EFFECT OF DIFFERENT TYPE OF SOIL IN EFFICIENCY OF THERMAL REDUCTION IN EARTH AIR HEAT EXCHANGER (EAHE)

NOR AZLIZA BINTI JAMILI

Report submitted in fulfillment of the requirement

for the award of the degree of

Bachelor (Hons.) Of Civil Engineering

Faculty of Civil Engineering and Earth Resources

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LIST OF ABBREVIATIONS

AR4	Fourth Assessment Report
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BS	British Standard
CFC	Chlorofluorocarbon
CIBSE	Chartered Institution of Building Services Engineers
COP	Coefficient of Performance
DBT	Dry Bulb Temperature
EAHE	Earth Air Heat Exchanger
EREC	Europe's Renewable Energy Policy Conference
GHG	Greenhouse Gases
HCFCs	Hydrochloroflourocarbons
IPCC	Intergovernmental Panel on Climate Change
PVC	Poly Vinyl Chloride
TAR	Third Assessment Report
TRNSYS	Transient System Simulation Environment

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ABSTRACT

This thesis tried to examine if different type of soil used in Earth Air Heat Exchanger (EAHE) can affect the temperature reduction of the air. EAHE is a passive cooling system that can provide cooled air without consuming a lot of electrical energy. EAHE consist of a connected pipe buried under ground at 1 meter depth and 23.2 meter length. The pipe connection needs to have an inlet and an outlet. Detector was placed to suck in the air. Air went through the pipe under the ground and heat transfer happened. The heat would transferred to the pipe by conduction and then to the soil. Different soil has different properties. This study is to determine which soil can reduce more temperature. Two soils were considered namely, sand and crushed aggregate soil. The soil was placed around the pipe under the ground before the hole was filled back with the sand. Properties of the soil such as specific gravity, particle size analysis and thermal diffusivity were tested in the laboratory. At the end of the study, the results indicated that a maximum temperature reduction of 5.3°C was achieved when the pipe was surrounded by the sand. The properties of sand gave the most thermal reduction to the air flow inside the pipe if EAHE system was installed. Particle size of sand was smaller. Smaller particle size had a large surface area. Number of surface area can helped in transferring the heat from air to the pipe and to the soil used. Water content also effects the temperature reduction of the air. Higher moisture content of the soil was proved to reduce the temperature reading of the air came out from the outlet. Thermal diffusivity also one of the soil properties which can affect the heat reduction of EAHE system. High thermal diffusivity helped in transmitting the heat and cooling the air inside the pipe. The result concluded that, soil with large surface are, high water content and high thermal conductivity can reduce the temperature of the air that went through the pipe and produce cooler air to the outlet.

ABSTRAK

Tesis ini dijalankan untuk mengenalpasti sama ada jenis tanah yang berlainan mampu member kesan pengurangan suhu udara kepada sistem Earth Air Heat Exchanger (EAHE). Sistem EAHE adalah sistem penyejuk pasif yang mampu menghasilkan udara sejuk tanpa menggunakan banyak tenaga elektrik. EAHE melibatkan paip yang telah disambung ditanam di bawah tanah pada kedalam 1 meter dan 23.2 meter panjang. Paip yang telah dipasang perlu ada lubang udara masuk dan keluar. Lubang udara masuk adalah dimana udara yang dipam oleh pam udara masuk manakala lubang udara keluar adalah dimana udara bersuhu rendah akan keluar dan udara tersebut akan diambil bacaaanya. Udara masuk ke dalam paip di bawah tanah dan pemindahan haba berlaku. Haba dipindahkan kepada paip secara konduksi dan kemudian kepada tanah. Tanah yang berbeza mempunyai sifat yang berbeza. Tesis ini adalah untuk mengetahui jenis tanah yang mampu mengurangkan suhu udara paling tinggi. Dua jenis tanah yang berbeza digunakan didalam kajian ini iaitu pasir dan agregat hancur. Tanah ini diletakkan di sekeliling paip dibawah tanah sebelum lubang tersebut dikambus semula menggunakakn pasir. Sifat-sifat tanah seperti specific gravity, saiz partikel tanah, dan termal konduktiviti diuji di dalam makmal. Pada akhir kajian ini, keputusan menunjukkan penurunan suhu maksimum, 5.3 °C apabila menggunakan pasir. Sifat-sifat tanah asal memberikan pengurangan haba yang paling banyak berbanding dengan agregat hancur. Saiz partikel tanah asal adalah lebih kecil. Saiz partikel yang kecil mempunyai luas permukaan yang besar. Luas permukaan yang besar dapat membantu oemindahan haba dari udara kepada paip dan seterusnya kepada tanah dengan lebih cepat. Kandungan air dalam tanah juga member impak kepada pengurangan suhu udara. Kandungan lembapan yang lebih tinggi di dalam tanah membuktikan ia mampu mengurangkan bacaan suhu udara yang keluar. Kekonduksian terma juga merupakan salah satu faktor yang boleh member kesan kepada pengurangan haba kepada sistem EAHE. Kekonduksian haba yang tinggi dapat membantu dalam menyalurkan haba dan justeru menyejukkan udara di dalam paip. Hasilnya, tanah yang mempunyai luas permukaan yang besar, kandungan air yang tinggi dan kekonduksian haba yang tinggi boleh mengurangkan suhu udara yang melalui paip dan meghasilkan udara yang sejuk.

CHAPTER 1

INTRODUCTION

1.1 Background

It is an undoubted fact the global temperature has increased by about 0.7°C over the last century (Florides *et al.*, 2010). One of the causes the temperature increase is the release of greenhouse gases which consist of mainly carbon dioxide (Florides *et al.*, 2010). These carbon dioxide comes from the burning of fossil fuels, the clearing of land and the manufacture of cement (Sulaiman and Rodzi, 2008). These events thus lead to the thermal comfort requirements and cooling energy demand for residential buildings (De Paepe and Janssens, 2002).

The population and economic growth of countries in the tropical regions undergo rapid increase and thus it is becoming inevitable that passive and low energy strategies must be used as suitable alternatives. Passive system can reduce operational energy consumption for cooling buildings in the tropical climate, help decrease rising energy demands and the associated greenhouse gas emissions that is detrimental to the planet. One of the greatest challenges of current generation is dealing with threat of global climate change. Global climate changes scientifically proven to result from human activity such as emission of greenhouse gases through burning of fossil fuels (CIBSE, 2005). However, conventional mechanical cooling systems are highly energy intensive and still utilise some Hydro Chloro-Flouro Carbons (HCFCs) as refrigerants, which releases some greenhouse gases to the atmosphere.

However, as IPCC maintains, human activities, primarily the burning of fossil fuels and clearing of forests, have greatly intensified the natural greenhouse effect, causing global warming. The greenhouse effect comes from molecules that are complex and much less common, with water vapor being the most important greenhouse gas (GHG), and carbon dioxide (CO_2) being the second-most important one. Greenhouse gases act like a blanket for infrared radiation near the surface that would otherwise escape directly to space (Schneider, 2008).

A combination of high ambient temperatures and solar radiation in tropical climate causes thermal discomfort in buildings (De Paepe and Janssens, 2002). So in order to maintain the comfortable thermal environment in buildings in tropical climates is by using mechanical air-conditioning systems. In buildings where mechanical cooling cannot be afforded, buildings are occupied in harsh conditions which affect performance especially in offices. The appliances such as cooling fan, ventilators and air conditioners were preferred to maintain a thermally comfortable indoor environment (Sulaiman and Rodzi, 2008). The rising in using of mechanical cooling is because of the increasing in building cooling load due to density of people and other heat emitting equipments in buildings and high ambient temperatures in urban centre (Santamouris, 2007). If well-established technologies were used such as glazing, shading, insulation and natural ventilation, 43% of thermal reduction can be achieved (Omer, 2008).

According to CIBSE (2005), the rising in global temperatures due to climate change have the potential to result in buildings overheating unless some adaptive measures are taking over the next 50 years. One of the most suitable techniques is the passive cooling Earth Air Heat Exchanger (EAHE) system (Ojebode and Gidado, 2012). EAHE is a subterranean cooling system that utilises ground temperature for pre-cooling or pre-heating ventilation air in summer and winter respectively. In an EAHE, ventilation air is drawn into the building through a system of tubes located in the soil near or beneath the building.

According to Sharan (2004), EAHE consists of loop(s) of pipe buried in the ground whether horizontally or vertically. Tubes or pipes were buried inside or into the ground, through which air is drawn (Zhao, 2004). The temperature fluctuations at the ground surface exposed to the exterior climate were damped deeper in the ground due to the high thermal inertia of the soil. At a sufficient depth, the ground temperature would be lowered than the outside air temperature whereas the air thus cooled in warmer surroundings (Santamouris, 1996). Most of passive cooling system had been established in Europe but not in places with hot climate because the potential to reduce the temperature is low due to higher soil temperature. However, it can be improved by using various soil cooling strategies to lower the natural subsurface soil temperature such as shading, surface irrigation, surface treatment using plants and pebbles (Givoni, 2007 ; Ahmed, 2008). Temperature difference between air and soil can be utilised to pre-cool or pre-heat ventilation air supply using EAHE, which consists of pipes buried below ground surface through which ventilation air is circulated.

EAHE can be used to increase thermal comfort in buildings and also decrease carbon dioxide emission (Joen *et al.*, 2012). The EAHE concept is quite simple where a tube is buried in the soil. The soil will be at a temperature warmer than the outside air in winter and cooler than the outside air in summer. Ventilation air is then drawn into the building through the buried tube, heating it in the winter and cooling it in the summer and then passively reducing the overall cooling and heating load. The efficiency of the EAHE varies from one location to another depends on the type of soil present within the vicinity although the system is practical (Ascione *et al.*, 2010)

1.2 Problem Statement

High ambient temperature is caused by global warming and excessive emission of carbon dioxide due to human activities and thus leads to thermal discomfort. By using the appliances such as cooling fans, ventilators and air conditioners will increase the amount of cost and also contributed to the energy consumption. So, EAHE system is used to overcome this problem as well as reduce the occurrence of carbon dioxide and global warming. However, the efficiency of EAHE is highly dependent on the type of soil. Thus, finding a suitable material to replace existing soil may be required to achieve a desired thermal for any given location.

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