Built Architecture: The Role of Natural Light

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Abstract: Designing of buildings according to daylight is a tool to provide adequate lighting to the interior and to exclude unwanted light from the room. Since human beings established their shelters with a lighting opening, they have been continuously searching for better methods to obtain suitable natural lighting in the living.

Although day lighting and architectural design have been studied for a long time, in-depth studies into day lighting has increased rapidly in recent years, Daylight has been used in buildings because it is free, Today it is still free but constructing and maintaining window openings is expensive, In the places, where electrical lighting is expensive, natural light, which is available free of cost, plays a role of problem solver whereas the places where electrical lighting is economical and widely available, natural lighting becomes a luxury which provides its users with a better working environment and more enjoyable living conditions.

In this piece of writing, the necessary definitions of lighting are discussed. Considerations of daylight control from several important view points, the quantity and quality of daylight, daylight and visual comfort, orientation of buildings for daylight, daylight design in planning of various buildings for different purposes, such as school, hospital and house, have also been discussed in the article.

Index Terms **- Natural light, day lighting in buildings, sustainable lighting, daylight control.**

I. INTRODUCTION

Architectural daylighting forms part of architectural physics and deals with natural light in buildings. Its purpose is to meet every requirement for good visual work and healthy environments by providing optimum illumination in a room.

In practice, improving the utilization of the incessant natural light would save millions of amps of electricity. However, the most important criteria for providing natural lighting in buildings is not limited to economic questions. Lighting is important for human physiological and sanitary well-being because man has been used to living in an environment of natural lighting. Besides this, sunlight has an important effect on the human psychological state.

The effect of natural light on the form of buildings is also very important. In many buildings planning, elevations, interior decoration and color selection are dependent on the availability of natural light. These factors have provided the field of architectural lighting with the impetus responsible for its recent development.

Some people think that natural light is free while we are using it in our buildings. Actually, we spend a great amount of money erecting a light opening and maintaining it. The expense depends on window size, shape of the opening, method of construction of the light opening, the type of climate in the region and also the main purpose of the building.

The importance of economic and health factors of natural lighting depend on the level of illumination in the room, the modes of lighting used the window construction and color of the glass. In each case, if we wish to obtain reasonable lighting, we should consider the climate, the use of the rooms and the specialty of visual work.

In buildings like factories and warehouses, provision of suitable amount of lighting is an efficient method not only to increase the productivity, but also to improve the quality of production. It may also reduce the ratio of waste products and decrease the frequency of occupation sickness. In domestic and public buildings, adequate lighting can improve the visual and health conditions, so that it protects the human being.

In conclusion, if we wish to design adequate natural lighting for buildings, we ought to plan the most suitable design for the openings by calculating the illumination and arranging the openings or windows to coincide with the requirements of the lighting standard.

II. WHAT HISTORY OF DAY LIGHTING SAYS?

Man likes natural light and he desires to have it in the house at all times. Light is as important as water and air for human health. In primitive period, man lived in the trees receiving air and sun-light. After he came down from the trees in order to escape the wild beasts, numbing cold, enervating heat, drenching rains and bitter winds, he went into a cave -- a dark environment. Then, he emerged to a hut. Caves and huts were windowless and gloomy. There was no material at hand to keep the weather out and let light in at the same time, however, being a light-Ioving animal, man invented a means by which to admit light. He brought light into his home through the doorway at first, and then from the smoke outlet of the roof. It was the beginning of that century - long struggle for lighting.

Later on, the primitive householder built a small “window " in the wall; he modified his door to a hatch or half-door arrangement, by which he gained a certain amount of illumination and protection against the weather at the same time.

These first "window", wall or roof openings, were constructed without covering or were covered by opaque materials, such as wood, woven thatch, rushes, leaves or stone sheets, which then the y were covered with animal skins or cloth, and as a result, light was kept from the room.

Gradually, these materials were supplanted by translucent stone, such as gypsum, or translucent sheets of marble, or by sheets, mica, or alabaster, or parchment, oiled paper or oiled linen.

Eventually, glass was discovered, probably in the second millennium before the time of Christ, with its discovery man had an increasingly efficient means of admitting light to his home. The Romans were likely the first people to use glass for windows, They learned the manufacture of glass from the Egyptians when Egypt became a province of their empire, However, they exploited glass chiefly for decorative purposes; and its development was not sufficient to displace stone, cloth, or shells entirely as a window covering because glass was deemed mysterious and it was produced in extreme secret. At that time glass was a precious item that only the rich and powerful could use, During the early Middle Ages, the church began to use glass for windows in a host of edifices, Clear glass was combined with small pieces of colored glass to admit colored light thereby producing a holy, religious environment, But the use of glass for domestic homes was still economically impossible and far away, In the latter years of the sixteenth century, when glass became economically available and common, it began to be extensively used for domestic windows.

However, it was only a temporary victory in the ancient struggle for natural lighting, and the proper evolution of natural lighting was limited and bound by the window tax which lasted from 1695 to 1851 in Europe, In nineteenth century , it also was restricted by the deliberate rejection of its technical possibilities by the architects and their spurious interest in styles, since the late Victorian era, a growing appreciation of the scientific principles of admitting daylight to buildings has gradually influenced architectural design, After the eighteenth century architects have been free to use as much daylight as possible.

Daylight in architectural design was investigated systematically only in the last century , Architects and engineers researched different ways of providing adequate illumination, They found some methods to calculate daylight, After the Second World War, the investigation of daylight in England and America became very progressive.

III. Sun and Sky as Sources of Natural Light

The sun is the original source of daylight. It shines directly and indirectly on both the exterior and interior of the building. The sun produces a strong and powerful flux of radiant energy. Part of this light flux known as sunlight reaches the earth's surface after passing directly through the atmosphere. The rest of the radiant energy is diffused by multiple reflections as it passes through the atmosphere and produces a diffuse light. The quantity of daylight received by a given building is continually changing, because the source of light, the sun, is constantly changing its position relative to the building.

In order to understand some of the simpler problems of day lighting illumination we assume the whole sky appears to be a uniform hemisphere. It follows that as the sun gets higher in the heavens the sky will be brighter. In actual fact, the blue sky is usually brighter near the horizon, and darkest at a point perpendicular to the sun, whereas the overcast sky is brightest at the zenith, and only 1/3 as bright at the horizon.

The amount of useful daylight at any point within a room is directly proportional to the area of sky that can be seen from that point through the lighting opening, If no sky is visible from a point in the room, the daylight at that point is not sufficient for any normal purpose.

Reflectance of Building Materials and Outside Surfaces

Material	Reflectance per cent
Asphalt (free from dirt)	7
Bluestone, sandstone	18
Brick :	
light buff	48
dark buff	40
dark red glazed	30
Cement	27
Concrete	55
Earth (moist cultivated)	7
Granite	40
Granolite pavement	17
Grass (dark green)	6
Gravel	13
Macadam	18
Marble (white)	45
Paint (white)	
new	75
old	55
Slate (dark clay)	8
Snow	
new	74
old	64
Vegetation (mean)	25

Thin clouds increase the amount of diffused light and decrease the amount of direct light. Sunlit cumulus clouds are much brighter than a clear blue sky even if the latter be hazy.

The amount of light received from such a sky may be as much as 1/3 to 2/5 of the total light received from the sky and sun together when the sun is visible. When the sky is completely overcast with white clouds the light received from the clouds may equal that received from the sun. Light from a clear blue sky does not vary greatly in intensity during a considerable portion of the day.

IV. Daylight Factor: The Definition

A more comprehensive concept of daylight illumination in an interior can be expressed either in absolute terms such as an illumination value in lumens per square feet or as a percentage of the total daylight illumination available from the whole unobstructed sky, that is, a DAYLIGHT FACTOR, It gives a more useful measure of the interior lighting in all regions; dry tropical, cloudy and humid climates and regions of high latitudes, where latitude, climate, and industrial haze result in widely variable daylight.

The Daylight Factor is defined as " The ratio of the daylight illumination at a point on a given plane due to the light received directly or indirectly from a sky with an assumed or a known luminance distribution, to the illumination on a horizontal plane due to an obstructed hemisphere of the sky (excluding sunlight), expressed as a percentage. "

To determine the daylight factor for a room being used for a specific purpose, it is only necessary to decide on the minimum exterior illumination level and the required internal illumination level.

V. DAYLIGHT CONTROL IN THE ROOMS

Daylight is a universal, freely distributed element which is a constituent of most buildings. For all structures that have windows, daylight should be considered in relation to the function and planning of the building.

Each type of building has its own particular day lighting problem, and the intensity of daylight used should be adequate for functional needs.

The factors upon which good natural lighting depends are as:

1. The amount of daylight available at the site of a building,
2. The size and position of the openings which admit daylight into a building,
3. The use of appropriate transparent or translucent material for filling these openings to admit and distribute daylight and to satisfy such requirements as insulation from weather, heat, and sound.

DAYLIGHT AND VISUAL COMFORT

Before the discussion of the visual comfort, we should understand certain basic laws of psychophysics which relate the "sensations" which human beings experience and the physical causes of these sensations --- the stimuli. For example, we can determine the relationship between the amount of light provided in a room and the sensation of brightness.

The Sensation of Comfort in a Living Room

Stimulus - Size of bulb	Sensation of light	Sensation of comfort
40W	Very dim	Uncomfortable (too dim)
60W	Dim	Uncomfortable (too dim)
100W	Bright	Not uncomfortable
150W	Bright	Not uncomfortable
200W	Very bright	Uncomfortable (too bright)
300W	Extremely bright	Uncomfortable (too bright)

Similarly, we must consider the “visual adaptation”- a form of physiological adaptation, that can alter our sensitivity to amount of 1ight, and also our sensitivity to change or contrast, If we are out of doors on a bright day, and look through an open door into a room, the interior of the room looks dark, and we cannot distinguish details of objects in the room. This effect arises, because we are adapted to the brighter conditions out of doors, If we come into the room and we have to give our eyes time to re-adapt to the darker room interior, then after a short time interval things will look quite bright and detail will be easily distinguished. Based on this effect, it can be suggested that the visual comfort in a room is related to the brightness of outdoors and other connecting rooms.

We architects must learn about psychophysics to distinguish between the two situations known as the" linked situation ", where the primary and secondary sensations both vary directly with the stimulus, and the" unlinked situation ", where the secondary sensation does not vary as the primary sensation with the stimulus.

COLOR

Bright colors as well as bright lights attract attention. In modern architecture color is quite important, and widely used in building design and interior decoration. Color design is very complex; therefore we will only consider the color relation with light and how it may affect the visual comfort, color design of the interior, and the effects of light and color interactions on the design.

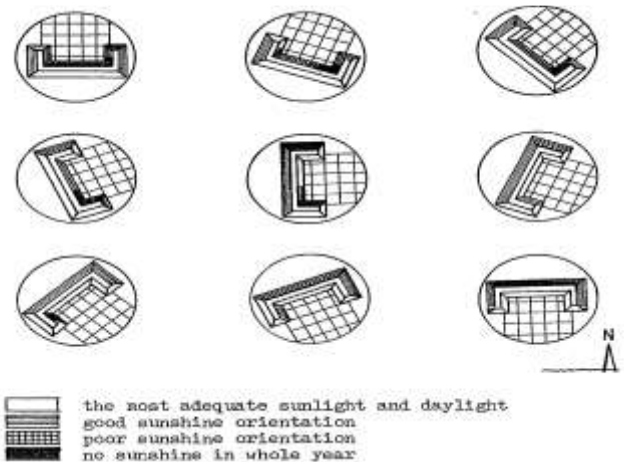
Firstly, color design affects the visual adaptation in a room, For example, the sky may be very glaring if the rooms are dark in color. By reprinting the walls off-White or some light color, the glare will be greatly reduced.

Secondly, the light can affect the color design in the interior. Usually, you add as much color as you wish in the rooms facing the north, while the walls of a room that looks to the south may be almost colorless. A dark ceiling is restful, unless the room is a low one. The ceiling should not be the blank white as is so generally and complaisantly accepted. Even where the walls are white, a tinted ceiling, unless the room is a low one, tempers any tendency to glare and distributes an opalescent bloom on the walls themselves.

ORIENTATION OF BUILDINGS AND DAYLIGHT

Building orientation is an ancient problem, in the last hundred years many new developments have occurred as the direct result of specific scientific investigations. Many years ago, people knew enough to design their houses facing towards the south or south-east and west, or to use the skylight in order to get more sunlight. But nowadays, with the aid of science, we can use different observations and the result of experiments or calculations to find out the most suitable orientation for different kinds of buildings.

The developments in studies of building orientation of the past forty years have shown the topic to be so important that it is now considered in computing heat loading factors for air-



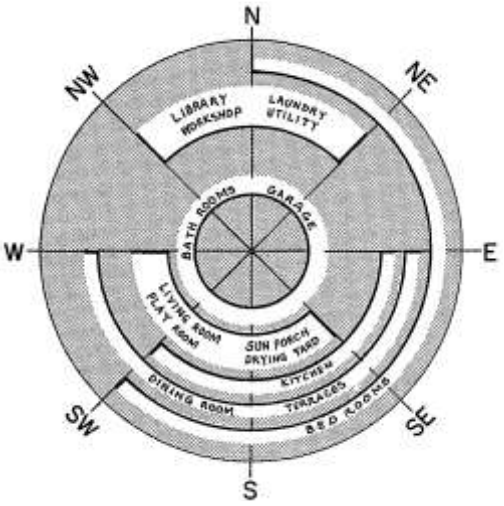
The conditions of sunshine of a U-shape building which faces to the, various directions

conditioning, since the amount of solar radiation entering a building through its walls and windows is so difficult to exclude from the building and varies so greatly, depending on the direction the wall or window faces.

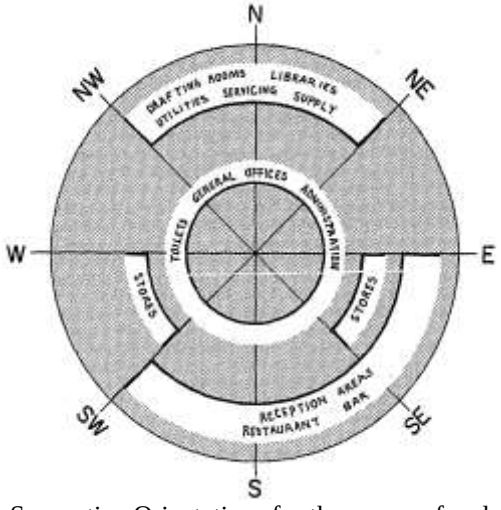
The amount of sunlight received by a building depends on both the building's shape and orientation. The several simple diagrams of building shapes exploit sunlight to the maximum when they are properly oriented.

The most successful residence designs, from the point of view of building orientation, make sunlight available in a kitchen in the morning, especially in winter, and provide sunlight in the living room in the afternoon,

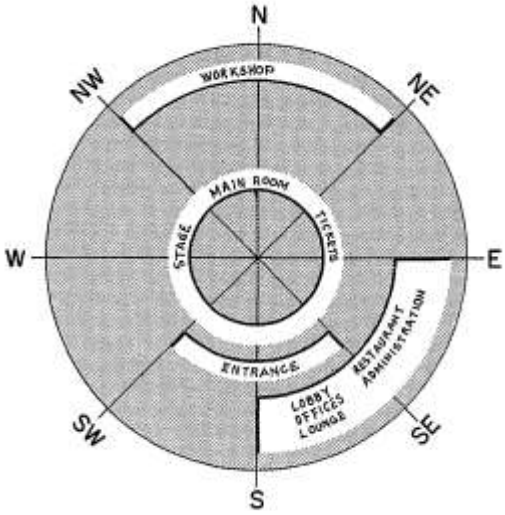
Owing to the different climates, various sites, and variations of individual tastes or requirements, it is difficult to present a standard of orientation for natural lighting, But diagrams of appropriate orientations for various rooms in different building types are proposed in the following figures;



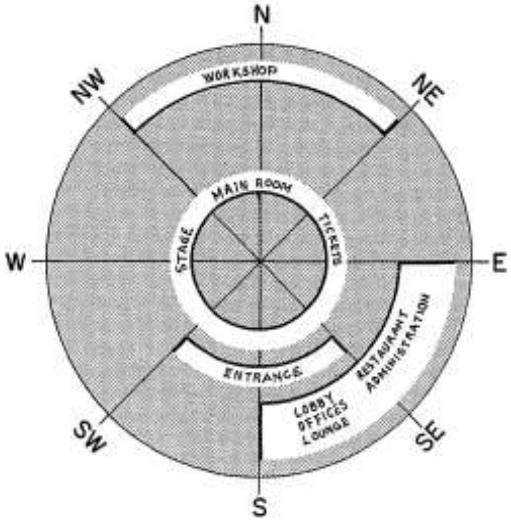
Suggestive Orientations for the rooms of Residence



Suggestive Orientations for the rooms of and offices and stores



Suggestive Orientations for the public buildings

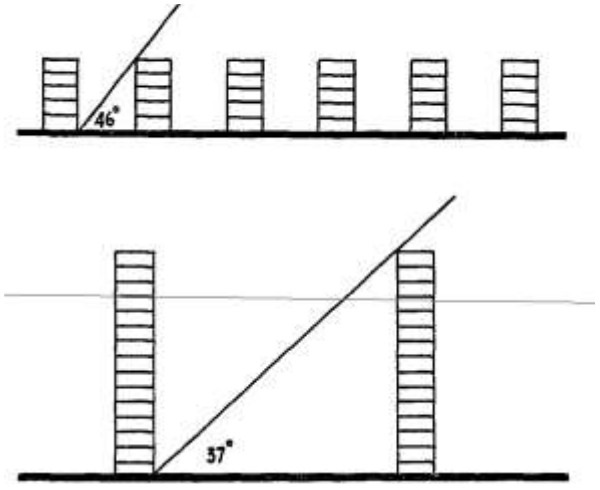


Suggestive Orientations for the public buildings

INFLUENCE OF DAYLIGHT ON CIVIC PLANNING

Planning for daylight demands that the effects of neighboring obstructions be considered. In the large cities, where the erection of lofty, tower-like structures is contemplated for economic and administrative reasons and considerations of amenity, it is desirable to explain that buildings of this kind need not necessarily entail loss of daylight to the extent that has caused such deep concern in the cities.

But, in point of fact, there are many cases where high buildings have destroyed the rental values of neighboring buildings, only to have had in some cases their own rental values destroyed by other buildings. There are limited areas that seem in the process of being smothered by their own



Mutual shading through parallel buildings. Tall blocks ensure better penetration of daylight.

growth; light and air are being shut off and the streets are becoming entirely inadequate.

At the present time, the standard of day lighting found on the lower floors of buildings in urban districts is governed largely by building codes and bye-laws which limit the heights of buildings, angles of setback, and so forth.

By limiting the extent of the loss of frontal light caused by a high building or skyscraper, on the opposite side of the street, and by making it possible for compensating lateral rays from a low altitude to have free access to the interiors of the opposite buildings, the quantity of illumination received would be very much higher than that obtainable without low lateral light. Everything depends upon the width of the frontage of the high building and the extent to which lateral light can be made available.

The extent to which the light available would penetrate the interiors would, in fact, depend to some extent upon the height and width of the window openings and the widths of the intervening piers. For buildings rising to an altitude of 20 stories above the street, scientific investigation by means of daylight plans would prove that desirable standards of illumination cannot be received without lateral light, in the case of 100 feet and 60 feet streets.

As in all town planning schemes, some land would have to be depreciated, in order to produce conditions that would permit selected sites to be fully developed, with some degree of amenity. When we rebuild our town and introduce the contemplated high buildings, as presumably we must, we shall have to remember the importance of lateral light and insist upon its reservation to the greatest practical extent and, wherever possible, arrange for low lateral buildings to subtend even smaller angle than45 degrees. We must also contract the width of the high buildings as far as practicable and recess the external angles, when this would not detrimentally affect the plan and aesthetic design.

VI. CONCLUSION

The theory of day lighting in architectural design represents the application of physics to the problem of obtaining the best effect for utilizing natural lighting and, providing the most suitable environment with adequate and comfortable illumination and healthy living conditions. The quality of both the exterior and interior of building depends on the availability of natural light. The planning, forms, elevations, orientation and the window design affect the daylight penetration and illumination; the interior and exterior forms and the selection of color in decorations are dependent on the existing natural lighting conditions.

Daylight design in architecture requires a consideration of the quantity and quality of natural light, the problem being to provide adequate wanted light to the interior and to exclude unwanted light from the room. The quantity of natural light is determined by the size and positioning of the fenestration. Numerical estimate can be obtained from many computational techniques. The quality of daylight in architectural design is important because good lighting can provide a pleasant and comfortable working environment and enjoyable living to human beings. Eliminating glare and providing diffused light are the two most important objectives in providing high qua lit y day lighting.

It is difficult to provide criteria for day lighting in all building designs but, as a general approach to the effect of daylight design in architecture, the following points must be considered essential:

1. Provide as much indoor daylight as possible; however ensure that it is glare-free;
2. Avoid strong sunlight sources which would become sources of glare & discomfort;
3. Control glare by using the proper type of glass, curtains, blinds or louvers and interior color rendering;
4. Ensure that the main visual task can be distinguished from its surroundings by being brighter, or more contrasting, or more colorful, or all of three;
5. Provide the suitable orientation capable of improving the daylight conditions of a building;
6. Consider the design and purposes of the building and evaluate the criteria of good and effective lighting relative to the total environment.

Daylight in building design must depend upon the main purpose of the individual building as well as considerations of local climate and the specialty of visual work.

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