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Optimization building orientation and windows by using solar radiant energy

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Abstract

The buildings are the largest consumers of energy in all countries. Especially in areas with bad air and water conditions, the main part of the energy go to the heating and cooling of buildings. Although there are many ways in reducing the heat load on buildings there. The most important of them the detailed design and choose the appropriate cover and construction elements. In this study, with a 71.5 m^2 area modeling located in Iran, Sari town, in the software Carrier Hap 4.5. Maximum thermal efficiency radiant energy of the Sun for 12 months a year in a sixteen-Division-directional, can be calculated. Operating on the basis of the lowest rate of solar energy in the hot months, and the maximum amount in the cold months, building facades stretch, in the direction of the South without any deviation to the East or West, it is recommended. On the other hand, the amount of heat transfer materials, walls, and the incoming radiant energy into space through Windows is calculated. According to the ratio of the radiant energy input rate of Windows, heat transfer rate of the walls and materials, And considering this important factor, which is not manageable after the construction of the wall, But after the windows construction, as well as the ability to control their performance, The window can be used as an important factor in controlling the environmental conditions and comfort in the building.

Keywords: Thermal efficiency, Heat transfer, Solar radiation, Windows, orientation

Introduction

Buildings are large consumers of energy in all countries, especially in regions with extreme climatic conditions and a substantial share of the energy goes towards heat and cool buildings. Though there are multiple ways of reducing the heat and air-conditioning load in the buildings, notable among them are proper design and selection of building envelope and its components [1]. The new EU law reviews, a high standard of protection of the heat in the House, according to the energy consumption of the logical, the satisfaction of the conditions of comfort and reduce the price of the performance [2].

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), According to the standard 55 thermal comfort under the title of " that state of mind which expresses satisfaction with the thermal environment." When it involves a feeling of comfort and health of the residents in a specified environment for a specific climate on their ability to catch up with the amount of thermal rate, Physiology, psychology and behavioral changes [3]. Thermal comfort is a domain dependent and under the influence of environmental factors such as air temperature, radiant temperature, humidity, air movement, human activity and metabolism, dressed [4,5]. Environmental Thermal stress influence the Health and efficiency of the individuals who worked in a space [6,7]. According to the study conducted by Nag et al., in 2011, 80% of the occupational groups in India exposed to higher indoor temperatures reported excessive sweat, thirst, tachycardia and dryness of mouth, 70% reported feeling of elevated body temperatures and 33% reported reduced urination and itchy skin. Thermal discomfort shall also impair a person's ability to do physical and mental work [8]. Conduction, convection and radiation are the major items of heat transfers from the building through the coating and façade, Windows and roof happens [9]. Materials such as marble, concrete, asphalt and gravel are good thermal transfer providers And should the outer construction of application they are avoided. Although materials that have the lowest amount of heat from the outside to the inside of the pass, Like some special glass materials, wood to build the walls, ceilings and Windows, to create a cool interior environment. Glass act as well as a heat transfer medium, where the glass absorb the heat and The imprisonment in a room. Mutual radiation, between the walls and ceiling affects the internal temperature. And the consequence of it, the thermal comfort of occupants in the House. Study shows that materials that reflect rather than absorb radiation and more readily release the absorbed quantity as thermal radiation will cause to the lower temperature with in the structure [10_12].Window and It's also the kind of materials have a big impact on indoor thermal comfort. The glass of the window, influence the Interior buildings with heat transfer and heat-balancing comfort [13_20]. and studies by Chaiyapinunt et al., showed that the thermal comfort was dependent on the optical properties (total transmittance and total absorbance) and the overall heat transfer coefficient of type of glass used in windows [21]. Singh et al., have also studied the impact of different glazing systems on human thermal comfort in an Indian scenario Window glazing like double or triple glazing, specialized transparent coatings, insulating gas sandwiched between panes, and improved frames provide lower heat exchange and air leakage that improve indoor comfort [22]. All of these features, reduce heat transfer, so cut the loss of energy from the window [23]. Paul Baker in a research about thermal efficiency of traditional window showed that the dropdown at the top of the window, and create the most effective method available in traditional methods is that the heat flow up to 51% [24].

Methodology

Solar calculations in this research is done with Carrier Hap 4.51 software For the 12 months in accordance with the regulations establishments American society for heating, Refrigerating and Air Conditioning Engineers (ASHRAE). The study sample is located in the city of Sari with Longitude 53° E and latitude 36° N. The height of the Sari from sea surface is 132 meters. maximum temperature in summer is 39.8℃ and minimum temperature in winter is -3.8℃ . Daily temperature difference in summer is 12.5℃ . Air cleanliness factor based on the assumption of clean air, is selected one. Average ground reflection capability is 0.14. Coefficient of heat conductivity of the soil the building location is 1.385 $\frac{w}{m^2.k^{\circ}}$. The time difference with the orbit of origin (GMT) is -3.5 hours. The factor of change hours of monthes year has been determined in 21March and 21 September.

General specifications of the space with a 71.5 m^2 floor area, The height of the floor-to-ceiling building is 3 m and The weight of the building equal to 312.5 kg/m^2. The effects of internal resources such as accessories, lighting and General interference calculations in residents. The area of the southern wall is 28.6 m^2 ,The Eastern wall 33.8 m^2, The North wall 28.7 m^2 and western wall 33.8 m^2. Coefficient of thermal conductivity of walls in accordance with the used materials equal to 1.28 $\frac{w}{m^2.k^{\circ}}$ that showed in detail at Table 1.

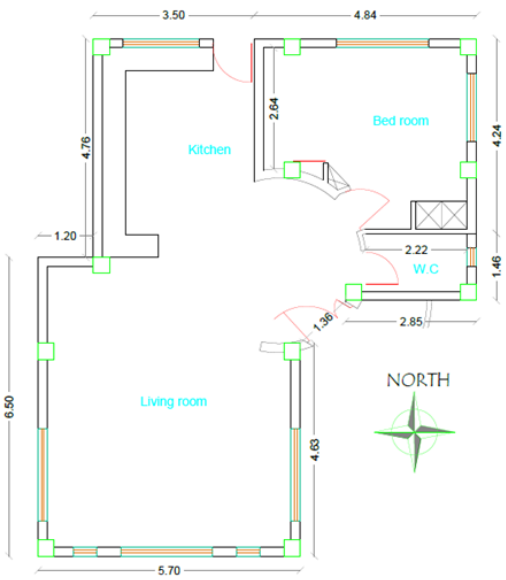
Tables and Figures

All of the Tables and Figures must be in the center of the page. Tables and figures should be cited consecutively in the text. Title of the Tables must be in the top left corner of the Table and the title of Figures must be in below of them at center. Before and after the Tables and Figures, an empty line must exist (Times New Roman, 10pt, Normal).

Table (1). Wall properties for calculating Coefficient of thermal conductivity

Wall Properties					
Layers : Inside to Outside	Thickness	Density	Specific. Ht	R-Value	Weight
	mm	Kg/m^3	kj/kg.k	$m^2.k/w$	Kg/m^2
Gypsum board	15.88	800.9	1.09	0.09866	12.7
LW concrete block	101.590	608.7	0.84	0.26681	61.8
Face brick	101.590	2002.3	0.92	0.07623	203.4
Total	219.06	-	-	0.78	278

Windows with aluminium frames without break thermal and without the internal canopy with coefficient of thermal conductivity equal to 3.775 $\frac{w}{m^2.k^{\circ}}$. The window has a double glazed glass that each cover glass thickness is 3mm and distance between them is 6mm filled with air. The cover glass has coefficient of reflection 0.078, transmission 0.841 and absorption 0.081. We have assumed on the ground floor of the building. Coefficient of thermal conductivity and total it 0.568 $\frac{w}{m^2.k^{\circ}}$ and The thermal resistance of the edge insulation is 1$\frac{m^2.k^{\circ}}{w}$. And finally the model without the internal default partition.



Figure(1). Plan of assumption building According to the metric unit

Solar thermal utilization and its effects on the orientation of the building

For more detailed and sharper analysis of energy, the months of a year divided into six-month hot and cold. Thus the Months of March, April, May, June, July, August, have located in hot categories and the Months of September, October, November, December, January, February, in part, the cold rather than months. In the figure number (2) maximum thermal efficiency obtained from the Sun for hot six months based on the 16 geographic directions to display accordingly. So that its maximum value can be specified in the directions East South East and West South West with the quantity 750 w/m^2. The lowest amount of it on the north side with a 143 w/m^2. To explain the whole picture, can easily see the movement of solar thermal efficiency from upside the North to East South east and then downside to South with thermal efficiency equal to 584 w/m^2. beginning of the move from the South to the West side with an ascending harmony of the Southwest with the same slope but in the opposite direction is clear. And ultimately move downward slope from West southwest tonorth-northwest, which is 358 w/m^2.The factors that is very evident in this diagram, There is a center of symmetry in the entire image is centered on the south side of desire. Architectural patterns, to build special buildings comply with minimum absorption of solar energy in the warmer months and the use of natural lighting direct sunlight, building on the south side stretch without any deviation to the east or west, is the best design pattern for this region. Of course, active or passive integration of solar systems for taking maximum advantage of solar energy can be the center for East Southeast or West southwest around them.
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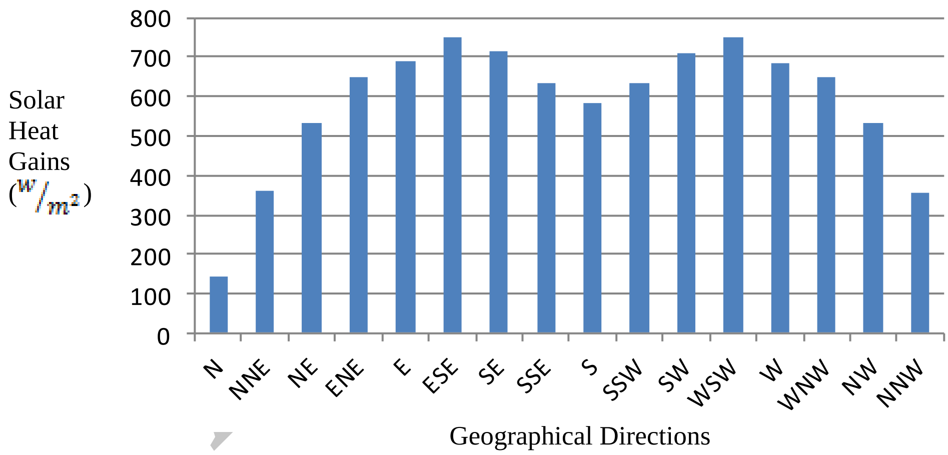
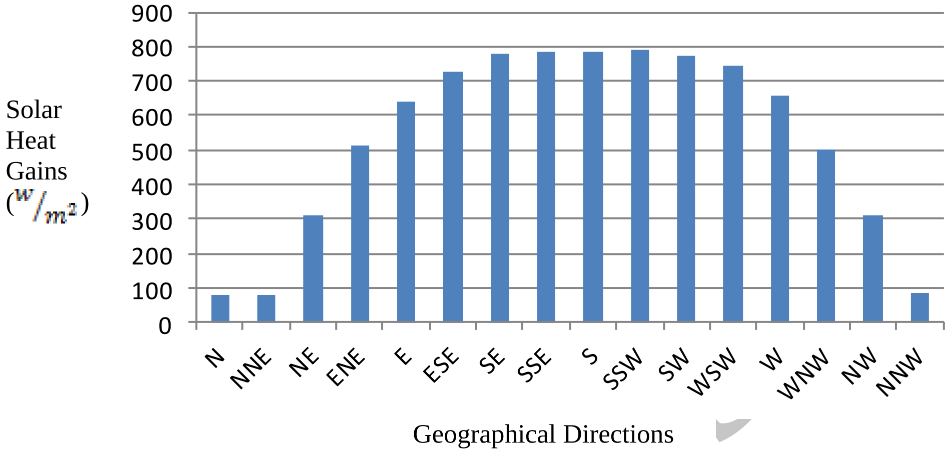


Figure(2). Semiannual Maximum Solar Heat Gains for Warmer months W/m^2

In the figure number (3) maximum thermal efficiency obtained from the Sun for cold six months based on the 16 geographic directions to display accordingly. So that the maximum amount to the South South-East, South, South-South West is characterized by the amount of 788 w/m^2. The lowest amount of it on the north side with a 78 w/m^2. To explain the whole picture can easily be seen solar thermal efficiency upside from the north side, to the South Southeast and then move it with zero slope, to the South of the Southwest and finally, the downside to the North North West with thermal efficiency equal to 86 w/m^2. Factor in this diagram is glaring, The existence of central symmetry in line with the desire of the South side in the whole image. Architectural patterns, to build special buildings comply with maximum absorption of solar energy in the colder months and the use of natural lighting direct sunlight, side stretch without any deviation to the east or west, is the best design pattern for this region. Of course, active or passive integration of solar systems for taking maximum advantage of solar energy can be centered to the south and its surroundings.

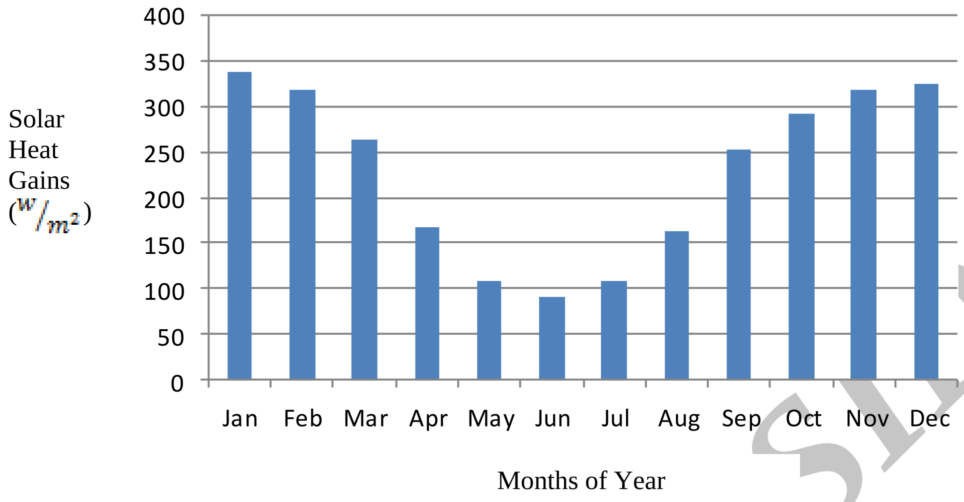


Figure(3). Semiannual Maximum Solar Heat Gains for Warmer monthes W/m^2

By comparing the figure (2) and figure (3) it appears that climatic design in architectural building in this region with a moderate climate, for the greatest advantage of the characteristics of solar energy, must stretch more in the South of the building facade. That reduces the thermal effect in hot seasons and Increase the heat efficiency in the cold seasons.

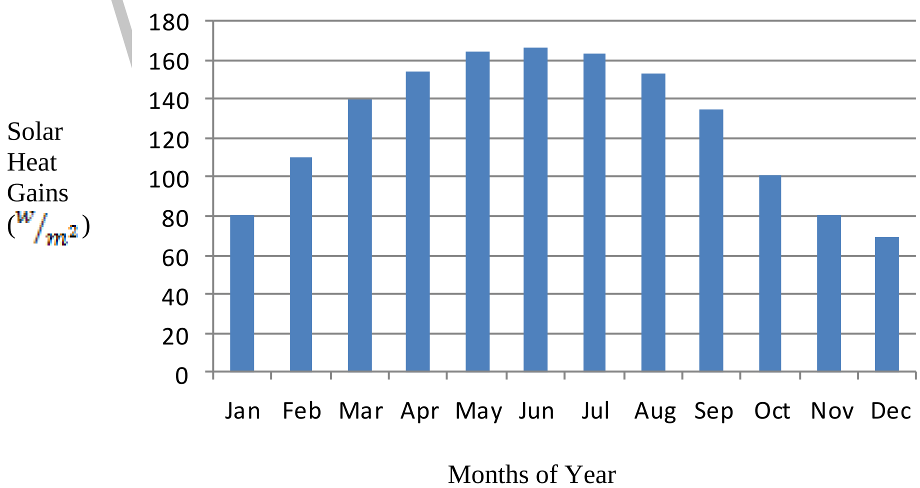
Solar radiant energy and its thermal impact on the building elements

Figure (4) show the rate of the arrival of the Sun's radiant energy from the window located on the south facade of the building given by the unit w/m^2 in 12 months a year. Most radiant energy input rate in January is 338.5 w/m^2 and the lowest rate in the month of June with the 291 w/m^2 is determined. As shown (4) the rate of incoming radiant energy from the month of January and from the peak to the June, the amount is minimal, with a slope downward move and After that increased with ascending slope and ends In the December with the 324 w/m^2. What is evident here is the fact that the South Front in the cold months of Feb, Jan, Dec, Oct, Nov, Dec has highest rates of radiant energy entrance. That as the architectural pattern and biological need natural sunlight to hot and cold seasons, is in the best condition. On the other hand the the natural reduction rates of radiant energy entering the south face in warm months of Mar, Apr, May, Jun, Jul, Aug reducing From the excessive rise building temperature in hot seasons. In general, it seems to increase the size of the windows in this facades would be reasonable and practical.



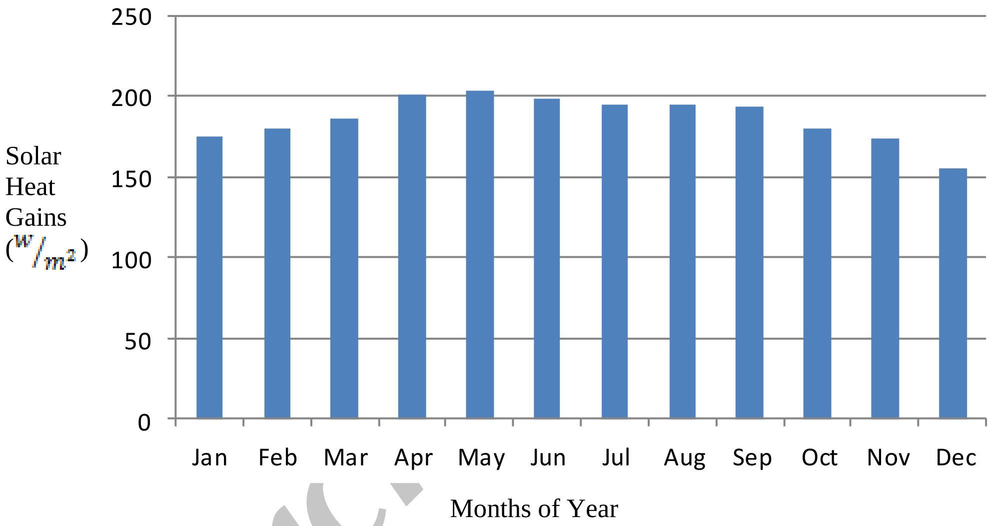
Figure(4). South Façade Rate of Enterance Solar from Window (w/m^2)

Figure (5) show the rate of the arrival of the Sun's radiant energy from the window located on the east facade of the building given by the unit w/m^2 in 12 months a year. Most radiant energy input rate in June is 166 w/m^2 and the lowest rate in the month of December with the 69 w/m^2 is determined. As shown (5) entrance radiant energy starts From the month of January and the amount of 84 w/m^2 . Until June that is maximum rate with a bullish tilt moves and After that with reduced downward slope that ends in December. What is obvious in these parts is the fact that the east facade in the cold months has lowest rates of radiant energy entrance. That as the architectural pattern and biological need natural sunlight in cold seasons, is in the chaotic condition. On the other hand with the natural increase in the rate of arrival of radiant energy to the eastern front in the warm 6 months of year, Increases too much heat in the building temperature. In general, it seems to increase the size of windows at this facades post despite canopy will be accomplished until in winter can be more energy into space and in summer with canopy From the excessive interior temperature can be prevented.



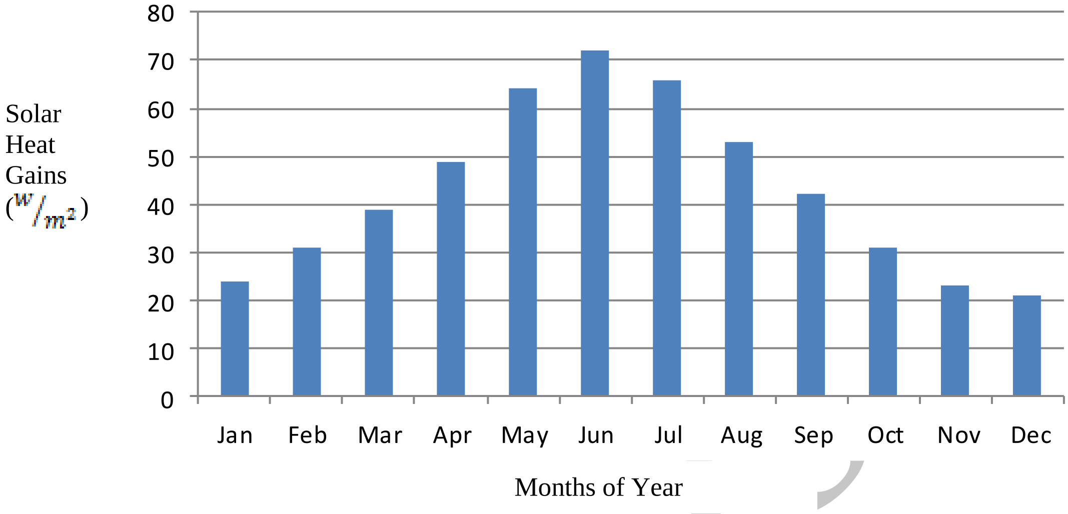
Figure(5). East Façade Rate of Enterance Solar from Window (w/m^2)

Figure (6) show the rate of the arrival of the Sun's radiant energy from the window located on the west facade of the building given by the unit w/m^2 in 12 months a year. Most radiant energy input rate in May is 204 w/m^2 and the lowest rate in the month of December with the 155 w/m^2 is determined. As shown (6) entrance radiant energy starts From the month of January and the amount of 175 w/m^2 . Until May that is maximum rate with a Slight steep moves and After that with reduced downward slope that ends in December. What is obvious in these parts is the fact The western side in almost all months of the year able to closely radiant energy incoming rate. That as the architectural pattern and biological need natural sunlight in Warm and cold seasons, with numbers close to both increase the temperature of the interior space. On the other hand with the natural increase in the rate of arrival of radiant energy to the western front in the warm months of year, Increases too much heat in the building temperature.
Another important factor harmful effects of light on residents of the West that destroys their welfare. In spite of these factors makes perfect radiant heat in winter, use the minimum dimensions of the window in facades of the West, or be dispensed with.



Figure(6). West Façade Rate of Enterance Solar from Window (w/m^2)

Figure (7) show the rate of the arrival of the Sun's radiant energy from the window located on the north facade of the building given by the unit w/m^2 in 12 months a year. Most radiant energy input rate in June is 72 w/m^2 and the lowest rate in the month of December with the 21 w/m^2 is determined. As shown (7) entrance radiant energy starts From the month of January and the amount of 24 w/m^2 Until June that is maximum rate with a Upside bias moves and After that with reduced downward slope that ends in December. What is obvious in these parts is the fact The northern side in the cold months has the lowest radiant energy rate of entry. That as the architectural pattern and biological need natural sunlight in cold seasons, is in the chaotic condition. And almost radiant energy due to the very low rate of radiation can not be effective heating. On the other hand with the natural increase in the rate of arrival of radiant energy to the western front in the warm months of year, Increases too much heat in the building temperature.
In general, due to lack of direct solar radiation on this face, and the maximum rate of radiative energy entrance from northern facade is less than the minimum rates in the other views. The arrival rate of the building because solar energy is reflected. Of course, by increasing the size of the windows can be more energy into the interior.



Figure(7). North Façade Rate of Enterance Solar from Window (w/m^2)

Heat transfer calculations based on conventional and standard materials used in different given building façades. The maximum heat transfer rate per unit w/m^2 is on the southern front 45.8, the eastern front 47.9, the Northern front 46.3, the West facades 39 . These numbers are significant differences with the maximum amount of radiant energy rates input from Windows. So that the maximum rate of entrance radiant energy from the windows to the maximum rate of heat transferfrom walls in watts per square meter, in the southern facade 7.39, Eastern facade 3.47, Western facade 5.23 and the northern facade is 1.56. This illustrates the value of a quantity of radiant energy is input through the windows and glass doors. In addition, because the transfer of heat through the walls only to construction, can be controlled and after completion of construction work can not have control over it; Therefore the windows because of the constant control (before and after construction) is manifold.

Conclusion

Architectural patterns, to build special buildings comply with minimum absorption of solar energy in the warmer months and the use of natural lighting direct sunlight, building on the south side stretch without any deviation to the east or west, is the best design pattern for this region.

Integration of passive and active solar systems for taking maximum advantage of solar energy in warm months with the central East southeast to or West southwest around them. In the cold months of adoption will be centered to the south and around them.

due to ratio of entrance radiant energy from windows into the rate of heat transfer from the walls and materials, with regard to this important factor that heat transfer from the walls can not be controlled after construction But the windows ability to control performance after construction.

Therefore Windows can be set as a significant factor in environmental conditions and comfort of the building named. and for utilizes the best of it, the following suggestions for Sari used:

South facing windows for maximum efficiency increase of solar energy in the interior of the building will be logical and useful.

Increase the size of the windows on the eastern facade will be achieved only with a canopy.

Increase the size of the windows in the western facade will be achieved only with canopy. Of course, due to the harmful effects of light on the West residents are advised to be ignored.

due to lack of direct solar radiation in the northern facade, the entrance rate come from of the reflection of solar radiation energy. Of course, by increasing the size of the windows can be enter more energy into the interior.

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