"Study of Roof Passive Cooling Techniques for Residential Buildings"

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ABSTRACT

The primary function of a building is to provide a comfortable indoor environment. Now-a-days the interior of building is made comfortable as required, with the help of electromechanical devices, air conditioners and other cooling devices. Such devices consume substantial power which increases with increase of cooing load of the building. In order to reduce power consumption in a building the cooling load is required to be reduced. About 50 % of heat gain is contributed by the roof therefore it is important to study the method of roof heat gain reduction by conducting suitable experiments. this project work present the method of Alternative Techniques to Air Conditioning in the country which helps to reduce the consumption of energy which is now a day utilized by conventional Air Conditioning.

Key skills: *Roof Passive Cooling, Green Roof, Ventilation, Roof Pond, Energy Consumption*

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1. Introduction:

Passive cooling techniques in buildings have proven to be extremely effective and can greatly contribute in decreasing the cooling load of buildings. Efficient passive systems and techniques have been designed and tested. Passive cooling has also proven to provide excellent thermal comfort and indoor air quality, together with very low energy consumption. When a building's internal and solar gains are sufficiently reduced, a lean acclimatization concept can be developed (Reinhart et al., 2001). The term lean signifies that the system is energy efficient so that only the amount of electricity needed to run fans and circulation pumps is required to maintain comfortable indoor temperatures year-round.

Passive cooling techniques can be classified in three main categories, (Santamouris and Assimakopoulos, 1996): a) Solar and Heat Protection Techniques. Protection from solar and heat gains may involve: Landscaping, and the use of outdoor and semi-outdoor spaces, building form, layout and external finishing, solar control and shading of building surfaces, thermal insulation, control of internal gains, etc. b) Heat Modulation Techniques. Modulation of heat gain deals with the thermal storage capacity of the building structure. This strategy provides attenuation of peaks in cooling load and modulation of internal temperature with heat discharge at a later time. The larger the swings in outdoor temperature, the more important the effect of such storage capacity. c) Heat dissipation techniques. These techniques deal with the potential for disposal of excess heat of the building to an environmental sink of lower temperature. Dissipation of the excess heat depends on two main conditions: 1) The availability of an appropriate environmental heat sink; and 2) The establishment of an appropriate thermal coupling between the building and the sink as well as sufficient temperature differences for the transfer of heat. The main processes of heat dissipation techniques are: ground cooling based on the use of the soil, and convective and evaporative cooling using the air as the sink, as well as water and radioactive cooling using the sky as the heat sink. The potential of heat dissipation techniques strongly depends on climatic conditions. When heat transfer is assisted by mechanical devices, the techniques are known as hybrid cooling.

2. Experimental setup

Two identical prototype rooms each having dimensions 1 m×1m× 1m as shown in Figure 2.1 were fabricated. All the walls of rooms were constructed using brick work. Both rooms have one door of 0.5m×0.4 m and one window of 0.4 m×0.3 m. The roofs were constructed using RCC slab of 100 mm thickness. A major heat load in building is from the roof, so only treatment on the roof was compared. Following five passive techniques were applied on one of the test rooms (room 1) while other test room was kept with bare RCC roof (room 2).

2.1 Roof pond

A roof pond was built over the roof. Roof pond is a unique passive system that can be used for both passive heating during winter and passive cooling of buildings during summer. Water was filled to a depth of 25 mm to build a roof pond, and net reduction in heat gain from room was calculated by using experimental data. Then similar experiments were performed with water level of 50 mm and 100 mm, to find the optimal water level in roof pond.

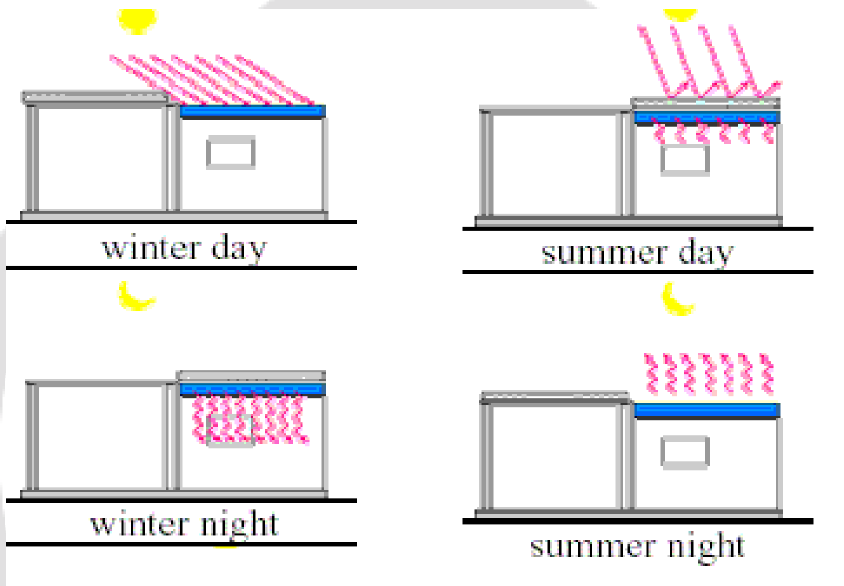

Figure : 1.1 Roof Pond

2.2 Evaporative cooling

Second method consists of laying a thin uniform organic material lining (a layer of empty jute cloth) on the roof in close contact. The cloth is soaked with water which evaporates by the heat absorbed by the roof and the air movement. The heat due to Sun’s rays incident on the roof are also utilized for evaporation of the water present in the wet matting and, therefore, prevents the heat content of the roof. The higher the incident radiation of the Sun and wind speed on the roof, higher will be the quantity of water evaporated resulting in more cooling effect. Therefore, this technique is very useful for cooling of buildings in arid areas where high solar radiation and high wind speed are available. By this technique, indoor dry bulb temperatures can be achieved near the outdoor wet bulb temperatures.

2.3 Spray over the roof

In third technique, water is sprayed over the roof. It is also a kind of evaporative cooling. A fine layer of water was maintained to increase evaporation rate. A small pump was used to circulate the water over the roof.

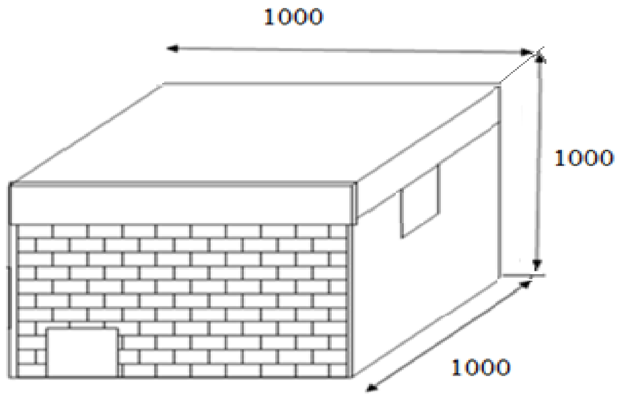

Figure 1.2 Experimental set up

2.4 Insulation over the Roof

In forth technique test structure's roof was covered with thermocol sheet, the thickness of insulation was 20 mm

2.5 Radioactive cooling

Fifth technique was to use reflective roof in which silver paint was used to reflect solar radiation. Heat load from the roof can be reduced by applying reflecting coating on the roof. Generally white wash is used over the roof. Its reflectance for short wavelength is about 0.7—0.9. This test structure, roof was painted using silver paint.

2.6 Inverted earthen pots

In this method, earthen pots having 100mm base diameter and 125 mm height were kept over the roof. Air gap between roof and earthen pot acts as a thermal insulation over the roof.

Sufficient number of experiments was performed under different climatic conditions using the above mentioned techniques one by one. Other climatic parameters such as ambient temperature, intensity of solar radiation and wind velocity, relative humidity were same for both the test structures as they were built side by side. A numbers of thermocouples were fixed on inside and outside surfaces of roof of both the structures for measurement of temperature. Temperatures were recorded at a regular interval of 15 minutes using PC based data logger. The provision was also made to measure the intensity of solar radiation using pyranometer with shading ring. The heat transfer through the roof was calculated by the following equation

$Q_R = U_R \times A\ (T_o — T_i)$

Following constants values were used in calculation.

L = 0.1 m, A =1 x 1= 1 m^2, K = 1.20 w/m-k.

3. Results and discussion

Using roof pond ,It was seen that the measured room air temperature under passive cooling to be lower than those of without passive cooling conditions during the one month measurement. In order to further evaluate the cooling potential of passive cooling with roof pond compared to the without passive cooling conditions; table 2.1 shows sample data for the variation of room temperature of room 1 (roof pond with water level 50 mm) and room 2 (with Bare RCC roof). It also indicates that the temperature below the RCC slab in room 2 was between 25.7 0C to 36.4 0C while it was 22.5 0C to 34.60C in room 1. This roof cooling system gives stable indoor temperature and reduce heat flux through the roof than bare RCC roof. Even in the afternoon, when the air temperature is relatively higher and solar radiation is intense, there is still a lower amount of heat flux flows through roofs into the room. Figure 2.2 indicates that the percentage reduction in heat gain from the roof varied between 40.4 % - 58.9%.

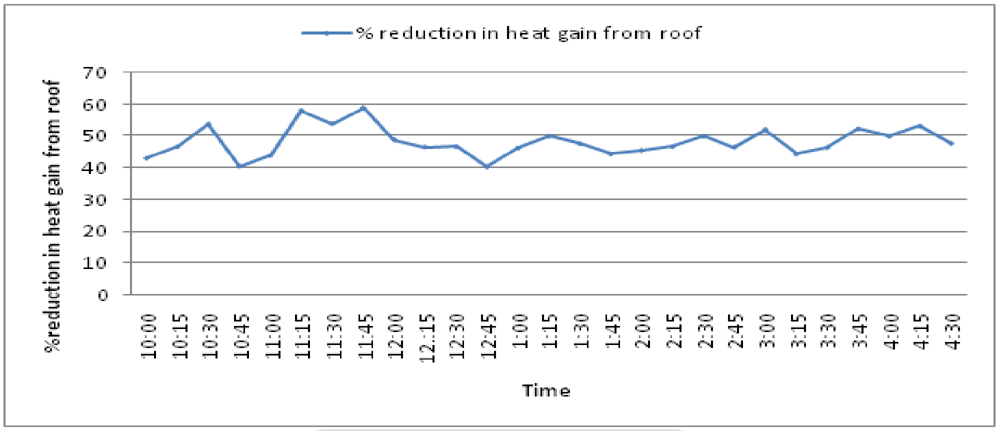

Figure 1.3: percentage reduction in heat gain through roof pond

4. Conclusion : The optimum type of rooftop garden is the rooftop garden with shrubs (exposed roof as the base case). The rooftop garden with shrubs (300 mm thick soil and shrubs) could achieve a saving of 73.8 % in the peak space load. The roof coved with dry clay soil (typical flat roof as the base case 900 mm thick soil) could achieve a 67.8% reduction in heat gain from roof. The roof coved with wet clay soil (typical flat roof as the base case 900 mm thick soil with 40% moisture contain) could achieve a 22.6% reduction in heat gain from roof. The lowest RMSE-value for test data was obtained using a trainlm algorithm. This network gave RMSE = 0.112 for training data, so most situations, we recommend that you try the Levenberg-Marquardt algorithm first. If this algorithm requires too much memory, then try the BFGS algorithm, or one of the conjugate gradient methods. The Rprop algorithm is also very fast, and has relatively small memory requirements. ANN gives satisfactory results with deviation of 4.7% and successful prediction rate of 93.8–98.5%.

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