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# SUN AND BUILDING

## Solar based Design

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***ABSTRACT****: In the present day context, due to globalisation, urbanisation, over crowding, Increase in population etc, there exists a shortage of land parcels in cities. It is also inevitable to build and cater the needs of people. So, in the role of an Architect, it becomes more important to build consciously adapting to the nature and try to reduce the adverse effects on nature. So, at the inception level of building itself, there is a need to understand the climate (Sun, Wind, Light etc) and its impact on the built structure. In due course, it is also difficult to address all the parameters of the climate together to generate a building. In my research, only solar radiation is been chosen, and tried to analyse different design stages in the lens of solar radiation which inturn helps in developing the form of a building based on the different attributes of sun. The form of the building is done to either channel the light into the building without getting glare and heat, at the same time shading the building in case of requirement. The method adopted to achieve this is, initially by incorporating software skills to understand the particular climate, analyse the climate parameters and design the form and facade. The advantage of adapting this process helps in reduction of heat inside the building and provide certain thermal comfort to the space. This way, it shall help in reducing the usage of hvac, Lighting etc., keeps the building sustainable for long time.*

***KEYWORDS: Climate, Solar radiation, Form generation, Solar carving, sustainable***

### 1. INTRODUCTION

Buildings in tropical climate have a great advantage of utilising and conserving solar energy. Solar energy is free and is completely a renewable energy. The fundamental purpose of buildings is to provide a man with a comfortable living and working condition, protected from the extremes of climate. In these days of fuel crisis it is important that such comforts be provided with as little expenditure of energy as possible.

The facade or a skin is a main element in a building which separates indoor environment with outdoor environment, also necessarily create environment for shelter, comfort, control weathering impacts. Hence, there exists a relation between climate and building.

The aim of this study is to introduce and discuss -in a conceptual and technical sense - an environmentally sensitive approach to architecture, influencing the 'form generation process' of architectural design. The original intent in this work is to make the relationship between the concepts of 'solar shading', 'solar access' and 'architectural form' literally and experimentally clear. The inquiry is about the possibility of controlling solar access by the help of form while responding to the functional, structural and aesthetic requirements of a building during the 'form generation process' of design. Solar based design assumes the sun as the most effective climatic factor in the scope of architecture. Solar design strategies are defined on the relative movement of sun and effects of it on human and their environment. These types of studies are necessary for proper environmental assessment, the development of proper precautions, and the development of design approaches during this age of green consciousness.

### 2. BACKGROUND

In this paper study is necessarily done for an office space in warm and humid climate. The aim is also to address the tall buildings. The location chosen is Mumbai, the coastal region of Maharashtra. The site is located in Dadar West, next to Elphinstone flyover. This particular site was selected due to the cities future proposal of developmental plans in Dadar. There are proposals of new centers of growth due to transit network, change in economic policies, economic activity etc, by which there would be significant increase in employment due to the growth pattern, thereby increasing demand. Since, Mumbai is a metropolitan region, every inch of a space is expensive in all ways.

Sun is the source of life. Existence of nearly all life on earth is fueled by light from the sun. It is the major source of energy on earth. In regard with building design also, Sun is the most primary element to start with. So, it is important to understand the relationship

between Sun and Earth.

Solar envelope is a Space-Time construct. Its spatial limits are defined by the parameters of land parcel size, shape, orientation, topography, latitude, and the site context

The relation between sunlight and thermal comfort in office space needs illumination and thermal comfort simultaneously. Here, there should be more concern as to the instantaneous effects of solar radiation on comfort exists, as well as energy conservation from good passive solar design.

The light of the sun is available on earth in two forms - Direct and Diffuse. When the sky is clear, buildings get a direct sunlight and reflected sunlight from surrounding surfaces. When the sky is overcast, it is diffused by clouds. So, it is very important to adapt few methods in designing.

### 2.1. Methodology

The methodology adopted in designing office building includes the complete analysis of climatic factors with respect to site and its context, building form. Here, to achieve an accurate result ecotect software is used as a tool to generate data. Software also helps in understanding the impact of the climatic factors on the building form and envelope.

The process of developing solar based design for envelope primary tool is to understand sun and its relation with the earth.

1. To understand the relation of site with its sunpath. To do that locate sun's path at your location. In this step, one has to find out

- Longitude and latitude of a particular site or a place
- Azimuth and altitude
- Rising and setting position of the sun(Based on the time of the year).
- Duration of the day and night in different seasons
- Understand the sunpath during Equinox and Solstice
- Sunpath in different seasons.

Find out sun movement in particular days like Solstices where extreme sun's position can be studied and Equinoxes where average Sun position could be studied. Table below shows the four important dates to do the analysis.

| NAME | DATE (Sth.Hem.) | DATE (Nth.Hem.) | DESCRIPTION |
|---|---|---|---|
| Summer Solstice | 22 Dec. | 22 Jun. | Sun at its highest noon altitude |
| Autumn Equinox | 21 Mar. | 21 Sep. | Sun rises due east, sets due west |
| Winter Solstice | 21 Jun. | 21 Dec. | Sun at its lowest noon altitude |
| Spring Equinox | 21 Sep. | 21 Mar. | Sun rises due east, sets due west |

*Table 1: Four important dates*

Sun path diagram provides a broader overview of sun on site as they map the path of the sun across the sky at different times during the day throughout the year. They can help establish the position of the sun relative to a site and can be used to determine the effect of shadows cast by buildings, trees and landforms on and around the site.

2. Shading analysis to be done based on the Occupancy hours: Based on the typology of building(Residence, Office building etc) and occupancy hours of the building (Eg: Office space - occupancy is generally in the day time) analysis to be done at specific timings or the duration of the day.

It could be particularly about the times when the building is most heavily occupied. This analysis is done to the site and its context. Software can be used to analyse the site conditions. In this particular study ecotect is used to analyse the shading pattern on the site from surrounding context and for the respective occupancy hours.

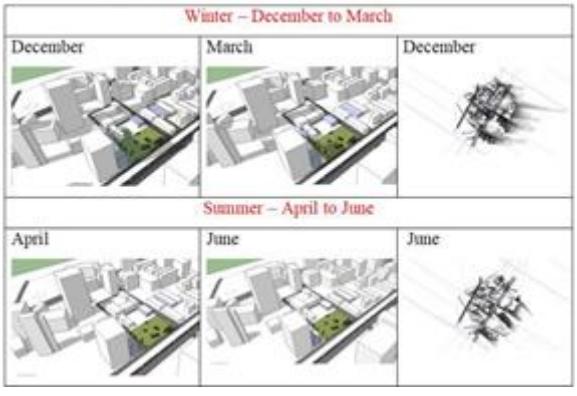


*Figure 1: Shading analysis for winter and summer.*

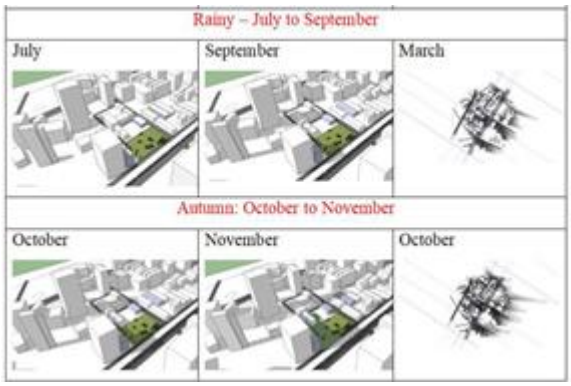


*Figure 2: Shading analysis for Rainy and Autumn.*

This analysis helps in locating the building position on site. Shade is often required in the summer, but in most parts of the country, winter sun is desirable. Obstructions on a site may block sunlight access at times when it is required.

When considering sunlight and building design, assess the impact of obstructions in the future as well as the present. It also helps in understanding the existing scenario of shadow pattern inside the site due to surrounding buildings and objects. This will help in analysing the location of building to receive shade or not.

3. As a guide to climate appropriate design, tables uses ready climate data and simple calculations to give design guidelines, in a spreadsheet format, as opposed to detailed thermal analysis or simulation. But, this is used to findout the solar radiation in Mumbai in harmony with other climatic factors and overall climate of Mumbai can be understood. Since each city has its own climate even though their broad classification of climates are similar, still there is a difference from other city which is having the same classification which is due to variations in other climatic factors.

Mahoney table is used to get a better idea of the climate. All the three parts of mahoney's table to be worked out and find the result.

| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thermal Stress; Day | H | H | H | H | H | H | H | H | H | H | H | H |
| Thermal Stress; Night | C | C | O | O | H | H | H | H | H | H | O | C |
| Humidity group | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 2 |

*Table 2: States the comfort limit*

- Part 1 is used to record the most essential climate data, directing and defining the extent of data search.

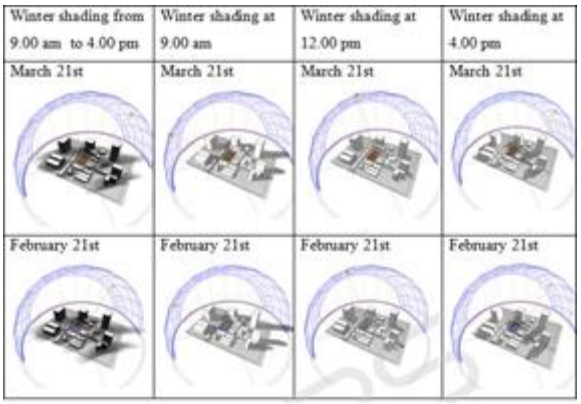


*Figure 3: Shading analysis only for winter.*

- Part 2 facilitates a diagnosis of the climate and develops a series of climatic indicators.
- Part 3 translates these into performance specifications or sketch design Recommendations.

Part 1 and part 2 helps in understanding the climate and response of building design towards it. Since the study is on solar radiation, if necessary in the part 3 few recommendations could be adopted for thermal stress and size of openings. For example in this study, analysis helped in understanding that Mumbai is hot over the day for all the months in an year and outdoor environment is not comfortable enough, even though there are more winds. So, this basis helped in choosing solar radiation as a climatic parameter to analyse.

4. Data collection and evaluation of solar radiation Since the envelope affects the thermal comfort, in this study only solar radiation is considered as a main parameter of the design. So, it is important to collect the solar radiation data for the whole year. The accurate data is generated by using ecotect software.

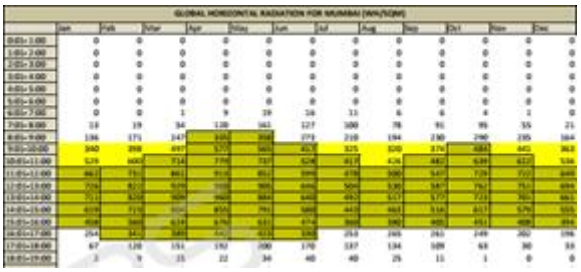

*Table 3: Data generated from ecotect software for Global horizontal radiation for Mumbai*

By combining solar radiation data and dry bulb temperature data from the weather file shading requirement for a building is derived. Dry-bulb temperature is an indicator of heat content. Comparing the combination of dry bulb temperature and global horizontal radiation with the Minimum DBT (Dry bulb temperature) as 20°c and maximum as 28°c, the higher values are considered for designing purpose.

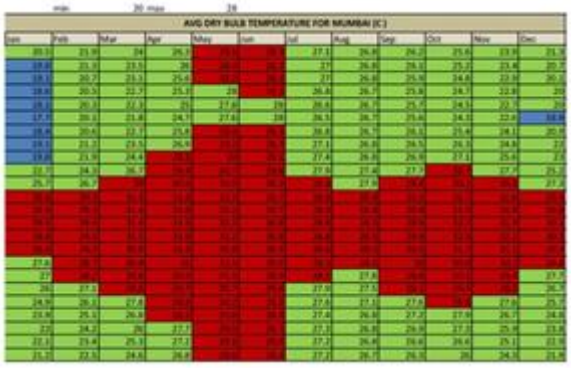

*Table 4: Data generated from ecotect software for Average dry bulb temperature for Mumbai*

Evaluation on incident solar radiation

Using simulation softwares like Ecotect, Vasari, Radiance, Equest etc, the analysis can be done to find out the difference between each façade of the building for better results. Here, Ecotect is been used as a main software to analyze the insolation levels.

As a first step, each wall needs to be simulated for global radiation, direct radiation for full hourly, shading percentage, exposure percentage and also tabulated form of these values to be generated to understand the values.

In this project, insolation studies are done with a comparison of base case which a square building is having a similar floor space index of designed building.

By generating solar shading and exposure graphs, the percentage of radiation on that particular wall is analyzed and then openings can be planned. Shading for the building can be designed.

This analysis leads designers to understand the quantum of radiation on each wall and decide the opening sizes and percentage of shading for the building.

## 3. DESIGN CRITERIA

### 3.1. Form: Strategies That Respond To Solar

**Seasonal conditions**

Siting and Orientation: Buildings in Tropical and Subtropical Regions, has the advantage of utilising solar radiation. Orientation of a building has three factors to be considered:

- Solar radiation
- Prevailing wind
- Topography

By setting the right orientation of the building in a site, huge amount of heat gain can be reduced. Optimal orientation reduces radiation to a minimum in the hot periods, while allowing adequate radiation during the cool months. It also helps in reduction of heat gain and can greatly improve heating and cooling performance when optimized, can greatly improve daylighting when optimized.

### 3.2. Massing and shape

The size and articulation of the building is fundamental to its overall massing in the achievement of a slender, elegant and well-proportioned building, because it will greatly influence its visual and physical impact on adjacent areas. In this study the aim of achieving climate responsive building mass and shape through the help of simulation and parametric softwares.

### 3.3. Building Envelope

All different surfaces of a building need to respond to the unique conditions created by the solar and seasonal cycles. so, it's very important to understand the solar condition acting on faces of buildings subject to respective hemisphere. So, to design any building it is advisable to adapt passive solar design strategies.

### 3.4. Shading

Shade sunlight to prevent glare and excess heat gain. To do this optimum orientation is essential. There are many different ways to control the heat and glare in the building, which could be active ways or passive ways. Why not control the amount of heat gain in the building at initial stage of design?

All of the above design criterias can be achieved easily by software usage. Parametric softwares can help in generating forms and also simulate. Since these softwares help in simulation it is advisable and good to use software as an analysis tool and generate better design options.

## 4. CONCLUSIONS

In any building design, there suppose to be a procedure adopted in pre design, site analysis, before executing the building. The usual way of doing predesign is by analysing the site and its context in all possible ways, finding all climatic data to understand the climate, analysing all climatic parameters to design a building. Further, designing the building based on its function with certain aesthetic and lighting design.

This study is focused on the particular procedure, wherein the initial stage of design is discussed. So, the study involves few methods in predesign. The reason for these methods is mostly to address the climate responsive and solar based design of tall structures in a dense urban cities. Here, Predesign analysis is done in particular way. It uses only one climatic parameter for most of its analysis. The climatic parameter is solar radiation. The methodology discussed in the paper is especially on solar radiation parameter. As discussed earlier, solar radiation is the most suitable parameter for detailed analysis, when the building is in tropical climate.

If the suggested methodology is used and adapted in a suggested way to find out the data and analyse the site, context and building, buildings design itself can help in reducing the solar radiation in building, increasing the efficiency of users of space, different forms could be generated and corms could be climate responsive, might reduce the usage HVAC, artificial lighting, reduce the amount of heat in the building due to the form itself, help the environment by utilising less resources, energy efficient buildings can be designed for future.

"Nature is not the enemy"

-Mark Igou

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