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Protect and Heat

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ABSTRACT

Ongoing climate change is the cause of recent geo-environmental disasters, such as floods and landslides, which occur more and more frequently and derive from the growing consumption of energy and the consequent increase in CO2 emissions. A change can only happen with the belief that the first thing to do is to reduce energy consumption derived from fossil fuels.

A positive contribution in this sense could be given by a new "Protect and heat" project. This project aims to safeguard the environment, reduce Co2 emissions and reduce the risk of collapse of buildings affected by earthquakes.

The “Protect and Heat” project is a way to heat and cool buildings, which uses a low-enthalpy, zero-emission geothermal system to simultaneously protect and attenuate seismic vibrations produced by earthquakes on buildings located in seismically sensitive areas.

To mitigate the catastrophic and destructive effects produced by earthquakes on the soil and existing structures and to produce geothermal energy, it will be necessary to create a series of works outside the buildings to be protected that intercept the vibrations and dampen them before they reach their final objectives.

The works will mainly consist of a double row of vertical poles placed side by side made of ferrous and plastic materials which allow the emptying and replacement of part of the surface soil. By taking advantage of the perforations of the works carried out for the attenuation of vibrations, of the vertical poles, it will be possible to lay low-cost closed-circuit geothermal probes in the ground outside the buildings to be heated/cooled using the energy poles. It should be underlined that, since specific tests have not yet been carried out for this new project, even if the tests on energy poles, with which it shares many aspects, have been widely documented (see Delmastro's manual and Savino Basta's publications), the tests Yield GRT of the new coaxial geothermal probes will have to be planned and executed during the first testing phase of the works. Encouraging results, even if only partial, for the damping of vibrations produced by mechanical presses have been successfully obtained with the use of vertical HDPE poles, located outside production warehouses, while the use of energy poles is commonly used for cooling and heating buildings.

Introduction

The “Protect and Warm” project aims to attenuate the effects produced by earthquakes (superficial and deep earthquakes) on the land and existing structures and at the same time would be able to produce geothermal energy at low enthalpy and low cost, bringing together the support technique and consolidation of the excavations with closed-circuit geothermal energy poles. Energy poles are commonly used for heating and cooling buildings in conjunction with heat pumps and photovoltaic panels, in low-enthalpy closed-loop geothermal systems.

The aim is to heat and cool the buildings adjacent to the works, using the geothermal resource, which avoids producing carbon dioxide emissions due to the combustion processes of gas or other exhaustible resources (Figures 7-8).

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For the study of the damping and propagation of surface vibrations in the ground, produced by earthquakes and coming from the epicenter of an earthquake, reference was made to [1-6].

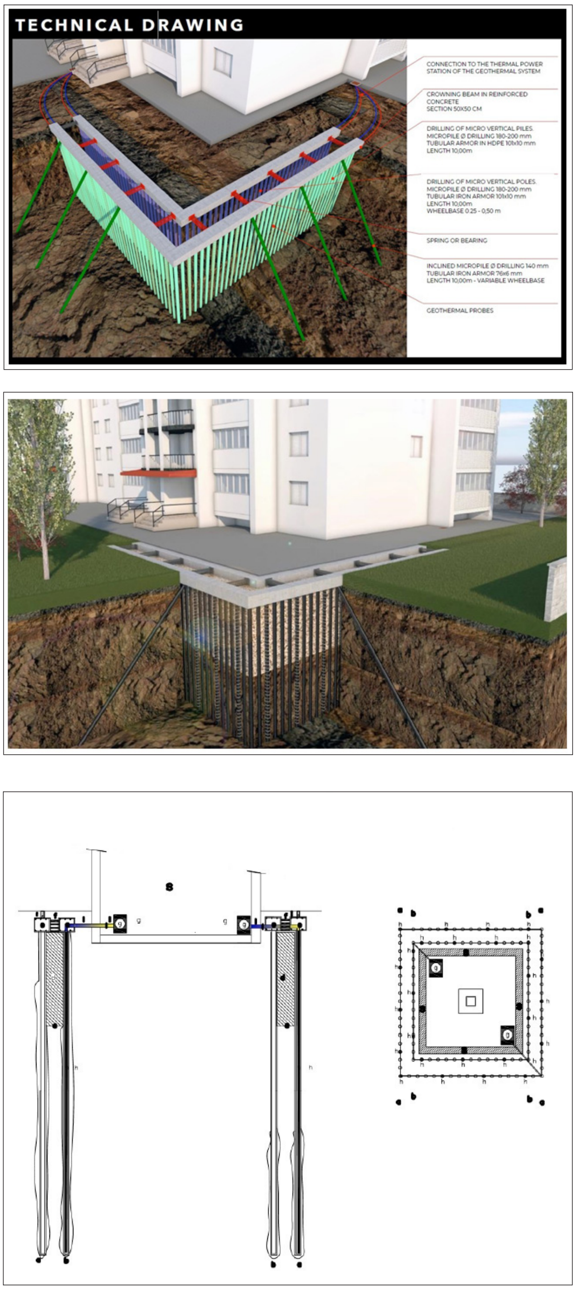

Figure 1: system configuration

Section and Plan of a building (tower...) with a square base, surrounded by a double alignment of vertical micro piles, in which closed circuit geothermal probes are inserted.

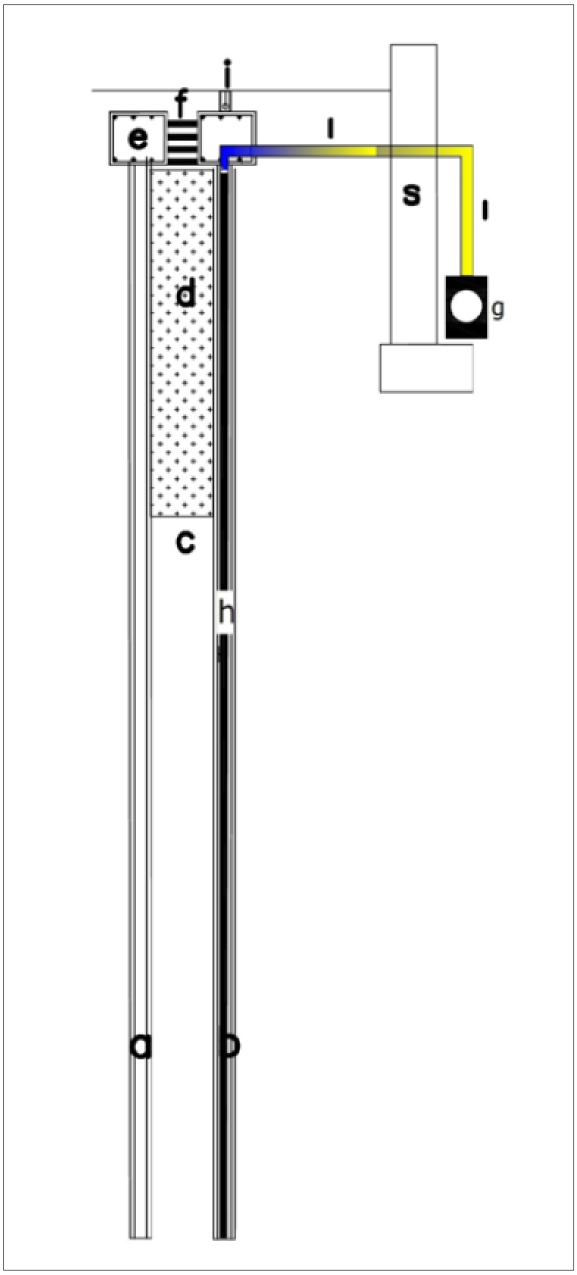

Figure 2: A particular of the damping barrier and closed-loop geothermal probes.

a) micro piles reinforced with steel pipes
b) micro piles reinforced with HDPE pipes
c) excavation between the two alignments of vertical micro pile;
d) filling of the excavation with expanded clays or light materials;
e) head beams of the piling;
f) springs between the reinforced concrete beams.
g) boiler room and the heat pump;
h) coaxial geothermal probe
i) monitoring station
l) connections to the heat pump;
s) section

Materials and Methods

To obtain vibration attenuation, the project involves the construction of a double row of aligned micropiles and the insertion into the ground, in the immediate external perimeter of the buildings, of HDPE and steel pipes, placed inside the vertical holes [7,8].

For energy saving and the reduction of CO2 produced by the buildings affected by the planned works, closed circuit geothermal probes will be positioned in series inside some vertical holes, capable of heating or cooling the surrounding buildings with a Low enthalpy closed circuit geothermal system [9,10].

The “Protect and Warm” project method is created by combining two technologies and two types of intervention:

The First Intervention

The first intervention concerns the interposition of damping barriers between the direction of origin of the seismic waves and the buildings to be protected. The barriers, simple or double vertical, of different sizes, will be arranged vertically, starting from the topographic surface, and will be positioned outside the buildings according to differently oriented geometries, but generally orthogonal to the direction and direction of propagation of the seismic waves.

The damping barriers can be made with different types of materials capable of absorbing, deflecting, and reflecting the train of waves and vibrations coming from the epicentre of an earthquake or from an explosion point.

The vertical damping barrier will have the purpose of dampening surface seismic waves before they intercept buildings located near the earthquake epicentre and/or fault lines.

If the direction and direction of origin of the seismic waves is not known, it will be possible to surround the entire external perimeter or external circumference of the buildings to be protected with vertical barriers.

The Second Intervention

The second intervention concerns the installation of geo-exchange pipes, coaxial or simple or double “U” geothermal probes. The pipes will be inserted inside the steel tubes or in the holes already made for seismic damping. These will then be connected in series or parallel and will reach a thermal power plant where they will be connected to the exchangers and heat pumps.

It is important to point out that the intervention sites must be investigated with a specific geological study, which preliminarily identifies and validates the heat exchange capabilities of the soil.

Naturally, the geothermal yield of the plant is a function of the subsoil temperature, which varies in the individual intervention sites, and is consequently conditioned by the presence or absence of the water table and the lithology of the subsoil affected by the drilling and new works. However, a certain yield is always guaranteed.

More experiments carried out in different locations, with GRT tests or similar tests, will be able to provide us with the correct yield statistics of future plants in different geological situations.

Detailed Description of the System

In particular, the damping system, created outside the structures, is combined with a system of closed-circuit geothermal probes, inserted inside the perforations used to support the excavation walls.

the operating system is at an experimental level but it seems simple to be able to create a system of closed circuit geothermal probes, inserted inside vertical HDPE pipes or similar; The pipes with diameters varying from 1" to 5" will be concentric and the external filling of the geothermal probes, i.e. the gap between the drilling diameter and the larger diameter pipe, is similar to that used for the casting of the micropiles and tie rods. These are cement mixtures, water and cement with the addition of bentonite, which can be added, in the upper section, the first three meters approximately, with aggregates which can vary in grain size from coarse sand to fine gravel. The injection pressures are normally low pressures, the same ones used for the construction of "Berliners" or micropiles and tie rods; electric or petrol injection pumps must not exceed a pressure of 4-5 bar, to avoid crushing the pipes, which are normally PN 16 pipes and therefore guarantee a seal of up to 16 bar; the injections will be performed from below, from the bottom of the hole. The connections and fittings of the heads of the geothermal probes can be inserted/embedded in the crowning RC beams to be created for the connection of the pile heads.

The damping system is composed of a barrier of pilings in a single or double row, positioned outside the buildings to be protected (Figure 1-2-3-4-5); the barrier is made up of aligned holes, reinforced with two types of different materials: steel and polymers. The pilings support the excavation walls and allow the removal of natural material and its replacement with lighter, looser and granular materials, in such a way as to create a stratigraphic discontinuity and a barrier between the incoming waves and the buildings to be protected (Figure 3-5).

Inside the drilled holes and before their filling, geothermal probes or coaxial probes are installed which will then be connected to the heat pumps (Figure 2).

The drilling holes will be aligned to the outside of the existing buildings, using vertical drillings, equipped with flexible and elastic materials capable of vibrating under the effect of horizontal vibrations, and in the second line with steel pipes (Figure 5). The space between the two parallel rows will be emptied and then filled with lighter materials (Figure 1-2-3-5).

How the system works and how the objectives can be achieved.

The operating concept of the external vertical damping barrier is simple: it involves placing one or more vertical barriers in the natural terrain, between the line of propagation of seismic waves and the buildings to be protected, made up of materials different from those existing underground, and placed in the immediate surroundings of the work to be protected, which also allow the creation of empty spaces and volumes or filled with light materials different from the natural ones existing on site, capable of dampening seismic waves.

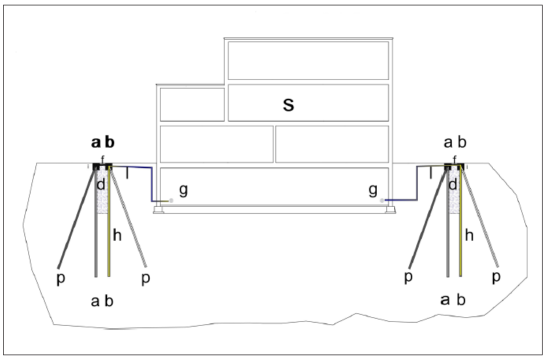

Figure 3: Section of two damping and geothermal barriers on the two sides of a building.

p) inclined micro pile reinforced with steel pipes
s) multi store building with basement

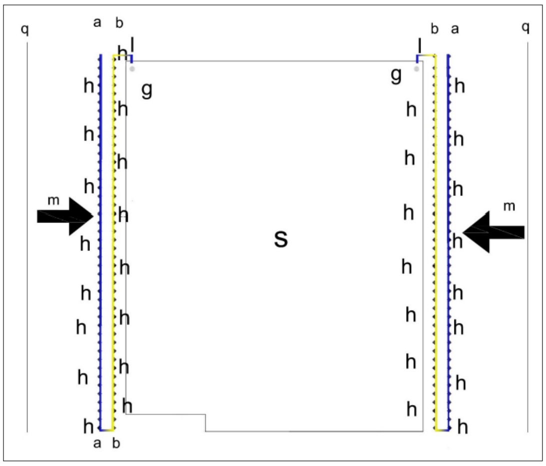

Figure 4: plan of a damping barrier placed on two opposite sides of a building.

m) direction of seismic waves;
h) position of the geothermal probes inside the micro piles;
q) presumed fault line;
s) floor plan of a building.

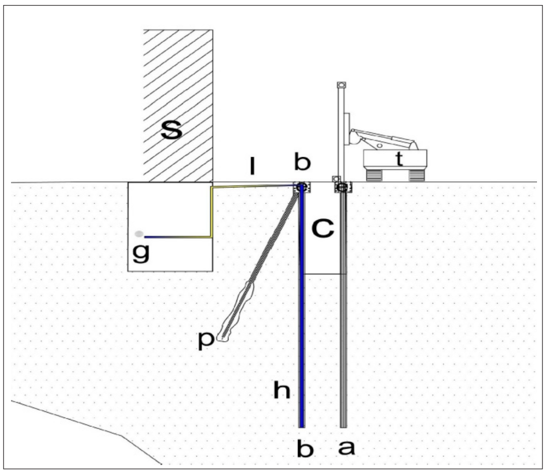

Figure 5: Section of a damping barrier with inclined micro piles.

p) inclined reinforcement micro piles
t) small auger

In the perforations of the damping barrier, some closed-circuit geothermal probes will be installed alternately (Figure 8).

The vibration and shaking of the damping barrier, which is flexible and detached from existing building structures and foundations, dissipates energy and protects buildings behind it.

The shapes, planimetric dimensions and depth of the flexible vertical barriers may vary depending on the size of the buildings to be protected and heated.

Fields Phlegrean Hills: 20 Wells for Safeguard the Area A' idea Alternative in Wait Of project And Of Financing!

Perimeter Area from Intervention: about 2,000 meters area: approximately 340,000 m^2. Number Wells willing long the Perimeter External. N. 20 well centre distance: 100 m. Depth' wells: variable from 200 to 1000 m

Figure 6: Fields Phlegraean, Pozzuoli, Naples, It

Figure 7: Gulf Of Pozzuoli

Objectives

Objective 1: Reduce the destructive effects generated by earthquakes. To achieve this objective, it will be necessary to create one or more elastic vertical barriers in front of the works and buildings to be protected, formed by a double alignment of drillings that reach at least the depth of the foundation works with two different types of reinforcement, one elastic in plastic polymer, and a more rigid one made of steel of different quality and type. The holes can be filled with semi-fluid cement-bentonite mortars and with fluidifiers so as not to stiffen the system. The half-space between the double row of vertical drillings will be emptied of natural soil, filled with loose and/or semi-fluid materials, or light clays or with pyroclastic material lighter than the material removed. On the top of each alignment of piles, head beams will be made of reinforced concrete or steel profiles, and opposing steel springs or bearings will be inserted between two facing beams (figures 1-3-5).

Objective 2: Provide geothermal energy to buildings being protected with low-enthalpy, closed- loop heat pumps. To achieve the second objective, it will be necessary to install inside the HDPE and steel poles some closed-circuit geothermal probes connected to the surface with a single collector which will transport the fluids or gases inside the buildings in which the technical equipment will be located. exchangers and heat pumps necessary for the operation of the air conditioning system of the adjacent structures (figure 2).

Objective 3: Monitor the earthquake swarm

To achieve the third objective, it would be appropriate to set up a continuous monitoring system of the chemical-physical characteristics of the drilled soil, with multi-parametric probes to be installed inside at least one of the vertical holes of the barrier. The monitoring system would have the purpose of recording and transmitting the data detected in the ground, to activate an alarm in the event of exceeding the pre-established limit thresholds (figure 2).

Objective n°4: Installation adaptable to any conditions.

Externally, adjacent or in to achieve the fourth objective, the barriers must be built in the immediate vicinity of load-bearing structures, buildings, artefacts, churches, works of art, bridges, etc. They can be oriented with different geometries to better adapt to the shape of the structures. They can also be carried out in the presence of groundwater. The accessory works are placed inside the existing buildings in small spaces which can also be underground or semi- underground (Figure 4).

Objective n°5: Fast installation and compatible with ongoing activities.

For this objective it will be necessary to create the barriers with light machinery, capable of carrying out small diameter drillings (Figure 5).

Lightweight drills require commitment and the delimitation of restricted areas which are moved as the work progresses.

Furthermore, the interventions can be carried out in stages and with increasing degrees of protection and energy saving depending on the type of works and the expected spending capacity.

Objective n°6: Low costs, with minimal environmental and energy impact.

The costs of the external vertical barriers are similar to those of geotechnical engineering works while the cost of the geothermal system will be lower than the standard one because the costs of drilling which are already counted in the geotechnical engineering works will be excluded. The two types of intervention will have no maintenance costs and no energy costs. The environmental impact is also minimal as the materials used are inert and therefore are not polluting or harmful to the environment or people.

Figure 8: Perimeter area of interest: Fields Phlegraean Fields

Purposes

- Safeguard the area phlegrean with monitoring from the pressures and from the temperature in hole
- Use energy geothermal of the gas and of the fluid's leakers come on tubes of the 20 wells drilled
- Download the pressures of the underground
- Diminish the raise of the soil in the areas limited
- Reduce the shocks seismic
- Use possible resources minerar- ie

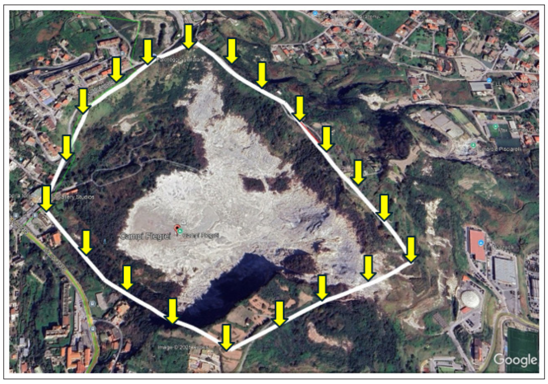

Figure 9: Position of the wells geothermal Of I unload from the pressures

Expected Results and Objectives to be Achieved

The tests of this new project have not yet been carried out and the work carried out so far has only concerned measurements of the damping of vibrations produced by large industrial presses used for steel stamping, like that produced by a low-grade earthquake. Vibration damping was achieved through drilling and the interposition of a single alignment of vertical HDPE plastic poles, orthogonal to the direction of wave propagation. In this case the measurement, carried out with a refraction seismograph, identified the halving of the amplitude and frequency of the seismic waves, produced by the percussion of an eight kg mallet against a plate positioned on the surface ground, near two measuring geophones, positioned a short distance from the energization point.

The "protect and heat" project could achieve the following objectives:

- The first objective is to reduce the devastating effects caused by the surface waves of earthquakes.

- The second objective is to provide low-cost geothermal energy to the buildings to be protected.
- The third objective is to control and monitor and study the changes in parameters with thermometers, seismographs, rare gas meters, and other sensors to try to predict the trend of the evolution of seismic phenomena.
- The fourth objective is to be able to adapt the methodology to any topographic, geological and infrastructural condition encountered.
- The fifth objective is to be able to build the system in a short time and without causing interference with the normal activity that should be carried out inside and outside the buildings and intervention areas.
- The sixth objective is to be able to build the geothermal system without further drilling costs, with low installation and maintenance costs and with zero environmental and energy impact.

Discussion and Logic of the Project

The logic of the project is to create a discontinuity (valley) in the ground in front of the structures to be protected, in a way like the damping methods that are implemented to dampen the vibrations produced by mechanical machines.

Eng. Giovanni Moschioni (1995). Reduction of mechanical vibrations on machines. Polytechnic of Milan (It) mechanical department, experimental technical measurements section.

To form the dissipative element, we want to create a sort of "Wall", near the buildings to be protected, heated and cooled without compromising the stability of the buildings themselves.

A part of the volume of soil between two alignments of piles will have to be removed and then filled with different materials, less dense and lighter than the natural soil present on site, so as to reduce the speed, frequency and amplitude of the waves that they will cross it.

To avoid the danger of "Resonance", the walls of the dissipative element will be built with different materials, using steel poles and HDPE (plastic materials) poles, capable of oscillating differently.

To further dampen the Love and Rayleigh waves, reinforced concrete beams, aligned and opposed, equipped with contrast springs, can be positioned on the heads of the piles.

Closed-circuit, low-enthalpy coaxial or helical geothermal probes will be inserted into part of the drilling holes performed. These techniques are already used successfully in “energy poles”.

Effectiveness of the New Project

To check the effectiveness of the new system it will be necessary to measure the amplitude and frequency of the vibrations entering and exiting the dissipative element (valley), comparing the data to the different degrees of energization of the ground. Reference may be made to natural earthquakes.

The measurements must be carried out before building the wall and then repeated in the same positions. The data analysis can be repeated on terrains of different lithological/structural nature and for the different types of dissipative elements, varying the length, diameter and geometry parameters of the works.

The control of vibration damping can be verified with vibration meters, accelerometers or seismographs to be positioned on the barrier or outside/inside the buildings, before and after the works are carried out.

The variations in the parameters of acceleration, amplitude and frequency of the vibrations produced by artificial earthquakes must be verified as the geometry of the dam, the diameters, lengths and spacing of the piles vary, depending on the materials used, the nature of the soil, the presence of the water table. and the intensity and frequency of seismic shocks.

The energy saving of the buildings will be achieved with geothermal foundation piles, inserted into the barriers, and the installation of closed-circuit geothermal probes, connected to heat pumps and exchangers; this technique has already been tested and is in current use. The thermal performance can be verified on site for each individual system with a GRT test, Ground Response Test, after inserting, alternately and inside the vertical holes of the barriers, geothermal probes like those used for energy poles.

Conclusions

The “Protect and Heat” project aims to be a way to achieve and bring together two main objectives in a single operation, heating/cooling buildings located in seismic areas without using fossil fuels, without producing carbon dioxide and at the same time dampening the vibrations produced by earthquakes that could cause damage to existing buildings and inhabitants.

The other objectives are

- control and monitor and study changes in parameters with thermometers, seismographs, rare gas meters, and other sensors to try to -predict the trend of the evolution of seismic phenomena.
- adapt the methodology to any topographic, geological and infrastructural conditions encountered.
- create the system in a short time and without causing interference with the normal activity that should be carried out inside and outside the buildings buildings and intervention areas.
- build the geothermal system without further drilling costs, with low installation and maintenance costs and with a significant impact environmental and energy equal to zero.

The works could be carried out in medium and highly seismic areas, outside the existing buildings and structures, (figure 1-2-3-4-5), without causing interference with the normal activity that should take place inside them.

The works could be carried out in almost all topographical conditions, following a geological investigation of the site and identification of any sub-services or obstacles. The works could be carried out with light and space-saving drills in a short time and the works carried out would not require maintenance and would not create constraints. The works could be carried out in steps and at the same time the chemical/physical parameters of the subsoil could be monitored. The works would not pollute or be harmful to the surrounding environment or to people.

Although the "Protect and Warm" project has not yet been tested in its entirety, there are good scientific reasons to consider it valid and feasible also because the experimentation carried out in the field in an industrial area, although partial, had good results. Even commercially, the project, if considered in its dual function of protecting the buildings and air conditioning, hot/cold, of the property concerned, is certainly advantageous because it avoids the expense of drilling vertical geothermal probes.

For example, I calculated that a 200 square meter three-storey building would need to drill approximately 6 closed-circuit vertical geothermal probes with a double "U" depth to create a geothermal system with heat pumps. of one hundred meters each, in the same way, if we wanted to protect the same building from earthquakes and at the same time condition it, we would have to create, along its perimeter, a double series of protective drillings, with a depth of approximately 10 m/each. (centre distance 0.5 metres), in which to insert approximately 60 concentric coaxial probes with a depth of 10 metres. Assuming a distance between the coaxial geothermal probes (such as energy poles) of 4 meters and a quincunx distribution, we would obtain a result like what we would have had with 6 vertical geothermal probes with a depth of 100 meters each, with a saving of approximately 30,000 euros, considering current market prices.

This new project could provide a positive contribution to the mitigation of ongoing climate change because, by exploiting the geothermal heat of the ground, it simultaneously generates energy and protects buildings from earthquakes by dampening seismic waves before their impact on the buildings.

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