The Basics of GEO-Slab Foundation Systems

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Learning Objectives

At the end of this presentation, participants will be able to:

- describe the components of a GEO-Slab foundation (GSF) system
- list the engineering disciplines that unite to create optimum engineering solutions for each individual GEO-Slab project
- state the performance and green benefits related to GSF systems, and
- discuss how GSF systems are recognized in various green building rating programs.

Introduction

- Life cycle assessments show that energy savings is the single most important environmental issue.

- Typically, operating energy outweighs embodied energy within the first ten years of a building's life.

- Over a 75-year life of a non-residential building:
  - @ 85% of the impact of a building comes from its use phase
  - @ 15% is traced to the building material product, transport and demolition.

Insulated Concrete Forms (ICFs)

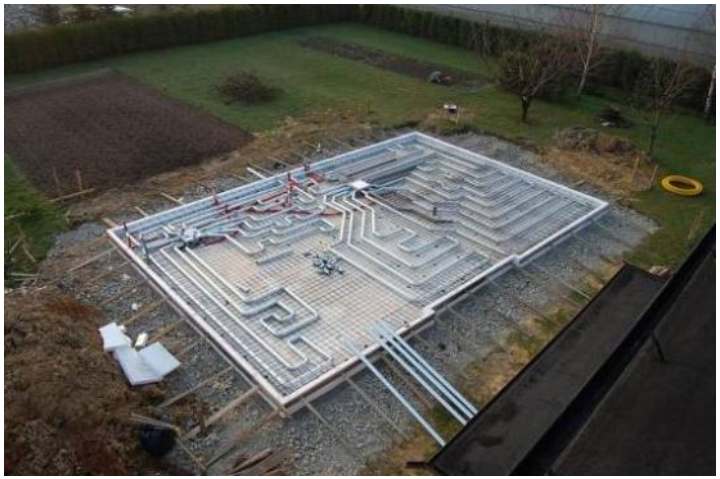
- ICF's for walls significantly reduce energy consumption for the duration of the building's use phase.
- GEO-Slab Foundations (GSF) have similar performance characteristics to an ICF wall assembly.
- GSFs offer a green and sustainable alternative to conventional footings.

GSF Construction: Serpent River Community Center, Ontario

GEO-Slab Foundations

A GSF (a type of slab-on-grade Frost Protected Structural Foundation System) can be designed for three building types:

1. unheated building
2. heated building
3. heated slab supplied with any form of in-floor radiant heating from a hydronic or electric, closed-loop warm air delivery system.



Expanded Polystyrene (EPS) & Concrete

A GEO-Slab is a composite design based on a combination of concrete and EPS insulation, an ideal blend of building materials offering:

- high strength
- high insulation value
- versatility
- ease of use
- relatively low cost, and
- sustainability.

Expanded Poly Styrene

The EPS material used in a GEO-Slab:

- does not contain any CFCs or HCFCs
- is shipped in a compact format, reducing transportation pollution
- is cost-effective
- is highly moldable, and
- it has the ability to be used as a seismic buffer to reduce the magnitude of dynamic earth pressures.

Expanded Poly Styrene

EPS Manufacturing

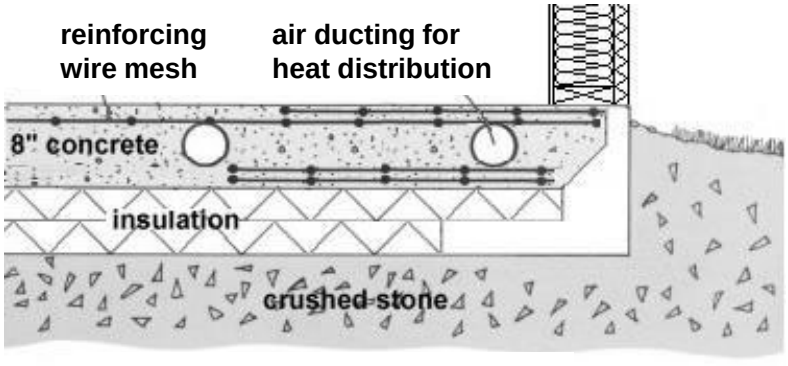
Wire-Cut EPS Foam Shapes

EPS forms provide the following functions:

- create the stay-in-place concrete formwork
- provide for an optimum engineered design
- create integrated strip footings and pier pads within the EPS layout
- provide the durable and decorative exterior covering, and
- provide a continuous thermal break for the building foundation.

Structurally Reinforced Concrete

Providing structural integrity, the concrete slab is reinforced to carry loads of interior and exterior walls, multiple levels, as well as the roof. It also supplies the enormous heat sink that is used to buffer the interior temperature of the structure.



Slab Section View

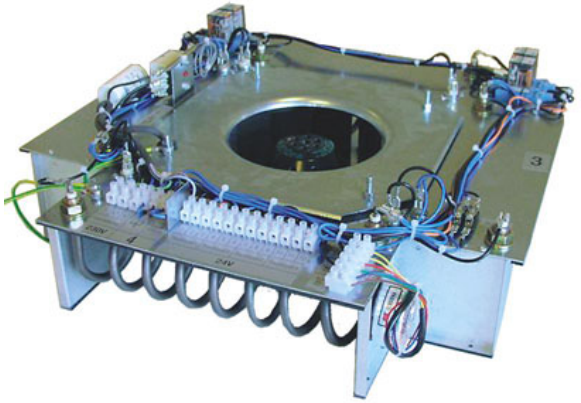
Piping

- For an air-heated GSF, piping is available in 2” or 4” diameter.
- Closed-loop piping carries the warm air throughout the slab system.
- Drafts and overall air movement are reduced to simply what is required for healthy ventilation.

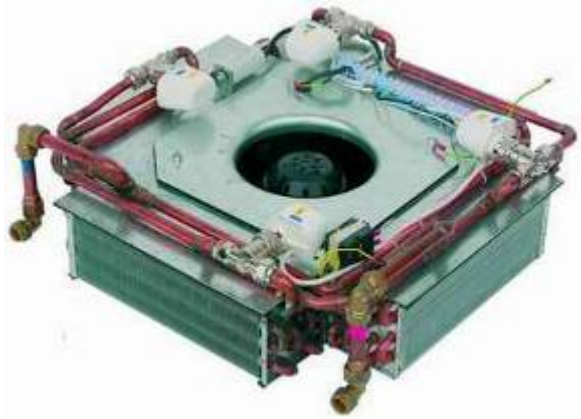
2” Diameter Piping

Furnaces

- Electric unit or water coil unit
- Up to two heating control zones per unit
- Heating zones: 200 to 900 sq. ft.
- Furnace is operated with wall-mounted thermostats
- Furnace box can be easily opened for maintenance
- Space-saving furnace box is recessed into the slab and can eliminate the need for mechanical rooms



Electric Unit



Water Unit

Environmental Factors of GSF Components

- GEO-Slab foundations are made with products that include recycled materials.
- Expanded polystyrene foam is a byproduct of the natural gas industry.
- Recently, EPS foam has been designated a “technical nutrient” by MBDC (McDonough Braungart Design Chemistry).
- EPS can be reground or down-cycled for use in other products, such as trim molding.

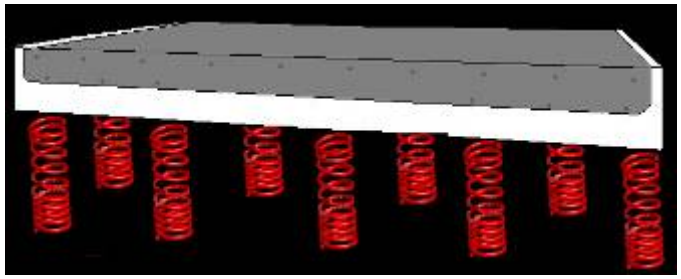
Environmental Factors of GSF Components

- Concrete can be crushed and reused, and much of the cementitious element can be replaced with recycled materials.
- Concrete is one of the better building materials for environmentally-sensitive people.
- Some green programs reward sourcing local/regional materials, as they support local economies and reduce transportation costs.
- Concrete, aggregate, EPS, piping and other base materials are usually obtained through a local supplier.

Structural Engineering

Structurally, a GEO-Slab behaves as a modified raft foundation resting on soil that is modeled as an infinite set of springs.

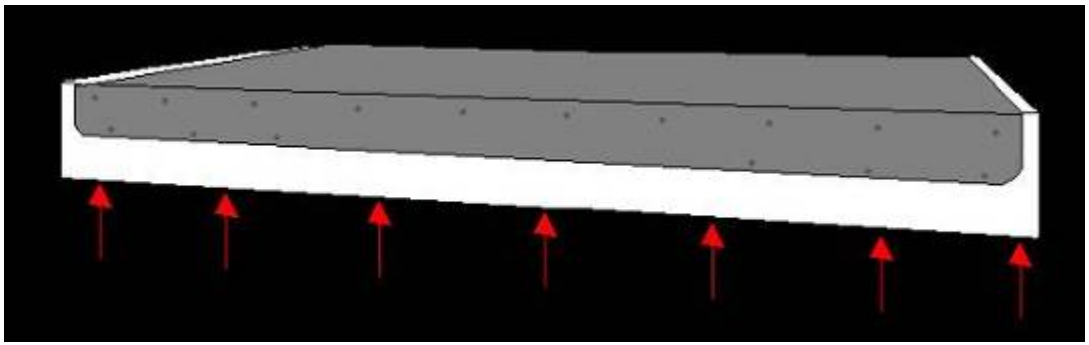
- Engineered to accommodate point loads of up to 100,000 lbs. within the thickness of the slab.
- Eliminates requirements for complicated formwork and additional excavation.



Structural Engineering

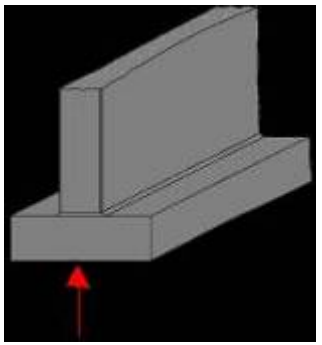
- The raft-style foundation allows edge and interior point loads to be spread out.

- This keeps native-soil interface bearing pressures very low, in contrast with conventional footings, which concentrate loads.



GEO-Slab

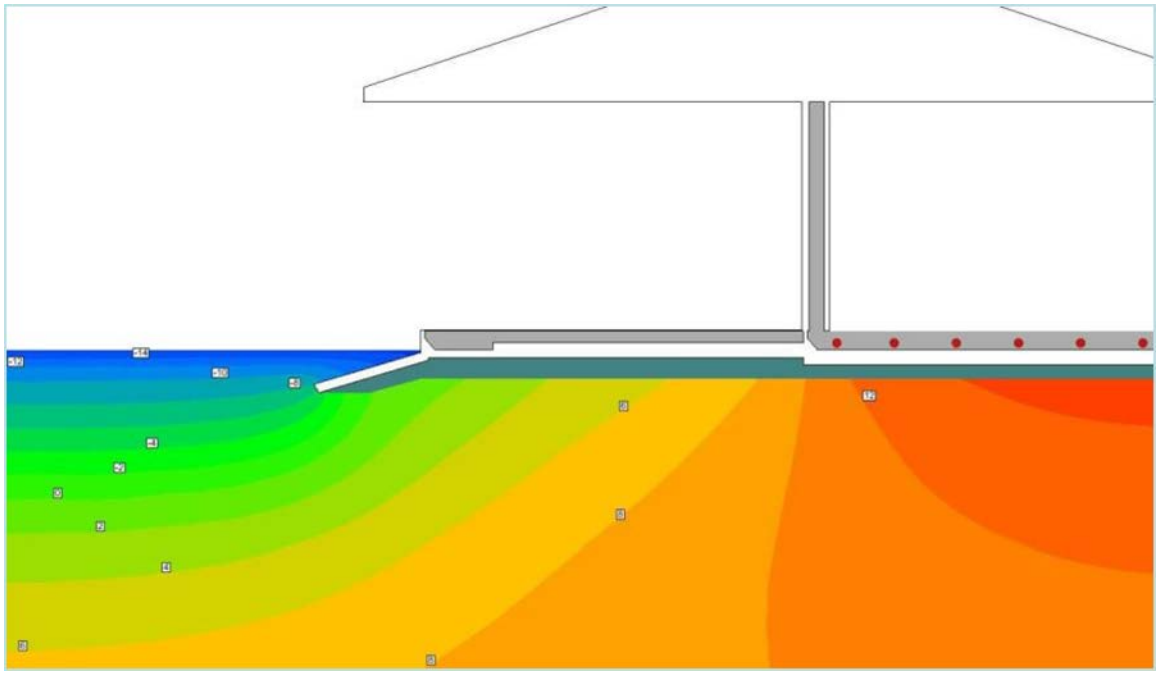
VS.



Conventional Footings

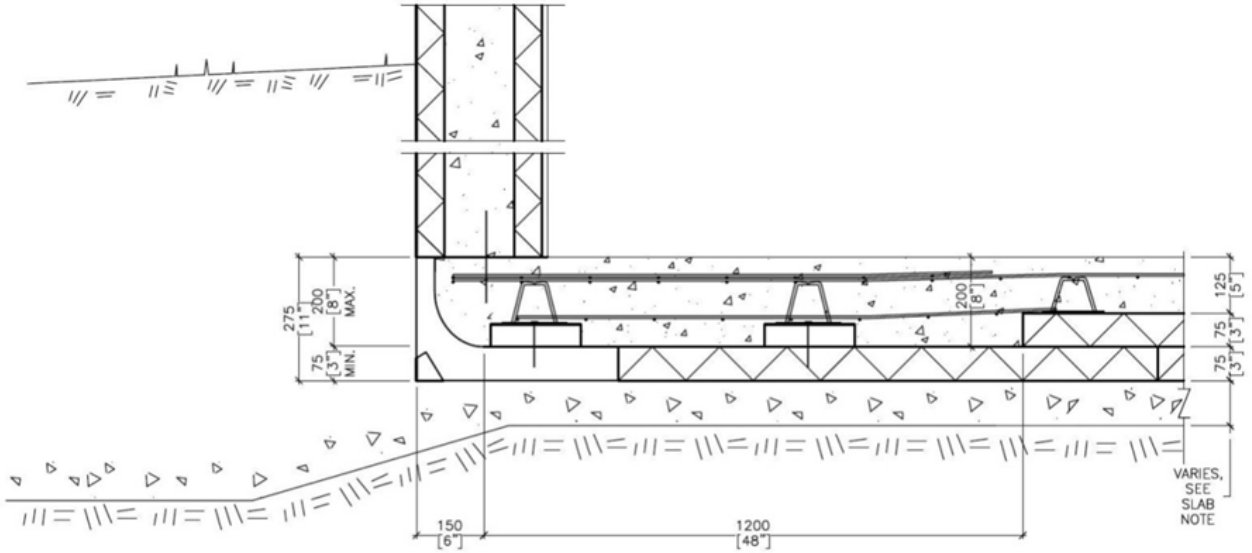
Geotechnical Engineering

Thermal modeling is factored into each design, considering such issues as climate, soil conditions, operating temperatures and air freezing index (AFI).



Geotechnical Engineering

GSF systems are typically built on grade and eliminate the need for digging below the frost line, however, GSFs can also be installed below grade.



PARTIALLY BURIED ICF WALL
TYPICAL 5" UNHEATED SLAB THICKENED EDGE SECTION A/201
(12/22/10)

Geotechnical Engineering

- Thermal modeling indicates how the frost line behaves below the slab.
- GEO-Slabs are designed in such a way that the frost line never penetrates underneath the slab edge.
- Instead of relying on the standard design methods typically used for FPSFs, GEO-Slabs are designed more accurately on a job-by-job basis.
- This eliminates the excessive material costs and difficult forming methods that would be encountered in a typical FPSF.

Geotechnical Engineering

- Soil bearing loads are matched to soil bearing capacities.
- A GEO-Slab is engineered to reduce soil bearings to less than 1/3 of that of conventional footings.
- The surface topsoil is replaced with EPS, a lighter material.

- Unheated garages, patios, porches, and exterior walkways can easily be incorporated into a GEO-Slab design.

Mechanical Engineering

- For cold climates, GEO-Slabs can store energy in the slab for use during peak hours.

- Heat load of a building is determined by calculating:
  - transmission losses (50-75% of total heating requirements)
  - ventilation losses (10-15% of total heating requirements), and
  - air infiltration losses (15-50% of total heating requirements).

Mechanical Engineering

- Radiant air-heated floors provide even, comfortable, warmth, as there is less air movement.
- There are no drafts except for building envelope infiltration and/or mechanical ventilation.
- Typical energy density in a heated GEO-Slab is 10 btu/hr/sq.ft.; this can be increased up to 20 btu/hr/sq.ft. for homes with areas of high glazing.
- As with any form of radiant heat, ventilation and infiltration losses must be provided by the required ventilation systems.

Uses of GSF Systems

A GEO-Slab foundation can be used on small additions and on a variety of buildings up to four stories in height, including multi-store commercial, multi-unit residential, community centers, schools and churches.

Advantages of GSF Systems

- GSF technology is a healthier solution:
  - By eliminating a basement and building above ground, the risks of mold, mildew, contaminants and odors are removed.
  - Seasonal Affective Disorder (SAD) affects many people. Natural daylight, which is gained when above ground, improves an individual's physical and mental health.

- GEO-Slab cost savings:
  - Minimal excavation is required
  - A single concrete pour for the slab is required, compared to two to three pours for footings and frost walls
  - Footing drainage is greatly reduced

Advantages of GSF Systems

- Savings are also realized with the labor time involved in assembling the slab - an experienced crew can typically have everything installed and ready for pour for a 1800 sq. ft. home in two days.

- With the absence of a basement, there are reduced system maintenance issues.

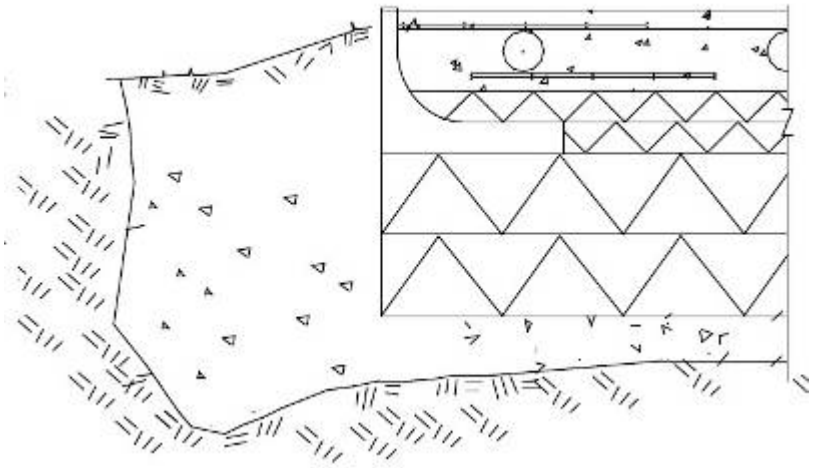
- Prerequisite 1 of Sustainable Sites category is erosion and sedimentation control; with a GSF foundation system, there is less excavation and less chance of site erosion and sedimentation of local waterways.

Advantages of GSF Systems

The use of EPS-shaped foam has opened the door to make some types of complicated slab-on-grade forming fast, easy and at great cost savings.

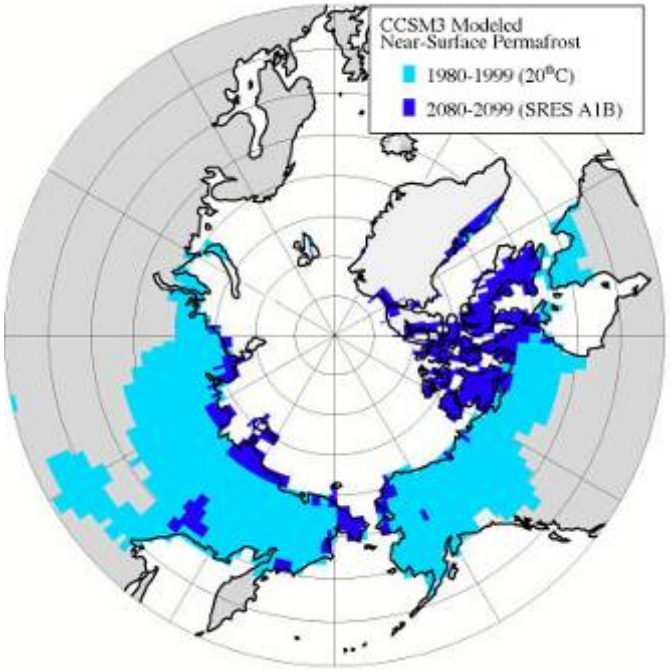
Reduced Soil Loading

- Another advantage of a GEO-Slab is the ability to reduce soil bearing loads.
- This allows cost-effective construction in areas where poor soils inhibit construction with conventional footings.
- A compensated GEO-Slab can be used to create a zero net load on the native material.



Permafrost

- Building on permafrost can be accomplished through the utilization of helical pilings with grade beams.
- This method allows cold air flow under the building, preventing the permafrost from thawing.
- Very costly method of construction.



GSF Systems & Permafrost

- GEO-Slabs can be designed for permafrost using similar techniques to a compensated foundation.

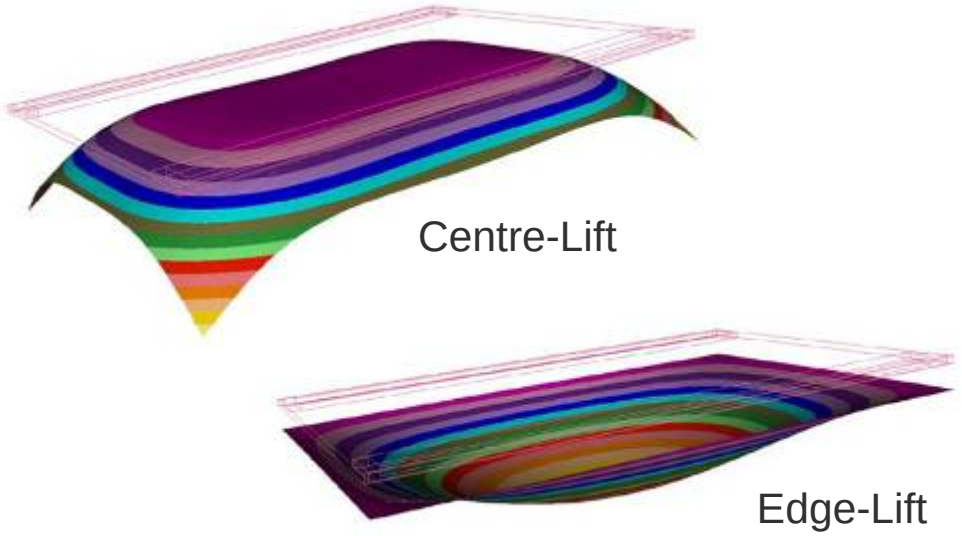
- The combination of heat loss and building weight are eliminated by using a thick layer of EPS to insulate the home beneath the slab.

- Additionally, the layer of EPS provides compensation so that the native soil doesn’t incur much loading.

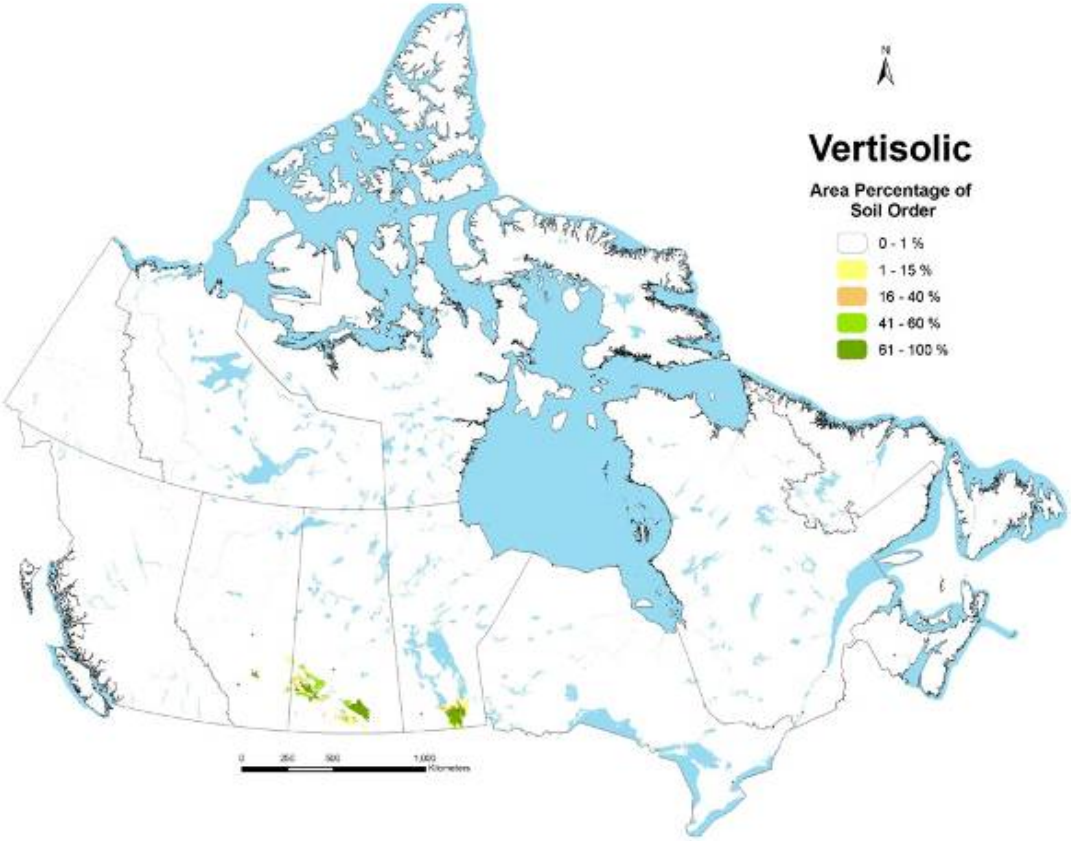
GSF Systems & Expansive Soils

- A GSF system is a cost-effective alternative for expansive soils.

- The watershield design stabilizes the thermal properties and moisture content below the slab and directs all water away from the soil close to the slab.



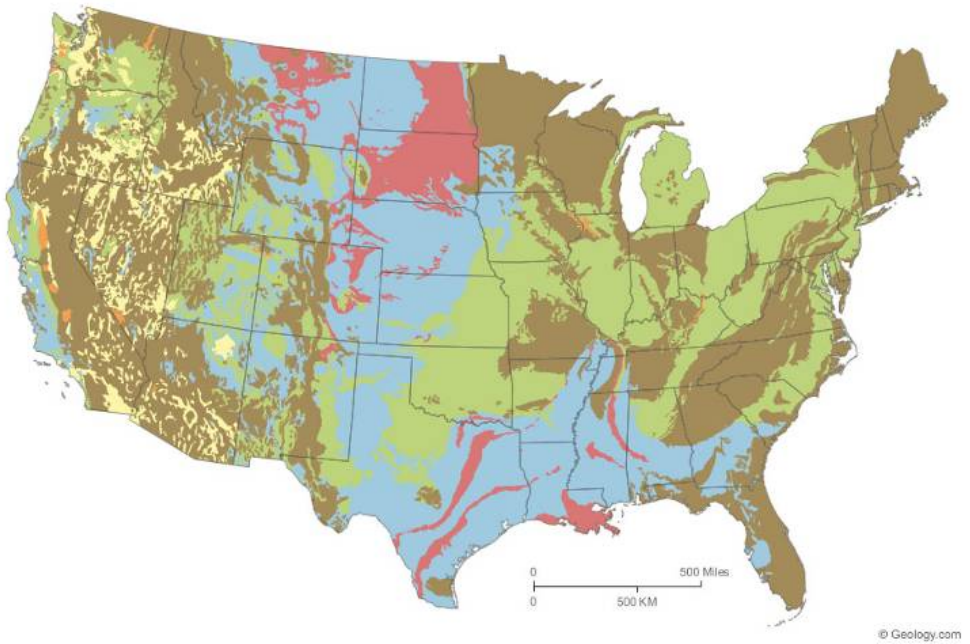
Canadian Expansive Soils



Vertisolic soils are highly expansive. In other areas of Canada, there may be a mix of soils that display some expansive characteristics.

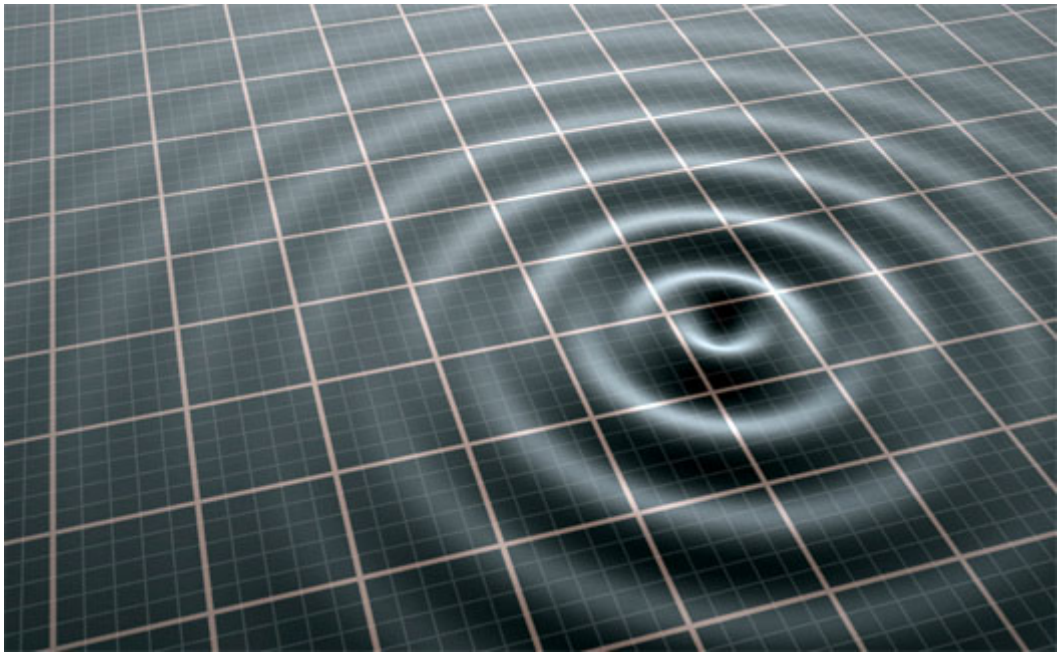
USA Expansive Soils

- Over 50 percent of these areas are underlain by soils with abundant clays of high swelling potential
- Less than 50 percent of these areas are underlain by soils with clays of high swelling potential
- Over 50 percent of these areas are underlain by soils with abundant clays of slight to moderate swelling potential
- Less than 50 percent of these areas are underlain by soils with abundant clays of slight to moderate swelling potential
- These areas are underlain by soils with little to no clays with swelling potential
- Data insufficient to indicate the clay content or the swelling potential of soils



Reduced Sound Transmission

The EPS in a GEO-Slab can effectively reduce vibration or sound transmission, which is often required in sound-sensitive applications.



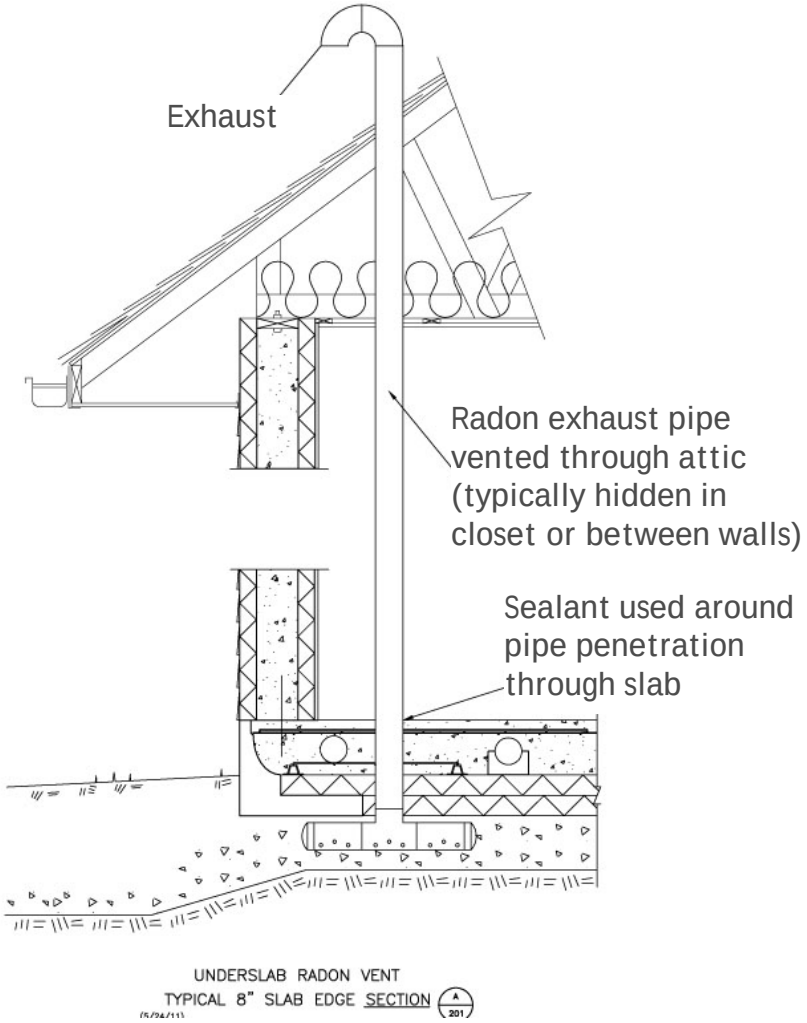
Water Table

- The water table has many effects on a traditional foundation.
- A GEO-Slab is built on the ground and has no effect on the water table.
- Damage to tree root systems and vegetation is reduced with GEO-Slab construction.

Water Table Effects

Radon Barrier

The combination of the continuous reinforced concrete slab, as well as the ¾” clear stone sub base that forms part of the GEO-Slab, becomes a radon barrier under the building.



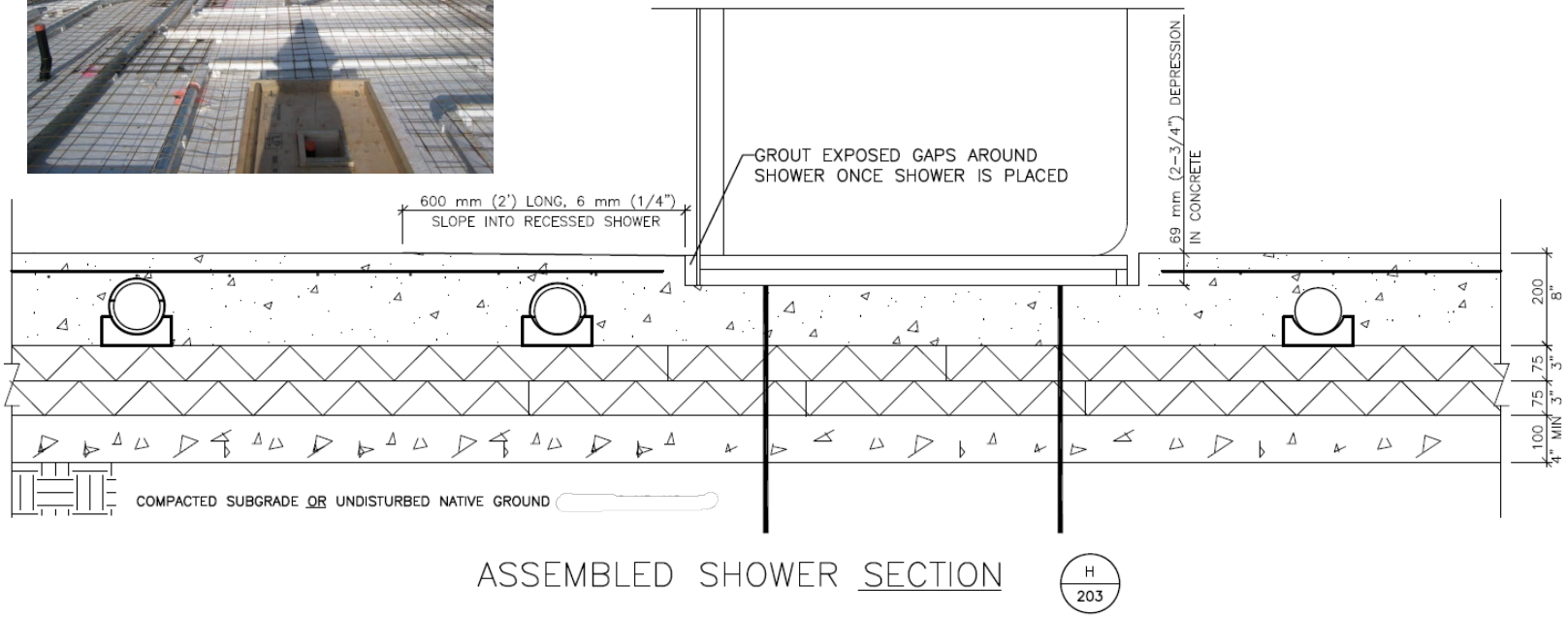
Barrier-Free Design

- GSFs eliminate accessibility issues.
- With the slab-on-grade design, ramps can be eliminated.
- A stair-free dwelling can easily be accomplished with single-level design.

MBQ Wellness Center, Tyendinaga, Ontario

Barrier-Free Design

EPS forms can easily be cut to provide the formwork for barrier-free showers and bathrooms.



Design Factors

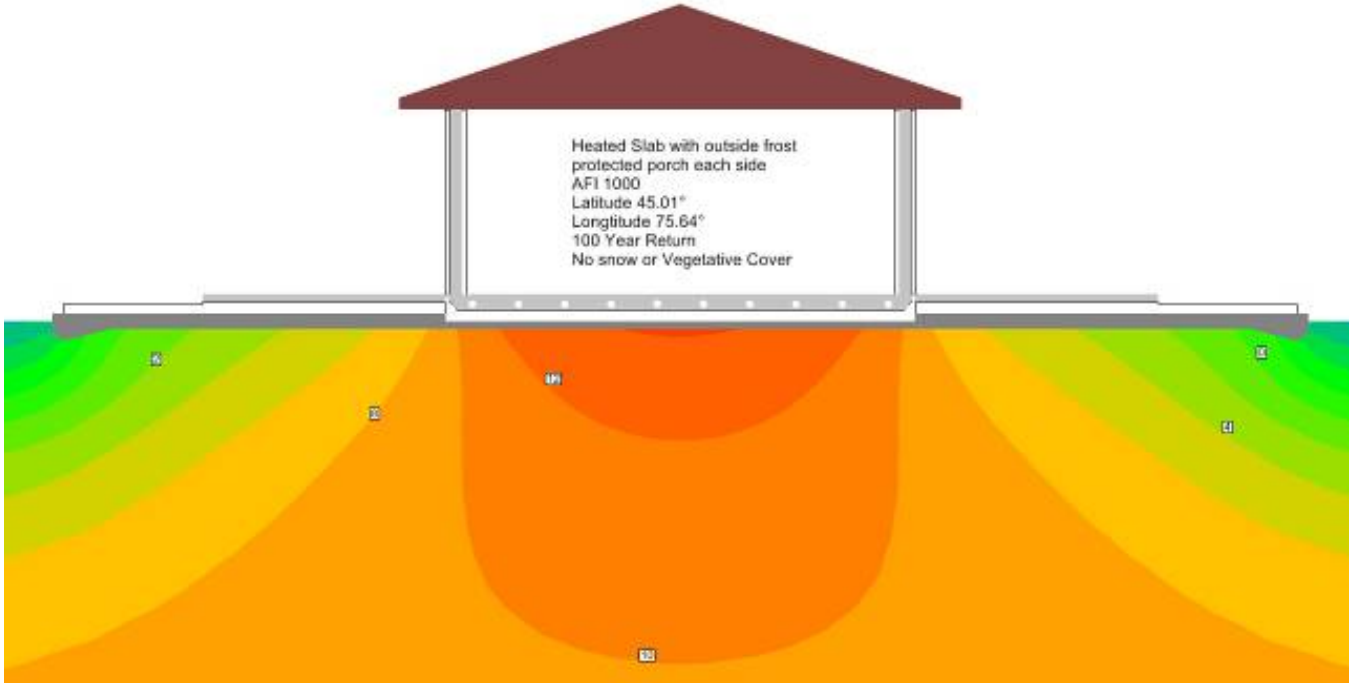
GEO-Slab design depends on several factors, including:

- climate
- structural loads
- building use (heated, unheated, partial heat)
- earth contours, and
- soils.

Frost Protected Shallow Foundations, similar to the GSF system, are compliant through local and national governing bodies.

Climate

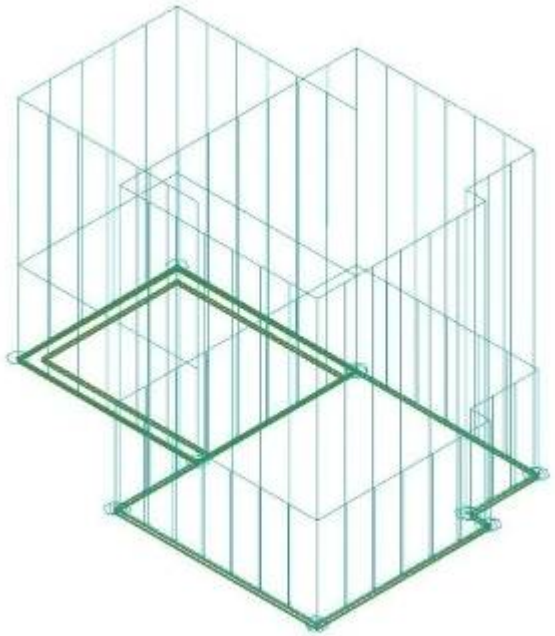
Designs are modeled according to climate specifics and building heating requirements to optimize frost protection and prevent frost heave.



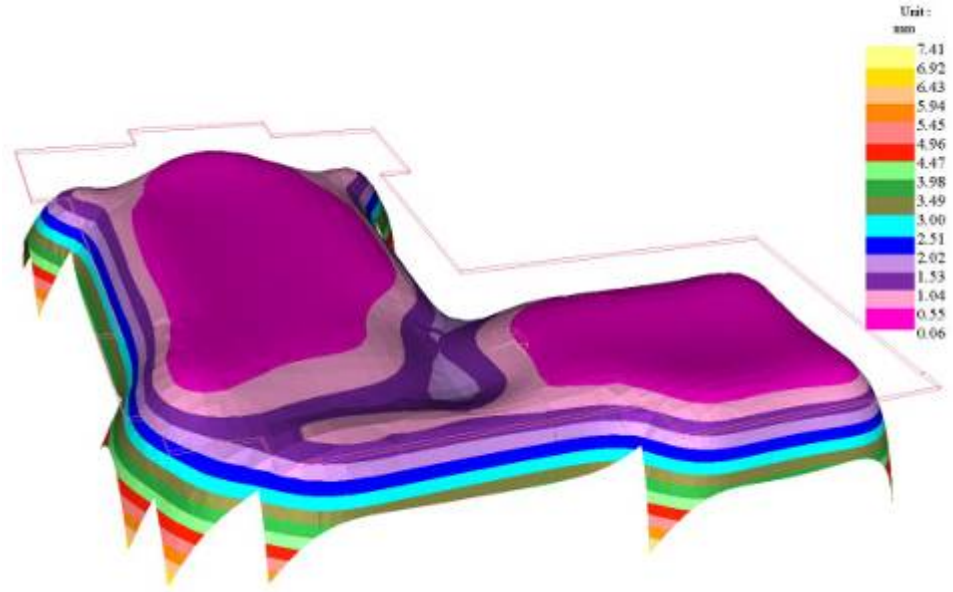
Modeled here is a heated home built with a GEO-Slab Foundation with frost protected porches on either side.

Structural Loads

GEO-Slabs are modeled structurally to analyze all bearing and point loads within the building. These loads are accommodated within the configuration of the GEO-Slab.

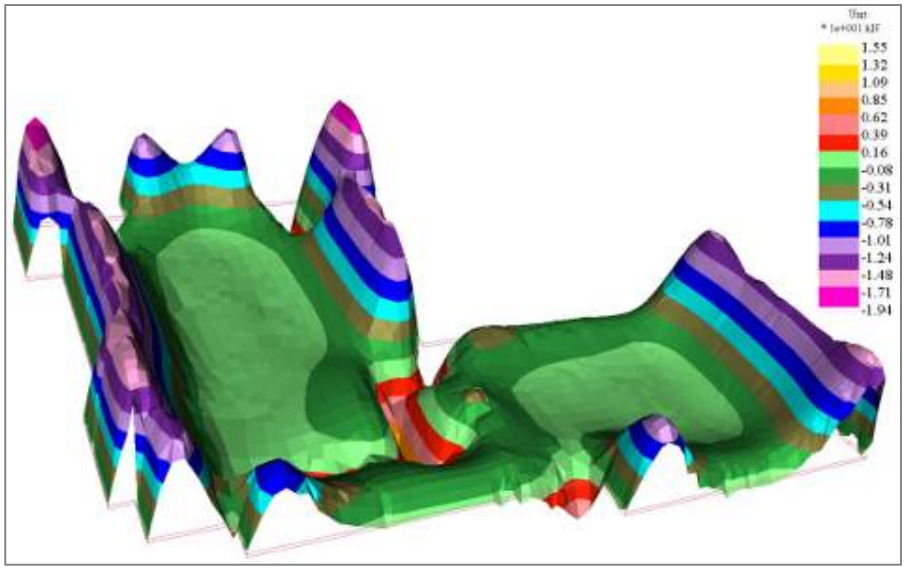


Line loads and point loads are applied to the slab to analyze behavior.



Deformation of the slab is analyzed and compared to deformation limits.

Structural Loads

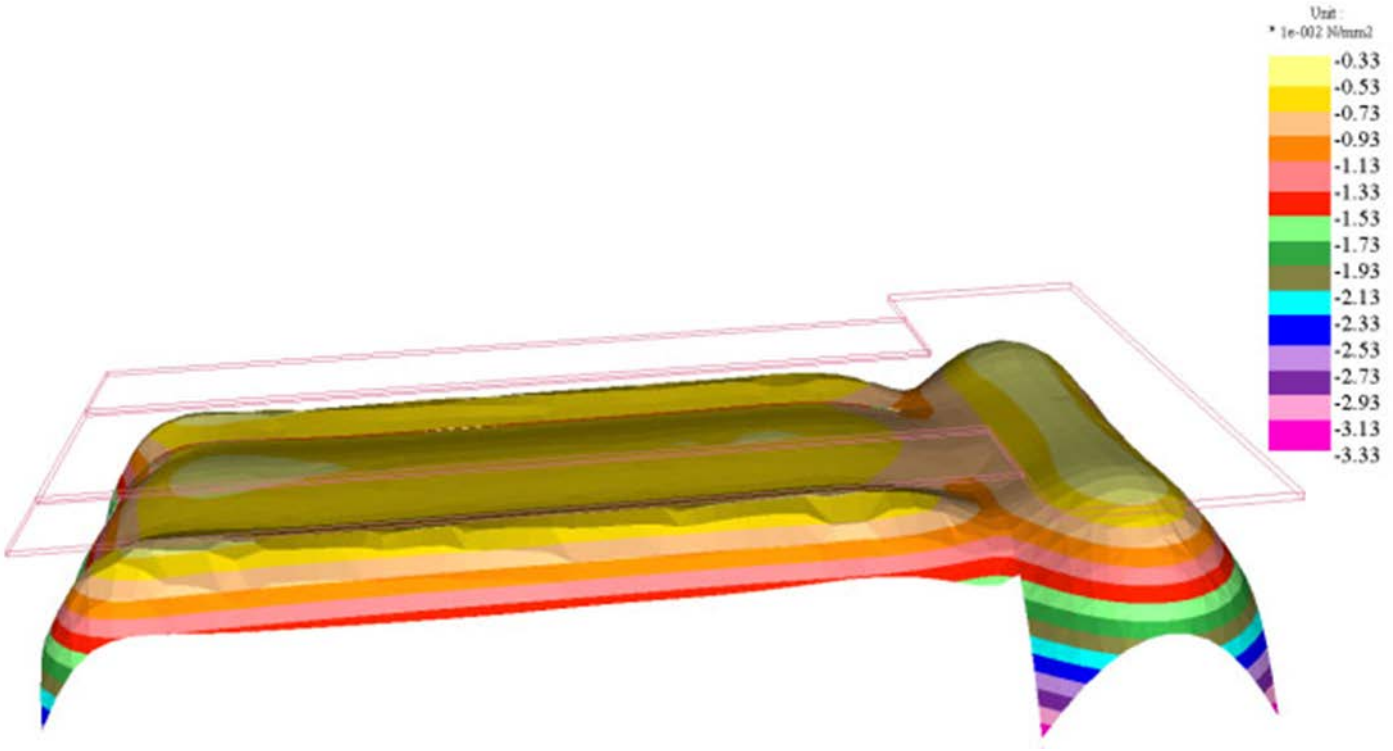


Moments at the edge of the GEO-Slab are examined for placement of reinforcement.

Reinforcement is derived from the modeled analysis to comply with site-specific requirements in accordance with the building code.

Structural Loads

Soil bearing is examined and compared to allowable soil bearing capacities.



Code Compliance

USA

EPS is governed by: ASTM C578-06 Standard for Rigid, Cellular PolystyreneThermal Insulation

CANADA

EPS is governed by: CAN/ULC-S701-05 Standard for Thermal Insulation, Polystyrene, Boards and Pipe Covering. (Type II EPS is the material of choice). In some applications Type III is used for its higher compressive strength and lower susceptibility to creep under load.

Code Compliance: EPS

USA

Building Code Requirements for Structural Concrete - ACI 318

CANADA

"Design of Concrete Structures" - CSA A23.3

Code Compliance: Concrete

USA

IRC (International Residential Code) section is R403.3 Frost protected shallow foundations.

ASCE SEI/ASCE 32-01 Design and Construction of Frost Protected Shallow Foundations

CANADA

The slab is designed in accordance with part IV of the NBC for frost protection.

Code Compliance: FPSF

Technical Support

GSF manufacturers provide a full suite of technical support services.

- Design and estimating resources are available, as are in-class and on-site training.
- GSF CAD details are typically available upon request.
- Installation guides are simple and easy to follow.

GEO-Slab Design

A typical GEO-Slab design includes:

- a flat, well-packed clear stone bed (min. 4”)
- two layers of 3” EPS insulation
- reinforcing mesh on top and at edge
- 8” of concrete with as little as 5” in the middle, and
- exterior edge protection, depending on climate.

Ease of Construction

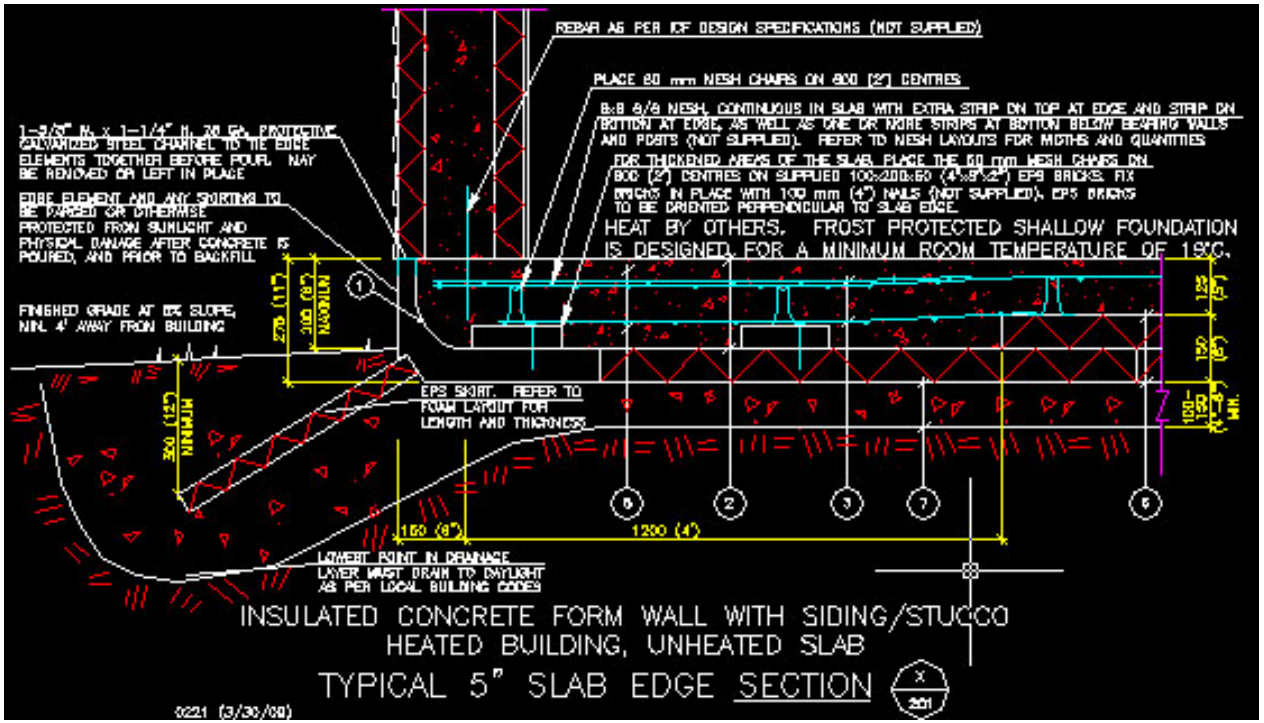
- Experienced builders find GEO-Slab construction to be an extension of general construction practices.
- Building GEO-Slabs requires few specialized tools.
- Most procedures can be accomplished with a simple handsaw and cordless drill.

Engineering Approval

Prior to concrete placement, heating components and reinforcement are reviewed by an authorized party and signed off by the manufacturer’s engineering department.

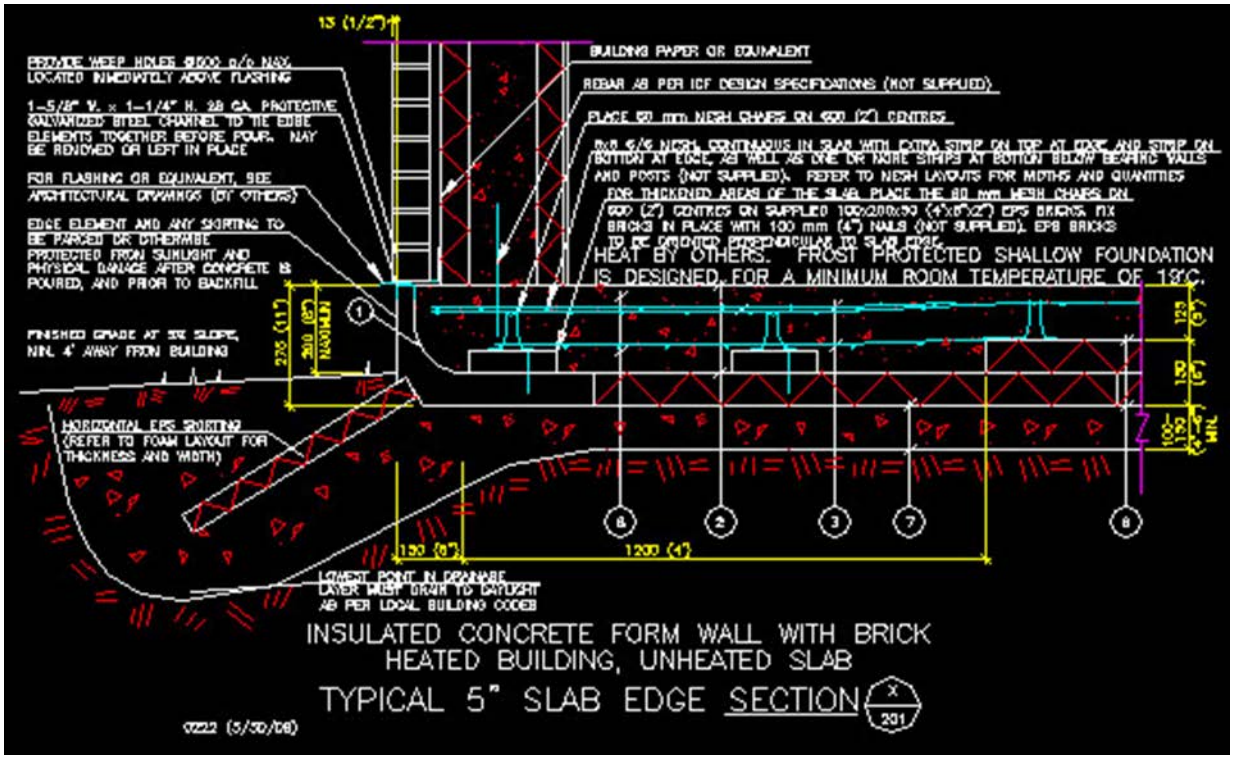
Typical Edge Detail

Illustrated below is a typical edge detail for a 5” unheated slab with ICF wall construction.



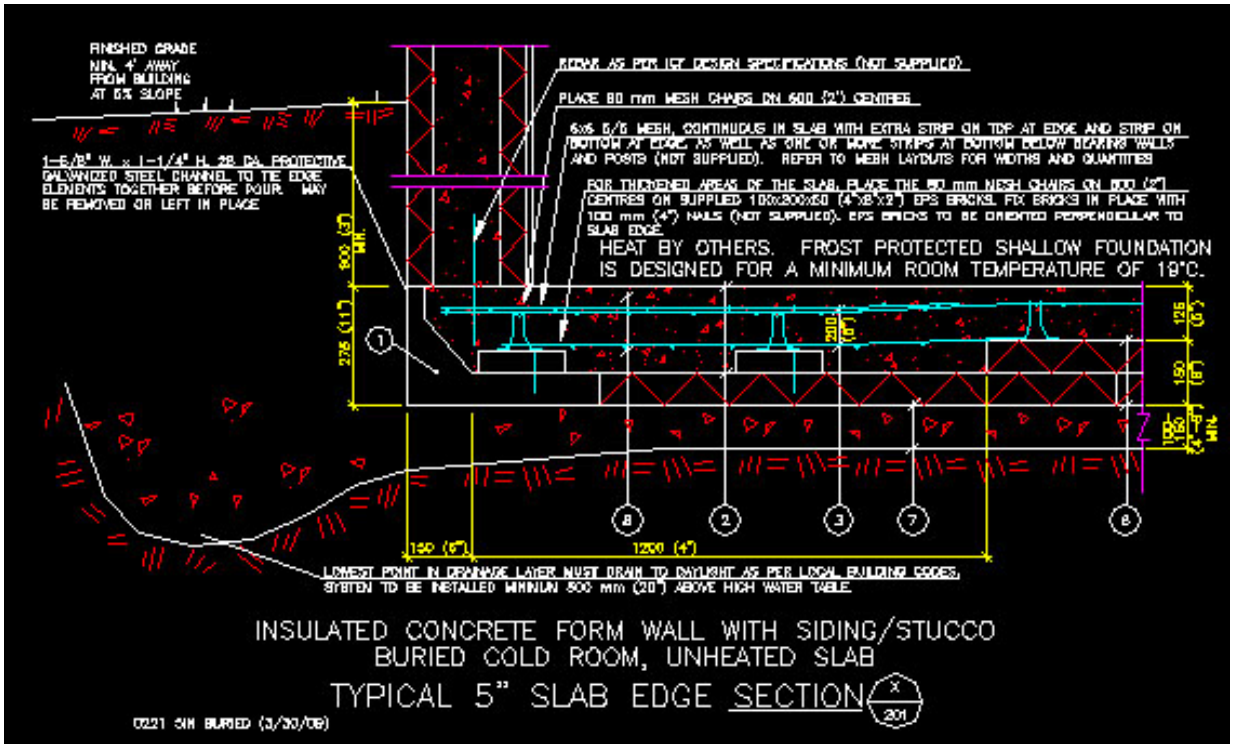
Typical Edge Detail

In this drawing, the GEO-Slab is constructed as a brick ledge and is designed to accommodate the extra loading.



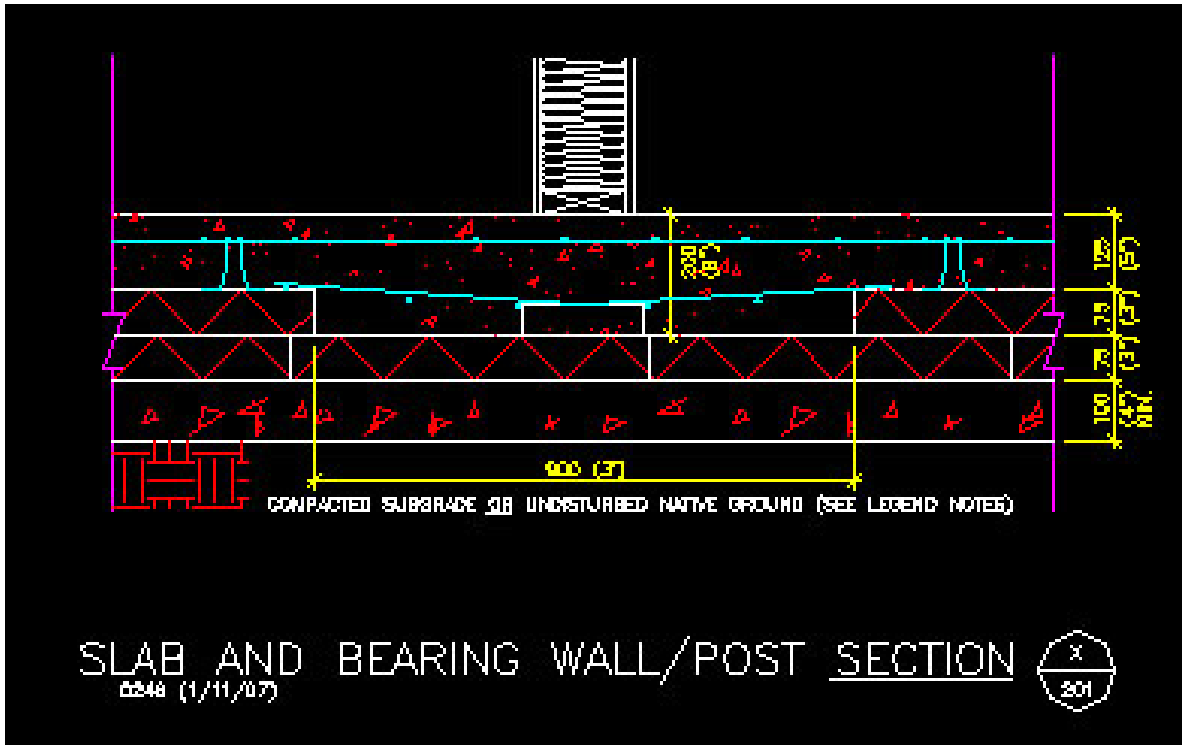
Walk-Out Basements

The GEO-Slab can also be buried and is a great solution to a walk-out basement.



Bearing Wall / Post

Bearing walls and posts are accommodated and reinforced within the thickness of the slab, avoiding complicated formwork.



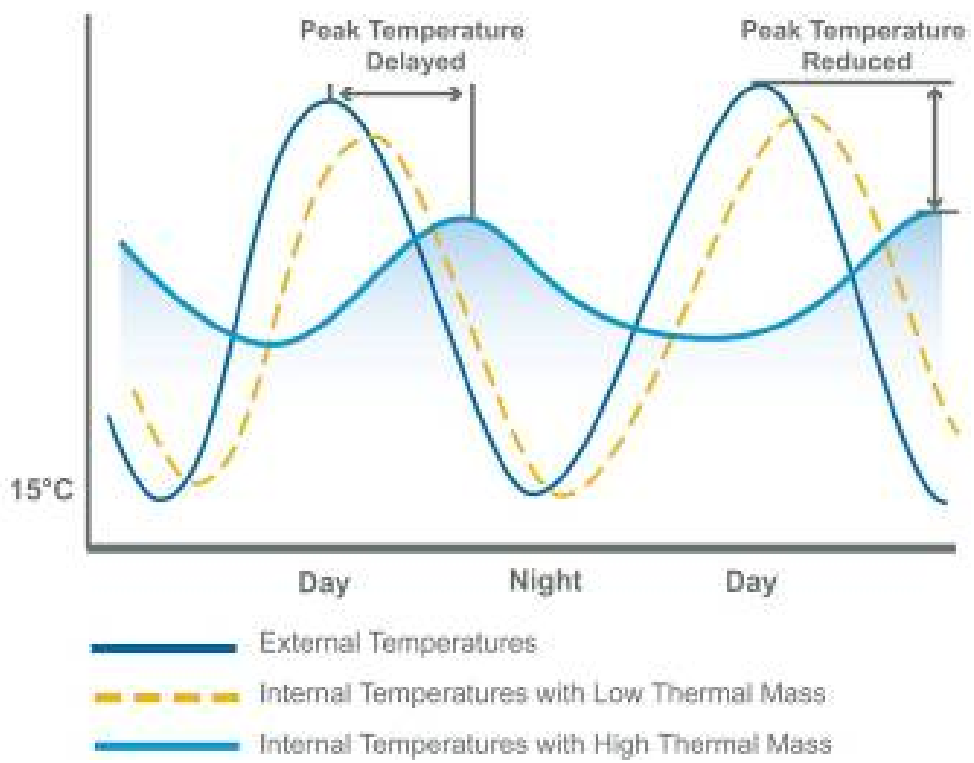
Green Benefits

A GEO-Slab solution provides a reduction in energy consumption due to the following reasons:

- enhanced underslab insulation (R-24) and slab edge insulation (R-12) decreases energy loss to the ground
- room temperature can be lowered 3°C (5°F) while maintaining same level of comfort
- the ability to passively collect and distribute solar energy through the slab for heating
- increased thermal mass of the concrete
- reduced heat loss through ceiling through optimum temperature stratification

Thermal Mass

- A GEO-Slab can passively absorb energy from the daytime sun and distribute it at night.
- The area between the two curves indicates the energy savings that are derived from high thermal mass.



Improved IEQ / Reduced Waste

- The EPS used in a GEO-Slab has no CFCs, HCFCs, or off-gassing.
- The airtight nature of the building provides better control of airborne contaminants.
- GEO-Slab system reduces the risk of mold and water damage.
- A heated GEO-Slab system contributes to occupant comfort as it has no reverse temperature stratification.
- Minimal amounts of on-site waste (less then 1%) are incurred.

Overview: LEED® Certification

The U.S. Green Building Council (USGBC) is a 501(c)(3) non-profit organization composed of leaders from every sector of the building industry working to promote buildings and communities that are environmentally responsible, profitable and healthy places to live and work. USGBC developed the LEED (Leadership in Energy and Environmental Design) green building certification program, the nationally accepted benchmark for the design, construction, and operation of high performance green buildings.

LEED credit requirements cover the performance of materials in aggregate, not the performance of individual products or brands. Therefore, products that meet the LEED performance criteria can only contribute toward earning points needed for LEED certification; they cannot earn points individually toward LEED certification.

For detailed information about the council, their principles and programs, please visit www.usgbc.org.

LEED & GEO-Slab Construction

GEO-Slab construction contributes positively towards a more sustainable built environment, and it is recognized in the various LEED and NGBS rating systems.

Green Building Rating System	LEED Point Threshold				Related Pts	Potential Pt Contribution
	Certified	Silver	Gold	Platinum		
LEED 2009 NC	40 - 49	50 - 59	60 - 79	≥80	30	5
LEED 2009 NC Schools					31	7
LEED 2009 Canada-NC					30	7
LEED 2009 Retail					30	5
LEED 2009 Core and Shell					33	5
LEED 2009 Canada Core and Shell					33	7
LEED Canada - Multi-Unit Residential	26-32	33-38	39-51	52-70	19	3
LEED – Neighborhood Development	40 - 49	50 - 59	60 - 79	≥80	8	<1
LEED Homes	45-59	60 - 74	75 - 89	90 - 136	48	11
LEED Canada-Homes					48	15
National Green Building Standard	**Bronze**	**Silver**	**Gold**	**Emerald**	178	73
	222	406	558	697		

LEED & GEO-Slab Construction

Sustainable Sites:

- Lower bearing pressure on soils than with typical footings
- Reduced site effects for slab-on-grade, reduced impact on water table and reduced damage to tree root systems
- Less expensive and resource intensive construction

Materials:

- Use of recyclable materials
- Advantageous during construction due to permanent edging units which reduce need for forms

LEED & GEO-Slab Construction

Energy Savings:

- Enhanced underslab insulation and slab edge insulation decreases energy loss to the ground
- Room temperature can be lowered 3°C (5°F) while maintaining same level of comfort
- Two heating control zones for up to 1800 sq.ft. of floor area
- Reduce ventilation to absolute minimum required for ventilation only during occupancy
- Slab can passively absorb energy from the daytime sun and distribute it at night, as well as store energy during off-peak periods, helping reduce energy costs
- Reduced energy spikes resulting from this storage capability allows for smaller sized, more efficient HVAC equipment

LEED & GEO-Slab Construction

Potential energy savings with GEO-Slab construction.

Building Type		% Building Energy for Space Heating[8,9,10]	Potential Space Heating Savings with GSF Systems	Potential Overall Energy Savings with GSF Systems	Relevant Rating System(s)
U.S.	Commercial	36.3%	30%	11%	LEED 2009 NC
	Schools	47.3%	30%	14%	LEED 2009 NCS
	Retail	33.5%	30%	10%	LEED 2009 NCR
	Residential	41.1%	46%	19%	LEED for Homes National Green Building Standard
CAN	Commercial	50.2%	30%	15%	LEED 2009 Canada-NC
	Residential - Detached	62.8%	46%	29%	LEED Canada for Homes
	Residential – Multi-Unit	57.6%	30%	17%	LEED MURB

8 Energy Use Data Handbook Tables, Natural Resources Canada, Residential and Commercial Sector. Accessed online 2010/11/1 @: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/handbook_res_ca.cfm?attr=0

9 Commercial Building Energy Consumption Survey, U.S. Energy Information Administration, 2008, Table E2. Accessed online 2011/02/05 @: http://www.eia.doe.gov/emeu/cbecs/contents.html

10 Residential Buildings Energy Consumption Survey, U.S. Energy Information Administration, 2008, Table US12. Accessed online 2010/11/2 @: http://www.eia.doe.gov/emeu/recs/contents.htm

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Indoor Environmental Quality:

- Closed system allows for complete control of airborne contaminants and odor
- Reduced noise
- No reverse temperature stratification
- Temperature overshoot is less common
- Increased thermal mass of system provides for more stable interior temperature than thinner heated slabs
- Eliminates the dependence on air barrier to provide radon proofing
- Reduced risk of mold and water damage
- Increased occupant comfort

Applications

GSF systems are especially well-suited for high-performance uses in a variety of markets, including:

- residential
- commercial
- industrial, and
- institutional.

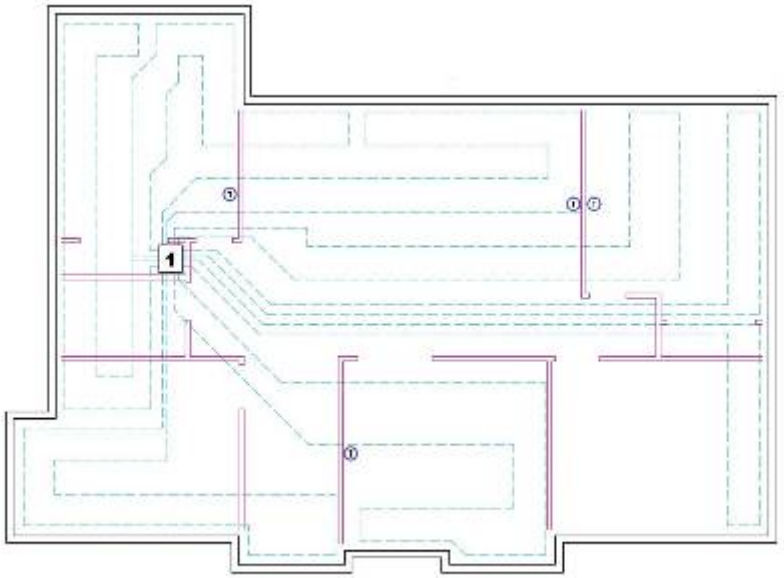
Log Home

Daycare / Nursery

Case Study: Residential

- This waterfront residence is built using GEO-Slab construction, which is the ideal solution for lots having high water tables.

- Mechanically, the system consists of a water coil heater, heating four independent zones, controlled by means of programmable thermostats.



Case Study: Apartment Complex

- This case study involves two apartment complexes.
- The first one has poured footing and walls up to the first floor, then pour-on-grade floors.
- Using GEO-Slab construction, the second complex was built - resulting in total savings of $112,850.

GEO-Slab Construction:
12-Unit Apartment Complex

Case Study: Winery

This 5,000 sq.ft. winery was built on a 2,400 sq.ft. GEO-Slab foundation. The owners chose this solution in part because of the requirement for absolute temperature stability.

Case Study: Winery

- Three heating zones were used since each zone had very different heating needs.

- The structural strength of the GEO-Slab foundation met the tremendous support requirements of the project, all without frost walls or deep footings.

Benefits to Architect / Engineer

GEO-Slab construction affords the following advantages for today's architects and engineers:

- Easy to specify
- Negates the need for foundation design
- Design and full site-specific engineered modeling is supplied by the GEO-Slab manufacturer
- Easy to control job costing (foundation cost consistency)

Benefits to Builder

GEO-Slab construction offers the following benefits to builders:

- Ease of installation
- Less:
  - cut and fill
  - excavation
  - backfill
- Elimination of frost walls and interior footings

Benefits to Owner

Heated GEO-Slab construction offers the following benefits to building owners:

- Warm, comfortable floors due to warmth rising from the floor
- Reduced operating costs as a result of:
  - passive solar collection
  - reduction in A/C requirements
  - make-up air operation is only required during occupancy

Retirement Residences

Industrial Building

Thank you for your time

Questions?

This concludes presentation

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