# COOLING OF BUILDINGS BY ROOF SURFACE EVAPORATION

## (Spraying Systems And Water Requirements)


*by*

**S. P. JAIN, S. P. CHAKRABARTI & S. A. SIDDIQUI**

Central Building Research Institute, Roorkee



*Reprinted from January 1978 issue of*

THE INDIAN ARCHITECT

***A-15 Pamposh Enclave, New Delhi-110 048***

# COOLING OF BUILDINGS BY ROOF SURFACE EVAPORATION

## (SPRAYING SYSTEMS AND WATER REQUIREMENTS)

*S. P. JAIN, **S. P. CHAKRABARTI AND **S. A. SIDDIQUI,
C.B.R.I., ROORKEE.

*Abstract*: The difficulties of (i) manual spraying of water on roof tops and (ii) water shortage in some parts of the country for cooling the buildings by Roof-Surface Evaporation, are the major short-comings for adopting the system into actual practice. Attempts have, therefore, been made to develop convenient, economical and functional roof spraying systems and to determine the actual water requirement to evaluate the relative cost of water versus the cooling effect obtained by this technique.

Trials of the various spraying systems designed and developed at this Institute to meet different requirements in practice, were conducted in actual buildings and the performance of these systems have been found to be satisfactory. About 9.0 litres per square metre was found to be the optimum requirement of water for this purpose at Roorkee (latitude N. 29° 51'; Longitude 77° 53'; MSL height in metres 274).

*Introduction*:

Cooling of buildings by roof surface evaporation has already been established (1, 2) to be an effective and economical method of improving the indoor thermal conditions and reducing (3) the capital and running cost of air-conditioning of order of 60% and 30% respectively, under Hot-Dry conditions. Since manual spraying of water is cumbersome it has been thus far difficult to adopt this method into actual practice. Higher water consumption, unregulated and non-uniformity of water spraying are also the other shortcomings of manual spraying. To overcome these problems and to cope with inadequate water pressure available at roof levels, different types of spraying systems are needed for this purpose. Attempts have therefore been made to develop economical and efficient spraying systems to satisfy different requirements in actual practice. Requirements of water for this purpose have also been determined experimentally for different months of the summer season to assess and compare the relative cost of water and the cooling effect produced by this technique.

*Basic Requirements of a Roof-Spraying System*

The following are the basic requirements of a roof-spraying system.

(i) The system should be capable of working at low pressure 0.07 to 0.35 Kg/cm² (1 to 5 p.s.i.) which are normally available at roof levels.

ii) It should ensure uniform spraying of water on the entire roof surface to avoid any lateral heat flow in the roof slab, which may influence the cooling efficiency of the system.

(iii) It should cover maximum possible roof area at available low water pressures.

(iv) It should be conveninent to operate the system from lower down floors.

Satisfying all these requirements two main spraying systems have been developed.

1. G.I. Perforated Pipe Grid System
2. P.V.C. sprayers.

*G.I. Perforated Pipe Grid System*:

In this system simple G.I. pipe having inward flaring diamond shaped perforations are laid over the roof in the form of a network as per conditions of ridges, slopes and spout positions. The perforations are provided a few inches apart by special tools which make them relatively free from choking and also produce a rapidly diverging spray with adequate coverage. Special care is needed in the fitting of pipe lines to keep all the perforations in a straight line. Fig. 1 shows the grid system arrangement on the roof of a residential building with diverging sprays on the water retentive material. Although

*Scientist, Efficiency of Buildings Division.
**Scientist, Building Process, Plants & Productivity Divn.

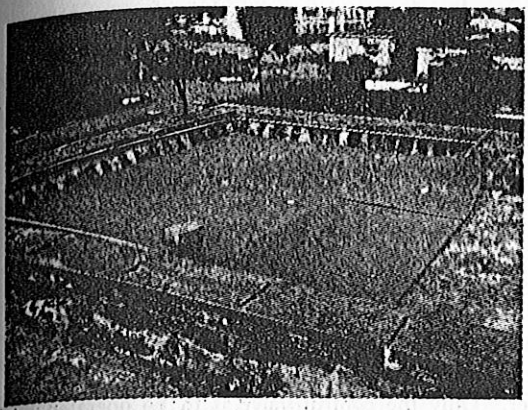

Fig. 1

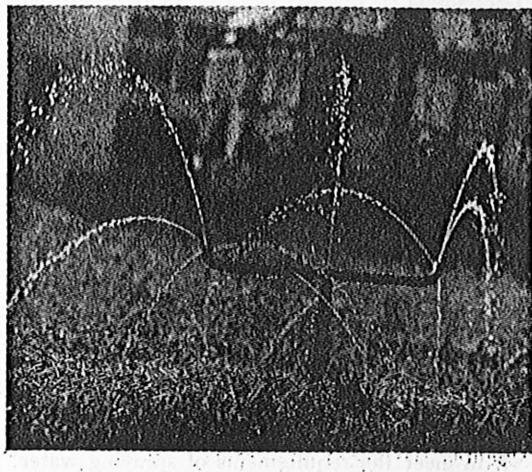

Fig. 2

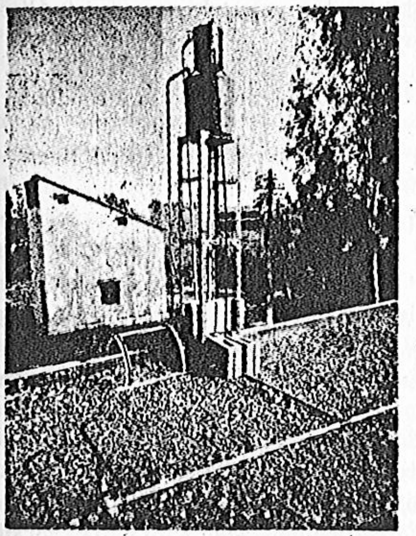

Fig. 3

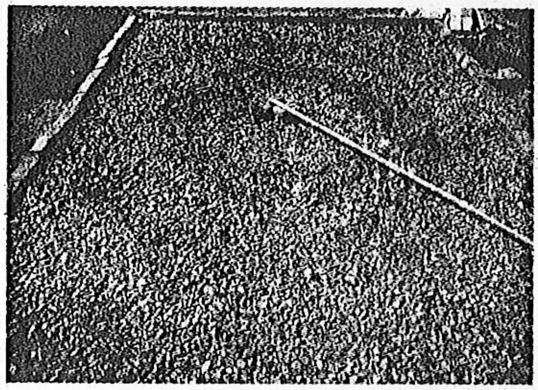

Fig. 4

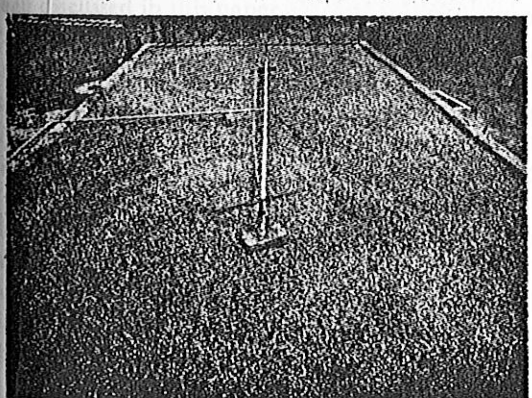

Fig. 5

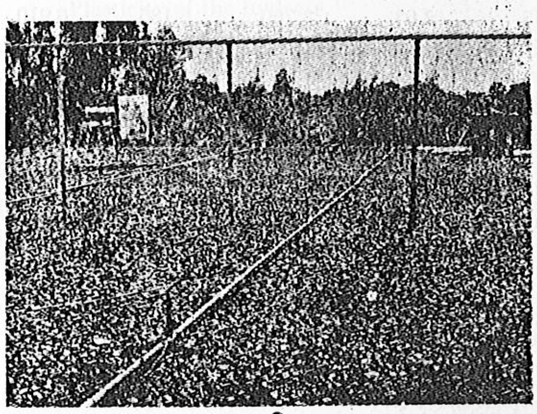

Fig. 6

this system involves a higher initial cost, it is a permanent one and can work at any available pressures, but economical layout of pipes should always be worked out according to the prevailing slopes, ridges and locations of rain water pipe inlet on the roof.

*P.V.C. Sprayer:* It has been observed that traditional metallic sprayers besides being costly do not fulfil the various requirements of the roof-spraying system since they require high pressures 0.66 to 0.7 kg/cm² (8 to 10 p.s.i.) to work, yet giving inadequate coverage. Therefore P.V.C. sprayers were designed (Fig. 2) at the Central Building Research Institute, Roorkee, to meet the requirements of spraying water on roofs. The provision of holes diameter, their location, angle and length of arm etc. have been optimised by conducting actual field trials. Every part of the sprayer is easy to fabricate, install and replace. The arms of the sprayer rotate by the torque produced due to pressure of water provided by an overhead tank at a height of about 2 metres. If the water pressure is adequate the sprayer can be connected directly to water supply line. Full mechanical details of the sprayer are being compiled separately for licensing the system.

TABLE 1: *Diameter covered in metres at different pressures and Angles of spray.*

| Spray Angle (Degrees) | Pressures (Kgm/cm²) | | | |
|---|---|---|---|---|
| | 0.07/ | 0.14/ | 0.21/ | 0.28/ |
| 0 | 1.675 | 2.690 | 4.150 | 4.575 |
| 15 | 1.980 | 3.300 | 4.165 | 5.490 |
| 30 | 1.980 | 3.505 | 4.775 | 6.405 |
| 45 | 2.03 | 3.760 | 5.185 | 6.910 |

It can be observed from table 1 that at water pressure of 0.21 kg/cm² (3 p.s.i.) the sprayer with arm angle of 45 covers a diameter of 5.19 metres which is suitable to cover large areas of roofs economically. Based on the data given in table 1, the sprayer angle can be selected for different areas of roof at different water pressures. The p.v.c. sprayer is placed at the centre of the roof connecting it with either G.I., P.V.C. or rubber pipe to the water supply line or the overhead water tank and a control valve is provided as per its desired position at the ground floor level for easy operation. In case of multistoreyed buildings where water supply is generally made by booster pumps, the system can be connected to the water supply line feeding the over-head tank, at roof level.

If an automatic intermittent system of spraying water is adopted for the sake of extra convenience, an additional siphonic tank arrangement may be provided. Stipulated quantity of water at regular intervals can be supplied for automatic spray of water. Only the control valve is to be operated by users once in the morning and once in the evening. Fig. 3 shows an arrangement on the roof of a test room for the automatic and intermittent siphonic system developed at this Institute. Its mechanical details are also separately compiled for licensing the process.

Water supply and pressure conditions of the locality of use also determine the design of water spraying systems. In general there can be two main conditions of supply:

(a) Constant supply

(b) Intermittent supply

At constant supply and sufficient pressure ( > 0.36 kg/cm² of 5 p.s.i.) at roof level the sprayer can be directly connected to the distributing line, but in case the pressure is insufficient, water has to be drawn from the overhead tank which has to be placed at a considerable height from the roof level. It is, therefore, recommended to place the tank over the roof of stair well for providing at least 2.0 metre water head to the p.v.c. sprayer.

When the water supply is intermittent due to scarcity of water, water from mains is stored in an underground reservoir or sumps during the supply hours and the same water is pumped to the sprayers directly or through the over-head tank.

*Water Requirements:*

In view of the shortage of water in some parts of the country it is important to determine the actual water requirement per unit area for a relative evaluation of the cost of water and the cooling effect produced by it. Since in this technique the cooling effect