BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE INDIA

ORIENTATION OF BUILDINGS

Introduction

The need to conserve essential building materials has again drawn attention to the importance of designing buildings so as to get the greatest possible functional comfort. Mechanical devices can create comfort conditions inside buildings but their 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 too is reduced considerably. This digest describes some important aspects of the orientation of buildings.

Factors Affecting Orientation

From the point of view of solar heat gain orientation is the primary consideration but other factors such as the direction of prevalent breeze, the direction of rain-fall and the site conditions generally cannot be overlooked in the final choice of 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 is more important. The best compromise is arrived at by using the solar and climatic data available for the place*.

Shading

Although it is not possible to increase the incident solar radiation on a surface during winter it is possible to reduce it in summer by the use of shading devices like trees, overhangs, louvers and verandahs. Because of the higher values of air temperature 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 times when the solar heat needs to be most reduced.

Room Location

The proper orientation of a building also involves the proper location of the rooms inside. 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, good 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 sufficient ventilation and good breeze.

It has been found by experiment that in deviating by 60° from the optimum wind direction, the wind velocity inside a room is reduced only by 25-30%. Sun-breakers, if provided on the windows may 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. The verandahs and the shading devices intercept the direct sun shine on the 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, it is possible to locate the day-time living rooms at places where other portions of the building provide shade in the summer months. The shadow-graph, designed and fabricated at this Institute is very useful for finding the duration and extent of shade on the respective walls of various types of buildings for any day of the year.

Air-Conditioned Buildings

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

How to Work out

The best orientation from a solar load 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 hourly solar-intensity data on the various external surfaces on representative days of the seasons. (If available, hourly air-temperature on these 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 days in question. From these values, it is easy to arrive at the proper orientation.

Example

As an example, a simple building with flat roof, 30′X60′ and 12′ 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 12′X30′=A (say) and 12′X60′=2A. The total direct diurnal solar loads per unit area on different vertical surfaces are given in Table (1) for two

*Climatological & Solar Data for India (C.B.R.I. Publication) 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 (Table 2) that for the above type of building, orientation (3) i.e. longer surfaces facing North and South, is appropriate as it affords the maximum solar heat gain in winter and the minium in summer. This is true for all places in India from a solar 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 greater.

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 lat. 23°N, orientation (2) should be preferred and at southern places orientation (4). 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 afternoons when the air temperature also is higher.

At hill stations, the winter season causes more discomfort and so merits greater consideration. The design for optimum orientation therefore requires maximum gain in solar energy during 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.

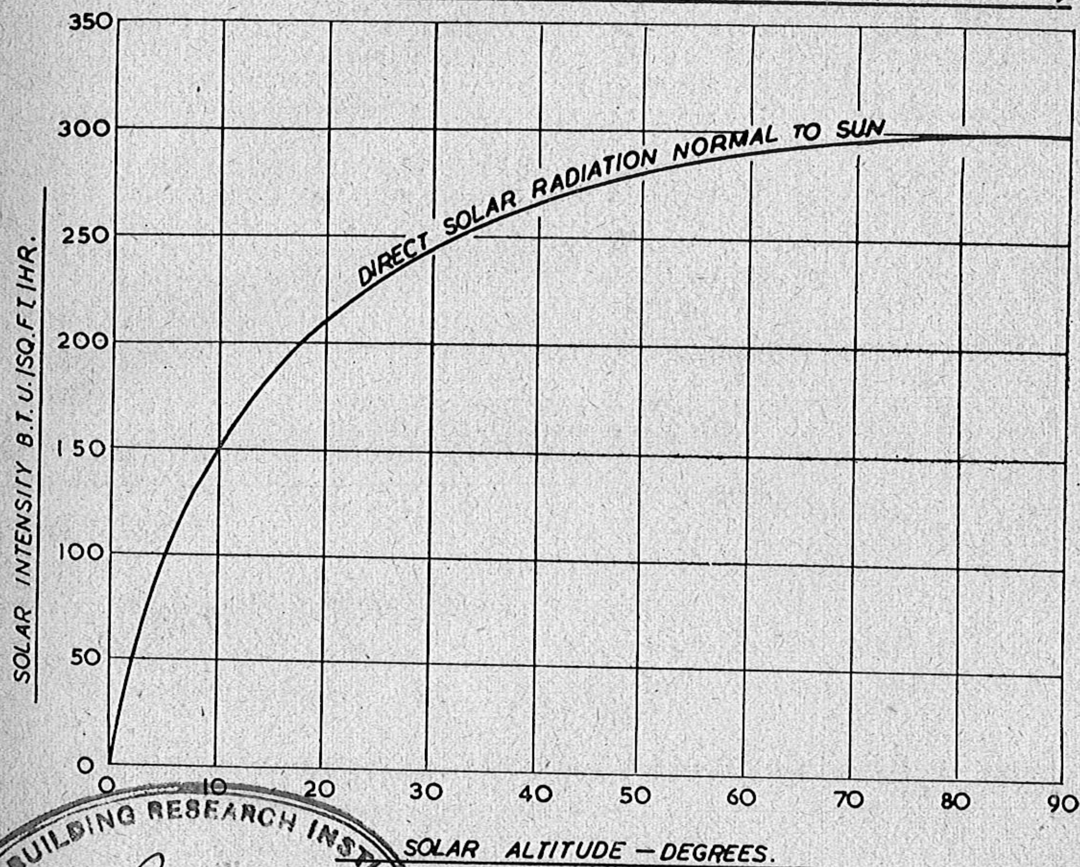
TABLE 1

Total Direct Solar Radiation on vertical surface in B.T.U./Sq. ft. 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 ...	690	—	515	—	305	—	235	—	170	—
North East ...	840	130	790	100	715	75	695	55	665	35
East ...	830	690	855	640	885	580	910	540	935	465
South East ...	370	1075	425	1085	520	1090	585	1095	695	1035
South ...	—	1320	—	1390	—	1450	65	1470	235	1440
South West ...	370	1075	425	1085	520	1090	585	1095	695	1035
West ...	830	690	855	640	885	580	910	540	935	465
North West ...	840	130	790	100	715	75	695	55	665	35

Note : The above direct solar radiation values are computed ones for specific atmospheric conditions.

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



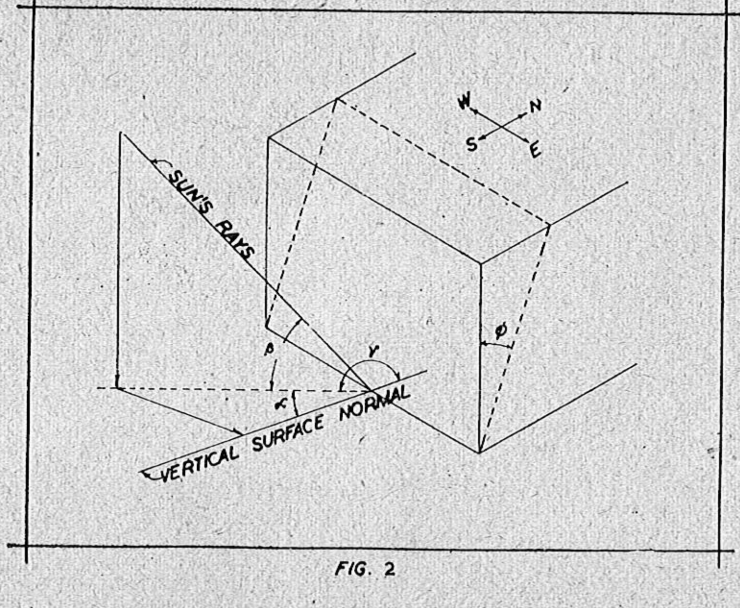
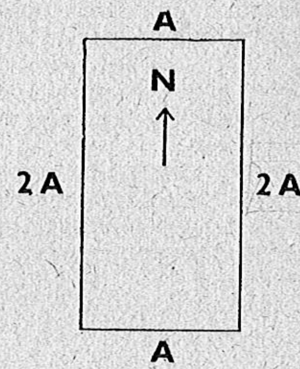
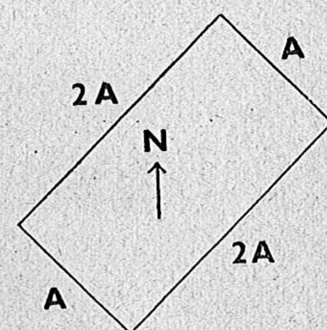
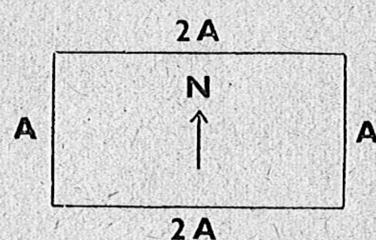
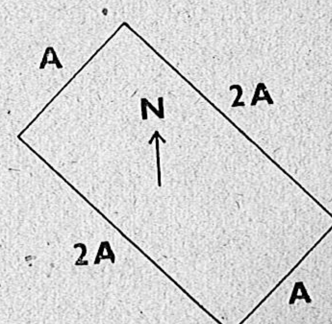


FIG. 2

		8°N Trivandrum		13° N. Madras		19°N Bomba	
		May 16	Dec. 22	May 16	Dec. 22	May 16	
1.	North	690×A=690A	—	515×A=515A	—	305×A=305A	
	East	830×2A=1660A	690×2A=1380A	855×2A=1710A	640×2A=1280A	885×2A=1770A	58
	South	—	1320×A=1320A	—	1390×A=1390A	—	14
	West	830×2A=1660A	690×2A=1380A	855×2A=1710A	640×2A=1280A	885×2A=1770A	58
	Total	4010A	4080A	3935A	3950A	3845A	
2.	N.E.	840×A=840A	130×A=130A	790×A=790A	100×A=100A	715×A=715A	75
	S.E.	370×2A=740A	1075×2A=2150A	425×2A=850A	1085×2A=2170A	520×2A=1040A	10
	S.W.	370×A=370A	1075×A=1075A	425×A=425A	1085×A=1085A	520×A=520A	10
	N.W.	840×2A=1680A	130×2A=260A	790×2A=1580A	100×2A=200A	715×2A=1430A	75
	Total	3630A	3615A	3645A	555A	3705A	
3.	North	690×2A=1380A	—	515×2A=1030A	—	305×2A=610A	
	East	830×A=830A	690×A=690A	855×A=855A	640×A=640A	885×A=885A	5
	South	—	1320×2A=2640A	—	1390×2A=2780A	—	14
	West	830×A=830A	690×A=690A	855×A=855A	640×A=640A	885×A=885A	5
	Total	3040A	4020A	2740A	4060A	2380A	
4.	N.E.	840×2A=1680A	130×2A=260A	790×2A=1580A	100×2A=200A	715×2A=1430A	75
	S.E.	370×A=370A	1075×A=1075A	425×A=425A	1085×A=1085A	520×A=520A	1
	S.W.	370×2A=740A	1075×2A=2150A	425×2A=850A	1085×2A=2170A	520×2A=1040A	10
	N.W.	840×A=840A	130×A=130A	790×A=790A	100×A=100A	715×A=715A	7
	Total	3630A	3615A	3645A	3555A	3705A	

23°N Calcutta		29° N. Delhi		ORIENTATION
May 16	Dec. 22	May 16	Dec. 22	
235×A=235A	—	170×A=170A	—	
910×2A=1820A	540×2A=1080A	935×2A=1870A	465×2A=930A	
65×A=65A	1470×A=1470A	235×A=235A	1440×A=1440A	
910×2A=1820A	540×2A=1080A	935×2A=1870A	465×2A=930A	
3940A	3630A	4145A	3300A	
695×A=695A	55×A=55A	665×A=665A	35×A=35A	
585×2A=1170A	1095×2A=2190A	695×2A=1390A	1035×2A=2070A	
585×A=585A	1095×A=1095A	695×A=695A	1035×A=1035A	
695×2A=1390A	55×2A=110A	665×2A=1330A	35×2A=70A	
3840A	3450A	4080A	3210A	
235×2A=470A	—	170×2A=340A	—	
910×A=910A	540×A=540A	935×A=935A	465×A=465A	
65×2A=130A	1470×2A=2940A	235×2A=470A	1440×2A=2880A	
910×A=910A	540×A=540A	935×A=935A	465×A=465A	
2420A	4020A	2680A	3810A	
695×2A=1390A	55×2A=110A	665×2A=1330A	35×2A=70A	
585×A=585A	1095×A=1095A	695×A=695A	1035×A=1035A	
585×2A=1170A	1095×2A=2190A	695×2A=1390A	1035×2A=2070A	
695×A=695A	55×A=55A	665×A=665A	35×A=35A	
3840A	3450A	4080A	3210A	

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 is called 'solar constant'-442 B.T.U./hr. sq. ft. This energy in reaching the earth's surface is depleted in the air atmosphere due to scattering by air molecules, water vapour molecules, dust particles etc. and absorption by water vapour and ozone. The depletion varies with varying atomospheric 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. In Fig. 1 is given 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 above 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,

$$I_s = I_N (\mathrm{Sin}\beta \mathrm{Sin}\theta + \mathrm{Cos}\beta \mathrm{Cos}\,\alpha\, \mathrm{Cos}\theta)$$

Where α is the wall solar azimuth angle, β is the solar altitude and θ is the angle of tilt of the surface from the vertical ($\theta = 0$ for vertical and 90° for horizontal surfaces), 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 the "Climatological & 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 will bring out a series of building digests from time to time and the present one is the first in the series.

Prepared at the Central Building Research Institute, Roorkee.
November, 1961

Asia Press, Delhi-6