BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

ORIENTATION OF BUILDINGS*

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. Mechanical devices can create comfort conditions inside buildings but the cost is a major consideration. Natural agencies like the wind and the sun are utilised to the best advantage in a properly oriented building. In such buildings the operational cost of mechanical devices is reduced considerably. This digest describes some important aspects of orientation of buildings.

Factors Affecting Orientation

From the point of view of orientation, Solar heat gain is the primary consideration but other factors like the direction of prevalent breeze, the direction of rain-fall and the site conditions cannot be overlooked in the final choice of the proper orientation. Before going into the several aspects of design and orientation it is necessary to decide whether for the place in question, summer or winter comfort needs more attention. The best compromise is arrived at by using the solar and 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 and vice-versa.

Shading

Although it is not possible to increase the incident solar radiation on a surface during winter it is always possible to reduce it in summer by the 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 a knowledge of the solar altitudes and azimuths it is possible to design effective shading devices and 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.

The Four Principal Facades

The different facades of a building have some inherent characteristics from solar point of view which can be utilised with advantage by a proper understanding thereof. For instance, a south facade has the advantage of receiving much larger solar radiation during winter than that during summer. Even for openings on the south facade, a small overhang can cut off direct solar penetration during summer and allow it during winter. This obviously, is the most advantageous aspect, not available on any other facade.

For most parts of the country north of 23°N latitude, the sun does not shine directly on the north facade, except during early mornings or late afternoons in summer. Even on other latitudes south of 23°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 and late afternoon sun on this facade by vertical louvers on either side of the opening and the mid-day sun south of 23°N, by a small overhang on top. A larger south facade necessarily implies an equal north facade and both together can be utilised advantageously throughout the year.

The eastern and western facades receive nearly equal amounts of daily solar radiation throughout the year. The only difference is that when the sun shines on the eastern facade, the building is comparatively cool after a cool night and the air temperature is also low. So the solar heat through this facade is not so pronounced indoors unless, of course, the eastern facade is all unshaded glass area. On the otherhand, western facade encounters a different situation. Due to the higher air temperature in the afternoon, the heat flow indoors is further augmented by the incidence of solar radiation on the western facade. Even opaque window shutter if not shaded by suitable louvers outside, transmit a large amount of solar heat indoors. This heat can be minimised by reducing the western facade or by providing thermal insulation on the

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**Climatological & Solar data for India (Sarita Prakashan, Meerut-C.B.R.I. Publication)

exterior or by shading this facade by verandahs, creepers, plants etc. Glass areas on the western fecade are a definite disadvantage, unless properly shaded. Provision of effective shading devices on the western and south-western facades is also expensive since only a combination of both vertical and horizontal louvers, to form an egg-crate type, can be purposeful.

Room Location

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 favourable breeze during the periods when these are likely to be occupied, and 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 and the requisite ventilation. It has been found by experiments that in deviating by 60° from the optimum wind direction, the wind velocity inside a room is reduced only by 25-30%. Therefore, slight departure from the optimum wind direction makes little difference to wind-flow indoors. Moreover, sun-breakers, if provided on the windows may also serve as good wind scoops.

Building Shapes

For the practical evaluation of correct orientation, for any specific building it is necessary to know its shape, the areas of various external surfaces and the location of shading devices and verandahs. For a hot climate the verandahs and the shading devices are used to intercept the direct sun-shine on walls at certain hours of the day; one projecting portion of the building may shade another and hence reduce the heat intake of the shaded surface. Therefore, a knowledge of the surfaces likely to be shaded during particular hours of the day is also important.* In a 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. The shadowgraph, designed and fabricated at this Institute is very useful to find the duration and extent of shade on the respective walls of various types of buildings for any time of the year.

Air-conditioned Buildings

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

How to work out

The best orientation from a solar point of view requires that the building as a whole should receive the maximum solar radiation in winter and the minimum in summer. Where site conditions preclude such a choice, the individual day-time living rooms should be made to conform to the above requirements. For practical evaluation, it is necessary to know the duration of sunshine and hourly 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 in-take 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 and winter. From these values, it is easy to read the proper orientation on the basis of the above criterion.

Example

As an example, a simple building with flat roof, 10m×20m and 4 m high is dealt with below. For the sake of generalisation, no shading device or verandah is taken. As the roof is horizontal, it will receive the same solar heat in any orientation**. The areas of the vertical surfaces are 4m×10 m=A (say) and 4m×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 and 22nd December, representative of summer and winter, for latitudes corresponding to some important cities all over the country.

Since the external wall surfaces are not in shade except 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 and South) is appropriate as it affords maximum solar heat gain in winter and minimum in summer. This is true for all places in India from a solar

*In such circumstances detailed analysis of solar heat intake on hourly basis is necessary.
**It will not be so for a slanting roof.

heat gain point of view. The advantage of this orientation will be more pronounced as the length to breadth ratio 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 the total solar heat on the building is the same for orientations 2 and 4. But if the site conditions require a choice between these two, at places north of latitude. 23°N, orientation 2 should be preferred and 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 and 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 afternoons when the air temperature also is higher.

At hill stations, the winter season causes more discomfort and 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 day time living rooms in the south-eastern part of the building to take advantage of the low altitude sun in winter and 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 be.

TABLE I

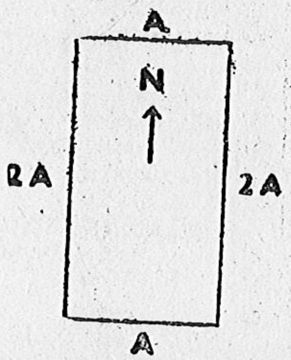
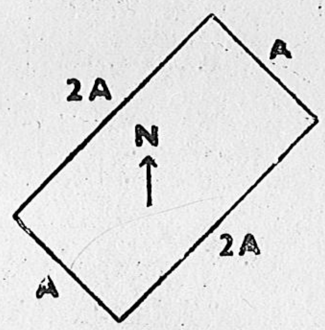
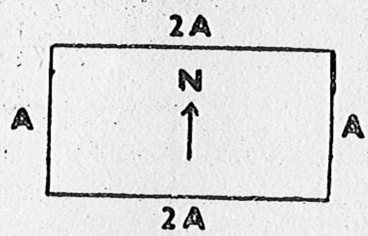
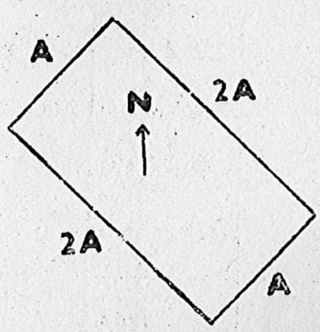
Daily Total Dircct Solar Radiation on Vertical surfaces in Gm. Cal./Sq. Cm./Day for two representative days.

	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

TABLE 2–Computation of Solar Radi

	8°N Trivandrum		13°N Madras		19°N Bombay	
	May 16	Dec. 22	May 16	Dec. 22	May 16	De
1. North	187×A=187A	—	140× A=140A	—	83× A= 83A	—
East	225×2A=450A	187×2A=374A	232×2A=464A	173×2A=346A	240×2A=480A	157×2
South	—	358× A=358A	—	377× A=377A	—	393×
West	225×2A=450A	187×2A=374A	232×2A=464A	173×2A=346A	240×2A=480A	157×2
Total	1087A	1106A	1068A	1069A	1043A	
2. N E	228× A=228A	35× A= 35A	214× A=214A	27× A= 27A	194× A=194A	20×
S E	100×2A=200A	291×2A=582A	115×2A=230A	294×2A=588A	141×2A=282A	295×
S W	100× A=100A	291× A=291A	115× A=115A	294× A=294A	141× A=141A	295×
N W	228×2A=456A	35×2A= 70A	214×2A=428A	27×2A= 54A	194×2A=388A	20×
Total	984A	978A	987A	963A	1005A	
3. North	187×2A=374A	—	140×2A=280A	—	83×2A=166A	
East	225× A=225A	187× A=187A	232× A=232A	173× A=173A	240× A=240A	157
South	—	358×2A=716A	—	377×2A=754A	—	393
West	225× A=225A	187× A=187A	232× A=232A	173× A=173A	240× A=240A	157
Total	824A	1090A	744A	1100A	646A	
4. N E	228×2A=456A	35×2A= 70A	214×2A=428A	27×2A= 54A	194×2A=388A	20
S E	100× A=100A	291× A=291A	115× A=115A	294× A=294A	141× A=141A	29
S W	100×2A=200A	291×2A=582A	115×2A=230A	294×2A=588A	141×2A=282A	29
N W	228× A=228A	35× A= 35A	214× A=214A	27× A= 27A	194× A=194A	2
Total	984A	978A	987A	963A	1005A	

Load on a Building (gm cal./day)

23°N Calcutta		29°N Delhi		ORIENTATION
May 16	Dec. 22	May 16	Dec. 22	
64× A= 64A 247×2A=494A 18× A= 18A 247×2A=494A	— 146×2A=292A 398× A=398A 146×2A=292A	46× A= 46A 253×2A=506A 64× A= 64A 253×2A=506A	— 126×2A=252A 390× A=390A 126×2A=252A	
1070A	982A	1122A	894A	
188× A=188A 158×2A=316A 158× A=158A 188×2A=376A	15× A= 15A 297×2A=594A 297× A=297A 15×2A= 30A	180× A=180A 188×2A=376A 188× A=188A 180×2A=360A	9× A= 9A 281×2A=562A 281× A=281A 9×2A= 18A	
1038A	936A	1104A	870A	
64×2A=128A 47× A=247A 18×2A= 36A 47× A=247A	— 146× A=146A 398×2A=796A 146× A=146A	46×2A= 92A 253× A=253A 64×2A=128A 253× A=253A	— 126× A=126A 390×2A=780A 126× A=126A	
658A	1088A	726A	1032A	
8×2A=376A 8× A=158A ×2A=316A × A=188A	15×2A= 30A 297× A=297A 227×2A=594A 15× A= 15A	180×2A=360A 188× A=188A 188×2A=376A 180× A=180A	9×2A= 18A 281× A=281A 281×2A=562A 9× A= 9A	
1038A	936A	1104A	870A	

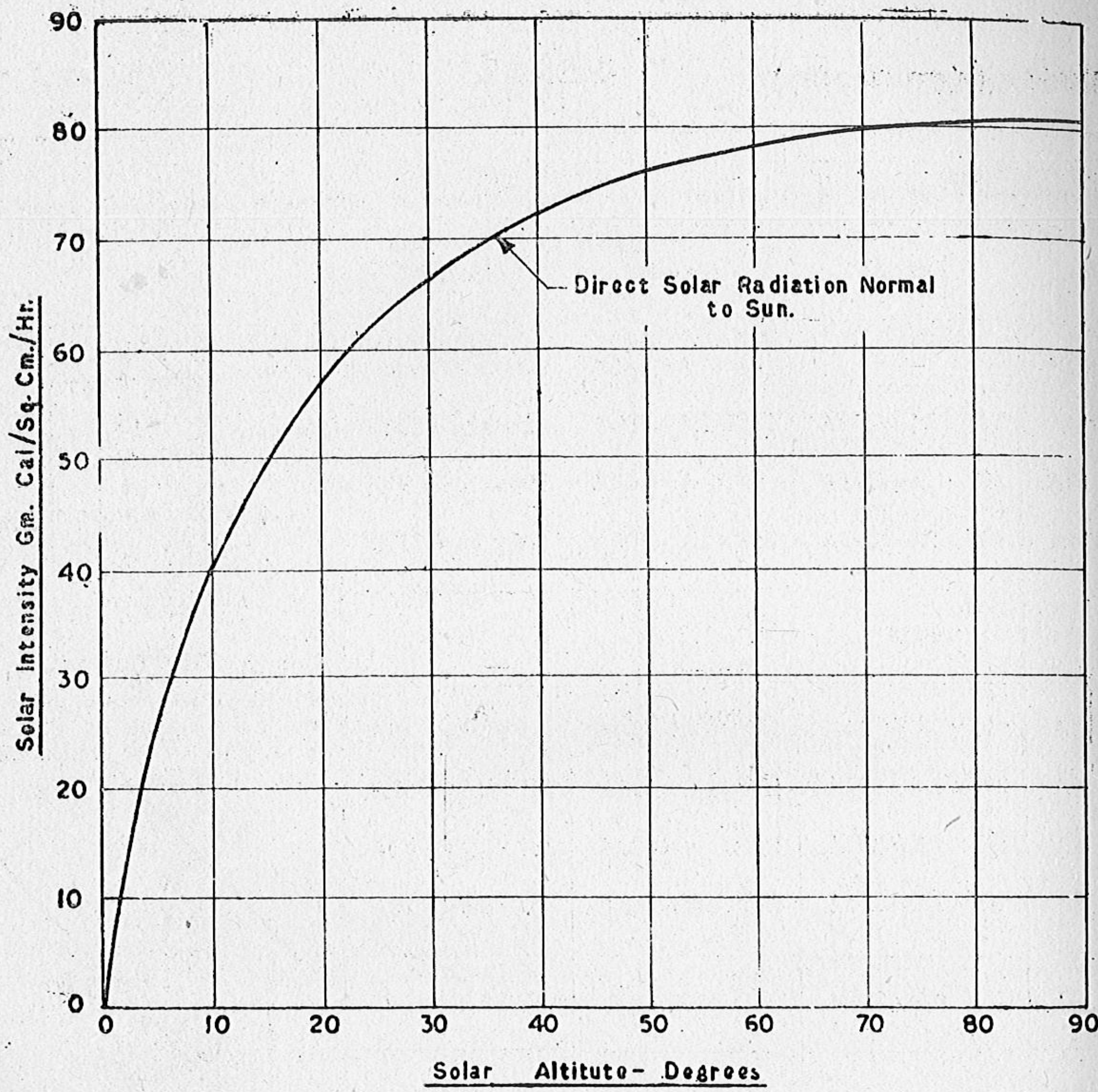
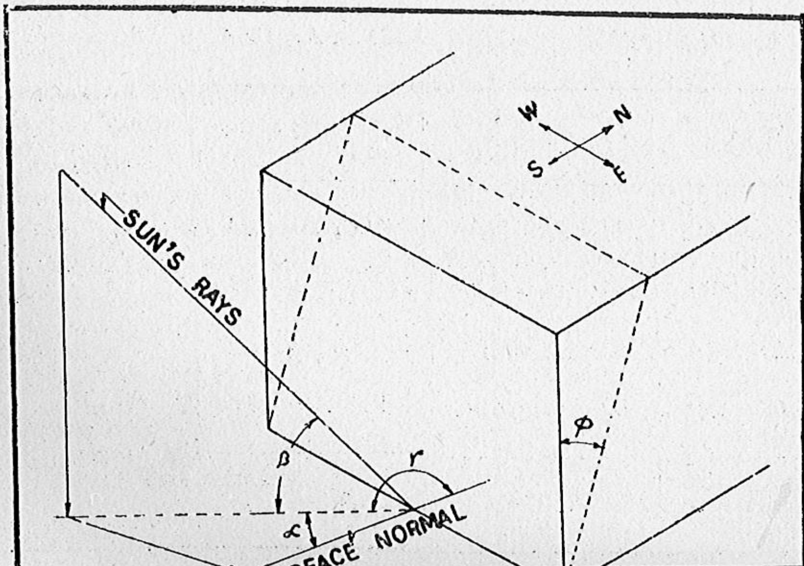


FIG. 1 - DIRECT SOLAR INTENSITIES NORMAL TO SUN AT SEA LEVEL FOR STANDARD CONDITIONS (COMPUTED)



APPENDIX

The method of calculating solar load on vertical surfaces of different orientations from the climatological and solar data.

The solar energy above the earth's atmosphere is constant and the amount incident on unit area normal to sun's rays is called solar constant (2 gm Cal/cm^2. min) This energy in reaching the earth's surface is depleted in the atmosphere due to scattering by air molecules water vapour, dust particles etc and absorption by water vapour and ozone. The depletion varies with varying atmospheric 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 and as the altitude of the sun decreases, the length of path in the atmosphere increases. Fig. 1 gives 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** and use Fig. 1 to find the corresponding value of direct solar radiation (I_N). The solar radiation incident on any surface (I_S) can then be computed with the help of the following relationship.

$$I_S = I_N (\sin\beta \sin\phi + \cos\beta \cos\alpha . \cos\phi)$$

Where α is the wall solar azimuth angle, β is the solar altitude and ϕ is the angle of tilt of the surface from the vertical. ($\phi=0$ for vertical and 90° for horizontal surfaces). (See Fig. 2).

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

**These are given for every hour at different latitudes in 'Climatological and Solar data for India'.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 74th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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LIST OF PUBLICATIONS OF CBRI AND SOURCE

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