BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

THERMAL PERFORMANCE RATING AND CLASSIFICATION OF WALLS IN HOT CLIMATE

Introduction

An efficient building design involves not only functional aspects with respect to structural and space utilization, but also environmental aspects. One of the main functions of a building in hot climate is to minimise heat stress imposed by external climate. Indoor-thermal-environmental control through design and planning can be achieved through an understanding of the thermal performance of building sections in relation to the relevant weather elements. Much can be done to mitigate heat stress in unconditioned buildings and reduce cooling and heating loads in conditioned buildings through a proper choice of building components.

The steady and periodic thermal characteristics, which in turn depend on the thermal resistance and heat capacity of building sections, provide the basic indication of their relative thermal performance under tropical climates. The actual thermal behaviour will also depend on climatic factors, exposure aspect, and surface colour. This is judged by the temperature and heat-flow variations that would result at the inside surface.

Rating Criteria

Suitable criteria have been evolved for thermal performance rating of building sections in hot climate and are given in Table 1. Based on these criteria, thermal performance index (T.P.I) and classification of a large number of flat roof sections in hot-dry climates were worked out and are given in Building Digest No. 94.

Table 1 Basis for thermal performance rating of walls

Unconditioned		Conditioned		Class	Quality of performance	Remarks
Peak degree hrs*. (P.D.H) °C above 30°C	Thermal performance index (TPI)	Peak heat gain** factor (PHGF) Kcal M^{-2} HR^{-1}	Thermal performance index (TPI)			
≤ 6	≤ 75	≤ 20	≤ 50	A	Good	Preferable where better standards are aimed at.
> 6 ≤ 10	> 75 ≤ 125	> 20 ≤ 40	> 750≤100	B	Fair	Acceptable though not adequate.
> 10 ≤ 14	> 125≤175	> 40 ≤ 60	> 100≤150	C	Poor	Unsatisfactory. Requires moderate treatment to upgrade to B.
> 14 ≤ 18	> 175≤225	> 60 ≤ 80	> 150≤200	D	Very Poor	Very unsatisfactory. Requires high degree of insulation to upgrade to B.
> 18	> 225	> 80	> 200	E	Extremely Poor	

*PDH 8°C corresponds to 100 in TPI

**PHGF 40 Kcal M^{-2} HR^{-1} corresponds to 100 in TPI

Wall Sections

In India, traditional constructions such as thick exterior walls made of brick, stone and mud are still common in most parts. In recent years, there is a trend to use light-weight constructions such as hollow blocks, cellular concrete, light weight concrete, sandwich panels etc., because of their advantages over the conventional units. It is often claimed that the hollow units provide better thermal insulation because of the enclosed air space. This need not be true in all the cases, especially under tropical climates where thermal capacity plays an important role in determining its overall thermal performance.

This digest provides data on the thermal performance rating and classification of traditional and modern wall constructions prevalent or likely to come into use in different parts of the country. For convenience, the wall sections have been divided into five groups, e.g. (1) brick, (2) concrete panels (3) hollow concrete blocks and panels, (4) stone and (5) sandwich panels.

The reference data for walls, presented in the Appendix are for the worst exposure aspect (West) and a surface colour finish having solar absorption coefficient (α) of 0.7 (cement grey or brick red colour).

Unconditioned Buildings

Brick Walls

It can be seen (Appendix) that a 11.5 cm brick wall with 1.25 cm plaster on both sides (I.1) falls under "Poor" (class C) whereas the most commonly used 23 cm brick wall with 1.25 cm plaster on both sides (I.3) falls under "Fair" (class B) and 34·5 cm brick wall (I.4) comes under "Good" (class A). This brings out clearly the effect of mass on thermal performance. For a given thickness, perforated bricks behave slightly better than a solid brick wall of the same thickness. A 20 cm brick cavity wall (I.8) is inferior to a 23 cm brick wall, though both fall in class B. Filling the cavity with some insulating material could improve its performance considerably and upgrade it to class A. A 15 cm light weight brick (developed at CBRI) compares favourably with a 23 cm conventional brick.

Concrete Panels

A solid dense concrete panel of 20 cm thickness (II. 3) is "Poor" (class C). Light weight aggregate concrete panels like sintered fly ash concrete of 20 cm thickness (II. 6) is "Fair" (class B). In the case of foamed concrete panels even with a thickness of 10 cm (II. 7), it falls in class B.

Hollow-Concrete Blocks

All the hollow concrete blocks of 15 cm and 20 cm thickness with 2,3,4 or 6 holes (III. 1; III. 2; III. 7; III. 8; III. 9) are "Poor" (class C). However, there is a drop in T.P.I. value with the increase in overall thickness of the block and to some extent with the number of holes present. New types of hollow concrete panels like cellular units with thin rib sections (III.15; III.19; III 20) are very "Poor" (class D). By filling the hollows with foamed concrete and low-priced loose insulating materials such as rice husk, their performance could be improved to some extent.

Stone Walls

Stone masonry walls (IV.1; IV.2; IV.3) which are normally of large thicknesses (more than 30 cm) are "Fair" to "Good" (class B or A).

Sandwich Panels

Thin wall sections like G.I. and A.C. sheets (V.1; V.2; V.3) even when used as double shells with enclosed air space are very "Poor" (class E or D). It is essential to use good insulating materials, sandwiched between such thin sheets to make them thermally acceptable.

Wall Sections in Conditioned Buildings

The above discussion is mainly concerned with unconditioned buildings. But in general, these observations will hold good for conditioned buildings as well. The actual T.P.I. values may be different and in certain cases there may be a change in class to the next higher or lower.

It is often of interest to get an idea of the peak-inside-surface-temperatures and peak-heat-gain-factors of a given wall under a given situation. These can also easily be obtained from the T.P.I. data presented in Appendix. The procedure for obtaining this is explained below:

Example

What will be peak-inside-surface-temperature and peak-heat-gain-factor of a 23 cm brick wall with 1.25 cm plaster on both sides (I. 3), with surface colour having $\alpha=0.7$, West orientation at Roorkee?

Peak inside surface temperature

From Appendix, T.P.I. value for unconditioned case=93

Peak Degree Hours (P.D.H.) $= \frac{8}{100} \times 93 = 7.4^{o}C$

Peak Inside Surface Temperature = P.D.H. + Base temperature

$= 7.4 + 30°C$

$= 37.4°C$

Peak heat gain factor

From Appendix, T.P.I. value for conditioned case = 102

$P.H.G.F. = \frac{40}{100} \times 102 = 40.8$ Kcal. $M^{-2}HR^{-1}$

Concluding Remarks

From the thermal performance index and classification data presented in this digest, designers may be able to make a quick assessment of relative performance of any wall section for making a proper choice of wall section in a hot dry climate.

The list presented covers most of the commonly used and recently introduced wall sections. Similar data for other sections can also be provided if referred to the institute

APPENDIX

Thermal performance rating (T.P.I.) and classification of walls (hot climates): West Orientation $\alpha = 0.7$

S. No.	Basic Element	Treatments		Unconditioned		Conditioned	
		Exterior	Interior	TPI	Class	TPI	Class
I	**BRICK PANELS**						
1.	11.5 cm solid brick	1.25 cm plaster	1.25 cm plaster	164	C	212	E
2.	23.0 cm ,, ,,	—	,,	96	B	107	C
3.	23.0 cm ,, ,,	1.25 cm plaster	,,	93	B	102	C
4.	34.5 cm ,, ,,	,,	,,	64	A	61	B
5.	46.0 cm ,, ,,	,,	,,	61	A	43	A
6.	11.5 cm perforated brick	,,	,,	151	C	181	D
7.	23.0 cm ,, ,, ,,	,,	,,	85	B	80	B
8.	20.0 cm brick cavity wall	,,	,,	109	B	112	C
9.	28.0 cm ,, ,, ,,	,,	,,	78	B	72	B
10.	20.0 cm ,, ,, ,, (filled with soil)	,,	,,	99	B	103	C
11.	20.0 cm ,, ,, ,, (filled with mineral wool)	,,	,,	68	A	26	A
12.	11.5 cm brick + 5.0 cm air space + 2.5 cm W.W. board	—	—	108	B	92	B
13.	11.5 cm brick + 5.0 cm foamed concrete.	1.25 cm plaster	1.25 cm plaster	90	B	58	B
14.	23.0 cm solid brick	7.5 cm sand stone	,,	76	B	82	B
15.	14.0 cm hollow clay unit	—	—	151	C	173	D
16.	14.0 cm ,, ,, ,, (filled with rice husk)	—	—	129	C	133	C
17.	14.0 cm hollow clay unit (filled with 'Thermocole beads)	—	—	125	C	125	C
18.	15.0 cm lt. wt. brick (1): 800 kg/m³	—	—	83	B	30	A
19.	15.0 cm lt. wt. brick (2): 400 kg/m³	—	—	92	B	59	B
20.	11.5 cm solid brick	—	5.0 cm lt. wt. brick (1)	95	B	61	B

(Contd.)

S. No.	Basic Element	Treatments: Exterior	Treatments: Interior	Unconditioned TPI	Unconditioned Class	Conditioned TPI	Conditioned Class
21.	11.5 cm soild brick	—	5.0 cm lt. wt. brick (2)	111	B	100	C
22.	11.5 cm ,, ,,	—	11.5 cm lt. wt. brick (1)	76	B	28	A
23.	11.5 cm ,, ,,	—	11.5 cm lt. wt. brick (2)	79	B	50	A
24.	11.5 cm ,, ,,	—	7.5 cm Thermocole	85	B	31	A
25.	23.0 cm solid brick	—	5.0 cm lt. wt. brick (1)	74	A	35	A
26.	23.0 cm ,, ,,	—	5.0 cm ,, ,, (2)	74	A	55	B
II	**CONCRETE PANELS**						
1.	10.0 cm precast concrete panel	—	—	223	D	321	E
2.	15.0 cm ,, ,, ,,	—	—	173	C	239	E
3.	20.0 cm ,, ,, ,,	—	—	135	C	181	D
4.	10.0 cm sintered fly ash conc. panel	—	—	196	D	257	E
5.	15.0 cm ,, ,, ,,	—	—	160	C	180	D
6.	20.0 cm ,, ,, ,,	—	—	116	B	128	C
7.	10.0 cm foamed concrete (Siporex)	—	—	112	B	84	B
8.	12.5 cm ,, ,, ,,	—	—	95	B	61	B
9.	15.0 cm ,, ,, ,,	—	—	84	B	46	A
III	**HOLLOW CONCRETE BLOCKS AND PANELS**						
1.	20.0 cm dense hollow concrete blocks (2 holes)	—	1.25 cm plaster	136	C	172	D
2.	20.0 cm (3 holes) ,, ,,	—	,,	142	C	174	D
3.	20.0 cm (4 holes) ,, ,,	—	,,	131	C	164	D
4.	20.0 cm lt. wt. hollow concrete blocks (2 holes)	—	,,	102	B	85	B
5.	20.0 cm (3 holes) ,, ,,	—	,,	114	B	100	B
6.	20.0 cm (4 holes) ,, ,,	—	,,	93	B	70	B
7.	19.0 cm dense concrete hollow unit (2 holes)	—	,,	141	C	178	D
8.	19.0 cm (3 holes) ,, ,,	—	,,	141	C	177	D
9.	15.0 cm D.C. hollow panel (6 holes)	—	,,	171	C	218	E
10.	15 0 cm ,, ,, (6 holes) (filled with foam concrete)	—	,,	125	B	136	C
11.	15.0 cm D.C. hollow panel (6 holes) (filled with rice husk)	—	,,	123	B	128	C
12.	15.0 cm hollow concrete panels (2 holes)	—	,,	171	C	218	B
13.	15.0 cm ,, ,, (2 holes) (filled with foam concrete)	—	,,	113	B	116	B
14.	15.0 cm hollow concrete panel (filled with rice husk) (2 holes)	1.25 cm plaster	—	105	B	9	B

(Contd.)

S. No.	Basic Element	Treatments		Unconditioned		Conditioned	
		Exterior	Interior	TPI	Class	TPI	Class
15.	7.5 cm cellular unit	—	—	211	D	287	E
16.	7.5 cm ,, ,, (filled with soil)	—	—	218	D	303	E
17.	7.5 cm cellular unit (filled with "Thermocole")	—	—	177	D	219	E
18.	7.5 cm cellular unit (filled with rice husk)	—	—	177	D	221	E
19.	10.0 cm cellular unit	—	—	214	D	284	E
20.	12.5 cm ,, ,,	—	—	170	C	216	E
21.	12.5 cm cellular unit (filled with rice husk)	—	—	144	C	160	D
22.	12.5 cm ,, ,, (filled with Thermocole beads)	—	—	142	C	154	D
23.	15.0 cm cellular unit (Two 7.5 cm units placed together)	—	—	132	C	155	D
IV	**STONE WALLS**						
1.	30.5 cm rubble masonry	—	—	89	B	104	C
2.	38.0 cm sand stone	—	—	75	A	87	B
3.	38.0 cm granite	--	—	99	B	144	C
4.	10.0 cm sand stone	—	—	227	E	324	E
5.	15.0 cm ,, ,,	—	—	177	D	243	E
6.	20.0 cm ,, ,,	—	—	142	C	185	D
7.	30.0 cm ,, ,,	—	—	96	B	117	C
8.	10.0 cm granite	—	—	248	E	377	E
9.	15.0 cm granite	—	—	201	D	304	E
10.	20.0 cm ,,	—	—	167	C	250	E
11.	30.0 cm ,,	—	—	121	B	177	D
12.	15.0 cm sand stone+5.0 cm air space +15.0 cm sand stone	—	—	76	B	77	B
13.	15.0 cm granite+5.0 cm air space +15.0 cm granite	—	—	82	B	98	B
V	**SANDWICH PANELS**						
1.	G.I. sheet	—	—	357	E	554	E
2.	0.64 cm a.c. sheet	—	—	324	E	490	E
3.	0.64 cm a.c. sheet+5.0 cm air space+0.64 cm a.c. sheet	—	—	211	D	270	E
4.	0.64 cm a.c. sheet+5.0 cm air space with Al foil+0.64 cm a.c. sheet	—	—	146	C	139	C

(Contd.)

S. No	Basic Elements	Treatments		Unconditioned		Conditioned	
		Exterior	Interior	TPI	Class	TPI	Class
5.	0.64 cm a.c. sheet+10.0 cm soil+0.64 cm a.c. sheet	—	—	187	D	247	E
6.	0.65 cm a.c. sheet+5.0 cm "Thermocole" + 0.64 cm a.c. sheet	—	—	100	B	50	A
7.	0.64 cm a.c. sheet+10.0 cm foam conc.+0.64 cm a.c. sheet	—	—	97	B	52	B
8.	5.0 cm reed board	1.75 cm plaster	1.75 cm plaster	113	B	79	B

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 101th 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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