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Indian Standard

RECOMMENDATIONS FOR ORIENTATION OF BUILDINGS

PART I NONINDUSTRIAL BUILDINGS

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Indian Standard
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PART I NONINDUSTRIAL BUILDINGS

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(*Continued on page* 2)

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PART I NONINDUSTRIAL BUILDINGS

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 9 December 1974, after the draft finalized by the Functional Requirements in Buildings Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 The chief aim of orientation of buildings is to provide, physically and psychologically comfortable living inside the buildings by creating conditions which suitably and successfully ward off the undesirable effects of severe weather; complete elimination of such undesirable situations may not be possible but with judicious use of the recommendations and knowledge of climatological factors, the ill effects can be reduced to a considerable extent.

0.3 Climatological factors are the most important of all factors which would normally help in deciding the orientation. However, in each individual case, ideal/desirable orientation may not be possible due to various other factors in a given situation. Fortunately however, in such cases, due to recent advances in types of constructions and materials and mechanical aids for lighting and ventilation, near ideal conditions can be achieved for living and work.

0.4 The Sectional Committee noted that work on thermal stress index for indoor summer conditions for people acclimatized in different parts of the country has been in progress in Central Building Research Institute, Roorkee. It was decided to include suitable data in this respect as soon as these are available.

0.5 Part II of this standard will deal with the orientation of industrial buildings.

0.6 In the preparation of this standard assistance has been drawn from the following publications:

Building Digest 74. Central Building Research Institute, Roorkee.

Climatological and solar data for India. Central Building Research Institute, Roorkee.

Ford Foundations Report on climatic evaluation and architectural recommendations for the region of Delhi.

Overseas Building Notes No. 71. Some principles of design for warm climates. Overseas Division, Building Research Establishment, England.

Overseas Buildings Notes No. 117. Nontraditional buildings for warm climates. Overseas Division, Building Research Establishment, England.

Technical information series. Climatic data for design of buildings. National Buildings Organization, New Delhi.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard (Part I) covers general principles and relevant factors which help to decide orientation of nonindustrial buildings.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following terms shall apply.

2.1 Cloud Coverage — The cloud coverage of sky is indicated in the meteorological data in the form of coverage of 'tenths of sky' by 'all clouds' and 'low clouds'. It is given in the form of tables for each month.

2.2 Relative Humidity — The ratio of the actual partial pressure of the water vapour in the air to the saturation pressure of water vapour at the same temperature.

2.3 Solar Loads — Direct solar radiation on roof and on vertical faces of differently oriented walls on clear days are given in the form of tables and graphs. They help to study the amount of heat received by the walls and roof of a building due to solar radiation.

2.4 Sun Charts — Sun charts indicate the diurnal path of the sun giving the points of its horizontal (azimuth) and vertical (altitude) locations in the sky at a particular hour of a particular month of a region.

2.5 Temperature — The means of daily maximum and minimum temperatures are given in the form of tables or isopleths for a particular region for a year or for different months for the country as a whole.

*Rules for rounding off numerical values (*revised*).

3. CLIMATOLOGICAL FACTORS

3.1 The following climatological factors which influence the optimum orientation of a building shall be taken into account:

a) Solar radiation and temperature,
b) Clouds and rains,
c) Humidity, and
d) Prevailing winds.

3.2 Solar Radiation and Temperature

3.2.1 The solar radiation is present during the day only. The normal practice has been to work during day and to rest during night. The two functions of work and rest are distinct. A residential building houses both the functions. But there are a number of buildings which are meant primarily for work. Working for twenty-four hours with shifts has also come to stay, but in many cases it would be adequate to orient buildings after taking into account climatological factors of the day only. Where work round the clock is carried on, both for working and comfort, mechanical aids in lighting and/or ventilation are called for during night. There is therefore likely to be no special problem for night in relation to orientation.

3.2.2 The climatological factors of day and night shall, however, be studied. To some extent this would help in deciding variations in orientation of buildings by taking into account the hours of work as well as the functions either of work and/or rest.

3.2.3 The temperature and solar radiation are related. The intensity of solar radiation depends on the direction of the sun's rays. The sun's radiation has the effect of both warming as well as creating glare. The question of glare has not been considered in detail here as it has been dealt with separately in IS : 2440-1968*. It may, however, be noted that this is an important factor and protection from it is necessary for comfort. The problem of glare arises due to the sun's radiation but measures taken against that radiation do not necessarily solve it. The field of glare is very wide. The important factors producing glare are the bright sky and the surrounding areas. But it is principally felt due to violent contrast and not due to total intensity of light or radiation. These factors affect all the sides irrespective of the sun's radiation which may vary and which may be practically absent on one side, as for example, on the north in winter. Glare may be reduced by screens and venetians or by plantations and colour treatments to the source of glare.

3.2.4 The effect of warming by the sun's radiation is experienced by rise in temperature. The temperature of a structure and living space is raised: (a) directly by the penetration of the sun's rays through openings, and (b) indirectly through the absorption and radiation of heat by the walling

*Code of practice for daylighting of buildings (*first revision*).

and roofing materials. For comfortable living at least during the summe both the factors should be considered. Thus, measures adopted to shiel direct penetration of the sun's rays through openings would not be useful the adjacent walls and roofs do not have sufficient insulation value. Roc is the most affected part of the structure because it receives direct sun's ray throughout the day, both in summer and winter. The treatment of roc should, therefore, receive adequate attention for creating comfort in building The four sides of the buildings should be considered individually and collec tively (*see* **3.2.5**). The easiest method of providing comfort through orienta tion is to avoid aspects which raises the temperature inside the building eithe by eliminating the penetration of the sun's rays or by providing an envelop of shade over as large a part of the building as possible. In case of col climates exactly the reverse considerations will prevail due to the need fc maximum warmth and the sun.

3.2.5 The different facades of a building have some inherent characteristic from solar point of view which can be utilized with advantage by a prope understanding of those characteristics. For instance, a south facade has th advantage of receiving much larger solar radiation during winter than tha during summer. Even for openings on the south facade, a small overhan can cut off direct solar penetration during summer and allow it during winte This, obviously, is the most advantageous aspect, not available on any othe facade.

3.2.5.1 For the most parts of the country north of 23°N latitude, the su does not shine directly on the north facade, except during early morning or late afternoons in summer. Even on other latitudes south of 23°N, th sunlight at mid-day during summer, in addition, comes from a very hig altitude sun. It is much easier to effectively cut off the early morning an late afternoon sun on this facade by vertical louvers on either side of th 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 bot together can be utilized advantageously throughout the year.

3.2.5.2 The eastern and western facades receive nearly equal amount of daily solar radiation throughout the year. The only difference is tha when the sun shines on the eastern facade, the building is comparativel cool after a cool night and the air temperature is also low. So the solar hea through this facade is not so pronounced indoors unless, of course, the easter facade is all unshaded glass area. On the other hand, western facade en counters a different situation. Due to the higher air temperature in th afternoon, the heat flow indoors is further augmented by the incidence o solar radiation on the western facade. This heat can be minimized b reducing the western facade or by providing thermal insulation on th exterior or by shading this facade by verandahs, creepers, plants, etc.

3.2.6 The best orientation from a solar point of view requires that th building, as a whole, should receive the maximum solar radiation in winte and the minimum in summer. 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. The total direct diurnal solar loads per unit area on different vertical surfaces are given in Table 1 for two days in the year, that is, 16 May and 22 December, representative of summer and winter, for latitudes corresponding to some important cities all over India. From Table 1, the total heat intake can be calculated for all possible orientations of the building for the extreme days of summer and winter.

TABLE 1 DAILY TOTAL DIRECT SOLAR RADIATION ON VERTICAL SURFACES IN g.cal/cm²/DAY FOR TWO REPRESENTATIVE DAYS

(*Clauses* 3.2.6 *and* B-1.3)

	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

3.2.6.1 The method of calculating solar load on vertical surfaces of different orientations is given in Appendix A.

3.2.6.2 An example to illustrate how to work out on orientation of a building from the solar point of view is given in Appendix B.

3.2.7 In order to ascertain good and bad aspects and to decide whether or not to take advantage of the sun's rays, day and night temperatures of the region, for which orientation is to be decided, should be studied in relation to the following broad classifications of temperature ranges (*see also* **3**):

Below 15°C	Cold	Sun's rays advantageous
15 to 20°C	Cool	
20 to 30°C	Temperate	
30 to 35°C	Hot	Protection from sun's rays advantageous
Above 35°C	Very Hot	

3.2.8 When the mean maximum temperatures during the day are of cool category or below it, it would be necessary to take the benefit of the sun's rays. As a rule such low day temperatures occur in winter between months of November and February. The movement of sun (between rise and set) during this period is invariably from E.S.E. to W.S.W. and its altitude is also low compared to summer months. This suggests that a south aspect would always be better than others for taking advantage of the sun in regions where it would be necessary to take it.

3.2.9 When mean maximum day temperatures fall within the limits of 20° to 30°C (temperate) the problem of orientation of building would be influenced more by considerations other than the radiation of sun such as glare, humidity, prevailing winds, view, etc, which are being dealt with separately under relevant headings.

3.2.10 In regions where mean maximum temperatures rise above 30°C (hot and very hot), high temperatures occur in the months of April to June and always between 2.0 and 5.0 P.M. The position of the sun during these hours of the day would invariably be towards the west. The exact location would vary from west to W.S.W. in latitudes higher than 20°N and from W.N.W. to west in latitude lower than 20°N. Therefore, in the northern plains of India, the west and W.S.W. aspects become worse. The altitude of sun is also low at these hours and it is difficult to devise simple and efficient methods of sun protection on the west aspect. During noon, solar radiation on a horizontal surface is maximum and air temperature is also pretty high. The sun shines on north/south walls from a high altitude and it is easy to protect these walls against solar radiation incidence by merely providing a small horizontal projection; small horizontal projection on walls would cast long shadows when the sun is at a high altitude. It is a popular belief that south aspect is bad in summer but it should be noted that in northern India during summer, the south wall receives the least solar radiation. In fact, the incidence of ground reflected radiation on the human body from a southernly sun in a south facade causes greater thermal discomfort and visual glare. To minimize the reflected solar heat suitable nonreflective and absorptive surfaces as for example, grassy lawns should be developed in front of the south facade.

3.2.11 The diurnal range of temperatures also gives important clues to the type of climate of a locality. A large difference (8°C or more) between the daily mean maximum and minimum temperatures would suggest a dry climate and if the maximum temperature extends to above 30°C, the conditions would be hot and dry. In such a climate, protection of openings against direct incidence of sunlight indoor is very essential; evaporative cooling brings great relief; roof spray proves very helpful. On the other hand if the daily mean maximum temperature extends to above 30°C but the diurnal range between the daily mean maximum and minimum temperatures remains below 8°C, the conditions signify a hot humid climate and in this climate, maximum relief is obtained only by the provision of profuse ventilation through large openings in opposite walls facing the prevailing wind direction.

3.3 Clouds and Rains

3.3.1 The other climatological factors are more important than clouds and rain but the clouds not only reduce the direct radiation but also make ineffective the devices of sun protection. It is, therefore, more convenient to take note of cloudy periods of the year and if they coincide with hot periods, then, the ideas of sun protection should be given up although high temperatures may demand such protection.

3.3.1.1 The meteorological data regarding clouds is given under three broad types 'low', 'medium' and 'high'. Low clouds are those whose heights of base vary from very low levels up to 2 500 metres. The amount by which low clouds cover the sky largely determines the effect of both incoming solar radiations and outgoing terrestial radiation.

3.3.2 The direction of the rain is generally the same as that of the prevailing wind except in case of storms. If the buildings are oriented to take such prevailing winds, special precautions and devices would be necessary to prevent rains beating into the buildings.

3.4 Humidity

3.4.1 In hot periods, the human body gives out moisture by way of perspiration to regulate its temperature. There is no discomfort as long as there is scope for absorption of such moisture in the air. Where there is no such absorption, the air around the body gets saturated with the moisture and gives rise to a sensation of discomfort. Movement of air during such conditions removes saturated air from the vicinity of the body and brings fresh air into its contact. This gives a relief although there may not be any change in room temperature. Due to this reason, movement of air and the use of prevailing wind are very important during periods of high humidity.

3.4.2 The discomfort due to high humidity can be counteracted, to a great extent, with electric fans or mechanical ventilation. In the past as solar radiation was largely counteracted with heavy construction and surrounding verandahs, there was apparently an over-emphasis on humidity and prevailing winds. . With the introduction of electric fan to effectively counteract humidity and taking into account the rise in costs of construction, perhaps, it would be better to shift the emphasis on solar radiation where temperatures are very high. When there is less diurnal variation between mean morning and mean maximum temperatures alongwith high humidity, the emphasis should be on humidity and prevailing winds.

3.4.3 A comparative study of relative humidity can be made under following categories:

0-25 percent	Very dry
25-50 ,,	Dry
50-75 ,,	Humid
75-100 ,,	Very humid

3.4.4 When humidity is of the category of 'dry' and 'very dry' it is easy to take its advantage by evaporative cooling in summers; when it is 'humid' or 'very humid' it is desirable to regulate the rate of air movement either artificially with the aid of electric fans or with the help of prevailing winds.

3.4.5 Comfort in relation to humidity becomes complex. During humid period one can feel very warm when the air temperature is 30°C and conditions calm. One may, however, feel cool even if temperature rises to 32°C and there is little breeze. It will be quite cool at the same temperature if there is reduction in the relative humidity and if there is breeze.

3.4.6 For assuring comfort in humid regions, the temperatures within the buildings should be kept as near as possible to the shade temperature by use of: (a) fans and forced ventilation to achieve speedy air movement up to 50-100 cm/s, (b) adopting light weight construction of low thermal capacity, (c) using materials externally with low absorption capacity for heat, etc, and (d) by minimizing the effect of solar radiation.

3.5 Prevailing Winds

3.5.1 The prevailing wind helps to create natural ventilation in a building to provide comfort during the periods of high humidity.

3.5.2 With judicious location of rooms inside a building and with location of suitable windows at proper points in the rooms, desirable wind movement indoors and the requisite ventilation can be ensured. For comfort it is also necessary that air movement should occur in building at the level of occupances and use.

3.5.2.1 Where there is extreme heat in summer and where it is necessary to close openings to avoid heat and glare it would be an advantage to orient buildings to face the winds of the humid months instead of average prevailing wind which may be from some other direction.

3.5.2.2 Where appropriate, reference shall be made to IS : 3362-1965*.

3.5.3 Where there are rows of buildings, wind eddies are produced on the leeward side. The field of eddies is determined by the height, length and width of building blocks. Prevailing wind becomes weak and indefinite in the field of eddies and cannot produce adequate natural ventilation in buildings located in such areas.

3.5.4 It is not necessary to face the buildings directly into prevailing winds because their velocity is not reduced considerably by facing the building away even up to 30°.

3.5.5 Specific consideration should be given to strong hot and cold winds in regions where they are present.

3.5.6 For the purpose of orientation, it is necessary to study the velocity and direction of the wind at each hour and each month instead of relying on generalizations of a month or a period or for the year as a whole. This helps to spot the right winds for particular period of day or night.

*Code of practice for natural ventilation of residential buildings.

4. BASIC DATA

4.1 The climatological factors necessary for the determination of orientation of buildings are available in the form of basic data, such as sun charts, solar loads, temperature, cloud coverage of the sky, relative humidity and winds.

4.1.1 Basic data available in publications of Meteorological Department; 'Climatological and solar data for India' issued by the Central Building Research Institute, Roorkee; and 'Climatic data for design of buildings — Technical Information Series' issued by the National Buildings Organisation may be seen.

4.1.2 Since the data given in **4.1.1** is on an average basis it would not cover special situations in the country, such as occurrence of severe hot or cold winds during some months in a year in places near desert areas. In such cases, it is necessary to obtain more climatological details for determination of a suitable orientation.

5. BASIC ZONES AND THEIR PROBLEMS

5.1 The study of climatological factors helps to divide India into suitable zones. In IS: 3792-1966* four zones have been indicated with regard to heat insulation. This standard may be referred to for more information and details.

5.2 For the purpose of orientation it would, however, be more convenient to divide the country in three broad zones :

a) Hot and arid,

b) Hot/warm and humid, and

c) Cold.

5.2.1 It is to be remembered that there may not be uniform climatic factors in a particular zone. They might even vary during day and night in the same zonal region. Each zone, all the same, poses certain basic problems. These problems call for solutions. Reference to each zone has been made separately in **5.3** to **5.6**.

5.3 The main problem of the hot and arid zone is to keep out the day time heat or the solar radiation. Past methods of shading the openings with *CHAJJAS*, thick walls with small openings, more height and deep verandahs do help in creating certain level of comfort; though except for provision of *CHAJJAS*, the other methods will prove uneconomical in the present day circumstances. Ultimately the most effective method will be the right orientation. More height does not improve ventilation. Ventilation depends on air intake rather than on the volume of room. Verandahs on the east and west are not very effective because of the general low altitude of sun on these sides. For sleeping purposes also, verandahs are not always satisfactory

*Guide for heat insulation of non-industrial buildings.

because of the radiation given out at night by their floor and the surrounding masonry. In single/double storey development courtyards offer physical and psychological advantages provided that they are shaded during day, landscaped properly and cooled by sprinkling water. In multistorey development, however, terraces, staggered balcony, etc, have to be resorted to in order to achieve this end.

5.3.1 In hot and arid zone, walls and roofs should have adequate thermal capacity and time-lag. Sunlit surfaces, and not just openings should be reflective and/or be heavily shaded. Air movement should, as a rule, be restricted to the minimum required for ventilation. But fresh air is very useful during the evening to counteract the heat gained by the structure which, by the evening, would be radiated to the interior.

5.3.2 Summer nights are very uncomfortable in this zone. Interiors are unbearable as surrounding walls and roof radiate thermal heat stored by them during the day. Terraces, open verandahs, staggered sleeping out balconies and structures enclosed with light construction and materials which give up heat quickly are necessary for comfortable sleep at night.

5.4 The main problem of hot/warm and humid zone is to provide maximum of ventilation, natural if possible, to counteract discomfort of humidity. It is simple to increase humidity but it is not at all possible to reduce it by any economical method. The best solution is, therefore, to make maximum use of prevailing winds. Glare is also generally present in this zone. Screens and *JALLIES* are more effective as they not only screen bright sky but also allow breeze to pass through them.

5.4.1 In the hot/warm and humid zone the effort should be to maintain indoor temperatures, as near as possible, to the ambient or shade temperature. Walls and roofs, if possible, should be of light weight construction having low thermal capacity. The external surface should absorb as little solar radiation as possible and the internal surface should emit minimum of long wave radiation. Air movement should normally be speedy up to 50-100 cm/s, which may have to be obtained artificially if prevailing winds do not help to do so.

5.5 The problems of the cold zone are that during summer if the sun's radiation is excessive, there should be some shading during day but at night both in summer and winter cold air should be shut out. During day, in winter, sunshine should be welcome.

5.5.1 In the cold zone, especially in hills, walls and roofs should be heavy weight with high thermal capacity for absorbing and storing heat during day and using the stored heat to warm the inside of the building during the night. If heavy weight roofs are not feasible, they should be insulated against loss of the heat of the interior during night. Air movement and ventilation should be restricted to the minimum. Regular flues or devices for minimal permanent ventilation at night should be provided to avoid concentration of carbon monoxide when open coal fires are used for heating in enclosed rooms, in winter, especially in hill town.

5.6 The main zonal factors and an appreciation of their problems cannot suggest orientation suitable to the whole area covered by different zones. For the orientation of a place, city or town, its climatological, topographical and other related factors should be studied in detail in the manner prescribed in this standard, to decide an optimum orientation.

6. INFLUENCE OF LAYOUTS AND ROAD SYSTEMS

6.1 Often layouts and road systems in them predetermine orientation of individual or group of buildings, it is therefore necessary to consider steps to minimize their handicaps and to suggest methods of assuring better orientation in case of fresh planning.

6.2 In a city or a town where building sites and road patterns are fixed, practically no choice is left for orientation. When the abutting road does not allow desirable orientation, insistence by bye-laws or otherwise, for facing the building on that road should be relaxed. At least on large plots, where buildings are detached, there should be no restriction to the siting of the building to achieve optimum benefits of orientation. An approach road at one side would help the building to face on that side instead of the statutory road. This should be acceptable because the present trend is to design all the four elevations properly and if so any one of them can face the statutory road without sacrificing public interest civic or aesthetic.

6.3 Statutory building lines which are parallel to the road sometimes force undesirable orientation to buildings. This can be improved by allowing to keep building faces at an appropriate angle to the road. If such facing is uniform throughout the street, it would not handicap harmony of street architecture which is the aim of enforcing building lines. While stipulating building lines, orientation aspect of the proposed development should be kept in mind, instead of following 'parallel to the road' approach.

6.4 Fresh planning of layouts and neighbourhoods should incorporate road patterns which enable desirable/good orientation to the maximum number of blocks.

6.5 The heights and depths of building blocks and the width of streets which decide the distance between the blocks, should be such that, in addition to providing adequate air, light and means of communications, each building may have access to natural winds or at least to those winds which are most useful either directly or through systematic channelizing. When a row of buildings faces directly against the wind, they block the flow of wind to other rows. If the blocks are oriented oblique to the wind direction and if gaps are provided between them, the obstruction to winds is lessened considerably.

6.6 Particular attention should be paid to the layout of terrace houses because they receive light and air from two sides only. For such housing, the road pattern and building faces should be designed to derive maximum benefit of orientation.

6.7 Planting of trees in streets and in open spaces should be done carefully to take advantage both of shades and sunshine without handicapping the flow of natural winds. Their advantage for abating glare and for providing cool and/or warm pockets in developed areas should also be taken. Some trees shed leaves in winter while retain thick foliage in summer. Such trees will be very advantageous particularly where southern and western exposures are concerned; by allowing maximum sun during winter and effectively blocking it in summer.

APPENDIX A

(*Clause* 3.2.6.1)

METHOD OF CALCULATING SOLAR LOAD ON VERTICAL SURFACES OF DIFFERENT ORIENTATION

A-1. DETAILS OF CALCULATION

A-1.1 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 g/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 the shortest when the sun is at the zenith and, as the altitude of the sun decreases, the length of path in the atmosphere increases. Figure 1 gives the computed incident solar energy/hour on unit surface area normal to the rays under standard atmospheric conditions* for different altitudes of the sun.

A-1.2 In order to calculate the solar energy on any surface other than normal to the rays the altitude of the sun at that time† should be known. The corresponding value of direct solar radiation (I_N) should then be found out with the help of Fig. 1. The solar radiation incident on any surface (I_S) is given by:

$$I_S = I_N \ (\text{Sin}\ \beta\ \text{Sin}\ \phi + \text{Cos}\ \beta\ \text{Cos}\ \alpha\ \text{Cos}\ \phi)$$

where

β = solar altitude,

ϕ = angle tilt of the surface from the vertical (*see* Fig. 2), and

α = wall solar azimuth angle.

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*The standard atmospheric conditions assumed for this computation are: cloud-free, 300 dust particles per cm^3, 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' published by the Central Building Research Institute, Roorkee.

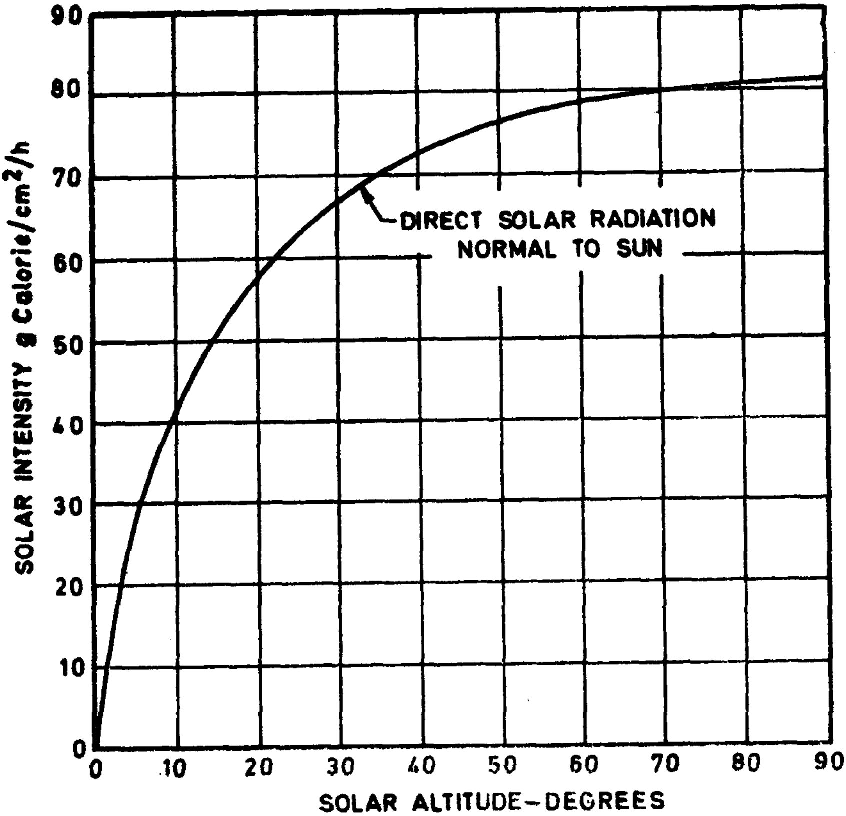


FIG. 1 DIRECT SOLAR INTENSITIES NORMAL TO SUN AT SEA LEVEL FOR STANDARD CONDITIONS (COMPUTED)

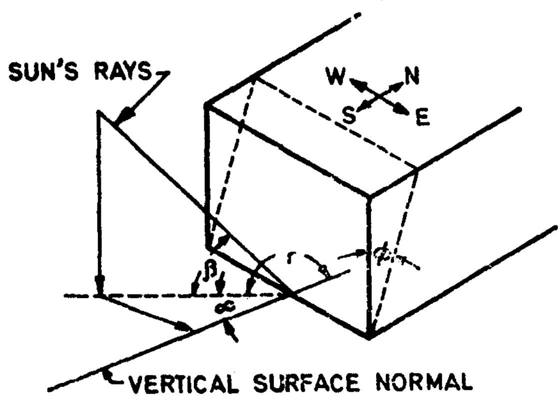


FIG. 2 DEFINITION OF SOLAR ANGLES

APPENDIX B

(*Clause* 3.2.6.2)

AN EXAMPLE TO FIND OUT ORIENTATION ON THE BASIS OF SOLAR LOAD

B-1. EXAMPLE

B-1.1 As an example, a simple building with flat roof, 10 m × 20 m and 4 m high is dealt with below. For the sake of generalization, no shading device or verandah is taken.

B-1.2 As the roof is horizontal, it will receive the same solar heat in any orientation.

B-1.3 The areas of the vertical surfaces are 4 m × 10 m = A (say) and 4 m × 20 m = 2 A. 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.

B-1.4 From 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 in summer. This is true for all places of India from the point of solar heat gain. By further increasing the length to breadth ratio, the advantage of this orientation will be more pronounced. It may also be noted that in higher altitudes, the relative merit of this orientation is more.

B-1.5 It is also seen that the total solar heat on the building is the same for orientation 2 and 4. But if the site considerations 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 wall increases. It would, therefore, 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.

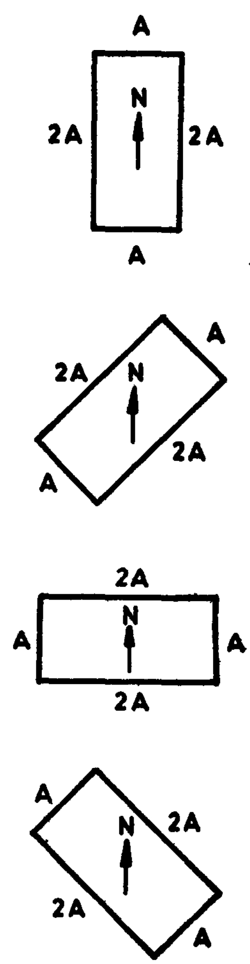
TABLE 2 SOLAR HEAT GAINED DUE TO ORIENTATION OF BUILDINGS

(*Clauses* B-1.3 *and* B-1.4)

	8°N Trivandrum		13°N Madras		19°N Bombay	
	May 16	Dec 22	May 16	Dec 22	May 16	Dec 22
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	157×2A=314A
South	—	358× A=358A	—	377× A=377A	—	393× A=393A
West	225×2A=450A	187×2A=374A	232×2A=464A	173×2A=346A	240×2A=480A	157×2A=314A
Total	1 087A	1 106A	1 068A	1 069A	1 043A	1 021A
2 N E	228× A=228A	35× A= 35A	214× A=214A	27× A= 27A	194× A=194A	20× A= 20A
S E	100×2A=200A	291×2A=582A	115×2A=230A	294×2A=588A	141×2A=282A	295×2A=590A
S W	100× A=100A	291× A=291A	115× A=115A	294× A=294A	141× A=141A	295× A=295A
N W	228×2A=456A	35×2A= 70A	214×2A=428A	27×2A= 54A	194×2A=388A	20×2A= 40A
Total	984A	978A	987A	963A	1 005A	945A
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× A=157A
South	—	358×2A=716A	—	377×2A=754A	—	393×2A=786A
West	225× A=225A	187× A=187A	232× A=232A	173× A=173A	240× A=240A	157× A=157A
Total	824A	1 090A	744A	1 100A	646A	1 100A
4 N E	228×2A=456A	35×2A= 70A	214×2A=428A	27×2A= 54A	194×2A=388A	20×2A= 40A
S E	100× A=100A	291× A=291A	115× A=115A	294× A=294A	141× A=141A	295× A=295A
S W	100×2A=200A	291×2A=582A	115×2A=230A	294×2A=588A	141×2A=282A	295×2A=590A
N W	228× A=228A	35× A= 35A	214× A=214A	27× A= 27A	194× A=194A	20× A= 20A
Total	984A	978A	987A	963A	1 005A	945A

	23°N Calcutta		29°N Delhi	
	May 16	Dec 22	May 16	Dec 22
1 North	64× A= 64A	—	46× A= 46A	—
East	247×2A=494A	146×2A=292A	253×2A=506A	126×2A=252A
South	18× A= 18A	398× A=398A	64× A= 64A	390× A=390A
West	247×2A=494A	146×2A=292A	253×2A=506A	126×2A=252A
Total	1 070A	982A	1 122A	894A
2 N E	188× A=188A	15× A= 15A	180× A=180A	9× A= 9A
S E	158×2A=316A	297×2A=594A	188×2A=376A	281×2A=562A
S W	158× A=158A	297× A=297A	188× A=188A	281× A=281A
N W	188×2A=376A	15×2A= 30A	180×2A=360A	9×2A= 18A
Total	1 038A	936A	1 104A	870A
3 North	64×2A=128A	—	46×2A= 92A	—
East	247× A=247A	146× A=146A	253× A=253A	126× A=126A
South	18×2A= 36A	398×2A=796A	64×2A=128A	390×2A=780A
West	247× A=247A	146× A=146A	253× A=253A	126× A=126A
Total	658A	1 088A	726A	1 032A
4 N E	188×2A=376A	15×2A= 30A	180×2A=360A	9×2A= 18A
S E	158× A=158A	297× A=297A	188× A=188A	281× A=281A
S W	158×2A=316A	297×2A=594A	188×2A=376A	281×2A=562A
N W	188× A=188A	15× A= 15A	180× A=180A	9× A= 9A
Total	1 038A	936A	1 104A	870A

Orientation



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