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Roof pond cooling of buildings in hot arid climates

Sahar N. Kharrufa*, Yahyah Adil

Department of Architecture, University of Technology, Baghdad, Iraq

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Abstract

The weather in Baghdad, Iraq is hot dry in the summer while water is plentiful and cheap. These are conditions which encourage the use of evaporative cooling. A building with one space in it was used to test the effect of a roof pond which was ventilated mechanically for summer cooling. Thermal measurements were taken for the room in normal conditions without a pond, with a lone pond and no mechanical ventilation, and then finally with mechanically forced ventilation. The results showed a marked improvement in the space temperature with a significant reduction during the peak time outside temperatures at 3 O'clock reaching 6.0 °C between the room without the pond and with a ventilated one and 6.5° at 18:00 during peak inside temperatures. The study also showed that improvements would be better in real-life conditions where exterior wall area is less than the test room.

Keywords: Roof pond; Sustainable design; Energy conservation; Evaporative cooling; Cooling load; Passive cooling

1. Introduction

This study will cover the use of rood ponds to improve thermal comfort and reduce cooling loads for buildings in Baghdad Iraq.

Thermal comfort has always been a major issue in Iraq because of the difficult weather. It has become even more of an issue lately because of the continuous blackouts. When the electricity is cut off in summer, inside temperature immediately rises. Means to improve them that depend less on electricity are now even more important.

Considerable resources have gone into the study of the use of roof ponds. Reference can be made to the work done by the Arizona Solar Centre [1] and the passive solar research group in the University of Nebraska [2,3]. Most of the work however has concentrated on utilizing roof pond's thermal mass or using them for heating. The efforts on cooling have been mainly directed to insulating the pond in the day and exposing it in the nighttime such as the work of Niles [4]. No record of any work on the subject exists in Iraq.

2. Situation in Iraq

The Baghdad area in central Iraq is generally hot dry in summer and cold in winter. The specifics inside the city however have changed considerably in the last 40 years. The temperatures used to peak at around 44–46 °C in the summer before 1970s. With the dry weather most houses were comfortable with a few evaporative coolers. Often only one for the whole house. The 1980s saw natural progress introducing much more cars, roads, industry and high-rise buildings. The temperatures in the city increased. Maximums of 49° became commonplace. This small 3° increase pushed the evaporative coolers outside their range of usefulness. Evaporative coolers introduce moisture into the output air and once the temperature rose the outcome crossed the threshold for comfort. The cooled air they produced was not only less cool, it was also damper. Where once one or two coolers were enough for a whole house, the norm became one cooler per room and still it was not comfortable. Suddenly wholesale migration started for air conditioners. These became the only acceptable solution. The result was a sharp increase in demand for electricity and power.

The country presently produces record levels of electricity but it is still not enough. Regular blackouts in the

*Corresponding author. Tel.: +964 7901 908362.
E-mail address: skarrufa@cbuilding.biz (S.N. Kharrufa).

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summer run at 16–20 h/day. Furthermore, from an energy point of view, a single evaporative cooler suitable for one room only spends around 1.5 A of electricity; a comparable 24 000 BTU air conditioner spends 15, an increase of 10-fold.

Considering the weather data and availability of cheap water, making use of the cooling effect of water evaporation as in evaporative coolers, seems to be the logical way to go. The moisture during the summer days rarely rises above 13% and the water is abundantly available and are cheaper (Fig. 1).

However, it is still necessary to get rid of the moisture, and combine the results with a small degree of air conditioning. It was with this idea in mind that this paper was written. The objective is to cool the space with water from the outside using a roof pond. No moisture would be introduced to the interior. If any extra cooling is required an air conditioner can be used but less cooling load would be required.

In a typical two-storey Baghdadi house, the roof is bombarded with hot sunrays that radiate the heat into the upper floor. The hot air from the ground floor also rises there. The second floor in Baghdad is usually the hottest place in the house. A roof pond would directly confront the weakest link in the comfort chain. The hot air rising could lose some of its heat through the roof and the roof would radiate below room temperature to the interior improving the comfort range (Fig. 2).

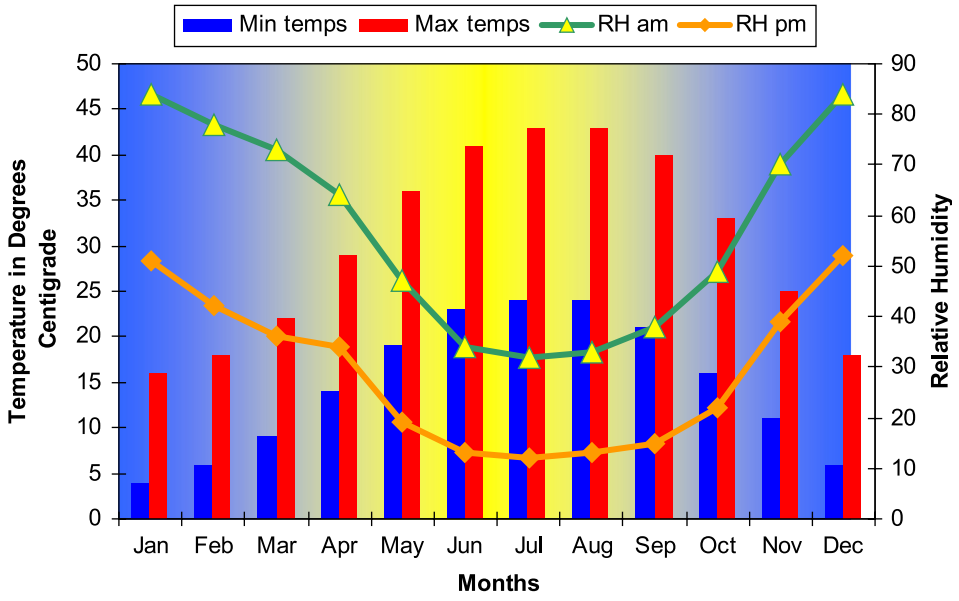

Fig. 1. Average maximum and minimum monthly temperatures and relative humidity for Baghdad Iraq [5].

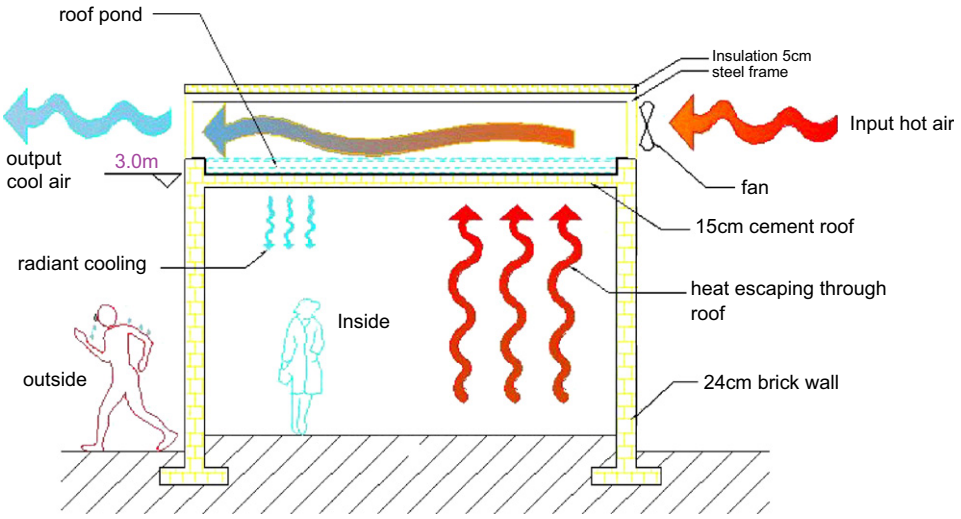

Fig. 2. Thermal performance of roof pond with forced electric ventilation.