CASE STUDY TECHNICAL SHEET

Case study 6 – Earth Rangers Centre for Sustainable Technology

To reduce the energy demand and cost of providing necessary ventilation, the Earth Rangers Centre for Sustainable Technology (ERC), located in Woodbridge, Ontario, uses a network of underground concrete tunnels to temper fresh air entering the building's ventilation systems. See Figure 1.

System description

The earth tube system is an earth-to-air heat exchanger system, which consists of nine 20-m lengths of 900-mm diameter precast concrete pipes buried beneath the frost line (approximately 1,500 mm below grade). All of the concrete pipes are straight and large enough for inspection and maintenance. See Figure 2.

Once the air enters the building through a series of rain and snow louvers and dust filters, it is fed along a double-foundation wall that provides further natural heating and cooling of the building's structure before the air enters the ventilation system. The second wall inside of the poured concrete foundation is constructed of insulated concrete masonry.

The tunnels and double foundation wall provide 1,500 m^2 of thermally conductive surface between the ventilation air and the surrounding earth. The concrete pipes allow all of the air used in the building's ventilation systems to be 100% outside air with minimal recirculation. Outside air is drawn through a series of buried concrete pipes, allowing the surrounding earth to moderate the temperature of the incoming air so that it is either heated or cooled, depending on the time of year. After passing through the earth tubes, the incoming air passes through two levels of filtration. Once cleaned, the air is distributed throughout the building via a displacement ventilation system.

Earth tube technical data	
Pipes	9
Pipe depth	1.5 m
Pipe length	20.0 m
Pipe internal diameter	900 mm
Material	concrete
Airflow rate (L/s)	7,236 (design)
Building type	wildlife centre, educational
Geographical location	Toronto, Canada
Maximum heating delta T[1]	15.0°C
Maximum cooling delta T	6.8°C
Distance between pipes	0.5 m

Figure 1. Earth Rangers Centre for Sustainable Technology, Woodbridge, Ontario
Photo courtesy of the Earth Rangers Centre

[1] Delta T is the temperature difference between the pipe inlet and pipe outlet.

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Performance of the earth tube system

Given the relative stability of ground temperatures, it is of interest to determine how the earth tube heat exchanger performed during cold days, as opposed to warmer days. Figure 3 illustrates the overall effectiveness of the earth tube heat exchanger. The outdoor temperature at the Toronto airport (T_{ext} YYZ) is plotted against the net temperature increase (T_{ext}-$T_{average}$), where $T_{average}$ represents the average temperature of downstream earth tubes P1, P5, and P9. The heat gain reached a temperature difference of +15°C on the coldest days (-20°C to -25°C), while on warmer days (0°C to 5°C), the heat gain was much lower (less than 5°C). The heat transfer relationship between the ground, concrete tube, and low velocity airflow in the tubes is more effective as the outside air temperature gets colder.

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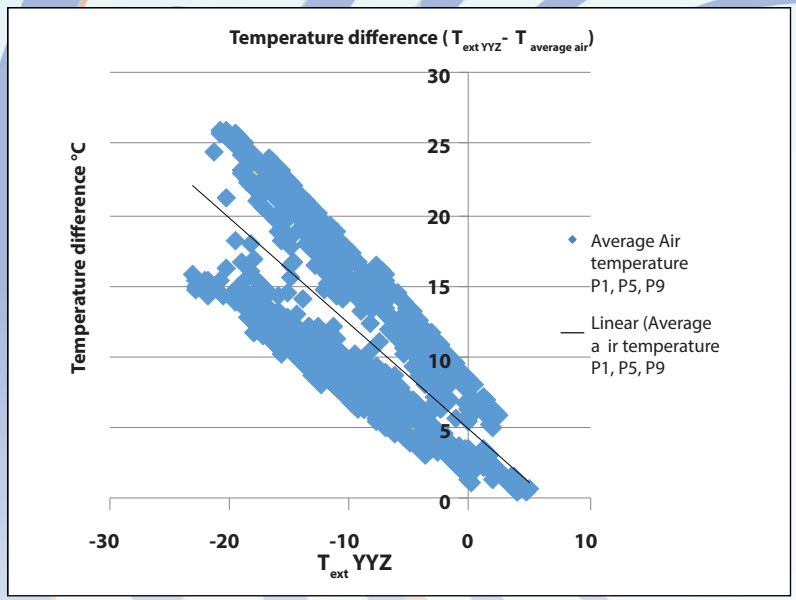
Figure 2. Culvert showing the pipes' inlets
Photo courtesy of the Earth Rangers Centre



Legend: T_{ext} YYZ means the external temperature at Lester B. Pearson International Airport.

Figure 3. Effectiveness of the earth tube heat exchanger in winter