BUILDING DIGEST
CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

SIMPLE AND EFFECTIVE ROOF SPRAYING SYSTEM OF COOLING BUILDINGS IN HOT DRY CLIMATES

Introduction

The use of light weight structures, reduced ceiling height, minimum possible floor area, and larger glazed openings in the present day buildings has necessiated greater attention on thermal comfort in buildings.

Comfortable thermal condition within a building could be obtained by (a) architectural design, (b) forced ventilation, (c) evaporative cooling and (d) air-conditioning. Improvement in thermal condition through architectural design is limited. Other artificial methods, besides being expensive due to energy consumption, have their own problems and limitations for general use.

In view of the above an indigenous, effective, economical and practical form of cooling technique of "Open Evaporation of Water from Roof Surfaces" has been found to be appropriate. This provides considerable thermal comfort and substantial reduction of energy in air conditioning. The digest deals with the guidelines of the roof spraying system and its efficacy.

Installation of Roof Spraying System

Water proofing treatment of the roof terraces should be checked and ensured. A 25 cm thick layer of brick ballast shall be spread over the terrace. This is found* comparatively better than the empty cement bags in regard to cost, durability, and water absorption/evaporation characteristics.

Manual spraying of water on the retentive material has not been found satisfactory. In developing a suitable water spraying system the following have been considered important :

(a) Uniform and constant wetting arrangement.

(b) Frequency and mode of spray in order to maintain desired rate of water evaporation and as per saturation capacity of the water retentive material.

(c) Capability of the system to work at very low pressures (1 to 5 p s i) which are normally available at single storey roof levels.

(d) Capability of the system to cover maximum possible roof area at the available low pressures.

(e) Convenience of operating the system from lower floors.

A PVC sprayer (photo 1) with proper hole size, its location, angle, and length of arm to ensure maximum coverage and uniform spraying is important. (The same has been designed at CBRI). The PVC sprayer is placed at the centre of the roof (photo 2) connecting it with GI/PVC or rubber pipe to the water supply line on the overhead tank and a control valve is provided at a suitable place. If it is located at the ground level, it would be easy to operate. In case of multi-storeyed buildings where water supply is generally made by booster pumps, the system can be connected to the water supply line feeding the overhead tank at roof level. In the case of intermittent water supply, water from mains is stored in an under ground revervior or sumps during the supply hours and the same water is pumped to the sprayer directly or through the overhead tank.

* CBRI Building Digest No. 117.

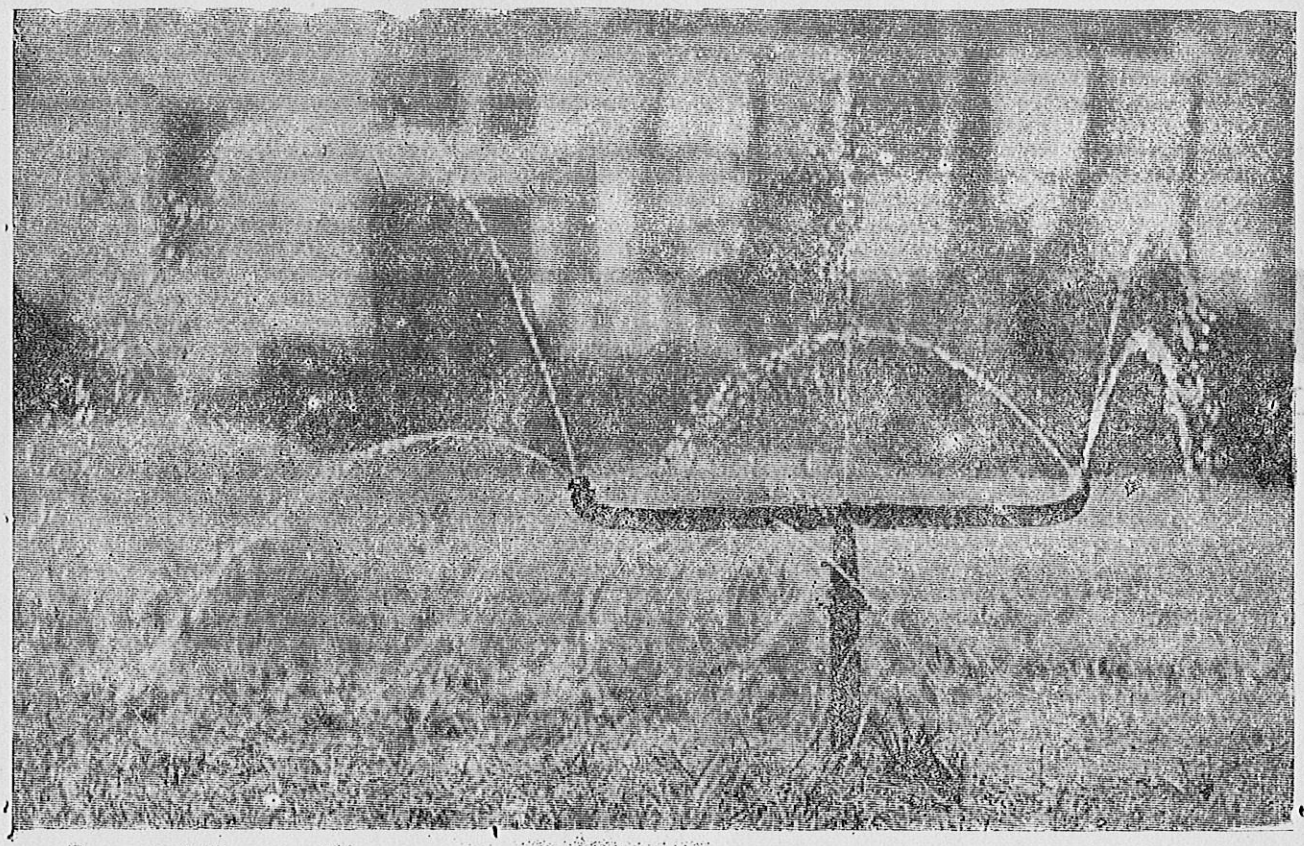

Photo 1. P. V. C. Sprayer Designed at C.B.R.I.

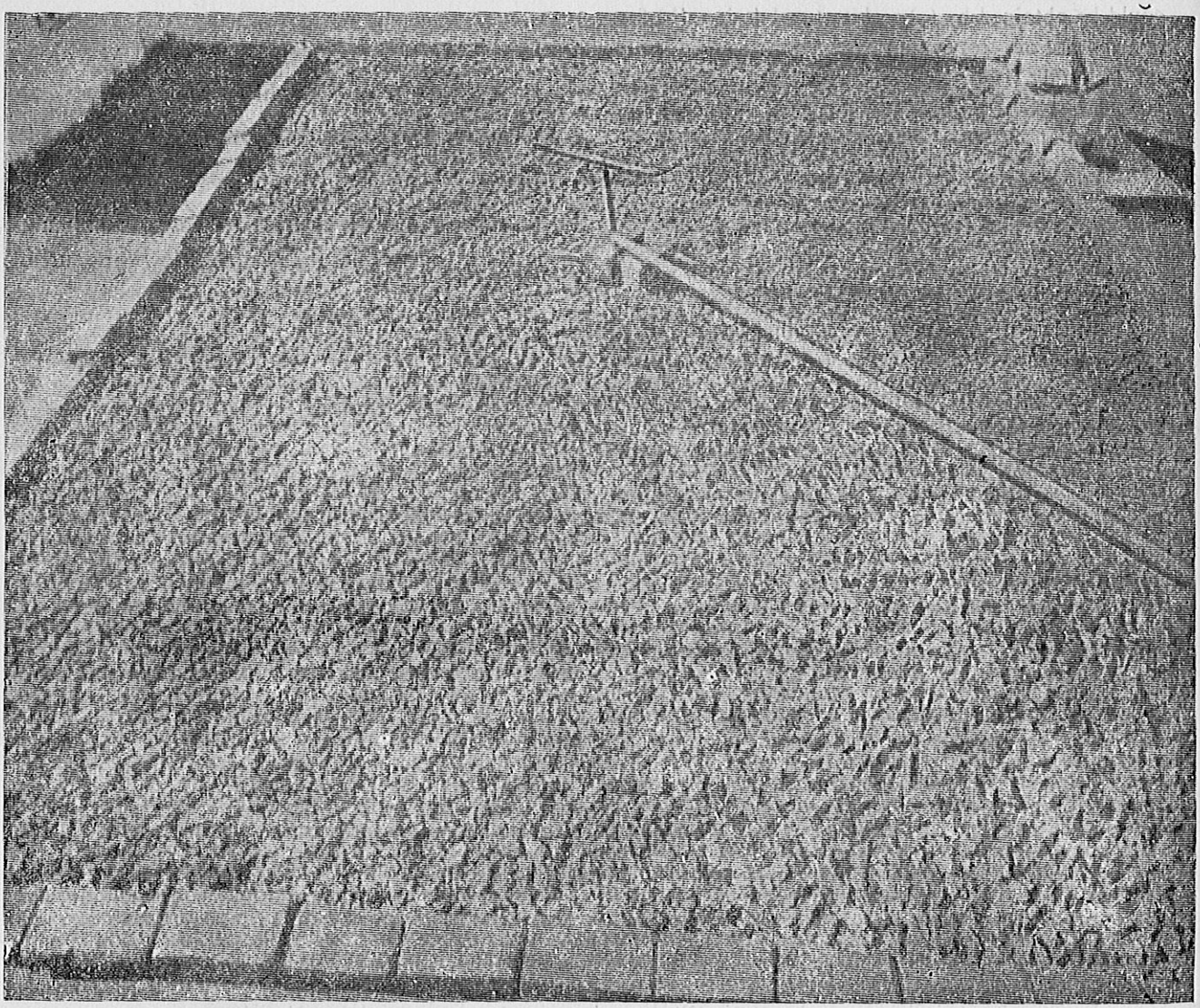

Photo 2. Roof of a Room Treated with Brick-Ballast & P.V.C. Sprayer

Table 1 provides data for the space coverage at different water pressures and angles of spray.

Table 1

Diameter of the area covered at different pressures and angle of spray.

Sprayer Angle (degrees)	Pressure (Kgm/cm^2)	Diameter covered in metres
0	0.07	1.675
	0.14	2.690
	0.21	4.150
	0.28	4.575
15	0.07	1.980
	0.14	3.300
	0.21	4.165
	0.28	5.490
30	0.07	1.980
	0.14	3.505
	0.21	4.775
	0.28	6.405
45	0.07	2.03
	0.14	3.76
	0.21	5.185
	0.28	6.910

Water Requirements

Table 2 gives the amount of water evaporated at different times on a very hot and clear sunny day in the month of May at Roorkee.

Table 2

Rate of evaporation under actual weather conditions.

Time Period (hours)	Evaporated Water in Litres from Roof Top (13. 6 Sq. m) (litres)
0600 to 0900	9.18
0900 to 1100	17.53
1100 to 1300	25.31
1300 to 1500	36.11
1500 to 1900	18.86
1900 to 0600	13 79

From Table 2 it can be worked out that the total consumption of water per square metre per 24 hours is about 9.0 litre. This is relatively a very small amount to produce considerable thermal comfort in unconditioned buildings and 9.0 litres of water used completely will produce somewhat more than 1.8 ton of refrigeration in the case of an airconditioned building.

Water Spraying Procedure

Water saturation capacity per unit area of the water retentive material should be determined to ensure that the water does not leak through the roof surface.

Table 3 gives the water saturation capacity per unit area of 2.5 cm thick loose brick ballast.

Table 3

Weights	Weights in Kgm per Sq. m.
Dry weight	20.3 Kg
Saturated weight	24.2 Kg
Total water absorbed for saturation	3.9 Kgs

Form Table 3 it is obvious that in an area of 10 sq.m. it is not advisable to spray more than 39 litres of water at a time. The spraying operation will have to be regulated to cope firstly with the evaporation rate at different hours of the day as per Table 2 for keeping the water retentive material wet all the 24 hours and also to check spraying so as to be less than 39 litres at a time The most appropriate timings of spraying water as per Table 2 and other requirements are 0600, 1300 and 1900 hours. Duration of spray will depend on the actual discharge rate at the available pressures from the sprayer. In the case of PVC sprayer developed at this institute, the discharge rate is nearly 2 litres per minute at a pressure of 0.21 kg/cm^2 (3 p s i) and therefore to spray 39 litres of water at a time one has to spray for about 20 minutes.

Efficacy of the System

(a) Unconditioned Buildings

Marked improvements in thermal conditions in quantitative terms as a result of direct comparative field studies in actual rooms with and without treatment have already been reported in an earlier building digest ** however the significant features of this system are listed below :

(1) Significant reduction upto 4^0C in Tropical Summer Index* at working level has been achieved in treated buildings.

** CBRI Building Digest No. 108.

* Tropical Summer Index correlate the thermal sensations of human beings with environmental parameters.

(2) During hot summer afternoons ceiling temperature were higher than of the exposed wet roof surface and heat-flow was from indoor to outside.

(3) The ceiling surface of the treated unit was found to be at the lowest temperature as compared to any of its other internal surfaces, thereby acting as a heat sink for other surfaces, on the other hand the ceiling of the untreated unit being at a higher temperature than its other surfaces, serves as a heat donor.

(4) The system works more effectively for buildings which could not be designed with thermal consideration. This is due to larger difference in indoor air and outside roof surface temperatures.

(5) Due to high rate of evaporation during day time better comfort conditions are achieved indoors.

(6) In multistoreyed buildings lower floors also get thermally cooled.

(7) The treated rooms can also be very well used during night for sleeping, due to the throwing of appreciable cool and comfortable air by ceiling fans.

(8) The system utilises natural energies for cooling buildings.

(b) Savings in the cost of air-conditioning

Fig. (1) shows the comparison of hourly heat flow at the ceiling surface of treated and untreated rooms of similar design and specifications when both of them were kept air conditioned for maintaining similar temperatures. A reduction of the order of 60 per cent in the heat flow is obtained in the treated unit.

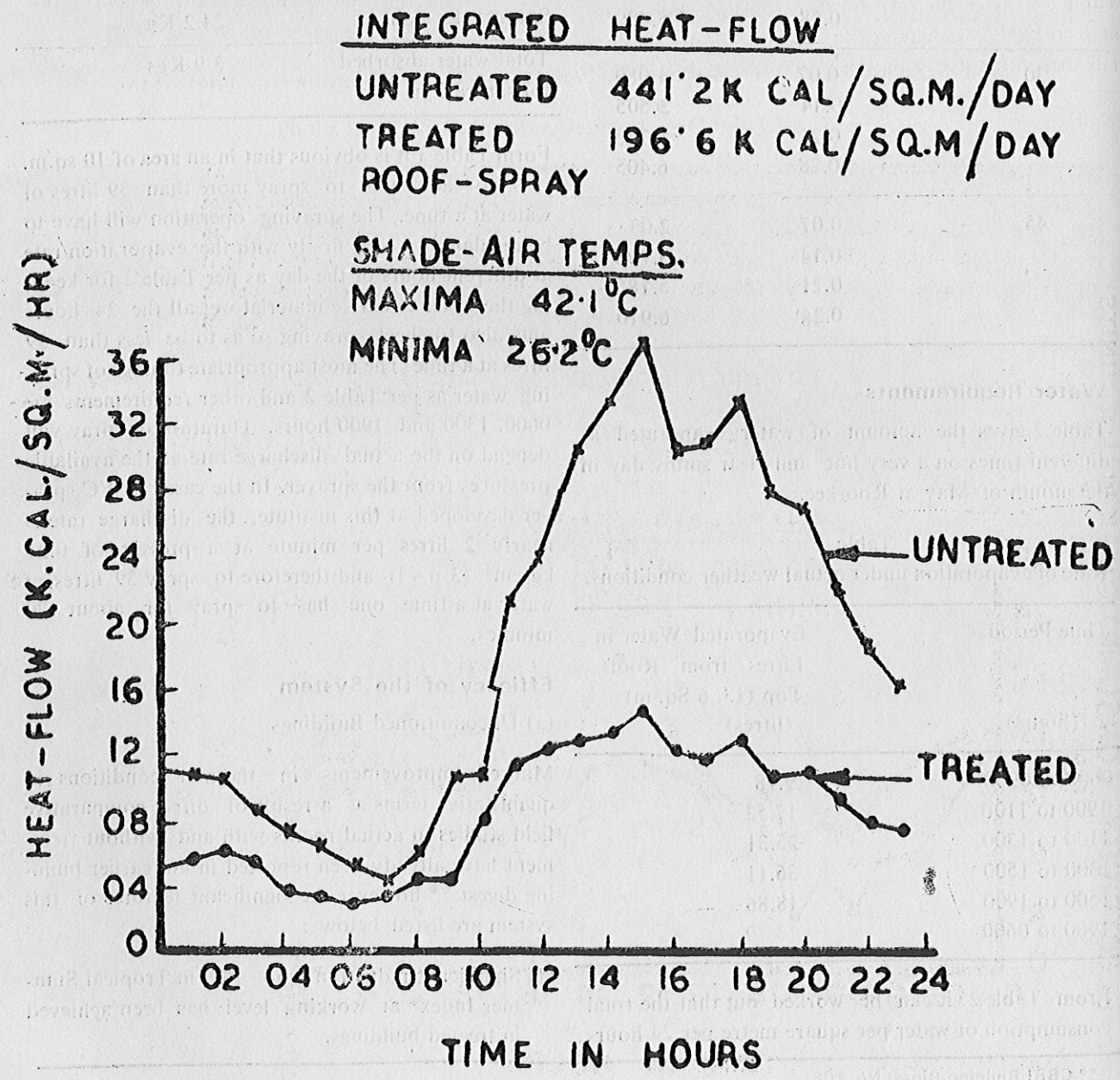

Fig. 1. Hourly Heat-Flow in Conditioned Test-Rooms with & without Roof-Spray

Fig.(2) shows the comparison of electric consumption in the treated and untreated rooms for maintaining similar temperatures in the conditioned spaces and a reduction of 30 per cent in the electric consumption is obtained in the treated one.

Integrated system of roof spray and air-conditioning obtains a reduction of 60 per cent in capital and 30 per cent in the running cost of air-conditioning single storey buildings.

Table-4
Cost of Treatment

	Single Room (One-sprayer)	Double Room (Two sprayer)	Large Office Building (Twenty sprayer)
Dimension (Metres)	4×3.6	7.32×3.65	25.5×20
Total Cost (Rupees)	95.00	125.00	2900.00

Economics of Treatment

Table—4 gives the present total cost of treatment at Roorkee. This includes the cost of labour, materials used for water retention, G.I. fittings and sprayers for single room, double room and a large office building.

Besides the initial capital expenditure, the running expenditure for water spraying is practically the cost of water only and it comes out to be Re. 1-00 per month for a single room at Roorkee.

Limitations & Practical Considerations

(1) The roof utilised or the surface to be treated.

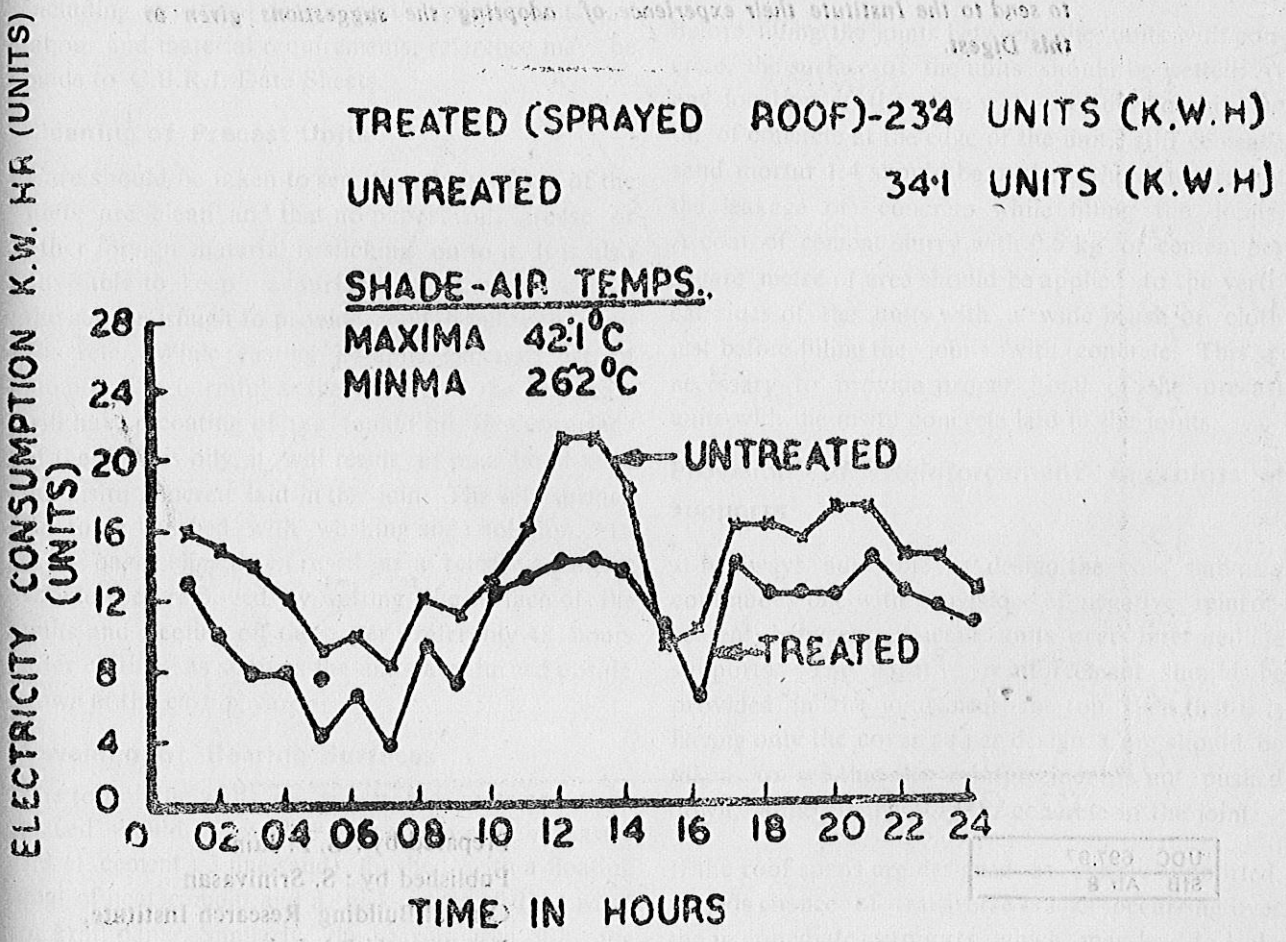

Fig. 2. Total Daily (24 Hours) Electric Consumption by the Air-Conditioner Units

must have an effective water proofing treatment. (2) A dwarf parapet wall is necessary to avoid trickling of water. (3) In view of the use of roof terrace for many other purposes, it is recommended to treat only those specific roofs of a dwelling house which are to be used for day time living in summer season.

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 124th in the series. Readers are requested to send to the Institute their experience of adopting the suggestions given in this Digest.

UDC 697.97
SfB Ab 8

Prepared by : S. P. Jain
Published by : S. Srinivasan
Central Building Research Institute,
Roorkee, (U.P.) India.
October, 1977

Printed at
Lakshmi Printers, Saharanpur. (India)