



'BPRI' (BURNT-POT ROOF INSULATION), THE NOVEL METHOD OF ROOF INSULATION IN BANGLADESH

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Abstract: The roof of the building needs insulation for thermal and humidity purposes. In Bangladesh lime-terracing is used for this purpose. Mortar made of slaked lime and powdered brick (local name: *surki*) is applied on the reinforced roof in 100 mm layer. It works fairly well in the situation where the variation of internal and external temperatures is low. In Bangladesh this variation in the naturally ventilated rooms is not over 3° C and lime terracing shows a time lag of about 5 hours at this range. Some of the problems of the conventional Lime terracing are (a) It is costly, (b) It allows heat leakage when atmospheric temperature rises above 35° Celsius and also when there is wide variation in internal and external temperatures due to air-conditioning of the room. The authors of this paper devised an alternate system. In this system air pockets were provided inside the layer such that it became lighter, consumed less material and had more insulating properties. The air pockets were provided by using burnt clay pots available in the market. The system was named Burnt-Pot Roof Insulation, abbreviated as BPRI. It was first applied in Khulna, Bangladesh in the year 2002. The cost of construction was only 10% of the cost of conventional lime terracing. The system at present is having increasing use in the country.

Key words: Roof insulation, thermal insulation, lime terracing, clay pot

Introduction

The thermal and humidity insulation used over R.C.C roof in Bangladesh is known as 'Lime terracing'. In this system mortar of Lime and *Surki* is applied on the reinforced roof in 100 mm to 150 mm layer. The material is heavily beaten that renders it water-proof. However, it increases the density of the material and hence its heat absorbing capacity. The conventional type of lime terracing works fairly well in the situation where the variation of internal and external temperatures is low. In the naturally ventilated rooms in Bangladesh this variation is not over 3° C. At this range of variation a 100 mm thick lime terracing shows a time lag of about 5 hours. However, during the summer season, most of the roofs are exposed to direct sunray for a period of 6 to 7 hours. In such case heat is found to transmit inside during the afternoon and evening. A user's response survey was conducted in 28 high-rise apartment buildings in Dhaka city in 2002. All the buildings under survey had lime terracing insulation. The respondents residing on the top floors complained of heat from the roof during hot days (Sarma, 2002).

It has been observed that 'Heat conduction through the material of the roof can be lowered by using materials with higher insulating properties, increasing thickness, using air cavities etc.'" (Sarma and Mallick, 2005). Following this principle the authors of this paper devised an alternative method and applied the same on the roof of a house in 2002. In this system burnt clay

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pots were placed in inverted positions and covered with mortar of Lime, *Surki* and Building rubbish. The thermal and humidity insulating properties of the layer was felt almost immediately. The system is known as 'Burnt-Pot Roof Insulation' abbreviated as BPRI. Burnt clay pots are manufactured in the country for the purpose of marketing yogurt and these pots have been found suitable for this purpose. Other materials used are : Polythene sheet, Lime, *Surki*, Building rubbish and Cement. The clay pots are placed in inverted positions and covered with mortar of lime, *surki* and building rubbish. The air trapped inside the pots act as insulator and their use considerably reduces the weight of the material and their cost. Polythene sheet acts against leakage of humidity or water. After observing its initial success and extremely low cost, this system has been used in a number of buildings all over Bangladesh.

Problems of traditional lime terracing: The traditional Lime terracing has got many disadvantages or limitations, notable among those are the following:

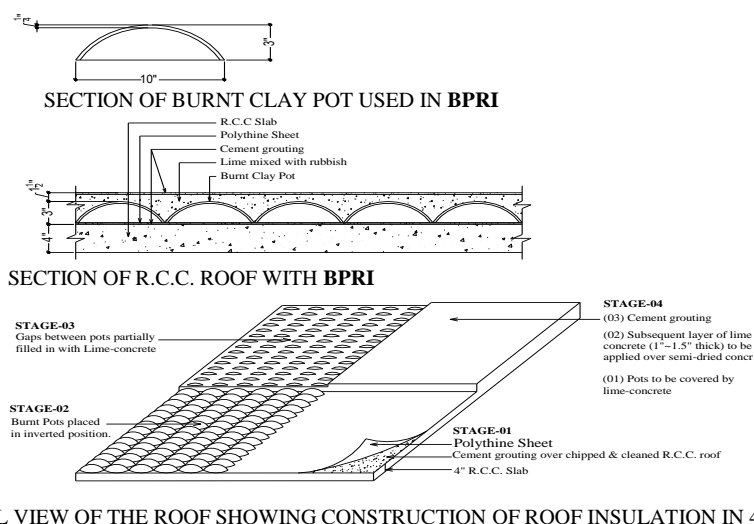
- (i) It is quite costly because of the cost of material, cost of labor for beating etc. When the owners go for vertical phasing, every time they go for vertical extension they need to remove the previous lime terracing and apply anew. Thus the money applied on it earlier turns to wastage.
- (ii) The traditional Lime-terracing is heavy in weight. It needs professional experts for the mixing of materials and contingent of laborers for beating. The beating creates hazardous vibration and noise pollution.
- (iii) The removal of the material after the expiry of life (after 15 to 20 years) is quite hard and quite often it damages the roof.
- (iv) Lime-terracing shows thermal leakage in the naturally-ventilated rooms at temperature above 35° C and at lower temperature in case of air-conditioned buildings.

Materials and Methods

The following methodology was followed for the BPRI:

- (a) The reinforced concrete roof was cleaned and all sharp edges, removed. It was then soaked with water for 6 hours. .
- (b) Cement slurry (cement: water = 1: 16 by weight) was evenly spread on the surface.
- (c) When the slurry turned semi-dry polythene sheet (weighing minimum 1 kg per 6.5 square meter) was spread evenly. An overlap of minimum half meter was provided at places where two sheets met.
- (d) Burnt clay pots (size : diameter 250 mm, height 75 mm) soaked for 6 hours were placed in inverted positions. Those touched one another at the rim and left minimum space in between.
- (e) The voids were filled with mortar made of lime, *surki* and building rubbish (proportion 1:4:16 by volume) up to a height of 25 mm. Prior to use the lime was slaked (soaked in water) for 8 hours. The size of the coarse aggregate (building rubbish) was less than 15 mm.
- (f) Twenty-four hours after the application of the first layer, another 50 mm thick layer of the same material was applied. This time bigger aggregates but less than 40 mm were used.
- (g) Twenty-four hours after the above application the final layer of mortar (thickness : 25 to 50 mm) was applied. This time the size of the coarse aggregate was less than 15 mm.
- (h) The job was left for drying for a period of 48 hours. Then cement slurry (Proportion - cement : water = 1: 16 by weight) was evenly applied on the surface.
- (i) Slope for drainage of water was maintained at the top layer.

The system has been explained in the Fig. 1.



ORTHOGONAL VIEW OF THE ROOF SHOWING CONSTRUCTION OF ROOF INSULATION IN 4 STAGES

Fig.1. Bpri (burnt pot roof insulation) for thermal and rain water purposes.

Results

BPRI was first applied in the roof a two-storied house in Khulna city in April, 2002. Immediately after application, the users reported to have similar thermal comfort as they usually feel due to conventional lime terracing. The comparative efficiency of BPRI in the following points was evaluated in 2006, i.e. after 4 years.

Wear and tear: After normal use for four years, the roof did not show any sign of crack, wear or tear.

Humidity leakage: A part of the BPRI was exposed to find out if there was any deposit of water or humidity in the void space. There was absolutely no such deposit and the material was found fairly dry.

Efficiency as thermal insulator: Heat transmission through the material of the roof is given by : $Q=AUT_{diff}$, where A = surface area in m^2 , U = transmittance value in $W/m^2 \text{ deg. Celsius}$ and T_{diff} = Temperature difference.

(i) Walls: Normally the external walls are constructed with 250 mm thick brick with plaster on both sides. Such walls have been found to have Time Lag of over 12 hours. In the summer seasons, the western and southern walls may be exposed to direct sunray for maximum 7 hours (10 AM to 5 PM). Since this period is less than the time lag of the wall-material, normally there happens no transmission of heat through the walls.

(ii) Roof: In the summer season the average sunshine per day in the major cities of Bangladesh varies from 5.7 to 9.1 hours (Sarma 1997). During this time the roof gets direct solar radiation from 10.00 AM to 5.00 AM, i.e. for about 7 hours. In a condition with atmospheric temperature exceeding 35° Celsius , 100 mm thick reinforced concrete roof with no insulating layer starts transmitting heat inside after half an hour. In Bangladesh most of the houses are naturally ventilated through windows, fanlights and ventilators. This makes the difference between the

external and internal temperatures quite low. Due to this low value of Temperature difference (T_{diff}) a 100 mm thick layer of lime-*surki* can resist the conducting heat for about 5 hours. In Bangladesh the experts recommend a time lag of 3 hours for the roofing materials (Alam and Ullah 1994). However, heat conduction starts much earlier when the atmospheric temperature exceeds 35° C.

In the above context, in order to find out the efficiency of BPRI in thermal insulation, it was decided to record simultaneous Temperatures at the surface above and below the roof. Two numbers of Electronic thermometers (thermo-hygrometer with clock and measuring up to 1/10 of a degree) were used for this purpose. The enumerators were asked to take readings exactly at times: 2.30, 2.45, 3.00, 3.15, 3.30 and 3.45 PM. The findings have been presented in Table 1.

Table 1. Temperatures above and below the roof with BPRI insulation.

| Time in PM : | 2.30 | 2.45 | 3.00 | 3.15 | 3.30 | 3.45 |
|----------------|------|------|------|------|------|------|
| a. Temp above | 31.4 | 31.9 | 32.4 | 32.2 | 32.8 | 31.6 |
| b. Temp. below | 28.3 | 28.5 | 28.8 | 28.7 | 29.4 | 27.7 |

Average of the differences between the 5 sets of reading = 3.48

On the following day the same readings were repeated in exactly the same time in a similar house with conventional lime-terraced roof. The findings in this building have been shown in Table 2.

Table 2. Temperatures above and below the roof with lime terracing insulation.

| Time in PM : | 2.30 | 2.45 | 3.00 | 3.15 | 3.30 | 3.45 |
|----------------|------|------|------|------|------|------|
| a. Temp above | 30.3 | 31.2 | 31.8 | 32.0 | 32.0 | 32.2 |
| b. Temp. below | 27.3 | 27.7 | 27.6 | 28.7 | 28.4 | 28.7 |

Average of the differences between the 5 sets of reading = 3.51

The above findings revealed that in point of thermal insulation BPRI is equally efficient like conventional lime-terracing. It may be noted that thermal leakage starts at lower temperature if T_{diff} is high, and it happens when the room is air-conditioned. The temperature in an air-conditioned room needs to be maintained below 20° C for comfort, where the external temperature may be 33°-39° C. Even though it was not possible to conduct this experiment with air-conditioned buildings for lack of logistics, it is expected that BPRI would show better performance because of insulation provided by the air-pockets of the burnt-pots.

Advantages of BPRI: Burnt Pot Roof Insulation (BPRI) has got a number of advantages over the conventional lime-terracing some of these are as follows -

- (i) BPRI is extremely cheap. The cost of civil works depends upon a number of factors like the cost of materials, labor, transport, storage etc., all of which varies from place to place and from time to time. So, it is not possible to find the comparative costs on global basis. However, in the Khulna region of Bangladesh the cost for the two types has been calculated and it was found that BPRI costs only 10% of traditional Lime-terracing.
- (ii) The construction of conventional lime-terracing needs expert masons, skilled workers and experienced beaters. It is possible to make BPRI by the semi-skilled laborers.
- (iii) The weight per unit area of BPRI is about 50% of the conventional lime-terracing.
- (iv) Quite often the house-owners construct buildings by vertical phasing. In such case, every time the building is extended vertically the owners need to remove the old layer of insulation. BPRI is suitable for such purpose because of its extremely low cost.

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(v) Lime-terracing needs to be removed and re-applied after every 15 to 20 years. It has been found that the process of its removal involving heavy beating damages the reinforced concrete roof. BPRI is free from such hazards.

Conclusion

Burnt Pot Roof Insulation or BPRI is now a popular term in Bangladesh. It has been used in many buildings and showing excellent results. One of the causes of its popularity is its cost which is extremely low. With increased demand the potters have increased their production. The first BPRI constructed in 2002 is still in excellent condition and has no sign of crack, wear and tear. Since the age of the oldest BPRI is only 4 years, it is not possible to predict its life-time. However, the users seem to have little headache for it because of its extremely low cost.

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