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A STUDY ON THE COMFORT LEVELS IN A ROOM OF AN EXPERIMENTAL BUILDING SITUATED IN A COMPOSITE TROPICAL CLIMATE

M.Srinivasa Reddy S.Krishnamoorthy
Department of Civil Engineering
Indian Institute of Technology
Hauzkhas; NEW DELHI 110 016 INDIA

The objective of the work is to assess the applicability of a specific type of construction with respect to human comfort for a composite climatic place like Delhi. A room in the top floor of an experimental multistorey residential (brick masonry) building was chosen for study. The roof of the room consisted of precast reinforced concrete planks of 60mm thick supported on a joist system unlike a conventional reinforced concrete slab of 100mm thick. Hourly room air temperature and relative humidity were recorded for a continuous period of one year. Two thermal comfort indices viz., Tropical Summer Index and Effective Temperature had been used to evaluate the degree of comfort. It has been observed that the construction more or less keeps the inside environment in the comfort level except for a short period during summer and winter.

1. INTRODUCTION

The main aim of a building is to provide an enclosure which will keep inhabitants at some level of comfort while the external environment is either too hot or too cold. In other words, the building envelope acts as a barrier as well as modifier at the same time. the modifying ability of a fabric depends to some extent on the method of construction also as the different methods of construction or design have been evolved to economise the cost of construction.
The present study, where the cost of reduction in building works had been 13%, deals with an experimental multistorey residential building (4 floors) of brick masonry (230mm thick walls), which has been built with prefabricated floor components unlike the large number of residential quarters are still being constructed with insitu concrete floors. The roof of the room consisted of precast reinforced concrete planks of 60mm thick supported on a joist system unlike a conventional reinforeced concrete slab of 100mm thick.
The main objective of the work is to assess the applicability of this type of construction with respect to human comfort for a composite climatic place like Delhi. The climate of Delhi is characterised by three seasons, viz., hot-dry, warm-humid and cool-dry.

2. EXPERIMENTAL INVESTIGATION

2.1 Description of test room

A room in the fourth storey of a four storeyed residential building in Delhi was selected for the experimental measurements. The test room had an internal dimension of 2.77m x 3.40m x 2.70m high. It had two doors, of 2.0m x 0.85m, one in its north facing wall and the other in its east wall and two windows of 0.9m x 1.2m and 0.5m x 1.2m in the south facing and north facing walls respectively. These windows were fitted with ordinary glass shutters and the one in the south facing wall had a sunshade.

In the south facing wall, there was a built in cupboard, which was projected horizontally outwards, covering a vertical area of 3.05m^2 of the wall area. The window in the south facing wall had a horizontal sunshade of 0.55m width and vertical drop of 0.55m on one side. The projected portion of the cupboard acted as a vertical shading device for the window adjacent to it.
All the walls were of common clay brick masonry with unplastered, exposed brick work texture on the external side for the south and west facing walls. The thickness of all walls, except that of north facing wall was 0.23m, whereas the north facing wall was of 0.12m. The walls were plastered internally with a composite cement-lime mortar.
The roof of the room consisted of precast, reinforced concrete planks supported on a joist system. The planks were 0.06m thick and were covered with mudphuska (combination of clay and hay) of 0.1m thick and brick tile of 0.045m thick for thermal insulation.
The floor of the room was also of precast reinforced concrete plank system. However, the flooring consisted of 0.025m thick cement concrete finish, with neat cement finish, over a 0.05m thick base layer of lean cement concrete which, in turn was laid over the planks.
Outside the test room, on the east wall side, there was another room, passage and water-closet and there was a verandah to the north.
Figure 1 shows the plan of the experimental test room.

2.2 Observations

The internal room air temperature and internal relative humidity were recorded continuously for every hour throughout the year by using thermohygrographs /1/. From the values of globe temperature, it is observed that there has been not much difference between the mean radiant temperature of the test room and room air temperature /1/.
Throughout the test period, the test room remained closed except for the purpose of

taking the measurements and hence this room has been considered as one with low air changes per hour. A ventilation rate of 3 air changes per hour had been considered based on the results obtained from the study /1/.

3. ANALYSIS AND RESULTS

For tropical summer conditions, Sharma/2,3/ proposed a Tropical Summer Index (T.S.I) to define the level of thermal comfort. Though this particular index does not specifically take into account the effect of differnet types of clothing ao activity levels, the index has been determined in the Indian context. The index is defined as the air/globe temperature of still air tat 50% relative humidity which produces the same overall thermal senstation as the environment under investigation. The index is given by

$$T.S.I = 0.308 t_w + 0.745 t_g - 2.06 v^{0.5} + 0.841$$

where,

t_w = wet-bulb temperature, °C
t_g = globe temperature, °C
v = air velocity, m/sec

and T.S.I is expressed in °C.

Sharma suggested further that the comfort limits are when the T.S.I is in the range of 25°C to 30°C. When the T.S.I is between 19°C to 25°C, it can be considered as slightly cool, when the T.S.I is between 30°C to 34°C, it can be considered as slightly warm.

The T.S.I has been calculated for each hour of each day for the whole year for the air temperatures of the test room. The air velocity has been assumed to be 0.003m/sec. Air temperature is assumed in place of globe temperature.

Koenigsberger et al/4/ have suggested that the comfort limits which are probably valid for most tropical regions would be between 22°C to 27°C when the values are expressed in terms of effective temperature scale with appropriate tropical summer clothing. Sharma has suggested that the comfort zone will be when the values of T.S.I are in the range of 25°C to 30°C/3/. When these limits are converted in to effective temperature scale, the range works out to 22.7°C to 27.5°C. As such it may be noted that the comfort zone suggested by Sharma is almost the same as that suggested by Koenigsberger et al. The limits suggested by Sharma have been used further in the analysis of the data of the test room.

It is observed that 61 days, out of the 365 days of the year, fall into this category of comfort, when, at no time the internal air temperatures exceed the specified limits. It is further considered that the winter season in Delhi is probably more or less similar to the summer season in U.K. in so far as the warm clothing adopted by the inhabitants are concerned. For summer season in U.K. Koenigsberger has suggested that the optimum and maximum limits of effective temperature, for comfort, could be 18°C and 22°C, respectively. Sharma has suggested that a T.S.I range of 19°C to 25°C (17.2°C to 22.7°C in ET scale) as slightly cool. Likewise, Sharma has also suggested that a T.S.I range of 30°C to 34°C (27.5°C to 31.5°C in ET scale) as slightly warm. Usually, in residential buildings in India, the occupants are habituated to use electric fans in summer for the purpose of local cooling of human body though not of the room and as such the slightly warm condition postulated by Sharma can be considered as acceptable for comfort when electric fans are used for the purpose.

Totally, 198 days out of 365 days (including the 61 days mentioned earlier) turn out to be comfortable within the limits of 17.2°C to 31.5°C of ET or 19°C to 34°C of T.S.I with the appropriate proviso of using electric fans during summer and warm clothing in winter. It may be noted that the limits are satisfied at all hours of a day.

The remaining 167 days consisted of 72 transient days and 95 uncomfortable days. During the transient days, the calculated T.S.I for each hour of a day may be within or beyond the comfort limit i.e., 19 to 34°C. The number of transient days during summer and winter seasons are 56 and 16 respectively. Among the 56 transient days of summer period, the duration of discomfort in a day is about 10 to 11 hours, approximately from 17.00 to 6.00 hours. The peak T.S.I during these days is 35.5°C. For the 16 transient days of winter season, it is observed that the period of discomfort occurs at different times of the day and it is difficult to identify a specific time of discomfort. The extreme lower limit of T.S.I observed, however, is 17.5°C, during such transient days.

During the uncomfortable period of the winter season (68 days) excepting for the days of transiency, the T.S.I was below 19°C throughout the 24 hour period of a day. Typically, the T.S.I was around 16 to 16.5°C. On a few occasions, the T.S.I was low at about 13 to 13.5°C. This discomfort due to cold can probably be taken care by sufficient warm clothing unless there are compelling or special reasons to incorporate heating.

During the uncomfortable period in the summer (27 days) excepting for the days of transiency, the T.S.I was above 34°C throughout the 24 hour period in a day. To mitigate this condition, one has to resort to a temporary evaporative or other cooling mechanisms and to shading of the room from direct solar radiation. Cooling of infiltration air entering the room by providing deep verandahs etc. would also be useful.

4. CONCLUSIONS

It has been observed that the construction more or less keeps the inside environment in the comfort level except for a short period during summer and winter. In fact the reaction of the building envelope to the diurnal changes does not keep pace with the changes in the outdoor conditions because of the inertia of its thermal capacity. Thus some discomfort is evident and unavoidable. During the short period of discomfort in summer, it was slightly warmer. But it can be taken care by providing mechanical ventilation which is a normal practice. Similarly, during the short period of discomfort in winter, it was slightly cooler. It can be taken care by sufficient warm clothing so that no heating is necessary.

In so far as the building fabric design is concerned, it appears that the thermal massivity provided by the 23cm thick brick wall, and 20.5cm thick roof seem to be adequate and further increase in thermal massivity, while it may bring down the number of transient days, particularly in summer to a smaller level, the cost effectiveness of such additional thermal massivity is probably marginal and has to be examined.

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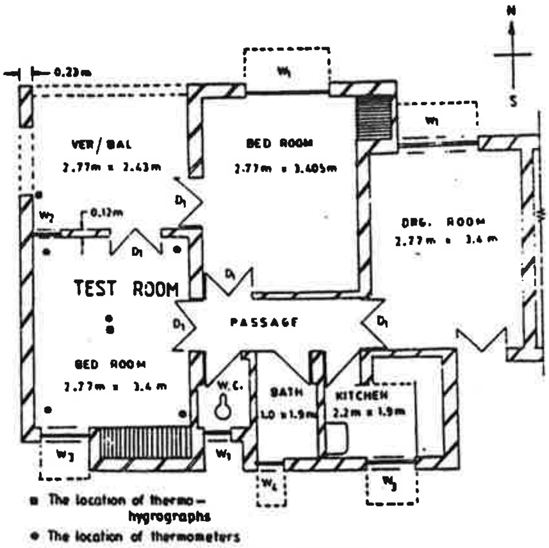

FIG.1. PLAN OF THE TEST APARTMENT