IS 3362 (1977): Code of practice for natural ventilation of residential buildings [CED 12: Functional Requirements in Buildings]

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CODE OF PRACTICE FOR NATURAL VENTILATION OF RESIDENTIAL BUILDINGS

(First Revision)

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Indian Standard
CODE OF PRACTICE FOR NATURAL VENTILATION OF RESIDENTIAL BUILDINGS
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 31 October 1977, after the draft finalized by the Functional Requirements in Buildings Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Provision for ventilation becomes necessary for the supply of fresh air for breathing, for dilution of inside air for control of odours, for the removal of products of cumbustion and for maintaining satisfactory thermal environments (*see* **3**). Therefore due consideration should be given on designing ventilation requirements of residential buildings. For the maintenance of satisfactory thermal environments in the residential building by means of ventilation, it is necessary to take into consideration the climate of the region in which the building is located. In hot and arid regions, the main problem in summer is to provide protection from sun's heat so as to keep the indoor temperatures lower than outside; and for this purpose windows and doors are generally kept shut and only minimum ventilation is provided for the control of odours or for removal of products of cumbustion. Again in hot and humid regions, the prime object in the design of residential buildings is to provide free air movement and to keep the indoor temperatures lower than outside, and for this purpose the buildings are oriented to face the direction of prevailing winds and windows and doors are kept open in both windward and leeward sides to provide large amount of ventilation. In the colder parts of the country in winter months again the windows and doors are kept shut particularly during the nights and only minimum ventilation is provided for the control of odours and for the removal of products of combustion.

0.3 This standard was first issued in 1965. In view of the experience gained in the country in this field, the Committee responsible for the preparation of this standard felt the necessity for its revision. In this revision, the definitions for comfort ventilation, permanent ventilation and indoor wind speed have been added. Requirements for comfort ventilation for hot humid regions, details regarding the calculation of probable indoor wind speed and some typical illustrative examples have also been included. The provision of general rules for natural ventilation have been modified.

0.4 This standard is one of a series of Indian Standards on functional requirements of buildings.

0.5 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 covers the essential factors necessitating ventilation, minimum standards of ventilation and factors affecting ventilation. The standard also recommends certain rules and guidelines in the design of residential buildings for natural ventilation. It also describes briefly the methods of calculating rate of airflow and probable indoor wind speed in residential buildings.

2. TERMINOLOGY

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

2.1 Air Change per Hour — The ratio of the volume of outside air allowed into a room in one hour to the volume of the room.

2.2 Dry Bulb Temperature — The temperature of the well ventilated air, read on thermometer placed in such a way as to avoid errors due to radiation.

2.3 Humidity, Absolute — The mass of water vapour per unit volume.

2.4 Humidity, Relative — The ratio of the actual to the partial pressure of the water vapour at the same temperature.

2.5 Indoor Wind Speed — The average of wind speeds measured at symmetrically distributed points on a horizontal plane in the normally occupied zone (a region lying between 0·6 to 1·2 m above the floor).

2.6 Openings — These are openings in the buildings provided for ventilation purposes.

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

2.7 Stack Effect — Convection effect arising from temperature or vapour pressure difference (or both) between outside and inside of the room and the difference of height between the outlet and inlet openings.

2.8 Ventilation — Supply of outside air to the interior for air motion and replacement of vitiated air.

2.8.1 *Comfort Ventilation* — The ventilation necessary only during certain weather conditions for the purpose of improving thermal comfort.

2.8.2 *Permanent Ventilation* — The ventilation needed under all weather conditions.

2.9 Wet Bulb Temperature — The steady temperature finally given by a thermometer having its bulb covered with gauze or muslin moistened with distilled water and placed in an air stream of not less than 4·5 metres per second.

3. ESSENTIAL FACTORS NECESSITATING VENTILATION

3.1 Maintenance of Carbon Dioxide Concentration of Air Within Safe Limits and to Provide Sufficient Oxygen Content in Air for Respiration — Even in the worst ventilated rooms the content of carbon dioxide in air rarely exceeds 0·5 to 1 percent and is therefore incapable of producing any ill effect. The amount of air required to keep the carbon dioxide concentration down to 1 percent is very small. The change in oxygen content is also too small under normal conditions to have any ill effects, the oxygen content may vary quite appreciably without noticeably effect, if the carbon dioxide concentration is unchanged. The concentration of carbon dioxide or reduction in oxygen content is thus not sufficiently critical to provide a basis for fixing rates of ventilation for residential buildings.

3.2 Control of Odours — Odours are disturbing and when present they cause headache and loss of appetite. It is, therefore, desirable that rate of ventilation is estimated on the basis of removal of noticeable body odour and other odours such as from tobacco smoke, cooking, etc.

3.3 Removal of Products of Combustion — Products of combustion discharged from *CHULLAS*, stoves, gas appliances, etc, used in a kitchen are likely to accumulate there and may also permeate into other rooms. Similarly *ANGIHHIS* used for heating rooms in certain colder parts of the country result in the production of carbon monoxide and other gases. Natural ventilation can play here significant role in controlling concentration of these products of cambustion.

3.4 Maintenance of Satisfactory Thermal Environment in a Room — Environmental factors like air temperature, humidity and air movement together with some other factors, such as clothing, level of activity·

food, etc, have a direct influence upon bodily processes. Maintenance of thermal equilibrium of the body is very essential for securing thermal comfort and for avoiding heat stress. Heat transfer between human body and the environment occurs through conduction, convection, radiation and evaporation; the relative magnitude of each process varying with changes in ambient conditions. However, under hot environments, evaporation is most important process of heat loss from the human body for securing thermal comfort. As the room air or especially the air around body becomes more nearly saturated due to humidity it becomes more difficult to evaporate perspiration and a sense of discomfort is felt. A combination of high humidity and high air temperature proves very oppressive. In such circumstances even a slight movement of air near the body gives relief. It would, therefore, be desirable to consider a rate of ventilation which may produce necessary air movement.

4. MINIMUM STANDARDS FOR VENTILATION

4.1 Standards for Permanent Ventilation — Since the amount of fresh air required to maintain the carbon dioxide concentration of air within safe limits and to provide sufficient oxygen content in the air for respiration is very small, the minimum standards of ventilation are based on control of body odour or the removal of products of combustion depending on the requirements of each case.

4.1.1 Where no contaminants are to be removed from air, amount of fresh air required for dilution of inside air to prevent vitiation by body odours, depends on the air space available per person and the degree of physical activity; the amount of air decreases as the air space per person increases, and it may vary from 20 m^3 to 30 m^3 per person per hour. In rooms occupied by only a small number of persons such an air change will automatically be attained in cool weather by normal leakage around windows and other openings and this may easily be secured in warm weather by keeping the openings open.

4.2 Air movement is necessary in hot and humid weather for body cooling. A certain minimum desirable wind speed is needed for achieving thermal comfort at different temperatures and relative humidities. Such wind speeds are given in Table 1. Where somewhat warmer conditions can be tolerated without perceptible discomfort, minimum wind speeds for just acceptable warm conditions given in Table 2 may be followed. For obtaining values of indoor wind speed above 2·0 m/s mechanical means of ventilation may have to be adopted.

4.3 Recommended Values for Air Changes

4.3.1 *Living Rooms and Bed Rooms* — In case of living rooms and bed rooms, a minimum of three air changes per hour should be provided.

TABLE 1 DESIRABLE WIND SPEEDS (m/s) FOR THERMAL COMFORT CONDITIONS

(*Clause* 4.2)

Dry Bulb Temperature, °C	Relative Humidity (Percentage)						
	30	40	50	60	70	80	90
28	*	*	*	*	*	*	*
29	*	*	*	*	*	0·06	0·19
30	*	*	*	0·06	0·24	0·53	0·85
31	*	0·06	0·24	0·53	1·04	1·47	2·10
32	0·20	0·46	0·94	1·59	2·26	3·04	†
33	0·77	1·36	2·12	3·00	†	†	†
34	1·85	2·72	†	†	†	†	†
35	3·2	†	†	†	†	†	†

*None.

†Higher than those acceptable in practice.

TABLE 2 MINIMUM WIND SPEEDS (m/s) FOR JUST ACCEPTABLE WARM CONDITIONS

(*Clause* 4.2)

Dry Bulb Temperature, °C	Relative Humidity (Percentage)						
	30	40	50	60	70	80	90
28	*	*	*	*	*	*	*
29	*	*	*	*	*	*	*
30	*	*	*	*	*	*	*
31	*	*	*	*	*	0·06	0·23
32	*	*	*	0·09	0·29	0·60	0·94
33	*	0·04	0·24	0·60	1·04	1·85	2·10
34	0·15	0·46	0·94	1·60	2·26	3·05	†
35	0·68	1·36	2·10	3·05	†	†	†
36	1·72	2·70	†	†	†	†	†

*None.

†Higher than those acceptable in practice.

4.3.2 *Kitchens* — Large quantities of air are needed to remove the steam, heat, smell and fumes generated in cooking and to prevent excessive rise of temperatures and humidity. However, for the requirement of kitchen in which cooking is done for a family of not more than five persons, minimum rate of ventilation of about six air changes per hour shall be provided.

4.3.3 *Bathrooms and Water-Closets* — Considerable ventilation of bathrooms and water closets is desirable after use, and the equivalent of six air changes per hour should be provided.

4.3.4 *Passages* — The period of occupation of passages, lobbies and the like is very short and as such no special consideration is necessary in designing their ventilation system.

5. FACTORS AFFECTING NATURAL VENTILATION

5.1 The rate of ventilation by natural means through doors and windows and other openings depends on:

a) direction and velocity of wind outside and sizes and position of the openings (wind action), and

b) stack effect.

5.1.1 When both wind and stack pressure are acting, each pressure may be calculated as acting independently under conditions ideal to it and then a percentage be applied. However, ventilation in residential buildings due to stack pressure both in hot arid region and hot humid region appears to be insignificant and at any rate may be neglected, as when both wind pressure and stack pressure are acting, wind pressure effect may be assumed to be predominant.

5.2 The method for determining the rate of ventilation based on wind pressure and the probable indoor wind speed induced by wind action is given in Appendix A.

6. GENERAL RULES AND DESIGN GUIDELINES

6.0 A few of the important rules of natural ventilation and some of the guidelines for designing buildings for the best possible utilization of outdoor, wind indoors are given in **6.1** to **6.9**.

6.1 Inlet openings in the buildings should be well distributed and should be 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 levels may only clear the top air at that level without producing air movement at the level of occupancy.

6.1.1 Maximum air movement at a particular plane is achieved by keeping the sill height of the opening at 85 percent of the height of the plane. The following levels of occupancy are recommended:

a) For sitting on chair = 0·75 m

b) For sitting on bed = 0·60 m, and

c) For sitting on floor = 0·40 m.

6.2 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. The distance of such obstructions from the openings should conform to local building byelaws.

6.3 Greatest flow per unit area of opening is obtained by using inlet and outlet openings of nearly equal areas at the same level.

6.3.1 For a total area of openings (inlet and outlet) of 20 to 30 percent of floor area, the average indoor wind velocity is around 30 percent of outdoor velocity. Further increase in window size increases the available velocity but not in the same proportion. In fact, even under most favourable conditions the maximum average indoor wind velocity does not exceed 40 percent of the outdoor velocity.

6.4 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. Where direction of the wind is quite variable the openings may be arranged so that as far as possible there is approximately equal area on all sides. Thus no matter what the wind direction be, there would be some openings directly exposed to wind pressure and others to air suction and effective air movement through building would be assured.

6.5 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.

6.6 In the case of a room with only one wall exposed to outside, provision of two windows on that wall is preferred to that of a single window.

6.7 Windows located diagonally opposite to each other with the windward window near the upstream corner (as shown in cases 2 and 7 in Table 4) give better performance than other window arrangements for most of the buildings orientations.

6.8 Provision of vertical louvers increases the room air motion, provided that the vertical projection does not obstruct the incident wind.

6.9 Verandah open on three sides is to be preferred since it causes an increase in the room air motion for most of the orientations of the building with respect to the incident wind.

APPENDIX A

(*Clause* 5.2)

VENTILATION DUE TO WIND PRESSURE

A-1. EFFECT OF WIND PRESSURE

A-1.1 When wind blows at right angles to one face of a rectangular building on an exposed site, a positive pressure is produced on the windward face, and regions of negative pressure are created on the two sides just adjacent to the windward face of the building and on the leeward side. If the wind is incident oblique (at about 45°) to one of the faces, positive pressure will be produced on the two windward faces and the negative pressure on the two leeward faces.

A-2. CRITERIA FOR DESIGN

A-2.1 In designing a system of natural ventilation, the aim should be to make effective use of wind forces. Since these are not constant, being dependent on the speed and direction of the wind, it is obvious that the ventilation is likely to be variable in quantity. For design purposes the wind may be assumed to come from any direction within 30° of the direction of the prevailing wind.

A-3. RATE OF AIR FLOW

A-3.1 Considering the simple case of an isolated enclosure in which an opening is provided in each of two opposite walls, the rate of air flow through an opening, due to wind blowing on to the wall containing the opening, is given by the expression.

$$Q = KAV$$

where

Q = the rate of air flow in m³/h,

K = coefficient of effectiveness (*see* **A-3.1.1**),

A = area of smaller opening in m², and

V = wind speed in m/h.

A-3.1.1 The coefficient of effectiveness K depends upon the direction of the wind relative to the opening, and on the ratio between the areas of the two openings. It is maximum when the wind blows directly on to the opening and it increases with the relative size of the larger opening.

Figure 1 gives the values of *K* for various ratios of the areas of the two openings, for winds perpendicular to the opening and at 45° to it.

NOTE 1 — For data on outdoor wind speed at a place reference may be made to 'Climatological and Solar Data for Design of Buildings for Comfort in India', published by the Central Building Research Institute, Roorkee.

NOTE 2 — From the formula given under **A-3.1**, it may be noted that the flow through a square opening of side nearly 0·36 m, with an outlet of equal area, and a wind of 5 km/h blowing inclined at 45° to the opening, would amount to nearly 194 m^3/h approximately sufficient for a room of 4 × 4 × 4 m size.

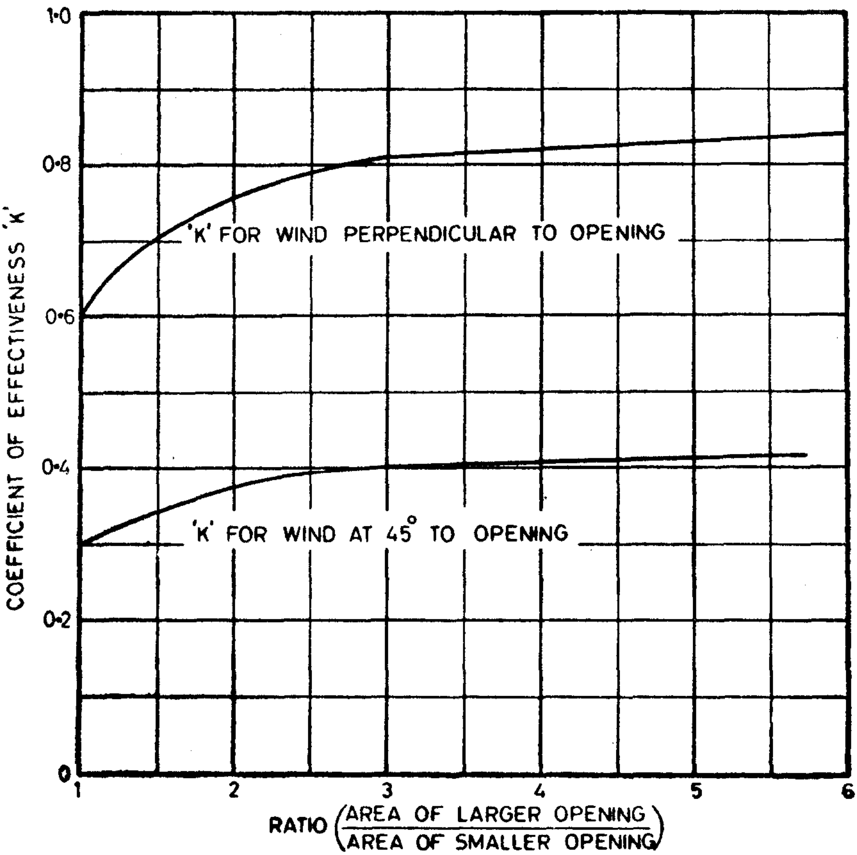


FIG. 1 VALUES OF COEFFICIENT OF EFFECTIVENESS 'K' FOR FLOW THROUGH TWO OPENINGS

A-4. PROBABLE INDOOR WIND SPEED

A-4.0 General — The simple conditions of an isolated enclosure in which an opening is provided in each of the two opposite walls seldom occur in practice, the problem being considerably complicated by the existence of openings into the building other than those in the room under consideration, and also by the effect of obstructions in the neighbourhood of the building, on the wind pressure distribution.

A-4.1 Room with Windows Only on One Wall

a) The available wind velocity in a room with single window on the windward side is about 10 percent of outdoor velocity at points up to a distance one-sixth of room depth from the window. Beyond this, the velocity decreases rapidly and hardly any air movement is produced in the leeward half of the room.

b) The average indoor wind velocity is generally less than 10 percent of outdoor velocity. The value however is increased up to 15 percent when two windows are provided instead of one and wind impinges obliquely on them.

A-4.2 Room with Windows on Two Sides

a) When identical windows are provided on opposite walls and one of the windows faces normally incident wind, the average indoor velocity at a plane passing through the sill of the windows 0·9 m above the floor, is determined from Fig. 2. For example, for windows with openings of 20 percent of the floor area, the average indoor wind velocity is about 25 percent of outdoor velocity.

NOTE — The value of local velocity at different points shows a deviation from the average taken over the whole room area. For window sizes normally used in practice, the root mean square deviation (RMSD) of local velocity from the average value may be obtained from Fig. 3. In this context a low value of RMSD connotes a more uniform air speed distribution in the room space whereas a high value of RMSD signifies very high air speeds at certain points in the air stream and very low air speeds at other points.

b) For a different sill height, the available average velocity (V_S) at the sill level may be computed using the equation:

$$V_S = V_{0 \cdot 9} + 0{\cdot}072\,(1 - S)\,V_0$$

where

$V_{0 \cdot 9}$ = average indoor wind velocity in km/h as determined from (a),

S = relative sill height with reference to normal sill height of 0·9 m, and

V_0 = outdoor wind velocity in km/h.

For example, for a sill of height of 0·75 m

$$S = \frac{0\cdot75}{0\cdot9} = 0\cdot83$$

and

$$V_s = V_{0\cdot9} + \cdot072\,(1 - 0\cdot83)\,V_o$$
$$= V_{0\cdot9} + \cdot0123\ V_o$$

c) When the sizes of inlet and outlet are not equal, the area of inlet should be first expressed as percent of the total area of openings and the corresponding value of performance efficiency (E) should be determined from Fig. 4. The average indoor wind velocity V should be then obtained by multiplying the value of E with that of V_s calculated in (b).

d) For obliquely incident wind the value of V determined in (c) should be multiplied by a factor given in Table 3.

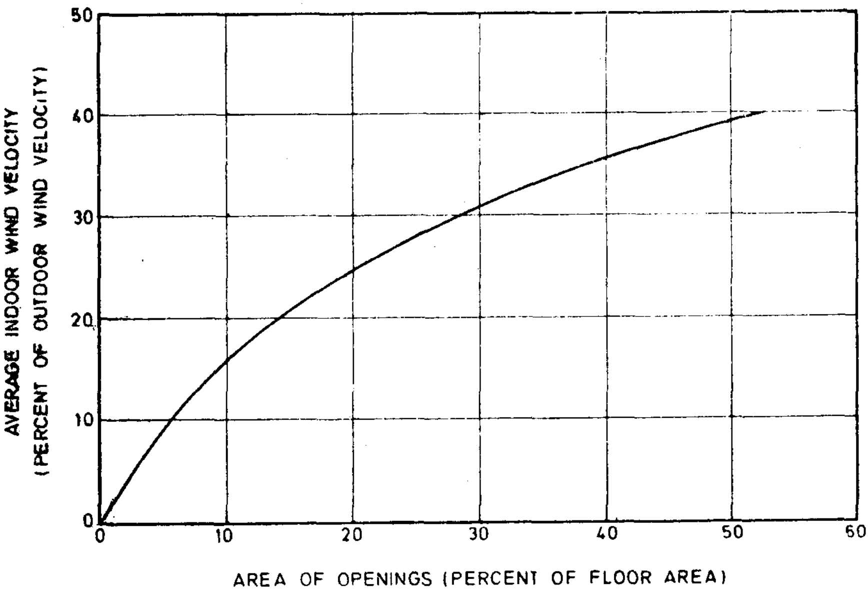


Fig. 2 Effect of Area of Openings on Average Indoor Wind Velocity

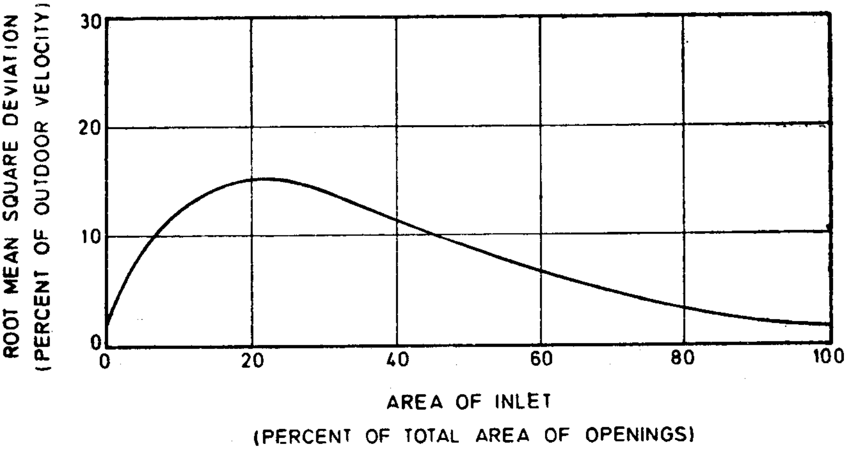


FIG. 3 EFFECT OF SIZE OF INLET ON ROOT MEAN SQUARE DEVIATION

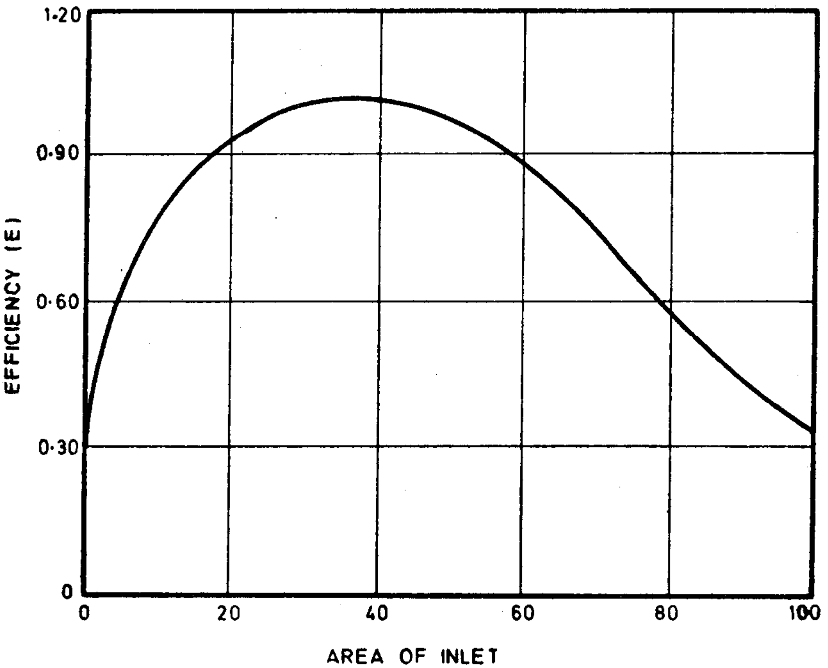


FIG. 4 EFFECT OF SIZE OF INLET ON THE PERFORMANCE EFFICIENCY

TABLE 3 EFFECT OF ORIENTATION ON INDOOR AIR MOTION

[*Clause* A-4.2(d)]

SL No.	RELATIVE SIZE OF OPENINGS	MULTIPLYING FACTOR FOR 45° INCIDENCE OF WIND
(1)	(2)	(3)
i)	Inlet > Outlet	1
ii)	Inlet = Outlet	Varying from 0·8 for area of openings 25% of floor area to 0·85 for larger area of openings.
iii)	Inlet < Outlet	0·7

e) The value of *V* determined in (d) is considerably influenced by change in the location of openings with respect to the outdoor wind. The factors representing the change in *V*, for some of the typical cases are given (as percentage of *V*) in Table 4. For a given window location and orientation, the average indoor wind velocity may be obtained by adding the corresponding factor to the value of *V* obtained in the foregoing steps.

f) Louvers which are provided for protection against rain and for prevention of direct entry of sun through the windows have a bearing on indoor air flow pattern. The influence of some simple types of louvers on room air motion is summarized in Table 5. Thus the average indoor wind velocity in a room with louvered window is obtained by adding the corresponding correction factors to the value of *V* obtained in (e).

g) The presence of a verandah on windward or leeward side of a room influences the room air motion. Table 6 shows the effect on average indoor wind velocity of some of the common types of verandah.

To get the value of average indoor wind velocity for the given type, location and orientation of a verandah, the correction factor may be taken from Table 6 and applied to the value of *V* obtained in (e). The value remains almost unaffected in case the verandah height is lower than that of the room.

h) The type of interconnection between different rooms and the location of the intermediate door play an important role in the establishment of indoor wind pattern. The value of average indoor wind velocity in a room of a multi-room house is determined by subtracting from *V* an appropriate value given [as percentage of *V* obtained in (f)] in Table 7.

NOTE — The correction factors given in different tables are applicable for the window sizes mostly used in practice. In case the building design details are not directly covered by this information, an appropriate value of the correction factor may be obtained by interpolation.

TABLE 4 EFFECT OF WINDOW LOCATION ON INDOOR AIR MOTION

[*Clause* A-4.2 (e)]

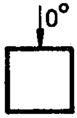
ORIENTATION → / WINDOW LOCATION ↓	CHANGE IN V (% OF V)	
		
	0	0
	-10	+40
	-10	-15
	-15	0
	-15	0
	0	0
	-10	+40
	-10	-15
	0	-60
	-20	-10
	-20	-60

TABLE 5 INFLUENCE OF LOUVERS ON INDOOR AIR MOTION

[*Clause* A-4.2 (f)]

Type of Louver	Change in V (Percent of V)	
	0°	45°
(1)	(2)	(3)
Chhajja	−20	−20
Horizontal and vertical	+5	+10
Box type:		
Contraction ratio 1 : 1	0	−25
Contraction ratio 2 : 1	0	0
Multiple horizontal	−10	−13
Multiple vertical	−15	−25

TABLE 6 EFFECT OF VERANDAH ON INDOOR AIR MOTION

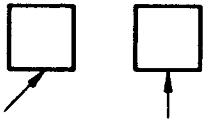
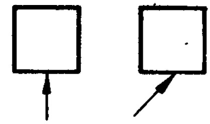
[*Clause* A-4.2 (g)]

Type of Verandah	Location of Verandah	Change in V (Percent of V)	
		0°	45°
(1)	(2)	(3)	(4)
Open on three sides	Windward	+15	+10
	Leeward	+15	+10
Open on two sides	Windward	0	0
	Leeward	0	0
Open side parallel to the room wall	Windward	- 10	−10
	Leeward	0	0
Open side perpendicular to room wall	Windward	−50	−30
	Leeward	0	+15

A-4.3 Illustrative Example — It is required to find out the probable average indoor wind velocity in the living room of two roomed house as shown in Fig. 5, when the wind is incident normally on the exposed side of the room. The living room has a floor area of 11·3 m². Area of the window opening on the exposed side is 1·6 m² and area of the window opening on the leeward side is 1·9 m².

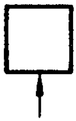
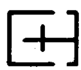
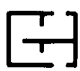
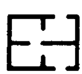
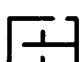
TABLE 7 EFFECT OF LOCATION OF INTERCONNECTING DOORS ON AIR MOTION IN ROOMS

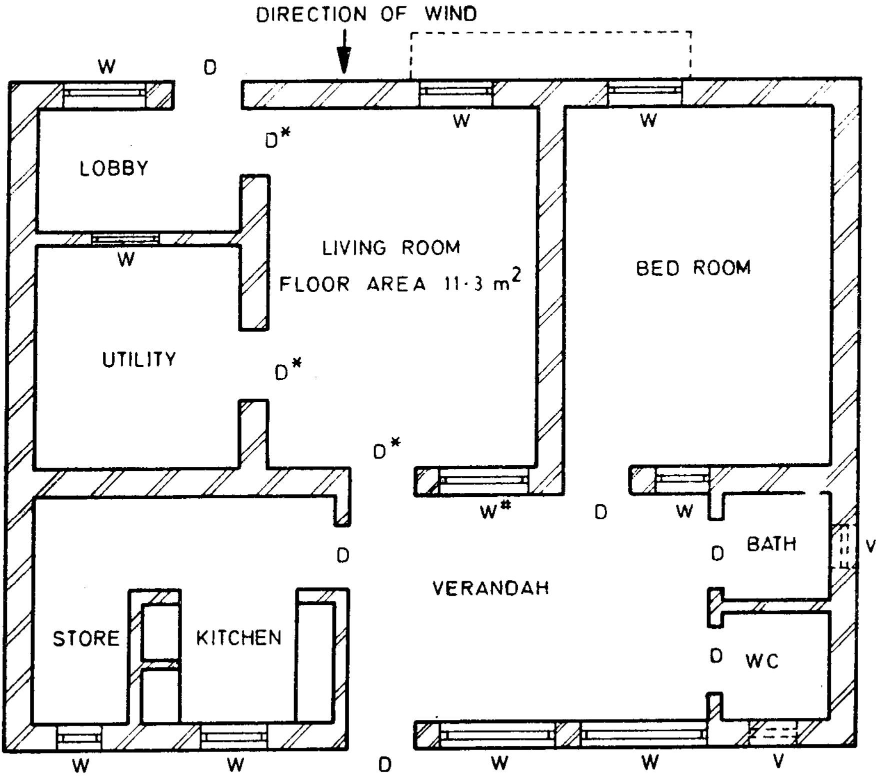
[*Clause* A-4.2 (h)]

		ORIENTATION → LOCATION OF INTER-CONNECTING DOORS ↓		
REDUCTION IN V (% OF V)			REDUCTION IN V (% OF V)	
			7·5 7·5	15 15
- -	- -		10 20	45 15
80 80	75 75		15 25	45 15
35 15	15 20		15 20	50 15
45 30	20 20		20 20	55 30
- 20	- 45		10 25	45 35
50 35	45 25		- 25	- 15
50 -	45 -		25 25	50 15
55 35	40 25		40 20	55 20

(*Continued*)

TABLE 7 EFFECT OF LOCATION OF INTERCONNECTING DOORS ON AIR MOTION IN ROOMS — *Contd*

		ORIENTATION ↔ LOCATION OF INTERCONNECTING DOORS ↓		
REDUCTION IN V (% OF V)			REDUCTION IN V (% OF V)	
25 15	15 15		15 30	40 15
- -	50 25		20 20	- -
- -	40 30		45 20	- -
- -	40 30		25 25	- -
- -	30 55		50 20	- -
- -	55 55		35 15	- -
- -	30 45		45 20	- -
- -	30 35		35 20	- -



D = Door, D* = Door shown closed position,
W = Window, V = Ventilator,
W† = Window of Area 1·6 m² and W‡ = Window of Area 1·9 m²

FIG. 5 PLAN OF A TYPICAL TWO ROOM HOUSE

Solution

a) Referring to Fig. 5

Size of the inlet	=	1·6 m²
Size of outlet	=	1·9 m²
Floor Area	=	11·3 m²
Total area of openings	=	3·5 m²
	=	31 percent of floor area

Total indoor wind velocity
($V_{0\cdot9}$) from Fig. 2 = 32 percent of outdoor velocity (V_0)

b) $\frac{\text{Size of inlet} \times 100}{\text{Total area of openings}} = 45$ percent

Performance efficiency from Fig. 3 = 100

Therefore $V_{0.9} = 0.32\ V_0$

c) Sill height in the present case = 0·76 m

Average indoor wind velocity V_s at a plane passing through the sill of window is given by

$$V_s = \left[0.32 + .072 \left(1 - \frac{0.76}{0.9}\right)\right] V_0$$
$$= 0.331\ V_0$$

d) Since the wind is incident normally and inlet is located almost in the centre of the wall, no correction is needed (Table 4).

e) Since the window is provided with a horizontal louver, the reduction in V_s as determined from Table 5 is 20 percent.

$$V_s = 0.331\ (1 - 20/100)\ V_0$$
$$= 0.265\ V_0$$

f) In the present case, the reduction in room air velocity due to series connection (as determined from Table 7) is 20 percent.

Final value of average indoor wind velocity

$$= 0.265\ (1 - 20/100)\ V_0$$

= 21·2 percent of outdoor wind velocity.

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