CEMATRIX™

Cellular Concrete Solutions

Geothermal Design Capabilities

CEMATRIX has the ability to perform a wide variety of geothermal designs using TEMP/W, a finite element geothermal modeling software package developed by GEO-SLOPE International in Calgary, Alberta, Canada. This powerful program allows the analysis of steady state or transient conditions; therefore, temperatures may be modeled over any time period. Boundary conditions may be defined using actual climatic, convective surface, steady state temperature, or thermosyphon data. Key soil properties such as thermal conductivity, unfrozen water content, volumetric heat capacity, and volumetric water content are also analyzed. In addition, this program features plotting capabilities for viewing of below ground temperature profiles over any time period.

Some examples of projects where thermal modeling is performed are as follows:

Insulation and Bearing Support for Roadways

Wet silty soils exhibit extensive frost-heaving when they freeze—as much as one-third meter at some locations in Alberta has been observed. The utility, safety and durability of such frost heaved roads is severely compromised.

Cellular concrete can be used to not only provide thermal insulation to prevent frost-heaving: but, the significant strength of the material means that road base gravel can be replaced, on as much as a 3 to 1 equivalency. The Resilient Modulus of cellular concrete typically used by CEMATRIX for road construction has been measured at 1.6×10^6 kPa (232,000 psi), by AASHTO Method T294. The structural layer coefficient has been determined to be 0.30 (gravel used in road construction in Alberta typically ranges from 0.10 for granular subbase to 0.14 for granular base course).

Silty soils are not only frost-heave prone, but they often exhibit very low plasticity. A typical course of action when such soils are encountered is to remove up to 2 m depth of the troublesome soil and replace it with sand and/or gravel. This can be very expensive. CEMATRIX has shown that an insulating, strengthening layer of cellular concrete can be placed over very weak silty soil, resulting in a very stiff, and frost stable road.

Figure 1 below shows the use of a 200 mm thick layer of cellular concrete placed below the pavement. The reduction of frost depth penetration is significant – from 2.4 m to only 0.8 m. Also, the cellular concrete provides an equivalent to 600 mm of granular subbase for structural support.

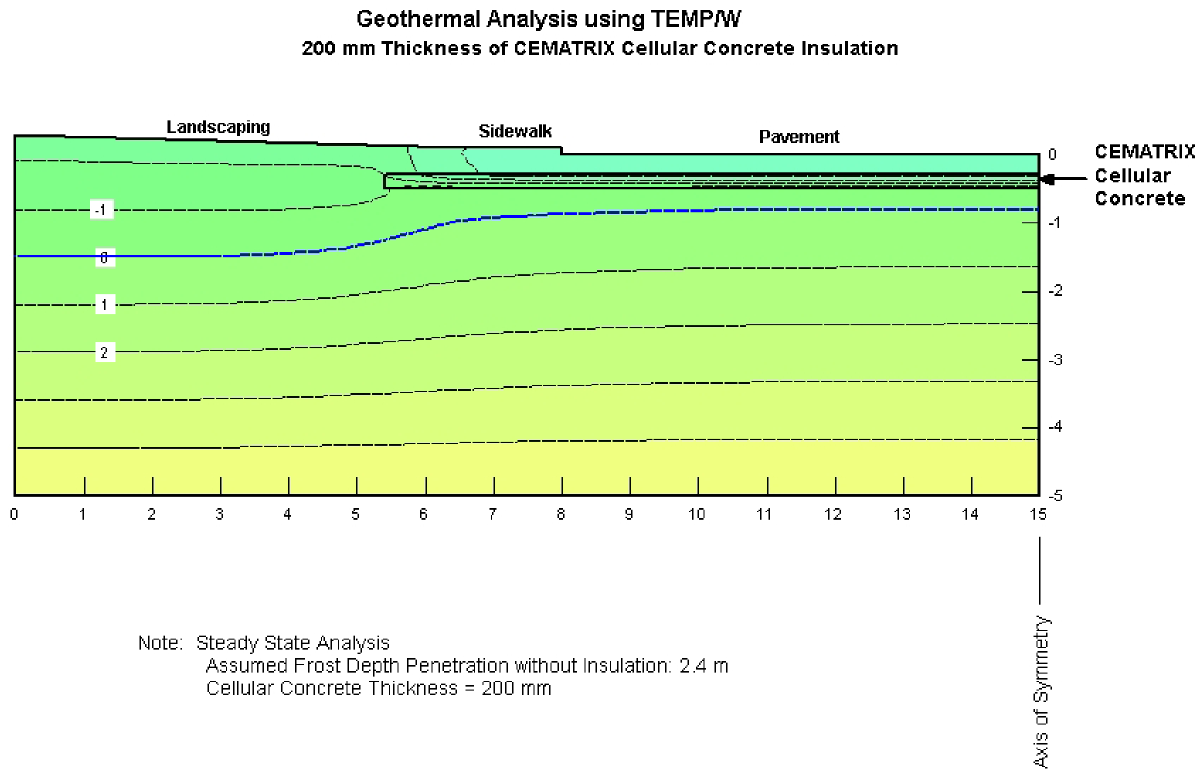

Figure 1 – Cellular Concrete Insulation and Roadway Support

Frost Protected Shallow Foundations

Under the *National Building Code of Canada,* foundations must bear on soil below frost penetration depth. For heated structures with no insulation to limit heat from being wasted to the underlying soil, the bottom of the footings are typically placed 1.2 m below grade in the southern part of Canada, and increasing in depth towards the north—until regions of permafrost are reached. South of the permafrost, 3 to 4 m of annual frost is common. The cost of building deep foundations—or going less deep but allowing extensive heat loss to occur under the structure to prevent frost formation—can be high.

Furthermore, backfill along footings and walls result in a preferential path for moisture – especially when backfill soil is uncompacted. This can result in softening / swelling of the soil at the footing grade, possibly resulting in damage to the structure.

A less expensive frost protected foundation can be built using insulation laid horizontally around the perimeter of a structure with shallow footings. Further cost savings can be easily realized by providing adequate insulation under the floor of the structure. Cellular concrete insulation has been used for such shallow foundation / insulation systems. The density of cellular concrete typically used for this application is in the order of 325 kg/m^3, with a compressive strength of 1.0 MPa and a thermal conductivity of 0.065 W/m◦K. Even at such a low density, the 'structural coefficient' of cellular concrete insulation is better than fully compacted gravel. This means that the insulation can play a structural role in the foundation system, contributing to the economic efficiency. For many small to medium size structures, a thickened-edge-slab on top of the cellular concrete insulation is sufficient to complete the foundation.

Using a Finite Element Analysis program to model the thermal behavior of a proposed insulated, shallow foundation, CEMATRIX can determine the optimum thickness and width of insulation, given climatic, soil property and geometry data. An example of such an analysis is shown in Figure 2. This analysis shows that the foundation can be protected from displacement with a layer of cellular concrete insulation just 100 mm thick, projecting 1.2 m outward from the building. In addition, approximately 50% of the heating costs are saved because of the reduction in heat loss into the underlying soil.

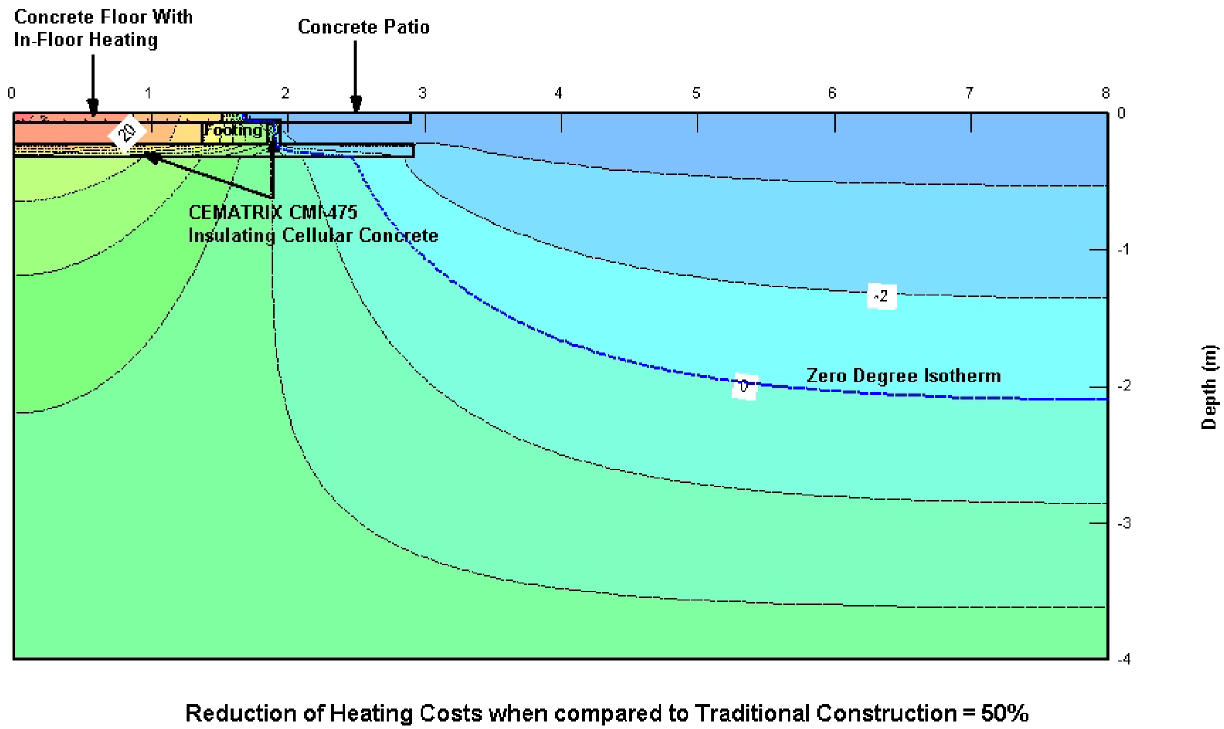

Figure 2 – Insulation below Heated Buildings for Energy Efficiency and Reduced Construction Cost

Insulation of Shallow Water Pipes

Pipes carrying water are often insulated when they cannot be buried below frost penetration depth. The reasons for shallow burial may include: conflicts with other utilities, change of grade, high groundwater level, high cost of blasting through solid rock, and others.

The amount and configuration of insulation will depend on several factors such as climatic conditions, depth of burial, width of trench, soil type and moisture content, and temperature and flow rate of water in the pipe. For instance, the depth of frost penetration is typically less for saturated soil versus that same soil in a dry condition because of the latent heat released during freezing of water.

The two most common configurations of CEMATRIX™ cellular concrete used for insulating shallow pipes, both of which are consistent with accepted engineering practices, are as follows:

- Horizontal insulating layer of cellular concrete – A layer of cellular concrete insulation is placed immediately above the pipe, thus trapping the heat of the earth below the insulation. This may be used on projects where a wider excavation can be tolerated. Generally, the total thermal resistance of insulation and soil cover provided, as well as the path length from the ground surface around the edge of the insulation to the pipe, must both be greater than the frost penetration depth.

- Cellular concrete insulation placed around the pipe – cellular concrete may also be used to completely surround the pipe, therefore providing insulation and support for the pipe. This design may be used where space is limited (i.e. main replacement projects), or where pipe support or protection is required such as for 'semi-rigid' pipe that normally requires burial below a certain depth.

Figure 1 shows the result of a typical analysis of a shallow water main. For this analysis, the climatic data was adjusted to give 3 m of frost depth (worse than the coldest winter in 100 years). Next, the insulation geometry was adjusted to keep the temperature at the pipe above freezing.

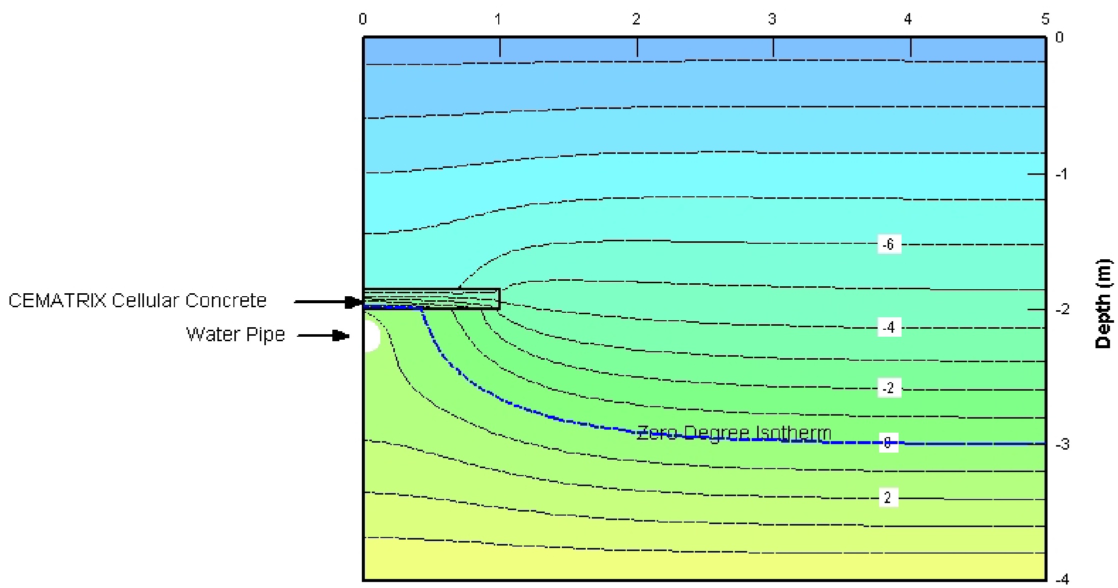

Figure 3 – Shallow Water Main Insulation using Cellular Concrete

RESOURCE SECTOR APPLICATIONS

Cellular concrete can be utilized under hot-oil storage tanks to very good benefit. As well as satisfying thermal insulation requirements, strength and absorption characteristics can be put to good use. The structural, layer coefficient of cellular concrete is up to three-times higher than gravel, making it a more efficient base material, and less prone to differential settlement. Additionally, cellular concrete insulation—with up to 75% porosity—can be incorporated into a system to comply with the EUB G-55 requirement for secondary containment. Zeolite, a mineral that will absorb up to 30% of its own weight in hydrocarbons, can be incorporated into cellular concrete to further enhance the absorption capacity. If a spill should occur, cellular concrete can be crushed to a fraction of its original volume, making transport to a disposal site much more economical.

Figure 4 below shows the output of thermal, FEA modeling of cellular concrete insulation and support under a large hot oil storage tank.

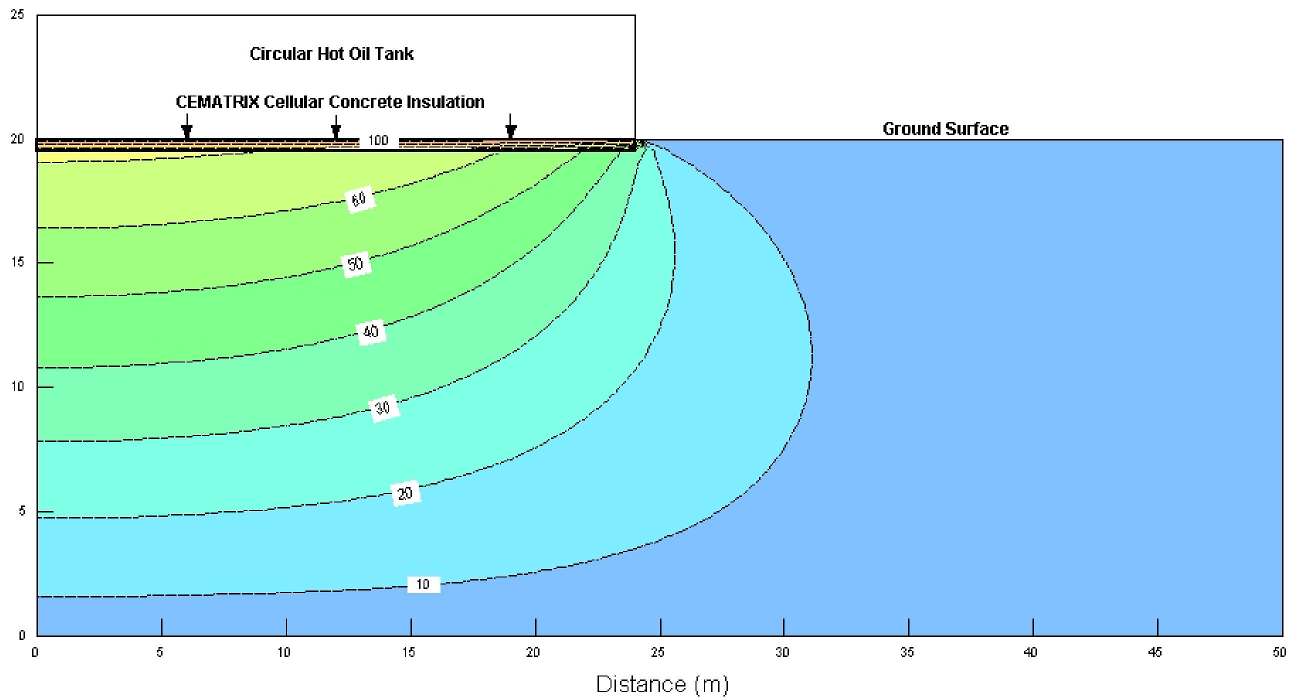

Figure 4 – FEA Modeling of a Hot Oil Tank

Figure 5 below shows the thermal analysis of a natural gas pipeline over sporadic permafrost areas in northwestern Alberta. The gas temperature of the pipeline was causing melting and settlement of the underlying permafrost. CEMATRIX devised a solution to place a cast-in-place horizontal layer of cellular concrete below the pipeline to stop any further thawing of the permafrost and provide a rigid support for the pipeline.

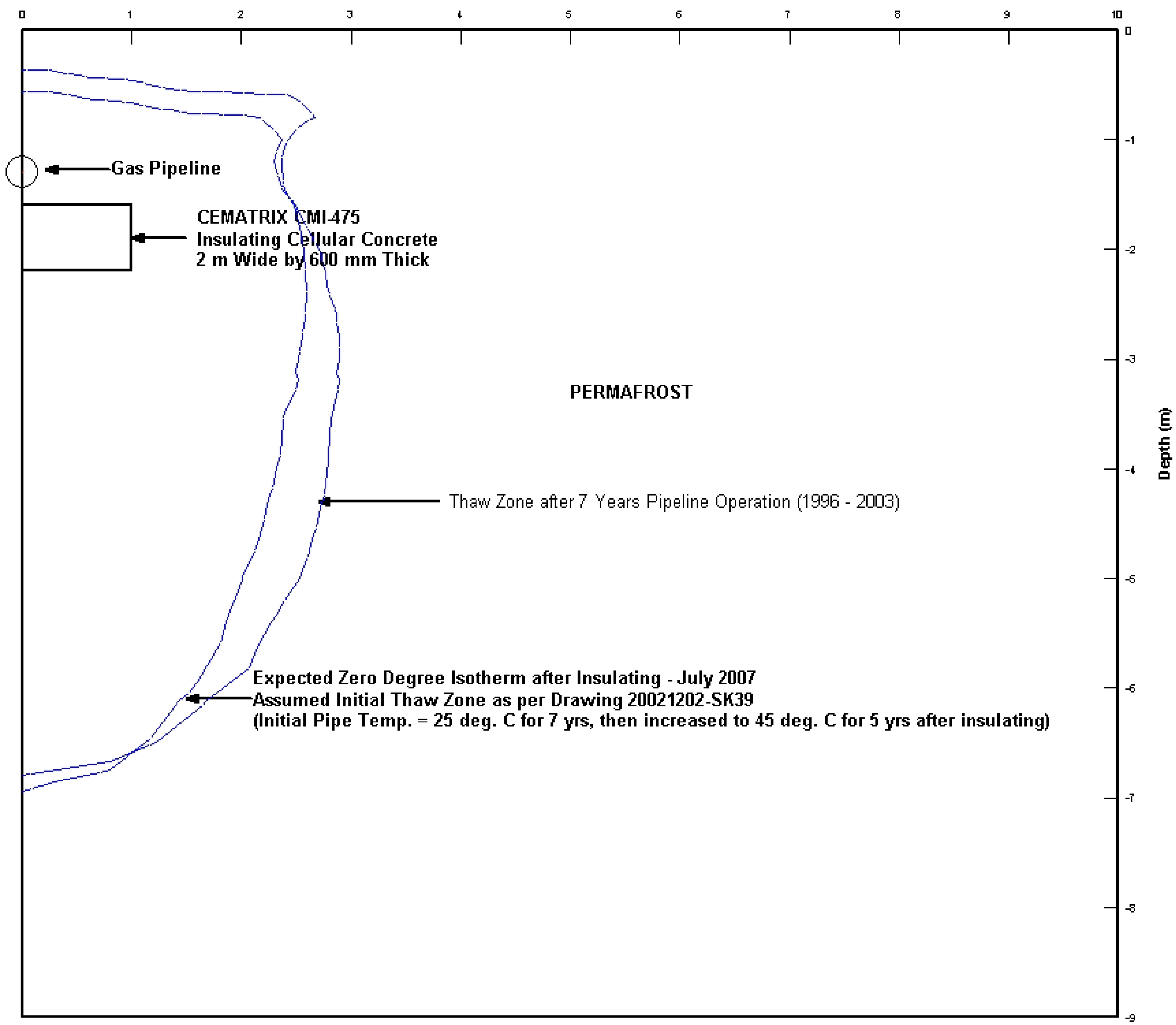

Figure 5 – Pipeline Insulation and Support to Prevent Permafrost Melting

Insulation below heated buildings in permafrost areas.

Foundation design in permafrost areas requires knowledge of geotechnical parameters, climate data, facility design life, and expected floor loads. Shallow foundation systems are generally the most economical, especially in situations where floor loads are high. Shallow foundations may be placed either at grade or on non-frost susceptible soil, such as a gravel pad: or cellular concrete when it is desirable to limit the impact of the structure on the underlying permafrost. Cellular concrete with a density of 325 kg/m^3, compressive strength of 1.0 MPa, and thermal conductivity of 0.065 W/mK would typically be used for such an application. Once again, the cellular concrete not only provides insulation, but also superior bearing performance to granular material.

In areas where gravel is scarce, cellular concrete may be used as material for the entire building pad as it is non-frost susceptible. Structures may be elevated above the soil to form an air gap (using either shallow or deep foundation methods). Cellular concrete may be used in this instance to protect the underlying permafrost 'foundation' from seasonal frost effects and/or to provide a lightweight, insulating floor underlayment.

Figure 6 illustrates the modeling of an insulating cellular concrete building foundation on permafrost. In the model, a grid of plastic pipes positioned at the bottom of the pad allows cold air to circulate under the pad in the winter, to keep the permafrost frozen. Precast cellular concrete sections may also be utilized for modular construction in extreme cold.

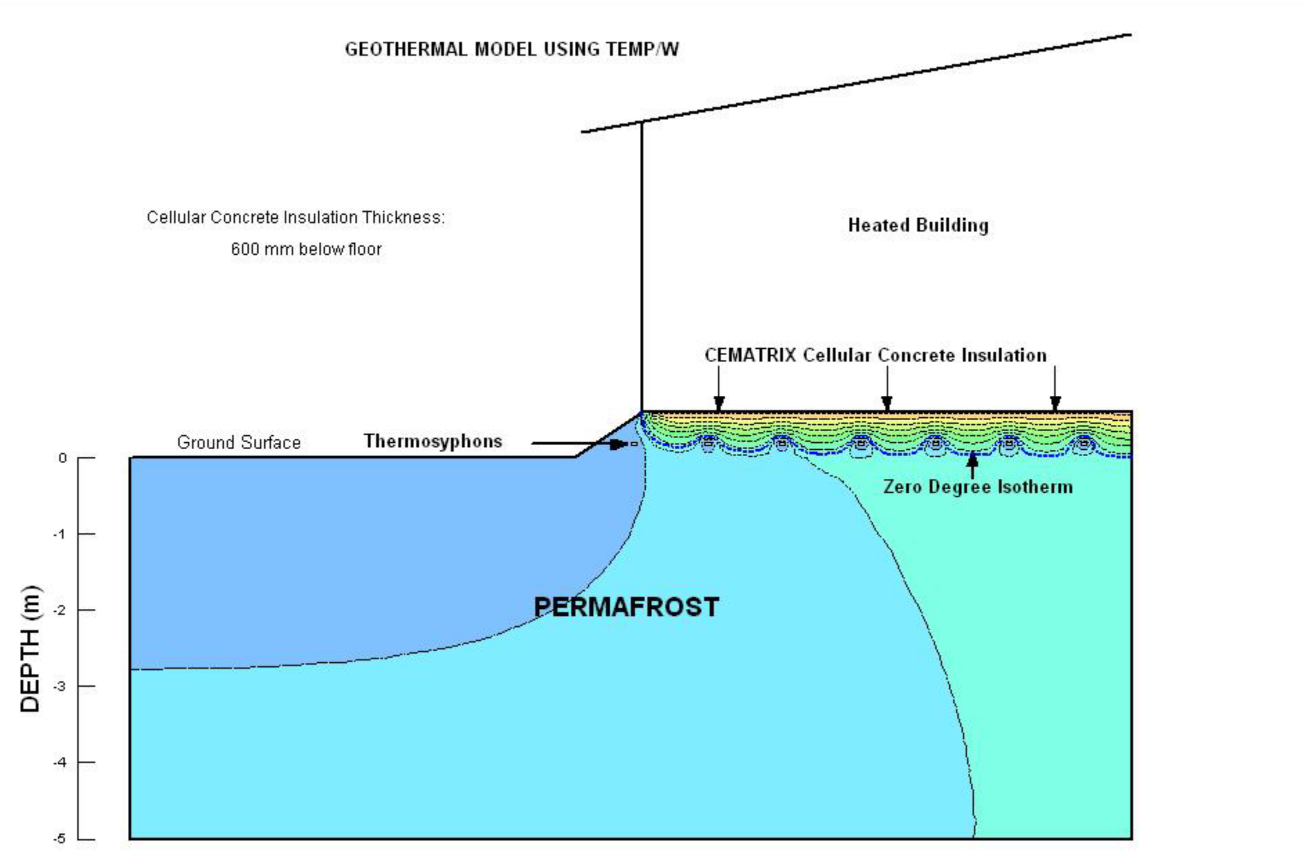

Figure 6 – Foundation on Permafrost

Closure

Typically, CEMATRIX provides geothermal modeling services at no cost to our clients. For more information, please contact Ed Brooks, National Sales Manager, at (403) 219-0484, or by email at ed.brooks@cematrix.com.