Influence of Roof Systems and Roof Materials on Indoor Thermal Comfort in High Altitudes of Sri Lanka

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Introduction

One of the primary objectives of the building designer should be to ensure that the built environment is thermally comfortable to its occupants, possibly throughout the day and round the year. Therefore, this should receive sufficient attention from the very beginning: a good thermal design is started during the sketch design stage. In Sri Lanka designers and builders pay little attention to the thermal aspects of structural elements. In high altitudes of Sri Lanka such as about 1500 m above the mean sea level (i.e. tropical uplands), there is indoor thermal discomfort due to low temperatures that occur during the night. Thus, there could be a tendency to use heating, specially using electric heaters. However, this is not a desirable situation since Sri Lanka is presently facing a serious energy crisis.

In Sri Lanka, roof orientation, roof material and external colours of the roof are determined more on the basis of the aesthetics and/ or cost than the thermal performance. Due to the prevailing thermal discomfort in high altitudes, it is prudent to determine the effect of various roof orientations and materials on the indoor thermal comfort. The roof should be designed in such a way that solar heat gain through the roof is kept at a reasonable level. This paper investigates the effect of roof orientation and various roofing materials on the indoor thermal comfort of passive houses located in high altitudes of Sri Lanka.

Objectives

The main objectives of the study are to determine the effects of the roof orientation and materials on the indoor environment of a single storey house under the climatic conditions prevailing in tropical uplands of Sri Lanka.

Methodology

To achieve the above objectives, the following methodology was adopted:

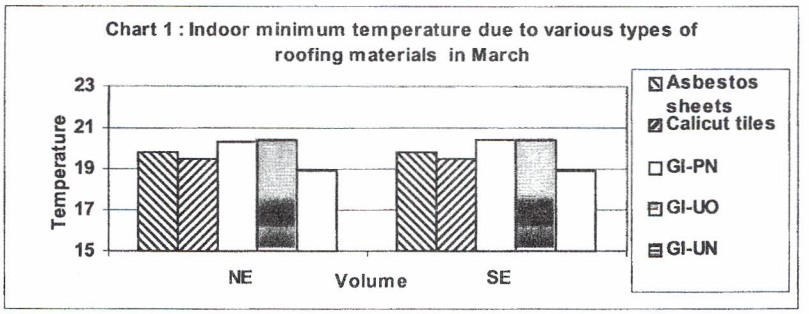
- The properties of various roofing materials and roofing systems available in Sri Lanka were obtained from literature.
- These different arrangements were used to generate a sufficient number of cases that can represent the thermal performance throughout the year
- These cases were simulated by using the computer program DEROB-LTH for a house of practical dimensions and the results were analysed to determine the desirable and the undesirable features.

Computer simulation

The model house is a single storey one and it consists of four volumes, namely NW, NE, SW and SE. It is also provided with openings facing either north or south only. Two roof orientations were selected for the simulations. One roof had its ridge along the east-west direction while other roof had its ridge along north-south. These roofs were combined with two ceiling types that are commonly used in houses in Sri Lanka.

Three types of roofing materials that are common to high altitude areas were identified. They are cement fibre sheets, GI sheets and calicut tiles. According to the physical differences that occur with time, GI sheets are again divided into three types. They are unpainted new, unpainted old and painted new.

Results obtained



For Bandarawela, the neutrality temperature is calculated as 24^0C. This indicates that indoor temperatures between 22^0C to 26^0C could be considered as thermally comfortable for high altitudes of Sri Lanka.

Chart 1 shows the results obtained for selected materials for the month of March. When all three materials are compared, it can be said that unpainted old and painted new GI sheets give higher indoor minimum temperatures than the other two materials ($20\text{-}21^0$C). Indoor minimum temperatures for calicut tiles and cement fibre sheets show indoor minimum temperatures around $19\text{-}20^0$C. Newly bought unpainted GI sheets show the poorest performance for the month March, indoor minimum temperature being less than 19^0C.

Conclusions

It is useful to develop houses with passive elements for the high altitudes of Sri Lanka, specially to reduce the discomfort from cold that generally occurs during the night. The findings of this study could be applied to new houses to be constructed and old houses could be made more satisfactory.

For the houses in tropical upland areas there is no significant effect of roof orientation. This is an important finding, because designers and house builders can use any direction as the ridge direction according to their preference.

Heat transfer through roofing materials is also an important factor to achieve a good thermal performance inside a house. The desirable thermal performance for high altitude area will gradually increase in the following order: unpainted new GI sheets, calicut tiles, cement fibre sheets, dark painted new GI sheets and unpainted old GI sheets respectively. For existing houses, as well as new houses, painting the roof surfaces with dark colours (for example, red, green, blue, brown etc) is desirable, as it would reduce the likelihood of discomfort from cold occurring at night. It is not advisable to use painted old GI sheets; therefore it is advised to paint the roof surfaces with dark colours like green, red or brown.