CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE-247667 (INDIA)

BUILDING RESEARCH NOTE

B.R.N. 01

INTEGRATED ENVIRONMENTAL DESIGN - OFFICE BUILDINGS

1.0 Introduction

A good physical environment inside office buildings is necessary for well being of workers and also for improving productivity. Maximum utilisation of natural means to provide an acceptable environment indoors is of vital importance from energy conservation consideration also. Design data given in this publication endeavours an integrated approach to provide advance information on the influence of design parameters on indoor environment in non-airconditioned office buildings in the country.

The study is relevant for tropical climate during summer, where air temperature above 32°C or humidity above 40% is an important atmospheric parameter dominantly influencing human comfort. The basis of this very classification not only simplifies the presentation but also helps designers in taking a decision at blue print stage.

2.0 Design Considerations

The information furnished in the publication deals with the following design situations.

2.1 Room width 3.0 to 4.5 m and depth varying from 6.0 m onwards, with ceiling height as 3.10m.,

2.2 Roof : 10.0 cm thick RCC with average 7.5 cm lime concrete and 1.5 cm cement plaster on ceiling.

or

10 cm thick RCC and 7.5 cm mud phuska with 5.0 cm thick brick tile over it.

2.3 Intermediate floor 10 cm RCC with floor finish.

2.4 Fenestration : Considering wide variations in office building plans, following cases have been accounted for in building layouts.

2.4.1 Hot and Dry climate : Windows are generally kept closed to avoid direct entry of hot air during most of the office hours. Closed in corridor type of office buildings are in practice. Uniform location of windows on exposed walls along bay width at a sill height of 0.9 m to 1.2 m above floor level.

2.4.2 Humid climate : Windows are kept open during office hours to augment ventilation for removal of sweat from human body.

Open plan type offices or open plan with cabins at one end or office plans with corridor on one side are normal practice. This facilitates natural ventilation. There are three variations

Case (A) Uniform location of windows on exposed and opposite walls (cross-ventilation) as sill height 0.9 m to 1.2 m above floor level.

Case (B) Windows on both walls at 0.9 m to 1.2 m sill height but with inclined horizontal lovers, open plan with cabin at one end.

Case (C) Windows on corridor side at a sill height from 1.2 m to 1.8 m above floor level.

For cases B and C Graph B curve can be used (as shown in Fig. 1)

2.5 Interior finishes : Walls and ceiling painted off white and white respectively. Floor either cement concrete or mosaic finish.

2.6 Provision of artificial light to achieve desired lighting levels in case of non-availability of natural light.

2.6.1 It caters for the following situations -

(a) Inadequate fenestration area.

(b) Working beyond normal daytime office hours.

(c) Presence of obstruction (50% shading due to external obstructions).

2.6.2 Lighting fittings (Luminaires) : 1.2 m long, 40 W or 36 W slim line cool daylignt fluorescent tube at mounting height of 2.2 m above floor level with

(a) Close end enamel trough, or

(b) Enclosed plastic diffuser type.

(c) Mirror optic reflectors

2.7 Exposed wall -

(a) 23.0 cm solid brick wall with 1.25 cm plaster on both sides or 30.0 cm stone block masonry wall.

(b) 11.5 cm solid brick wall with 1.25 cm plaster on both sides or 15 cm stone block wall with 1.0 cm lime plaster for interior finish, and

(c) The exposed surface colour is grey or equivalent reflectance.

2.8 Partition walls : 11.5 cm solid or perforated brick wall with 1.25 cm plaster on both sides or 14.0 cm hollow clay units, or 15 cm sintered fly ash concrete panels.

2.9 Stipulation of ceiling fans for thermal comfort has been worked out considering their mounting height, number, position and sizes.

2.10 Four cardinal orientations (viz : North, South, East and West) of building plan have been considered, with roof exposed (single storey or top floor of building) and shaded (Intermediate storeys in a multi-storey building).

3.0 Description of Multi-Graph

It represents the interdependance of various environmental parameters responsible for indoor physical environment of office buildings. The curves plotted in various graphs viz. A, B, C & D, (Fig. 1) and A, D, (Fig. 2) have been worked out for humid and hot dry climatic zones of the country respectively. Some of the important cities under these zones are listed in Table 1. These figures represent comprehensive values of various parameters and establish inter-relationships between them. A brief description of graphs A, B, C and D explains their functions, assumptions and limitations.

3.1 Graph A

It provides the number and location of ceiling fans and fluorescent lights along the central line of each room module, for various room depths and fenestrations, expressed as percentage of floor area. Number of ceiling fans and fluorescent lights more than specified, do not give proportionate advantage. Minor variations in the specified positions according to room depth will not make appreciable change in visual and thermal environment. The fenestration areas have been grouped into three main categories viz; 5 to 8%, 9 to 12% and 13 to 16% of floor area (Fig. 1) and 3 to 6%, 7 to 10% and 11 to 13% of floor area (Fig. 2). If fenestrations are provided on two opposite walls, in a very deep room total fenestration may be multiplied by 1.2 to obtain effective fenestration.

3.2 Graph B

Indoor wind speed is of great significance in augmenting evaporation from human body under humid conditions. The windows provided only on one side of the rooms (e.g. in closed-in corridor type office buildings) hardly contribute any natural ventilation indoors. Average indoor wind speed in such cases is limited to only about 10 percent of the outdoor wind speed and is confined only to one-sixth of the room depth.

Values of available indoor wind speed, expressed as a fraction of outdoor wind speed (ratio factor) are marked on the left hand vertical axis of the graph.

3.3 Graph C

It helps in evaluation of the absolute indoor wind speed for any specific case stated above. Outdoor wind speed inscribed on the bottom axis of the graph is related to the cities given in the data under the prevailing average monthly wind speed for the months of May and August (Table 1). Various curves represent absolute value of outdoor wind speed ranging from 0.5 to 6.0 m/sec, at an interval of 0.5 m/sec.

The intersection of ratio factor line with the curves of outdoor prevailing wind speed for various cities gives the value of absolute wind speed available indoors at work plane level as read on the top horizontal axis of this graph.

3.4 Graph D

It consists of curves indicating the influence of various design factors on subjective thermal sensation of the occupants. These curves represent orientations, wall thickness and roof conditions. The limits of subjective thermal conditions are shown along the left hand vertical axis of the graph.

Comfort conditions may be assessed on the North or East orientation curves for North-South or East-West orientation respectively.

Absolute wind speeds (m/sec) are given on horizontal axis. The intersection of these with different curves gives the assessment of thermal sensation pertaining to the specific situation.

3.5 How to Use

(a) Select room width as a multiple of module size varying from 3.0 m to 4.5 m in relation to total floor area and functional requirements. The floor area should also be a multiple of module size.

(b) Decide the fenestration (to be provided) as a percentage of module floor area, on individual module basis.

(c) Decide the city of location of the building.

(d) Decide the orientation and thickness of exposed wall and roof conditions (whether exposed or shaded).

(e) After considering all the above factors together, locate the light and fan points along the central line inside room module and connect the module with the percentage fenestration.

(f) Proceed further along the dotted line as shown in Fig. 1 or Fig. 2 as the case demands (Humid or Hot dry conditions respectively) to intersect the curves of required parameters.

(g) The intersection of specific curve in Graph D, Fig. 1 or Fig. 2, indicates the level of thermal comfort,

The evaluation process can be repeated or reversed to achieve fenestration percentage for comfortable environment indoors. When change in fenestration percentage is not feasible, the following remedies are resorted to in isolation or in combination :

(i) Change of building orientation.

(ii) Change of wall thickness.

(iii) Provision of shade on roof top (viz. Intermediate floor in multi-storey buildings).

Design decision arrived at by use of these multi-graphs will help in minimising energy required for obtaining thermo-visual comfort indoors during normal working hours.

TABLE 1. PREVAILING AVERAGE WIND SPEEDS (m/sec) FOR A FEW INDIAN CITIES

Hot & Dry			Hot & Humid			Warm & Humid		
Place	**May**	**Aug**	**Place**	**May**	**Aug**	**Place**	**May**	**Aug**
Agra	2.01	1.65	Ahmadabad	2.19	1.88	Barhampur	1.7	1.3
Ambala	1.65	1.03	Asansol	2.55	2.10	Belgaun	2.1	2.4
Ajmer	2.91	2.28	Aurangabad	4.42	4.53	Bangalore	2.5	3.3
Allahabad	2.10	1.92	Bombay	2.99	4.42	Coimbatore	1.7	2.4
Aligarh	2.32	1.83	Baroda	2.59	2.19	Cochin	2.2	2.4
Bareilly	1.30	0.64	Bhavnagar	3.22	2.82	Chitaldurg	2.7	3.3
Bhopal	2.46	2.28	Kolkata	2.24	1.55	Dibrugarh	0.5	0.4
Bikaner	2.82	2.82	Dohad	3.80	3.53	Darbhanga	2.0	1.4
Delhi	1.88	1.39	Jamshedpur	1.88	1.78	Dhubri	2.6	1.6
Gonda	2.28	1.61	Jamnagar	6.62	5.87	Dwarka	5.1	5.6
Gorakhpur	1.30	0.89	Madurai	1.92	1.70	Gauhati	0.9	0.6
Hissar	2.24	2.19	Mangalore	2.45	2.00	Jal Paiguri	1.1	0.8
Hyderabad	2.88	3.87	Masulipatnam	2.95	2.68	Khazi Kode	3.1	2.0
Indore	2.50	2.28	Chennai	5.27	4.78	Malda	2.5	2.1
Jabalpur	1.34	1.39	Patna	2.28	1.74	Motihari	2.2	1.7
Jaipur	2.69	2.01	Rajkot	5.05	4.36	Mysore	2.7	3.4
Jodhpur	4.70	4.07	Salem	1.60	1.65	Port Blair	3.8	6.0
Kanpur	3.53	2.86	Surat	2.95	2.64	Puri	5.9	4.4
Kota	1.83	1.52	Tiruchirapalli	2.06	2.77	Ratnagiri	3.3	3.4
Ludhiana	0.98	0.67	Vellore	1.70	1.79	Trivandrum	2.3	3.0
Lucknow	1.12	0.85	Vishkhapatanam	2.50	2.06	Voraval	3.7	4.9
Nagpur	2.95	2.54						
Roorkee	1.43	0.89						
Varanasi	1.74	1.43						

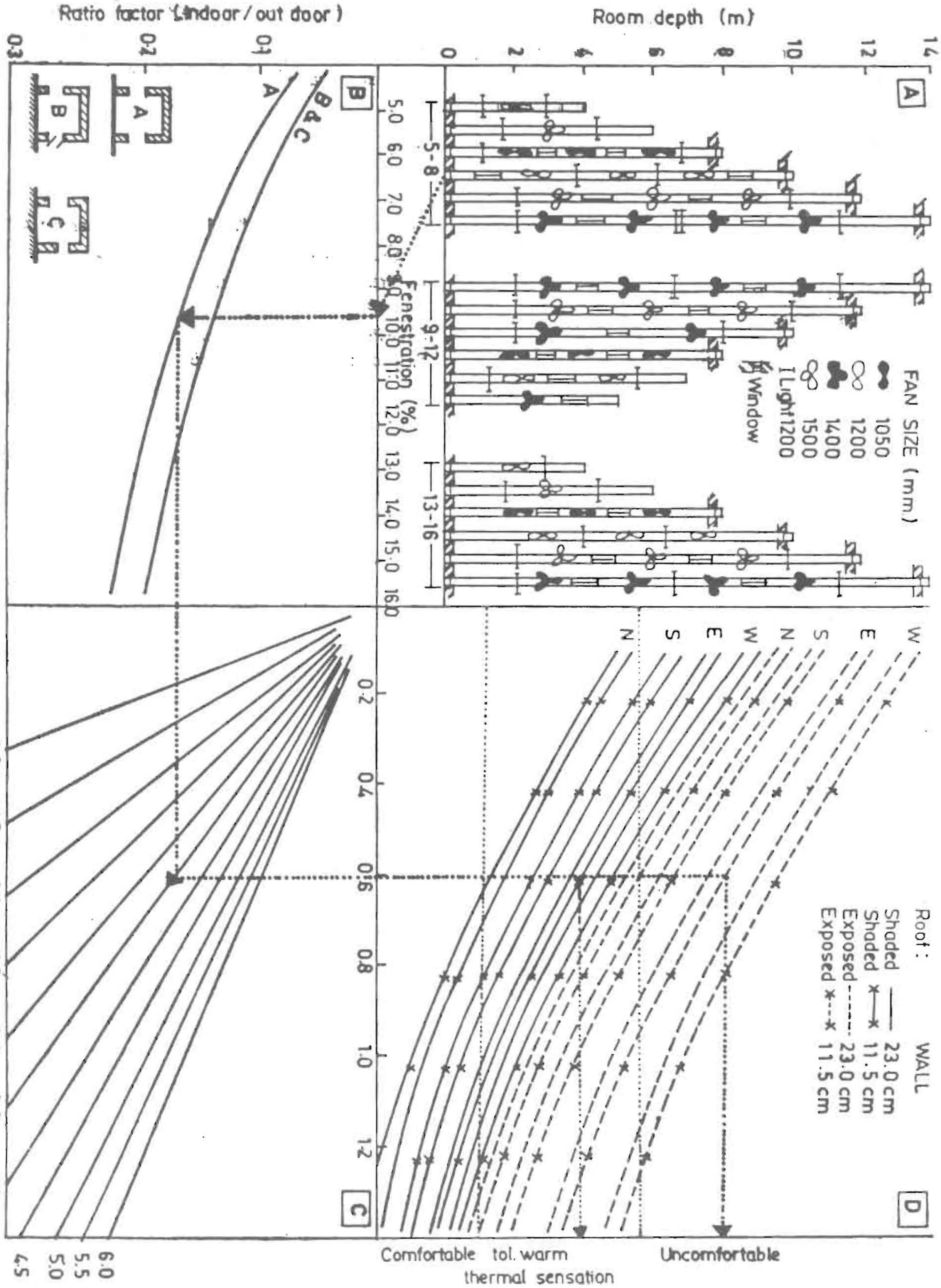
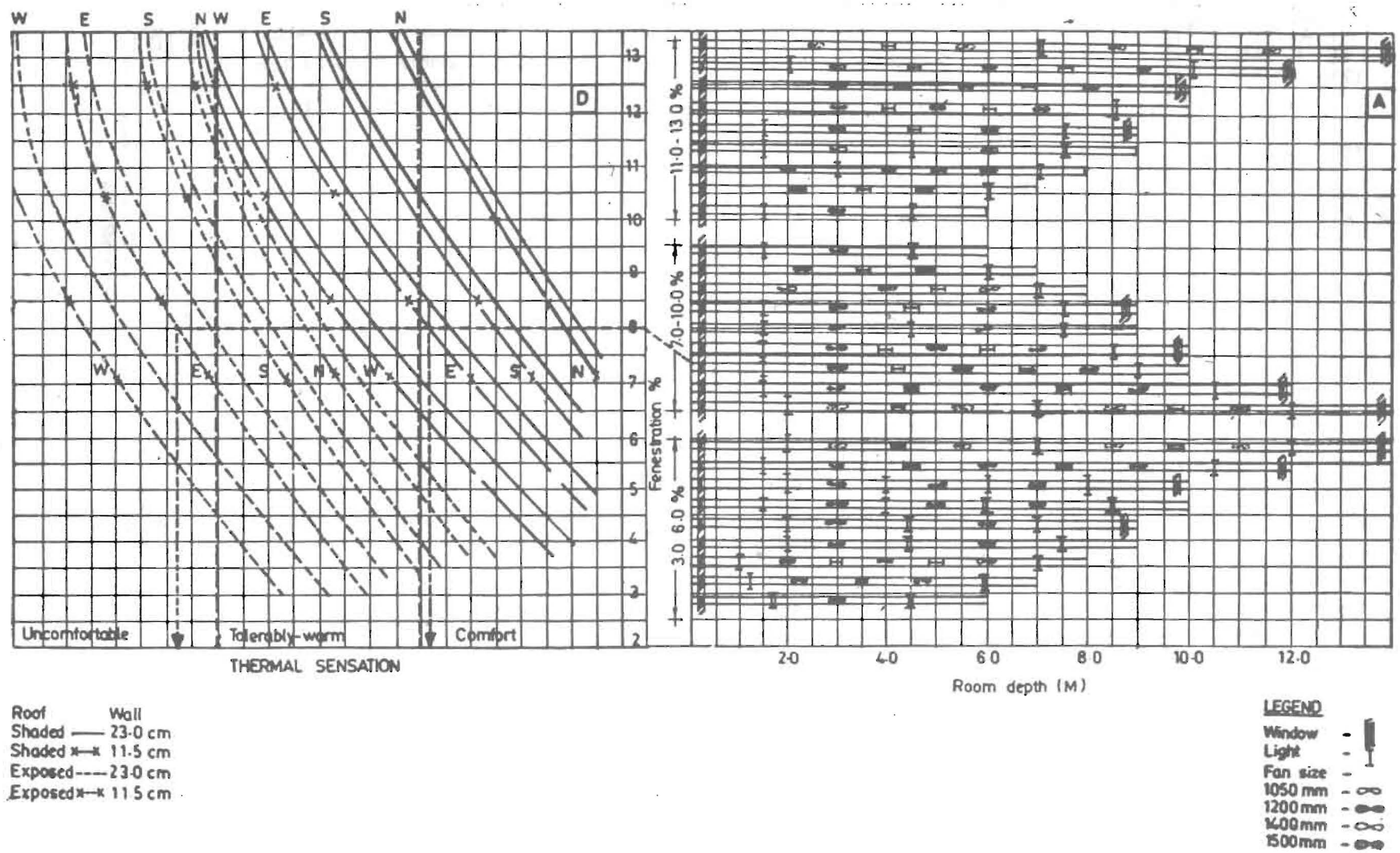

Room depth (m)
Ratio factor (indoor / out door)
FAN SIZE (mm.)
1050
1200
1400
1500
I Light 1200
Window
Fenestration (%)
5-8
9-12
13-16
Roof: WALL
Shaded 23.0 cm
Shaded 11.5 cm
Exposed 23.0 cm
Exposed 11.5 cm
B & C
Out door wind speed (M/Sec)
Comfortable tol. warm
thermal sensation
Uncomfortable
A
B
C
D

Fig. 1



W E S N W E S N
D
A
Uncomfortable
Tolerably-warm
Comfort
THERMAL SENSATION
Fenestration %
11.0 - 13.0 %
7.0-10.0 %
3.0 6.0 %
2.0
4.0
6.0
8.0
10.0
12.0
Room depth (M)
Roof Wall
Shaded —— 23.0 cm
Shaded x—x 11.5 cm
Exposed - - - - 23.0 cm
Exposed x--x 11.5 cm
LEGEND
Window
Light
Fan size
1050 mm
1200 mm
1400 mm
1500 mm

Fig. 2

Case Study

A module of room depth 10 m with provision of 8% fenetration has been selected. The requirement of fan size, and light points with their number and location can be found out from Graph A (Figs. 1 & 2).

Connect the module with 8 percent fenestration point. If fenestrations are provided on two opposite walls as in humid climate for taking advantage of natural ventilation, total fenestration may be multiplied by 1.2 to obtain the effective fenestration for assessment of indoor wind and thermal aspects (Fig. 1). Extend the point along the dotted curve to intersect the specified curve (11.5 cm thick wall; exposed roof and East orientation) in Graph D (Fig. 2). The comfort conditions in case of cross-ventilation may be assessed on the North or East orientation curve respectively Fig. 1.

It can be seen that intersection of the fenestration line with thermal sensation curves indicates that the nature of thermal condition falls under "uncomfortable". When roof is shaded it is found to be "Comfortable" Fig. 2 (D) with the same orientation and thickness of wall. In humid climate, by natural ventilation in the month of August in Mysore or Ratnagiri when outside wind speed is 3.4 m/sec, thermal condition is found to be "tolerably warm" Fig. 1.

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