GOVERNMENT POLYTECHNIC FOR GIRLS

AHMEDABAD

COURSE: BUILDING SERVICES

COURSE CODE : 3360604

TOPIC: Lighting and Ventilation

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Natural Lighting

•The primary source of lighting for day lighting is the sun.

• The light received by the earth from the sun consists of two parts, namely, direct solar luminance and sky luminance

.

• For the purposes of day lighting design, direct solar luminance shall not be considered and only sky luminance shall be taken as contributing to illumination of the building interiors during the day.

➢The relative amount of sky luminance depends on:

1. The position of the sun defined by e its altitude
2. altitude of the locality
3. The day of the year
4. The time of the day



For cold climate	–	6800 lux
For composite climate	–	8000 lux
For warm humid climate	–	9000 lux
For temperate climate	–	9000 lux
For hot - dry climate	–	10,500 lux

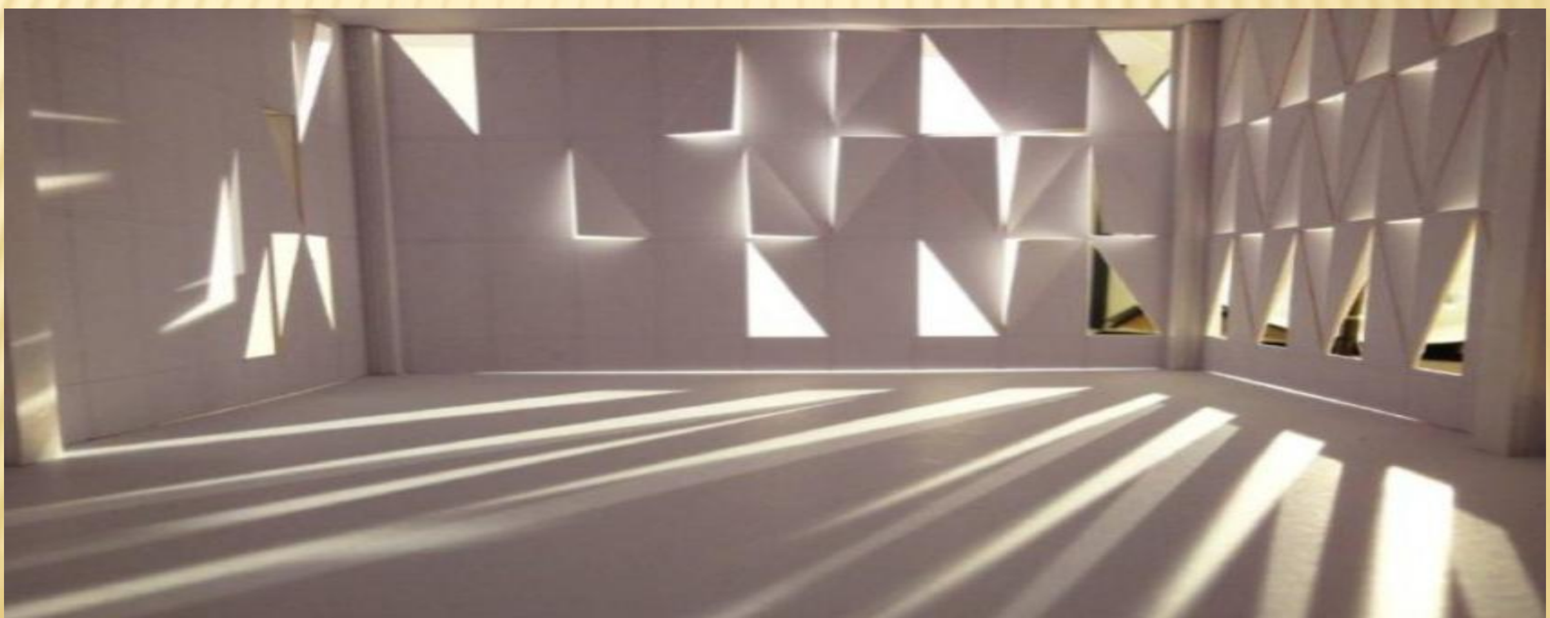


Table 1.2

Percentage sky components on the horizontal plane due to a vertical rectangular opening for the clear design sky

l/d / h/d	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0	Inf
0.1	0.036	0.071	0.104	0.133	0.158	0.179	0.198	0.213	0.225	0.235	0.276	0.288
0.2	0.141	0.277	0.403	0.516	0.614	0.699	0.770	0.829	0.878	0.918	1.079	1.125
0.3	0.300	0.589	0.859	1.102	1.315	1.499	1.653	1.782	1.888	1.976	2.333	2.437
0.4	0.460	0.905	1.322	1.702	2.041	2.377	2.590	2.804	2.984	3.134	3.753	3.937
0.5	0.604	1.189	1.741	2.247	2.700	3.099	3.444	3.704	3.992	4.204	5.126	5.410
0.6	0.732	1.443	2.114	2.732	3.289	3.781	4.211	4.582	4.900	5.171	6.397	6.802
0.7	0.844	1.665	2.441	3.159	3.808	4.385	4.891	5.330	5.708	6.034	7.551	8.092
0.8	0.942	1.858	2.727	3.532	4.262	4.914	5.488	5.989	6.423	6.798	8.587	9.276
0.9	1.026	2.025	2.974	3.855	4.657	5.375	6.011	6.567	7.051	7.470	9.515	10.355
1.0	1.099	2.169	3.188	4.135	5.000	5.776	6.465	7.071	7.600	8.060	10.343	11.335
2.0	1.456	2.880	4.244	5.527	6.714	7.798	8.778	9.656	10.440	11.137	14.975	17.372
Inf	1.657	3.282	4.846	6.327	7.710	8.986	10.155	11.220	12.186	13.060	18.410	26.111

•As is known, the sun apparently moves between the Tropic or Cancer and Tropic of Capricorn during the year, that is, to the north and south of the equator.
•Therefore, the diurnal movement of the sun With respect to a building will depend on the altitude of the place in which the building is situated.
•If the place happens to be beyond the Tropic of Cancer, the sun will always be to the south of the building and “sky radiation will be from north.

•Since sky radiation is generally taken for day lighting design. the northern latitudes beyond the Tropic of Cancer. the source of day lighting in from the north, and therefore. in European countries, for example, the term north light' in buildings, is common.

• Though this concept has been in vogue India, it is not correct north lighting should not be applied in India except for places beyond the Tropic of Cancer. Similarly, for places beyond Tropic of Capricorn,
•'south light' is valid- For Indian conditions, IT solar altitude is assumed as the standard for design purposes.
•The external available horizontal sky luminance (diffuse luminance) values which arc exceed for about 90 % of the day time working hours may be taken as outdoor design luminance values for ensuring adequacy of day lighting design. The outdoor design sky luminance varies for different climatic regions of the country.

SKY COMPONENT :

- A Sky component is the percentage of that part of daylight illumination a a point in the interior on a given plane which is received directly room the sky as compared to the simultaneous exterior illumination on a horizontal place From thee entire hemisphere of an unobstructed clear sky.

- Sky component for a window of any size is computed as per NBC 2005, 1, Annexure A. The values of sky components are shown art 8, section Table 1.2. (G) The recommended sky component level should be ensured generally on the working plane at the following sections At a distance of 3 m to 3.75 75 m m from from the window along the centre to the window. line perpendicular at the centre of the room.

- at fixed locations, such as school dinks, black boards and office tables. (ii) The daylight area of the prescribed sky component should not normally be less than half the total area of the room.

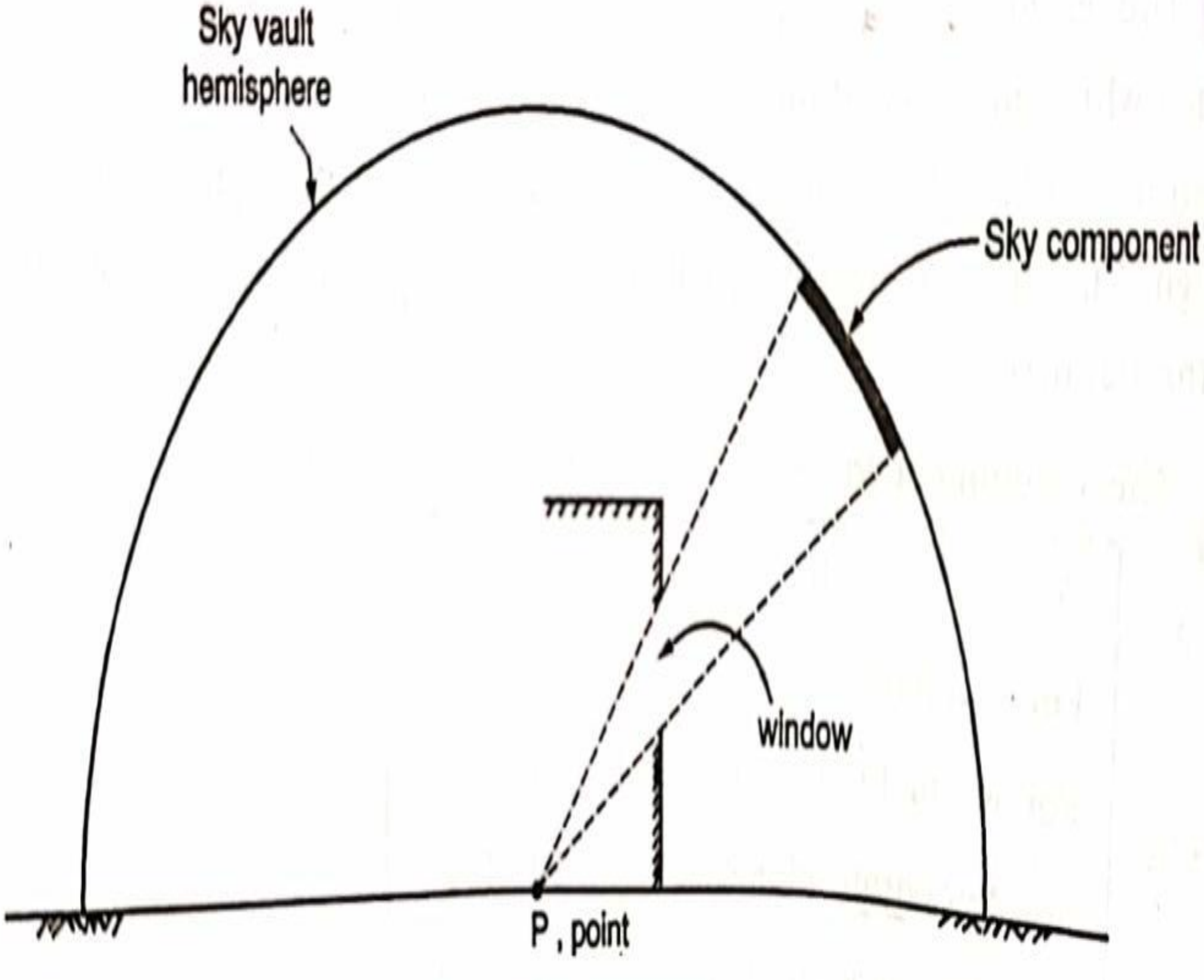
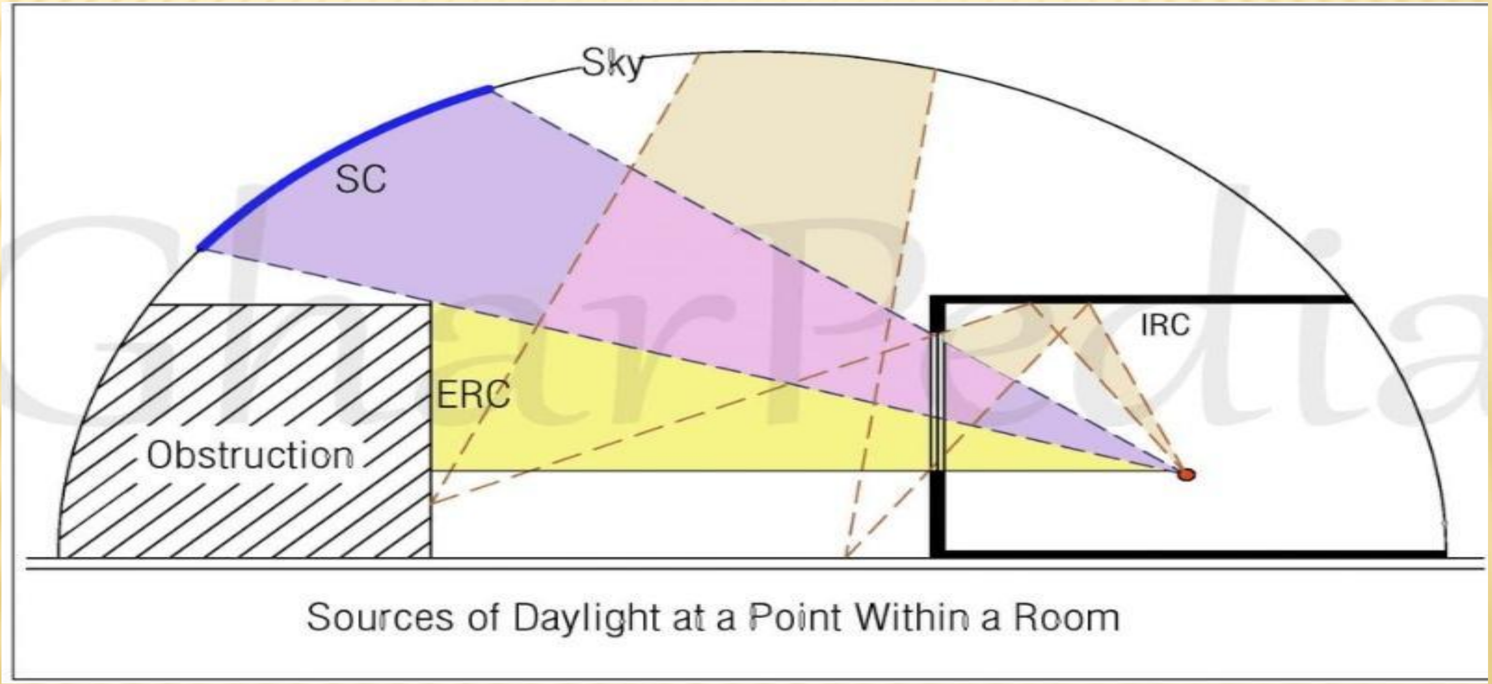


Fig. 1.1 Sky component

The values of sky components obtained from annexure A (or Table 1.2) shall be corrected for the presence of window bars, glazing and external obstructions
.
Therefore, the correction factor is given by clear opening overall opening Correction factor Where windows are glazed the sky components obtained from annexure-A Dr Table 1.2) shall be reduced by 10 to 20 % for clear glass, 15 to 30 6 for round glass and 50 % for tinted or reflected glass.



Daylight factor

•Daylight factor is the sum of all the daylight reaching on an indoor reference point from the following sources :

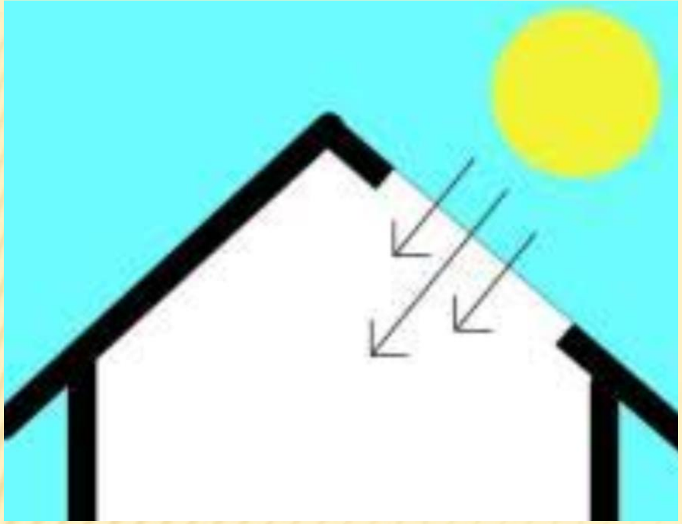
- The direct sky visible from the point
- External surfaces reflecting light directly
- Internal surfaces reflecting light to the point

•The daylight factors on the horizontal plane only are usually taken, as the working plane in a room is generally horizontal.

• however, the factors in vertical planes should also be considered when specifying daylight values for special cases such as day lighting on class rooms , black boards, pictures and paintings hung on walls.

• Daylight factor has three components:

- Sky three components
- External reflected components
- Internal reflected components
-




External Reflected Component (ERC)

- The ratio (or percentage) of that part of the day light luminance at point on a given plane which is received by direct reflection from external surfaces as compared to the simultaneous external luminance on a horizontal plane from the entire hemisphere of an unobstructed clear design sky.

- The value of the sky component corresponding to the portion of the window obstructed by the external obstructions is computed. The luminance of obstructions varies widely, but it is generally assumed to be 1/5 of the average luminance of the sky (i.e. $k = 1/5 = 0.20$)

Internal Reflected Component (IRC)

•The ratio (or percentage) of that part of the daylight luminance at point in a given plane which is received by direct reflection or inter-reflection from the internal surfaces as compared to the simultaneous exterior illuminant€ on a horizontal plane due to the entire hemisphere of an unobstructed clear design sky.

•The internal reflected component (IRC) varies from point to point in a room depending on the interior finish. It directly varies as the window area and inversely as the total area of internal surfaces.

•IRC depends on the reflection factor of the floor, wall and roof surfaces inside. The portion of the light reflected is called the reflection factor. Light surfaces have high reflection factors, e.g. for white surfaces, the factor is 70 to 80 % and dark surfaces have a low factor of the order of 10 to 20 %.

•The actual calculations of IRC are a little complicated. Generally, it can be assumed that for normal finishes, say around 40 % reflection factor and for normal window sizes, say around 20 % of the floor area, the internal reflection factor is 0.7 %.

•This value can be safely assumed for most of the calculations and must be added to the sky component and ERC.

General principles of openings to afford good lighting :-

The following general rules should be observed in the design of windows to afford good lighting.

1.Generally, while taller openings give greater penetrations, broader openings give better distribution of light. It is preferable that some area of the sky at altitude of 20 -25 should light up the working plane.

2. Border openings may also be equally or more efficient, provided their sills are raised by 300 mm to 600 mm above the working plane.

3. A number of small windows properly positioned along the same, adjacent or opposite walls will give better distribution of illumination than a single large window. (

4. For rooms deeper than 7 m or more, windows on the two opposite walls would give greater uniformity of illumination. This arrangement would also reduce the glare because the walls surrounding the windows are illuminated by the opposite window.

5. Windows with deep reveals tend to minimise glare effects. The advantage of deep reveals is that the direct solar illumination is cut off to some extent and the surrounding areas of the window and the interior surfaces of the wall have graded illumination, reducing the effect of glare.

6. Openings shall be provided with chajjas, louvers, baffles or other shading devices to exclude, as far as direct sunlight entering the room. Though direct sunlight increases illumination, excessive glare is also caused if it falls on reflective surfaces. Light control media such as translucent glass panes surfaced by grinding or etching, corrugated glass, prismatic glass, tinted glass, are often used. They should be provided, especially in the upper portions of the openings.

General Rules For Window Design

<u>Artificial Lighting :</u>

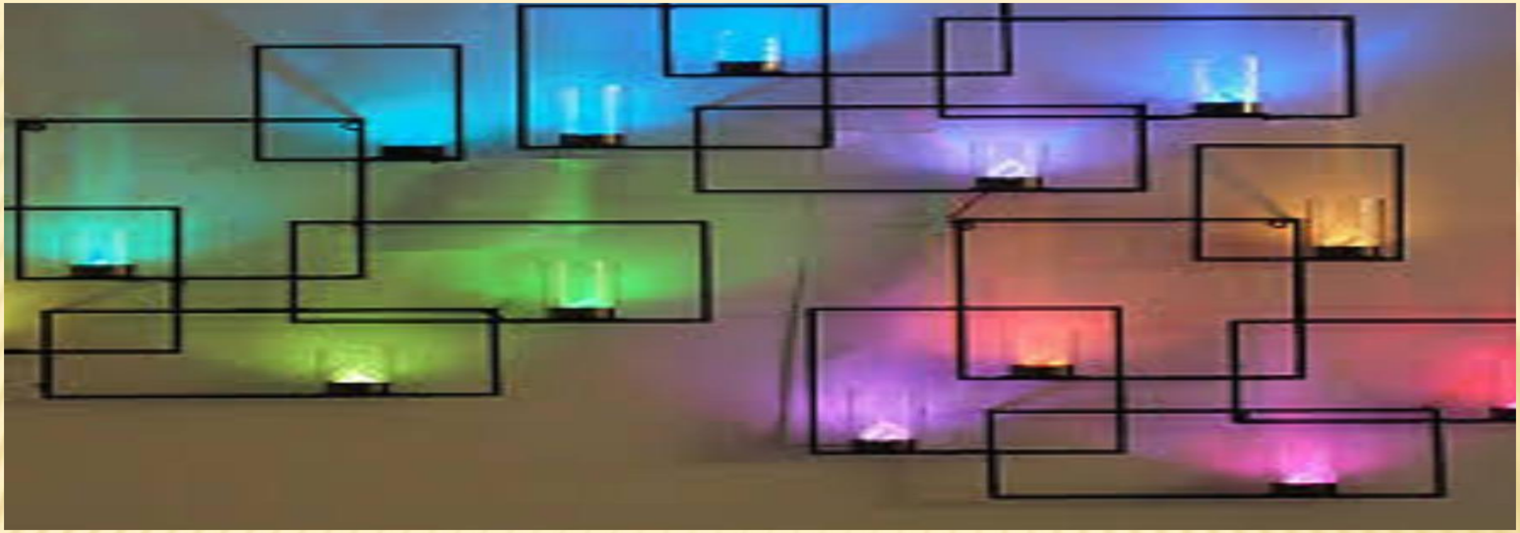
Artificial lighting is necessary in the following cases :

- Where the recommended illumination levels have to be obtained by artificial lighting only.
- To supplement day lighting when level of illumination falls below the recommended value.
- Where viral task may demand a higher level of illumination.

Stepwise guidance regarding designing the interior lighting systems for a building using the **"Lumen method"** is given below.

1. **<u>Determination Of The Illumination Level :</u>** Recommended value of illumination level on a working plane shall be taken from NBC - 2005, part 8, section 1, Table 4.

<u>2. Selection of the light source and luminaries :</u>The luminous flux (**Φ**) reaching the working plane depends upon the following:



- lumen output of the lamps
- type of luminaries
- Proportion of the room (room index)
- reflectance of internal surfaces of the room
- depreciation in the lumen output of the lamps after burning their rated life
- depreciation due to dirt collection on luminaires and room surfaces.

(a) <u>Utilization factor (uF) or coefficient of utilization :</u>

The total light of the lamp does not reach to the work plane. Some amount of light distribute on the walls and ceiling of the room, and by reflection from these surfaces it reaches to the work plane.

utilization factor = Lumens available on the work plane/Lamp lumens.

Higher the lumens available on the workplane, higher will be the utilization factor. The utilization factor (uF) depends+ upon the following factors:

- Area of the workplane
- Height of lamp from the workplane (more the height of lamp, lesser will be the illumination)
- Type of lighting arrangement, i.e. direct, semi-direct or indirect lighting.
- Colour of the surrounding walls. If walls are light in colour reflection will be more and for walls with dark colour, reflection will be less.
- The values of utilization factor may be taken as 0.25 to 0.50 for dire. In lighting and 0.1 to 0.3 for indirect lighting.

The reflection factors of walls and ceiling of a room are:

White and very light colours	= 0.7
Light colours	= 0.5
Middle tints	= 0.3
Dark colours	= 0.1

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4. Arrangement of the luminaires

The arrangement of luminaries' in a room is necessary to achieve better uniformly distributed illumination. The location of the luminaries has an important effect on the utilization factor.

- In general, luminaries are spaced 'a' metre apart in either direction, while the distance of the end luminaries from the wall is a/2 metre. The distance 'a' is more or less equal to the mounting height H between the luminaries and the working plane.
- For small rooms where the room index (k_r) is less than 1, the distance 'a' should always be less than H since otherwise luminaries can not be properly located. In most cases of such rooms, four or two luminaries are placed for good lighting. If, however, in such rooms only one luminaries is installed in the middle, higher utilization factors are obtained, but the uniformity of distribution is poor.

For good distribution and integration of day light with artificial lights the following guidelines are recommended.

1) Employ cool daylight fluorescent tubes for supplementary artificial lighting.

2) Distribute luminaires with a separation of 2 m to 3 m in each bay of 3 m to 4 m width.

3) Provide more supplementary lights such as twin tube luminaires in work areas where daylight is expected to be poor for example in the rear region of a room having single window.

<u>Following recommendations may be followed in the choice of light sources for different locations :</u>

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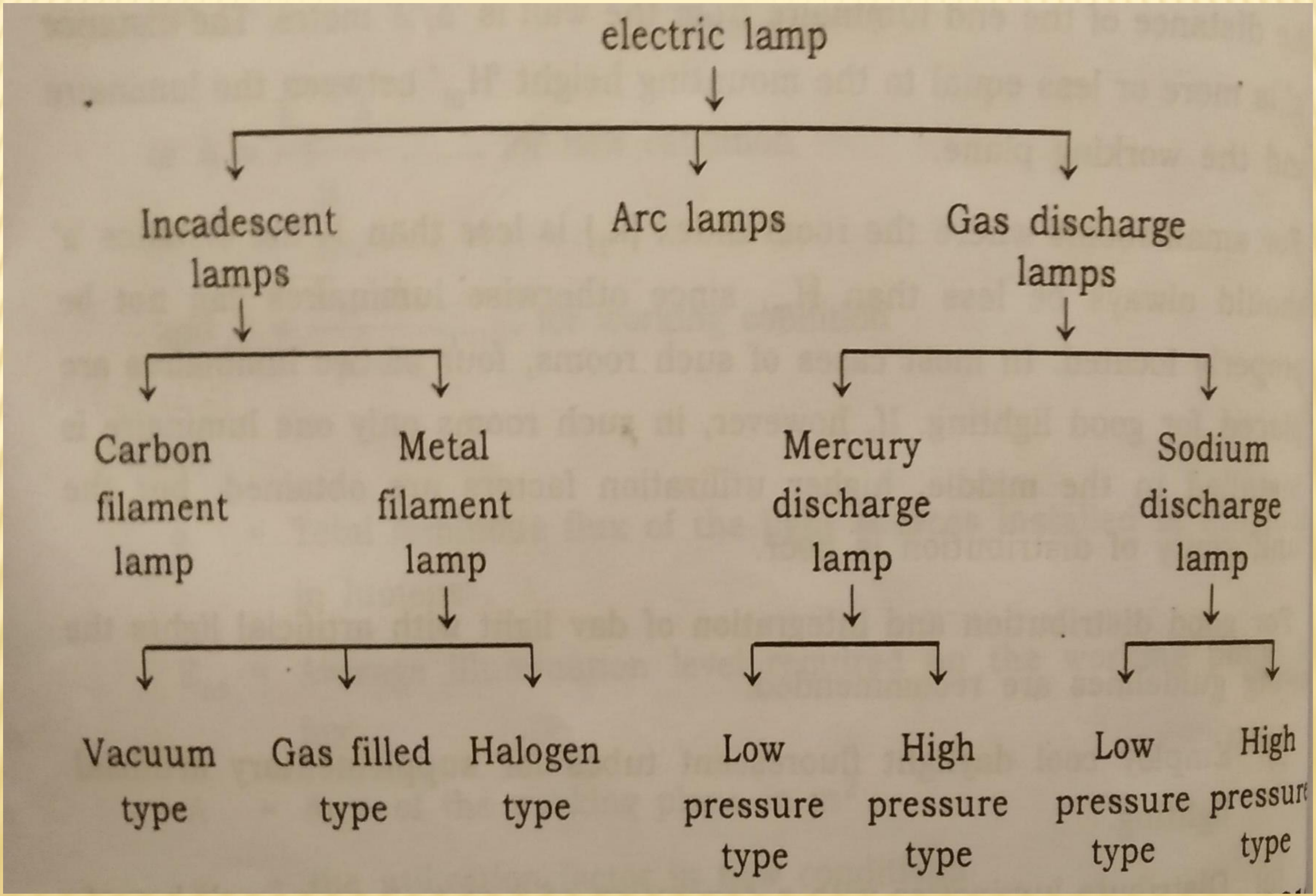
Various types of lamps used in lighting system are :



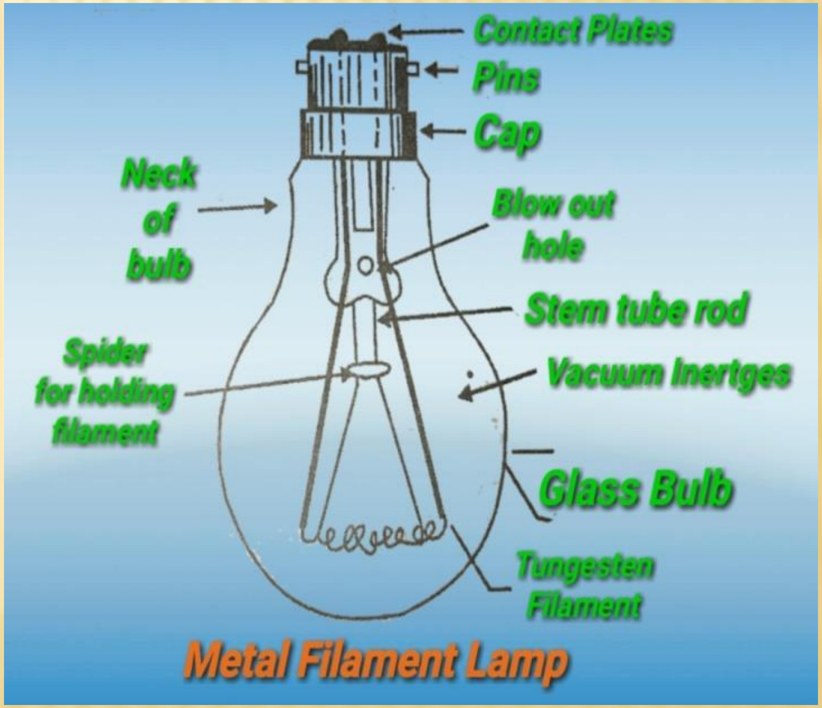
Incandescent lamps

Carbon filament lamp

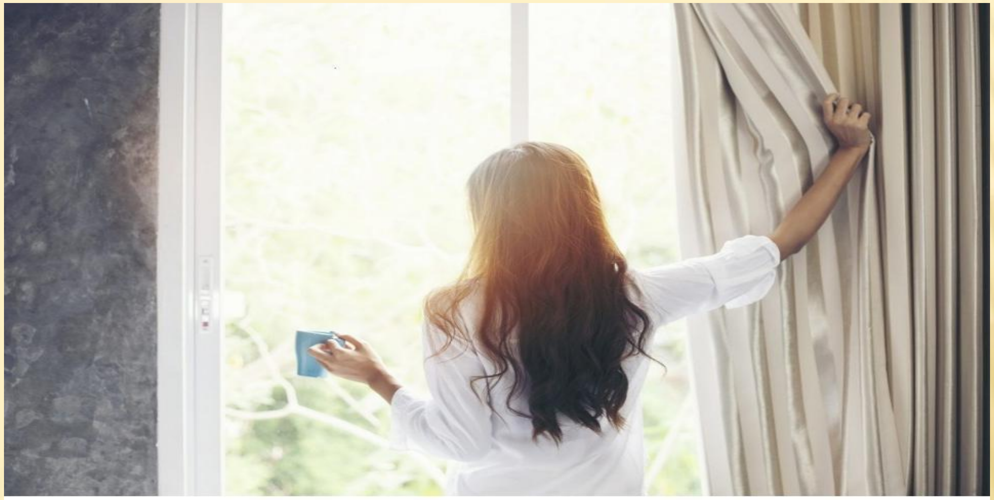
Gas discharge lamps

Mercury discharge lamps

SODIUM DISCHARGE LAMPS
CARBON FILAMENT LAMP



Necessity of ventilation :



Ventilation may be defined as supply of fresh outside air into an enclosed space or the removal of vitiated inside air from the enclosed space. Ventilation means the free passage of clean air in a building.

Necessity of ventilation :

Ventilation is necessary for the followings reasons :

1. Removal of carbon dioxide (co2) from the building. If the room is not properly ventilated, there will be excessive quantity of carbon dioxide in the air. The More the amount of co2,the more difficult is the breathing.

It is observed that breathing is difficult when the amount of co2 by volume is about 6 % and a man loses consciousness when it reaches about 10 % . For comfortable working, the co2 content in the building should not exceed 0.06 %.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2. To supply fresh air rich in oxygen.

3. To suppress odours, smoke and concentration of bacteria.
4. To reduce humidity inside the building and to prevent condensation of moisture on wall surfaces.
5. To control dust and other impurities in the air.
6. For removal of body heat liberated or generated by the occupants.
7. Prevention of suffocation conditions in conference rooms, committee halls, cinema hall, big rooms, etc.
8. Prevention of odour caused by decomposition of building materials.

Functional requirements of ventilation system :

From the point of view of human comfort, ventilation system should meet the following functional requirements :

1. Air changes
2. Humidity
3. Quality of air
4. Temperature

Air changes

In an enclosed space, where people are working or Living, air has to be changed for proper ventilation.
The minimum rate of air change is 1 per hour, while the maximum rate of air changes is 60 per hour.
An air change per hour is the volume of outside air allowed in the room per hour compared to the volume of the room.
If the rate of air changes is less than 1 per hour, there will be no ventilation, while if the rate occupants because of high velocity of air.
Cross ventilation is provided to increase the rate of air movement in a naturally ventilated building while fans, exhaust fans, air conditioning, etc. Are provided for mechanically ventilated buildings.]

Is : 3362 – 1965 recommends the following air changes in residential buildings :

(i) Living rooms and bed rooms - minimum 3 air changes per hour

(ii) Kitchen - minimum 3 air changes per hour

(iii) Bathrooms and water closets - minimum 6 air changes per hour

(iv) passages - no need as it is open

Table : Air changes per hour

Sr. No.	Application	Air change per hour
1.	Assembly halls	4 – 8
2.	Bath rooms	6 – 10
3.	Bed rooms	2 – 4
4.	Banks	4 – 8
5.	Cinema and theatres	10 – 15
6.	Club rooms	12 (min.)
7.	Conference rooms	8 – 12
8.	Factories and workshops	8 – 10
9.	Hospital wards	6 – 8
10.	Lecture theatres	5 – 8
11.	Libraries	3 – 5
12.	Restaurants	8 – 12
13.	School rooms	5 – 7
14.	Toilets	6 – 10
15.	Welding shops	15 – 30

Humidity **:**

Air contains certain amount of water vapour or humidity in it. Relative humidity is defined as the ratio of amount of water vapour present in the air to the amount of water vapour if the air is saturated at the same temperature.

Thus, the relative humidity of saturated air is 100 %. Relative humidity within the range of 30 to 70 % and the working temperature of 21°c is considered to be desirable.

For higher temperatures low humidity and greater air movements are necessary for removing greater portion of heat from the body.

3. QUALITY OF AIR :

- The ventilating air should be free from impurities, odours, organic matter and inorganic dust.
- It should also be free from gases such as carbon dioxide, carbon monoxide, sulphur dioxide etc.
- The ventilating air should not come from the vicinity of chimneys, kitchens, laterines, urinals, stables etc.
- The carbon dioxide content of air in residential buildings should not exceed 0.06 %.
- Air containing less than 0.5 mg of suspended impurities per M3 and less than 0.5 ppm of sulphur dioxide is considered to be clean and does not require further treatment.

4. Temperature :

It is desirable that the incoming ventilating air should be cool in summer and warm In winter, before it enters the room.
The temperature difference between outside and inside is kept not more than 8°c.
With regards to human comfort, the term ‘effective temperature’ is more useful.
It is an index which combines into a single value, the effect of air movement, humidity and temperature.
Effective temperature is the temperature of air at which a person will experience sensation of some degree of cold or warmth as in quite air fully saturated at the same temperature.
The common values of effective temperature in winter and summer are 20°c and 22°c respectively.

TYPES OF VENTILATION

There are two main systems of ventilation

1. Natural ventilation
2. Mechanical ventilation

Natural Ventilation

Natural ventilation is the one in which ventilation is effected by the use of doors, windows, skylights and ventilators.

This system is suitable for residential buildings and small houses. However, it is not for big buildings, offices, conference halls, auditoriums, large factories.

The rate of ventilation depends on two effects

Wind action

Stack effect

Wind action

- The rate of ventilation depends upon the direction and velocity o wind outside and sizes and location of openings.
- When wind blows at right angles to one face of a building, pressure-differences are created pressure is produced on windward face and negative pressure (or suction) is produced on leeward face.
- If the wind direction is at 45° to one of the faces positive pressure will be produced on two windward faces and negative pressure on two leeward faces.


Rate of ventilation

For determining the rate of ventilation based on wind action the wind may be assumed to come from any direction within 45 degree of the direction of prevailing wind. Ventilation due to external wind is given by the following.

FORMULA

$$Q = k\,A\,V$$

Where,

Q = Rate of air flow in m3/h

k = Coefficient of effectiveness

= 0.6 for wind perpendicular to openings

=0.3 for wind at an angles less than 45degree to the openings

A = free area of inlet openings in m^2

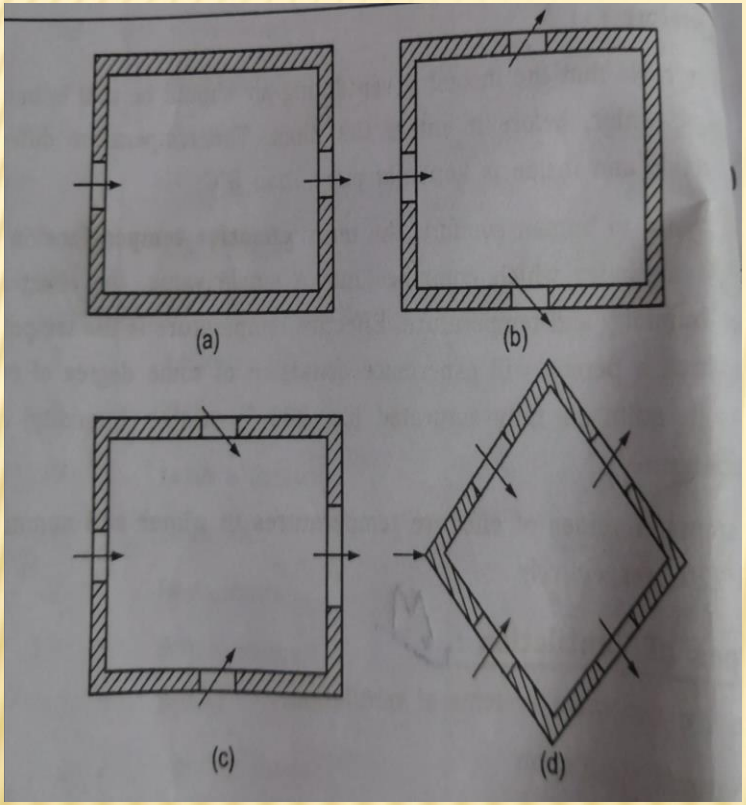
v = wind speed in m/h

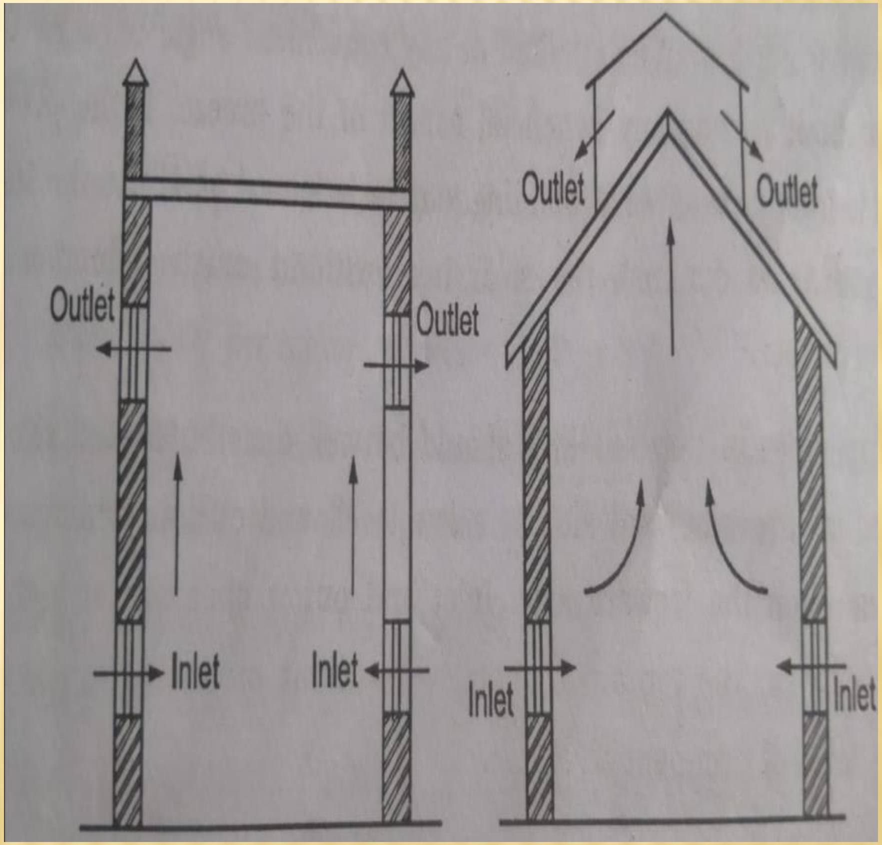
Stack effect

The rate of ventilation is effected by the convection effects arising from temperature difference between inside and outside of the room and the difference in the height between the and inlet openings.

When air temperature inside the room is higher than the outside, warmer air rises and passes through openings located in the upper part of the room whereas incoming cool air enters from the lower openings.

Movement of wind through building		Ventilation due to stack effect





Rate of ventilation

Ventilation due to convection effects arising from temperature difference between inside and outside of a room is given by $Q=7.0A\sqrt{h}(t_r - t_0)$

Where

Q = Rate of air flow in m3/h

A = Free area of inlet openings in m2

h = Vertical distance between inlets and outlets in m

t_r = Average temperature of indoor air at height h in ◦c

t_0 = Temperature of out side air in ◦c

Factors to be considered in the design of Natural Ventilation

A building need not necessarily be oriented perpendicular to the prevailing outdoor wind; it may be oriented at any convenient angle between 0^0 and 30^0 without loosing any beneficial aspect of the breeze.

If the prevailing wind is from east or west, building may be oriented at 45^0 to the incident wind so as to diminish the solar heat without much reduction in ail motion indoors.

Inlet openings in the buildings should be well distributed and should bf located on the windward side at a low level, and outlet openings should be located on the leeward side. Inlet and outlet openings at high level± may only clear the top air at that level without producing air movement at the level of occupancy.

- Maximum air movement at a particular plane is achieved by keeping the sill height of the opening at 85 percent of the critical height (such head level) for the following recommended levels of occupancy
- (1) For sitting on chair 0.75 m
- (2) For sitting on bed 0.60 m, and
- (3) For sitting on floor 0.40 m
- Inlet openings should not as far as possible be obstructed by adjoining buildings, trees, sign boards or other obstructions or by partitions inside in the path of air flow.

- In rooms of normal size having identical windows on opposite walls the average indoor air speed increases rapidly by increasing the width of window up to two-third of the wall width; beyond that the increase is in much smaller proportion than the increase of the window width.
- The air motion in the working zone is maximum when window height is 1.1 m. (vi)
- Greatest flow per unit area of openings is obtained by using inlet and outlet openings of nearby equal areas at the same level.
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- Greatest flow per unit area of openings is obtained by using inlet and outlet openings of nearby equal areas at the same level.

- For a total area of openings (inlet and outlet) of 20 percent to 30 percent of floor area, the average indoor wind velocity is around 30% of outdoor velocity.
- Further increase in window size increases the available velocity but not in the same proportion. In fact, even under most favorable conditions the maximum average indoor wind speed does not exceed 40 percent of outdoor velocity.
- Where the direction of wind is quite constant and dependable, the size of the inlet should be kept within 30 to 50 percent of the total area of openings and the building should be oriented perpendicular to the incident wind.
- Windows of living rooms should open directly to an open space. In places where building sites are restricted, open space may have to be created in the buildings by providing adequate courtyards.
- In the case of rooms with only one wall exposed to outside, provision of two windows on that wall is preferred to that of a single window.
- Windows located diagonally opposite to each other with the windward window near the upstream corner give better performance than other window arrangements for most of the building orientations.
- Provision of horizontal sashes inclined at an angle of 450 in appropriate direction helps to promote the indoor air motion. Sashes projecting outward are more effective than projecting inward.
- Air motion at working plane 0.4 m above the floor can be enhanced 30 percent using a pelmet type wind deflector.

- Roof overhangs help promoting air motion in the working zone
- VERANDAH open on three sides is to be preferred since it increase in the room air motion for most of the orientations of the building with respect to the outdoor wind.
- Air motion in a building unit having windows tangential to the is accelerated when another unit is located at end-on Position down stream side.
- (xvii) Air motion in two wings oriented parallel to the prevailing breeze promoted by connecting them with a block on downstream side.

- Trees with large foliage mass having trunk bare Of branches up to top level of window, deflect the outdoor wind downwards and promote air motion in the leeward portion of buildings.
- Ventilation conditions indoors can be ameliorated by constructing building on earth mound having a slant surface with a slope of 100 on upstream side.
- In case of industrial buildings the window height should be about 1.6 and width about two-third of wall width. These should be located at height of 1.1 m above the floor.

Mechanical ventilation or Artificial ventilation

Mechanical ventilation or Artificial ventilation involves the use some mechanical equipment for effective air circulation inside the building.

It is applied where natural ventilation is unsatisfactory in respect of quality, quantity and controllability.

This system is costly, but it results in considerable increase in the efficiency of persons.

The following system of Artificial ventilation are commonly used:

1. Exhaust system
2. Supply system
3. Conbination of exhaust and supply system
4. Ceiling fans
5. Air conditioning

Exhaust system

It is based on creation of vacuum in the room by exhausting the vitiated inside air by means of propeller type fans (exhaust fans).

The extraction of air from the room permits the fresh air to flow from outside to inside through openings (windows). This system is more useful in removing smoke, dust, odours etc. from kitchen, laterines, industrial plants etc.

Supply system (plenum system) :

In this system, fresh air is forced into the room and the vitiated air is allowed to leave through ventilators.

The incoming air which is mechanically forced into the room is passed through a fine gauge screen or filter.

A constant to stream of water is kept flowing down the screen giving a fine mist of water through which the air is drawn by means of blower fan.

Combination of exhaust and supply system

This is an extension of plenum system in which input fans are used to force fresh air inside the room while extraction fans are used for the exit of the vitiated air from the room.

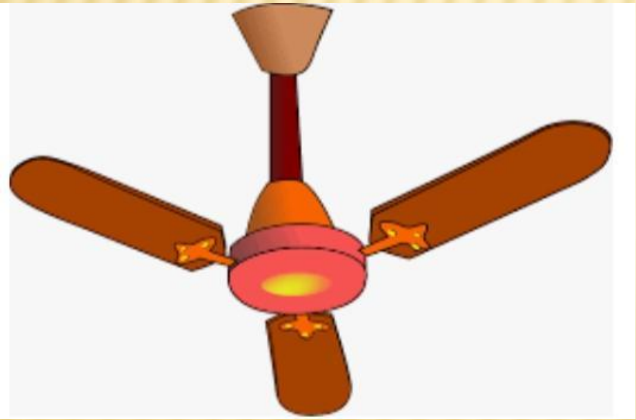
This system is adopted where the delivery of fresh air is either sluggish or where it is desired to discharge vitiated air containing obnoxious fumes as from kitchens, latrines or various manufacturing processes in specially isolated areas.

Ceilling fans

Almost all types of houses and offices use fans in bedrooms, and office area.

Variety of fans like-ceiling fan, table mounted fan, pedestal fans, wall mounted fans are available in the market.

Air circulation by ceiling fans covers normal area of 9 to 10 m2. Ceiling fans are widely used in all premises for the purpose of ventilation.



Air – Conditioning

Air conditioning is the best system of artificial ventilation in which provision is made for filtration, heating or cooling, humidifying or dehumidifying etc thus creating most comfortable working conditions.