enercret
thermo-active Foundations

Energy piles   Energy diaphragm walls   Energy foundations

Planning Aspects

1. Design Parameters

1.1 Geotechnical Parameters

The relevant geotechnical parameters are the constellation of soil layers along with the following soil mechanical values:

- Temperature
- Thermal conductivity and
- Thermal capacity of ground
- Depth of water table and
- Direction and velocity of groundwater flow.

The values for the thermal conductivity and thermal capacity of the main types of material found in ground layers are given below in the table:

Material	W/mK	MJ/m³K
Earth, dry	1.0	2.0
Earth, moist-wet	2.2	2.4
Clay, dry	0.4	1.6
Clay, moist-wet	1.6	2.4
Sand, dry, compacted	1.2	1.7
Sand, moist	1.0	1.8
Sand, saturated	2.4	2.5
Silt, moist-wet	1.8	2.2
Fine sand, groundwater flow 0.1 m/d	4.0	
Medium-grain sand, ground-water flow 1 m/d	15.0	
Fine gravel, groundwater flow 8 m/d	100.0	

W/mK → Thermal Conductivity
MJ/m³K → Thermal Capacity

In Central Europe, the average temperature in the ground tends to be in the region of between 10 °C and 12 °C. Daily and seasonal fluctuations are virtually levelled out at a relatively low depth.

Soil layers above the water table are best suited for energy storage, or at least those with low permeability and still groundwater since flowing water will rapidly dissipate any heat stored in the ground.

For the same reasons, more permeable soils with groundwater flow are better suited in cases where heat extraction and cooling are required.

Fluctuations in the groundwater level must be taken into account.

Investigations have shown that the temperature variations caused by absorber piles do not normally have any significant effect on temperature-sensitive soils such as clays which are prone to shrinkage and expansion.

However, cooling to below the zero level as a result of inadequate inflow temperatures should be avoided at all costs as this can lead to frost damage.

1.2 Structural Parameters

The following structural parameters are required for the preliminary design of an enercret installation and for calculation and/or simulation of the thermal capacity values:

- Type and size of the ground-contact concrete members to be used (diameter, thickness, length, depth)
- Depth of the foundations in relation to ground level
- Layout drawing showing positions of foundations
- Details of reinforcements
- Regulations and statutory requirements

Drawings of sublevels and cross sections giving the location of the technical services centre and foundation plans should at least be available in the form of preliminary designs. The structure of the ground slab including insulation and subbase must be clarified. Enercret installations do not affect the load-bearing capacity of the foundations. To install the absorber lines in piles and diaphragm walls, reinforcing cages, to which the piping is attached, are always required.

All steel-reinforced concrete piles, such as bored piles, cast-in-situ driven piles, precast driven piles, augered piles, mixed-in-place piles and ductile cast iron piles, can be used for enercret installations.

1.3 Energy Parameters

In order to calculate the geothermal energy potential of an enercret installation for a particular building it is necessary to know the peak demand and the monthly distribution of the heating and cooling energy requirements for the building. Prolonged cooling or heating periods which do not allow any time for the system to regenerate will reduce peak performance levels. For this reason the weekly distribution of the heating and cooling energy requirements for the building should also be taken into account.

In cases where the ground slab is fitted with an enercret system, data on the room temperatures in the rooms above it must be provided and taken into account when designing the enercret installation.

1.4 Questionnaires

The main parameters mentioned under sections 2.1 to 2.3 are obtained by means of questionnaires 1 and 2. These data form the basis for the calculation plus simulation of an enercret installation.

2. Planning Phases

2.1 Preliminary Studies

It is possible to assess whether an enercret installation is technically feasible and economically viable for a specific building.

As a rule it can be said that in the case of a building with deep, ground-contact concrete structures (piled foundation, diaphragm wall or piled retaining wall for the construction pit) and a cooling requirement the use of an enercret installation is always technically feasible and will be cost-effective. In many cases the enercret installation will suffice to satisfy the energy requirements - this will largely depend on the ratio of the size of the foundations to the size of the building. The ground conditions and the specific energy requirements of the building must also be considered in the assessment.

Even before the preliminary studies, the overall HVAC concept for the building must be considered, bearing in mind that the enercret system is used both for heating and cooling (geothermal balance in the ground) and that the energy is introduced into the building via a low-temperature heating system which is also suitable for cooling.

The output values given below can be used to obtain a rough estimate of the energy capacity of an enercret installation:

Absorber pile, 30 - 50cm dia.	40 - 60 W/linear metre
Absorber pile, 60cm dia. and above	35 W/m² rigged surface area
Diaphragm wall, piled retaining wall	30 W/m² rigged surface area
Ground slab	15 - 30 W/m² rigged surface area (depending on insulation)
Output per linear metre of piping	2 - 8 W/m
Assumptions	Damp soil or still groundwater, normal periods of use, soil types with good thermal capacity, standard pipe spacing, min. soil depth 5m

The above values must be corrected downwards in the case of:

- Dry soil, soil with low thermal conductivity and capacity
- Prolonged periods of use
- Single application (heating or cooling)
- External factors influencing ground temperature

The above values must be corrected upwards in the case of:

- Groundwater flow

In the case of a heating application, the capacity for the building will increase, depending on the performance ratings, by the drive power of the heat pump.

The period of use for “direct cooling” is limited if there is no groundwater flow as the absorption/heat transfer medium will no longer be adequately cooled once a ground temperature of 19 °C is reached. The system can be operated with a refrigerator unit (reversible heat pump), while it must be borne in mind that the heat produced by the drive power must be dissipated in the ground.

The following ballpark figures can be used to obtain a rough estimate of the cost-effectiveness of the investment.

Investment costs:

Absorber piles, diaphragm walls

(standard design)	approx. € 460.--/kW installed capacity
Ground slabs	approx. € 560.--/ kW installed capacity

Operating costs:
(based on electricity charge: 7 cent/kW)

“Direct cooling”:	virtually nil
Heating with geothermal heat pump:	approx. 2 cent/kW

Cooling with refrigerator unit or reversible geothermal heat pump: approx. 2 cent/kW

2.2 Design

Once the preliminary studies show that cooling/heating a building with energy extracted by means of an enercret system is a viable proposition, the detailed engineering work can begin.

The first step is to plan the layout of the circuits in the foundation structures, which will usually be HDPE piping DN 20/2.0 and/or 25/2.3mm. Here a distinction should be drawn between the incorporation of piping in a foundation slab (in some cases with cavity insulation), and cast-in-situ or precast piles, diaphragm walls as foundation or construction pit shoring elements as well as combinations of these types of foundations or other concrete structures with ground contact such as piled retaining walls.

The pipe spacing is derived from the calculation of energy use and is usually between 15cm and 30cm; the dimensions and length of the piping systems are derived from the hydraulic calculations. As a rule, a pipe circuit (water circuit) will have a length of 150m – 300m from manifold to header block. The flow rate of the heat transfer medium should be between 0.2 and max. 0.1 m/sec.

When planning the building it must be borne in mind that it should be possible to protect the connecting lines from the foundation structures during subsequent work in the construction pit and for these lines to be properly connected.

The type of pipe connectors used are usually thermofusion connectors.

The connecting lines from the individual water circuits in the foundation structures up to the manifold block are laid in the layer of compressed concrete below the ground slab and run along the outer wall of the building. It may be necessary to provide watertight openings in the ground slab for design reasons. The pipes must be suitably cushioned in areas where they might be exposed to edge pressure or shear forces (for example at structural joints).

The manifold block must be located in the technical services room or on the outer wall of the room in an accessible shaft above groundwater level. It must be possible to calibrate flow rates in the individual circuits by means of fine adjustment valves. The flow and return lines lead from the manifold block to the control centre.

It is often necessary to include intermediate manifolds and/or ring circuits based on the Tichelmann system. This will largely depend on the size and shape of the building.

2.3 Installation Planning

When planning the installation, the exact piping layout drawings for the structures must be determined along with details of connection to the connecting lines. Pipe connections in the area of the pile head must be planned to ensure minimal interference with the building contractor. If possible the connecting lines to the manifold block should be laid by the shortest route, in parallel, with adequate spacing and without crossing. They must then be suitably lined up before the manifold block so that they can then be directly connected up to it.

The concrete pouring stages must be clarified with the building contractor and taken into account in the planning in order to avoid unnecessary spigot and socket joints.

Any settlement areas must be checked with the structural engineer and crossing such zones is to be avoided.

In individual cases it will also be necessary to consider different longitudinal expansion due to the setting temperature of the concrete.

In addition, the structural engineer must stipulate any taboo zones for the pipe laying.

The location of the manifold block must be selected to allow easy access as well as easy operation and monitoring of the regulating valves.

All components must be checked to ensure that they are frost-proof. As a rule, expansion chambers and bleed valves are to be incorporated after the manifold block.

The required openings in foundation beams, walls, ceilings and joists for absorber, collecting or ring pipes must be taken into account in the construction planning and the structural design.

3. Calculation and Simulation

On the basis of the information provided in Questionnaires 1 and 2, plus the supplementary data from the proposed design, the **enercret** installation can then be calculated with the specially developed TRNSPILE/TRNSSLAB software.

The main data to be entered are the geometry, size and number of foundations and the spacing of the absorber pipes. Other important parameters include information on the subsoil such as moisture content, groundwater table plus approximate flow velocity and the temperature of the subsoil. To calculate coverage of the building's load profile for heating and/or cooling operations, the monthly and weekly distribution of heating and/or cooling energy requirements as well as the heating and/or cooling peak demand must be stated.

The program uses the data on the thermal conductivity and storage capacity of the soil layers and the respective climatic data stored in its databases to compute the geothermal energy potential present in the ground for heating and cooling purposes. It also calculates and visualizes the percentage of heating and cooling requirements covered on a monthly basis plus peak heating and cooling demand. The temperature fields in the area of the foundations can be checked at any point in time during the heating or cooling period.

Clearly, it is essential to use the appropriate software when calculating an enercret installation since there are a series of parameters which mutually influence one another within the three-dimensional volume of ground and ultimately determine the capacity limits of the system. In the area of the foundations, for example, it is vital to avoid frost which might jeopardize their structural integrity.

The software makes it possible to select the most cost-effective use of the geothermal energy present in the ground to suit the energy requirement profile of the building. The effects of energy flows from an enercret installation in the building can be reproduced through interfaces with the building simulation software TRNSYS.

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