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Glazed Facades Buildings in the Different Climatic Regions in Algeria: The Architects' Viewpoint

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Abstarct

Abstract: During the recent few decades, fully glazed facade system has been increasingly used in Algeria. While neglecting its climatic impacts, this design trend is always tangible especially for office buildings. This article presents the main results of a survey carried out for 49 selected office buildings. These latter are located in the three different climatic zones of Algeria. The study is specially focused on these office buildings' designers. This research main objective is to inquiry about the glazed facade architecture in Algeria and to expose architects' points of view about the building glazed envelop in relation to climate factors. A face-to-face administered questionnaire survey has been used for this field study. The investigation results highlight Algerian architects' desire for office buildings with large glass facades even if most of them (90%) agreed that this kind of facades causes overheating and discomfort glare problems. Besides, the architects' preference for a glazed façade is revealed as being more associated to psychological and physiological aspects than to the consequent environmental impact. In addition to the positive features that the glazed facades can provide for a building, in Algeria, some constraints and problems remain for its on-site use. Finally, and from design' practice point of view, the investigation outcomes point out that the 30%-40% window-to-wall ratio is judged as the lowest for the hot and dry climate regions characterized by a clear sunny sky.

Key words: Architect, Climate conditions, Daylight, Glazed Façades, Office Building, Perception, Questionnaire survey

INTRODUCTION

The glazed envelope topic constituted one among the modern movement specific characteristics during the 20th century, and especially in the last few decades, the architectural language has given more and more emphasis to the "lightness" and the "transparency" of buildings, pushing towards fully glazed envelopes (Butera, 2005). Glass conveys in the first place a message of technicality. One could also say that modernity is somewhat translated by the facade dematerialization (Buydens, 2004). Thus, glass became one of the significant and extensively used materials that characterized the 20th century architectural language. His impact upon the built environment has been continuous and largely obvious (Sadeghi et al., 2015).Glazed facades allowed the design of a light and open appearance for the building whilst providing a view out for the user (Flodberg, 2012; Bülow-Hübe, 2008). On another hand, it creates an illusory beauty due to natural light additionally to lightweightness and openness to outside (Sun, 2016). However, fully glazed envelopes created a challenging indoor climate and caused high-energy consumption (Poirazis&Blomsterberg, 2005;Villekjær Pedersen, 2016). More other problems and disadvantages are also related to fully glazed façades buildings at the indoor space and the urban surrounding area levels. They directly impact the occupant's thermal and visual comfort and have an intrinsic relationship with overheating, glare, and the high-energy demand (Hien et al., 2005;Bustamante et al., 2014;Ibraheem et al., 2017). Surprisingly, Flodberg (2012) concludes that energetic consumption for lighting, in office buildings' case, is not always lowered by the large glazed external walls. This is due to the occupants' recourse to shading devices in order to reduce glare effects (Ibraheem et al., 2017). These latter have been extensively studied in different countries for the case of glazed facades buildings. According to some research works, the window-to-wall ratio highly impacts the interior illuminance of office buildings affecting thus their occupant's comfort. In fact, high illuminance levels occur generally glare problems for occupants (Bustamante et al., 2014).

At the urban scale, emerges a notorious problem accordingly to the fully glazed facades use. Effectively, large glazed facades are extremely reflective and could cause severe visual discomfort due to the reflection of sunlight falling on buildings' surface. These intense reflections can cause an intolerable glare, which can impair the vision of near buildings' occupants and contribute to overheating of surrounding buildings(Abdelwahab et al., 2019; Ishak et al., 2018).(Figure 1) shows an example of sunlight bounced of glazed façade causing blinding glare, while(Figure 2) illustrates the results

of the reflected irradiance ,where the clear-sky results show a more intense and continuous area of extreme reflection intensities(Danks& Good, 2016).

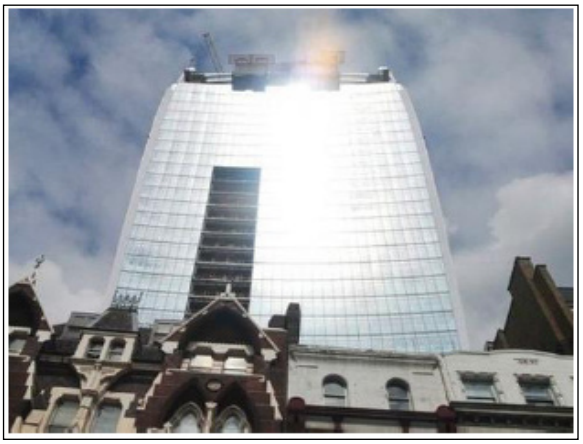

Figure 1. The Walkie-Talkie skyscraper' glazed facade causes glare problem to the londonian citizens.

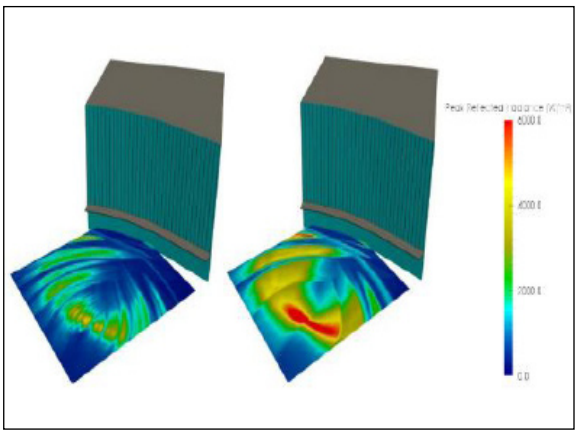

Figure 2. Hourly peak reflected irradiance for 'typical' (left) and 'clear sky' (right) ambient solar conditions.

Despite the risk's severity, there is surprisingly little urban and building regulation regarding such sunray's reflections' phenomenon. It would seem that this lack of such regulation remains partially to the fact that there are no universally accepted criteria from the scientific community defining acceptable limits of reflected visible light and thermal irradiance in the urban realm (Danks et al., 2016). Nowadays, building quality and sustainability are guaranteed by building certification systems. Additionally, social, economic and environmental aspects must be considered.

In front of the conceptual and pragmatic changes suggested by environmental questions, that are central in contemporary architecture, this research attempts to investigate: i) the Algerian architects' preference reasons for glass as a construction material for the facade, and ii) these architects perception of the fully glazed façade located under different climate zone conditions in Algeria. To achieve this objective, a questionnaire survey was conducted with the designers of 49 existing office buildings located in three different climatic zones in Algeria. These zones differ significantly in terms of average annual temperature and solar potential. The selected buildings are characterized by high window-to-wall ratio' facades.

A BRIEF HISTORICAL LOOK TO GLASS BUILDING IN ALGERIA

In Algeria, glass facades buildings emerge during the last years of the French colonial period concretizing the fifties modernity. Thus, many buildings presented, at that period, more transparent office building facades contrasting with colonial previous eras ones. However, it is really at the present century beginning that appears most of the very impressive and large use of glass in office building' facades. This phenomenon is nearly uniform in all the Algerian cities whatever the climatic region where they are located. In cold as well as hot climatic conditions, the fully glazed façade has become a design trend attracting many Algerian architects. Specifically, it is this open, lightweight and transparent new public building seems to mark the break with the enclosed, heavy and opaque traditional architecture. In this design context, the window size area increased to become the building envelope in itself (Figure 3 and 4).

(a)WWR= 30% (a)WWR= 45% (a)WWR= 80%

Figure 3. Samples of office buildings show the evolution of window size area in cold climate zone in Algeria, Annaba city: (a) treasure center70s ;(b) Public equipment center 90s; (c) Tourism building 2000s.

(a)WWR=35% **(b) WWR=55%** **(c) WWR=90%**

Figure 4. Samples of office buildings show the evolution of window size area in hot climate zone in Algeria, Biskra city: (a) CNAS building 70s; (b) CRMA bank 90s; DTP building 2000s.

METHODOLOGY

This research is mainly based on the study of the architects' perception of the glass facades buildings in Algeria. So, and in respect to the varied climatic contexts in Algeria, it was decided that the study corpus must be as varied as are the different regions of the country. Hence, a set of glass facades buildings were selected across the different climatic regions of the country. Because of their non-uniform distribution among the country territory, there has not be any previously designated selection criteria based on a uniform distribution of the office buildings through Algeria geographical areas.

The Study Corpus

From a climatic point of view, Algeria consists of three main zones: i) Warm Mediterranean climate zone in the North (Zone I), ii) warm Saharan Desert climate in the south (Zone III), and iii) Cold semi-arid on the high plains in between (Zone II) (Figure 5). The 49 selected office building are located in 13 cities within the three different climatic zones as follows: i) (14) buildings in the Zone I, ii) (15) buildings in Zone II, and iii) (20) ones in Zone III (Figure 6).

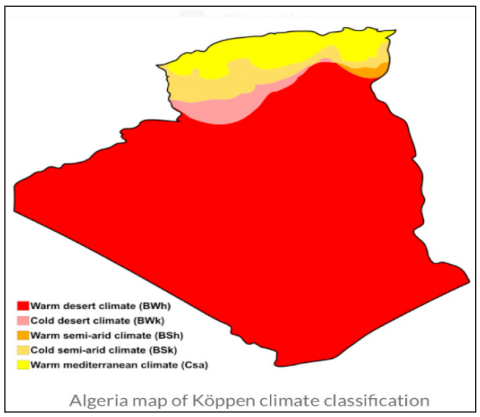

Figure 5. A Köppen-Geiger Algerian climate classification map

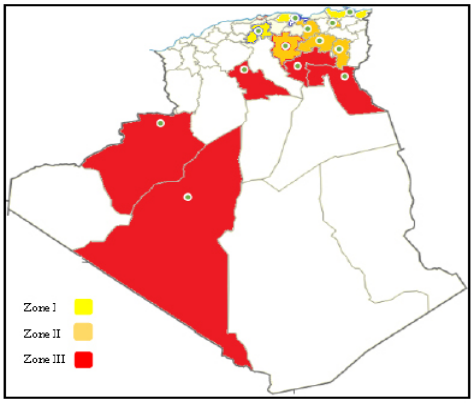

Figure 6. The situation of the Algerian territory division map of the climatic zones and the cities where are located the selected office building corpus.

They all were built during the 21st century and are mainly characterized by large window-to-wall ratios (WWR ≥ 65%) (Figure 7).

Figure 7. Samples of office buildings case studies. Climate Zone I: (a)Rectorat building; (b)Profert building; (c) Affaire center. Climate Zone II:(d) CASNOS building;(e)Forests building;(f)SONALGAZ building. Climate Zone III: (g) Doniaoffice building;(h)Commerce office building;(i)Tourism office building.

The Survey

The survey was undertaken with the architects that design of the selected office buildings. All these architects possess an in-field experience in terms of office buildings design. In addition, these architects originate from various cities situated in the three climatic zones of Algeria.

For this survey, a rigorous literature review allowed the development of a questionnaire to be addressed to the selected office buildings' architects (Baker, 1994; Van Teijlingen& Hundley, 2001; Van Teijlingen&Hundley, 2010; Sadeghi et al., 2015).The survey was carried out in two steps: i) a pilot study in order to check the questionnaire relevance as a survey tool (Asımgil, 2004; Al-Shwani, 2011), and ii) the main field study conducted from 20 June to mid-October 2017.

In the first step, a face-to-face interview was conducted with 30 practicing architects in order to discard all unnecessary, difficult or ambiguous questions, and to assess whether each question gives an adequate range of responses (Klein, 2013). In the second step, the survey was carried out with 49 architects. distributed as follow: i) (14) Design architects operating in zone I, ii) (15) Design architects in zone II, and iii) (20) Design architects in zone III. This survey was directly face-to-face conducted with 30 architects whilst the 19 other designers received the questionnaire via email. The consisted of three main sections (Table1): 1) Design' decisions, 2) Window-to-wall ratio, and 3) Architect's perception of the glass façade. The questionnaires contain a variety of question types such as: i) open and closed questions, ii) with single and multiple responses depending on the sought information. This questionnaire survey' collected data was analysed using statistical software STATISTICA 7.0.

Table 1. The questionnaire items

Items	**Questions**
Design decision	• Please rank the actors in respect of influences on decision from most influent (1) to least influent (4) • During the conceptual stage of the design process, do you use building simulations software? • Please rank the factors influencing the choice of the type of glass used in your project , from the most influent (1) to the least influent

Widow-to-wall ratio	• The office building must be 100 % transparent • Which window-to-wall ratio do you prefer for office building? • What is the reason for a glass façade preference?
Architect's perception of glazed facade	• Which plane do you want to percept more glass façade • What is the meaning of glazed facade? • Do large glass facades contribute to overheating problems and discomfort glare in building? • Do large glazed façade causes an urban heat island (UHI) and a glare discomfort on urban dwellers?

RESULTS AND DISCUSSION

Design Decisions

The main actors mostly influencing the decision of a glass facade use were classified by the architects as follows (Figure 8): i) The owner-builder is pointed as the most influent actor (79%), ii) the architect (62%), and iii) the building engineer and façade constructor as the least influencing actors.

If it is not opposite to other countries ones, this situation differs widely from their case because of the integrated design process which constitutes 'a procedure considering and optimizing the building as an entire system including its technical equipment and surroundings and this for the whole lifespan. This can be reached when all the project actors are cooperating across disciplines. It could be also possible when they are agreeing on far-reaching decisions jointly from the beginning' (Kanters& Horvat, 2012).

During the design process preliminary stage, building simulation software's are never used as stated by a very significant majority of architects (85%). Thus, only a minority among them (15%) use these tools. This minor group is constituted by the youngest architects (Figure 9).

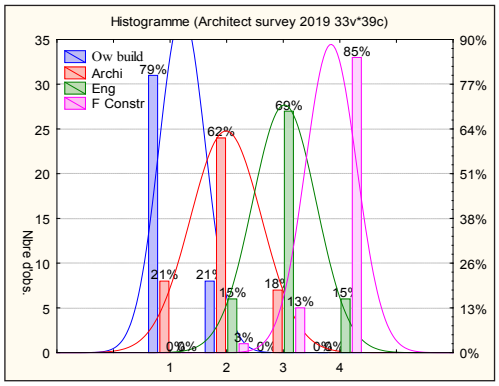

Figure 8. Actors influencing the glass Facade use decision during the buildings Design process.

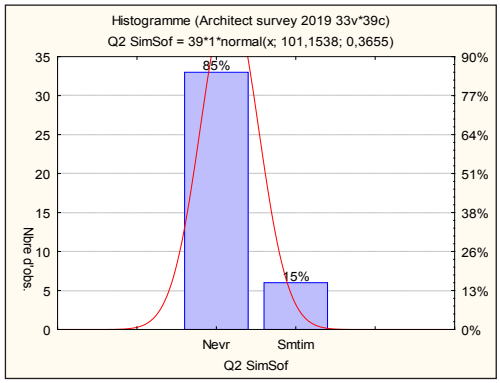

Figure 9. The building simulations software tools'use during the conceptualstage of the design process.

This situation could be explained by the fact that the building simulation software's are not included, neither theoretically nor practically, in the basic curriculum of several architecture and engineering schools. However, the youngest architects seem surpassing the simulation tools' training lack by a self-training in this field. Such attitude should be consequent from their motivation for learning new technology based methods including simulations software (Figure 10). It must be underlined, however, that a previous research work revealed the clear association between the software trend decreasing use and the architects' increasing age (Weytjens&Verbeeck, 2010).

Besides, the architects ranked the price of the glass as the most influencing factor (77%) for their choice of the type of glass used in their projects (Figure 11). This factor is followed by: i) the glass availability (69%), ii) the low environment impact (62%), and iii) the light and heat transmission quality of the glass (56%).

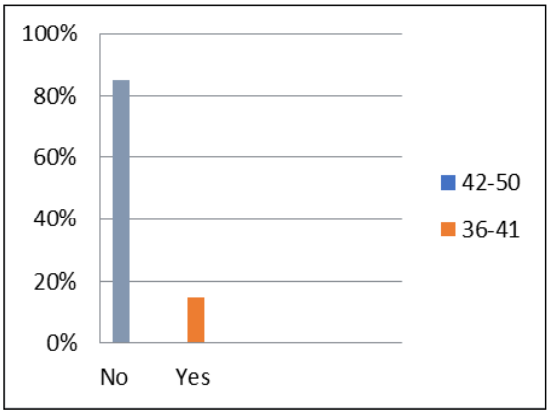

Figure 10. The building simulations software' Use in relation to the respondents' age.

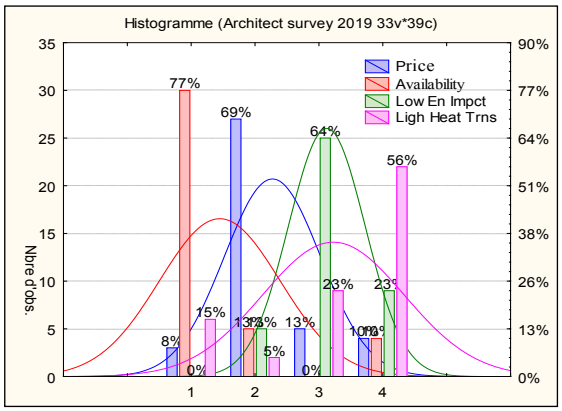

Figure 11. Factors influencing the choice of the type of glass.

Window-to-wall ratio (WWR)

Architects are not categorically equal about the obligation, or not, of using a 100% transparent glazed facades for office buildings (51% of them are for whilst 49% are against) (Figure 12). The window-to-wall ratio values they prefer could be classified into three categories (Figure 13): i) the most preferred one has a score of 48% and varies between 60% and 70%, ii) the averagely preferred ratio (28%) illustrates the most transparent glazed facade (WWR between 80% - 90%), and iii) the less preferred one (23%) is the case of a ratio value going from 20% to 40%. Such preference trends are not very dissimilar to those revealed by previous research works carried out in different contexts (Vidler, 2003;Konis, 2011; Hoffmann et al., 2012).

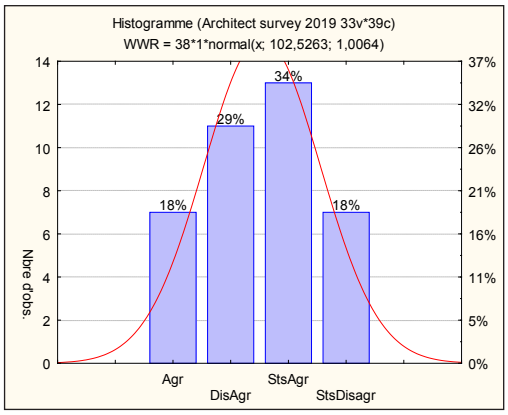

Figure 12. Office building architects' opinion About the necessity of a totally (100%) Transparency for the façade.

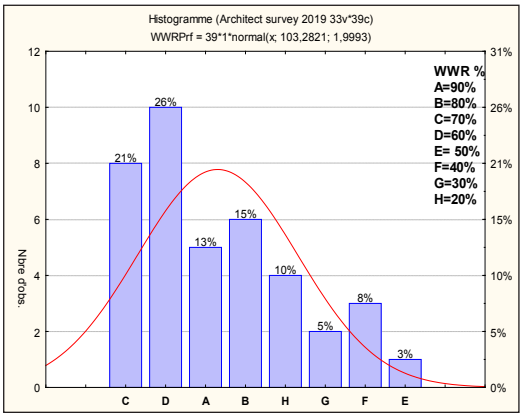

Figure 13. Office building architects' window-to-wall ratio preferences.

Furthermore, a correspondence analysis has been used in order to locate the association level between the following two variables: i) the preferred window-to-wall ratio, and ii) the climatic zones where the selected architects practice. The analysis outcomes (Figure14) point out a significant dependency between climatic zones and the WWR. In fact, the architects working in : i) the zone I preferred high WWR (80%-90%), ii) the zone II choose WWR (70%), and, iii) the zone III are more attracted by low WWR (30%-40%). Hence, it becomes obvious that the WWR is lowest when the climatic context is hot and dry. Thus, this outcome corresponds to existing recommendations suggesting that windows surfaces, in any orientation, should be minimized in the hot and dry regions (Lee et al., 2013).

On another hand, most of the architects (90 %) said that transparency is the reason behind their preference for a large glass area for the office building facade whilst the aesthetic aspect was the argument of a little over half among them (56%) (Figure15). Unfortunately, 'energy considerations' and 'the building material contemporaneity' were significantly revealed as the less influent factors (respectively 28% and 23%) on transparency's preference.

It must be noticed here that, elsewhere also, the environmental aspects are less important for the architects. This was highlighted by a research work carried out in a different climatic context, that is Istanbul one (Asımgil, 2004).

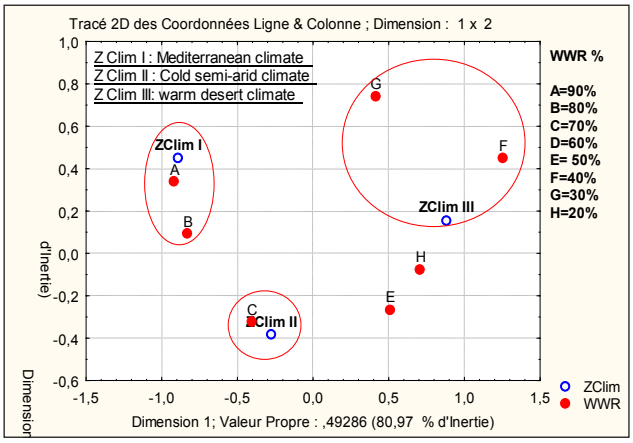

Figure 14. Window-to-wall ratio and the related climate zone as pointed out by the correspondence analyse.

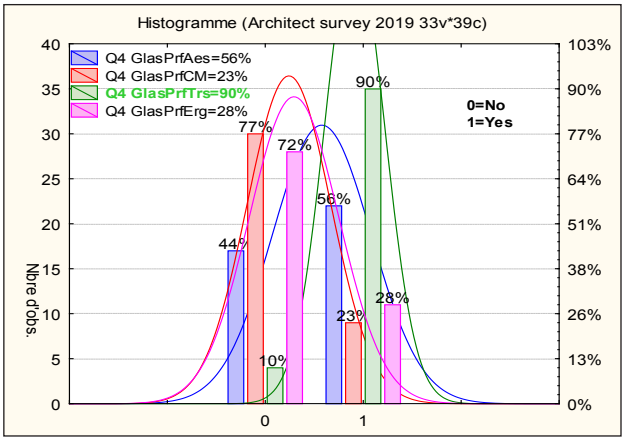

Figure 15. The reasons of Architect's preference for large glass facades.

The Architects' Perception of Glazed Facade

The architects' perception of office building' glazed façade has been investigated through the following aspects: 1) The aspect from which the glazed façade is perceived, 2) the glazed facade significance from the architects' point of view. 3) The glazed facade impact on indoor environment comfort, and 4) the urban heat island problem (UHI) consequences as well as the discomfort glare conditions lived by urban dwellers.

Firstly, the glazed façade is perceived for the large majority of respondents (85%) as "an exhibition device of the building's inner and outer"; secondly, as "the building architectural form" (79%).

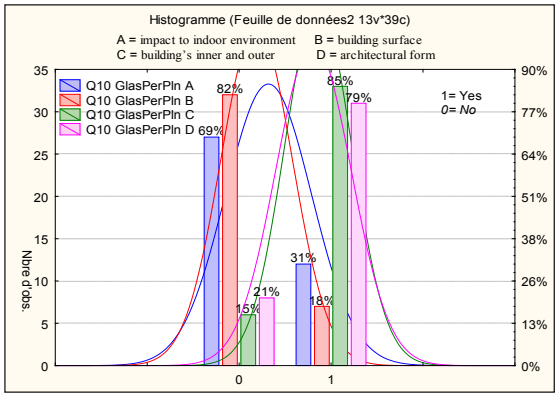

Figure 16. Architects perception's dimensions

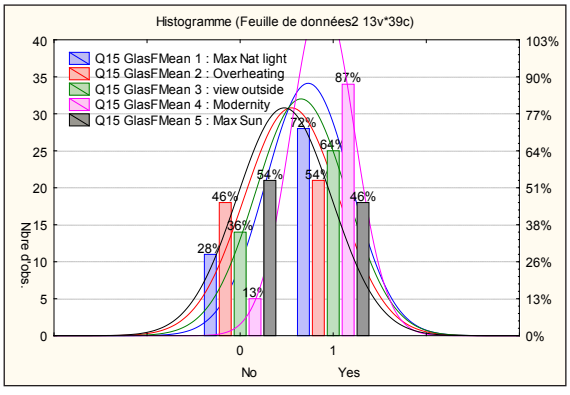

Figure 17. Significance of the glazed façade Of glazed façade for an office building. From the architects' point of view.

However, "the impact upon the indoor environment" and a "plane from the building surface" seem to be the less important perceptual aspects respectively with (31%) and (18%) (Figure 16). Hence, it could be said that architects are

more attracted by psychological aspects of the glazed façade than conscientious its' environmental impact.

The architects think that the significance of a glazed façade is related to: i) the "Modernity" as the most important meaning associated to the glazed façade (87 %), ii) the provision of a "Maximum of natural lighting" (72 %), iii) "View outside" (64 %), and at last iv) "Overheating" and "Maximum of sunrays" (respectively 54 % and 46%). Architects design buildings in order to express the modernity and to create a new landmark for the city. So, transparent architecture is certainly symbol of modernity, but according to user's viewpoints there is different meaning for each transparent building (Sadeghi et al., 2015). This research results related to both "the Maximum natural lighting" and "the View outside" provided agree with the findings of earlier research, where the provision of a view out and the admission of daylight through windows are much appreciated. This might explain the office workers preference for the big window size (Boyce et al., 2003;Hellinga&Hordijk, 2008; Markus, 1967)(Figure 17).

The outcomes point up a significant dependency between these three variables (Figure 18). The difference between architects in terms of glazed facade' perception and meaning depends on the climatic region where they practice. The glazed facade is perceived: i) as a provision of a maximum of sunrays in the cold context (Zone II), and oppositely as ii) a consequent overheating within the hot and dry desert context (Zone III).

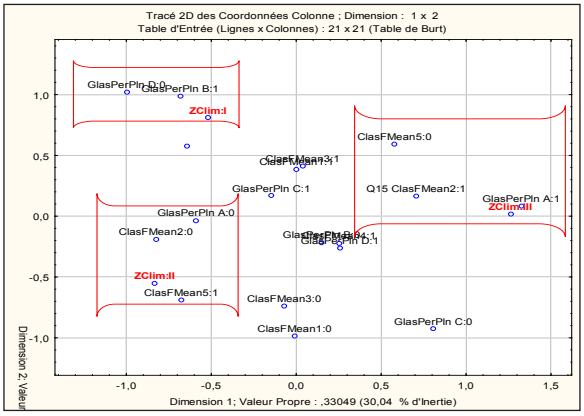

Figure 18. Multiple correspondence analysis indicate the distribution of i)Which plane is glazed façade perceived , ii) the meaning of glazed façade and iii) the context where architects practices.

The major number of the architects (90%) agreed that large glass facades contribute to indoor overheating problems and discomfortable glare (Figure19). On the contrary, about two thirds among them (67%) disagree about the fact that large glazed façade causes urban heat island (UHI) and eye-stinging for urban dwellers (Figure 20). These results are dissimilar to previous research works findings clearly revealing the glazed facade impact on the surrounding environment. Hence, as there are more and more reflective surfaces, the situation become increasingly dangerous (Schiler& Valmont, 2005) causing excessive visual and thermal discomfort outdoor (Ishak et al., 2018).

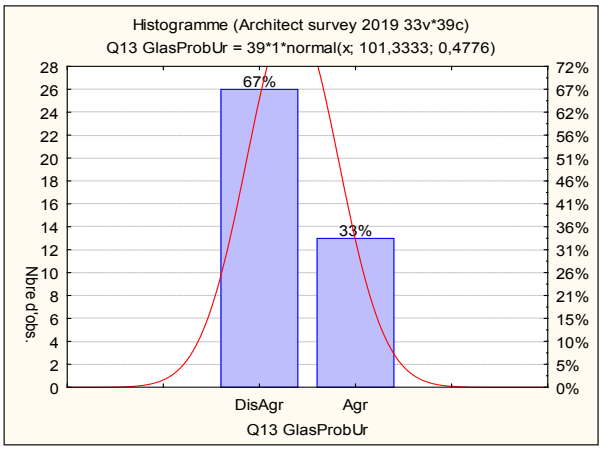

Figure 19. Architects 'opinions about the glass Facades' contribution or overheating problems And discomfortable glare in building.

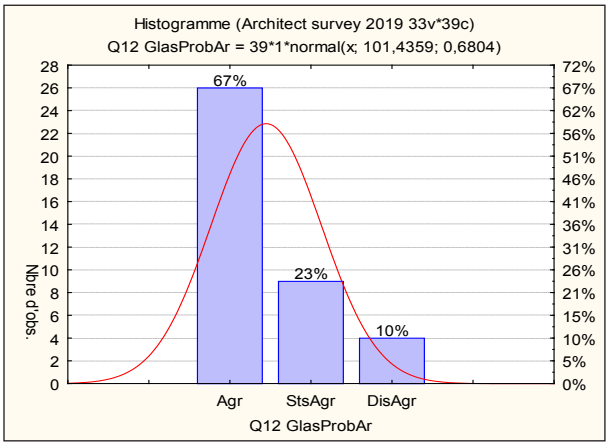

Figure 20. Architects' points of view about the impact of glass facades regarding the Creationof urban heat island (UHI) and Discomfortable glare for citizens

CONCLUSION

This study assessed practicing architects' point of view about the Glass office buildings facades in various climatic regions in Algeria. The questionnaire survey concerned 49 architects' designers of 49 selected office buildings. These later are characterized by a large window-to-wall ratio and located in the three major Algerian climatic zones (Mediterranean climate, Cold semi-arid, and desert climate).

Firstly, it must be highlighted that during this decade (2000- 2019), many offices were built with a single glass skin and without solar control devices. The building wide glazed surface is often oriented towards the main street, where is most commonly located the access to the building.

The results show that the Algerian architects' desire for the office building with wide glass façade design is mainly related to transparency and aesthetic aspects whilst neglecting any energy considerations related aspects. However, the climate impact is revealed as still sensitive through the clear trend of preferring the lowest WWR for buildings located in more severe climatic regions. The owner-builder influence also the architects' decision about the choice, or not, of the office building glazed facade because it could be more expensive than conventional building materials. These constraints could constitute, in turn, a major constraint for the large use of glass facades in Algeria.

In addition, the architects seem to be conscientious about the glass facades energetic and environmental impacts at the architectural as well as the urban levels. However, other kinds of factors, mainly aesthetical and psychological nevertheless prevail. That said, the extreme characteristics of the climate still affect the architects' perception.

Mainly, this research contributes to explain the Algerian architects' recourse to the glass facade within their local context and considering its climatic variety and severity. To be more efficient in this kind of design, the architects need more technical background to better discern and understand the glass facades application issues especially for the hot dry desert context. Moreover, an awareness campaign towards the natural environment must be conducted with practicing architects as well as students in architecture. This will allows the both to perform such building design defiant of the natural context factors. Furthermore, a comparison between the architects' perception and the office workers' one should be undertaken in order to envisage the glazed facade office buildings' best future in Algeria as well as in any hot and dry region under clear sunny skies.

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