BY GEOFF MCDONELL

SYNERGIES AND SYSTEMS IN ACTION

Rising out of the ground across from the City of North Vancouver's city hall at 14th Street and Lonsdale Avenue is an example of a low energy extensive hydronic heating and cooling system application driven by the city's need for a new, expanded library. The existing library was becoming cramped and maintenance and operating costs were increasing rapidly. North Vancouver also needed more parking in the area. A public plaza that connects the city hall campus to Lonsdale Avenue, the main north-south thoroughfare, was to be expanded as well.

The library building project was envisioned to include a two-storey underground parkade, integration of a local district energy plant, an expanded public plaza and a 3,200 sq.m. library in three floors of the cast in place concrete structure. As part of the real estate deal that raised money for the library and plaza development, some city land was sold to developers to build high-rise condominium buildings. These buildings would also be customers of the Lonsdale Energy Corporation (LEC) district hot water energy service.

The city wanted a minimum LEED Silver registration green building standard to be achieved within the project budget approved previously. This was a challenge given the rapid escalation of construction costs in the lower mainland and the difficulty finding qualified sub-trades and contractors. To meet this challenge the project design team, led by the city's facilities office, began an integrated design process (IDP). Many full-team (including library staff) design meetings and charettes were held initially to determine design synergies and the priorities for the project goals.

Geo-exchange slinky coils being laid out in the sub-grade below the lowest underground parking area slab. A total of 28 HDPE (high density polyethylene) slinky pipe loops were installed under the parkade slab on grade areas for the water-to-water heat pump plan in-ground heat exchanger function.

Photos Geoff McDonell

STATS: Installed HDPE and PEX

Geo-exchange piping = 10,960 meters of HDPE piping.
Radiant slab tubing = 9,500 meters of PEX tubing.

DESIGN STAGE

One of the first steps was to design a high performance envelope to take advantage of the expansive views to the south, while minimizing solar heat gain and excessive heat losses through the windows. This was achieved by using a 65 per cent glass to opaque wall ratio for the east, south and west facades, along with exterior sun-shades to keep direct sunlight off 75 per cent of the windows. The windows were also selected to have low-e coating and an argon gas fill to keep the U value as low as possible and the thermal resistance (R value) as high as possible. Opening window panels were incorporated for supplemental natural ventilation around the perimeter spaces.

The next synergy was found by reviewing the amount of excavation that was going to be required to relocate existing site services (sewers, water main and electrical/communications duct banks) as well as the 3,500 sq. m. underground parkade footprint. It was determined that the cooling load of the building, coupled with the available free excavation area, would allow a horizontal geo-exchange system to be used with a water-to-water heat pump plant.

The net extra cost for the geo-exchange system would

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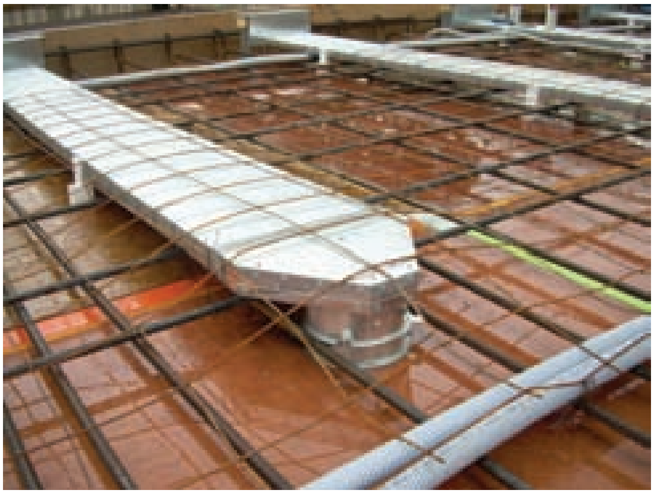
be for the HDPE slinky-coils buried into the sub-grade of the lowest parkade levels and in the services trenches, and a couple of loops strung along the sidewalls of the parkade excavation. This allowed enough safety factor for the geo-exchange system based on the assumed soil conductivity calculations. A single 45-ton capacity single water-to-water heat pump is used, along with an auxiliary 10-ton air cooled water-to-air heat pump unit suspended in the parkade, piped in series with the main heat pump unit to ensure that the peak summer cooling loads could be handled.

As it happened, the lowest excavated levels of the parkade exhibited slow and steady water infiltration, requiring a sump pump to be used constantly during the parkade elevator pit excavation. For geo-exchange system designers, "the wetter the better" is the motto due to the greater soil conductivity available in wet soils.

COOLING FRONT-RUNNER

The low cooling loads of most of the building, coupled with the cast-in-place concrete structure made a radiant slab ceiling heating/cooling system a front-runner for the library's thermal control system. The south side and east and west corners would still require supplemental cooling at peak summer conditions, which would be provided by re-cool coils on the ventilation air supply. The radiant slab cooling system can provide approximately 25 Btuh/SF of radiant slab surface area, using a surface temperature of 63F at an interior air temperature of 75F (80 watts/sq.m. at a surface temperature of 16.5C with an air temperature of 23.5C). Do not forget that with a radiant cooling system, the key comfort control parameter is the operative or resultant temperature of the space. This is defined as (Radiant Surfaces Temperature + Air Temperature) / 2. So, in a room with an average of all the surface temperatures of around 66F (18.9C), with an ambient air temperature of 76F (24.4C), the operative temperature would be approximately 71F (21.7C). Of course, air movement can affect that. The greater the ambient air velocities the cooler it will feel while in still air conditions you would feel the specific operative temperature.

The radiant cooling system requires water temperatures in the range of 60F (15.6C) to 64F (17.8C) for the slab tubing to impart a surface temperature of 62F to 65F (16.7C to 18.3C) to the exposed ceiling slabs. Since dehumidification was not a requirement the cooling coils in the main air handlers and the re-cool coils could be selected to operate with the higher chilled water temperatures. A nominal 55F (12.8C) chilled water supply temperature was selected to ensure there would be sufficient cooling in the main ventilation air handlers during peak summer temperatures and to offer some ability to blend and tune the radiant slab zone temperatures as needed.



The displacement ventilation air supply ducts were cast directly into the structural slab, to provide supply air to floor registers. The fact that the supply air ducts are also integrally cast into the radiant slabs means that the supply air is tempered by the controlled slab temperature for a constant temperature indoor design capability. The Eccoduct product was installed by NorthWest Sheet Metal Ltd.

This also allows the geo-exchange heat pump unit to operate at a very energy efficient cooling EER of over 21 based on the geo-exchange field source water temperature of 62F (16.7C). Similarly, in heating mode, the radiant slab systems only need fluid temperatures of 85F (29C) maximum. With an average geo-exchange field fluid temperature of 55F (12.7C), a heating COP of well over five can be achieved.

During peak heating periods, the library is supplied with 175F (79.5C) high temperature heating water from the local LEC energy plant. The library's heat pump plant can then provide basic heating for the spring and fall seasons if required.

PROTECTING THE GEO-EXCHANGE FIELD

When the ventilation air heating loads demand higher heating requirements, the LEC system heating water is used via a plate heat exchanger integrated into the library heating circuit. This ensures that the geo-exchange field would never be taken to freezing conditions during the heating-dominated climate here on the coast. Buried temperature probes are incorporated into the geo-exchange slinky-coil layouts to monitor ambient soil temperatures. This allows the building operators to ensure the geo-exchange system is not over-heated during peak summer conditions or over-cooled during heating mode operations. The buried soil temperature sensors also allow the use of the geo-exchange system for free cooling. When the geo-exchange system temperatures are lower than the

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DESIGN TEAM

- Mechanical Contractor: Division 15 Mechanical Ltd.
- Mechanical Consultant: Omicron AEC
- Radiant Systems Sub-Trade: Trident Hydronics – Dwight McKimmon
- Geo-exchange system Sub-Trade: ExchangeEnergy Ltd - Jeremy Jacob
- Architects: CEI Architects/Diamond & Schmitt Associates in Joint Venture
- Structural Consultant: Read Jones Christoffersen Structural Engineering
- Electrical Consultant: MCW Consultants Ltd.
- Civil Engineering: Kerr Wood Leidal
- Landscape and Plaza Design: Phillips Faarevag Smallenberg Associates
- Project Management: Turnbull Construction Management
- Commissioning Agent: Airmec Ltd – Kevin May
- General Contractor: PCL Constructors Westcoast Inc.

spring/fall radiant cooling system requirements, the heat pump is bypassed to a plate heat exchanger to harvest the low grade cooling directly from the slinky coils.

An array of 120 flat panel style solar water heating panels are racked on the library roof to provide the majority of hot water heating required by the LEC energy plant during the summer when the energy plant load is primarily domestic hot water for the surrounding connected buildings.

Ventilation air is supplied to all rooms and zones of the library via low level floor registers and low sidewall displacement ventilation air outlets, sized to provide an average of 25 to 30 cfm/person during normal full occupancy. The two 100 per cent outdoor air/100 per cent exhaust air main air handlers on the roof are equipped with air-to-air heat reclaim sections, a heating coil and a cooling coil to provide tempered 100 per cent fresh air. The two air units are also equipped with variable frequency drives on the supply and exhaust fans to allow the fan speeds to be ramped up from the base level of 65 per cent fan speed to 100 per cent fan speed as required to respond to either indoor temperature trends and/or local carbon dioxide sensors.

At maximum speed the ventilation air systems can provide 25 per cent more heating and cooling to the building to deal with variable occupancy loads and peak winter and summer climate conditions, while the radiant slab heating/cooling system along with opening windows can provide comfortable conditions for the majority of the year. Motorized windows on a north facing roof clerestory section are operated from the building controls to allow natural ventilation through the indoor atrium that runs up through the library space. Since the displacement ventilation air supply system relies on supply air temperatures in the range of 64F to 68F (17.8C to 20C) to maintain a low level pool of fresh air throughout the space, the ability to use a greater range of outdoor temperatures for free cooling can be achieved. Cooling energy is also saved at peak summer conditions.

LIGHTING EFFICIENCIES

Lighting energy use is reduced significantly by the daylighting allowances through the east, south and west facades. The large north facing clerestory windows on a roof monitor allow diffuse daylight to penetrate down through the building's interior. The building lighting systems are circuited and controlled from occupancy and daylight sensors. The mechanical engineers worked with the architects on the design of the exterior shading panels to achieve high level direct sunlight penetration along the south and west facades during the summer and winter low altitude sunlight for daylighting as well as passive solar heating in the winter.

The library is on track to achieve a LEED Gold standard for sustainability and to use 62 per cent less energy than the Model National Energy Code for Buildings reference building. A full suite of energy metering and verification points in the mechanical and electrical systems will permit the commissioning, monitoring and tuning of the building systems over the first year of occupancy. In addition, its actual performance can be measured in comparison to the design modeling. A weather station on the roof will record the local climate conditions to provide accurate local design conditions. Rain and wind sensors in the weather station will operate the motorized window panels to prevent excessive natural airflow inside the building and rain ingress.

One of the keys to designing a low energy/high comfort building is for the mechanical designers to understand and work with the architects on maximizing the building envelope performance, with an emphasis on the windows' solar performance. Remember that a good team can show that for every dollar spent on a better envelope (especially window performance), a dollar can be saved on the capital cost of the mechanical and electrical plant, to say nothing of the substantial savings in energy costs over the building's lifetime. HPAC

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