BUILDING DIGEST 130

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

FENESTRATION DESIGN FOR SCHOOL BUILDINGS (Warm and Humid Zones)

1. Introduction

A comprehensive fenestration system is important for the interior physical environment and functional design of buildings. The multiple functions of windows are to provide light, ventilation and view, etc. Integration of all these have always been a problem in its design. The present publication is an attempt to design fenestration, integrating the above parameters for different situations In school buildings all endeavour should aim at achieving a thermo-visual environment suitable for school children. The provision of natural ventilation indoor helps in mitigating thermal discomfort. It is more so in warm and humid conditions characterised by its equable weather and steady temperature. Resort is often made to electric fans when inside breeze is calm (i. e., less than 0.2 m/sec) or insufficient to provide thermal comfort.

The study is relevant for various cities classified under warm and humid climatic zones. The interaction of various parameters has been depicted by means of a multigraph. A worked example explains its use in ascertaining an optimum window design for a comfortable physical environment.

2. Design Considerations

The graph has been developed to cater for the following design situations :

1. Class room sizes 7.3 m × 6.0 m and 4.8 m × 6.0 m with ceiling height 3.05 m.

2. Three window sizes viz., (i) 75 cm × 135 cm, (ii) 105 cm × 135 cm and (iii) 135 cm × 135 cm with a sill height of 90 cm to 105 cm or 67 cm to 85 cm for furniture and squatting/sitting arrangements respectively.

3 23 cm brick wall and 11.5 cm RCC or RBC roof. 11.5 cm brick or 5.0 cm reed boards, panels with plaster on both sides as partition walls.

4. Room interiors, walls and ceiling painted with off-white and white respectively.

5. No internal and external obstructions in front of windows.

6. Various possible orientations with 1.8 m wide verandah, on one side of the class room.

7. Locations of windows : (i) on exposed wall, (ii) on two walls (exposed and verandah sides) except that windows on verandah side are at sill height 60 cm more than windows on exposed wall, and (iii) on two walls (i. e., on exposed and verandah side) with same sill height.

8. Windows assumed to remain open during school hours.

3. Multigraph

It represents the interdependence of various environmental parameters viz., daylight, wind speed and tropical summer index which are responsible for thermovisual environment in classrooms. These parameters could, in the graph, be quantified within given range and limitations for specific situations. The curves plotted in the four graphs 'A', 'B', 'C', and 'D' have been worked out to represent comprehensive values and to establish interrelationships between above mentioned environmental parameters. A set of values, in relation to the assumptions, could be arrived at for achieving optimum window design for warm and humid climatic regions of the country. Prevailing average monthly wind speed in the months of May and August for many of the important cities of India under this climatic zone is marked in the graph The specific situations and assumptions are also shown in the graph.

A brief description of the graphs 'A', 'B', 'C', and 'D' explains their functions, assumptions and limitations.

4. Graph 'A'

Interdependence of daylight levels with window size, their location and spacing, have been worked out in this graph. Daylight levels (lux) are indicated on vertical axis whereas the spacings between windows are given on horizontal axis. The values of lighting levels are based on the Indian Standard Code of Practice for Daylighting of Educational Buildings (IS-7942 : 1976).

The curves in the graph represent (a) three window sizes (viz., X, Y, Z) and are symbolised by continuous, continuous-dotted and dotted lines respectively, and (b) three different locations of windows as shown in Case 1, 2 and 3 with sill dimensions of 'H' in the section. These locations have also been elaborated in para 2.7.

5. Graph 'B'

The indoor wind speed is of great significance in controlling the indoor thermal environment for warm and humid climates. The windows, provided only on one side of classrooms, hardly contribute any air motion indoors. The maximum value of indoor wind speed would be less than ten per cent of the outdoor speed and upto not more than one-sixth of the room depth.

This graph provides inter-relationship between available indoor wind speed with window sizes and location. The ratios of average indoor wind speed to outdoor wind speed for various cases are indicated on vertical axis whereas the spacing of windows are given on horizontal axis.

Case (i) of para 2.7, in combination with any window size, has been found to produce negligible indoor speed irrespective of window sizes considered. Hence the corresponding curves have not been shown.

6. Graph 'C'

It helps in evaluation of absolute indoor wind speed for any specific location. The outdoor wind speed marked on the bottom axis of the graph is related to the cities from the data presented under the prevailing average monthly wind speed of such cities for the month of May and August.

The values of available indoor wind speed, expressed as a fraction of outdoor wind speed (ratio factor), are presented on left hand vertical axis of the graph. The various curves represent absolute values of outdoor wind speed ranging from 0.5 to 6.0 m per second at an interval of 0.5 m per second.

The intersection of ratio factor of indoor to outdoor wind speed, with curves of outdoor prevailing speed for various cities, gives the value of absolute wind speed available indoor on the top horizontal axis of the graph.

7. Graph 'D'

Tropical summer index is defined as the air temperature of anvironment with 50 per cent relative humidity at still air, imparting the same thermal sensation as the environment under consideration and has been presented on the vertical axis of the graph. The impact of various orientations, surface colours on exposed walls, etc., on the tropical summer index for varying absolute wind speed, is given in the Graph.

The curves represent various combinations of orientations, surface colours, etc., for various combinations designated as A, B, C, D, E, F, G and H as outlined in Table adjoining the graph.

The values of the absolute wind speed (metre per second) are given on horizontal axis, whereas the tropical summer index (°C) are given on vertical axis.

The intersection of absolute wind speed at the different curves gives the value of tropical summer index on Y axis. This depicts the state of comfort and discomfort in relation to thermal environment.

8. Working of the Graph

The following should first be decided :

(a) Size of the classroom, window sizes, location of windows, illumination level required.

(b) Region or city of location of the buildings.

(c) Orientation of the classroom, and whether roof is exposed or shaded and the finishes of the exposed walls.

Having decided the above parameters, proceed in the following manner :

Step 1

Select the level of illumination on the vertical axis

of Graph 'A'. Proceed horizontally and intersect the curve representing desired window sizes and window location. At the point of intersection proceed below to horizontal axis to find out the spacing between windows, which will provide the selected level of illumination. If the spacing is already decided the reverse process will quantify the illumination level.

Step 2

After determining the spacing of windows, proceed further below in Graph B and intersect the same combination of curve as in Graph A. At the intersection, proceed to right hand side to cross vertical axis, which will indicate ratio of indoor/outdoor wind speed. Proceed further to intersect such curve of the Graph C which represents the outdoor wind speed of the desired month (either May or August) of the required city.

Move upwards to cross the horizontal axis to know absolute indoor wind speed (m/sec.) Move further upward and cross the curve of the group representing desired room location, orientation and exposed surface colour. The crossing point will indicate the level of the comfort conditions i.e., whether it is comfortable zone or tolerable warm or it needs fan to be comfortable.

Again move right to intersect the vertical axis which will provide the Tropical summer index value.

9. Case Study

A case study has been worked out in order to demonstrate the working of the multigraph. The following are the assumptions :

(a) 150 lux Lighting level

(b) Window sizes of 75 × 135 cm.

(c) Windows provided on both the long walls as in case No. 3.

(d) Building situated at Trivandrum.

(e) Situation and location of Group E as mentioned in the Graph.

Fix up 150 lux lighting level at 'P' on the vertical axis of Graph 'A'. Move right and meet the curve 3X at 'Q'. Proceed downward to cross at horizontal axis at 'R' which indicates 115 cm spacing between windows to achieve 150 lux in the room. If any other spacing is already decided by designer it may be proceeded in reverse direction to find out the lighting level with the particular spacing between windows. From Point 'R' move downward in Graph B to cross 3X at 'S' and move towards right side to meet at 'T'. This indicates ratio of outdoor and indoor wind speed as 0.17. From the point 'T' move further to intersect the curve of 3 m/sec outdoor wind speed in the month of August in Trivandrum, at 'U'.

From the point 'U' move up to cross horizontal axis at 'V' which indicates absolute indoor wind speed as 0.5 M/sec.

Move further upward to cross the curve E (representing the group as shown in the drawing) at 'W'. This point indicates thermally comfortable zone. From the point 'W' move towards right to meet the vertical axis of Tropical Summer Index at 'X' which provides the value in comfort zone as 30.25° C.

The process can be repeated in reverse direction at any point if the requirement is known or desired.

There is a demand for short notes summarising available information on selected building topics for the use of Engineers and Architects in India. To meet the need, this Institute is bringing out a series of Building Digests from time to time and the present one is the 130th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

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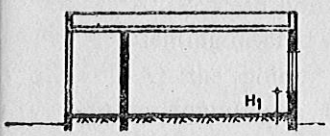
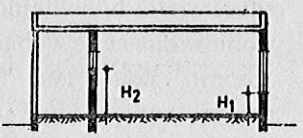
CASE 1



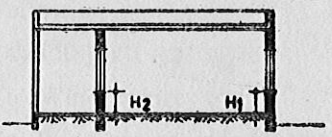
SILL HT H_1 = 82 cm
H_2 = 0 cm

CASE 2



SILL HT. H_1 = 82 cm
H_2 = 142 cm

CASE 3



SILL HT. H_1 = 82 cm
H_2 = 82 cm

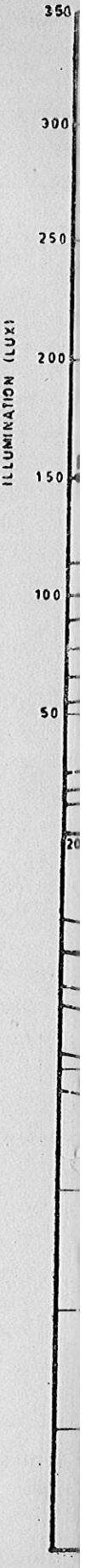
TYPE OF WINDOWS	SIZE (cm^2)	
———	75 x 135	X
——·——·——	105 x 135	Y
- - - - - -	135 x 135	Z

RECOMMENDED ILLUMINATION LEVELS FOR VARIOUS TASKS

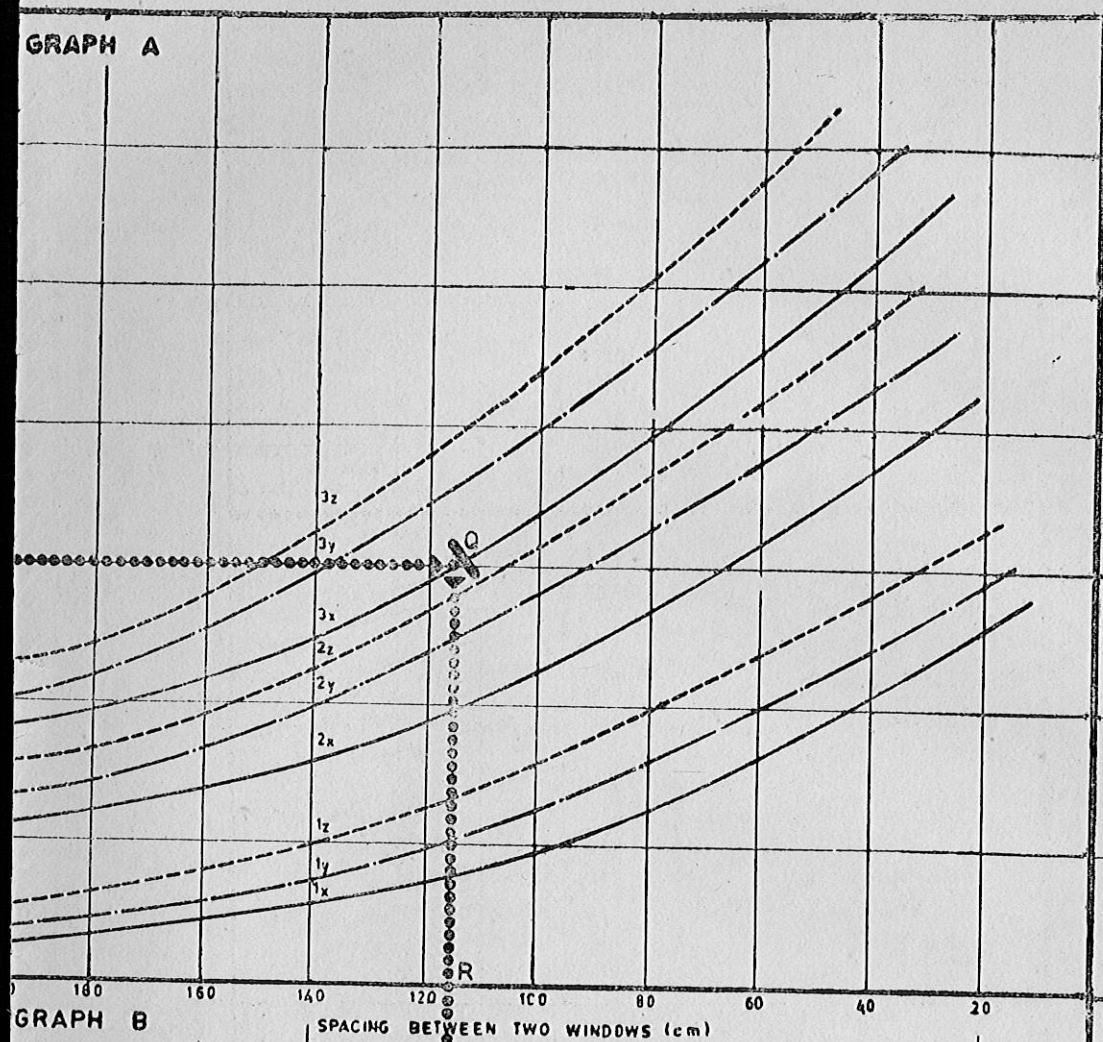
S NO	VISUAL TASK	MIN. ILLUMINATION (LUX)
1	CLASS DESK TOP	150
2	LIBRARY READING TABLES	150
3	DRAWING AND SEWING	300
4	CHALK BOARDS	150
5	MANUAL TRAINING	150
6	LABORATORIES	200
7	TOILETS	150

PREVAILING AVERAGE MONTHLY WIND SPEEDS M/SEC IN THE MONTH OF MAY AND AUG.

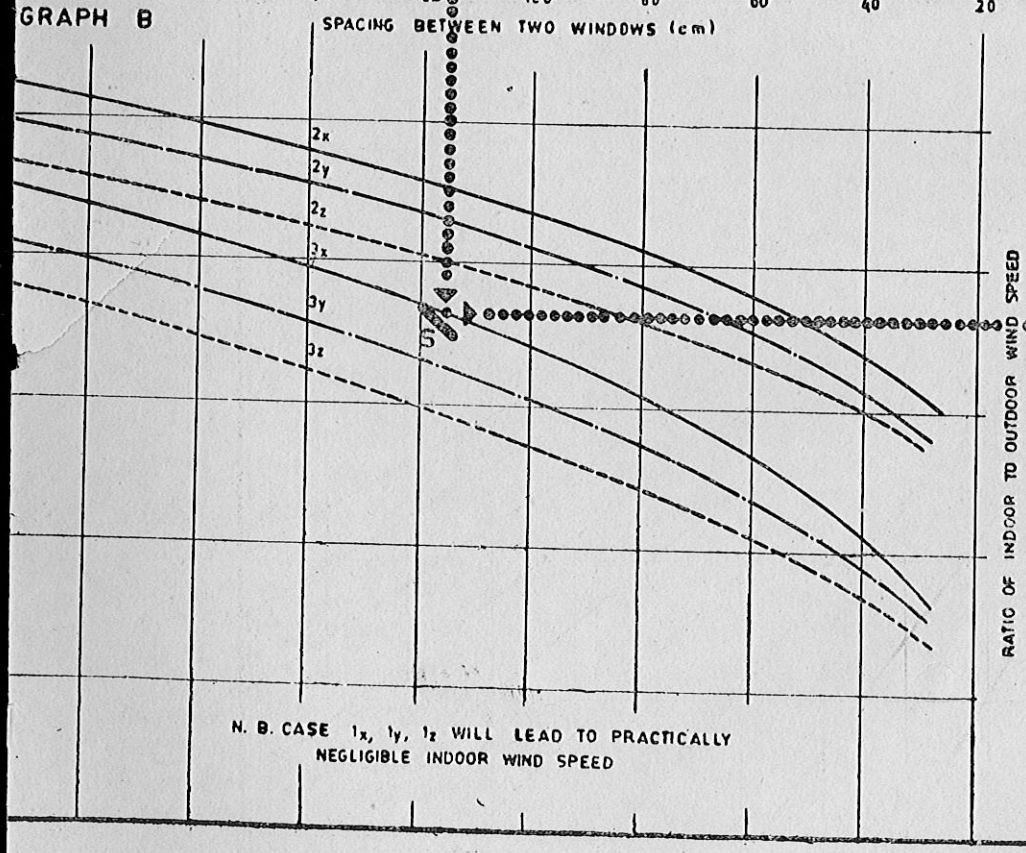
S NO.	MAY	AUG.		S. NO.	MAY	AUG.	
1	0·5	0·4	DIBRUGARH	12	2·5	2·1	MALDA
2	0·9	0·6	GAUHATI	13	2·5	3·3	BANGALORE
3	1·1	0·8	JAL PAIGURI	14	2·6	1·6	DHUBRI
4	1·7	1·3	BERHAMPUR	15	2·7	3·3	CHITALDURG
5	1·7	2·4	COIMBATORE	16	2·7	3·4	MYSORE
6	2·0	1·4	DARBHANGA	17	3·7	4·9	VERAVAL
7	2·1	2·4	BELGAUM	18	3·1	2·0	KHOZHIKODE
8	2·2	1·7	MOTIHARI	19	3·3	3·4	RATANGIRI
9	2·3	3·0	TRIVANDRUM	20	3·0	6·0	PORT BLAIR
10	2·2	2·4	COCHIN	21	5·1	5·6	DWARKA
11	2·5	2·0	MANGALORE	22	5·9	4·4	PURI



GRAPH A

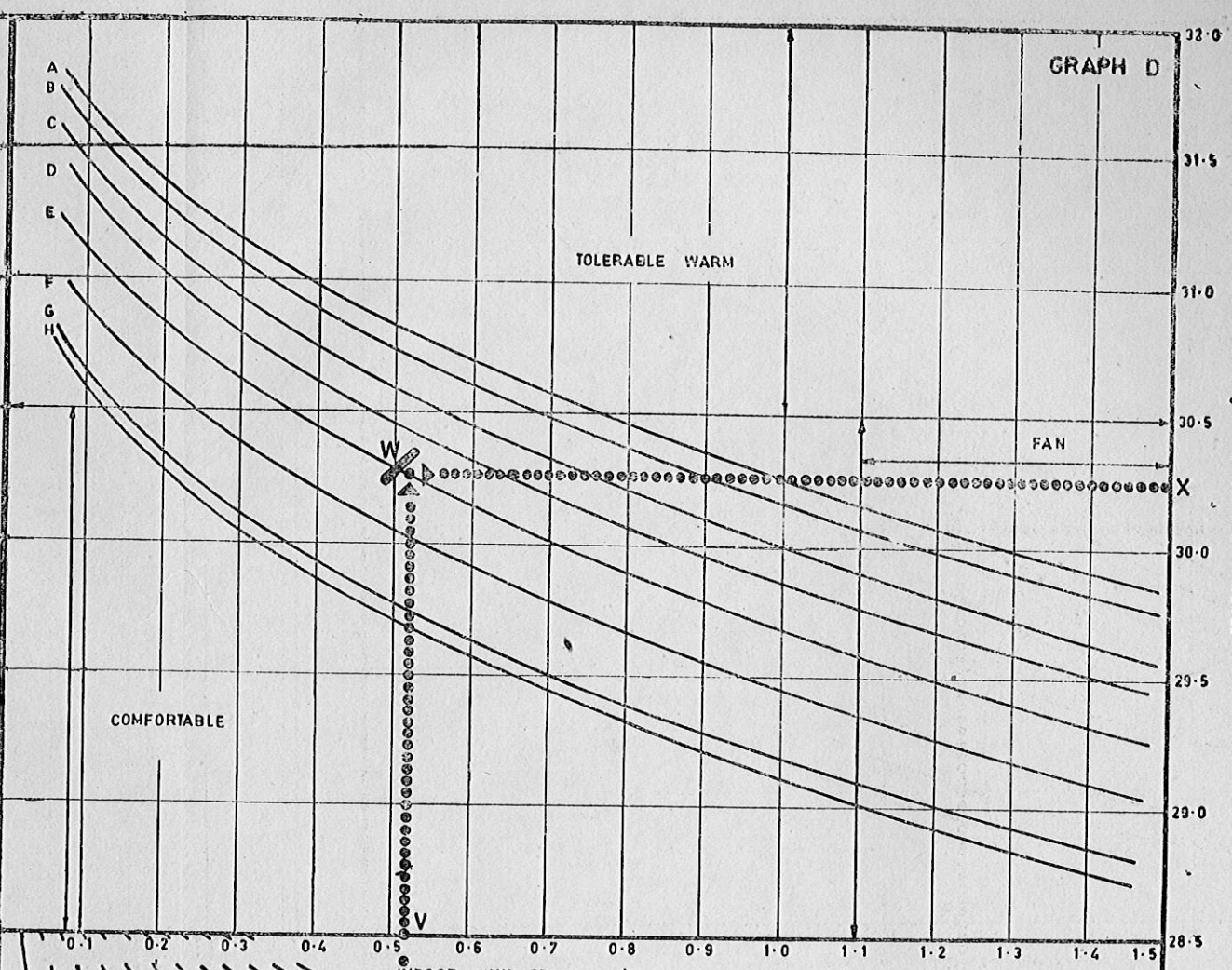


GRAPH B

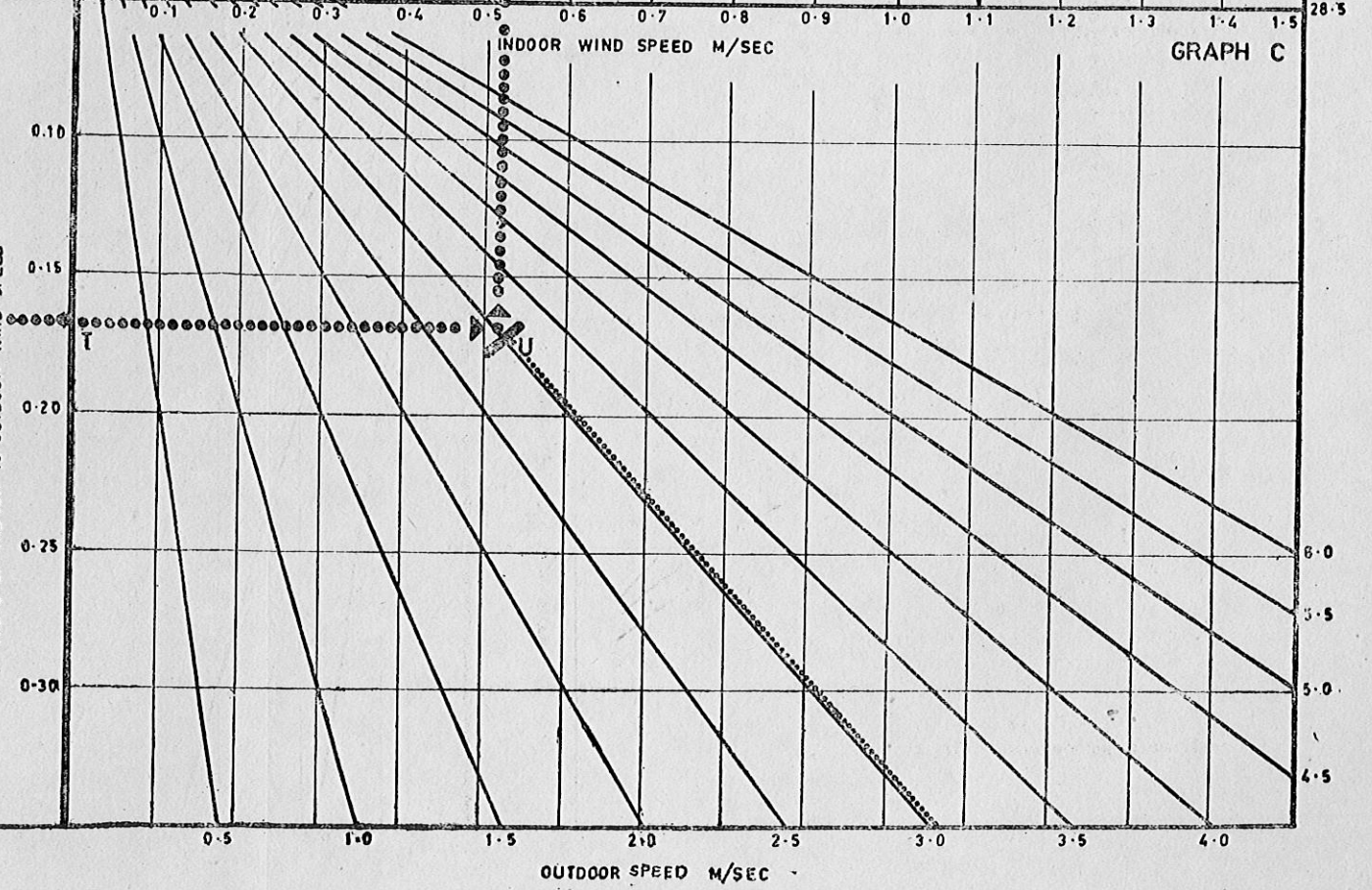


N. B. CASE 1x, 1y, 1z WILL LEAD TO PRACTICALLY NEGLIGIBLE INDOOR WIND SPEED

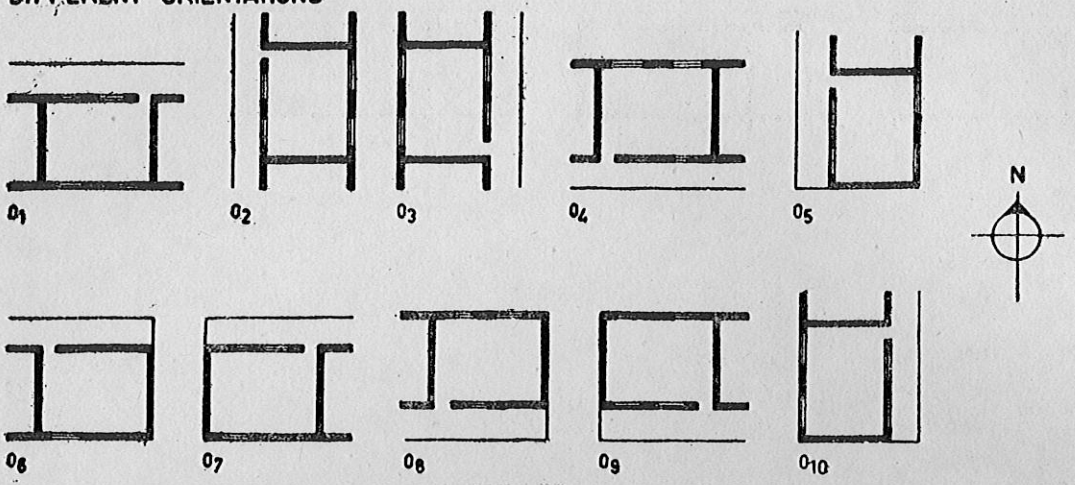
GRAPH D



GRAPH C



DIFFERENT ORIENTATIONS



DETAILS OF ORIENTATIONS, ROOF EXPOSED & EXPOSED WALL FINISHING

GROUP	PLANS AS ABOVE	ROOM LOCATION	EXPOSED SURFACE COLOUR
A	O_3	ROOF EXPOSD	DARK
	O_7	ROOF EXPOSED	"
	O_{10}	ROOF EXPOSED	"
B	O_2	ROOF EXPOSED	"
	O_6	ROOF EXPOSED	"
	O_5	ROOF EXPOSED	"
C	O_4	ROOF EXPOSED	"
	O_1	ROOF EXPOSED	"
	O_8	ROOF EXPOSED	"
	O_3	ROOF EXPOSED	LIGHT
D	O_2	ROOF EXPOSED	"
	O_6	ROOF EXPOSED	"
	O_9	ROOF EXPOSED	"
E	O_1	ROOF EXPOSED	"
	O_4	ROOF EXPOSED	"
	O_8	ROOF EXPOSED	"
F	O_{10}	ROOF SHADED	DARK
	O_7	ROOF SHADED	"
G	O_3	ROOF SHADED	LIGHT
	O_7	ROOF SHADED	"
H	O_8	ROOF SHADED	"
	O_1	ROOF SHADED	"

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