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Implications of Glazed Facades on Occupants' Productivity in Office Buildings "A Review of the Literature"

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Abstract. Nowadays architects are evidencing a trend towards office buildings that are covered with glazing façades. The goal of this paper is to reviewing the current literature to explain the relationship between the effect of glazing façades on the quality of the indoor environment and the efficiency of occupants in an office environment. To achieve the aim of the study, a literature review which have cases studies for office building has been performed. The research provides a thorough discussion and examination of various IEQ variables affected by glazing façades that influence the productivity of occupants. This paper recommends that the necessary studies be made on office buildings before using glazing facades, because of their implications on the productivity of occupants.

KEY WORDS: Productivity, Occupants, Office Buildings, Glazing facades, Indoor Environmental Quality

1. INTRODUCTION

Nowadays there is a trend towards office buildings that are covered with glazing façades

This study is investigating the notion of how the using of glazing facades in an office building have an impact on employees' productivity.

2. GLAZING FACADES

It has become a typical feature in commercial construction, like certain other properties that pose a challenge to the thermal efficiency of the building envelope.

Glass in contrast to the less robust metal surroundings has seen a substantial environment of research and development activities, with continuous efficiency enhancements ongoing. Nevertheless, it is possible that untreated float glass is an unusual material in skin of construction. Today, glass is tinted, polished, laminated, sealed, rubbed, perforated, stitched, wired, tempered, adjusted, and in many forms. Glass materials on construction sites are somewhat different from the conventional wall curtain schemes. This improvement aims to fix the issues and drawbacks of flat float glass on skin of houses. (Patterson, 2011).

is a window that allows for a variety of visual contact between building inside and outside, as well as a means of natural illumination. Also, it has a significant impact on the building's thermal efficiency which has a significant impact on the building's inhabitants and their degree of productivity of occupants.

The usage of glazing facades to cover modern buildings is touted because of the technical advances that have rendered possible glazing facades on modern buildings. Furthermore, office buildings also use glazing facades to offer to daylight access, but visual communication is often encouraged. While reducing the transmittance of the sun's rays, the glazing curtain walls of buildings might increase the risks of overheating and visual discomfort. (Patterson, 2011)

Overheating is happening due to the glass property of high thermal conductivity while glare, negative aspect of light, happens due to high contrast either directly or by reflection and it creates both discomfort and disability (Phillips, 2004).

It is accepted that inadequate light levels, which may be induced by low levels could induce poorer focus, decreased efficiency and impact the well-being. In opposition, elevated amounts have a beneficial impact on the alertness, fitness, and vigilance of the human body.

2.1 TYPES OF GLAZING FACADES

The basic glazing types are categorized into framed and frameless systems (Fig.1). Frameless glass systems include the two variations of point-fixed system types so often used in SGF applications. The other systems are also used and are briefly reviewed here, but with an emphasis on the frameless systems. (Patterson, 2011)

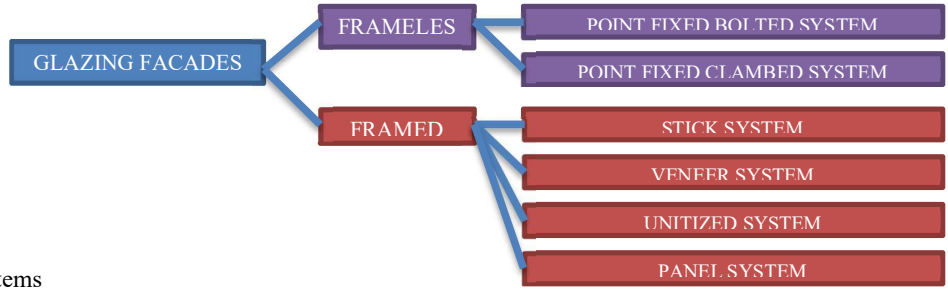

Fig.1 glazing systems

2.1.1 Stick system

It is the earliest form of curtain wall technology in which vertical extrusion span between floor plates (fig.2). It is much of the fabrication and assembly work that occurs on-site where the quality control and general conditions are more challenging. The system is appropriate for geographic regions with cheap site labor.

Fig.2 Stick system

2.1.2 Veneer system

Veneer system (fig.3) is a minimal approach borrowing the curtain wall technique which similar to a stick system, but nonstructural. It requires almost continuous support to the extrusion receiving the glass. In addition, it can be used with wet or dry seals. Therefore, veneer is quietly economical, however, it erases the demands on glass supply.

Fig.3 Veneer system (Patterson, 2011)

2.1.3 Unitized system

The unitized system (fig.4) has largely replaced stick technology in large commercial applications. The units are assembled in the factory and shipped to the field as it shifts more labor to factory-controlled conditions. Additionally, it is better quality and quality control from factory assembly and, thus, may reduce expensive site labor.

Fig.4 Unitized System (Patterson, 2011)

2.1.4 Panel system

Panel system (fig.5) provides moderate to high relative transparency depending upon the glass type. Regarding glass, its surface can be lifted off the supporting structure in which butt-glazed silicon joints can be used throughout. Moreover, facilitates the installation process and potentially more economical than point-fixed systems.

Fig.5 Panel system (Patterson, 2011)

2.1.5 Point fixed bolted system

Point-fixed bolted system (Fig.6) provides maximum transparency for any specified backer structure. The glass is raised off the supporting structure. However, it adds to system cost, particularly with multiply panels. Furthermore, though butt-glazed silicon joints, they require harsh and more expensive glass supplies. PFBS demands high-tolerance installation and is thus, most costly.

Fig.6 Point fixed bolted system (Patterson, 2011)

2.1.6 Point fixed clamped system

The point-fixed clamped system (Fig.7) has comparable degrees of retaining strength to the point-fixed drilled systems without the added expense of drilled holes. Clamp plates are clear on the outer glass surface. Hardware may be more costly than off-the-shelf devices with glass bolt hardware. PFBS and panel device have butt-glazed silicon. A benefit of PFCS is simpler glazing criteria. Moreover, the high installation specifications for the backer structure that places PFCS as a lower-cost alternative to PFPS. (Patterson, 2011)

Fig.7 Point fixed clamped system (Patterson, 2011)

Society of Heating, Refrigerating and Air-Conditioning Engineers describes any office environment as being treated as a healthy indoor environment if 80 % of its occupants are environmentally pleased. Comfort levels are directly linked to occupying satisfaction with the physical environment (Frontczak, 2012).

Looking at comfort, when there is no uncomfortable sensation, it is characterized by a state. Comfort is a complicated subjective state that is influenced by several physical factors. Comfort depends on the following factors (fig.8) in an office environment (Feige, 2013).

3. OCCUPANTS' PRODUCTIVITY

To explore this topic further, productivity needs to be understood. It is the performance-input ratio. Productivity depends on the input and outcome context and content (Kotler, 2006). The productivity ratio of money spent in employee cost to company turnover can be measured in the case of organizations. Productivity is measured at individual level, team and company level in the office environment (Feige, 2013).

Four factors are affected: financial, organizational, social and environmental. Nothing can map the degree of impact of each factor, interdependencies and links. The American

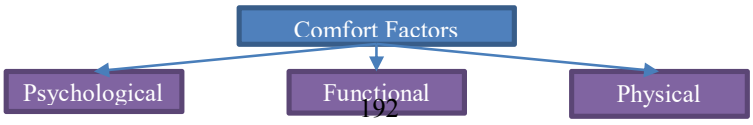

Fig.8 Comfort factors

*Psychological comfort

In this particularity, territoriality, and psychological dimensions. People ought to feel comfortable and safe when operating. They have to think they own the place.

*Functional comfort.

The inhabitants require a workplace atmosphere with sufficient facilities. The job workplace is based on work flow and how easily workers can reach the workplace.

*Physical comfort

Physical comfort requires physical specifications of the indoor environment including temperature, humidity, noise, and lighting levels.

Comfort is a mixture of physiological, psychological and physical influences in an office space. The Physical environment may be listed into (fig.9)

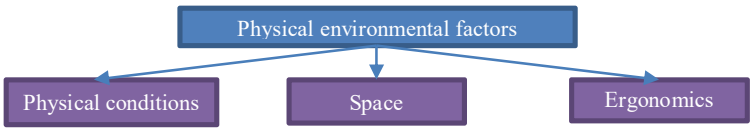

Fig.9 Physical environment factors

* Physical conditions

These are physical environmental parameters. The internal temperature, lighting, indoor air quality and sound levels are included.

* Space

The productivity and well-being of the users are also influenced by the layout and quality of the room constructed for indoor work. Includes factors like the presentation of workflow in office design with layout, privacy and an atmosphere without disturbance.

* Ergonomics

an office. Both of these factors often affect productivity in the workplace. Haynes has indicated that comfort makes up the physical environment from the layout of office space and that social aspects such as contact, privacy and interaction constitute the office's behavioral environment (Haynes, 2008).

3. METHODOLOGY

The research was developed to create a solid basis for the research results using a wide-ranging literature analysis looking at journal papers, conference articles and books. The research followed a three-stage method to classify the selection and classification of literature.

Occupant comfort is increased thanks to ergonomic factors like office chairs, workstations and light management. Occupant comfort is a function of the health and construction influences (physical and mental). There are psychological points to know, including the psychological environment.

A room has its own behavioral environment. Urban space and comfort are affected by subjective and behavioral aspects. Preferences such as frequency of contact, possibilities for teamwork, anonymity and awareness of disturbances should be addressed. The office environment affects occupant behavior and societal expectations. It is a function of the office. (Haynes, 2008).

Haynes introduced a system involving the pattern of a resident affect the physical and behavioral environment of

important variables identified from literature that influence occupants' satisfaction.

They were further investigated in a post occupancy evaluation (POE) on four office buildings. These yield design strategies which combined the variables in an office space to enhance task performance. A mixed method of experimental and observation techniques were employed in an office space 2900mm x 4400mm x 3200mm with window opening.
The experiment was carried out on 136 participants, out of these observational methods was applied on 32 participants. The data from the experiment were analyzed using SPSS version 20 and content analysis was carried out on the observation. The finding shows that a work plane IL luminance (WPI) of 200lux to 326lux is achievable at the OTPZ of within 1800mm to 2800mm from the window opening. This is irrespective of the seating arrangements and is in line with MS 1525: 2007 and ISO 89951-1: 2002.
This implies that, in order to perform a task comfortably within the OTPZ in an office space a 25% WWR and a good view is required.
This study contributes to better sustainable design research and practice. This study suggests effective daylight and view windows design recommendations in respect of office window openings and occupant's location to attain visual comfort in a single office to improve task performance which can be employed as a guideline for future office space designs. (Aminu, 2015)

A paper in 2017 describes the preliminary findings of a post-occupancy evaluation campaign conducted on contemporary and energy-efficient office buildings with different façades treatments. The aim is to investigate occupants' comfort and perceived productivity and to observe to what extent the space appearance and the façade design play a role in the ultimate user's satisfaction and overall comfort.

Two Swiss office buildings with different vertical enclosures are considered for this preliminary study: one has regular-shaped windows and regular blinds while the other presents a double-skin façade with a colored silk-printed pattern partially covering the external pane and semi-transparent internal roller blinds. The findings recorded in this paper refer to a detailed online survey spread among the occupants of the building to provide a global estimate of the comfort and impression they feel in their workplace. Study found that these significantly affect the overall comfort assessment of individuals but not the self-rated productivity in the event of elevated frustration with certain environmental variables. However, where comfort ratings are less important, but not optimum, average comfort and perceived efficiency are more closely associated with workspace satisfaction than with environmental factors. Nevertheless, in the case of patterned glazing, the façade

design has a low influence on comfort perception.
The study suggests that further research should be conducted, especially to look at façade designs that play a greater role in determining the appearance and/or a certain level of personal environmental control in a workspace. (Luisa Pastore, 2017)

In step 1, determining the keywords for the analysis. The goal of the study is to evaluate the impact of the use of glazing facades on occupant productivity in an office environment. The keywords for the search were: workplace satisfaction, indoor environment quality, occupant comfort, thermal comfort, office building, glazing facades, thermal comfort, occupant productivity and occupant satisfaction.
2. The main focus of the study is to define and gather data on the influence of various glazing facades variables on occupant productivity for the literature search by the researcher using the keywords listed in step 1.
3. The researcher looked through the bibliographies of the downloaded articles after reviewing the original group of papers to look for more relevant papers.

4. FINDINGS:

In 2006 Chabane and Bensalem observed in Algiers the tendency that architects use the glass curtain walls. To maintain the vision between the nature and privacy; for reflecting sun rays, glass must be tinted and not reflective. Through this glass tint, the natural light is reduced greatly in offices, especially those non-exposed to sunshine, and the lighting environment becomes almost static with very limited changing levels of sensation. The authors concentrate on the effect of this lighting environment on occupants' health, particularly visual and bio psychological effects.
The results of the survey conducted in a tight office building in Algiers showed some negative effects, such as eye strain, tiredness, deficiency in notion of time etc., which disturbed the occupants in their work tasks. (Chabane & Bensalem, 2006)

In 29 office buildings, YW Yom, CY Chun, RY Kwak explore the connection between occupant satisfaction and potential for window service. There are three standards for occupant satisfied: satisfaction with the quality of indoor air (IAQ), with the thermal environment indoor and with facilities for maintenance management. Occupant satisfaction with indoor air quality (IAQ), indoor thermal environment, and maintenance management services were all higher in the 19 buildings in which the windows were operable than in the 10 buildings in which they were not operable.
There is a clear connection between the three requirements for satisfaction (IAQ, indoor thermal environment, and maintenance management services). Those with a floor area of less than 20,000 m2 displayed comparatively high occupant satisfaction with IAQ, indoor thermal environment and building maintenance management facilities among the buildings with operable windows. (Yoon Wha Yom, 2011)

A PHD study in 2015 focused on IEQ with respect to office window openings which enhance occupants' comfort. This opening provides daylight and view which have different design considerations and location on a façade.
A combination of both would reduce cost as well as glare problem in an optimal task performance zone (OTPZ) within an office space. Windows used for both functions usually compromise required performance. View, daylighting, window to wall ratio (WWR), and seating arrangements are

DesignBuilder 5.5 and EnergyPlus 8.9 lighting and energy simulation systems, the two classrooms were simulated.
The findings showed that a 50 percent glazing ratio would minimize the artificial lighting need by at least 15 percent, as well as have more comfortable conditions. (Touraj Ashrafian, 2019)

Another study in 2019 focused on the impact of different transparency ratios (WWR) and window combinations in two critical orientations (west and east) on occupants' comfort and the energy demands of a classroom. At the design stage, a building was chosen for a case study investigation.
One east-facing classroom and one west-facing one is examined. With the assistance of the DIALux Evo 6.0,

5.CONCLUSION

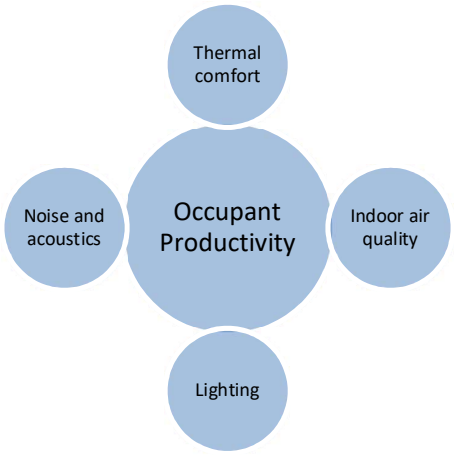

Fig.10 IEQ factors affected by glazing on Occupant Productivity

characteristics of the environment. Industry standards from different countries recommend different acceptable levels for the physical attributes in an indoor environment. However, these recommended levels have received a broad spectrum of occupant acceptance and response in various surveys.

The study indicates that there is no point measurement for comfort, but there is a comfort zone for each factor to get higher productivity form the occupant.

The complexity of defining and achieving comfort has two facets. Firstly, there is a need to identify the comfort zone of each physical factor and to achieve the comfort zone of the overall physical state to get higher productivity. Secondly, there is the complexity of the occupants' response to the overall physical state. Occupant productivity is highly subjective and depends on various independent personal variables such as individual metabolism, clothing preference, activity patterns and the localized conditions of different zones inside an office. The study has tried to identify these two facets of comfort for each of the identified IEQ physical factors.

This literature review has highlighted four physical factors (Fig.10) that affect Indoor Environmental Quality (IEQ) by glazing facades on occupant productivity. Thermal comfort, Lighting environment, indoor air quality, and noise and acoustics have been shown to be extremely critical in influencing the efficiency of occupants. A vast variety of case studies and literature suggest a high association between these variables and the productivity of inhabitants. Interactions and associations occur between these IEQ variables as well. The research indicates a strong relationship between daylight, thermal comfort and the consistency of indoor air,' look and feel' and views, and the indoor environment's workplace design and acoustic properties. This review can be taken as starting point to develop experiments to look at magnitude and impacts of various interactions between these IEQ factors.

The literature review also draws attention towards the understanding, measuring and achieving occupant productivity in an office environment. Occupant comfort and productivity directly relates to the physical factors of the indoor environment. Productivity is a response to the physical state created by the combined effect of the physical

quality factors which have a significant effect on occupant productivity.

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The majority of researches on office building acknowledge the effect of the glazing facades on the indoor environment

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