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Experimental Thermal Performance Analysis of Simple & Hybrid Earth Air Tunnel Heat Exchanger in Series Connection at Bikaner Rajasthan India

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Abstract: *The Earth Air Tunnel Heat Exchanger System is a passive air-conditioning system which has no side effect on earth climate and produces better cooling effect and heating effect comfortable to human body. It produces heating effect in winter and cooling effect in summer with the minimum power consumption of energy as compare to other air-conditioning devices. In this research paper Thermal Analysis was done on the two systems of Earth Air Tunnel Heat Exchanger experimentally for summer cooling . Both the system was installed at Mechanical Engineering Department Government Engineering College Bikaner Rajasthan India . Experimental results concludes that the Average Air Temperature Difference was found as 11.00°C and 16.27°C for the Simple and Hybrid Earth Air Tunnel Heat Exchanger in Series Connection System respectively . The Maximum Air Temperature Difference was found as 18.10°C and 23.70°C for the Simple and Hybrid Earth Air Tunnel Heat Exchanger in Series Connection System respectively . The Minimum Air Temperature Difference was found as 5.20° C and 11.70° C for the Simple and Hybrid Earth Air Tunnel Heat Exchanger in Series Connection System respectively.*

Keywords: *Earth Air Tunnel Heat Exchanger, Hybrid, Series Connection, Summer Cooling, Thermal Analysis, Water Cooled Heat Exchanger.*

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I. Introduction

During the decades, the global energy consumption for winter heating and summer cooling of buildings has significantly increased. So the energy saving is much important factor for the entire world. Costly and power consumable air-conditioning system are used for maintaining surrounding air temperature comfortable to human body which works on VCRC in which harmful CFCs are used as refrigerant. Since CFCs have bad impact on environment of earth i.e. causes global warming and ozone layer depletion. Therefore there are two important factors: power consumption & environment pollution . These two factors can be eliminated by using other passive techniques such as EATHE . Most of people feels comfort zone when the surroundings air temperature is kept in the range of 22°c to 28°c and the relative humidity of ambient air is kept in the range of 45 to 55%. The physics of EATHE is so simple: the earth ground temperature at a certain depth remains same and comfortable to human body throughout the year. So this uses as winter heating and summer cooling purpose. This research paper is based upon Experimental Thermal Analysis of Simple & Hybrid Earth Air Tunnel Heat Exchanger in Series Connection System i.e. installed at Mechanical Engineering Department Government Engineering College Bikaner. Bikaner city is situated in Rajasthan State, Country India. The climate of Bikaner city is dissert i.e. hot and arid climate. Due to geographical condition of Bikaner the summer temperature of Bikaner is reached to extreme hot and winter temperature of Bikaner is reached to extreme cold. So the air-conditioning plays much important role in Bikaner to survive life here and this is also be achieved by using EATHE system. Therefore the installation of EATHE system was carried out in our college campus. We used waste water of water cooler for further reducing air temperature which is coming from ground, inside the buried pipes of EATHE in Series Connection System. So Water Cooled Heat Exchanger was connected at outlet of EATHE in Series Connection System. Thus the Coupled System is known as Hybrid System, that is having two heat exchangers: EATHE & Water Cooled Heat Exchanger. EATHE in Series Connection System occupies less space as compared to Simple EATHE System so space limitation problem was also analyzed. Several researches were carried out on the EATHE System that concludes that the Thermal Performance of EATHE System is depended upon Air Inlet Velocity, Buried Pipe Geometry, Pipe Material, Climate Conditions and mostly on Thermo-Physical Properties of Soil. This research paper investigates the Experimental Thermal Analysis of Simple EATHE in Series Connection System and Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger System. Experiment were carried out in the month of September at Bikaner on the both system.

II. Experimental Setup & Methodology

2.1 Description of experimental setup:

Experimental setup of both systems has been installed at Mechanical Engineering Department Government Engineering College Bikaner (28.0229° N, 73.3119° E) Rajasthan India (334004). Since soil temperature remains constant throughout the year at a depth of 3 to 4 m [1]. So our system was placed at a depth of 3.3528 m. Mild steel pipes were used in the system due to lower cost, strength and durability. The total length of Simple and Hybrid EATHE in Series Connection System was taken as 13.92 m and 16.36 m respectively. And the length of Water Cooled Heat Exchanger was taken as 1.83 m. The inner diameter and thickness of the buried pipes for the EATHE in Series Connection was taken as 0.04 m and 0.003 m respectively. The inner diameter and thickness of the buried pipe for the Water Cooled Heat Exchanger was taken as 0.11 m and 0.0025 m respectively. The experimental setup of both systems is shown in Fig. 3.

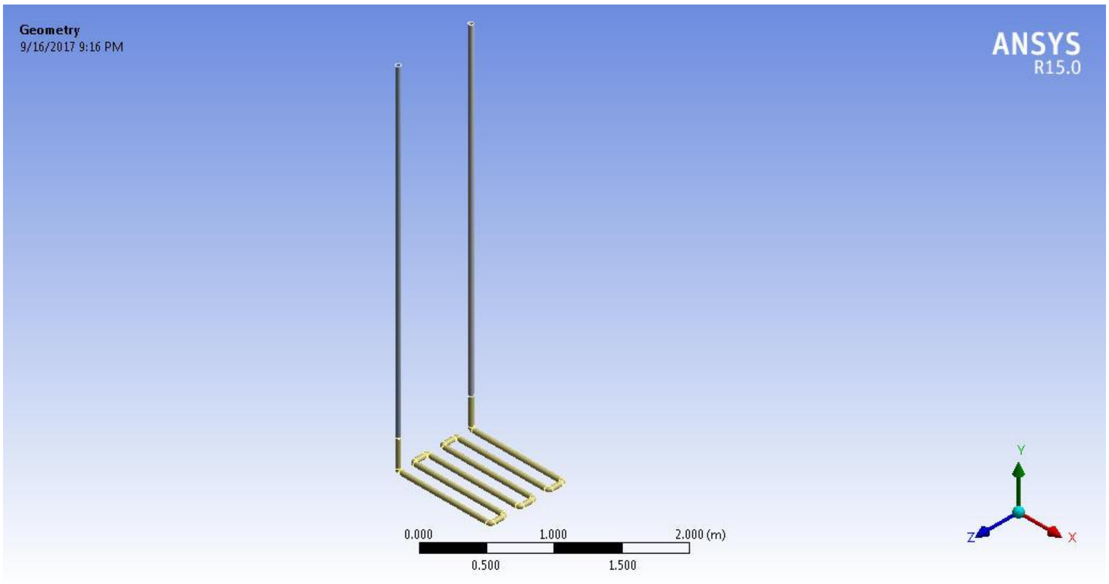

Fig. 1: ANSYS geometry of simple EATHE in series connection system-I

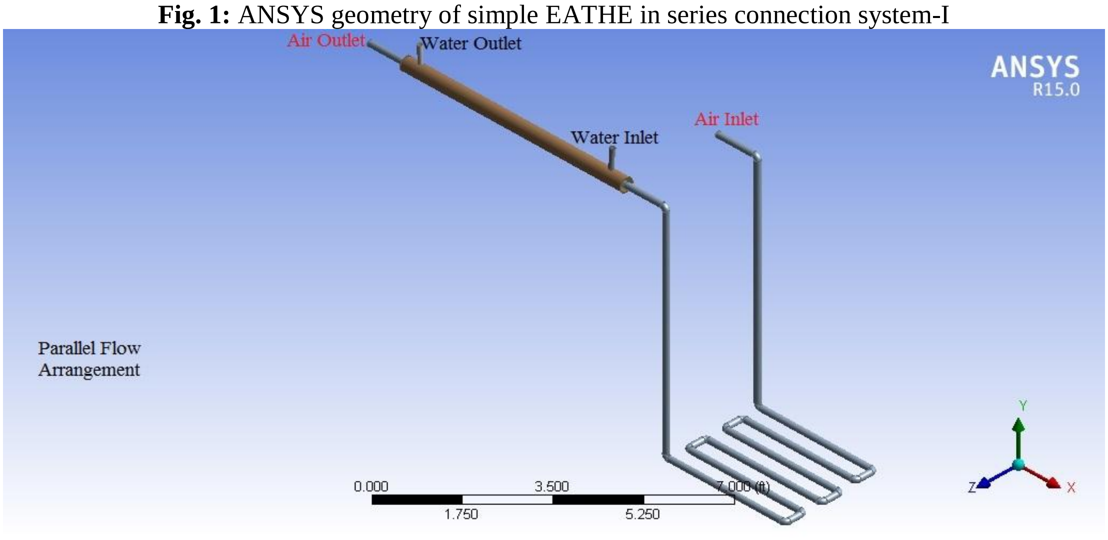

Fig. 2: ANSYS geometry of hybrid EATHE in series connection system-II

Fig. 3: Experimental setup of the both systems

Fig. 4: Series connection of mild steel pipes in mechanical workshop

Fig. 5: Experimental setup of water cooled heat exchanger

Fig. 6: Installation of setup using JCB machine

2.2 Instruments used:

I. Cheston Air Blower of 5.5 kW having variable speed regulator was used to force surroundings air into the buried pipes of the system.
II. Digital Vane Probe Type Anemometer was used to compute air velocity.
III. Digital Thermometer +2-k-Type Thermocouples were used to compute air temperature.

2.3 Experimental methodology:

The experimental results were recorded on the both systems in the month of July, August and September at a constant inlet air velocity of 10m/s. Readings of air temperature were recorded in the month of July, August and September from 9A.M. to 1P.M. i.e. I-Session and from 3P.M. to 6P.M. i.e. II-Session. Readings were taken every after one hour interval of time. Thus the readings were recorded at 9A.M., 10A.M., 11A.M., 12P.M., 13P.M. & 15P.M., 16P.M., 17P.M. & 18P.M. The system was kept shutdown from 6P.M. to 9A.M. (15 Hours) for soil regeneration. The ambient air was forced through the buried pipe of the system with the help of Cheston Air Blower of 5.5 kW having variable speed regulator at a constant air velocity of 10m/s. The air velocity was measured by using Digital Vane Probe Type Anemometer. Digital Thermometer + 2-k-Type Thermocouples were used to record air temperature of Ambient, Inlet & Outlet.

2.4 Calculation of experimental results:

Using experimental results, the air temperature difference (ΔT) for the both systems was calculated. Also the average air temperature difference ($\Delta T_{avg.}$) for the both systems was to be computed.
Air Temperature Difference is given by following equation:

$$\Delta T = T_1 - T_2 \tag{1}$$

Average Air Temperature Difference is computed by following equation:

$$\Delta T_{avg.} = \frac{\sum_1^{72} \Delta T}{72} \tag{2}$$

Where T_1 & T_2 are inlet air temperature & outlet air temperature respectively.

III. Results & Discussions

Table 1: Air temperatures for system-I

Air Temperature (˚C)	**Minimum**	**Average**	**Maximum**
Ambient Air Temperature (T_a)	35.60	42.69	49.60
Inlet Air Temperature (T_1)	36.50	43.91	50.00
Outlet Air Temperature (T_2)	30.20	32.90	35.50
Air Temperature Difference (ΔT)	5.20	11.00	18.10

Table 2: Air temperatures for system-II

Air Temperature (˚C)	Minimum	Average	Maximum
Ambient Air Temperature (T_a)	37.50	42.53	49.20
Inlet Air Temperature (T_1)	38.20	43.36	49.90
Outlet Air Temperature (T_2)	25.50	27.09	28.80
Air Temperature Difference (ΔT)	11.70	16.27	23.70

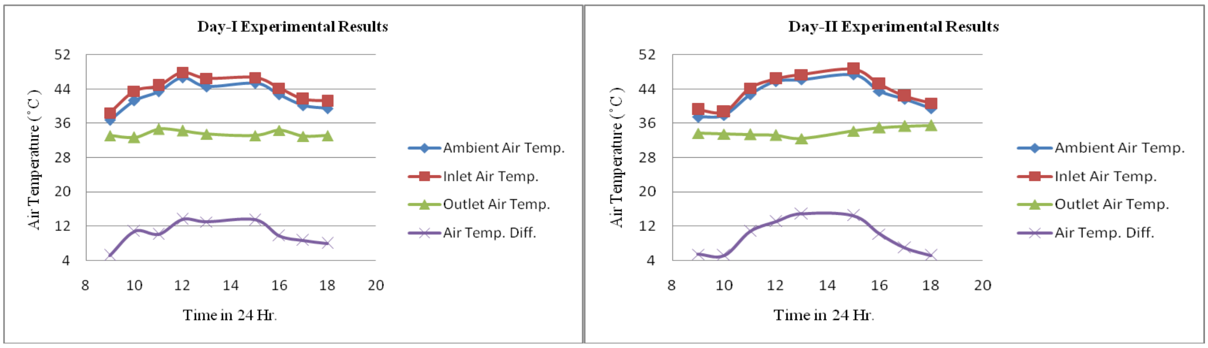

Fig 7: Day-I and II experimental results for the system-I

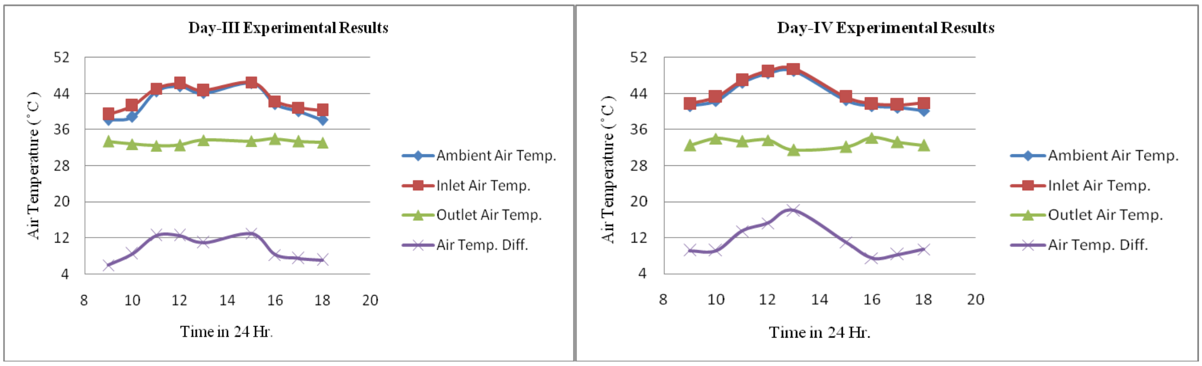

Fig 8: Day-III and IV experimental results for the system-I

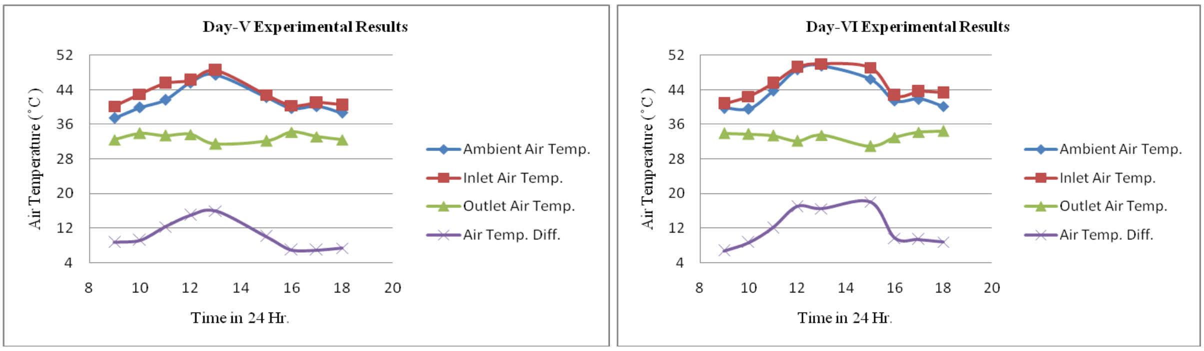

Fig. 9: Day-V and VI experimental results for the system-I

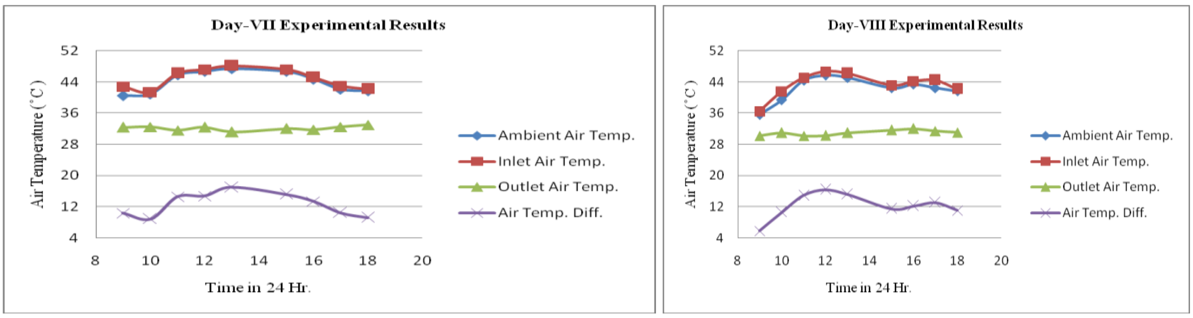

Fig. 10: Day-VII and VIII experimental results for the system-I

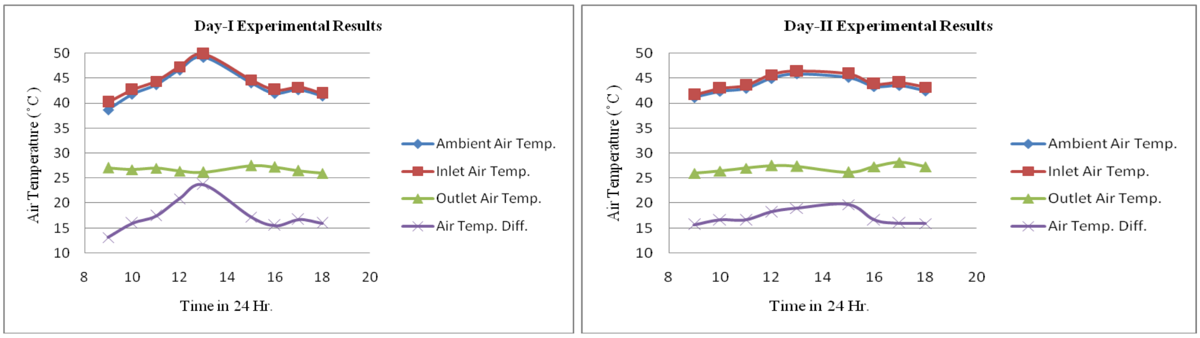

Fig. 11: Day-I and II experimental results for the system-II

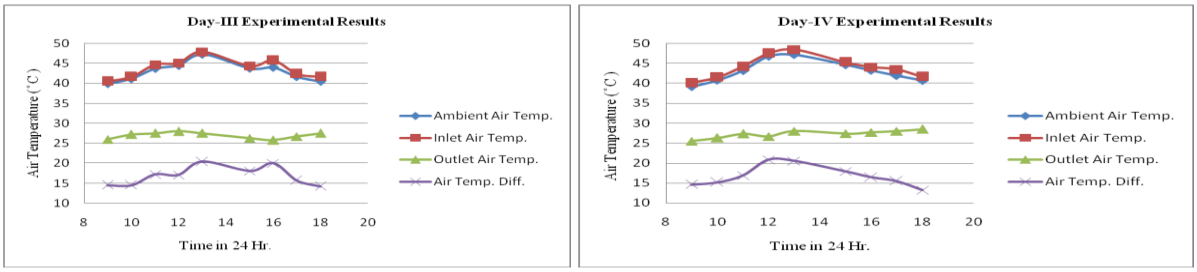

Fig. 12: Day-III and IV experimental results for the system-II

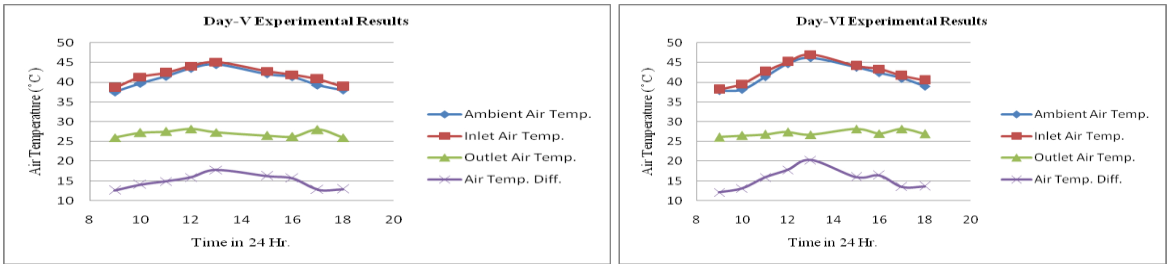

Fig. 13: Day-V and VI experimental results for the system-II

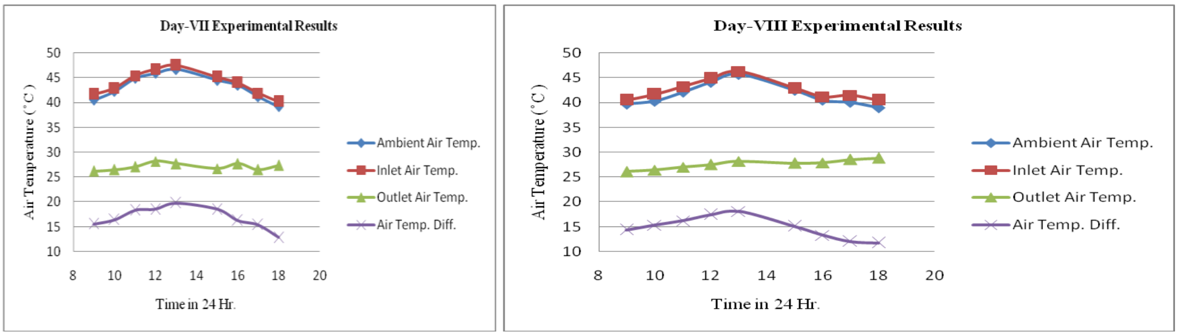

Fig. 14: Day-VII and VIII experimental results for the system-II

The Maximum, Minimum & Average Ambient Air Temperature were recorded as 49.60° C, 35.60° C & 42.69° C respectively for the Simple System.
The Maximum, Minimum & Average Inlet Air Temperature were recorded as 50.00° C, 36.50° C & 43.91° C respectively for the Simple System.
The Maximum, Minimum & Average Outlet Air Temperature were recorded as 35.50° C, 30.20° C & 32.90° C respectively for the Simple System.
The Maximum, Minimum & Average Air Temperature Difference were found as 18.10° C, 5.2° C & 11.00° C respectively for the Simple System.
The Maximum, Minimum & Average Ambient Air Temperature were recorded as 49.20° C, 37.50° C & 42.53° C respectively for the Hybrid System.
The Maximum, Minimum & Average Inlet Air Temperature were recorded as 49.90° C, 38.20° C & 43.36° C respectively for the Hybrid System.

The Maximum, Minimum & Average Outlet Air Temperature were recorded as 28.80° C, 27.09° C & 25.50° C respectively for the Hybrid System.
The Maximum, Minimum & Average Air Temperature Difference were found as 23.70° C, 11.70° C & 16.27° C respectively for the Hybrid System.
When ambient air is forced through the buried pipes of the system with the help of blower then the inlet air temperature increases due to blower running at very high speed & frictional effects also the blower rise the pressure of ambient air so corresponding temperature of air rises.
Thus the Hybrid EATHE in Series Connection Coupled with Water Cooled Heat Exchanger provides comfort summer cooling by utilization of waste water of water cooler as compare to Simple System.

IV. Conclusion

Comparatively study of both system concludes several points. Space limitation problem was analyzed by introducing Series Connection of Earth Air Tunnel Heat Exchanger System. Utilization of waste water of water cooler was carried out using Hybrid System. Experimental results shows that the Hybrid Earth Air Tunnel Heat Exchanger in Series Connection Coupled with Water Cooled Heat Exchanger is more effective and efficient as compare to Simple Earth Air Tunnel Heat Exchanger in Series Connection. The better cooling effect is provided by using waste water of water cooler in the Hybrid System as compare to Simple Earth Air Tunnel Heat Exchanger in Series Connection System. Higher Air Temperature Difference is found for Hybrid System as compare to Simple System during the working days.

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