The role of L/W in the solar radiation for Saharian cities

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Abstract. The urban fabric of the desert cities is based on the principle of reducing the impact of urban canyons on direct solar radiation. Here comes this research, which is based on a comparative study of the periods of direct solarisation and values of the solar energy of urban canyons via two urban fabrics that have different building densities, where the ratio between L/W is different. In order to obtain the real values of the solar energy (thermal, lighting), the test field was examined every two hours, each three consecutive days. The measurement stations are positioned by the three types of the relationship between L/W, ($L \geq 2w$, $L = w$, $L \leq 0.5w$). According to the results, we noticed and recorded the difference in the periods of direct solarization between the types of urban engineering canyons, reaching 6 hours a day, the difference in thermal values of air, reaching 4 °C, and the difference in periods of direct natural lighting, reaching 6 hours. It should be noted that the role of the relationship between L/W is to protect the urban canyons by reducing the impact of direct solar radiation on urban canyons, providing longer hours of shading, and reducing solar energy levels (thermal, lighting) at the urban canyons. This research is classified under the research axis (the studies of external spaces in the urban environment according to the bioclimatic approach and geographic approach). But this research aims to focus on the tracking and studying the distribution of the solar radiation - thermal radiation and lighting radiation - in different types of street canyons by comparing the study of the direct solarization periods of each type and the quantity of solar energy collected during the solarization periods.

1 Introduction

The typical study of the distribution of natural physical loads is very important to guarantee the physical comfort of human, especially in the desert cities. This is an obligatory principle for the survival of the desert cities [1-3].

The physical comfort of these cities is re-value and the fundamental authenticity [4-6]. The role of urban fabric is the protection from the environmental loads.

The objectives were as follows:

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- Studying the effect of the relationship between L and W. To improve the solar radiation in urban canyons (street).
- Identifying the best of the typical relation between L and W. To improve the solar radiation in urban canyons (street) through a comparative study between them.

Methodology

The comparative method is the scientific method for this research. The theoretical axis and the practical axis are divided into three axes. The first is definition of the urban environment. The second is determination of the research tool, the field of work. The third is a process of analysis interpreted by the comparative method and a discussion of the results [15].

2 Theoretical part

2.1 Solar radiation

Fig. 1. The solar radiation division. Source: Author.

The solar radiation is the main source of all renewable natural energies reaching to the earth - thermal energy, light energy, electromagnetic energy.

The solar radiation is composed by three main types: thermal radiation, light rays, and ultraviolet rays, with a percentage of the total solar radiation. Also, these rays, which known as infrared radiation, formed a range from 0.75 to 4.00 microns, with 49% of a total solar thermal radiation. It is shown in the figure [1].

2.2 Thermal comfort

The concept of thermal comfort is formed by combinations of the climatic factors that affect the heat exchange between climate and human [1]. So, the thermal comfort is a zone of a very short period within a period of thermal equilibrium.

That area reflects interaction of the components and combinations of the climatic factors that affect the heat exchange between climate and human [9] in order to reach the case of thermal equilibrium. The elements that make up practical human activity: the coefficient of thermal insulation of clothing, air temperature, air speed, relative humidity, the amount of solar radiation falling on the human body, and the average temperature of the surrounding surfaces [6].

2.3 Visual comfort

The field of optical radiation for visual comfort and visual perception is in the range from 100 to 1000 lux [10]. This area provides levels of optical radiation for ease of performing tasks and visual functions in urban fabric [6]. This is the area in which the shaded and solar zone is located, which is the reason for comfortable human visual perception [10].

2.4 The relationship between L/W

2.4.1 The different models of the street structure

The relationship between the height of the building and the section of the street in three geometric patterns ($L \geq 2W$, $L=W$, $L \leq 0.5W$) - open street, dihedral street, canyon street [7].

2.4.2 Construction density

The responsible for the height of the facade is the construction density [2]. This density is controlled by two criteria. The first is the coefficient of the exploitation of the land (CEI). The second is the coefficient of the occupation of the land (COI) [12].

Table 1. The different models of construction density.

Occupation of land	High or more (R + 6)	Medium (R + 2) to the (R + 5)	Low floor, (R) or (R1) R upper floor
Strong 50-100%	Skyscrapers	Residential building in urban residential area without elevator	Houses of a central space
Medium 50-20%	High barriers	Little group of buildings, accommodations (individual entrances)	Collective houses or urban housing
Weak up to 20%	Towers in green spaces	Low land	Individual paired, individual single, pavilion

3 Practical part

3.1 The site measuring points

The geographical location of the City of Biskra is East of the Greenwich line between the 5 ° and 6 °, the North East latitudes between 34 ° and 35 °. Thus, the direction of the North-West / South-East is the trend of the greatest period of the path of the sun over the city, it is the sunniest part of a day. This was the reason for choosing the distribution of the three points in the urban canyons on the fabrics according to the direction: North-West / South-East, where the general sample of the city is presented, as they are shown in the following figure.

Fig. 2. (a) The measuring points (01). (b) the measuring points (03,02). Source : Google Earth 2015.

3.2 Description of measuring points

3.2.1 Measurement point N°01. The low ratio between the height/width ($L2\leq W$). Open street

Fig. 3. Section of the measurement point №01. Source: Author.

3.2.2 Measurement point N°02. The medium ratio between the height/width ($L=W$). Dihedral street

Fig. 4. Section of the measurement point №02. Source: Author.

3.2.3 Measurement point N°03. The high ratio between the height/width ($L \geq 2W$). Canyon street

Fig. 5. Section of the measurement point N°03. Source: Author.

3.3 Measuring instruments used

a. Technical card of Instrument TESTO 480

- Measuring range: -200.0 to +1370.0 °C
- Accuracy: $\pm(0.3\text{ °C} + 0.1\text{ \% of meas. val.})$
- Resolution: 0.1 °C

b. Technical card of Instrument Lux Light meter.

- Résolution : 0,1 LUX
- Précision : $\pm 5\%$ ($<10000\text{ LUX}$)
- Précision : $\pm 10\%$ ($<10000\text{ LUX}$)

Fig. 6. (a) Testo 480. (b) lux meter. Source: Author.

4 Results and discussion

4.1 Compared (S.V.F) for the three models of urban canyons

The difference of s.v.f results from the difference in the ratio L/W . This leads to differences in the periods of direct solarization and amount of the solar energy for the three models of urban canyons, because the sky is the main access of solar radiation to the urban canyons. The sky view factor, scientifically, must be the sky view factor that is low in the external space in the desert cites in order to ensure more shade, low amount of solar energy, and low air temperature. Thus, the main controller for the sky view factor is the relationship between L/W . Therefore, the larger the proportions between L/W , the lower the sky view factor, the smaller the amount of solar energy.

Fig. 7. The compared (S.V.F) for the three models of urban canyons. Source : Author.

4.2 The air temperature for the three models of streets, north west / south east

Fig. 8. The level of air temperature for the three models of streets- North west / South east. Source: Author.

As a result of the test, we recorded that the measuring point n°01 has higher values: max temperature - 44.4° , estimated total thermal energy - $6326 \text{ W/m}^2/\text{d}$. Then the measuring point n°02: max temperature - 42.3° , and estimated total thermal energy - $5314 \text{ W/m}^2/\text{d}$. The measuring point n°03: max temperature - 40.6° , and estimated total thermal energy - $3288 \text{ W/m}^2/\text{d}$. Thus, we understood that the temperature difference between the open street and canyon street reached 4° , and difference of estimated total thermal energy is of 3038 W/m^2 . This difference in values is a consequence of the difference in the ratio between L/W , where the lowest values were on canyon street. This result proves the influence of the relationship between the height of the building (L) and the section of outer space (W) in reducing the amount of thermal energy and improving the air temperature.

4.3 The level of natural lighting for modes of streets, north west / south east

Fig. 9. The level of natural lighting of streets. North West / South east. Source: Author.

By the test and according to measurements, the measuring point n°01 has: higher values of reached max level of natural lighting - 90 k/lux, and estimated total light energy in direct lighting - 277.7 k/lux, this type of street is exposed to direct sunshine 08 hours, 14.5 hours of the day. Then the measuring point n°02: max level of natural lighting is of 90 k/lux, and estimated total lighting energy in direct lighting - 176 k/lux, this type of street is exposed to direct sunshine 06 hours of the day. The measuring point n°03: max level of natural lighting - 83.5 k/lux, and estimated total light energy in direct lighting - 83.5 k/lux, the street is exposed to direct sunshine only two hours of the day. So, the difference of estimated total lighting energy between the open street and canyon street is of 194.2 k/lux. This difference in values is a consequence of the difference in the ratio between L/W, where the lowest values of direct sunshine and less light energy were on canyon street. This result proves the impact of the relationship of L/W in improving of the level of natural lighting in the street.

Note. The samples were taken from different stations for the air temperature, outer wall temperature, ground temperature, and natural lighting value by scientific instruments approved by the research lab (Iacomofa)- univ of Biskra. All samples were taken within 6 minutes, the measuring points are 800 meters away from each other. The repeated samples were taken every two hours, 24 hours a day, each three consecutive days, with assistance of three persons. There are no error limits, since the measurement conditions do not change between different stations and a very short time difference between samples taken from different stations.

5 Scientific suggestions

According to the results obtained, we can suggest the following:

- The construction density of the urban fabric of desert cities should be high in order to provide long hours of shade in the free spaces during the day.
- The need to reduce the openness of free spaces in relation to the sky by reducing the of the sky view factor (s.v.f).
- The height of the building should be always double the width of the street in the desert cities.
- The need to provide shade of buildings alternately throughout the day.
- The need to focus urban planning on the choice of the optimal direction, the least exposed to solar radiation in the daytime, to constantly maintain a shadow on the street.

6 Conclusion

In conclusion, the relationship between L/W can be a controller of the openness of the urban canyons towards the sky. S.V.F is considered a door for solar radiation entering the urban canyons. Thus, a large proportion between the L / W makes a small sky over the city canyons to enter solar radiation. So, the urban fabric more construction density and more proportion between L/W is the lowest in terms of the solar radiation in the urban canyons, and reaches for the shade alternation throughout the day. This is very important for desert cities in order to reduce natural loads and improve the urban environment of desert cities.

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