BUILDING DIGEST
CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

THERMAL RESPONSE OF 4.5 INCH SOLID BRICK WALL ROOM IN HOT-DRY CLIMATES

Introduction

The challenge before building engineers is to evolve ways and means of economising in housing construction, so that the maximum number of houses can be built from the available resources. In conventional buildings both external and internal walls upto roof level are built with 23 cm brick masonry. From strength considerations use of 23 cm brick wall upto two storey building is unnecessary and results in heavy wastage of building materials and also involves greater expenditure on the sub-structure cost. In view of all this the practising architects and engineers strongly feel the need to reduce the thickness of conventional brick wall to a bare minimum value.

Reduction in wall thickness will create disturbances in the existing thermal conditions of buildings; therefore, to assess its effect quantitatively and to collect actual design data of its influence on indoor thermal conditions, a field study was initiated.

Experimental

In this study two full size (3.5×2.9×3.2 m) test rooms were used. These are 13 metres apart to have unobstructed wind and solar exposure. The test rooms have similar roof (16.5 cm R.C.C. with 1.3 cm cement plaster on both sides) but with walls of different thicknesses. The three exposed walls towards east, south and west in each of these test rooms were constructed with 11.5 cm and 23.0 cm bricks respectively and finished with a cement plaster (13 cm thick) inside and cement pointing outside. These walls were constructed by the same set of masons using similar bricks and cement mortar, etc.

Test Conditions

To observe the effect of wall thickness on indoor thermal conditions, the following sets of observations were recorded under the various exposure conditions.

Set No.	Exposure conditions to outside weather
1	All the three walls (East, South & West) fully exposed.
2	Two walls (East & South) fully exposed, West walls shaded.
3	One wall (South) fully exposed, East & West wall shaded

Shading of walls was arranged with heavy tarpolines to ensure absence of solar radiation and unrestricted air movement over the wall.

Results and Discussions

In tropics much stress is laid on summer conditions while designing buildings and so this study was concentrated on summer conditions only. Further, the period of optimum discomfort indoors lies during the day time when windows and doors have to be necessarily kept closed to prevent hot air entering from outside and the occupants have to remain inside the houses. Also the actual usage period (day, night or both) of a building dictates for considering the period of thermal behaviour. Here the results, in terms of basic parameters, are discussed mainly on the basis of optimum discomfort period (1000 to 1900 hours) However discomfort position for any other usage periods can also be obtained from the available data of round-the-clock observations.

Inside Surface Temperatures

The first parameter which governs the inside thermal conditions of an enclosure is the variation of inside surface temperatures of the various building elments (roof, walls, floor). Here the inside surface temperatures of 11.5 cm brick wall was found to be considerably higher (upto 7.4°C for west wall) than the 23.0 cm brick wall during the day time, but it also cools down quickly to a greater extent (upto 2.0° C for east wall) during night hours leading to better thermal conditions than the 23.0 cm brick wall. The maximum difference of 7-4° C for west wall during day time under the worst exposure conditions gradually decreases to 3.5 and 3.2° C as the number of exposed walls decreases under the other two conditions, whereas the difference in minima temperature does not vary much with the decrease in the number of exposed walls.

Discomfort Degree Hour Rating

The concept of Degree Hour Rating gives a realistic comparison of the intensity and duration of discomfort conditions inside during the optimum or usage periods. Table 1 gives the comparison of hourly integrated discomfort degree hours above 30° C during the periods 1000 to 1900 hours on a hot summer day for the various inside wall surfaces of the two test rooms under the three test exposure conditions. Lower values of integrated discomfort degree hours indicate for better thermal performance.

The integrated discomfort degree hours for the inside surface temperatures of the two thicknesses of wall in three orientations differ in the range of 66 to 98 per cent when all the three walls were exposed but when two or one walls were exposed the corresponding ranges of differences were reduced to 57 to 70 per cent and 43 to 56 per cent respectively. The temperatures of the inside surfaces of the two walls remained above 30° C throughout the day and night, i. e., discomfort due to walls was found to prevail for all the 24 hours in both the cases.

Tropical Summer Index (T.S.I.)

Tropical summer index correlates the thermal sensations of human being with the environmental parameters and it can be calculated from the measured values of wet bulb, globe temperatures and wind speed indoors. Wind speed indoors during the period of optimum discomfort is considered zero here. Fig. 1 shows the comparison of hourly variation of T.S.I. in 24 hours on hot summer days, under the three test conditions of exposure, for the two test rooms. A difference upto the order of 2.3, 1.4 and 0.8°C in T.S.I. can be observed between the two cases in the three test conditions respectively.

On comparing the integrated discomfort degree hours of T.S.I. for the two enclosures above 30°C it was observed that the values differed by 37, 28 and 15 per cent respectively in the three test conditions for the two wall/enclosures of different thicknesses.

The maximum resultant difference of 37 per cent in the total discomfort degree hours is caused as a result of a corresponding difference of 66, 78 and 98 per cent in the performance of two types of walls in east, south and west directions under the worst exposure conditions.

Time Lag

In hot dry climates another fundamental and important parameter for thin sections is the time lag in attaining indoor temperature maxima with respect to the outdoor temperature maxima. Time lag depends mainly on the heat-storing capacity of the structure, when indoor maxima reaches before the time of opening windows and ventilators in the evening hours, it considerably enhances heat stress to the occupants and so it is always desirable if indoor maxima reaches late in the evening so that its effect on indoor thermal conditions may be neutralised by taking advantage of natural ventilation, i. e., by allowing the cold air to enter into the openings provided in the room. It has been observed that the inside surface maxima of 11.5 cm thick wall reaches quite earlier than the 23.0 cm thick wall in all the cases which finally results in a difference of 3, 2 and 1 hours between the occurrence time of Tropical Summer Index maxima, for the two test cases, under the three test conditions respectively. At the occurrence time of minima this difference comes out to be 2, 2 and 1 hour respectively for the three test conditions.

Conclusions

In general, the thermal discomfort indoors in 11.5 cm solid brick wall enclosure has been found to be more than the 23.0 cm solid brick wall enclosure during the day time, but lesser during night time.

The actual resultant discomfort indoors in the 11.5 cm solid brick wall enclosure during day time has been found to be more by 37 per cent when all the three walls were exposed, by 28 per cent when two walls were exposed and by 13 per cent when only one wall was exposed, than the 23.0 cm solid brick wall enclosure. The maximum resultant difference of 37 per cent in the total

Table 1

Comparison of Integrated Discomfort Degree Hours during 1000 to 1900 Hours on a Hot Summer Day in Enclosures of 11.5 cm and 23.0 cm Wall Thicknesses

ELEMENTS	Three walls (East, South & West) exposed				Two walls (East & South) exposed (W-wall shaded)				One wall (South) exposed (E & W walls shaded)			
	23.0 cm solid brick wall	11.5 cm solid brick wall	Difference	Difference (per cent)	23.0 cm solid brick wall	11.5 cm solid brick wall	Difference	Difference (per cent)	23.0 cm solid brick wall	11.5 cm solid brick wall	Difference	Difference (per cent)
East wall inside surface	71.6	118.6	47.0	66	64.8	101.6	36.8	57	55.1	81.0	25.9	47
South wall inside surface	44.6	79.7	35.1	79	44.4	75.4	31.0	70	46.7	72.7	26.0	56
West wall inside surface	50.3	99.6	49.3	98	42.5	70.3	27.8	65	48.8	69.6	20.8	43
T. S. I. at 1.2 metre above floor centre	61.3	83.8	22.5	37	58.0	74.2	16.2	28	57 5	66.4	8.9	15

Note :—1.3 cm thick cement plaster was applied at the inside surface of all the walls.

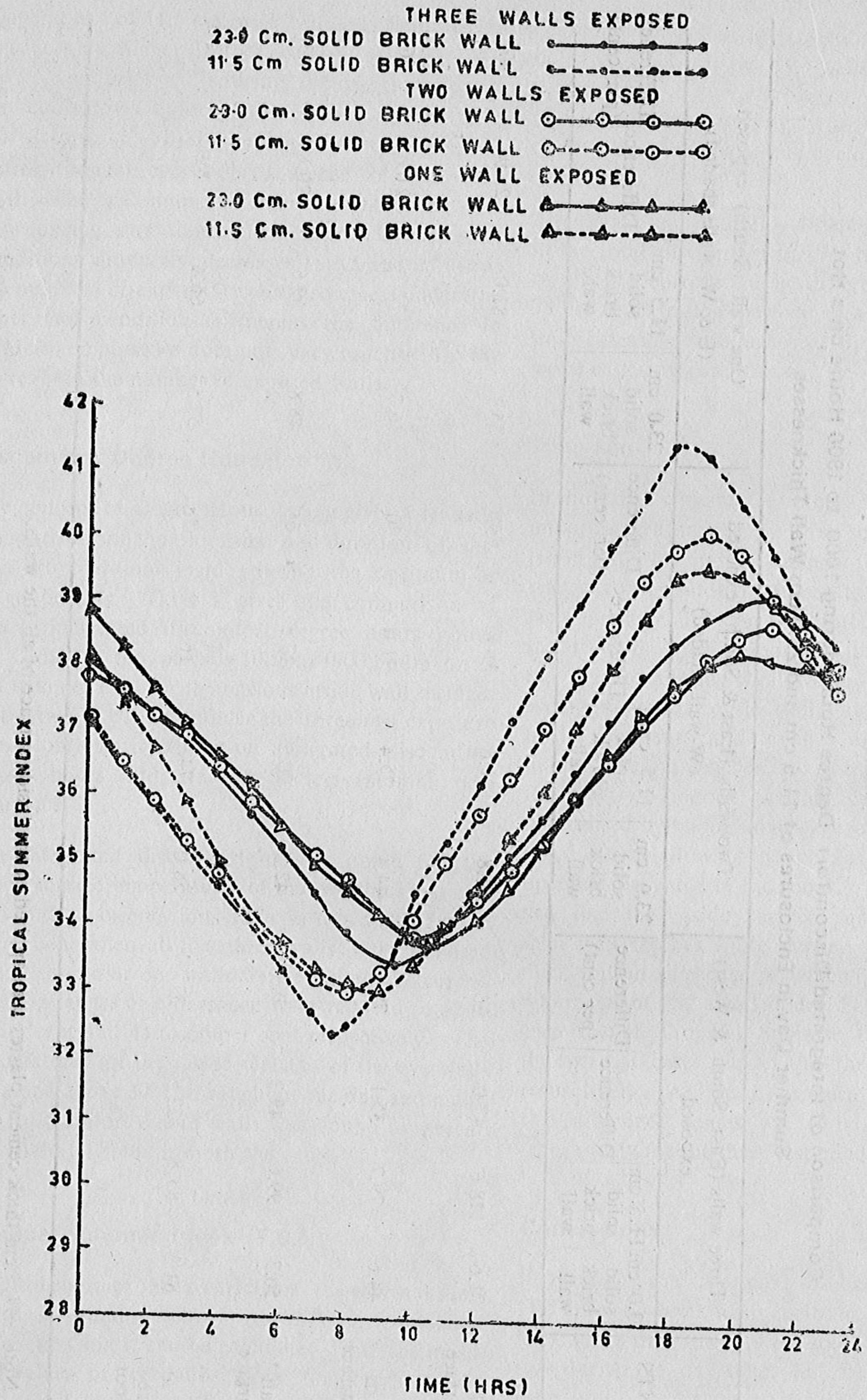

Fig. 1. Comparison of Hourly Variation of Tropical-Summer-Index of 11·5 cm and 23·0 cm Solid Brick Wall Enclosures Under the Three Test Conditions

discomfort degree hours is caused as a result of a corresponding difference of 66, 78 and 98 per cent in the thermal performance of the two walls of different thicknesses, in eastern, southern and western directions, under the worst exposure conditions.

The difference between the performance of 11.5 and 23.0 cm brick wall decreases during the day time with the decrease in the number of exposed walls, hence at the design stage care can be taken to keep minimum number of walls exposed for achieving better thermal conditions.

Night time performance of 11.5 cm thick brick wall room based on T. S. I. values is better upto 10 per cent than the 23.0 cm thick brick wall room.

Design data for the quantitative assessment of thermal performance under different usage periods and under different wall exposure conditions can be evaluated from the curve and table given in this Digest. Based on the present knowledge of thermal data for 11.5 cm solid brick wall enclosure, buildings can be designed more efficiently and economically to suit various situations and requirements in actual practice.

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 131st 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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