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Orientation of Building

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I. INTRODUCTION

The need to conserve essential building materials has drawn attention again to the importance of designing buildings to get the greatest possible functional comfort. The mechanical devices can create comfort conditions inside buildings but the cost is a major consideration. Natural agencies like the wind & the sun are utilized to the best advantage in a properly oriented building. In such buildings the operational cost of mechanical devices is reduced considerably. It explains important aspect of orientation of buildings.

II. FACTORS AFFECTION ORIENTATION

Orientation point of view, solar heat gain is the primary consideration but other factors like the direction of prevalent breeze, the direction of rain fall & the site conditions cannot be overlooked in the final choice of the proper orientation. Before going into the several aspects of design & orientation it is necessary to decide whether for the place in question mark, summer or winter comfort needs more attention. The best compromise is arrived at by using the solar & climatic data available for the place. For places where summer causes greater thermal discomfort, the building as a whole should be oriented to intercept minimum solar radiation in summer & vice-versa.

III. BUILDING SHADING DEVICES

Although, it is not possible to increase the incident solar radiation on a surface during winter, it is always possible to reduce it is summer by use of shading devices like vegetation, overhangs, louvers, verandahs or by choosing optimum orientation. Because of the higher air temperatures in the afternoon, western walls need special consideration. From knowledge of the solar altitudes & azimuths it is possible to design effective shading devices & building shapes which provide maximum self shading on summer days for rooms likely to be occupied at those hours when the solar heat needs to be most reduced.

IV. POSSIBLE PRINCIPAL FACADES

The different facades of a building have some inherent characteristics from solar point of view which can be utilized with advantage by a proper understanding thereof. For example, a south façade has the advantage of receiving much larger solar radiations during winterthan that during summer. Even for opening on the south façade, a small overhang can cut off direct solar penetration during summer & allow it during winter. It obviously is the most advantageous aspect, not available on any other façade.

For most parts of the country North of 23 degree N latitude, the sun does not shine directly on the north façade, except during early morning or late afternoon in summer. Even on other latitudes south of 23 degree N, the sunlight at mid-day during summer, in addition, comes from a very high altitude sun. It is much easier to effectively cut off the early morning & late afternoon sun on this façade by vertical louvers on either side of the opening & the mid–day sun south of 23 degree N, by a small overhang on top. A larger south façade necessarily implies an equal north façade & both together can be utilized advantageously throughout the year.

The eastern & western facades receive nearly equal amounts of daily solar radiations throughout the year. The only difference is that when the sun shines on the eastern façade, the building is comparatively cool after a cool night & the air temperature is low also. So the solar heat through this façade is not so pronounced indoor unless, of course, the eastern facade is all un-shaded glass area. On the other hand, the western façade encounters a different situatio. Due to the higher air temperature in the afternoon, the heat flow indoors is further augmented by the incidence of solar radiations on the western façade. Even opaque window shutter if not shaded by suitable louvers outside transmit a large amount of heat inside. This, heat can be minimized by reducing the western façade or by providing thermal insulation on the exterior or by shading this façade by verandahs, creepers & plants etc. Glass areas on the western façade are a definite disadvantage, unless properly shaded. Provision of effective shading devices on the western & south-western facades is also expensive since only a combination of both vertical & horizontal louvers, to form an egg-crate type, can be purposeful.

V. LOCATION OF ROOM

The judicious location of rooms inside a building is also imperative with the choice of proper orientation. Much of the discomfort of solar heat inside rooms can be offset by favorable breeze during the periods when these are likely to be occupied,& selective ventilation throughout the year results in greater comfort. In addition to the correct location of rooms inside a building, it is necessary to locate suitable types of windows at proper points in the rooms to ensure desirable wind movement indoors & requisite ventilation. It has been found by experiments that in deviating by 60 degree from the optimum wind direction, the wind velocity inside a room is reduce only by 25-30 per cent. Therefore, slight departure from the optimum wind direction makes little difference to wind-flow insides. Moreover, sun-breakers, if provided on the windows may also serve as good wind scoops.

VI. SHAPES OF THE BUILDING

For practical evaluation of correct orientation, for any specific building it is necessary to know its shape, the area of various external surfaces & the location of shading devices & verandah. For a hot climate the verandah & the shading devices are used to intercept the direct sunshine on walls at certain hours of the day; one projecting portion of the building may shade another & hence reduce the heat intake of the shaded surface. Therefore, knowledge of the surfaces likely to be shaded during particular hour of the day is also important. In the building, therefore, it is possible to locate the day-time living rooms at places where other portions of the building provide shade during summer afternoons. Alternatively, such exposed surfaces can be shaded by overhangs or verandahs or even insulated against heat entry.

VII. AIR CONDITIONED BUILDINGS

For buildings intended to be air-conditioned, orientation from solar point of view is the only consideration. Sensible heat gain through building fabrics due to incident solar radiation, form a sizable proportion of the total load to be handled by air-conditioning equipment & in a properly oriented building, installation & running costs are considerably reduced.

VIII. HOW TO WORK OUT

The best orientation from a solar point of view requires that the building as a whole receive the maximum solar radiation in winter & the minimum in summer. Where site conditions preclude such a choice, the individual day-time living rooms should me made to confirm to the above requirements. For practical evaluation, it is necessary to know the duration of sunshine& honesty solar-intensity on the various external surfaces on representative days of the seasons. (If available, hourly air-temperature on those days will yield a more accurate estimate of the total heat intake by the building during the day). The total heat intake is calculated for all possible orientations of the building for the extreme days of summer & winter. From these values, it is easy to read the proper orientation on the basis of the above criterion.

A. Exampl

As an example, a simple building with flat roof, 10 m.X20 m. & 4.0 m. high, is dealt with below. For the sake of generalization, no shading device or verandah is taken. As the roof is horizontal, it will receive the same solar heart in any orientation. The areas of the vertical surfaces are 4m.X10m. = A (say) & 4m.X 20m. = 2A. The total direct diurnal solar loads per unit area on different vertical surfaces are given in (Table – 1) for two days in the year, i.e. 16th May & 22ndDecember, representative of summer & winter, for latitudes corresponding to some important cities all over the country Since the external wall surfaces are not in shade expect when the sun is not shining on them the total solar load in a day on a surface can be obtained by multiplying the total load per unit area per day (Table -1) by the area of the surface. For four principal orientations of the building, the total solar load on the building is worked out in (Table – 2). It can be seen that for the above type of building orientation 3 (longer surfaces facing North & South) is appropriate as it affords maximum solar heat grain in winter & minimum in summer. This is true for all places in India from a solar heat gain point of view. The advantages of this orientation will be more pronounced as the length to breadthratio of the building increases. It will also be noted that in higher latitudes the relative merit of this orientation is more.

It is also seen that solar heat on the building is the same for orientation 2 &4.But if the site conditions require a choice between these two, at places north of latitude. 23 degree N,orientation 2 should be preferred & orientation 4 at Southern places. This is so because the total solar load per unit area in summer on the north-western wall decreases with the increase in latitude & that on the south-western increases. Therefore, it would be advantageous to face only the smaller surface of the building to greater solar load in the summer afternoon when the air temperature also is higher.

B. The method of calculating solar load on vertical surfaces of different orientations from the climatologically & solar data.

The solar energy above the earth's atmosphere is constant & the amount incident on unit area normal to sun's rays is called solar constant (2gm.Cal/cm.square).This energy in reaching the earth's surface is depleted in the atmosphere due to scattering by air molecules water vapor, dust particles etc.,&ozone. The depletion varies with varying atmosphere conditions.

Another important cause of depletion is the length of path traversed by the sun's rays through the atmosphere. This path is shortest when the sun is at the zenith & as the altitude of sun decreases, the length of path in the atmosphere increases, (Fig. 1) shows the computed incident solar energy/hr. on unit surface area normal to the rays under standard atmospheric conditions for different altitudes of the sun.

In order to calculate the solar energy on any surface, other than normal to the rays, one should know the altitude of the sun at that time &(Fig.1).to find the corresponding value of direct solar radiation (In). The solar radiation incident on any surface (Is) can then be computed with the help of the following relationship:

Is = In (Sin β Sinϕ +Cos β Cosα Cos ϕ)

Where α is the wall solar azimuth angle, β is the solar altitude &ϕ is the angle of tilt of the surface from the vertical. (ϕ = 0 for vertical & 90 degree for horizontal surface). (Fig.2).

IX. CONCLUSION

At hill stations, the winter season causes more discomfort & so merits greater consideration. The sole criterion for optimum orientation, therefore, is to obtain maximum solar energy on the building in winter.

It is, therefore, advantageous at places where summer causes greater discomfort, to locate the daytime living rooms in the south-eastern part of the building to take advantage of the low altitude sun in winter& at the same time to avoid summer sun. Another advantage of such rooms would be that the western wall would be covered by other rooms or verandahs as the case are.

REFERENCES

[1] The standard atmospheric conditions assumed for this computation are: cloud free, 300 dust particles per c.c., 15 mm of perceptible water, 2.5 mm of ozone, at sea level.

[2] These are given for every hour at different latitudes in 'Climatologically & Solar Data for India'.

Table – 1 Daily Total Direct Solar Radiation on Vertical Surfaces in Gm. Cal./Sq. Cm./Day for two Representative Days

	8°N		13°N		19°N		23°N		29°N	
	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22
North ...	187	—	140	—	83	—	64	—	46	—
North East ...	228	35	214	27	194	20	188	15	180	9
East ...	225	187	232	173	240	157	247	146	253	126
South East ...	100	291	115	294	141	295	158	297	188	281
South ...	—	358	—	377	—	393	18	398	64	390
South West ...	100	291	115	294	141	295	158	297	188	281
West ...	225	187	232	173	240	157	247	146	253	126
North West ...	228	35	214	27	194	20	188	15	180	9

Fig.1. Direct Solar Intensities Normal to Sun at Sea Level for Standard Conditions (Computed)

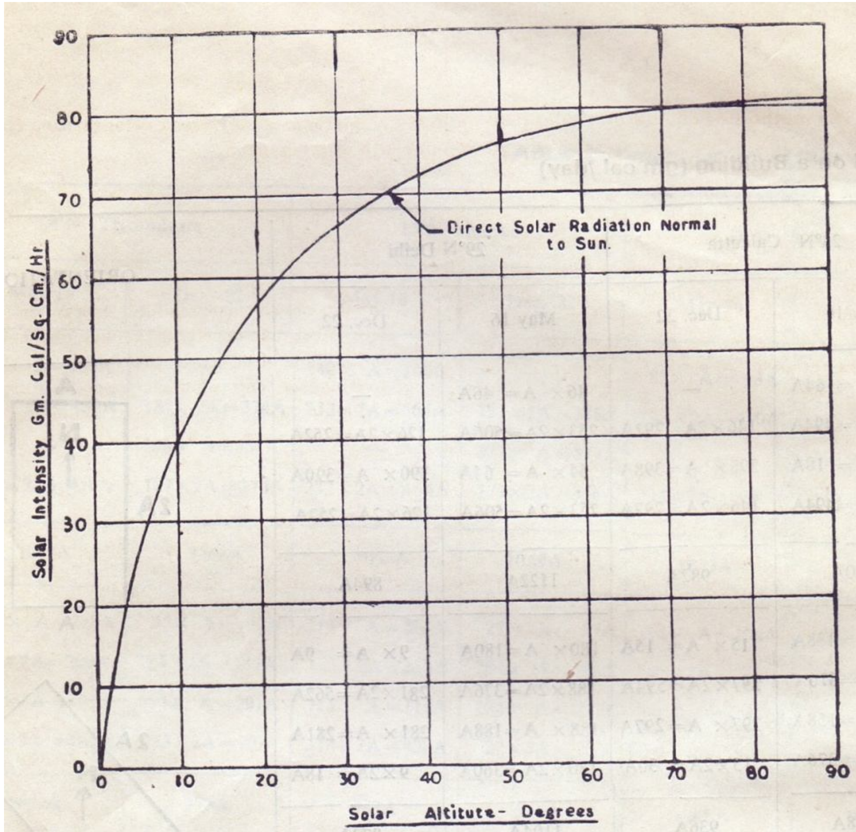
Direct Solar Radiation Normal to Sun.
Solar Intensity Gm. Cal/Sq. Cm./Hr.
Solar Altitute- Degrees
0
10
20
30
40
50
60
70
80
90

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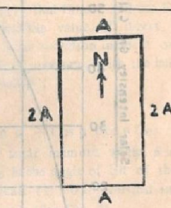
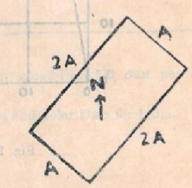
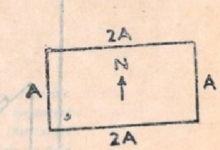
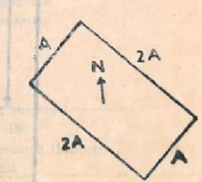
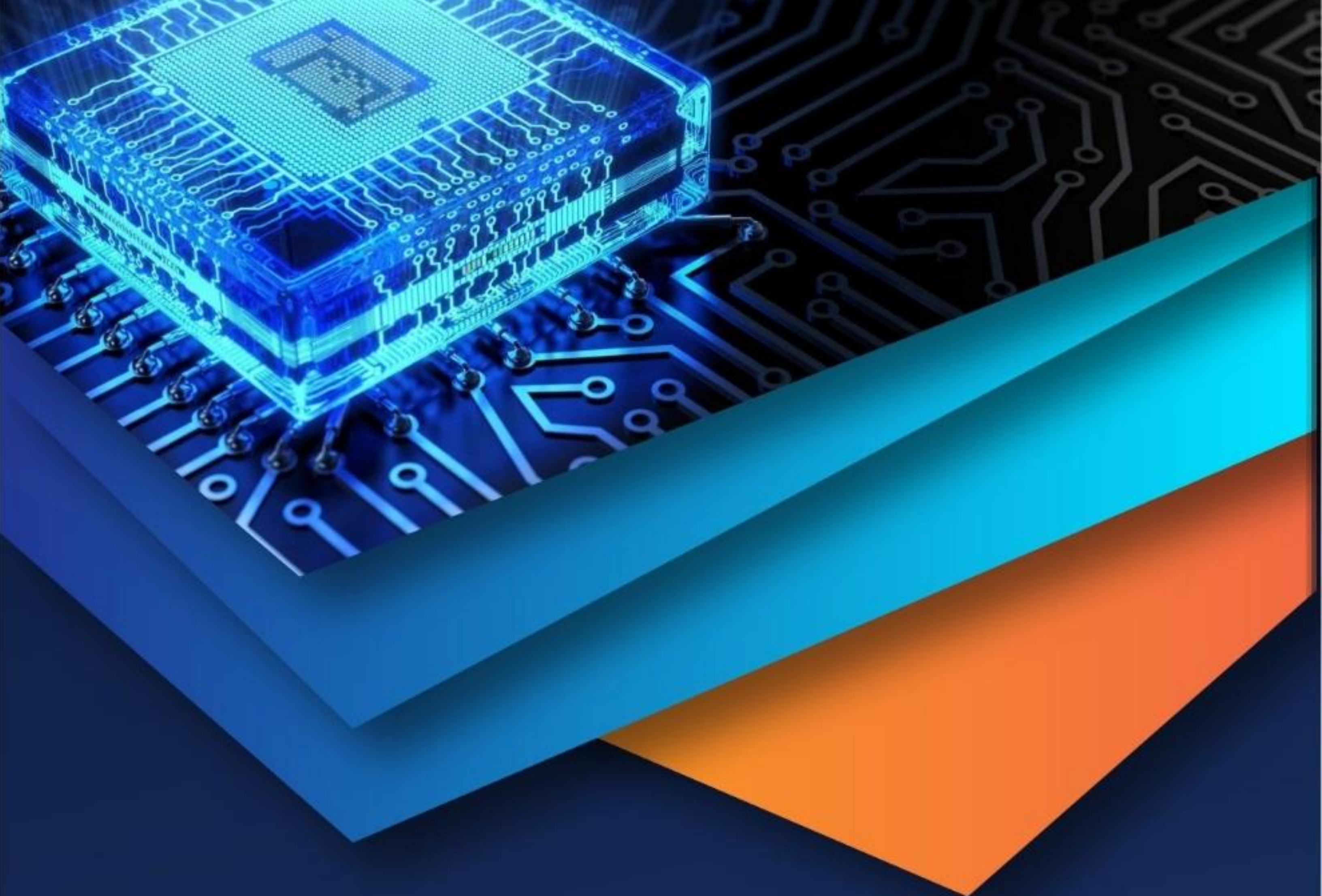
TABLE-2 Computation of Solar Radiation Load on a Building (gm cal./day)

	8°N Trivandrum		13°N Madras		19°N Bombay		23°N Calcutta		29°N Delhi		ORIENTATION
	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22	May 16	Dec. 22	
1. North	187× A=187A	—	140× A=140A	—	83× A= 83A	—	64× A= 64A	—	46× A= 46A	—	
East	225×2A=450A	187×2A=374A	232×2A=464A	173×2A=346A	240×2A=480A	157×2A=314A	247×2A=494A	146×2A=292A	253×2A=506A	126×2A=252A	
South	—	358× A=358A	—	377× A=377A	—	393× A=393A	18× A= 18A	398× A=398A	64× A= 64A	390× A=390A	
West	225×2A=450A	187×2A=374A	232×2A=464A	173×2A=346A	240×2A=480A	157×2A=314A	247×2A=494A	146×2A=292A	253×2A=506A	126×2A=252A	
Total	1087A	1106A	1068A	1069A	1043A	1021A	1070A	982A	1122A	894A	
2. N E	228× A=228A	35× A= 35A	214× A=214A	27× A= 27A	194× A=194A	20× A= 20A	188× A=188A	15× A= 15A	180× A=180A	9× A= 9A	
S E	100×2A=200A	291×2A=582A	115×2A=230A	294×2A=588A	141×2A=282A	295×2A=590A	158×2A=316A	297×2A=594A	188×2A=376A	281×2A=562A	
S W	100× A=100A	291× A=291A	115× A=115A	294× A=294A	141× A=141A	295× A=295A	158× A=158A	297× A=297A	188× A=188A	281× A=281A	
N W	228×2A=456A	35×2A=70A	214×2A=428A	27×2A= 54A	194×2A=388A	20×2A= 40A	188×2A=376A	15×2A= 30A	180×2A=360A	9×2A= 18A	
Total	984A	978A	987A	963A	1005A	945A	1038A	936A	1104A	870A	
3. North	187×2A=374A	—	140×2A=280A	—	83×2A=166A	—	64×2A=128A	—	46×2A= 92A	—	
East	225× A=225A	187× A=187A	232× A=232A	173× A=173A	240× A=240A	157× A=157A	247× A=247A	146× A=146A	253× A=253A	126× A=126A	
South	—	358×2A=716A	—	377×2A=754A	—	393×2A=786A	18×2A= 36A	398×2A=796A	64×2A=128A	390×2A=780A	
West	225× A=225A	187× A=187A	232× A=232A	173× A=173A	240× A=240A	157× A=157A	247× A=247A	146× A=146A	253× A=253A	126× A=126A	
Total	624A	1090A	744A	1100A	646A	1100A	658A	1088A	726A	1032A	
4. N E	228×2A=456A	35×2A= 70A	214×2A=428A	27×2A= 54A	194×2A=388A	20×2A= 40A	188×2A=376A	15×2A= 30A	180×2A=360A	9×2A= 18A	
S E	100× A=100A	291× A=291A	115× A=115A	294× A=294A	141× A=141A	295× A=295A	158× A=158A	297× A=297A	188× A=188A	281× A=281A	
S W	100×2A=200A	291×2A=582A	115×2A=230A	294×2A=588A	141×2A=282A	295×2A=590A	158×2A=316A	227×2A=594A	188×2A=376A	281×2A=562A	
N W	228× A=228A	35× A= 35A	214× A=214A	27× A= 27A	194× A=194A	20× A= 20A	188× A=188A	15× A= 15A	180× A=180A	9× A= 9A	
Total	984A	978A	987A	963A	1005A	945A	1038A	936A	1104A	870A	



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