CHILOQUIN COMMUNITY CENTER
CHILOQUIN, OREGON

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Geo-Heat Center

LOCATION & BACKGROUND

The Chiloquin Community Center is located in Chiloquin, Oregon, which is in southern Oregon, about 30 miles (48 km) north of Klamath Falls, and about 250 miles (402 km) south of Portland. It is a single-level, 13,000 ft^2 (1,210 m^2) structure that provides space for the Chiloquin Public Library, the Two Rivers Art Gallery, public arts and crafts work-rooms, a large public meeting room with full kitchen, and also leases offices to the local Sheriff's Department. Portions of the building are in use 7 days per week, year round. A sketch of the building footprint and borefield are shown in Figure 1.

The building is constructed of insulated concrete form (ICF) walls and a conventional wood frame roof. As a consequence of using ICF with fixed windows, the building is extremely well insulated and air-tight. The entire slab is insulated using 1-inch polystyrene board to reduce downward heat loss in winter.

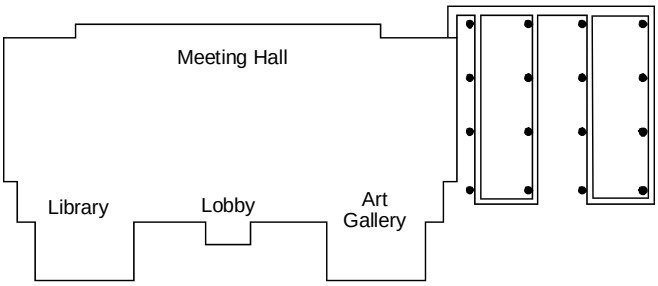

Figure 1. Chiloquin Community Center site sketch showing ground loop field.

The building was constructed in 2003-2004, and formally opened in the Spring of 2004. The ground-source heat pump system installation began prior to the commencement of the main building with the drilling of the network of vertical bores comprising the earth heat exchanger for the facility.

Average high temperatures in the area in July are about 85°F (29.4°C) and average low temperatures in January are about 22°F (-5.6°C). There are approximately 7000 (3890°C-day) heating degree days and 200 (110°C-day) cooling degree days per year (65 °F (18°C) base).

SYSTEM DESCRIPTION

Ground Source System

The ground source system (shown in Figure 1) is a vertical network of 16 bores, each 6-inch (152-mm) diameter and 320 ft (98 m) deep, and arranged in a rectangular grid with a bore-to-bore spacing of 20 ft (6.1 m). The u-tube assemblies were fabricated using 1" (25.4 mm) diameter high-density polyethylene pipe (HDPE). Following insertion of the u-tubes, a bentonite/silica sand grout was pumped into the bores to achieve a nominal grout thermal conductivity of 1.0 Btu/hr-ft-°F (1.7 W/m-°C).

To aid in the design of the borefield, an in-situ thermal conductivity analysis was performed on a test bore. The resulting test data were used to determine that the average thermal conductivity of the earth surrounding the bore is approximately 0.62 Btu/hr-ft-°F (1.07 W/m-°C). The mean earth temperature was measured at 56°F (13.3°C).

The geology at the site, based on the drilling logs, consists of sands and gravels to a depth of approximately 16 ft (4.9 m), with the remainder of the bore depths consisting of gray clay deposits interspersed with occasional sandstone

layers. The drilling was accomplished using air-rotary methods (Figure 2).

Figure 2. Photograph of drilling activities

Interior System

A highly unusual integrated system design was conceived for the project that addressed the energy efficiency goals of the building owners, and built on the very high thermal integrity of the shell. A crucial initial step in this process was agreement on design criteria that allowed for a wider range of indoor air temperatures than is typical for a building of this type. This determination facilitated the choice to use radiant floor heating as the primary means of thermal distribution, and this concept was then extended to include radiant floor cooling.

The building's 15 control zones are connected by a hydronic piping system to a central plant that has only one heat pump. The heat pump is a water-to-water unit (Figure 3) with a nominal rating of 15 tons (53 kW), and is equipped with a single compressor and refrigerant circuit. To prevent short-cycling, a thermal energy storage tank (Figure 4) is employed on the building side of the heat pump a significant buffer volume and de-coupling the control of building water distribution from the operation of the heat pump.

Because the building has no operable windows, all ventilation air is provided by mechanical means. A heat-wheel type air handling unit with a nominal capacity of 4000 cubic feet per minute (cfm) (6,800 m^3/hr) is installed in the attic space, together with ducting to distribute the air to each zone. At the zonal level, occupancy sensors operate a damper in the ventilation duct to minimizing the air handled by the fan system. These occupancy sensors also control lighting in the individual zones. The fan speed is modulated by means of variable frequency drives.

Figure 3. Photograph of the 15 ton water-water heat pump serving the entire building. Note the storage tank on the right.

The building's hydronic circulation pumps are in-line centrifugal types, with variable frequency drives that are controlled based on pressure in the supply pipe. At the heat pump, the ground loop pump is also controlled with a variable frequency drive. The tank circulation pump between heat pump and thermal storage tank is constant speed.

Figure 4. Photograph of the mechanical room, showing the distribution piping and storage tank.

To allow the programming of desired control sequences, a direct-digital control (DDC) system was installed. The system uses ASHRAE's BACnet communications protocol set over TCP/IP. It is therefore possible to use conventional internet browser software to access and interact with the control system, and a dedicated server is located in the building to accomplish this task.

PROJECT COSTS

The installed cost of the interior HVAC system was \$189,400 or \$14.57/ft^2 (156.83/m^2) and the cost of the ground loop was approximately \$48,000 or \$9.38/ft

($30.77/m) of vertical borehole. Thus, the total installed cost of the entire ground-source heat pump system was $237,400 or $18.26/ft^2 (196.55/m^2).

PacifiCorp provided incentives to the owners, underwriting the costs of pre-design analysis and construction. Additional efficiency incentives were provided through the State of Oregon's Business Energy Tax Credit (BETC) program. Together these incentives totaled approximately $80,000.

SYSTEM PERFORMANCE AND OPERATING COST

The first full year of operation has just completed, and the building has proven itself to be even more efficient than anticipated. Average energy use index is 19,800 Btu/ft^2/yr or 5.8 kWh/ft^2/yr (62.4 kWh/m^2/yr), which is especially impressive because the building operates with no night setback due to the dynamics of the radiant slab.

Sub-metering of the building zones allows the HVAC energy costs to be broken out and tracked. From utility bills, the operating cost of the HVAC system for the first year was about $5,350 or $0.41/ft^2 ($4.41/m^2).

OPERATING EXPERIENCES

Chiloquin Visions in Progress (CVIP), a non-profit organization who raised funds to construct the building, report that they are very happy with the low energy use and operating cost of the building. Low operating costs are an especially attractive feature for non-profit organizations.

As anticipated, the building design does not provide for rapid adjustment to load changes with its radiant slab heating/cooling systems. This might be perceived as a drawback, but the building has no morning warm-up or cool-down time since it is operated without night setback of thermostatic controls. As designed, it seems to work reasonably well with the normal functional requirements of the building.

One rapid load change scenario that has been somewhat difficult to deal with is the occasional large public gathering in the meeting hall room. To best provide for the sudden cooling load, it has been necessary to anticipate the event by overcooling the room, and then keeping the supply water temperature lower than would normally be called for at the central thermal storage tank. In addition, decorative ceiling fans have been proposed in the meeting hall room to increase air circulation as well as to give occupants a visual perception of air movement.

ACKNOWLEDGEMENTS

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OVERALL SUMMARY

Building Description:

Location: Chiloquin, Oregon
Occupancy: Community Center with continuous occupancy is some zones
Gross Floor Area: 13,000 ft^2 (1,210 m^2)
Number of Floors: 1
Type of Construction: New
Completion Date: 2003
July Avg. High Temp.: 85°F (29.4^{o}C)
Jan Avg. Low Temp.: 22°F (-5.6^{o}C)
Annual Heating Degree Days: 7000°F-day (3890°C-day)
Annual Cooling Degree Days: 200°F-day (110°C-day)

Interior System:

Total Installed Heat Pump Capacity: 15 tons (53 kW)
No. of Heat Pump Units: 1
Pumping System: Central pumping, variable speed control
Additional notes: Radiant floor heating and cooling

Ground-Source System:

Geologic Materials: Sediments
Mean Ann. Ground Temp.: 56°F (13.3^{o}C)
Type: Vertical closed loop, single U-tube
Configuration: 16 boreholes (4x4 grid pattern)
300 ft (98 m) deep, 20 (6.1 m) ft spacing
Borehole per ton: 342 ft/ton (29.6 m/kW)
Heat Transfer Fluid: Methanol/water solution

Economic Analysis:

Installed Geothermal HVAC Capital Cost:
$237,400 ($18.26/ft^2) (196.55/m^2)
Estimated Conventional HVAC Capital Cost:
$130,000 ($10.00/ft^2) (107.64/m^2)
Annual HVAC Energy Use:
19,800 Btu/ft^2 (62.4 kWh/m^2)
Annual HVAC Energy Cost:
$5,350 ($0.41/ft^2) ($4.41/m^2)