Trans. Isdt & Ucds 5 (1) 72-79, 1980

(124)

THERMAL DESIGN OF BUILDINGS IN DESERT AREAS

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ABSTRACT

Desert areas are characterissed by high dry bulb mean temperature, low relative humidity, high solar radiation intensity on different surfaces and low mean temperatures during nights. Under such climatic conditions, the indoor environment in these areas are not comfortable. Upto a certain extent the indoor temperatures can be controlled by a careful planning and optimum thermal design of buildings.

The various factors that affect indoor air temperature are thermal performance of walls and roof, design of window for daylight and proper selection of shading devices. The paper deals with various measures to control indoor thermal conditions. Design of window and selection of proper shading devices for optimum daylight will also be discussed. Desert coolers will be very effective in these areas for providing thermal comfort indoors. These can also be used for night ventilation to cool the building without employing evaporative cooling.

INTRODUCTION

Indoor thermal conditions upto a rtain extent can be improved by judicious ection of building components, optimum ientation and proper design of glass areas d selection of shading devices. The main oblems requiring solution in the design thermal comfort for desert areas are minimising the flow of solar heat and reducing wall and roof surface temperatures under similar conditions.

MATERIALS AND METHODS

Thermal Performance of Building Components

In hot arid region mean maximum dry bulb temperatue exceeds 40% and relative

Table 1 Thermal Performance Standards.

Building Component		Hot Dry U	Hot Dry TPI	Hot Humid U	Hot Humid TPI	Warm Humid U	Warm Humid TPI
U.C.	(i) Exposed Wall	2.2	125	2.2	125	2.5	175
	(ii) Roof	2.0	100	2.0	100	2.0	125
C	(i) Exposed Wall	2.0	100	2.0	100	2.5	175
	(ii) Roof	1.5	75	1.5	75	2.0	125
		U	S				
	Window (UC)	4.5	0.5				
	Window (C)	4.5	0.3				

U.C — Unconditioned Building
C — Conditioned Building
S — Shade factors
U — Overall heat transfer coefficient, K. cal/hr^{0}C.m^2.
TPI — (Surface temp.—30) x 12.5.

humidity is less than 40% during peak summer months May & June. The thermal performance requirement of this type of climatic region are given in Table 1 under the category "Hot Dry". These are the maximum prescribed values and should not be exceeded. Representative towns under this category are given in I.S-3792-1966.

Thermal performance of a building section depends upon thermal properties, outside surface finish, orientation and climatic conditions. Here a thermal performance rating index (T.P.I.) has been evolved to evaluate the effects of different variables on indoor thermal conditions. Computed T.P.I. values of roof and wall constructions are given in building digests No. 94 and 101(2)3. From this a selection of the building components satisfying the minimum requirement can be worked out. T.P.I. values for any other component can also be calculated if required.

Heat Insulation of Roof

Heat insulating material can be applied externally or internally on the roof or ceiling respectively. In case of external application, insulating material should be protected by water proofing treatment. For internal application these materials can be applied either by an adhesive or false ceiling with an air gap may be employed. The optimum thickness of insulation both for flat and sloped roofs for different type of insulating materials have been worked out.

Table 2. Optimum thickness of insulation for roofs inHOT DRY CLIMATE in unconditioned (U.C) and conditioned (C) buildings

S. No.	Name and type of insulating material	Density Range kg/m3		Maximum Thermal Conductivity values	Optimum Thickness in Centimeters			
					FLAT ROOF		SLOPED ROOF	
		Min.	Max	Kcal/hr^{0}cm.	UC	C	UC	C
1	Cellular Concrete	320.0	350.0	0.070	5.0	7.5	—	10.0
2	Coconut Pith Concrete	500.0	600.0	0.075	5.0	7.5	—	10.0
3	Light Weight Bricks	400.0	450.0	0.070	5.0	7.5	—	10.0
4	Vermiculite Concrete	480.0	560.0	0.090	5.0	10.0	—	12.5
5	Wood Wool board	350.0	450.0	0.065	2.5	5.0	2.5	7.5
6	Foamtex	150.0	200.0	0.040	2.5	5.0	2.5	5.0
7	Thermocole	16.0	20.0	0.035	2.5	3.5	2.5	5.0
8	Fibreglass	24.0	32.0	0.035	2.5	3.5	2.5	5.0
9	Minéral wool	48.0	64.0	0.035	2.5	3.5	2.5	5.0
10	Fibre Insulation Board	200.0	250.0	0.045	1.5	2.5	1.5	20.5

These have been presented in table 2 alongwith the range of densities and maximum recommended thermal conductivity values.

like cellular concrete can also be used provided structural requirement is satisfied. Light calour distemper may also be applied on the exposed side of the wall.

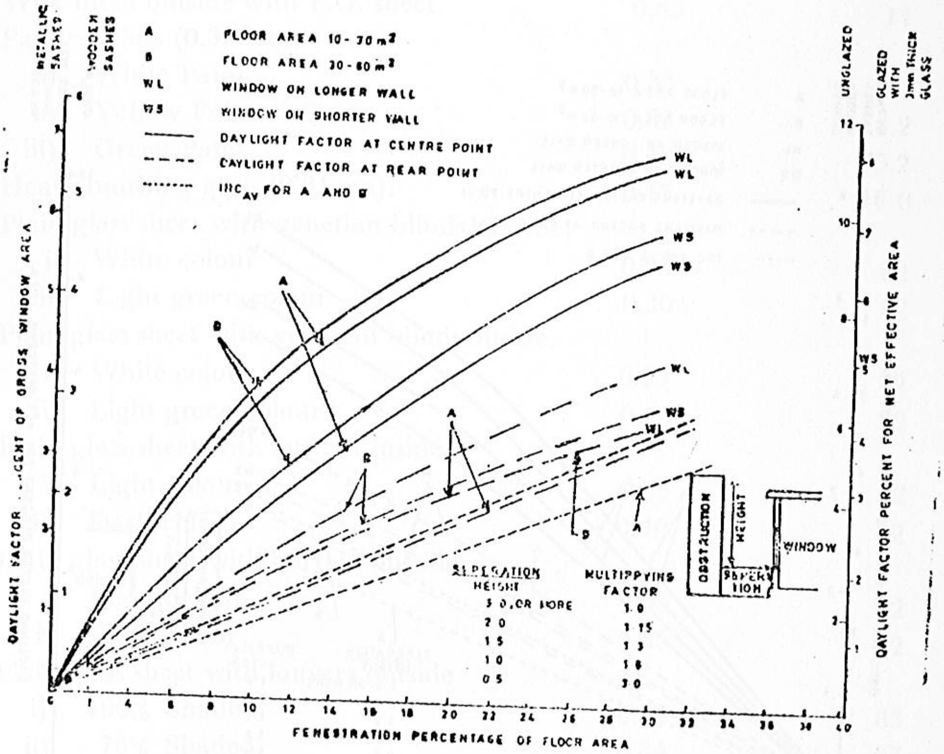

Fig. 1 Daylight factors on the working plane for a centrally located window

Thermal Insulation of Walls

Use of thermal insulating materials on wall is not recommended due to high cost of insulating materials. Shading of walls is very effective and economical method reducing heat ingress. Cavity walls, hollow bricks, light weight materials

Orientation of Building

The best orientation from the point of view of thermal comfort will be that of longer walls facing north and south (with long axis of a building along E.W.) which receive maximum solar rediation in winter and minimum in summer. Where best orientation is not possible for building,. the next choice for a compromise between solar heat gain and site condition the orientation may be provided with longer walls facing north-west and south-east.

ventilation(4) a good part of this glass area should be openable with possibility of cross ventilation through inlet and outlet openings (totalling 20 to 30% of the the floor area) on opposite. The maximum glass area is limited by consideration in reduction of heatflow.

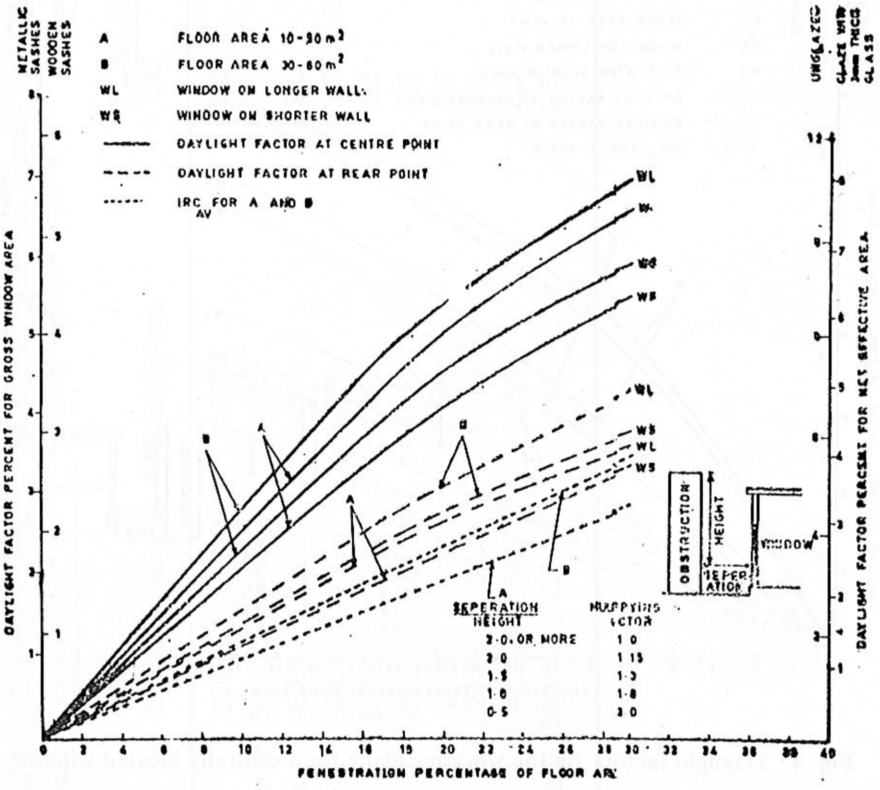

Fig. 2 Daylight factor on the working plane for a corner located window

DESIGN OF WINDOWS

While providing windows the minimum glass area for a building is mainly worked out according to the daylight requirement(6). For promoting natural

structure design and heating requirement during winter, minimum glass area (5) satisfying daylight requirement for different tasks are given in Fig (1) and (2).

Table 3. Measured Value of Shade Factors.

S.No.	Type of Shading devices	Shade Factor	% increase in cost over plain-glass window*
1.	Plain glass sheet (0.31 cm.)	1.0	0
2.	Wire mesh outside with P.G. sheet.	0.65	11
3.	Painted glass (0.32 cm).		
	i). White Paint	0.35	3.1
	ii). Yellow Paint	0.37	3.2
	iii). Green Paint	0.40	3.2
4.	Heat absorbing glass (0.31 cm).	0.45	16.0
5.	Plain glass sheet with venetian blinds outside.		
	i) White colour	0.25	62
	ii) Light green colour	0.30	62
6.	Plain glass sheet with venetian blinds inside.		
	i) White colour	0.35	62
	ii) Light green colour	0.40	62
7.	Plain glass sheet with curtain inside.		
	i) Light colour	0.35	12
	ii) Dark colour	0.40	12
8.	Plain glass sheet with curtain outside.		
	i) Light colour	0.30	12
	ii) Dark colour	0.35	12
9.	Plain glass sheet with louvers outside		
	i). 100% Shaded	0.14	83
	ii). 75% Shaded	0.34	67
	iii), 50% Shaded	0.56	48

* Cost of plain glass window is taken as Rs. 33.50 per sq.m.

SHADING DEVICES

Shading devices are generally classified in three groups (i) external shading devices such as louvers, verandah etc. (2) Internal shading devices like curtain, venetian blinds etc. (3) double glass and heat reflecting glasses. The effectiveness of these shading devices is evaluated in terms of shade factor and the cost of a shading device. The measured values of shade factor and increase in cost are given in table (3). The recommended value of shade factor for unconditioned building should not exceed 0.5 whereas for airconditioned building it should be 0.3. The required shade factor can be obtained by several combina-

Table 4. Design data for evaporative coolers.

S.No.	Fan diameter mm	Pad area m^2	Water tank capacity litres.	Cooling capacity tons.	Vol. cubicmeters of the room cooled.
1	300	1.3	40	1.00	30 to 50
2	400	1.5	60	1.2	40 to 60
3	400	1 9	80	2.0	80 to 120
4	450	2.1	90	2.2	80 to 140
5	450	4.0	140	3.0	100 to 180
6	600	4 8	180	3.2	120 to 200
7	600	5.5	200	3.6	150 to 250

tion of both internal and external shading. The computed values of shade factors for a combination of external and internal shading are given (7).

USE OF EVAPORATIVE COOLERS

The coolers employee blower or exhaust fan. The blower type of cooler consume more power and are less effective as compared to the exhaust fan type. Both the types of coolers are usually fitted with pump to lift water from the tank to this cooling pads. The requ'red cooling load of a building can be estimated from the knowledge of heat gain factors and climatic data (8). For this computed cooling capacity in tons the size of cooler (exhaust fan type) can be worked out from table (4). The required number of cooler can be adjusted depending upon the seating arrangements.

The performance of these cooler have been compaired with unit air conditioner during summer month, and found quite satisfactory. For same capacity of air conditioner, the average power consumption is found to 4 to 5 times lower.

In desert areas where the night temperatures are quite low these coolers can provide a source of cooling of building during night even if sufficient water is not available. Within a few hours the inside temperature of the building will be approximately equal to outside temperature.

ACKNOWLEDGEMENT

This paper forms a part of regular research programme of this Institute and is presented to the symposium with the permission of the Director, C.B.R.I., Roorkee.

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