Thermal performance analysis of earth air tunnel system applicable to Green buildings

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Abstract -

The present power crisis and global scenario trend is favouring renewable energy sources like solar, wind, biomass and locally available energy sources from buildings which are untapped. Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies.

As a new initiation in building energy technologies, Earth air tunnel system is a new revolutionary technology which will reduces the buildings thermal loading. These technologies are in early stage in India and more standardization is required for economical operation. In this paper, an analysis has been done to how to plan for a Geothermal based Earth Air tunnel system for green buildings.

Key Words: Geothermal power, Earth Air tunnel systems, Energy performance, Green buildings.

1. INTRODUCTION

Ground possesses an immense impact on temperatures. By comparing air temperature and ground temperature a difference of minimum of 2^0C to 6^0. Hence by utilizing this temperature difference the buildings thermal properties can be improved. Technically, the temperature of the air remains almost constant at a depth of 2m to 4m. The temperature is higher than outside air temperature in winter and opposite in summer[1].

Green building is a design which is in practice to meet the standards if energy efficient building with sustainable practices. All the materials should adopt green concepts and completely recyclables in that local area. A complete solution to be given for the life cycle cost of the building.

Some innovative strategies to be adopted to meet all these standards for complete green building with energy efficient technologies.

An Earth Air tunnel integrated building will gives these following benefits:

- Reduction in energy consumption of the building to a tune of 10 to 15%
- 5 to 10% reduction in Air-conditioner demand
- Saving in electricity bills to a tune of 8 to 10%
- Environmental benefits
- Conserving the natural resources

Hence, to benefit from the EAT systems, a better understating of the local climatic conditions, air temperature and earth temperature values are required.

A naturally adopted building will also set the occupant mind set in more stress free environment. In an overall improves the quality of the life.

2. Applications of geothermal energy in buildings

Geothermal energy can be used for many applications like, domestic water heating, agricultural, industrial applications. These technologies can used wisely in buildings hence the buildings energy efficacy will improves and reduction in the air-conditioners energy consumption.

Ground source heat pumps are the main components in Earth air tunnel systems. They use the geothermal energy to heat or to cool the buildings. Either air or antifreeze liquid is used to circulate it in pipes buried in the ground. In summer, it will cool the building and in winter it will heats the building by taking the temperature difference of air and earth temperatures[2].

To maximize the heat transfer of the building with proper ventilation will reduces the burden on the buildings ventilation system. Some cases, compressors and pumps can be used to maximize the performance of the Air-conditioners load.

2.2 Earth Air Tunnel systems

EAT is mostly used for to cool the buildings in summer, but it can be used in winter also by utilizing the constant temperature few meters below in earth. In general, these systems can be considered as the breather of a building or technically they will work as wind towers connected to an underground tunnel.

Technical features of Earth Air tunnel system

The difficulty to analyze the Earth air tunnel systems performance is a complex one, because of its diversity in many ways. Software tools are available to analyze these systems; GAEA, RETScreen, Energy plus, TRANSYS etc.,[3]

While designing these systems, an analysis has been done to suit the technical performance of the system with economical viability of the system with better payback periods.

These systems are usually designed with temperature differences of 4^{0}C to 6^{0}C. The pipes size will vary from 3 inch to 30 inch sizes. Sizing the pipe will plays a crucial role in EAT systems; the lesser diameter tubes require more energy to move the air because of the friction in the pipes. Similarly larger pipes require more energy to exchange the large quantity of air or liquid. Hence, the design of a pipe can be optimized in a proper way to move the air in more efficient way. A careful design will prevents from the objectionable odors but it will affect the performance of the system[7].

Three types of systems are commonly being used in EAT systems:

Closed loop system: A U-shaped tube will be placed in duct work and the air will be re-circulated in more effective way. As the air is purified initially; the burden on the system will decreases and improves the performance of the system.

Open system: This system will always observes the air from outside with filtering option. The disadvantage of the system is air to be purified continuously[5].

Combination system: This system is a combination of open loop and closed loop to allow any one of the system by adjusting the dampers in the system. These systems can be used with a combination of Solar chimney to maintain some pressure in the system naturally.

Advantages of EAT

- **Low Energy Use:**

The main advantage of EAT is that they use very less energy than conventional systems and the energy can be saved to a tune of 25 to 50% in an overall performance of the system. Depending on the systems it will reduced the heating load and cooling load of the building.

Reduced cost on Hot water:

EAT systems will reduces the cost on hot water. The bills on hot water reduces to one-fourth to half by EAT systems.

Year round comfort:

Year round comfort with humidity control of the building by EAT. Heating of the water, less electric bills and more importantly warm conditions in winter and cool conditions in summer are some of the comforts.

Aesthetics: These systems will improve the buildings aesthetics due to the elimination of the rooftop solar hot water systems and other conventional equipment. Because EAT systems equipment are placed in underground[4].

Low Environmental Impact:

EAT systems are more efficient when they are integrated with conventional design to reduce the buildings energy consumption in a sustainable way. Hence, these systems are more environmental friendly, less GHG emissions[6].

Low Maintenance

These systems are based on air circulation with minimum auxiliary equipment and hence very less maintenance. A recent survey suggesting that EAT coupled buildings maintenance costs are very less comparing to the conventional buildings[8].

Disadvantages:

EAT systems are not effective in hot and humid climates, because the air temperature and earth temperature are equal to the room temperatures.

All regions are not suitable for EAT systems, due to the earth properties, bedrocks near the project site, avialbilty of the space.

2.4 Simulation results:

RETScreen software will gives good results to test the technical feasibility of a Earth air tunnel system to test the EAT feasibility in a particular site.

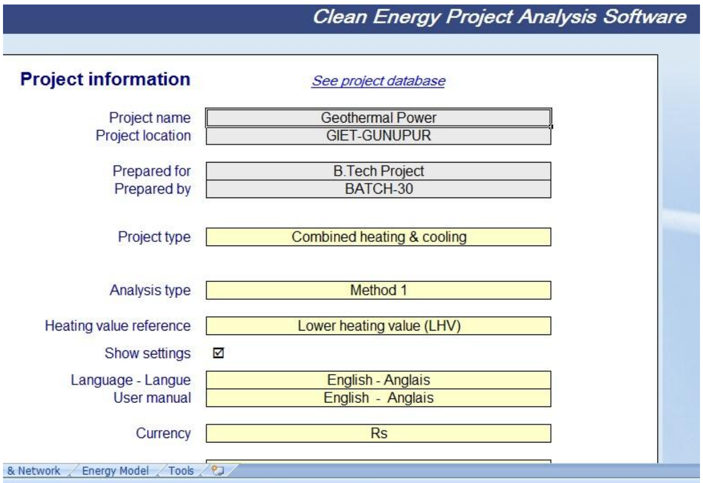


Fig 2.1: Home screen of the RETScreen Software

Fig. 2. 1 is the home screen of the RETScreen Software. All the settings are to be entered according to the site conditions.

Fig. 2.2 shows the Weather conditions of the project site. Air temperature and Ground temperature clearly indicting the temperature differences of the project site.

The adaptability of the software is it can identify from the NASA database and by taking into consideration of the air temperature and ground temperature.

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	21.7	56.7%	4.73	99.1	2.8	23.3	0	363
February	24.0	60.4%	5.43	99.0	3.0	26.5	0	391
March	26.9	58.8%	5.97	98.7	3.6	30.2	0	525
April	28.2	64.5%	6.36	98.4	3.9	30.9	0	545
May	28.8	70.0%	6.15	98.0	3.6	31.1	0	583
June	28.3	78.0%	4.30	97.8	3.8	29.4	0	549
July	27.4	81.0%	3.75	97.8	4.0	28.1	0	540
August	27.1	81.4%	3.68	97.9	3.8	27.7	0	530
September	26.8	80.5%	4.10	98.2	2.9	27.7	0	503
October	25.7	74.9%	4.49	98.6	2.9	26.7	0	485
November	24.0	60.3%	4.44	99.0	3.5	24.8	0	419
December	22.0	52.5%	4.48	99.2	3.2	23.0	0	371
Annual	25.9	68.3%	4.82	98.5	3.4	27.4	0	5,803
Measured at	m				10.0	0.0		

Fig. 2.2 : Air & Ground Temperatures at Gunupur

Cooling project	Unit		
Base case cooling system		Single building - space cooling	
Cooled floor area for building	m²	250	
Fuel type		Electricity	
Coefficient of performance - seasonal		3.00	
Cooling load calculation			
Cooling load for building	W/m²	28.4	
Non-weather dependant cooling	%	0%	
Total cooling	MWh	45	
Total peak cooling load	kW	7.1	
Fuel consumption - annual	MWh	15	
Fuel rate	Rs/kWh	6.000	
Fuel cost		Rs	89,980
Proposed case energy efficiency measures			
End-use energy efficiency measures	%	80%	
Net peak cooling load	kW	1.4	
Net cooling	MWh	9	

Fig. 2.3: cooling project requirement

Base case load characteristics

Month	Cooling average load kW	Heating average load kW
January	4	0
February	4	0
March	5	0
April	6	0
May	6	0
June	6	0
July	6	0
August	5	0
September	5	0
October	5	0
November	4	0
December	4	0
Peak load - annual	7	5

Fig. 2.4: Base load characteristics

From Fig, 2,4 and 2.5 the comparison has shown between the base load characteristics and Proposed load characteristics.

Fir 2.6 and 2.7 showing the yearly cooling load demand of the base case and proposed case

Hence, by adopting the EAT systems there is much improvement the thermal comfort of the building and the demand on the Air-conditioners are also reducing substantially.

Proposed case load characteristics

Month	Cooling system load kW	Heating net average load kW
January	1	0
February	1	0
March	1	0
April	1	0
May	1	0
June	1	0
July	1	0
August	1	0
September	1	0
October	1	0
November	1	0
December	1	0
Peak load - annual	1	1

Fig. 2.5: Proposed load characteristics

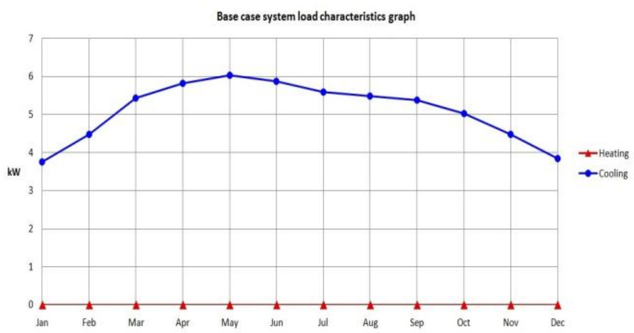
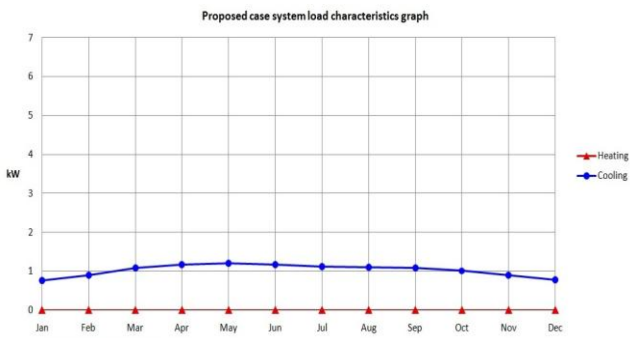


Fig. 2.6 Yearly cooling load demand (Base case)



Fig, 2.7: Yearly load demand (Proposed case)

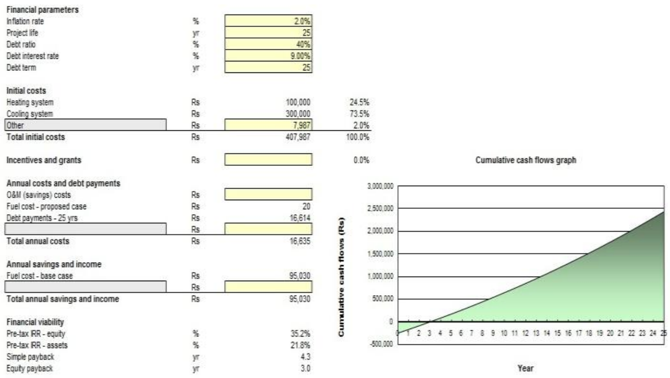


Fig. 2.8: Financial analysis of the Project

3 Conclusions:

A building integrated with Earth Air tunnel system will improve the energy efficiency and it will reduce the power consumption of the Air conditioners. In this paper the results are impressive and clearly indicating from Fig. 2.5 and 2.6; the power consumption of a building with EAT systems will reduces to a margin of 10%.

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