PROMOTING ENERGY EFFICIENCY IN BUILDINGS IN EAST AFRICA

SUN SHADING CATALOGUE

Adequate shading: Sizing overhangs and fins

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1. INTRODUCTION

The indoor thermal comfort of a building depends on several factors which include the prevailing climatic conditions, site location, building orientation and building materials used. All these factors, if not appropriately considered in the building design, can result to discomfort for the occupants and or increased energy consumption in a bid to reach optimal comfortable conditions.

Regions located near the equator such as Nairobi 1° 17′ S, 36° 49′ E receive far more solar radiation compared to those located farther from the equator such as London 51° 30′ N, 0° 7′ W. Glazed surfaces are the easiest ways for solar radiation to penetrate buildings. The amount of solar radiation and visible light transmitted inside a building depends on the type of glazing used. For example, commonly used clear glass transmits more than 80% of incident solar radiation and more than 75% of visible light. This solar radiation penetration can be favourable or extremely unfavourable depending on the prevailing climatic conditions, season, time of day, function of the building and space use (occupant's activity).

Therefore, in hot tropical climates, it is necessary to eliminate the penetration of solar radiation into buildings through glazed surfaces through strategies such as appropriate building orientation (along the east – west axis), adequate sizing of openings (window to wall ratio), proper location of openings (facing north and south), careful selection of glazing properties and appropriate solar protection using sun shading devices.

External shading devices are desirable in hot climates for the control of solar heat gains in buildings by intercepting unwanted solar rays especially during the overheated periods thus substantially reducing the cooling load resulting to huge energy savings. They must be carefully designed and oriented to maximise shading during the overheated periods in order to reduce heat gain and to maximise solar heat gain during the cold / under heated periods.

For the tropical climates, the most appropriate building orientation to minimise solar heat gain is along the east – west axis with the long façades of the building facing north and south. However, site constraints (such as topography, surrounding buildings, street etc.) and conflicting wind direction may not favour this type of orientation. This may result to major openings being exposed to direct solar radiation hence necessitating the need for solar protection.

This document illustrates how to properly size shading devices for windows on different orientation in different latitudes at selected cut-off times. The six major latitudes considered include 0, 2° S, 4° S, 6° S, 8° S and 10° S while the sixteen different orientations that are considered for the vertical reference surface are N, E, S, W, NNE, ESE, SSW, WNW, NE, SE, SW, NW, ENE, SSE, WSW and NNW.

The British High Commission building in Kampala, Uganda is located on a steep site that conflicts with the sun's movement. This resulted to the long sides of the main building facing directly east and west. This contradicts the recommended building orientation with the long sides facing north and south and minimal openings on the east and west facing facades to minimize unwanted solar heat gain.

Multipe horizontal fired-clay louvres were thus designed and installed on the west facing openings for sunshading.

In order to avoid unwanted heat gains and glare, windows should ideally be shaded during all daylight hours in the tropics. However, by doing so, it might result to impractical overhangs and fin designs especially in the early morning and late afternoon hours when the sun is low in the sky. This document attempts to develop a more practical design solution for different latitudes and orientations based on the following assumptions:

1. Heat gain is less of a concern during early June in the southern hemisphere as low temperatures are usually experienced than other times of the year.
2. Heat gain is of less concern during the early morning hours before 9 am where it is welcome into the building when the temperatures are lower than other times of the day.
3. Occupancy hours that have been considered are assumed to be 9 am to 4 pm. The exterior shades design in this section will shade windows completely during these hours.
4. Interior shades can be used to eliminate glare when necessary.
5. The different climates in which the representative cities occur have not been considered in the design of the shading devices.

2. THE SUN'S POSITION

To control heat gain and provide adequate shading, it is important to have a good understanding of solar geometry, solar radiation and solar energy in various hours of the day and during different seasons. This is essential in order to: design for passive heating and cooling; orient buildings properly; understand seasonal changes within the building and its surroundings and design shading devices.

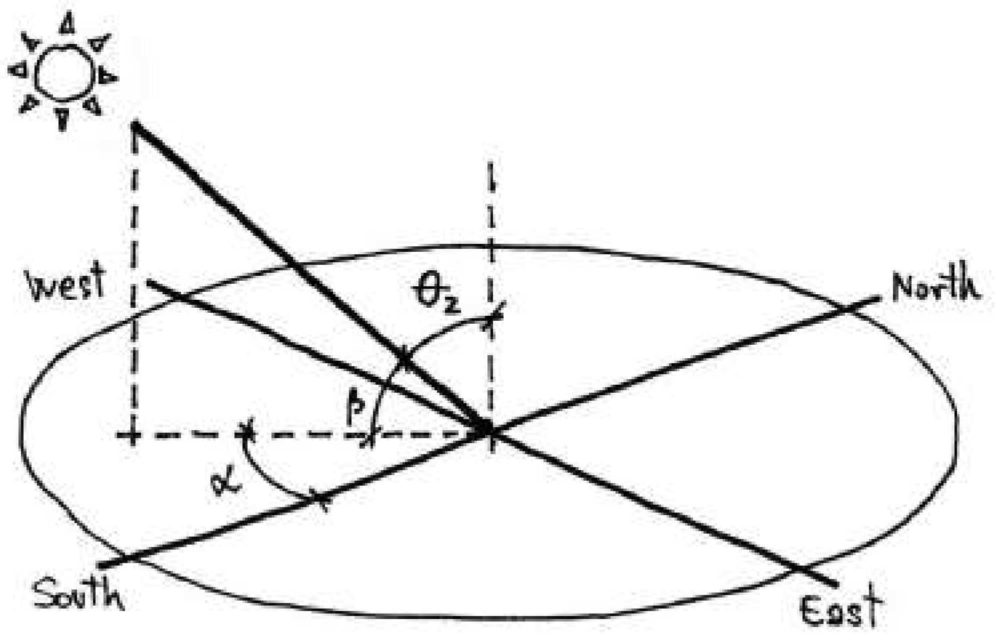
2.1. SOLAR GEOMETRY

The earth's movement around the sun results to different solar paths characterised by variable heights and lengths depending on the time of the year and latitude. The sun's apparent movement is from the east to west. Its position at different times of the year can be found though two angular coordinates namely (Figure 1):

- **Solar altitude β**, represented by the angle between the line joining the centre of the sun with the observation point and the horizontal plane
- **Solar azimuth α,** which is the angle, measured on the horizontal plane, from the south-pointing coordinate axis to the projection of above joining line.

Solar control through shading devices is most effective when designed specifically for each façade, since time and duration of solar radiation vary with the sun's position in the sky - its altitude and azimuth.

Figure 1 **Angular coordinates of the sun**



2.2. SUN PATH DIAGRAMS

Sun path diagrams are a convenient way of representing the sun's changing position in the sky throughout the year. They are projected onto a horizontal plane, on which the four cardinal points (North, South, West and East) are represented. The plane has a base with concentric circles and radial lines (Figure 2). The position of the sun at any time of the day can be plotted on the horizontal plane. It is therefore possible to develop specific diagram for any latitude.

The values of solar altitude β are represented by the circumferences (outermost corresponds to β = 0°, horizon, while the centre corresponds to β = 90°, zenith). The values of solar azimuth α are indicated by the radial lines, and can be read out as the angular distance from the south-pointing coordinate axis.

2.3. SHADING PROTRACTOR

The solar shading protractor (Figure 3) is another useful tool which allows one to study the effects of sunshades, overhangs and fins on the building façades. It has the same dimensions as the polar diagram and can be overlaid to it to show the shading effects caused by vertical and horizontal overhangs, with respect to a specific point of view, which must coincide with the centre of the chart. This produces the shading mask of the solar shading device.

The pseudo-horizontal curved lines represent the influence of shadows created by overhangs characterized by horizontal edges parallel to the façade, and are drawn by calculating the angle ε (VSA – Vertical Shadow Angle) (Figure 4). This is the angle lying in a vertical plane orthogonal to the façade, formed by the horizontal line passing through the analysis point P and the line joining this point with the outer edge of the horizontal overhang. The corresponding values can be read on the vertical lower semi axis of the diagram.

Figure 2 **Polar sun path diagram at the equator**

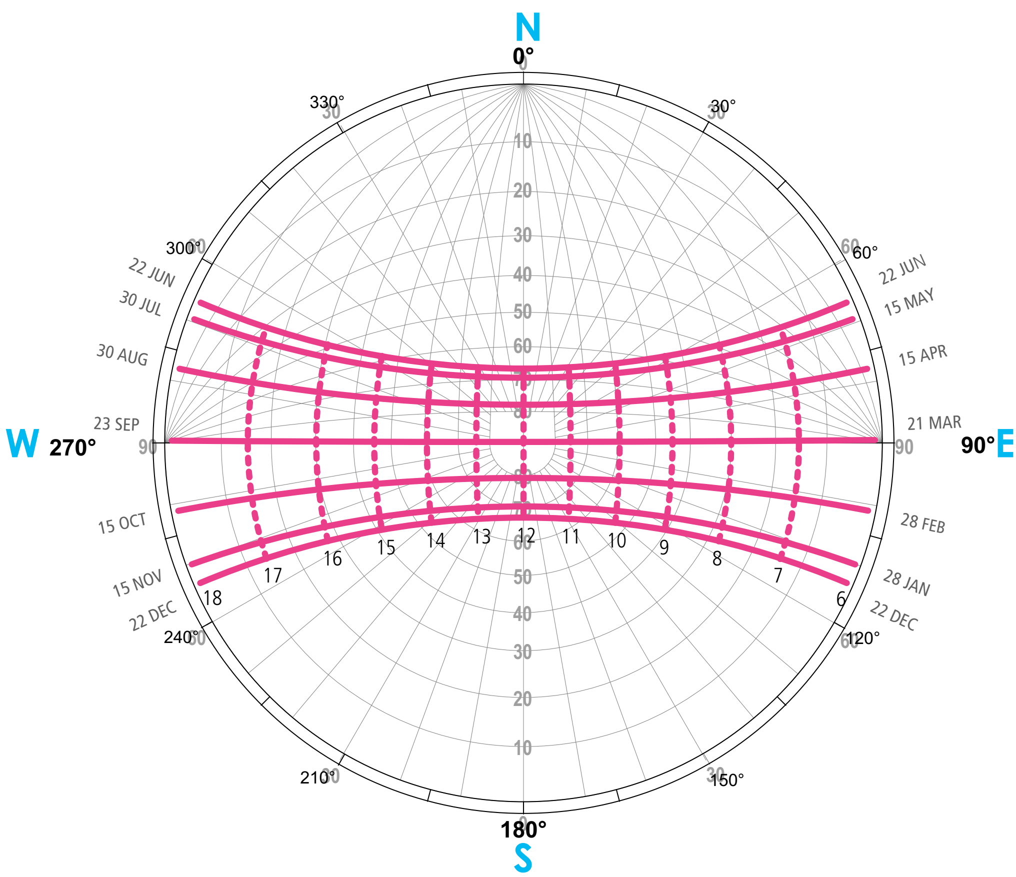


Figure 3 **Solar shading protractor**

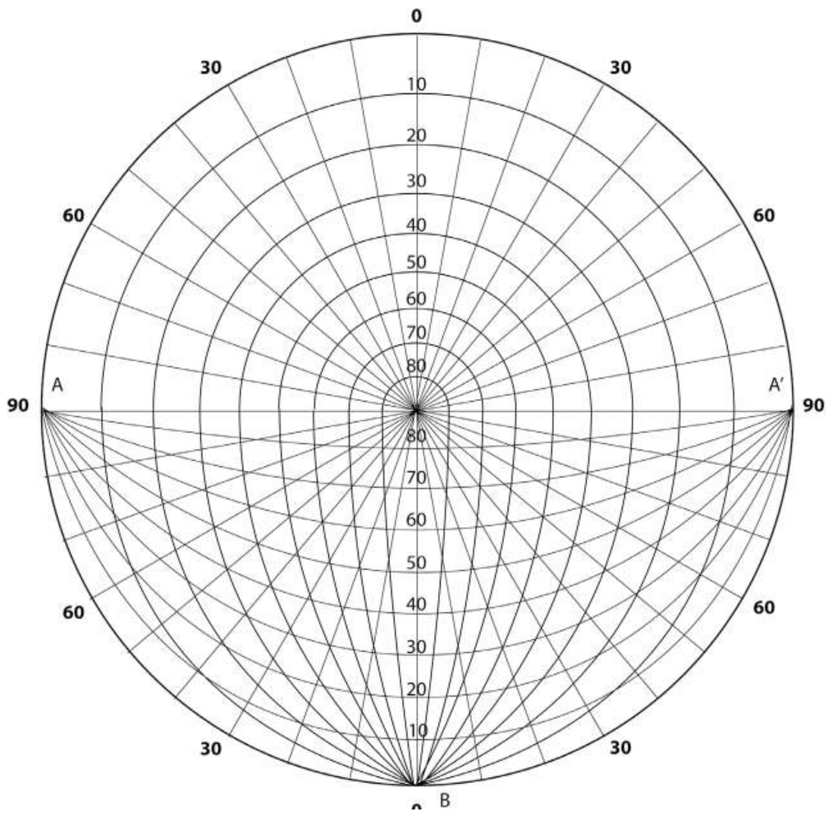
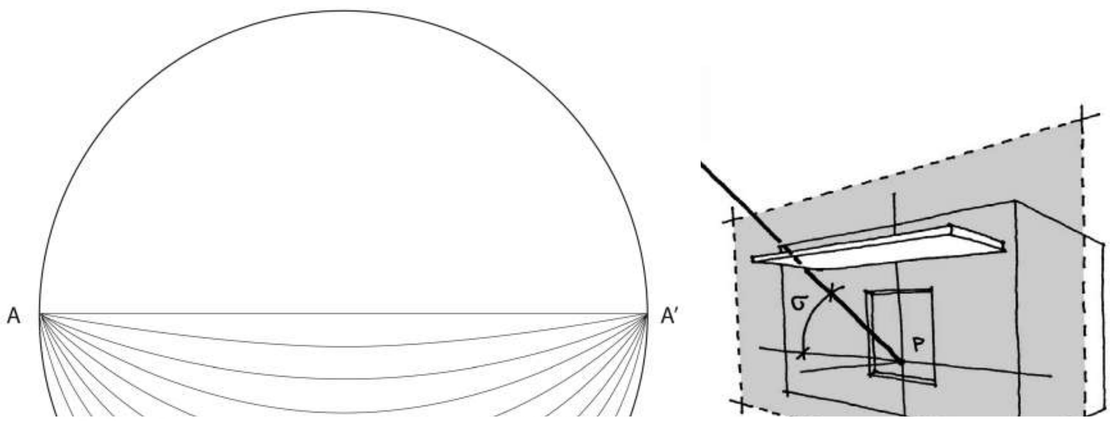


Figure 4 **Construction lines of ε**



Appropriate and well-designed sun shading devices can dramatically affect indoor conditions by controlling indoor illumination from daylight, solar heat gains and glare.