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IMPACT of STREET DESIGN on SHADING REQUIREMENT for HOT ARID CLIMATE (BISKRA): SHADE NET EFFECT VALUES ASSESSEMENT over BUILDING FACADES

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***Abstract*— Shading in open spaces has a decisive effect on the thermal comfort of human beings, particularly in arid climate where summer shading and passive winter heating is essential. The urban canyon is conceived as a geometric abstraction of the basic urban space, defined by height/width ratio, and the orientation that is defined by its long axis. This directly influences the absorption and the emission of incoming solar and outgoing long wave radiation which has a significant impact on the desirability of shade within the street as well as the surrounding environment. The objective of this research is to develop a parametric study that evaluates the effect of street geometry on shading requirement over building facades. To achieve this aim a contemporary urban street will be analyzed. The investigation was conducted during summer period (21st Juin-21st September) in city of Biskra (Algeria) characterized by hot dry climate. The modelling simulation has been done, using parametric tools (Rhinoceros-Grasshopper-Ladybug) to determine the shade net effect values over building facades. Afterward a statistic tool SPSS.20 has been used to determine the correlation between H/W ratio, and shading requirement. The results reveal that a number of useful relationships can be developed between the geometrical parameters of urban street dimensions and the desirability of shade over building facades.**

***Keywords*— shading requirement, parametric study, building facades, Rhinoceros-Grasshopper-Ladybug, H/W ratio.**

I. INTRODUCTION

Urban spaces form the major component of the urban environment and also affect the performance of the buildings which border them. They can be comfortable or uncomfortable places depending on their detailed design [1]. Urban spaces in cities have a large variety of forms and surface characteristics. The microclimate of these spaces is influenced by several parameters such as the urban geometry, the vegetation, the water levels and the properties of surfaces. The inappropriate uses of these parameters cited before contribute to the harshness of the environment and makes the temperature in the urban environment higher than in the suburbs (Urban Heat Island phenomenon) [2]. Therefore, microclimatic design of urban spaces requires knowledge of prevailing climate conditions, understanding of the ways in which objects in the landscape affect climate to create microclimates, and methods for applying this knowledge, through landscape design, to create microclimates that are comfortable for people and minimize the energy use of buildings [3]. The urban street canyon which is conceived as a geometric abstraction of the basic urban space has been the focus of numerous urban climate studies both as a framework for describing urban canopy layer conditions at the micro-scale, and as building block for describing the larger urban surface at the meso-scale. Urban canyon microclimate is largely affected by solar access and shading conditions, since solar access affects air and surface temperatures, canyon geometry and parameters such as street pattern, height of buildings/street width ratio and street orientation determine solar access and shading conditions. Consequently they play a crucial role in thermal comfort in urban spaces and affect largely the energy performance of buildings. It has also been suggested that urban geometry is much important at the micro scale than the thermal behavior of materials and the albedo effect [4] .In summer, shading is the key strategy for promoting thermal comfort in hot and dry climate [5], since it reduces considerably solar flows, by limiting the heating of surfaces which normally should be sunny, it also reduces thermal radiative flows [6]. In order to understand the multiplicity of energy phenomena overlapping at urban contexts, numerous studies examine the effect of street canyons geometry on solar access and shading requirements ([4] [5]; [7]; [8]; [9]; [10]). This paper aims to develop a parametric simulation that visualizes the desirability of shade in terms of comfort temperature for hot arid climate, and

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evaluates the effect of street geometry (height to width H/W ratio, and length L); on the shade net effect values over building facades, for different orientations. To achieve this objective the modelling simulation has been done, using parametric tools (Rhinoceros-Grasshopper-Ladybug), to determine the favourable geometrical parameters of urban street, in which shading is desirable. Afterward a statistic tool SPSS.20 has been used to determine the correlations, and the regression coefficient of the above parameters.

II. METHODOLOGY OF RESEARCH

Street shading is first and foremost a function of the basic canyon geometry and can be determined quantitatively as a function of time, location and the streets geometric proportions (book urban microclimate). In this regard, the main aim of this paper is directed towards, showing how the urban canyon geometry including street length (L), street canyon aspect ratio height to width (H/W), and street orientation, affect the shade net effect values over building facades during summer period. Also founding clear and flexible guidelines, that ensures shading requirements for each building and spaces between them during summer period. On this basis a workflow that combines parametric modelling (Rhinoceros-Grasshopper-Ladybug), and statistic tool SPSS.20 has been developed. Firstly we started by using Rhinoceros-Grasshopper (parametric design tool that provides a very dynamic design environment where the designer can continuously explore solutions by changing parameters and the primitive geometries) for modelling urban rules, also for making a simulation of fictitious fabrics by varying the above geometrical parameters of the urban canyon (see figure1). Afterward we have used Ladybug Comfort Shade Benefit Evaluator; this is a component for visualizing the desirability of shade in terms of comfort temperature by using solar vectors. The coloured mesh outputs component, illustrate the desirability of shade, where a higher saturation of blue indicates that shading is desirable. A higher saturation of red indicates that shading is harmful, which means that shading is not desirable. Subsequently, we have used SPSS.20, to determine the regression coefficients, and the correlations between the geometrical parameters of urban street and the desirability of shade over building facades. Weather data were obtained from Meteonorm 7. To ensure that the urban geometry is the only factor for comparison, vegetation was excluded and materials for buildings and streets were unified.

III. STUDY AREA

A. Biskra city and climate

The investigation was conducted during summer period (21st Juin-21st September), in city of Biskra (Algeria) located at (34°51′ N, 5° 44′ E). The climate of Biskra is hot and dry, with an average temperature of 38 °C occurring in July. The air temperatures recorded reach a maximum of 35 °C and 40 °C, with occasional peaks of 46 ° C that occurs at about 15:00.The humidity is relatively low; it varies between 23% and 27% during some periods of drought and it can reach the minimum rates between 2 and 6%. The intensities of solar radiation on the region are very high; the horizontal solar radiation is important, it can reach 1040 W/m² between June and July. The wind is dry and hot steering north - east with an average speed between 1 and 2.5 m / s. All these elements contribute to the climate harshness of this city.

Three different architectural styles can be recognized in Biskra, vernacular architecture, colonial, and modern contemporary architecture. They are different in style, applied techniques and materials.

B. Site selection

Shading in urban spaces has an important impact on the overall appearance and ambience of a development. Requirement for shading will vary according to climate.

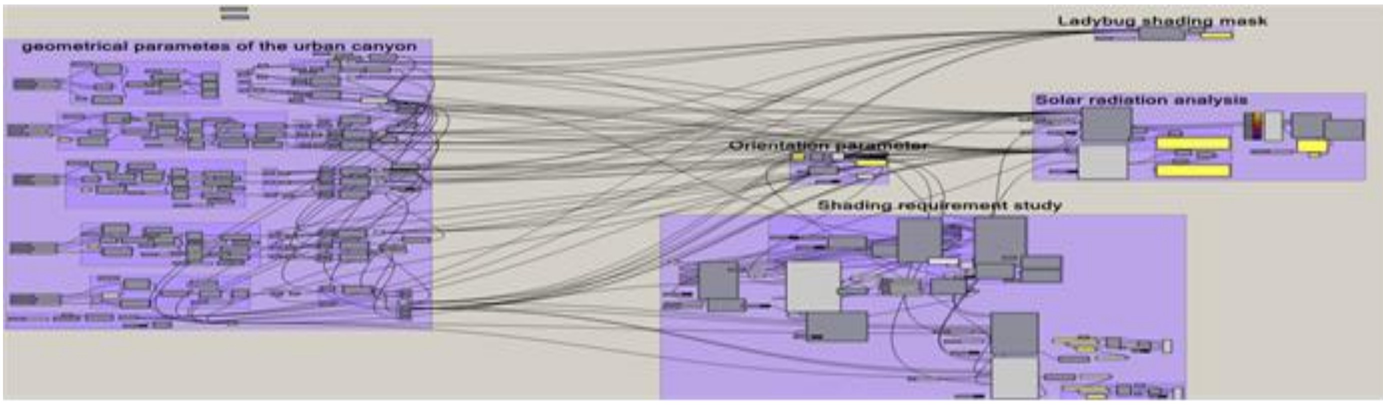


Fig. 1 The parametric definition of geometrical profile of the study canyon and shading requirement study

In Algeria, unlike vernacular urban space heritage which illustrates a real concern and consciousness in designing with climate, the contemporary urban space consists of recent urban rules application is not in accordance with the climatic context, and shading or sunlight needs for a given region. Under these circumstances, the shortcoming of the existing urban rules must be highlighted, also evaluated in comparison with shading requirement. In order to achieve this aim, a contemporary urban space must be analysed. Compared to more inclusive descriptions of urban spaces, the urban canyon model makes it possible to simplify geometric relationships by reducing the description of the space to an essentially two-dimensional cross-section, defined as the ratio between the average height of adjacent vertical elements (such as building facades) and the average width of the space (The wall-to wall distance across the street) [12]. Therefore an urban canyon of (H/W=1, and length =70m) represents a model of the recent urban rules will be investigated. The height, H, and the length L were varied relative to the fixed street width, W, to create building height/street width ratios (R=H/W) or urban canyon ratios of R=0.5; 1; 1.5; 2; 3; and 4. These ratios cover a wide range of traditional and contemporary building in North Africa (Bourbia et al, 2004). For assessing the effect of the long axis of the urban canyon, the length (L) of street is taken as following L/2; L; and 3L/2; 2. Correspondingly for evaluating the precise canyon shade net effect values, street orientations are taken in steps of 450 from the north (S1) to east (S4).

IV. Observations and findings

In order to determine the desirability of shade on the surface of urban structures, it is necessary to take into the shade net effect value, which is the sum of the shade helpfulness, and the shade harmfulness for each cell. This will be negative if shading the cell has a net harmful effect, and positive if the shade has a net helpful effect.

Figure (2) shows that for all canyon configurations investigated, shade net effect values in summer period (21stJuin-21stSeptember) are positives, thus the shade has a net helpful effect over building facades.

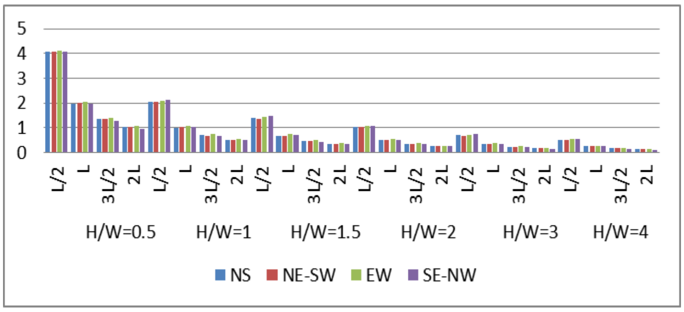


Fig. 2 Shade net effect values over building facades

A. *Shade net effect values (shading requirement):*

1)The effect of lenght on shading requirement:

The results obtained by SPSS.20 revealed the correlations coefficients values between street length, and the shade net effect values over building facades, according to their orientations (NS, NE-SW, EW and SE-NW) were ranged between (-0, 510*;-0, 508*;-0, 515**;-0, 540**) (see table1) These results indicate a strong negative correlation between the parameters cited before and the desirability of shading. Therefore the average values of the shade net effect depend on length variation. In order to verify the intensity of the correlation, the (sig) was used which is considered as a tool of evaluation when is ranged under 0.05 means that there is a significant correlation between the parameters. All street configurations, which are oriented on (NS, NE-SW, EW) directions their sig results are less than 0.05. These confirm the significant relationship between all the parameters tested. However all street configurations which are oriented on SE-NW direction their (sig) is 0.06 which is less than 0.05. Therefore the effect of length on shading requirement over building facades in this direction is trivial.

2) The effect of H/W ratio on shading requirement

Another importunity of this study was to examine the correlation between H/W ratio and shading requirement over building facades. According, to Bourbia [9], floor shading fraction in summer increase with increasing (H/W) ratio. Chang (2015) reported that the Ta inside a deep canyon (H/W= 2.2) is lower than in a shallow canyon (H/W=0.42) by an average variation in the maximum temperature of 4.3°C. Alznafer (2014) stated that increasing the H/W ratio from 0.5 to 2.0 leads to a reduction in Ta of 2.5°C, on average. These results show that reductions in the Ta in deep canyons are mainly attributed to the effect of shading during the daytime that helps the different surfaces to remain cool [11].

The results obtained by SPSS.20, show the correlations coefficients between H/W ratio, and the shade net effect values over building facades were ranged between (-0, 657**; - 0, 657**;-0, 661**-0, 637**), respectively to their orientations NS, NE-SW, EW and SE-NW, as represented in table2.Hence, there was a strong negative correlation between them. This means that increasing H/W ratio leads to decrease shading requirement over building surfaces, where the facades of the model canyon of urban rules of length (L),height to width ratio (H/W=1),and NS direction, require a higher shading of <u>(2.06 C^0-day/m2)</u> in comparison with facades of length (L), height to width <u>(H/W=4)</u> which require

TABLE1.The binary correlation coefficient of lenght and shade net effect values on facades

Correlations					
		Shade net effect over building facades NS	Shade net effect over building facades NE-SW	Shade net effect over building facades EW	Shade net effect over building facades SE-NW
Length	Pearson Correlation	-,510*	-,508*	-,515**	-,540**
	Sig. (2-tailed)	.011	.011	.010	.006

shading value of (0.52C^{0}-day/m2) as displayed in figure (3). Therefore recent urban rules are not adapted to hot arid climate. However the previous table (2) shows that the level of significance (Sig) for H/W ratio was less than 0.05 in the four cases. This confirms significant correlation between H/W ratio, and shade net effect values over building facades, in comparison with ground surfaces where the level of significance (Sig) for H/W ratio was more than 0.05 in the four cases [8]. Hence the effect of H/W ratio on shading requirement over building facades is more noteworthy than its effect on ground surfaces.

Fig 3.Shade net effect values over building facades for length (L),

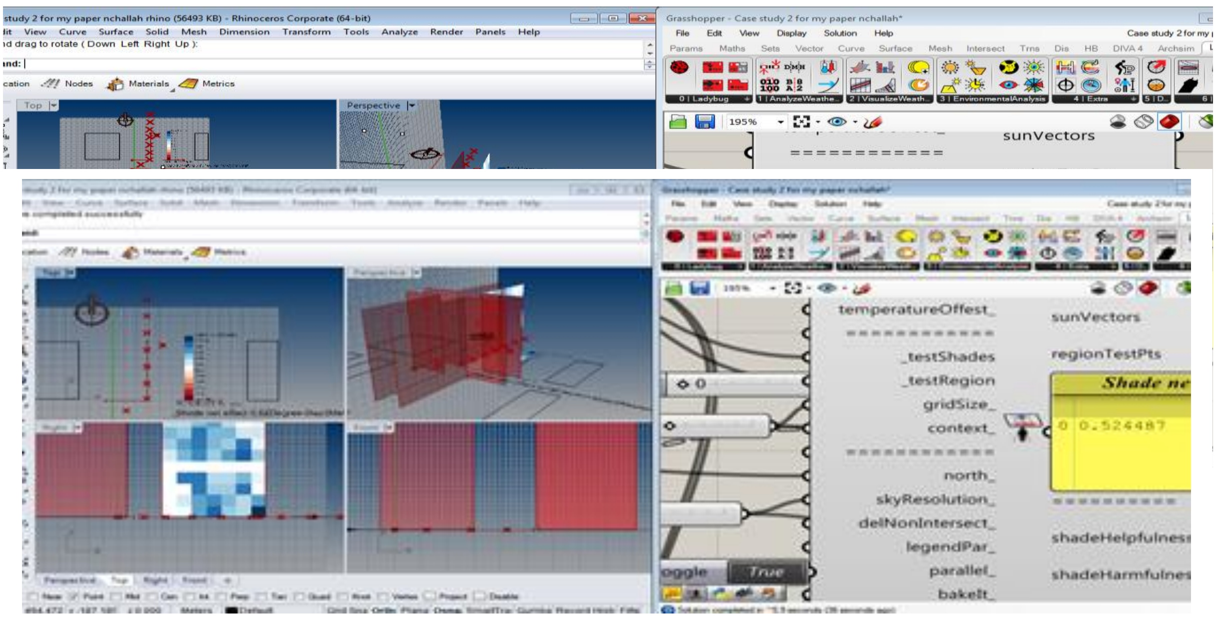
1) The coefficient of determination between H/W ratio, length, and shade net effect values:

TABLE2.The binary correlation coefficient of H/W ratio and shade net effect values on facades

		building facades NS	building facades NE-SW	building facades EW	ect over building facades SE-NW
W/H Ratio	Pearson Correlation	-,657**	-,657**	-,661**	-,637**
	Sig. (2-tailed)	.000	.000	.000	.001
	N	24	24	24	24

**. Correlation is significant at the 0.01 level (2-tailed).

The coefficient of determination must be calculated, in order to determine accurately the influence of length, and H/W ratio, on shade requirement value. Table (3) obtained after analysis of the results by SPSS.20, shows that R (Chi-square) over building facades of the (NS; NE-SW; EW; SE-NW) were respectively as following: 0.691; 0.689; 0.703; 0.697.



These values designate that: 69.1%; 68.9%; 70.3%; 69.7% represent the effect of length, and H/W ratio on the change of the shade net effect values over building facades correspondingly to the aforementioned orientations.

The previous table also shows the linear regressions between length, H/W ratio, and the average values of the shade net effect over building facades for each direction, the aformentioned linear regressions are represented by the following equations : **Y**(Shade requirement **NS**) = -,011 X_1 -,329 X_2 + 2,967 ; **Y**(Shade requirement **NE-SW**) = -,011 X_1 -,0329 X_2 + 2,966; **Y** (Shade requirement **EW**) = -,011 X_1 -,335 X_2 + 3.043; **Y**(Shade requirement **SE-NW**) = -,012 X_1 -,322 X_2 + 3.013.

Knowing that:

Y represents the dependent variable of the shade net effect

X_1 represents the independent variable of length

X_2 represents the independent variable of H/W ratio

(2,967; 2,966; 3,043; 3,013) represent the constants which are the impact of other parameters that we will examine in other studies. These equations proof that the values of shading requirement over building facades for all canyon configurations which are mainly oriented on the EW direction are higher than the other orientations. Which explains that the EW orientation is the worst, also must be avoided in hot and arid climate. However, the NS direction gives smaller desirability of shade in comparison with all other orientations.

TABLE3. The coefficient of determination between H/W ratio, length, and shade net effect values

	Shade net effect over building facades			
	Shade NS	**Shade NE-SW**	**Shade EW**	**Shade SE-NW**
R (Correlation)(Lenght and H/W Ratio)	-0 ,831*	-0,830*	-0,838*	-0,835*
R(Chi-square) (Length and H/W Ratio)	0,691	0,689	0,703	0,697
Constant(Length and H/W Ratio)	2,967	2,966	3,043	3,013
Length	-0,011	-0,011	-0,011	-0,012
H/W Ratio	-0,329	-0,329	-0,335	-0,322
Sig.(2-tailed)(Length and H/W Ratio)	,000^b	,000^b	,000^b	,000^b

V. CONCLUSION:

In this paper the effect of geometrical parameters of urban street (H/W ratio, and length) on shading requirements over building facades during summer period (21stJuin-21st September) in hot arid climate is assessed for contemporary urban street. . In order to reduce the level of shading requirement in hot arid climate, a simulation of fictitious fabrics by varying the geometrical profil of urban canyon model has been done. The findings of this study showed that shading requirement can be reduced by the correct orientation of buildings for shading, while ensuring adequate H/W ratio, and length in order to moderate the harshness of the climate. The results presented in this paper have also shown that there were negative correlations between shading requirement, and the geometrical parameters of urban street. In addition all canyon configurations which are mainly oriented on the EW direction require more shade than the other orientations. Though, the NS direction requires less shade in comparison with all other orientations.

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