

# Energy efficient building using passive cooling technique of roof pond

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## ABSTRACT

Roof Pond in the effective mode of passive cooling in the building. Solar radiation is much more on the roof of the building compared to surfaces of the building. The roof of the building is covered with insulation material is a small amount of building inside temperature reduced, But far better instead insulation on using roof pond technique which provide cooling effect also. The vast quantity of water availability is use as the heat transfer fluid in the roof pond. Water is stored in the building roof ceiling to open at the night time which is store the cool energy by cold night climate and Movable insulation is provided at day time to avoid sun radiation on roof pond. The stored cold energy of the water releases to the building through the roof.

**KEY WORDS:** Passive Cooling, Roof Pond, Energy-efficient Building.

## 1. INTRODUCTION

The last two decade has witnessed a severe energy crisis in developing countries especially during summer season primarily due to cooling load requirements of buildings. The energy consumption in Buildings is quite high and is expected to further increase because of improving standards of life and increasing world population. Air conditioning use has increasingly penetrated the market during the Last few years and greatly contributes in the upsurge of absolute energy consumption. According to the World watch Institute, buildings consume about 40% of the world's energy Production. As a result, buildings are involved in producing about 40% of the sulfur dioxide and Nitrogen oxides that cause acid rain and contribute to smog formation. Building energy use also produces 33% of all annual carbon dioxide emissions, significantly contributing to the climate changes brought about by the accumulation of this heat-trapping gas (Tormenta, 1999). In India, the building sector represents about 33% of total electricity consumption, with the commercial sector accounting for 8% and 25 % respectively. Roof ponds can be inexpensively constructed by enclosing water in plastic bags, metal or fiberglass tanks with rigid transparent plastic covers. Moveable insulation panels are usually made of 2" polyurethane foam reinforced with fiberglass strands and sandwiched between aluminum skins (Batty, 1991). According to Givoni (Jain, 2006), the necessary condition for applying the technique efficiently is that the wet bulb temperature (WBT) of the air should be lower than 20°C. Further studies described below give environmental principles for the variety of systems. The advantages of roof pond systems are that performance is independent of building orientation, the provision of both heating and cooling and even when there is a lack of water, brackish water can also be used. Disadvantages are that most of them can only cool the spaces under the roof and the lack of experience by the construction company. (Venkatraman, 2015). To remove these errors off the equation in manufacturing dies, one of the modern techniques of manufacturing, Electrical Discharge Machining (EDM) can be implemented. Precision is important in die making; punches and dies must maintain proper clearance to produce parts accurately.

Additionally extra attention of the roof required being watertight, able to support 200-400kg/m<sup>2</sup> (Jain, 2006; Mazria, 1979; Cook, 1985; Yannas, 1998). The below table mention the maximum temperature attain in Tamilnadu, Madurai (Yannas, 2006).

**Table.1. Temperature in Madurai (India)**

Month	Day (max) <sup>0</sup> C	Night (Min) <sup>0</sup> C	Month	Day (max) <sup>0</sup> C	Night (Min) <sup>0</sup> C	Month	Day (max) <sup>0</sup> C	Night (Min) <sup>0</sup> C
Jan	30	21	May	38	26	Sep	35	25
Feb	33	22	Jun	37	26	Oct	32	24
Mar	36	23	May	38	26	Nov	30	23
Apr	37	26	Jun	37	26	Dec	30	31

## 2. EXPERIMENTAL SETUP

The test section of roof pond considering a room size of 2m x 1.5m x 2m ceiling is 2m x 1.5m x 0.10m.

**Roof Pond:**



**Figure.1. Roof Pond**

**Table.2. Specifications of the PDC**

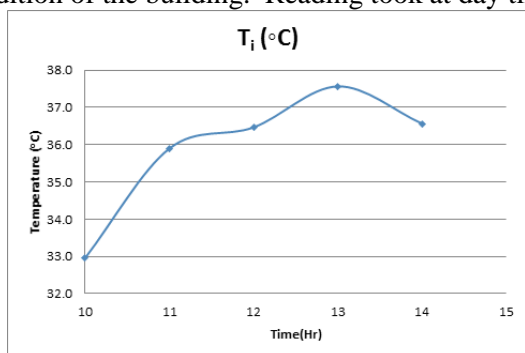
Room Length	2.0m
Room Width	1.5m
Room Height	2.0m
Ceiling Length	2.0m
Ceiling Width	1.5m
Ceiling Height	0.10m

**Measurement system:** In Roof pond, temperature measurement is carried out by a thermometer. Five thermometers fixed inside of the room. 1. Top Left 2. Top Right 3. Bottom Left 4. Bottom Right 5. Middle. Another thermometer is used for measuring outside temperature. This experiment carried out from the whole day. Measurements reading carried out from morning 10.00am to 02.00pm at day time. During the experiment after solar radiation, the ceiling is open to the atmosphere of night climate. The water reaches the temperature around 26 degrees Celsius at the morning 6am.

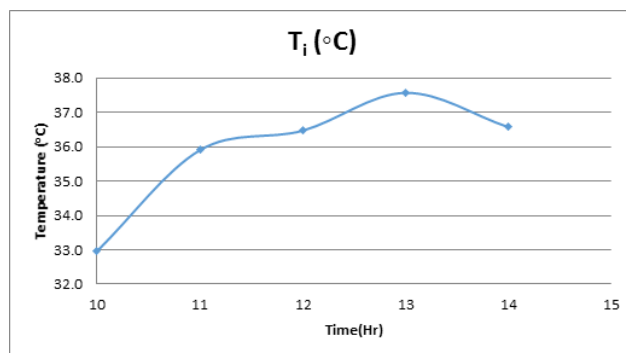
Following experimental Setup carried out better analysis of Roof Pond Cooling.

- The roof is open to the atmosphere without water at Night and Day.
- The roof is filled with water one-half of the roof height and open to the atmosphere at night and Movable insulation provided at Day.
- Roof is filled with water one-half of the roof height and also placed on another Movable roof pond having one-half of the water and open to atmosphere at night and Movable insulation at Day
- Roof of the building is filled with air and placed on another Movable roof pond having one-half of the water and open to atmosphere at night and Movable insulation at Day

**Experiment Setup 1:** The roof is open to the atmosphere without water at Night and Day. This is the normal condition of the building. Reading took at day time.

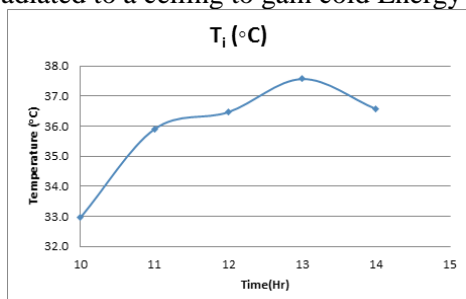


**Figure.2.Represents set up 1 Measurement carried out at hourly from 10.00am to 02.00 pm**

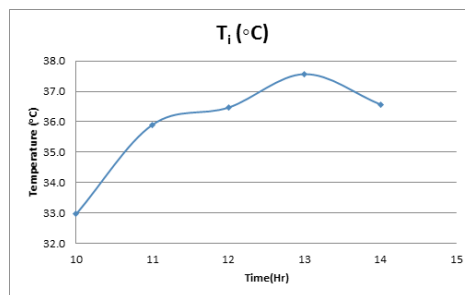


**Figure.3.Represents set up 1 Measurement carried out at hourly from 10.00am to 02.00pm**

**Experiment Setup 2:** The roof is filled with water one-half of the roof height and open to the atmosphere at night and Movable insulation provided at Day. 60 litres of water is stored in the roof of the building. Water is gain the cold energy at night time reach 27 °C at morning 06.00am. Then the roof is covered with insulation materials (thermocouple used as insulation) to avail solar radiation to a roof of the building. During daytime, the heat energy from is radiated to a ceiling to gain cold Energy from water.

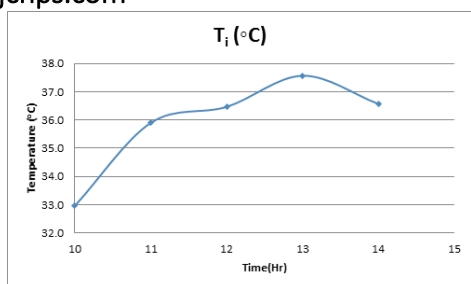


**Figure.4.Represents set up 2 Measurement carried out at hourly from 10.00am to 02.00 pm**

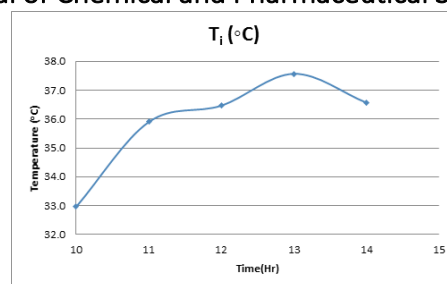


**Figure.5.Represents set up 3 Measurement carried out at hourly from 10.00am to 02.00 pm**

**Experiment Setup 3:** Double layer roof pond both the pond filled with the water one-half of the roof height and open to the atmosphere at night and Movable insulation provided at Day. 100 liters of water is stored in the roof of the building. Water is gain the cold energy at night time reach 27 °C at morning 06.00am. Then the roof is covered with insulation materials (thermocouple used as insulation) to avail solar radiation to a roof of the building. During daytime, the heat energy from is radiated to a ceiling to gain cold energy from water.

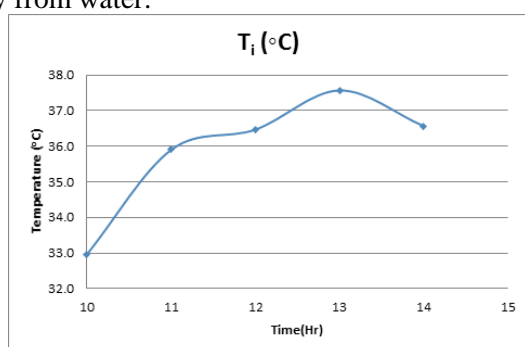


**Figure.6. Represents set up 3 Measurement carried out at hourly from 10.00am to 02.00pm**

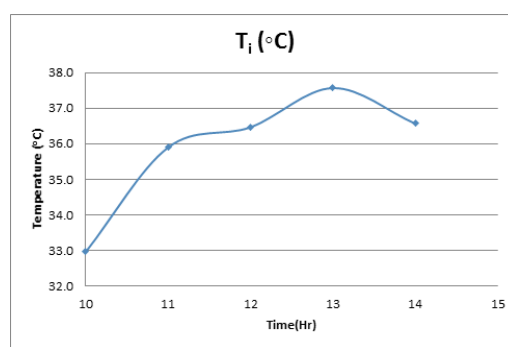


**Figure.7. Represents set up 3 Measurement carried out at hourly from 10.00am to 02.00pm**

**Experiment Setup 4:** Double layer roof pond technique, top of the pond filled with water of half of the roof and a bottom roof is empty. Top of the roof pond open to the atmosphere at night and Movable insulation provided at Day. 100 litres of water is stored in the roof of the building. Water is gain the cold energy at night time reach 27 °C at morning 06.00am. Then the roof is covered with insulation materials (thermocouple used as insulation) to avoid solar radiation to the roof of the building. During daytime, the heat energy from is radiated to the ceiling to gain cold energy from water.



**Figure.8. Represents set up 4 Measurement carried out at hourly from 10.00am to 02.00pm.**



**Figure.9. Represents set up 4 Measurement carried out at hourly from 10.00am to 02.00pm**

### 3. RESULTS AND DISCUSSION

Experiment setup of temperature measurement as shown in the below table -6. It shows at normal condition indoor average temperature 35.9°C for the outside temperature of 40.2°C. For single roof pond average temperature 31.6°C for the outside temperature 41.6 °C. For Double Pond water system maintain the average indoor temperature 30.7°C for the outside temperature of 39.1°C For Double roof pond having top roof is maintain 31.9°C for the outside temperature of 39.6°C.

**Table.3. Experimental temperature measurement details**

Condition	$T_{ao}$ (°C)	$T_{ai}$ (°C)	$T_{o\ Max}$ (°C)
Normal	40.2	35.9	42.1
Single Pond Water	40.1	31.6	41.6
Double Pond	39.1	30.7	40.6
Double Pond one is air and Water at top.	39.6	31.9	41

#### Nomenclature:

Outside Temperature	—	$T_o$ (°C)
Inside Temperature	—	$T_i$ (°C)
Average Outside Temperature	—	$T_{ao}$ (°C)
Average Inside Temperature	—	$T_{ai}$ (°C)
Maximum Outside Temperature	—	$T_{o\ max}$ (°C)
Maximum Inside Temperature	—	$T_{i\ max}$ (°C)

### 4. CONCLUSION

The feasibility study of roof ponds in the passive cooling technique. The double layer of water air roof is maintaining the better results than the other single pond and double pond with air. The difference of normal condition and double roof pond technique reduce the room temperature 4 degree Celsius. For this condition human feels better comfort then normal condition which will reduce energy consumption in the building will be reduced considerably. This indoor temperature will be used as air conditioning system the amount of 78W per hour is consumption is reduced.

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