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A Coupled Earth to Air Heat Exchanger for Assessment of Non Active Structural Cooling

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Abstract

Background: Everyone in the world started using their home air conditioners as a result of the escalating global warming circumstances. However, the power output of the power plants is consistent throughout the day, therefore it cannot satisfy this enormous demand.

Objectives: After several hours of research on conventional air conditioning systems, engineers created a new idea for an Earth to Air Heat Exchanging System that may be used for passive cooling of buildings.

Methods: The changeable properties of a pipe include its buried depth, cross section, length, design, number, and inlet and outflow cross sections. Thermal inertia, chimney wall insulation, input and output parts and positions, direction, height, and upper and lower chimney components. The two identical, well-insulated structures are simulated numerically over the summer. The first building serves as a model because it has the mentioned passive cooling system, whereas the second has no passive elements.

Conclusions: The outcomes confirmed about Reviewing numerical, experimental, parametric, and economic studies of an earth-to-air heat exchanger with an emphasis on its application in semi-arid and arid climates is the topic of the current study.

Keywords: Coupled systems, earth to air heat exchanger, air ground heat exchanger; geothermal cooling, hot arid climate, Soil temperature.

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1. Introduction

EAHE (Earth-to-Air Heat Exchanger) is a device that allows heat to be transferred from ambient air to deeper layers of earth and vice versa. Open type and Closed type Earth Tube Heat Exchanger [1]. Use of constant ground temperature to absorb and emit the heat during summer and winter respectively. Environment friendly and cost effective method. Renewable Resource for Passive Cooling of Buildings like Schools, Universities, Hospitals, etc. Almost research returns to the appearance of humanity on Earth. To guarantee stability, a man has always been trying to adjust the residence of him. Recent design of building construction emphasized the benefits and possibilities of natural ventilation systems for thermal comfort of residents [2, 3]. Natural ventilation not only saves money and energy but also provides good air quality and is thermally comfortable. The air heat exchanger, the solar fireplace, and the wind tower are a few instances of creative ventilation.

An eco-friendly, renewable, and passive technique is air-ground heating. People in dry climates have utilised them to control and heat their housing since 3000 BC [4,5]. The idea is straightforward: at a particular depth in the subsurface, buried pipes with high thermal conductivity maintain the soil's annual temperature at a fixed level. Air is usually used as the working fluid to conduct heat transfer while it is moving through the pipe. Due to its ability to store heat, soil can act as a heat source or sink in this pipe. [6]. It generates two distinct thermal states.

2. Objectives

A passive method to lower heat losses from ventilation and raise thermal comfort in buildings is the use of an Earth Air Heat Exchanger (EAHE) to heat or cool air[7,8]. By burying a network of pipes in various configurations in open areas or at a certain depth beneath the building, this system takes advantage of geothermal energy.

The same technique helps to heat the air, keeping the inner atmosphere warmer than the outdoors in the winter when the ambient temperature varies from 4 to 9 degrees Celsius depending on location [9]. Conduction allows the earth's heat to be transferred to the pipes, causing the temperature of the buried pipes to rise or fall. Mechanical equipment like fans, blowers, and passive systems are employed to create an adequate pressure differential in order to maintain a steady flow of air through the intake [10].

EAHE performance is influenced by a number of variables, including pipe diameter, length, material, moisture content, soil properties, temperature difference between the earth and ambient air, and others [11,12]. The pipe material should have a high heat conductivity depending on the soil conditions, such as mild steel, PVC pipes, cemented pipes, and so on. Unchanged deep earth soil often has a lower summer temperature and a greater winter temperature than the surrounding air [13]. Air is cooled in the summer and heated in the winter as it flows through the pipes, prior to any other active conditioning. This is a subtle detail, but the HETS should behave differently in the summer and winter. Summertime research on sensible and latent cooling focuses on how quickly temperature and air moisture drop once it reaches the dew point[14–17]. Other studies have referred to this system using several words, including ground-coupled heat exchangers, earth-air tube ventilation system, earth-to-air heat exchangers, earth-to-air heat exchangers (EAHE, EAHX, ETAHE, ATEHE), and simply buried pipes, which we also employ in this study. Earth-to-air heat exchangers (EAHE), which use the ground for heat storage and dissipation, have been the subject of several studies. Even though a WAHE has more advantages than an EAHE, less research has been done on WAHEs [18].

As a result, tests were conducted on undersea pipes of various lengths. Numerous factors have been shown in the literature to influence heat exchange with a heat sink. To improve heat exchange, a balance must be struck between pipe diameter, pipe length, air velocity, and airflow rate. [19]. Additionally, considerable work has been done in India. A part of a guesthouse was cooled using an EAHE-based cooling system by Sawhney et al. in 1998. In Knoxville, Tennessee, at the Baxter facility, a detail study was conducted (USA).

In the past ten years, researchers and scientists have paid a lot of attention to solar chimneys. Solar chimney auxiliary wind towers used for natural ventilation in buildings were researched and analysed by Bansal et al. [20]. Natural ventilation is thought to be significantly influenced by solar chimneys at low wind speeds.

3. Methods

Tunneling

The initial phase is to tunnel up to 3 metres below the surface. Installing pipes is the next quick step after tunnelling. PVC pipes are used for outdoor areas, aluminium pipes with brass coatings are used as heat exchanger pipes, and composite pipes are used to reduce heat exchange. A two-headed pipe with a unidirectional valve is installed in North-West and South-East directions to accommodate the PVC inlet's need that air enter the pipe whenever the wind blows. After the PVC, the aluminium pipe should be connected in a zigzag pattern to increase the surface area available for heat exchange.

The composite pipe must then be connected to the building's wall as the next stage. There will be an expander and a unidirectional valve attached at the end of the composite pipe. Connect the exit pipe with a unidirectional valve in line with the inlet at the opposite wall to expel the low-conditioned air. For better comprehension, Figure 1 displays the tunnelling process and the CAD design.

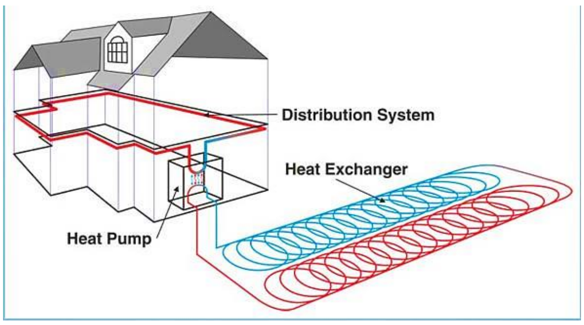

Fig. 1 Tunneling Process

To determine the ground temperature on and near the campus utilizing the various data that are available. To improve efficiency and adapt to this climatic situation, updated pipe architectures and layouts are used in existing models. To gather information and contrast it with ideal values. To put into practice and recommend additional features and add-ons so that the suggested model might, if possible, be improved. Earth-to-air heat transfer: The tubes were buried in the ground in a horizontal plan surface, as shown in Figure 3, with fixed intervals between them and a single inlet and output air. The heat exchange between the soil and the air inside the tubes may be computed using the equations below [10] because the tubes have the same properties as the soil and the soil was assumed to be homogeneous. The heat flow from the input to the output is given by for a distance of X;

$$T_{air\_tube} - T_{soil} = \frac{dQ}{dX} R_{total}$$

The proposed solar system consists of a ground-to-air heat exchanger and a solar chimney. The solar chimney consists of a south-facing glass surface and an absorption wall that acts as a collection surface. In the SC, heat from the sun causes the air to warm up and rise as a result of the chimney effect. Through the cooling pipe, it generates driving power and draws outside air in. EAHE is composed of a long horizontal tube that is buried at a particular depth beneath the exposed surface. These underground pipelines run parallel to one another. The pipe spacing is thought to be more than the thickness of the heat penetration depth in order to improve heat exchange between the earth and the air. According to the facts, the system can offer comfortable interior conditions and satisfy the adaptive comfort standards (ACS) for thermal comfort in naturally ventilated buildings. According to the adaptive comfort model, Figure 2 shows the necessary indoor temperatures.

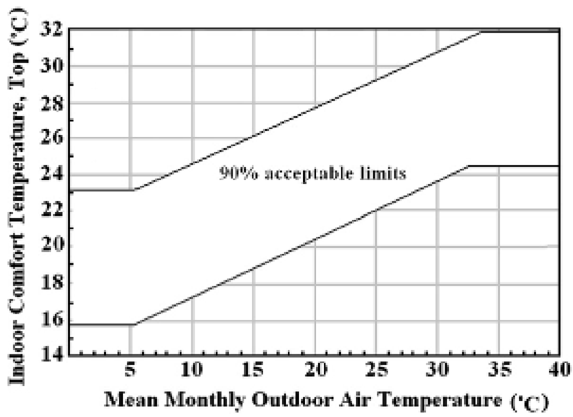

Fig. 2 Adaptive comfort Indoor temperatures

4. Results

Velocity of the air = 10km/hr (= 2.78m/s)
Ambient temperature = 35 ℃
Diameter of the inlet pipe = 0.0635m
Density of air at 35 ℃ = 1.1455 kg/m3
Viscosity of air at 35 ℃, μ = 1.895 ×10^−5
Reynold's No. = $\rho vL/\mu$
and, Re < 2000 = Steady Flow

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$2000 < Re < 4000 =$ Transition Flow

$Re > 4000 =$ Turbulent Flow

Calculating Re for pipe analysis:

$$Re = 1.1455 \times 2.78 \times 0.0635 / 1.895 \times 10^{-5} = 10670.98 > 4000.$$

The flow is turbulent.

Regarding these calculations, the simulations that follow are made. EAHE-based systems are environmentally benign because they don't release any toxic emissions. Although they use some refrigerant, Ground Source Heat Pumps (GSHPs) use far less than conventional systems. Water is not needed for EAHE-based cooling systems, which is advantageous in desert regions like Kutch

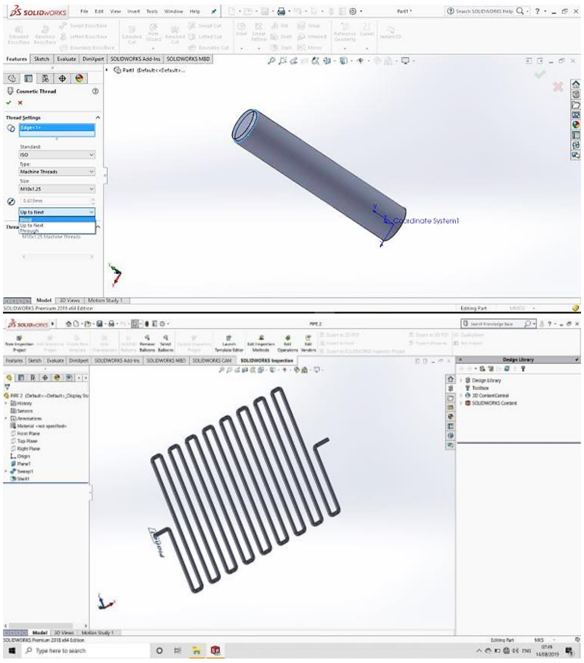

Fig. 3 Variation of Indoor temperatures

The creation of ETHE was motivated by this characteristic. EAHEs are low maintenance and have a long service life. They are very inexpensive to operate.

Error investigation

The least reliable ideals for temperature, flow velocity, and relative humidity are 14.3 degrees Celsius, 5 metres per second, and 10.4 percent, respectively, according to the information in the sections that came before it. The smallest number of measuring sensors is 0.1 C, 0.1 m/s, and 0.1 percent for temperature, flow velocity, and relative humidity, respectively. The highest measurement mistake is equal to the ratio of the measuring instrument's least count to the parameter's smallest recorded value, according to an examination of experimental measurement errors made using various technologies [21]. The measurement errors are therefore predicted to be 1.20 percent, 2.0 percent, and 0.96 percent, respectively, for temperature, flow velocity, and relative humidity. This mistake study explains the instrumental error that occurred throughout the experiment. The error analysis shown above only includes the largest measurement error since the performance of the different EATHE system operation modes is compared using actual experimentally recorded values of temperature and relative humidity parameters.

5. Discussion

Environment pollution minimization. It is possible to stop the ozone layer from depleting. The pace of economic expansion will quicken, and people's standards of living will rise. Effective use of EAHE is necessary to lower the earth's temperature. The Earth to Air heat exchanger is expected to lower the room's temperature by up to 14 degrees Celsius throughout the summer. Compared to the current model, an enhanced and more effective models.

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