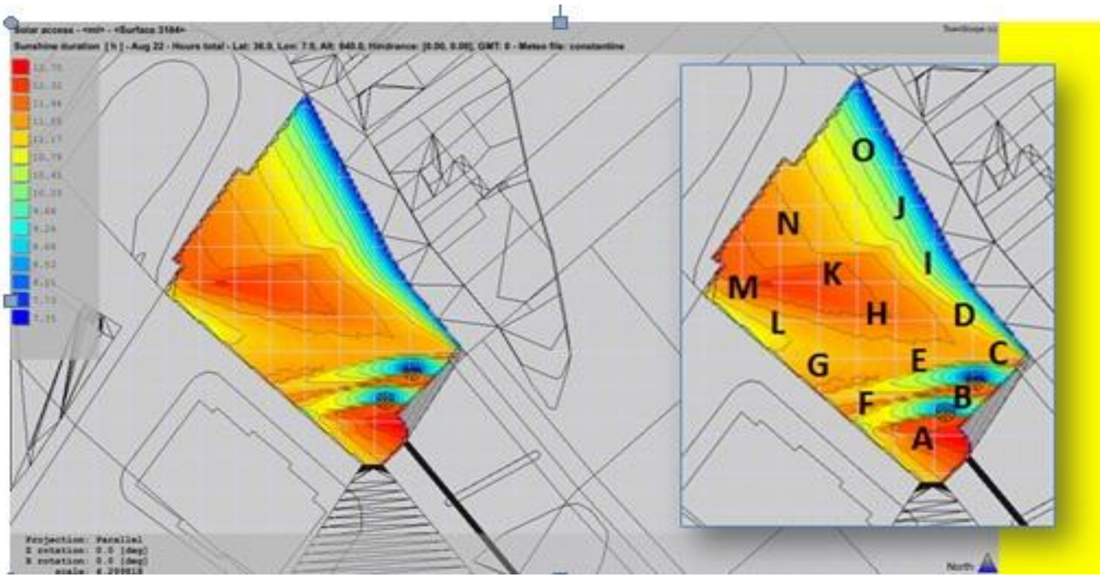


Fig. 6 Intensity of solar radiation at each station of “la Brèche” plaza

2) Simulation of Wind Using Autodesk Flow Design: The climate data revealed that the prevailing winds in summer come from the north. The simulation of the movements of the air on «la Brèche» plaza gave the following results (figure 8): We notice that the morphology of the traditional fabric which dominates the Place on the north side facilitates the entry of the wind on the place from his side (with a velocity of 4 m/s).

3) Estimation of Thermal Comfort Using ComFa Formula: we choose the period that receives the most rates of visitors on the place between 13h30 and 18h for assessment. The rates of solar radiation that we have simulated with Townscope, as well as the wind speeds obtained by Autodesk Flow design software, served as inputs data to assess the conditions of comfort at each station with ComFa. It is a simplified tool for landscape design developed by Brown and Gillespie in 1986. It is a quantitative model that assesses the level of thermal comfort of outdoor spaces as an energy budget, calculated with the following formula (1):

$$Budget = M + R_{abs} - Conv - Evap - TR_{emitted}$$

where : M= energy metabolism that we use to warm up, =absorbed radiation (solar and terrestiale), = gain or loss of sensible heat by convection, = loss of heat by evaporation, =amount of terrestrial radiation by emission.

The graph below (figure 7) shows that «la Brèche» plaza is overheated in the summer, specifically from 14h to 16h with a surplus of energy budget of 230W/m² (the ideal value of energy budget varies between -50W/m² and 50W/m²).

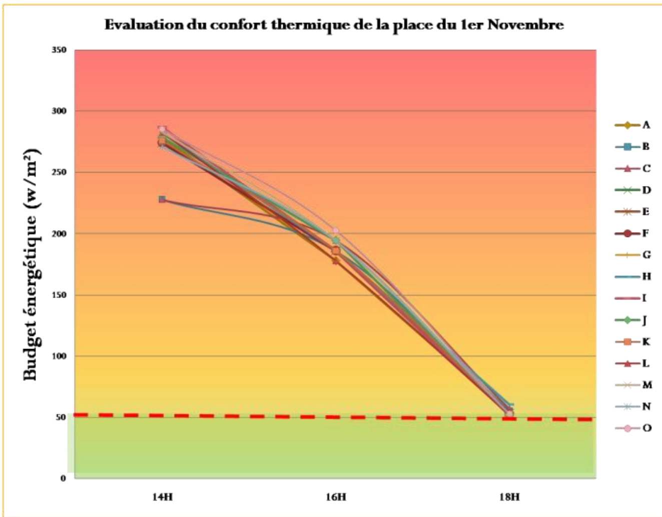


Fig. 7 Evaluation of thermal comfort on “la Brèche” plaza at each station

B. Second Scenario: Improving Comfort Conditions

1) Simulation of Site Potentialities of Cooling: The simulation of winds on the plaza shows that at about 9 meters in height, the winds are stronger than to the man height. We know that the velocity increases with the heigh (figure 9)t, which allows us to provide highest malqafs where wind speed is important. Other potential: A large Sky View Factor (SVF of 90%), the surrounding buildings are relatively distant. This offers an easier design.

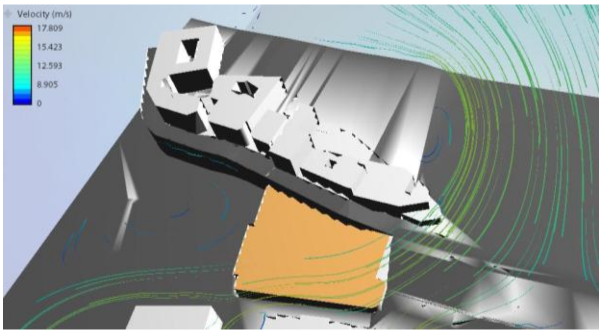
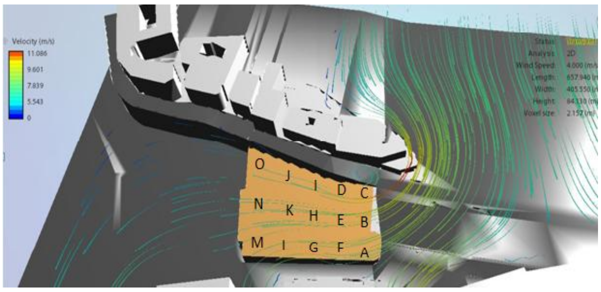


Fig. 8 The air movement (v=4m/s) simulated for August 22, 2013 on “La Brèche” plaza

Fig. 9 Potentialities of cooling on “la Brèche” plaza at 9meters of heigh



2) Proposition: Adaptive skins method using Photoshop: The map below (figure 10) show the types of areas according to the intensity of solar radiation from 14h to 18h, and the types of areas according to the wind velocities.

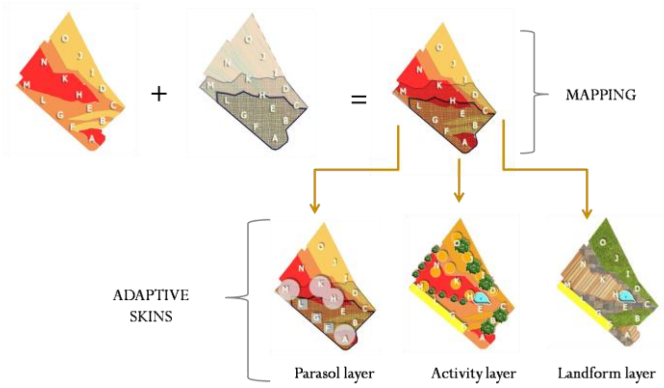


Fig. 10 mapping (superposition of solar radiation intensities with wind velocities to settle between different potential areas) and adaptive skins design (by three layers)

3) Landscape Designing Following The "Adaptive Skins”: <u>Parasol layer:</u> high canopies (4 to 6m) , climbing plants with deciduous leaves in order to benefit from winter’s sun, malqaf to catch the winds (9m and more), canopies with malqaf, louvered shelters (roof). <u>Activity layer:</u> Banks (wood/ stone) with flowers, louvered walls, watered walls, a fountain to consume the excess of energy and kiosks with shelters, shrubs (Birch). <u>Landform layer:</u> slate pavment/ Lawn/ wood, borders to use as benches (figure 11.

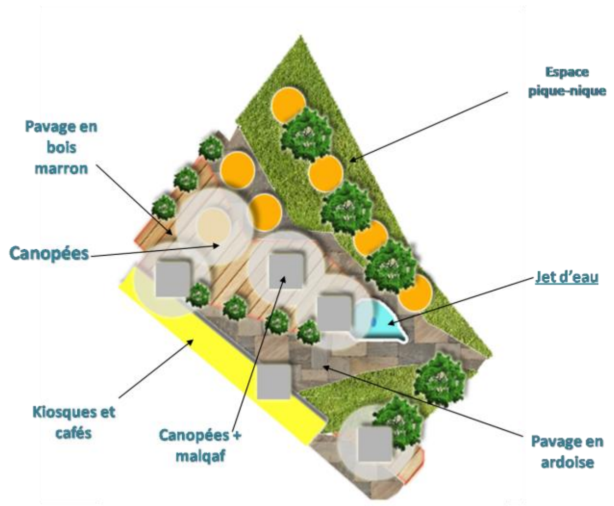


Fig. 11 Design proposition of “la Brèche” plaza (result)

4) Evaluating The Thermal Comfort After Rehabilitation: (Remark: we have planned lattice canopies in areas with wood pavement “A’1”, while we used solid canopies for area with slate pavement “A’2”) (figure 12).

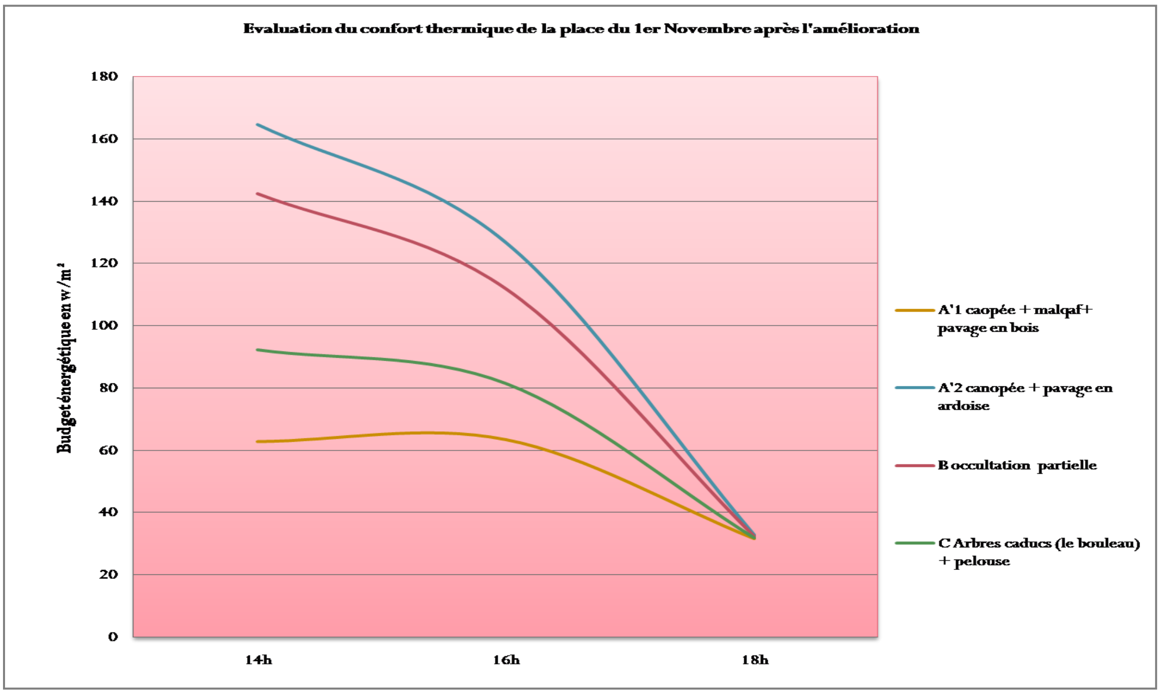


Fig. 12 Evaluation of thermal comfort on "la Brèche" after rehabilitation

V. Conclusions

Our method of rehabilitation has allowed us to integrate the different strategies of development by similar zones. This technique is a form of responsive climate design. And while having taken advantage of the site's passive potential, developed a model for improvement of the microclimate, and through which we have been able to achieve a reduction of about 200 w/m² knowing that the margin of comfort is between -50 w/m² and +50w/m². We confirm that we can improve considerably comfortable conditions in public plazas, and make them more attractive so that people can go out and use them.

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