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Experimental studies on a novel roof pond configuration for the cooling of buildings

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Abstract

A new evaporation based passive cooling technology was tested. The technology is based on the exposure of "floating" wetted cloth to the ambient air. It was compared to various other passive cooling techniques, with very favorable results. Two identical shallow ponds were constructed. One of them was covered with white cotton towels stretched on a densely perforated PVC panel supported by pieces of waterproof polystyrene keeping it just floating on the water surface. Five comparable experiments of different cooling techniques have been carried out. The results indicate that the new cooling technique performed slightly better than the pond with movable insulation, which is widely considered as one of the best roof cooling techniques based on evaporation. It seems that the higher efficiency of the tested technique is due to the thermal stratification created in the water inside the pond, which more effectively resists the transfer of heat gains from the sun and ambient air into the deep water of the pond. In turn, the water temperature near the floor of the pond is lower, thus heat flow from the building to the pond is increased. During the experiment, all the ponds which were compared were ranked according to performance (from best to worse): shaded pond with towels floated on it, pond with towels floated on it and pond with movable insulation, shaded open pond, open pond, covered pond.

Keywords: Roof pond; Evaporative cooling; Thermal stratification

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1. Introduction

The roof offers most of the opportunities for passive cooling of buildings, but if not performing well, it can present a huge liability to the building. On the one hand, the roof is the building element that is the most exposed to the sky, and nearly half of the heat load of a single story building comes from the roof [1]. Justifiably, therefore, serious efforts are made to reduce this heat load by improving the roof design. On the other hand, the roof opens a wide range of possibilities for dissipating heat from the building, either by nocturnal long wave radiation to the sky, simple convection to exterior ambient air and evaporative cooling. Evaporative cooling is probably the most effective and potent approach for passive cooling of buildings in hot-arid regions.

The reduction of heat flux using roof ponds was probably first observed at the University of Texas [2] in the 1920s, but the technique introduced some structural difficulties to buildings, and thus its use was restricted. To date, many theoretical and experimental studies on roof ponds, thin water film, water spraying roofs, and roofs with wetted gunny bags have been performed [3–11], and a few of these cooling techniques were put to practical use [2,8]. Comparative experimental studies on evaporative cooling systems have indicated that roofs with wetted gunny bags and ponds with movable insulation are the most efficient techniques for passive cooling of buildings [1,3,9]. However, the volume of water supplied for the first system must match the evaporation potential, since otherwise the roof will be flooded, whereas the second technique requires a mechanical system, operated either manually or automatically, that will cover the roof before sunshine and expose it immediately after sunset.

The present study, suggests an improved roof pond, one in which gunny bags or cloth float over the water surface, thus combining the advantages of both previously described cooling techniques: roofs with wetted gunny bags and pond with movable insulation (Fig. 1). Gunny bags or cloth are placed on a light waterproof grid or mesh, which is supported afloat by polystyrene strips or other floatable material attached to it from underneath. Wet gunny bags or cloth are used to intercept the solar radiation, and to dissipate the heat resulting from this radiation by evaporating the water soaked in them and by convection as well as thermal radiation (at night). Heat gain from the building is absorbed by water in the pond, and in turn dissipated by the same techniques.

This study examined experimentally the efficiency of such a cooling system, and compared it with other roof ponds used for the cooling of buildings in hot-arid regions.

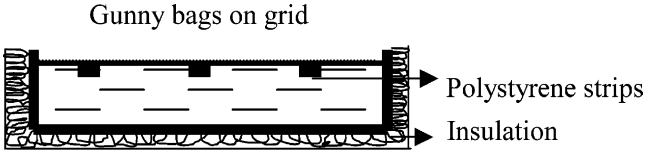

Fig. 1. Schematic section of the suggested pond.