An Approach To External Shading Device Design And İstanbul Example

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***Abstract*—In design of shading devices, evaluation of many variables data causes the design of complex process. This paper describes an approach to simplify and clarify of external shading device design. So a table is generated to determine how to select the criteria for the interior comfort device in any building area. Phases and priorities of shading device criteria are analyzed and determined in the table. It is found that, ovehang is effective in all orientation in İstanbul and latitude 41º North to prevent solar heat gain. Therefore, The design strategies that were followed in this study could be applicable to any building area.**

Keywords—Shading device, passive solar control, energy efficiency, thermal comfort, computer aided design.

NOMENCLATURE

AZI Azimuth of the sun
INC Angle of incidence
ORI Orientation
ZEN Zenith angle of the sun
VSA Vertical shadow angle
HSA Horizontal shadow angle
ALT Altitude of the sun
W Window
SC Shading coefficient
DF Daylight factor

INTRODUCTION

Control of solar radiation, by passive solar tools is an important part of building design. External shading device, which is the part of passive solar systems, is an artificial environmental variable or element to control interior solar radiation on the base of desirable orientation of window. Solar heat gain, particularly via fenestration, typically dominates cooling performance[1].

The proper application of energy efficient shading devices in new buildings have the technical potential to save 50-70% of total perimeter zone energy use. Therefore, even if only 25-50% of potential could be captured, the economical benefit due to decrease in the size of HVAC plant and the energy consumption make them competitive, with large spin-off benefit on the visual comfort [2]. Moreover, overshading of the windows reduces daylighting, which results in increasing energy use for artificial lighting or internal heat gains [3]. In that case, this can be possible with determination of optimum dimension and shape in the shading device design. However, evaluation of many needed variables, such as dimensions of window, solar geometry and climate data in design of shading devices needs a period of long time and include complex process [4]. This situation makes the designer to pay insufficient attention to the external shading device applications [5-6-7-8]. For this reason, the sun control elements that the users or designers can apply to buildings at Istanbul city, Mediterranean climate zone with latitude 41º north cannot provide expected energy efficiency because of unsuitable types and dimensions of external shading devices. In addition, like eaves overhangs, terrace and beams horizontal building elements which are not designed as an external shading device but their shape on the face as an extension of functional or structural devices, shade to transparent surfaces and this shading can negatively influence of the thermal performance of the building[9]. For this aspect, external shading device's shape and dimension should be evaluated carefully at design of the building especially in the Mediterranean climate zone which solar heat gain is effective.

In shading device design methods, the trigonometric connection between angle of altitude and azimuth of the sun with dimension of window and shading device are taken basic criteria [4-10-11-12-13]. However, design criteria of shading device is classified in four basic groups as given below.

A. Solar geometry data: The formulations and ground plane angle of the sun's yearly motion[6-10].

B. Shape and dimension alternatives of window and shading device: The formulations for determining the geometry of window and shading devices [10-13].

C. Geographical location and climate data: Climate data and required comfort data that are obtained based on these climate data [10-13-14-15].

D. Function and usage: The shading devices' material detail and usage [4].

As mentioned above, the most important point at shading device design is to show variability of shading device performance on the base of sun's one-year motion [6]. Thereby, calculation of shading device design with traditional methods requires comparison of various drawings and equations on the base of sun's one-year motion. Computerized realization of the design with simulation programming, in the aspects of offering various numerical and graphical alternatives, are made a contribution to the designer by shortening the design period [15-17-18].

I. MATERIAL and METHOD

Data of location and climate in Istanbul city, where is the area of research, are given in Figure 1. In general, Mediterranean climate conditions show influences in Istanbul city (Figure 1). At Mediterranean, climate prevention of solar heat gain is a preferential criterion at building design[4]. [19]. In Istanbul city, at the planned residential areas which were designed without taking into consideration of solar heat gain, the compulsory mechanical cooling systems to get interior comfort in summer months are caused important energy consumption.

In this situation, shape and sufficiency of sun control devices in latitude 41 North, which cover Istanbul city, are the key factors to determine energy consumption and interior comfort.

In this article, Solar Tool computerized simulation program is used to analyze shading devices for dimension and shape. As a calculation of shading device design with traditional methods requires comparison of various drawings and equations on the base of sun's one-year motion. The algorithm of Solar Tool software program includes the framework of solar geometry subjects [20]. The Solar Tool program for the scientific analyses which were enhanced and used at Cardiff University C/O Centre of Research in Built Environment, in England, contains three main menus.

- **Location:** Building's latitude and longitude, month, date and time data are entered.
- **Sun Path:** On the stereographic and orthographic diagrams of this menu, sun's seasonal and daily positions and shading blocks are followed.
- **Window Model:** With this menu, includes all of the dimensions of window and shading device, shading devices orientation and shape are obtained.

II. DISCUSSIONS and RESULT

Although the computer technology offers infinitive numbers of graphics, shading device type and dimension alternatives, the selection of the optimum solution is belong to the designer. In other words, performance parameters such as comfort levels, energy requirements, etc., are defined as those that the decision maker uses to judge the appropriateness of the product [21].

So, the most important part of the shading device design is selection of the solution alternatives that provide optimum type and dimension.

This paper describes an approach to simplify and clarify of external shading device design. In this aspect, Table 1, based on shading device design criteria given above has generated in order to determine how to select the interior comfort of shading device dimensions at any site layout. With the aim of clarification and facilitation of the design, "shading device design criteria" have divided in two main part as seen in Table 1. Some of these criteria are varies and the rest are fixed. In this aspect, the shading mask, which monitors the shading device's performance, and solar radiation, day light, climate and comfort graphics that are used to determine thermal and visual comfort were evaluated as a design criteria to determine geometry of shading devices' optimize dimension and its shape. Then, as seen in the Table 1, by taking the criteria interactions with the each other into account, design criteria are selected on the base of priorities of the climate data of the determined building residential district.

Table 1.shading device design criteria

SHADING DEVICE DESIGN CRITERIAS			
VARIABLE VALUE		FIXED VALUE	
SOLAR GEOMETRY DATA	FENESTRATİON	LOCATİON DATA	CLİMATE DATA
*AZİ *INC *ARİ *ZEN *ALT *VSA *HSA	*Window dimension (Height, Width, sill) *Rear wall (Width, Deptth, Heigth) * Shading device (Horizontal, Vertical, Eggcrate) *glazing	*Orientation (from 0° to 360°) *Latitude *longitude *time zone	*Annual average temperature (overheat period, underhead period, comfort zone) * Annual vind direction *Annual solar radiation (direct, diffuse)
	DESIGN	TOOLS	
Sun path diagrams	Design options	Comfort charts&Standards	
*Stereographic projection *orthograhic projection *equidistant projection	*material, cost, *economy *function *color *aesthetics *montaj, detail	*Bioclimatic chart *psychrometric chart *CIE, Daylight factor (DF) *ASHREA (Standard 142, 199) *ISO (Standard 7730) * SC% (shading coefficient, ASHREA/ DOE)	
MANUAL OR COMPUTER AIDED DESIGN PROCESS			
OPTİMUM DIMENSION › INTERIOR COMFORT ENERJI EFFICIENCY			

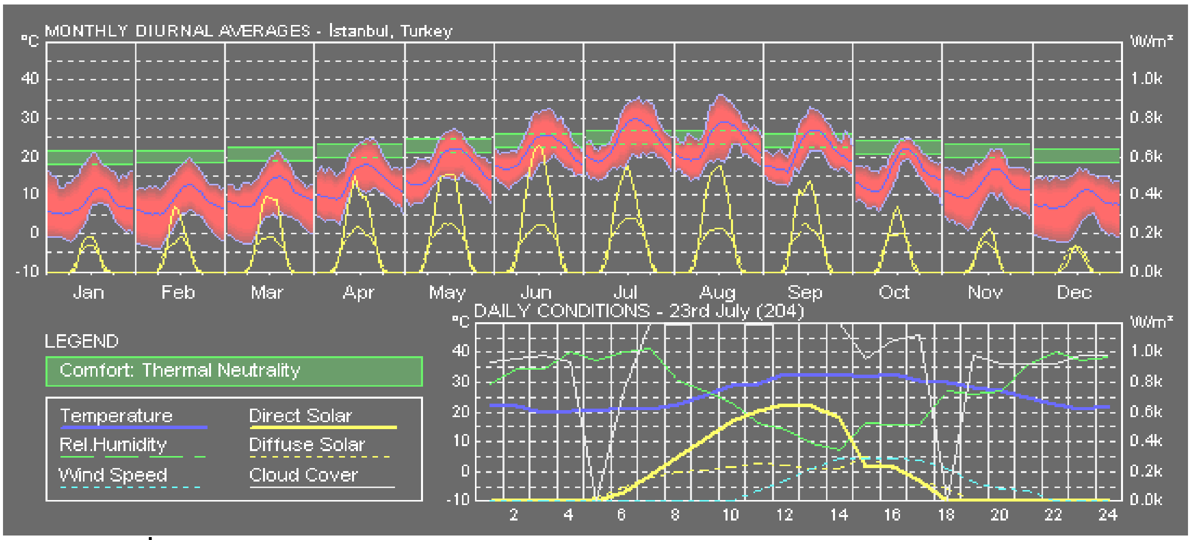


Figure 1.İstanbul city and its climate [28].

When the design criteria stated in Table 1 applied to a specific site layout, parameters of related dimension of the window and shading device could become definite on the direction of providing thermal and visual interior comfort. However, at the building design, dimension of the window and shading devices, which are used for determination of the thermal comfort and sun light quality which can sometimes interact with each other. For example a shading device that can on one hand provide desired shading during one year period and on the other hand can reduce daylight factor (DF) or prevent the ventilation [22]. Furthermore, a shading device dimension, which provides shading in summer months, can provide the same shading in winter months and so it can reduce interior thermal comfort [7]. Also, design options of the window and shading devices criteria tools like material, usage, economy and application details effect the shading devices dimension, too [16]. The colours applied to building material show different behaviour in the aspect of reflecting and absorbing the sun light [23]. Shading devices, which are made from a material, that absorb sun light, are made shading in summer months, but it may increase heat in interior space [24]. Beside this, window glasses with coatings for the limitation of solar irradiation partially reflect or absorb incident solar radiation [25]. So, glazing system effectiveness in controlling solar penetration is also effect the shading device form and material. In order to resolve the above mentioned problems, shading device dimension and type should be determined firstly. In this situation, to determine optimum device dimensions in a building that can provide energy efficiency during one-year period comparison of a series of drawings, which are repeated for every window's dimension, specifying the orientation and geographical position and using the climate data between accounts, is essential. Finally, evaluation all of the design criteria stated in Table 1 introduces the design procedure which takes long time and contain complex process. More importantly, it could not be always possible to evaluate all criteria that are in the continuous interaction. In this aspect, to give priority to variables or eliminate some of them will be a facilitative approach of shading device design. For example, in hot climate zone, interior heat comfort, which can be acquired naturally, could be a priority design criteria of shading device [3]. Furthermore, in cold climate zones, shading device may not be required. Otherwise, protection from sun and heat plays an important role in the Mediterranean zone with a hot climate during the summer months, while the problems of areas with a cold climate are quite different [26]. At the building residential district, which is determined with this procedure, selection one of the effective shading device types and elimination of the others are a solution for making the design easier. When it is looked logically to the subject, material, colour, cost and economy that depend on these, only can be applied to a shading device with undetermined dimension and shape. From this aspect, in this study, for a selected building area both necessity of shading device type determination and dimension analyses were made. In this case, priorities of shading device criteria presented in Table 1 are determined on the base of sequence stated below.

1. Reasons of the shading device priority that will be applied to the site layout.
2. Determination of the shading device type that provides shading only at the required time during one year period.
3. Determination of the selected shading device type dimension alternatives' shading behaviours.

The determined priorities of shading device design stated in Table 1, in other words "design strategies" were defined as stated below.

1. To determine the precedence reason of shading device that will be applied to site layout.

As stated in Figure 1, June, July, August and September months' temperature are at the level those effect interior comforts negatively on the base of ASHREA temperature standards [29].In addition, solar heat gain that are earned in November, December, January, and February months is necessarily for interior comfort [27]. In this case, 6th, 7th, 8th, and 9th months bright sunshine duration are priority shading device criteria for latitude 41°. In this aspect, shading blocks which shading device has scanned in one year period, must stay in June, July, August and September months and between 8:00-16:00 o'clock that the time interval solar heat gain is the highest level. In Table 2, Latitude 41, it is seen the time, month, and orientation that are needed at shading. In Table 2, the time, which the Sun return from North to South and South to West are considered as a basis at Istanbul city which is located North and West side, at latitude 41° and longitude 28°.

Table 2. In Latitude 41, months, and orientations that are needed at shading.

Location: 41.0°, 28.0° Time zone: +2, Istanbul	
Comfort zone	March, April, May, October
Underhead period	November, December, January, February
Overhead period	June, july, agoust, september
ORIENTATION	**Effective Shading**
North	Not required
South	8.00-16.00
East	From sun rising to 12.00
West	From 12.00 to sunset

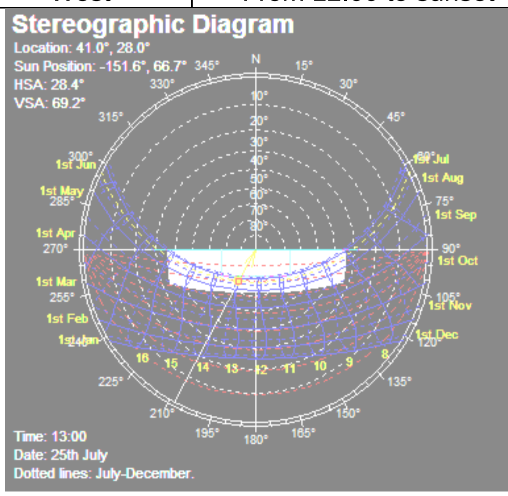


Figure 2. The scanned shading blocks on stereographic diagram define the required shading block in one year at latitude

2. To determine effective shading type that provides shading only at the required time.

Stereographic diagram in Figure 2 shows shading blocks includes time, month, and orientation 180º. The scanned shading blocks on stereographic diagram define the required shading block in one year period at latitude 41º.The scanned shading blocks in Figure 2 can be defined by "horizontal" type shading device [10]. In this case, horizontal type and south facade are a priority-shading device for latitude 41.

3. To determine shading behaviors of established type dimension alternatives.

To investigate established horizontal type shading devices' dimension behaviours, window, wall and shading devices dimension alternatives, which effect directly productivity of shading device, have determined. In this situation, horizontal device priority-dimension alternatives are as like on horizontal shading device priority-dimension alternatives are applied separately to a fixed "W" type window with width 1.00m., height 1.20m., and shading blocks are analyzed as seen in Table 3. For dimension all analyzes of horizontal shading device increased the values are given to every dimension of the scanned shading blocks in Table 3 and window and wall dimensions are hold fixed.

Table 3. Horizontal shading device dimension alternatives

Window/m.		**Rear wall/m.**		**Horizontal shading device[1] /m.**	
Height	1.20	Width	3.00	Depth	
Width	1.00	Depth	0.20	Angle	
Sill	0.90			Left	
Side	0.10	height	0.300	Right	
Top	0.10			No.	1

Horizontal shading device : It is oriented on the window with 10-cm. width and 10-cm. run to both left and right sides of window width.

Depth: Shading device's width

Angle: Shading device's angle with window surface, that is angle with vertical surface/ + values define down-slope direction, and – values define up-slope direction. To follow the angle's shading block reflection more clearly, it was analyzed for ± 30 degree angles.

Right: Length of shading device according to window right side axle

Left: Length of shading device according to window left side axle

No. of shades: shading device's part number, analyses are made for single part.

These dimension alternatives are analyzed and result are presented in Table 4. So, optimum dimension alternatives are determined. To follow clearly the shading blocks that shading devices make on stereographic diagrams (Table 4), shading blocks are analyzed on the base of 100% and 50% shading block values. On stereographic diagrams, light grey defines 100% value and the dark grey defines 50% value shading blocks. Whereas, the dotted grey lines are defined horizontal shadow angles which are laid on the stereographic diagrams and widen with 10-degree angle (HSA).The software of solar tool program has been made by 3mm single glass and SC=1. In this aspect, it is accepted that glazing is not shading.

As seen in Figure 1, according to Istanbul climate data, the hottest day is determined as July 25. So, horizontal parts' dimension behaviours are analyzed on July 25 at 13:00 o'clock with south face that has the longest bright sunshine duration.

III. CONCLUSION

In this research, through Istanbul city and applicable to latitude 41, shading device type, dimension alternatives and shading behaviours were determined. In this aspect, the underlined design criteria and tools in Table 1 for Mediterranean climate zone in latitude 41º north where Istanbul city present, were determined as "priority" shading device design criteria by computerized supported analyses. External shading devices' optimum types and dimensions principles, which were founded from analyses, are stated below.

- In summer months, between 8:00-16:00 o'clock, to prevent undesirable increase of indoor temperature and glare because of solar penetration, horizontal device (overhang) is effective at all of the orientation, which sun scan.
- Horizontal shading device's dimensions and shading behaviours are shown in Table 4.

The criteria which are determined from the results of analyses, should be used as a substructure for commercially supplied shading devices like awnings, louvers, shutters and Venetian blinds by designers and users. Furthermore, "the design strategies" which are established in this study are applicable to any building of residential district.

Table 4. Dimension alternatives of horizontal shading device

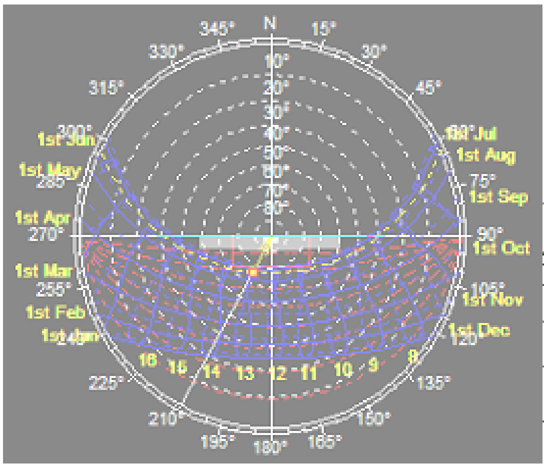
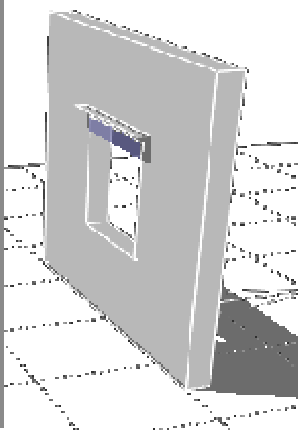
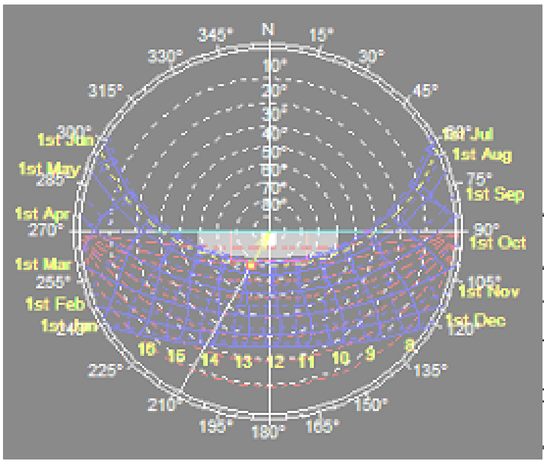
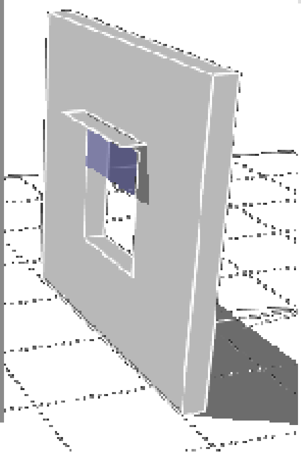
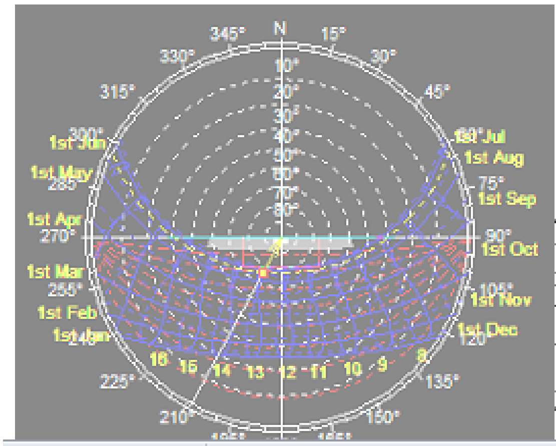
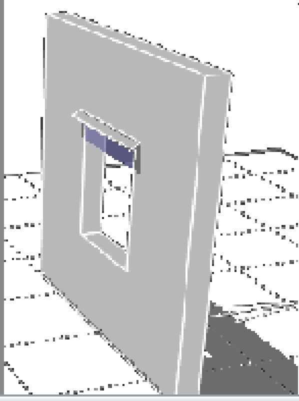
SUN PATH DİAGRAM 180° Location: 41.0°, 28.0° Sun position: -151.6°, 66.7° HSA:28.4° VSA:69.2°	WİNDOW 100/12(Rear wall depth: 0.:	DİMESION BEHAVIOR & SHADING %			
		depth	angle	right	left
		0.10	0.00	0.10	0.10
		W1 At the direction of horizontal shading angle (from summer months to winter months) disperse on the graphics. Shading=12%			
		0.20	0.00	0.10	0.10
		W2 The daytime efficiency is fixed, shading is windened at direction of horizontal shading angle. Shading=36%			
		0.10	30°	0.10	0.10
		W3 Shading month is fixed, The daytime efficiency is widened. Shading=14%			

Table 4. Dimension alternatives of horizontal shading device

SUN PATH DİAGRAM 180°

Location: 41.0°, 28.0°

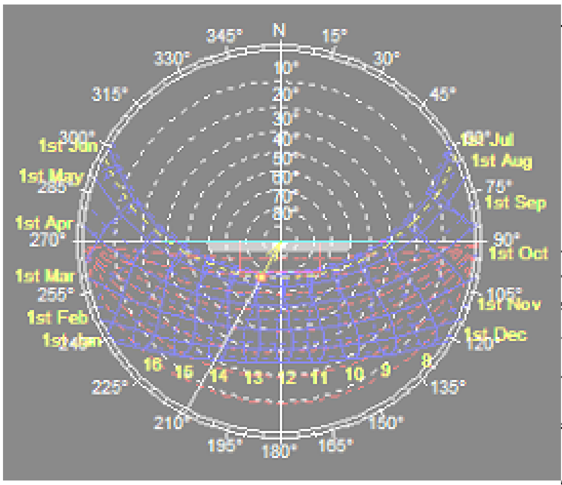
Sun position: -151.6°, 66.7°

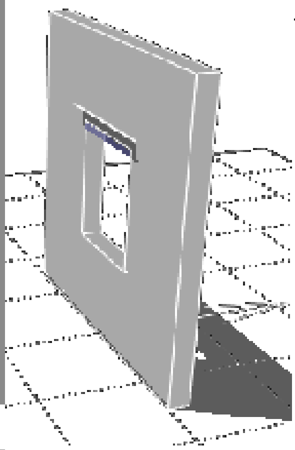
HSA:28.4° VSA:69.2°

WİNDOW 100/120 Rear wall depth: 0.2

DİMESION BEHAVIOR & SHADING %

depth	angle	right	left
0.10	-30°	0.10	0.10



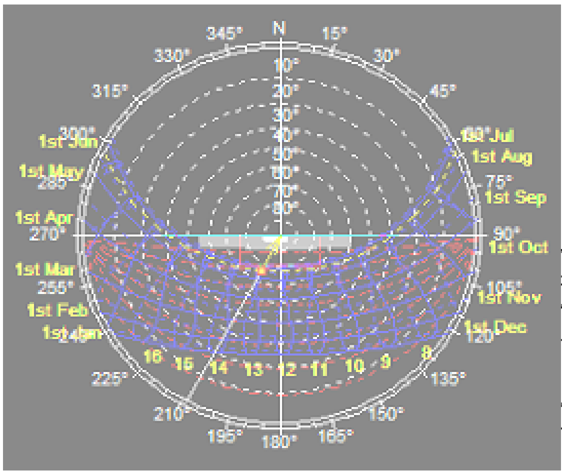


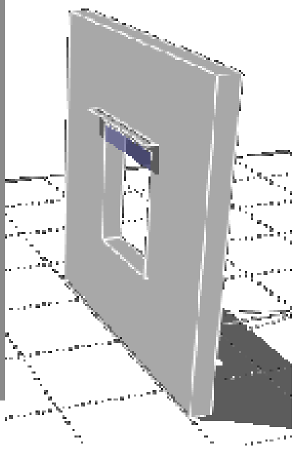
W4

The shading month is fixed, efficiency in day is narrowed.

Shading=%7

depth	angle	right	left
0.10	0.00	0.20	0.10



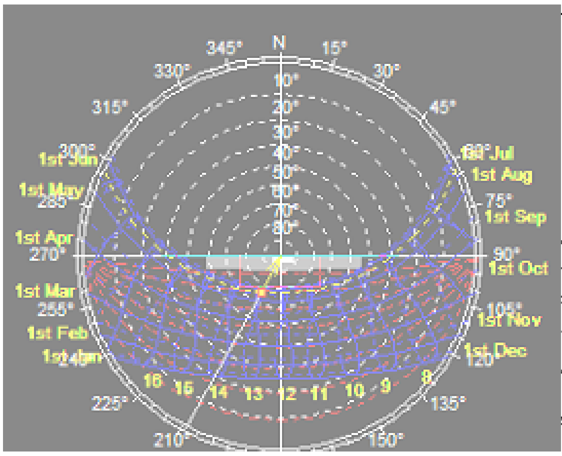


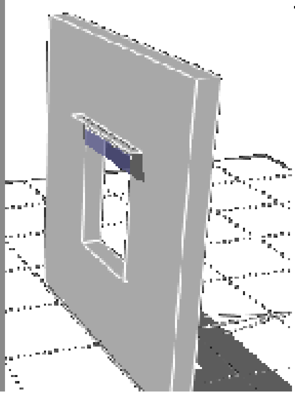
W5

The shading month was fixed, efficiency is widened toward evening hours,

Shading=12%

depth	angle	right	left
0.10	0.00	0.10	0.20





W6

The shading month is fixed, efficiency is widened toward morning hours.

Shading=12%

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