Effect of Window Wall Ratio (WWR) on Heat Gain in Commercial Buildings in the Climate of Lahore

M. Rashid, A.M. Malik, and T. Ahmad

***Abstract*—In commercial buildings in Lahore, artificial cooling systems are needed to attain the required comfort level due to high heat gain inside. Energy efficient window design is the only solution which can limit this cooling demand. This simulated study is carried out in order to obtain a desirable window size (WWR).**

The study is carried out by the interpretation of graphical data which is generated through software named as Comfen. This software is specifically designed to investigate the parameters of window design of commercial buildings. Window wall ratio is investigated by putting the testing window samples on different orientations. As orientation is one of the fundamental parameter of design, not only window design. The results show that there is gradual decrease in heat gain by decreasing the size of window and vice versa. In addition, the impact of south façade is highest regarding heat gain.

***Keywords*— Heat gain, Commercial Buildings, Window Wall Ratio (WWR), Orientation,**

I. INTRODUCTION

The study of history reveals that windows were not provided with glass panes before Renaissance. Glass pane has been a major technological innovation after fire in the history. Glazed windows provided a remarkable improvement in the indoor environment with respect to thermal comfort. The next step towards symbiosis of glass and buildings was the invention of central heating systems in the latter half of 19th century. This led to the formation of buildings with entire glazed wall. [1]

Like any other modern city, Glass has become a dominant feature of building facades in Lahore. Previous studies have concluded that the glazed facades of commercial buildings are adding to environmental problems. These facades are responsible for heat gain in the buildings. And to counter this heating effect, artificial cooling systems are required. [2]

A pictorial survey is presented to support the excessive use of glass in facades of commercial buildings.

Fig. 1 West facing façade of Siddiq Trade Canter

Fig. 2 West facing Façade of Rabi Center

Fig. 3 Mega Tower's Front Façade

Fig. 4 Liberty Heights' Front Façade

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Fig. 5 Ibrahim Trade Center

Fig. 6 Eden Tower's Front Façade

Fig. 7 Front façade of Big City Tower

In Pakistan, like any other developing country, building sector is consuming huge amount of energy and other natural resources which further leads to increasing 〖CO〗_(2^) emissions into the atmosphere. [3]

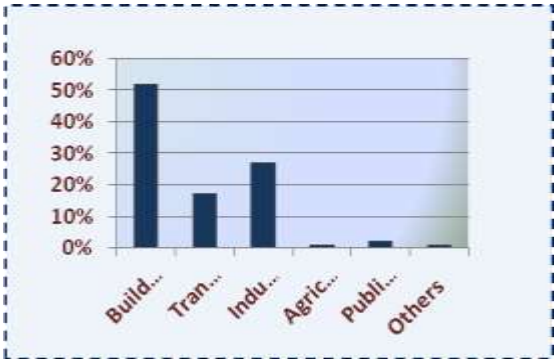


Fig. 8 Energy consumption breakdown sector wise: Pakistan

The solution to this problem is the passive design techniques. Energy efficient windows are a passive technique which can be adopted to attain the required thermal comfort level in the buildings.[4]

This study is focused on the impact of one of the key parameters of window design which isoptimum window size (WWR) on heat gain in the climate of Lahore.

A. Window Wall Ratio

The thermal conditions in a building can be affected by the area of the exterior wall to the area of the window/opening, known as window to wall ratio (WWR). [5]

It is one of the primary factors which affect the thermal performance of the window. Besides the thermal performance, the daylight should be considered as well in order to analyze energy efficient window.

A study carried out in the hot humid climate of Singapore to investigate the optimum window size suggested the window area investigated in this study ranged from 10% to 40% on all orientations. The concluded window to wall ratio was 24%. Shading devices had been suggested for larger windows on all orientations.[6] [7]

H.Daboor (2011) investigated the impact of window size on energy consumption in the arid climate of Gaza strip. According to this study, the heating load decreases and the cooling load increases in a linear manner by increasing the size of the windows.In hot climates like that of Lahore, it is not desire able to increase cooling loads.

It can also be concluded from this research thatthe impact of south façade is highest on energy consumption. And likewise the impact of north façade is the lowest on energy consumption.

II. OBJECTIVES

This aim of this work is to study the role of one of key parameter of window design i-e window size (WWR) on heat gain through computer simulation. Thermal performance of windows of different sizes are measured on different orientations. As orientation is one of the fundamentals of design and also the window design.

III. MATERIALS AND METHODS

The research is conducted for the climate of Lahore, located between 31 degree north to 33 degree North Latitudes and, 73 and 75 degrees East longitudes. The Climate of Lahore falls in the semi-arid (Steppe) with hot summer and mild winter zone. It has hot climate for 8 months and has mild winter for the rest of 4 months. Hence the hot season predominates the whole year.[8]

Thermal performance of windows of different sizes are measured on different orientations.

A. Computer Simulation

In order to conduct this research, computer software is used. The name of the software is "Comfen". Comfen is a tool which investigates key parameters of windows which affect the thermal and visual comfort. [9]

According to different books and research publication, the key variables of window design that affect the heat gain through windows are Window Size, Glazing Type, Shading Device, Window shape, Orientation etc. But in this study, we

are focusing the two parameters i-e Thermal properties of glazing material used and Orientation.

Comfen requires some information at the start of each project before conducting the simulation. Every project requires a name, location, building type and vintage. Location includes weather data for energy plus simulation. Building type includes the lighting and occupancy. The building type can be set to office, Mid-rise Residential, Hotel, Hospital etc. Each type controls its specific occupancy and lighting along with equipment schedules. Vintage is restricted to new ASHRAE 90.1 2004. Four different types of windows are analyzed to conduct this study.

B. *Façade Models*

Different sizes of glass have been analyzed in software i-e

Scenario 229

60 % i-e 60 % of the wall is covered with glass.

Scenario 230

50% i-e 50 % of the wall is covered with glass.

Scenario 231

40% , i-e 40 % of the wall is covered with glass.

Scenario 237

30% , i-e 30 % of the wall is covered with glass.

have been analyzed on 4 orientations in climate of Lahore. The glazing, frame remains same in the above mentioned 4 scenarios.

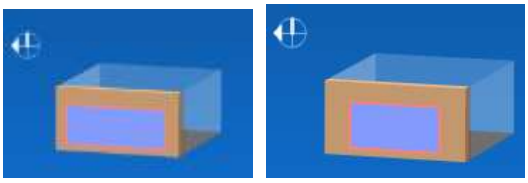


Fig. 9 (Left) Scenario 229 (Right) Scenario 230

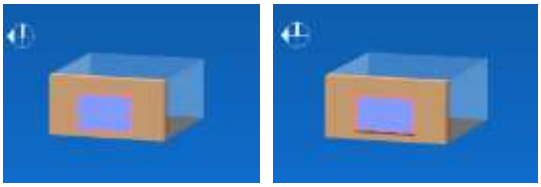
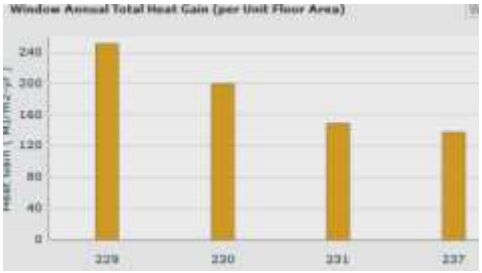
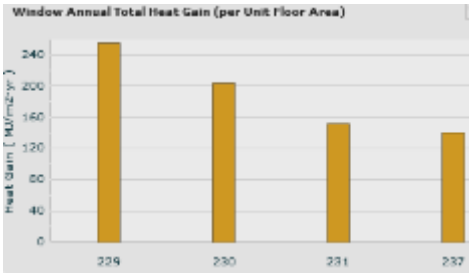


Fig. 10 (Left) Scenario 231 (Right) Scenario 237

Following results have been generated after simulation in Comfen.

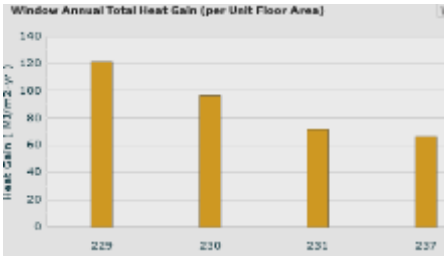


(a)

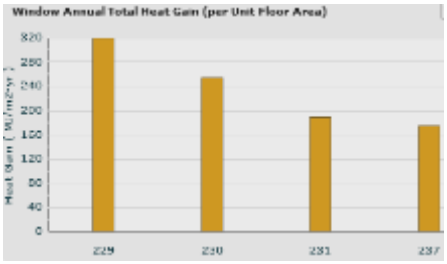


(b)

Fig. 11 Comparison Charts of Annual Heat Gain through East (a) and West (b) facing windows



(a)



(b)

Fig. 12 Comparison Charts of Annual Heat Gain through North (a) and South (b) facing windows

IV. DISCUSSION

Results show that the heat gain generally decreases with the decrease in size of windows on all orientations. It can be concluded that the cooling load decreases with the decrease in the window size. This is desire able in hot climates like that of Lahore.

Similarly, the heat gain is maximum with the largest window on the south side i-e up to 320 MJ / m2-yr. And it is lowest on the North side i- e up to 120 MJ / m2-yr. The descending order of impact of different orientations on heat gain is South, East, West and North respectively.

On the basis of results generated in this study, some recommendations are being suggested in local climate.

Larger windows are suggested on the north side in hot climate as compared to the rest of orientations.

The heat gain on south can be handled by either giving smaller windows i-e with WWR 0.20 - 0.30 or by providing large windows with appropriate shading devices countering sun angles and peak time.

East and West are not very desire able to have large windows because of the critical sun angles at these orientations. So,

lesser windows or high level ventilators are suggested on these orientations in hot climate

V. CONCLUSION

Heat gain through window is a phenomenon which has different results on different orientations. The size of window varies on different orientations. So the treatment of a window on every orientation should be different from the other.

The heat gain is a phenomenon which cannot be isolated from daylight. In this study, the character of daylight is not studied simultaneously.

It is also desire able to design areas like washrooms , storage spaces etc on the critical orientations like west specially in the hot climate that of Lahore. The interaction of people with these type of spaces is for lesser period of time as compared to the other type of spaces, like work areas, living rooms etc.

Heat gain is one of the factor which can determine the window size. There are numerous others as well like, type of living space, orientation, daylight.

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