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Evaluate Performance of Earth – Air – Pipe System under Laboratory Condition

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Abstract **-The ambient temperature getting hot especially in the city region of Malaysia due to impact of vary rapid growth of population and economic. Fans, single air condition units and central air condition units are commonly used in the cities commercial and residential buildings for cooling purpose. The dependency on electricity appliances is also increased indirectly the pressure on environment. The passive cooling system can be used to reduce the space of the commercial building temperature into comfortable rage (298K to 300K). In this study the passive cooling system is defined as solar chimney assisted ventilation and earth air pipe (EAP) air cooling system. An earth air pipe model is designed and conducted experiments at Mechanical Engineering Laboratory, Faculty of Engineering, Universiti Malaysia Sabah. The length of the earth air pipe system, air flow rate, soil moisture and depth of the soil are considered as independent variable whereas temperature is considered as performance indicator as well as dependent variable. The experimental results show that the earth air pipe model is able to reduce 5.5K from ambient temperature 305K when the length of the pipe is about 5.68m and the depth of the soil is about 1 m.**
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Keywords: Passive Cooling, Earth Air Pipe System, Heat Exchanger.

I. INTRODUCTION

The demand of commercial and residential building is increasing in cities all over the world due to the rapid growing population as well as industrialization. This leads to increase the demand of clean energy is used by the livelihoods. In addition, the commercial and residential buildings in the urban and semi urban areas are the major single largest consumer of pure energy and contributor of global worming base on the statement of World Green Building Council. According to the International Energy Outlook Report it is expected that total global energy consumption will be grew up by 56% in between the year 2010 to 2040 [1] [2] [3] . During this time, the energy consumption of the commercial and residential building will be reached between 20% and 40% in the developing countries [3].

In Europe, about 40% of the pure energy is used by the building sector which considered as the largest consumer of electric energy in Europe. It is estimated that about 74% electricity is used by the commercial and residential buildings in 2010. In Malaysia, numbers of building are increasing that has a significant impact on the development of the country as well as on energy demand. In Malaysia, it is estimated that 54% of the total generated electricity is consumed by the building sector. The commercial buildings consume about 33% of generated electricity whereas residential buildings consume about 21%. Study also showed that about 94% electricity is generated by using fossil fuel as a source of energy in Malaysia and it is expected this figured will be remain same in the next decade [1] [4][5].

In addition, the supply of primary energy increases about 2.99% between the year 2009 and 2010, which was about 74,582 ktoe to 76,809 ktoe. Final energy demand has also grown up by about 1.54% and reached 41,476 ktoe in 2010 whereas the value was 40,845 ktoe in 2009. Comply with the demand and supply of primary energy in Malaysia, the gross production and demand of electricity has been increased by 2.3% and by 8.53% respectively in the 2010 compare to previous year [2] [6]. The changes of energy demand are significant in Malaysia due to the increasing demand of electric energy in the housing sectors.

In the residential and commercial building, the highest electric energy is consumed by the cooling and heating appliances. In the year 2009, Saidur et al mentioned that air conditioner in the office building is consumed about 57% of electric energy and followed by lighting and elevators are about 19% and 18%. Rest about 6% electric energy is consumed by pump and other applies. Although the residential buildings consume less electricity then commercial building but the quality of living standard had resulted in the increase of electric cooling appliances used during hot climate [7].

Therefore, this can be considered an indicator of the importance of renewable energy or passive cooling for buildings. The passive cooling is considered as one of the sustainable approach for building cooling by natural processes in hot climate or in the topical region. In the passive cooling system the energy losses from the system due to natural phenomena: radiation, conduction, or convection without help of any electrical appliance [4] [5] [8]. There are diffident type of passive cooling systems are design to ensure the space or building cooling. According to Kamal, 2012 building passive cooling can be achieved with solar shading; insulation; solar chimney assisted ventilation; air vents; wind tower; radiative cooling; diode roof; roof pond; evaporative cooling; earth coupling; earth air pipe; desiccant cooling etc [5]. In this paper, the performance of the earth air pipe system is investigated under the laboratory condition. The aim of the project is to design an earth air pipe system for commercial and residential building in Sabah, Malaysia. The earth air pipe system can be used for building cooling to achieve thermal comfort and it is also be used for cooling of agricultural green house [9] [10] [11] [12]. The implementation of earth air pipe system can be used for building cooling as well as help to reduce of greenhouse gas emissions by reduced the dependency on fossil fuelc[13].

II. MTHODOLOGY

In the earth air pipe system consist of long metallic pipe which is buried underground. One end of the pipe is connected to the building and the other end of the pipe is placed at environment. Hot air from outside is drawn through the earth air pipe system and transferred heat to the soil which is having lower temperature than environment. Under this project model earth air pipe system is designed and is fabricated. The diameter of the pipe keep 0.0381 m and the air flow rate varied from 8 to 9 m/s. Sanusi et al 2014 conducted experiments to determine soil temperature between 1 m and 5 meter in West Malaysia. The experimental results showed that the soil temperature varied from 26.6ºC to 30.7ºC at the depth 0.5 m to 1.5m. The variation of soil temperature was less than 1% between 0.5 m and 1.5 m. Alam et al 2012 was mentioned that soil temperature was 3oC to 5ºC higher at 11.30am to 2.00 pm at heights of 0.1 m, 0.6 m. 1.1 m and 1.7 m. Study also showed that the temperature reduction capacity of earth air pipe system significantly depends on length of the pipe. Therefore in the model earth air pipe system the length of the pipe is varied from 1.60 m to 5.68 m and depth of the soil varied from 0.2m to 1.0 m.

In addition, wire mesh screens are used create turbulence and water added with soil to understand the effects of wetted soil and turbulence flow in the temperature and heat load reduction. The soil temperature, inlet and outlet air is measured with K type thermocouple. The air flow rate is measured with the vane anemometer. The temperature reductions are compared with different length of pipe as well as different depth of buried pipe to understand the relation between length of pipe and depth of soil on heat load reduction. Computer assisted data acquisition system is used to collect temperature reading during experiment. The main consideration of selecting tube material is cost, strength and locally availability. The tube material is zinc sheet that has good influence in thermal performance..

III. RESULTS AND DISCUSSION

The initial depth of the soil is kept 0.2m. The depth of soil increased up to 1 m with interval of 0.1m. From the experimental results it is found that minimum temperature reduction in the model is about 0.59 K at the depth of the soil 0.2 m and maximum temperature reduction is about 2K at 1m soil depth. Figure 1 shows the relation between temperature difference and depth of soil. The soil temperature is varied from 300K to 299K and the ambient temperature is varied from 300K to 301K. The relations between temperature reduction and depths of soil are significant since the R square value is 0.9198. The experimental results is supported by the Yusof et al 2015 [9].

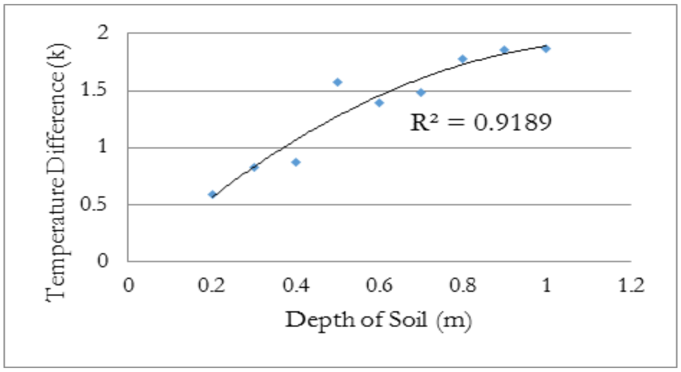

Figure 1: Effects of soil depth on inlet and outlet temperature difference

Figure 2 shows the relation between inlet and outlet temperature difference and amount of water added in the soil. Experimental results shows soil moisture does not have significant effect on temperature reduction. About 3K temperature different between inlet and outlet is found when 40 liters water is added to the soil. The ambient temperature is measured about 303K. The relation between soil moisture and temperature reduction by earth air pipe system is very week and not significant since the R square value is less than 0.8. Therefore this relation can be rejected.

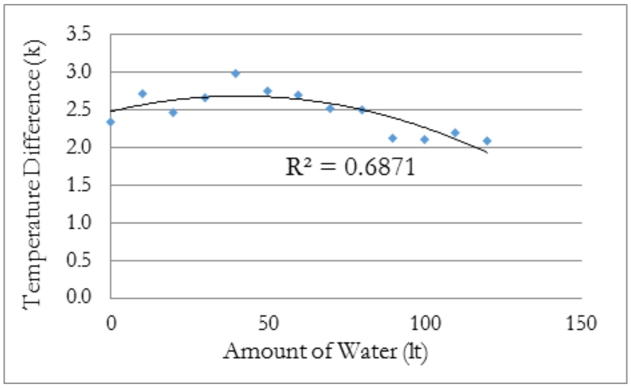

Figure 2: Effects of water on inlet and outlet temperature difference

The effect of pipe length is also determined under this project. The length of the pipe is varied from 1.60 m to 5.68m. It is found that the temperature reduction capacity significantly varied with length of the pipe (Figure 3).The temperature reduction is directly proportional with the length of the pipe. The model can be reduced about 5.5K from ambient temperature about 305K when the length of the pipe is about 5.68m. The minimum temperature difference is observed when the length of the pipe is about 3.64 m.

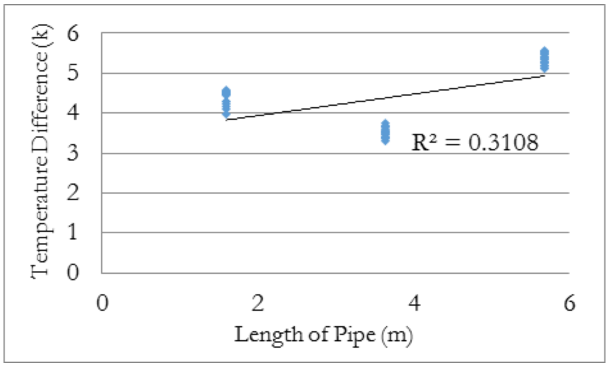

Figure 3: Effects of length of pipe on inlet and outlet temperature difference

The relation length of the pipe and temperature is not strong R square value is low. This is may be the effects of wire mesh screen in the earth air pipe system and the turbulence of the fluid. The experimental results cannot supported by Mathur et al 2015 numerical result. This is because the experiment is conducted under laboratory environment. In addition the model are able to reduce about 16J heat efficiently (Figure 4) [13].

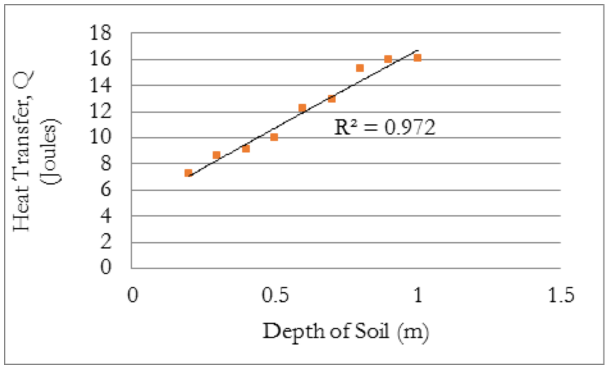

Figure 4: Relation between heat rejection and Depth of Soil

IV. CONCLUSION

The earth air model heat exchanger has been effectively reduced the temperature in the laboratory environment. The temperature difference between inlet and outlet of the heat exchanger increased with the length of the heat exchanger and depth of the soil. So the earth air heat exchanger can be used for cooling and reduce the dependency on mechanical cooling system. This system can also be used in the poultry industries that may reduce production cost significantly and ensure the food safety.

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BIOGRAPHY

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