BUILDING DIGEST
CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

COOLING OF BUILDINGS BY ROOF SURFACE EVAPORATION
(Choice of Materials for Retention of Water)

Introduction

Cooling of buildings by the evaporation of water at roof surface using gunny bags has already been established to be an effective and economical way of controlling the indoor thermal conditions. Extensive trials of this technique on a variety of buildings showed that gunny bags * used to retain water on roof tops had to be changed after every two or three years resulting in inconvenience and expenditure. Therefore attempts were made to search for other efficient and durable materials to serve the same purpose.

A survey of materials to serve the required purpose resulted in the selection of a few materials based on their efficiency, cost and durability. Finally such materials were laid on the roofs of indentical test rooms to study their relative effectiveness on the indoor thermal conditions.

Method and Significance of Evaporative Cooling of Buildings

Suitable materials are spread on the entire conventional roofs having properly treated for heat-insulation and water-proofing purposes. The material spread on the roof should be able to abs-orb sufficient water and allow quick evaporation The essential requirement of the water spraying is its uniformity over the entire surface to keep it constantly wet day and night. Also the quantity of water in the material at any instant should not be in excess of its saturation level, otherwise the extra water on the roof may tend to leak through the water proofing treatment. By keeping continuously the roof surface in wet conditions the life of the slab will be more due to its protection from the daily periodic heating and cooling in the summer season. The significant feature of this roof treatment has been that even during the hot summer afternoons ceiling temperatures were higher than those of the exposed roof surface and heat flow was from indoor to outside.

Properties of Materials for Roof Treatment-Purposes

Since in this process cooling takes place through evaporation the material used for the retention of water at the roof surface should be able to allow enough evaporation, which depends on the pore-structure of the material. Gunny bags were found to be good for this purpose, where evaporation was 84 per cent by weight. The material must have the ability to absorb water at least 20 per cent by weight. Intervals of sprinkling water depends upon the abs-orption and the evaporation properties of the mate-rial. Its durability governs expenditure and freq-uency of replacement. Cost, availability and fire safety have also to be taken into considerations.

A number of materials were examined for this purpose. Inorganic materials included :

(a) different kinds of concrete.
(b) brick ballast with and without binding materials.
(c) bloated clay aggregate.
(d) sintered fly-ash.
(e) blast furnace slag and
(f) sand.

Organic materials were :

(a) coconut husk either loose or in the woven/ rubberised matted form.
(b) thatch and
(c) Jax Board.

To check the evaporation properties, samples of 30×30 cm in varying thicknesses were saturated with water for 24 hours, weighed and placed on a plane concrete platform for exposure to the clear weather conditions in the first week of April at Roorkee. The amount of total water absorbed and the evaporated water in three hours was determined which is given in Table-1.

From this Table it can be observed that for inorganic materials tested evaporation percentage is more for 2.5 cm thick layer as compared to higher thicknesses of the same material, whereas for the organic materials tested evaporation does

* C. B. R. I. Building Digest No. 108 "Roof Surface Evaporative Cooing of Buildings by Water Soaked Gunny Bags".

Table-1

S. No. MATERIALS	Thickness	Weight of Absorbed Water (gms.)	Absorption percentage by weight.	Weight of evaporated water (gms.)	Evaporation per cent (after 3 hours).
Organic Materials					
1. Gunny Bags	0.5 cm double layered.	290	200	244	84
2. Gunny Bags with Sawdust	4.0 cm	3500	—	700	20
3. Thatch	2.5 cm	330	106	274	83
4. Woven Coconut or Coir Matting	0.25 cm. (Single layered)	200	100	178	89
,,	0.5 cm. (Double layered)	410	180	361	88
5. Coconut Husk (loose)	2.5 cm	346	180	294	85
6. Coconut Rubberised Matting.	2.5 cms.	180	—	155	86
7. Jax Board	2.5 cms.	445	—	156	35
8. Fibreglass	2.5 cms.	962	—	350	36
9. Polyurethane	4.0 cms.	1664	—	417	25
Inorganic Materials					
1. Brick Ballast (2.0 cm size)	2.5 cm	400	20	362	90
,, ,,	3.8 cms.	605	—	363	60
,, ,,	5.1 cms.	811	—	430	53
2. Brick Ballast Binded with Lime and Surkhi	2.5 cms.	680	—	170	25
3. Sintered Fly Ash					
,, ,, ,, Solid	2.5 cms.	301	20	238	79
,, ,, ,, ,,	3.8 cms.	450	—	220	49
,, ,, ,, ,,	5.1 cms.	605	—	277	46
,, ,, ,, Crushed	2.5 cms.	460	—	301	65
4. Foam Clay Brick	2.5 cms.	250	—	224	90
,, ,,	5.0 cms.	480	—	408	89
5. Concrete Light Wt.	2.5 cms.	165	20	105	64
,, ,,	5.0 cms.	320	—	161	50
6. Concrete Cellular	2.5 cms.	280	—	154	55
,, ,,	5.0 cms.	577	—	240	42
7. Blast Furnace Slag (Air cooled)	2.5 cms.	613	—	400	65
8. Sand	2.5 cms.	750	—	548	73

not depend on the thickness of the material. For example in woven coconut fibre the evaporation remains almost the same even if the thickness is doubled. Further, materials having a high evaporation percentage like foam-clay-bricks or thatch are ruled out because of considerations of cost or durability.

Water absorptivity is defined as the ratio of total water absorbed by the material to its dry weight. It can also be seen generally all inorganic materials of 2.5 cm thickness have 20 per cent of water absorption. In single layered organic materials like coir-matting water is evaporated in less time which requires use in double layers, otherwise more frequent wetting would lead to extra cost.

Choice of Material Finally Made

In view of the cost, efficiency and durability three materials i.e. brick ballast, sintered fly ash and coconut husk (loose or rubberised matting) or coir matting were finally selected. Table -2 gives the comparative idea of cost and durability for these various treatments for a roof of dimensions 3.6 m×3.0 m.

Recommended Use of Material for Practical Purposes

For water retention the use of loose brick ballast is recommended in view of its cheapness, efficiency, durability and fire proofing aspects. Use of binding materials to produce a smooth walkable surface results in loss of efficiency. Loose brick ballast can also be removed and reused subsequently, use of coir or rubberised matting of coconut fibre is similarly useful. The durability of such materials is rather good, but it will have to be treated for fire safety and this can be easily rolled and kept safe for the next season or can be used otherwise inside the buildings in the winter season.

The following points from practical considerations are also to be taken note of in adopting this technique :

The roof surface must have an effective waterproofing treatment. In case there is no parapet wall a dwarf parapet wall over the treated roof shall be provided to hold the brick bats etc. and also proper drainage to drain out surplus water, if any, unabsorbed by the brick bats shall be provided.

Table–2

S. No.	MATERIAL	Thickness	Total Qty. of material required.	Cost Per Unit	Total Cost* of Material	Durability.	Efficiency **
1.	Gunny Bags	0.5 cm. (Double-layered	35 empty cement bags.	Rs. 0.75 per bag	Rs. 26.25	2 to 3 years.	Most efficient
2.	Woven Coconut or Coir Matting.	0.5 cm. (double layered)	10.8 Sq. metres	Rs. 10.00 per sq. metre	Rs. 108.00	Long life	Most efficient
3.	Brick-Ballast	2.5 cms. (2.0 cms. size)	0.28 cubic metre	Rs. 35.71 per cubic metre	Rs. 10.00	,,	Most efficient
4.	Coconut Husk (loose)	2.5 cms.	20 K.gms.	Rs. 0.50 per kg.	Rs. 10.00	,,	Most efficient
5.	Coconut Rubberised Matting	2.5 cms.	10.8 Sq. metres	Rs. 22.00 per sq. metre	Rs. 140.00	,,	Most efficient
6.	Sintered Fly Ash	2.5 cms.	0.25 cubic metres	Rs. 57.14 per cubic metre	Rs. 16.00	,,	Quite efficient

* Roof Dimension 3.6×3.0 metres.

** Based on Evaporation Per cent.

This treatment should be done specially for those rooms only which are being used for day time living in the summer season.

Experiments in Actual Test Rooms

For final verification and assessment of the effect on the indoor thermal conditions, some of these materials viz. Brick ballast, sintered fly ash, coconut husk or woven coconut fibre coir-matting etc. were laid on the roofs of a group of test rooms. Five identical test rooms with the same roof and wall specifications were used for the study. The roof of the four test rooms was treated individually with (i) gunny bags (ii) brick ballast (iii) sintered fly ash and (iv) loose coconut husk and the fifth room was used as untreated one to compare the effect of these treatments. Water on these treated roofs was sprinkled to keep these materials wet for all the 24 hours. Hourly temperature observations of roof ceiling and indoor air, were measured by callibrated copper-constantan thermocouples correct to ± 0 5°F round the clock for several days in the summer months, but data for a hot clear and calm weather day has been considered for the analysis and discussion of results.

It was observed that all these treatments have reduced the roof, ceiling and indoor air maxima temperatures to the extent of 22 to 25, 15 to 17 and 4 to 5 degree centigrade respectively in comparison with the untreated roof. The maximum reduction was observed in the case of brick-ballast and minimum in the case of sintered fly-ash.

Similar experiments were also performed in another test room with conventional wall and roof specification. The roof of this test room was also treated with brick ballast which was kept wet for all the 24 hours. In this case also a drop of the order of 5 degree centigrade in the resultant indoor air temperatures have been observed as a result of this treatment.

Conclusions

Gunny bags can be replaced by a number of other durable and efficient materials like brick ballast, coconut husk (loose or rubberised), coir mat and sintered fly ash to obtain nearly the same cooling effect with that of the gunny bags.

The final choice depends upon the availability of the particular material in the concerned area, convenience of the user and the amount one would like to spend on such a treatment. However brick ballast in 2.5 cm. thickness is recommended because of its cheapness, durability and efficiency.

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 117th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

UDC 697.1 : 69.07
SfB Ab8

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Published by : S. Srinivasan
Central Building Research Institute,
Roorkee, India.
February, 1976.

Printed at
Lakshmi Printers, Saharanpur. (India)