EVALUATION AND TESTING OF THE NEBRASKA MODIFIED ROOF POND FOR SEVERE HEATING AND COOLING ENVIRONMENTS

by

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ABSTRACT

OBJECTIVES

Although roof ponds are not a new passive solar heating technique (1,,2,,3,4),, they have not received widespread acceptance in climates with severe winters, Test rooms of the traditional passive solar heating techniques have undergone testing and evaluation at the Passive Solar Research Test Facility. Located on them Omaha campus of the University of Nebraska, the facility has twelve passive solar test rooms which have been operated by the Passive Solar Research Group (PSRG) since 1978, but only in 1982 was any serious effort made to evaluate roof ponds. Although apparently successful in the southwestern portion of the United States where sustained freezing conditions do not exist and where sunny and dry conditions prevail in the summer, roof ponds have not been extensively tested in severe winter heating environments.

The principal design objective of the PSRG was to develop a modified roof pond which would avoid the severe winter problems associated with the technique and also to overcome certain disadvantages associated with its operation (5). These changes are discussed in succeeding paragraphs.

The concept for the Nebraska roof pond was developed jointly by Richard C Bourne of the Davis Energy Group. As shown in Fig. 1 and Fig.2, a fixed cement coated rigid insulation made by Dow Chemical for roofing applications floats over the pond itself. At night, during summer operation (Fig 2), a submersible pump in the pond places water above the roof. Through the twin processes of evaporation and radiation by night sky, the water is cooled. This cooled water then migrates downward to the pond via seams and cracks in the floating insulation. During winter time, the roof pond water is heated by employing a thermosiphon passive solar heating drive system. This is shown in Fig 1.

In contrast to traditional roof ponds, there is no need for moveable roof insulation systems. Cooling performance is because evaporation is used as part of the cooling strategy to aid night sky radiation Previous attempts used south facing windows with shutters and sloped roofs over the roof pond in order to get around the problem of freezing water in severe winter climates. This led to reduced cooling performance since the night sky aperture was reduce with the presence of a roof. Nebraska roof pond does not have any structure over the pond itself. The fixed, rigid insulation prevents the water from freezing during the winter.

SUMMARY OF METHODOLOGY

The experiments during the summer of 1984 sought to determine the cooling contribution by radiation and evaporation. A number of tests used a transparent membrane which was stretched over the pond. This strategy reduced evaporation as a cooling component. A dew point meter was acquired to compute the cooling contribution due to evaporation as was a Weathertronics 3040 pyrradiometer which could read both sky and roof radiation. The Mylar is itself, covered by rigid cover opaque to sunlight during the day. This cover is then removed at night. Once the experiments were completed, the Mylar was removed to allow evaporation cooling to occur. This procedure permits an empirical assessment of roof pond cooling, performance with and with evaporation as a component.

Because the test room has insulated masonry sides, it was decided to determine the effect of the thermal mass to cooling performance. For these tests the pond depth was 2,54 cm (1 inch), 25.4 cm (10 inches), and 0 cm or finally emptied. With the pump always off, these experiments were dubbed static tests.

For winter operation the shutters to the thermosiphon drive were opened. The pump is turned off for the entire heating season. Airflow rates, solar insulation and temperature readings throughout the test room were collected by an Instrulab 2000 data logger.

RESULTS

1. Static Test (No Pump): With no water in the pond**,** the ambient outdoor temperature for the test period ranged between 19.4 °C and 35.7 °C. The center of the test room ranged between 26.0 °C and 28.10 °C.
2. Static Test (No Pump): With 2.54 cms of water in the pond, the ambient outdoor temperature varied between 19.0 °C and 34.5 °C. The center of the room varied between 26.7 °C and 27.3 °C. Meanwhile the. roof pond itself ranged from 25.1 °C to 27.5 °C.
3. Static Test (No Pump): With 25.4 cms of water in the pond, ambient temperature this period was from 20.8 °C to 34.2 °C. The center of the room ranged from 27,8 °C to 29.0 °C and the pond temperatures varied between 26.9 °C to 28,2 °C,
4. Dynamic Test (with Mylar attached): This would tend to reduce evaporation. The room temperature varied from 22.3 °C to 28.7 °C; the pond temperature varied from 20.6 to 28.2 °C and the outdoor temperature varied from 12.1 °C to 36.1 °C.

5. Dynamic test with Mylar off: With the Mylar, one evaporation component was unhindered. For the test period, the room temperature ranged from 18.1 °C to 22.9 °C; the pond temperature ranged from 12.6 °C to 19.5 °C and the ambient temperature ranged from 5.60 °C to 31.1 °C,

CONCLUSIONS

I. For cooling requirements, the Nebraska modified roof pond has the advantage of not requiring moveable insulation systems on over the roof and of utilizing evaporation as a component in cooling. It is a unique solution to roof designs (6).

2. For winter operation, the Nebraska modified roof pond utilizes a thermosiphon drive which eliminates the need for an additional roof with an operable south aperture ("Skytherm North"). Moveable roof insulation would not function in a severe winter climate, so was not considered as a design alternative.

3. The thermosiphon drive is a good match for roof ponds located in winter heating climates. For summer operation, the thermosiphon drive need only be turned off by covering the glazing or shutting the vents.

4. In a static test to measure the impact of interior thermal mass, with water in the pond, the temperature fluctuation inside the test room is less than with no water in the pond.

5. Evaporation is an important component of cooling in the Nebraska modified roof pond in summer and further experiments are planned for the summer of 1985.

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