SfB : Ab 8
UDC : 699.38

BUILDING RESEARCH NOTE

57

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

THERMAL PERFORMANCE OF BUILDING SECTIONS IN DIFFERENT THERMAL CLIMATIC ZONESS OF THE COUNTRY

Introduction

During these days of energy crisis it is important that the buildings are designed in such a manner that minimum energy ia needed during usages. In this context, proper selection of roof and wall materials and sections in a specific climate is significant to achieve comfortoble living and working conditions. The requirement for designing thermally comfortable building is minimum flow of solar heat into the building in summer and increase in heat flow in winter. In the present Research Note data on thermal performance of walling and roofing sections in different climatic zones of the country and cost index have been provided. Suggestions have also been made for likely treatment to improve the thermal performance of commonly used sections.

Climatic Zones

India is a large country comprising climates which vary from severely cold to very hot. From thermal consideration, the country has been divided into four climatic zones, namely, (a) hot and arid, (b) hot and humid, (c) warm and humid and (d) cold zone. These zones are based on the following criteria as given in IS Code of Practice 3792-1978

(a) **Hot and arid zone**—Regions where mean daily maximum dry bulb temperature equals or exceeds 38°C and relative humidity does not exceed 40 per cent during the hottest month of the year.

(b) **Hot and humid zone**—Regions where mean daily maximum dry bulb temperature ranges between 32-38°C and relative humidity exceeds 40 per cent during the hottest month of the year.

(c) **Warm end humid zone**—Regions where mean daily maximum dry bulb temperature ranges between 26-32°C, and relative humidity exceeds 70 per cent during summer months.

(d) **Cold zone**—Regions where mean daily minimum dry bulb temperatures are 6°C or less during the coldest month of the year.

Performance Criteria

In order to achieve desirable thermal conditions in the buildings in different zones, the maximum acceptable values of overall thermal transmittance (U) and thermal performance index (TPI) for roofs and exposed walls have been worked out. Overall transmittance value (U) is defined as the reciprocal of the total resistance offered to heat flow by a building section including film heat resistance on both sides of the section. Thermal performance index (TPI) is defind as the rating, 100 of which corresponds to 8°C excess of peak inside surface temperature above 30°C for unconditioned buildings.

The recommended values (except for cold climate) have been included in IS Code of Practice 3792-1978 and are given in Table 1. For cold climates also these values have been formulated and are given in Table 1.

Table 1

Thermal performance standards for building elements (unconditioned buildings).

Building component	Hot Dry Zone 1		Hot-Humid Zone 2		Warm-Humid Zone 3		Cold Zone 4	
	U*	TPI	U	TPI	U	TPI	U	TPI
Wall	2.2	125	2.2	125	2.5	175	2.0	-
Roof	2.0	100	2 0	100	2.2	125	1.5	—
Window Glass	4.5	—	4.5	—	4.5	—	2.5	—
Shade factors for windows in differeat zones.								
Window glass	0.5		0.5		0.5		1.00	

*K. cal.$m^{-2}h^{-1}°C^{-1}$

Windows are generally provided on side walls for outside view, daylight and ventilation. The minimum amount of glass area on a wall is mainly decided by the illumination level required inside the building, while the maximum glass area is limited by the considerations of reduction in heat flow, structural design and heating requirements during winter. Use of shading devices may be made to control the heat input into a building. It is, therefore, essential that a compromise be made between the precentage of glass area and the amount of shading to get adequate protection against solar heat during summer. The effectiveness of these shading devices in minimising the heat flow can be evaluated in terms of shade factors. The recommended values for overall heat transmission coefficient and shade factors for window glass have also been worked out for all the zones and are given in Table 1. These values are without curtains on the wiodow. In zones 1 to 3, light curtains may, however, be used during daytime. Heavy curtains may be used during night to retain the heat inside the building in cold climate. No curtains need to be used during day in zone 4.

Cost Index

Based on CPWD schedule of rates, cost of all the commonly used sections have been worked out. Since RCC slab with mud phuska and brick tiie waterproofing treatment for roof has been found acceptable in most of the cases, an index has been worked out which gives an idea of the cost of construction as compared to this basic section. These data on roof sections have been included in Table 2 (a) and (c) alongwith TPI values of the sections. Similarly for walls 23.00 cm brickwall has been taken as basic acceptable section. The data on cost index for walls are given in Table 2 (b).

Table 2 (a)

Thermal performance of different roof sections in various zones

S. No.	Basic Element	Treatment		TPI			U-Value Kcal/m²hr°C Zone 4	Cost Index
		Interier	Exterior	Zone 1	Zone 2	Zone 3		
1.	10 cm. R.CC.	1.5 cm cement plaster	tarfelt	225	215	222	3.143	1.068
2.	,,	,,	9.0cm lime con.+white wash	(91)	(86)	(90)	2.221	1.053
3.	,,	,,	5 cm. brick tile+10 cm mud phuska	(100)	(96)	(98)	1.695	1.000
4.	13 cm channel unit	—	tarfelt	312	297	308	3.913	0.837
5.	,,	—	12 cm lime conc.+whitewash	(96)	(93)	(95)	2.317	0.881
6.	,,	—	5 cm. brick tile+10cm mud phuska +whitwash	(84)	(80)	(80)	1.909	0.718
7.	7.5 cm. cellular unit	—	tarfelt	232	222	229	2.807	0.794
8.	,,	—	10 cm lime conc.+whitewash	(93)	(90)	(94)	1.988	0.922
9.	,,	—	5 cm. brick tile+12 cm mud phuska	(100)	(97)	(99)	1.500	0.728
10.	5 cm. R.C. plank	—	tarfelt	324	309	320	3.876	0.751
11.	,,	—	15 cm. lime conc.+whitewash	(94)	(91)	(94)	2.092	0.881
12.	,,	—	5 cm. brick tile+10 cm. mud phuska +whitewash	(91)	(86)	(90)	1.900	0.692

—The figures enclosed in brackets satisfy the thermal standards as per IS : 3792 (1978).
—Waterproofing treatments should be done as per I.S.I. standard.

Table 2 (b)

Thermal performance of different wall sections in varions zones (West orientation) a=0.7

S. No.	Basic Element	FINISH		TPI			U-Value Kcal/m²hr°C Zone 4	Cost Index
		Interior	Exterior	Zone 1	Zone 2	Zone 3		
1.	11.5 cm brick with cement mortar (1:4)	1.25 cm cement plaster	—	173	148	(157)	2.779	0.617
2.	23.0 cm. brick with cement mortar (1:6)	,,	—	(96)	(86)	(90)	(1.944)	1.000
3.	34.5 cm. brick with cement mortar (1:6)	,,	—	(65)	(62)	(63)	(1.495)	1.444
4.	20 cm. brick cavity wall	1.25 cm plaster		(109)	(97)	(101)	(1.729)	0.886
5.	21 cm brick cavity wall	,,	—	(78)	(72)	(74)	(1.458)	1.091
6.	11.5 cm brick+air space+7.5 cm. brick	—	—	(101)	(90)	(94)	(1.634)	0,989
7.	20 cm stone masonry block (light colour wash)	—	—	(117)*	(113)*	(116)	2.805	0.686
8.	30 cm stone masonry block	—	—	(96)	(86)	(90)	2.288	(1.030)
9.	40 cm stone masonry block	—	—	(71)	(66)	(68)	(1.931)	1.373)
10.	2.5 cm. timber+air space+ 2.5 cm. timber (light colour on exterior face)	—	—	(116)*	(112)*	(115)*	(1.472)	2.482
11.	20 cm. cellular concrete hollow block (2 holes) 25%	1.25 cm. cement plaster	—	(102)	(91)	(95)	(1.200)	2.109
12.	20 cm concrete hollow blocks (2 holes) 25% (light colour wash)	,,	—	(112)*	(108)*	(111)*	2.569	1.045

* These values are determined with light colour wash treatment on exterior face.

The figures enclosed in bracket, satisfy thermal standards as per IS : 3792-1978.

Table 2 (c)

Thermal performance of pitched roofs in various zones Pitch angle 30°. East-West Orientation

S. No.	Basic element	Ceiling	TPI			U Kcl/m² hr°C Zone 4	Cost Index
			Zone 1	Zone 2	Zone 3		
1.	3 0 cm. R.C. L-pan scheme (1:4)	—	337	315	312	4.290	0.507
2.	,,	0.64 cm plywood	196	185	183	1.678	1.103
3.	0.64 cm A.C. sheet	—	321	300	298	4.240	0.612
4.	,,	0.64 cm plywood	194	183	182	1.739	1.209
5.	C.G.I. sheet	—	350	327	325	4.740	1.053
6.	,,	0.64 cm plywood	199	188	186	1.809	1,631
7.	1.3 cm Mangalore tile	—	331	310	307	4.419	0.680
8.	,,	0.64 cm plywood	196	185	183	1.764	1.276

Performance of building sections

Thermal performance of commonly used sections in different climatic zones in terms of thermal performance index (TPI) and U-value has been studied. The data are presented in Table 2 (a), (b), and (c) for roofs, walls, and sloped roofs respectively. It may be seen that 10 cm RCC slab with mud phuska and brick tile weathering course treatment is acceptable in zones 1,2 and 3 while insulation treatment is needed in zone 4 to make it acceptable. Also cellular unit with similar weathering course is acceptable in all the zones. In case of channel units and R.C. planks a white or light colour wash is needed as an additional treatment to make them acceptable in zones 1, 2, and 3. However, a layer of insulation will be required in cold zone.

It is clear from table 2(b) that 23 cm brick wall is acceptable in all the zones. Similar is the case with 20 cm brick cavity wall. Stone masonry wall of 20 cm thickness satisfies the thermal standards in zone 1 and 3 with light colour wash. For cold regions a layer of insulation is required.

Pitched roofs with or without plywood ceiling as such are not acceptable in any zone and need to be insulated to bring them to the desired level of thermal performance.

Recommended treatments in different zones

In case of flat roofs an increase in thickness of materials like lime concrete and mud phuska improves the thermal performance considerably. A white or light colour wash treatment on these sections brings them to desired level. Alternatively a layer of 5 cm foam concrete or 2.5 cm thermocole over the basic element viz., slab, channel or cellular unit or R.C. plank can bring the TPI of the section to desired limit in all the zones. However, in case of R.C. plank additional thickness is needed in case of walls in general, although a layer of 2.5 cm thermocole or equivalent thickness of material like woodwool board in cold zones in some cases on inner wall as given in Table 2 (b) is sufficient to satisfy the thermal requirements.

To render the pitched roofs perform to desired thermal level, insulation is needed. Insulation thickness may be either 2.5 cm fibreglass or thermocole or 5 0 cm woodwool board along the inner face of of the inclined roof with an air gap of 5 cm. Alternatively 2.5 cm mat of reed or compressed thatch on the top face of the pitched roof may be used. Efficiency of such roofs can be further improved by providing aluminium foil over ceiling.

Concluding Remarks

The thermal performance index in this note has been worked out based on periodic heat flow theory and may be used for proper selection of wall and roof sections in zones 1 to 3. However, U-value criterion has been chosen for cold climate. Detailed studies are needed to work out TPI values in cold region. The cost index of sections will be helpful in the selection of economic section and thus economical building designs.

Prepared by : Prakash Chand & K.N. Agarwal
Published by :
Central Building Research Iustitute
Roorkee India
February, 1981 as Building Digest No. 143
Reprinted : Feb. 1987

Printed at :
Jain Printing Press, Roorkee
2000 Copies