Journal of Engineering and Applied Sciences 1(4): 346-350, 2006

A Guide to Selecting Glazing Options for Amman Buildings

Dajeh D.A.
Hijjawi Faculty for Engineering Technology Yarmouk University Irbid-Jordan

Abstract: The number, orientation and the type of glazing can significantly affect the amount of energy required to heat or cool a building. Effect of glazing type on solar heat gain through windows for the city (Amman) Jordan is studied. Solar energy gain is calculated using the monthly average data. The effect of window orientation on the total gain is analyzed. It is found that for all directions, solar gain is season-dependent and this dependency varies from one direction to anther. Also, the effect of number of glazing layers together with the glazing type on solar energy gain through windows is given. It is found that, south facing windows should have high SHGC to allow solar heat gain in winter. East or west facing windows should have lower SHGC. Consequently, considerable cooling and heating demand can be reduced when clear glass is replaced by bronze or low-e glass.

Key words: Cooling, heating, solar energy gain, jordan, energy efficient windows

INTRODUCTION

Energy is used to provide a variety of services in buildings. Human comfort can be increased and energy demand can be decreased through good building design and proper component selection. Windows can be one of the single largest sources of unwanted heat gain and loss in the thermal envelope. There exist many studies on the impact of windows on heating and cooling demand. Most of them are just calculations of a single building. One attempt to make a more systematic analysis was made by Johnson *et al.*[1]. Sullivan *et al.*[2] stressed the importance of window solar heat gain for cooling demand. Many researchers have studied the energy demand for cooling and heating in residential buildings in Jordan. Koda and Al-Shaarawi[3] have assumed that the amount of solar radiation is a constant value through south- facing windows throughout the hole-heating period. Hamdan *et al.*[4] and Audi[5] studied the applicability of active liquid and air solar systems, respectively, to space heating in Jordan, without taking solar energy gain through windows into consideration. Rousan and Shariah[6] have studied for three different sites in Jordan the solar and thermal energy gain through windows. Their results are given in the form of tables. Shariah *et al.*[7] calculate the cooling and heating loads in residential buildings for three cities in Jordan.

Until recently, clear glass was the primary glazing material used in windows. Although glass is durable and allows a high percentage of sunlight to enter buildings, it has very little resistance to heat flow. Research and development into types of glazing have created a new generation of materials that offer improved window efficiency and performances.

Today, several types of advanced glazing systems are available to help control heat loss and gain. The advanced glazing include double-and triple-pane windows with such coatings as low-emissivity (low-e), spectrally selective, heat-absorbing (tinted) or reflective, gas-filled windows and windows combinations of these options. The aim of this present work is to present the effects of window glazing types on solar heat gain to buildings in Jordan (represented by Amman), which represents mild to hot climate.

MATERIALS AND METHODS

Solar Heat Gain Coefficient (SHGC) is the fraction of solar heat that enters the window and becomes heat. This includes both directly transmitted and absorbed solar radiation. The following equations can be used to generate SHGC, where all angles are in degrees[8]:

Solar heat gain coefficient = Energy transmitted + N_i (Energy absorbed) (1)

Where energy transmitted is equal

$$E_d = E_D \sum_{j=0}^{5} t_j \cos^j \theta + E_d^2 \sum_{j=0}^{5} t_j/(j+2) \quad (2)$$

The energy absorbed is equal:

$$E_d = E_D \sum_{j=0}^{5} a_j \cos^j \theta + E_d^2 \sum_{j=0}^{5} a_j / (j+2) \quad (3)$$

Where:

$$E_D = E_{DN} \cos\theta \quad \text{If } \cos\theta \rangle 0$$
$$\text{Otherwise} \quad (4)$$
$$E_D = o$$

And

$$E_D = E_{ds} + E_{dg} \quad (5)$$

Where:

$$E_{ds} = CYE_{DN} \quad \text{For vertical surfaces} \quad (6)$$

$$E_{ds} = CE_{DN}(1 + \cos\Sigma/2) \quad \text{For surfaces other than vertical}$$

And

$$E_{dg} = E_{DN}(C + \sin\beta)\rho_g(1 - \cos\Sigma)/2 \quad (7)$$

Where:

$$E_{DN} = A\exp(-B/\sin\beta) \quad (8)$$

Values of A, B and C are given in[8] for the 21st day of each month. The solar heat gain coefficient is characteristic of each type of window and varies with the incident angle θ. The absorption or transmission of direct solar radiation incident at an angle θ is:

$$\alpha_D = \Sigma\alpha_j \cos^j\theta \quad (9)$$

$$\alpha_D = \Sigma\alpha_j \cos^j\theta \quad (10)$$

The incident angle θ is defined as:

$$\cos\theta = \cos\beta\cos\gamma\sin\Sigma + \sin\beta\cos\Sigma \quad (11)$$

And the solar altitude angle â is:

$$\sin\beta = \cos L\cos\delta\cos H + \sin L\sin\delta \quad (12)$$

And the solar azimuth angle ô is:

$$\cos\phi = \frac{\sin\beta\sin L - \sin\beta}{\cos\beta\cos L} \quad (13)$$

Where the surface – solar azimuth angle γ is :

$$\gamma = \Phi - \psi \quad (14)$$

Table 1: SGHC values for the different types of window

Window and glazing types	SHGC
Single-glazed, clear	0.79
Double-glazed, clear	0.65
Triple-glazed, clear	0.52
Single-glazed, bronze	0.69
Double-glazed, bronze	0.55
Double-glazed, spectrally selective(0.08)	0.44
Double-glazed, spectrally selective(0.04)	0.31

The above equations were used to calculate the solar heat gain coefficient for a wide variety of glazing. Glazing can be single, double or triple pane. It can be clear, tinted, reflective or spectrally selective coatings such as low emissive (low-e) coatings. Calculations are made for two-window orientations south, east or west. The types of windows glazing all together with their SHGC values are shown in Table 1.

LOCATION AND CLIMATIC DATA

Windows investigated in this analysis are located in Amman (32.0o N, 36° W, altitude 766 m). The city of Amman represents a climate between moderate and hot with a Mediterranean sub-zone and mountainous sub-climate. The weather data were provided by the Jordanian Meteorological Department. The ground reflectance ρ_g is taken to be a fixed value and equal to 0.2. The clearness index K_T values used in this study are shown in Table 2,[9].

RESULTS AND DISCUSSION

A shareware Javascript program was employed to calculate the solar heat gain through windows for different types of glazing and for two orientations, namely south window and east or west window. The area of the window is taken to be one meter square. The results of the calculation are shown in Fig. (1-8). Figure 1 shows monthly average daily solar heat gain values for single, double and triple ordinary clear glass. One notices that increasing the number of glazing layers reduces the amount of solar heat gain. This is due to the fact that increasing the numbers of glazing layers will increase the amount of solar radiation reflected by the glass, especially at times, when the incident angle is greater than 60 degrees. It is clear that the maximum solar heat gain is in winter and the minimum is in summer. However, an opposite regime is noticed for values of solar heat gain, in December less than in October or in November. This is due to the different values of the clearance index as one can see in Table 2. Fig. 2. As one expects, the number of glazing

Table 2: K_T values for amman

Month	1	2	3	4	5	6	7	8	9	10	11	12
K_T	0.56	0.6	0.59	0.63	0.68	0.74	0.76	0.75	0.74	0.71	0.65	0.56

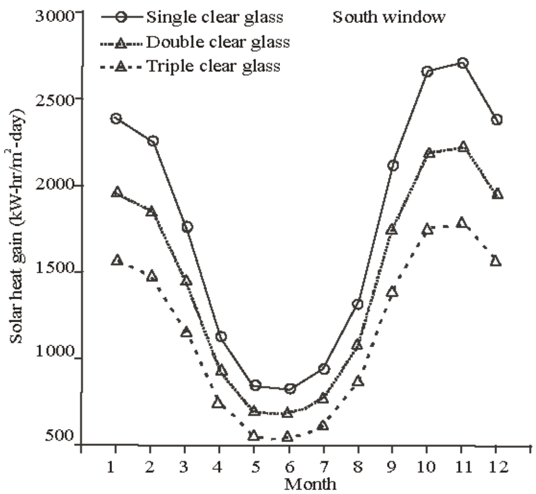

Fig. 1: Effect of number of glazing layers on solar gain for clear glass

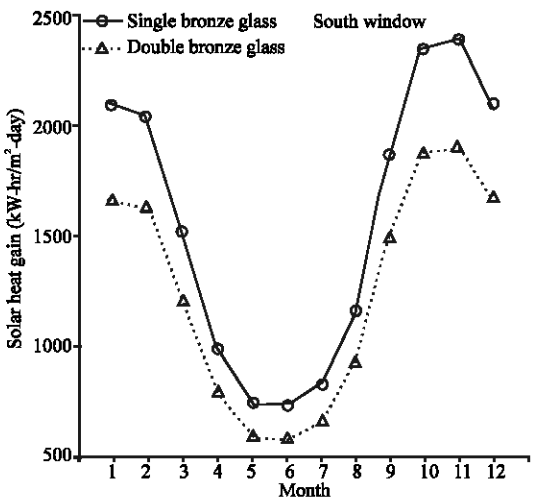

Fig. 2: Effect of number of glazing layer on solar gain for bronze glass

The monthly solar heat gain for single-glazed and double-glazed bronze windows oriented due south is shown in layers, affects the amount of solar heat gain similar to that for clear glass[7]. It is noticed from this figure that, the solar gain is reduced by 35 percent when single glazing is replaced by double-glazing. Figure 3 compares the solar heat gain for single clear and single bronzed glazing. It is noted that SHG is reduced by 2.6 times, when clear glazing is replaced by bronze glazing. The Plot for the monthly SHG for four types of south-facing windows, double clear glass, double bronze glass, double low-emittance (Low-E) glass (0.08) and double spectrally sensitive glass (0.04) is shown in Fig. 4. Although the trend is the same for all the

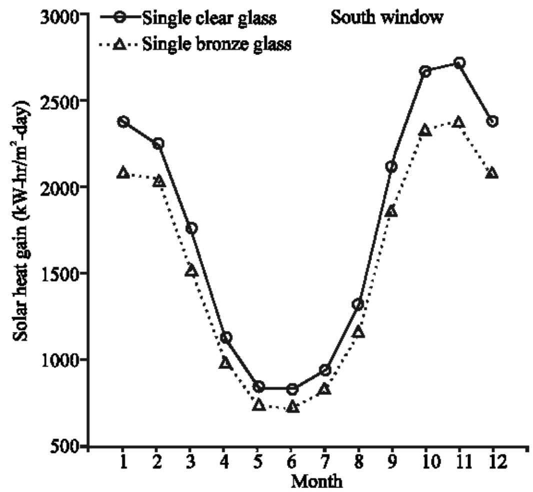

Fig. 3: Effect of glazing type on solar heat gain for two different type of glasses

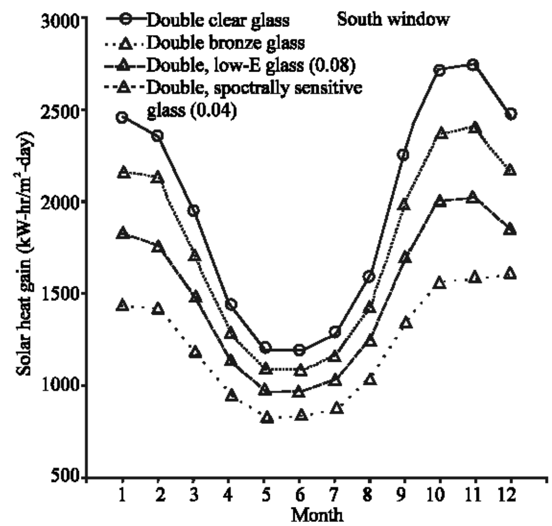

Fig. 4: Effect of glazing type on solar heat gain for different type of glasses

four double-glazing glass, they are different quantitatively to the different type of glass is used. As one expects, the amount of the solar heat gain for the four types is higher in winter and less in summer.

Figure 5-8, show the SHG for west and east oriented windows. he lazing ypes here are the same as in Fig. 1-4. It is seen from the Fig. that the minimum SHG for south-facing windows Fig. 1-4 and the maximum gain for the other orientations, Fig. 5-8, occur in summer. The aforementioned minima and maxim are due to the variation

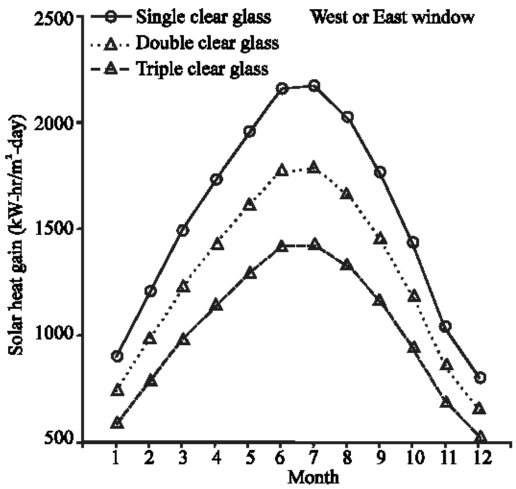

Fig. 5: Effect of number of glazing type on solar gain for clear glass case {West or East}

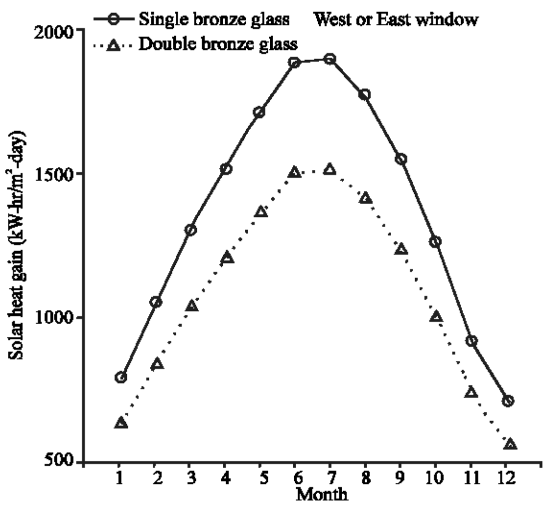

Fig. 6: Effect of number of glazing layers on heat gain for West or East window

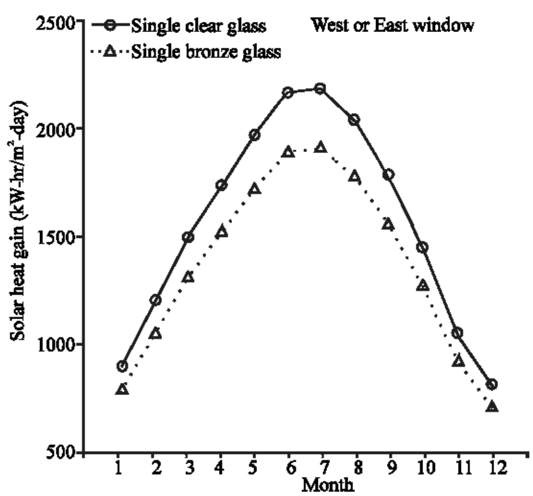

Fig. 7: Effect of glazing type on solar heat gain

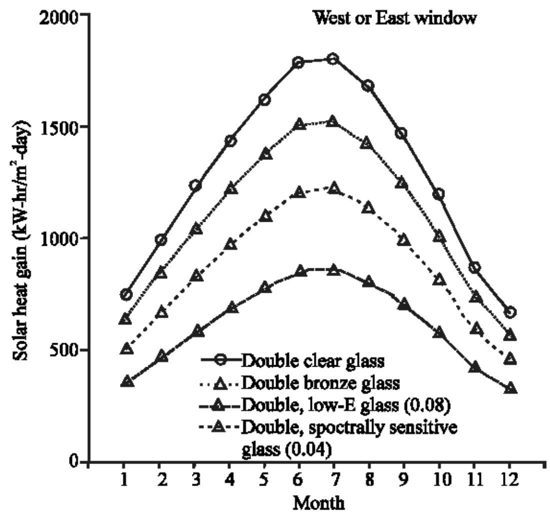

Fig. 8: Effect of glazing type on solar heat gain for different type on glasses

in the angle of incidence of beam radiation, since it is large in summer and smaller in winter.

CONCLUSION

The effect of glazing types and orientation on solar heat gain through windows in Amman-Jordan is calculated. The study made use of the available weather data to give complete picture of solar gain. The main feature of solar heat gain is that it is lower in summer than at other times of the year for south-facing windows, while it is the opposite for other orientations. From the foregoing discussion, it is evident that the Solar Heat Gain (SHG) through windows is measured by the Solar Heat Gain Coefficient (SHGC) Table1. Also, the orientation of a window affects the levels of solar heat gain. In general, south facing windows should have a high SHGC to allow in beneficial solar heat gain in winter. East or west facing windows in buildings in hot climates should have lower SHGC assemblies. Consequently, considerable energy savings can be obtained throuh proper selecting the type of glazing.

ACKNOWLEDGMENT

Author is thankful to Dr. A.Shariah, Jordan University of Science and Technology for many helpful discussions.

NOMENCLATURE

β solar altitude

A apparent solar constant

B	atmospheric extinction coefficient
C	sky diffuse factor
E_D	direct irradiance
E_{DN}	direct normal irradiance
E_{ds}	diffuse sky irradiance
E_{dg}	diffuse ground reflected
E_d	diffuse irradiance
H	hour angle
L	latitude
Y	ratio of vertical/horizontal sky diffuse
δ	declination
ϕ	solar azimuth
ψ	surface azimuth
γ	surface-solar azimuth
Σ	surface tilt
θ	incident angle
ρ_g	ground reflectance
α_D	absorptance of DSA glass
τ_D	transmittance of DSA glass

REFERENCES

1. Johnson, R., S. Sullivan, S. Selkowitz, S. Nozaki, C. Conner and D. Arasteh, 1984. Glazing Energy Performance and Design Optimization with Day-lighting. Energy and Buildings, 6: 305-317.
2. Sullivan, R., F. Beck, D. Arasteh and W. Selkowitz, 1995. Energy Performance of Evacuated Glazings in Residential Buildings. (Report LBL-37130). Berkeley, CA: Lawrence Berkeley Laboratory.
3. Kodah, Z.H. and M.A.I. El-shaarawi, 1990. Weather data in Jordan for Conventional and Solar HVAC Systems. ASHRAE Trans., 96: 124-131.
4. Hamdan, M.A., S.M. Habali and B.A. Jubran, 1992. Community solar heating systems: a case study for Jordan. Intl. J. Solar Energy, 7: 85-91.
5. Audi, M.S., 1992. Experimental study of a solar space heating model using Jordanian rocks for storage. Energy convers. Mgmt., 33: 833-842.
6. Rousan, A.A. and A.M. Shariah, 1996. Solar and thermal energy gain through windows in Jordan. Renewable Energy, 7: 251-269.
7. Shariah, A., B. Tashtoush and A. Rousan, Cooling and heating loads in residential building in Jordan.
8. ASHRAE, 1993. Handbook of Fundamentals, Am. Society of Heating, Refrigeration and Air- conditioning Engineers, New York.
9. Hamdan, A.M., 1994. Solar Radiation Data for Amman. Applied Energy, 47: 87-96.