CONSOLIDATION OF FOUNDATIONS FLOOR SLABS AND PAVEMENTS

IS IT:

- [ ] *Product*
- [X] *Technology*
- [ ] *Equipment*

APPLICABLE FOR:

- [X] *Restoration*
- [X] *Rehabilitation*
- [ ] *New Construction*

APPLICABLE ON:

- [X] *1. Foundations and underground structures*
- [ ] *2. Vertical structures*
- [ ] *3. Horizontal structures and vertical connections*
- [ ] *4. Roof and terraces*
- [ ] *5. Façade and building envelope*
- [ ] *6. Finishes and completion elements*
- [ ] *7. Integrated services*
- [ ] *8. General strategies for building recovery*

Related companies: *GEOSEC*

DESCRIPTION

Each building is supported on the terrain beneath its footprint and this volume of ground is called the "pressure bulb". When the volume of soil or "pressure bulb" on which the building is supported is disturbed or does not have sufficient load-bearing capacity to support the overlying structure, due to settlement of the soil and/or the building. In these cases, there are two possible solutions: 1) to reinforce the volume of soil by consolidating it, 2) to cross the volume of soil and support the construction in a deeper and more compact area. In the first case, injections of expansive resins are the best solution, while in the second case it is necessary to carry out pile works that do not affect the pressure bulb and have the structure support a deeper zone. In this second case the problem arises when the most compact zones are at a very high depth that cannot be reached or can be reached with costs that do not justify the solution. In these cases, the system of injections of expansive resins in the pressure bulb that supports the building can also be used. It is important to specify that resin injections cannot be applied in areas with sliding.

WHY TO USE

It effectively counteracts differential settlement of the foundation; it is minimally invasive, fast, and accurate thanks to integrated geophysical ground control systems.

HOW TO USE AND APPLY

The procedure foresees the execution of injections of expansive resin on the surface and at depth, even up to 15 m and at different levels, in order to consolidate in a direct, efficient and uniform way the volume of soil that supports the load of the structure, avoiding differential settlements. Before injections, geophysical studies and geotechnical tests must be carried out to ensure the best intervention conditions. Compatible with the existing structures and installations, a series of boreholes (diameter 20-30 mm) will be drilled with an inter-axis between 0.50 and 1.50 m, both horizontally and in depth under the footprint of the settled foundation. A constant instrumental control by means of geophysical surveys, both in the affected areas and in the unsettled areas, and penetration tests will allow to verify in almost real time the effective improvements of the ground, adapting on the basis of the need the planning of the injections until obtaining a correct consolidation of the foundation and the uniformity of balance between settled and unsettled areas.

The inter-axis is established according to the geological studies of the ground and the anomalies observed before the treatment.

After analysing the results of the studies and geotechnical tests performed, we proceed with the following steps:

1) Secure the area and clear it of furniture and any interfering objects.
2) Drill small holes in the floor slab using hand drills.
3) Once the desired depth has been reached, the injection nozzles will be placed for subsequent consolidation. Several injection levels may be foreseen in the interventions, even superimposed, and it will be possible to use the same borehole to reach different depths.
4) 4D LIVE ERT tomography performed before, during and after treatment. To cover both the settled areas and the more stable and unsettled areas taken as a reference during consolidation. Once the injection system is connected to the nozzles in the ground, a special eco-compatible expansive resin is injected. The treatment continues under the constant control of 4D resistivity tomography, thanks to sequential and repetitive images of what is happening in the soil below the foundation.
5) Specialized technicians can verify precisely and in real time what is happening and make the necessary modifications to achieve the best consolidation result.

Final validation of the intervention through the use of a specialized calculation software with which it is possible to obtain, during the work, the resistivity variation of the soil to be treated.

TECHNICAL CHARACTERISTICS

Compressive strength - EN ISO 844: MAXIMA® expansive resin, at the density at which it is usually employed, offers a compressive strength with values higher than the standard load-bearing capacity of the soil below the foundation, ranging from 0.5 Kg/cm² (wet clay) to 5 Kg/cm² (compacted gravel). The results obtained show, as indicated in the reference technical standard, in the booklet n. 4 (page 5) where the variation of the compressive strength as a function of the density (figure

3.2.1) and the resin temperature is detailed. Under normal conditions it is observed that:

Resistance between 400 - 500 KPa

Deformation Ɛ (%) ≤ 5

On the other hand, the results of the compressive strength of the resin that remains in the consolidated ground are superior because they solidify in a "non-free" reaction, i.e. without the constraints of the surrounding environment, reaching a compact state of crystallization.

Environmental Compatibility - Decree Law 152/06 of 07/27/84: The engineers of the Giordano Institute have used the procedure of confinement and physical or chemical stabilization of contaminated sites (especially by heavy metals) for which the total content (mg/kg) remains the same but decreases within the limits of table 2 title V part IV of the D.L. 152/06, the lixiviation and the possible environmental risk. In summary, the results have shown that the MAXIMA® resin samples are lower than the limit values indicated.

Dimensional Stability – UNI 8069-80:

(Linear variation at 20 h – 70°C) <1%

(Linear variation at 48 h – 70°C) <1%

RECOMMENDATIONS AND OTHER INFORMATION

All geophysical and geotechnical studies must be carried out in order to intervene efficiently, precisely and in the right place to ensure the elimination of any settling and/or cracking problems in the building. In addition to constant monitoring before, during and after completion of the work, under the supervision of specialized technical personnel.

Possibility of uprisings due to the intervention: It is possible that the intervention may cause the ground and buildings to rise, but this is not the purpose of the method. When dealing with expansive resin injections, it is possible that during the treatment, the ground may experience a lifting due to an increase of tensions induced by the injections at the points of application, especially in the presence of water. Such lifting is in no case synonymous with a good consolidation result. The working procedure is based on geological verifications by means of studies and tests exclusively in the terrain.

Types of resin used: GEOSEC uses (mainly) two types of expansive resin with different polymerization times. One resin is used for the superficial consolidation of soil under pavements and slabs (anisotropic) while a different resin is used for the deep consolidation of soil underneath the foundation (isotropic). The latter has proven to be effective and reliable in every type of settled ground, especially because it is injected directly where it is needed, thanks to geo-diagnostic studies, carried out during the construction work, which monitor the treatment.

No soil contamination: According to periodic analyses of resin samples carried out by the Giordano Institute for control tests, the results obtained have shown that the resin respects the environmental standards in effect, therefore, if an area is not contaminated, it remains uncontaminated also after the SEE&SHOOT® treatment.

EXAMPLES

Underpinning of the facade foundation in the "Bodegas Fundador": https://www.geosec.es/recalce-de-cimentacion-de-fachada-en-las-bodegas-fundador/

Fig.1: Bodegas Fundador. Underpinning of the foundation of the facade of the wineries, affecting 42.50 linear meters of continuous stone masonry foundation, supported on yellowish clays of low strength located between 0.50 and 1.00 meters deep, and then gray clays with coarse sand. ©*GEOSEC.ES*

Fig.2-5: To solve the problem of differential settlement, the soil is consolidated using the SEE&SHOOT method by injecting at a maximum depth of -3.50 m. ©*GEOSEC.ES*

Partial underpinning consolidation of the building "Museo de la Minería": https://www.geosec.es/recalce-parcial-consolidacion-del-edificio-museo-de-la-mineria/

Fig.6: The Puertollano Mining Museum has an isolated foundation, distributed in 9 footings supported on a ground with a first layer of anthropic fill up to -4.00m, a second level of clay and silt of low compactness up to a depth of -15.00m, and a second layer of clay and silt of low compactness up to -15.00m.. *©Javier Martin. Public Domain.*

Fig.7-9: Cracks caused by differential settlements, mainly due to the presence of moisture under the foundation that generates a washout of fine soil fillings. *©GEOSEC.ES*

Fig.10: Intervention using the SEE&SHOOT method for soil consolidation under the foundations using 4 levels of intervention at a depth of approximately -4.50m. *©GEOSEC.ES*

Courtyard of the fishermen, Royal Palace of Aranjuez: https://www.geosec.es/patio-de-los-pescadores-palacio-real-de-aranjuez/

Fig.11: Royal Palace of Aranjuez. The geotechnical and geophysical characterization (on water sheet) shows that the backfill of the wall was carried out with remobilized soil and the phreatic level was found at a depth of -4.30m. *©GEOSEC.ES*

Fig.12-13: Intervention through the use of expansive resins aimed at filling the porosity of the soil, preventing the washout of fines. The bearing capacity of the soil is increased. ©*GEOSEC.ES*

Consolidation of the foundation soil using expansive resin injections at the University of Seville: https://www.geosec.es/referencia/universidad-de-sevilla/

Fig.14: The Royal Tobacco Factory (18th century), currently the University of Seville. The structure of the building has multiple cracks and fissures with a collapse of the facade wall of 1 to 3 cm. The foundation rests on a clayey soil of weak consistency. ©*GEOSEC.ES*

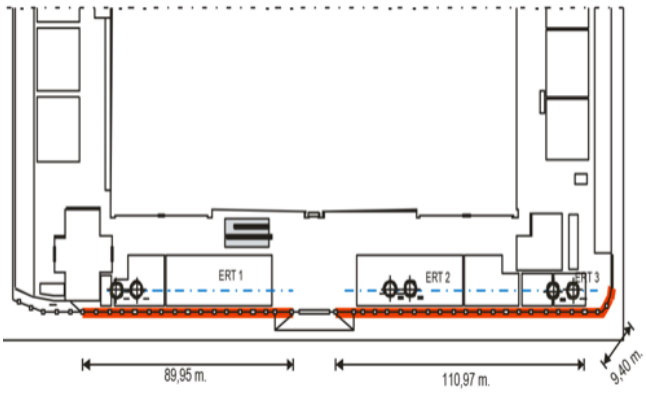

Fig.15: The intervention was carried out from inside the building without affecting the main access. Three monitoring stations, dynamic penetration tests and multilevel injections were used under constant instrumental control. ©*GEOSEC.ES*

Consolidation of the foundation soil using expansive resin injections at the San Pedro Advincula Parish Church: https://www.geosec.es/referencia/iglesia-de-la-parroquia-san-pedro-advincula/

Fig.16: Church of the Parish of San Pedro Advincula (XVI century) Sayatón. ©*GEOSEC.ES*

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WEBSITE OF THE COMPANY

www.geosec.es/

IMAGES AND CAPTIONS

Fig.17-18: Drilling process, placement of the spears and subsequent injection of the resin. ©GEOSEC.ES

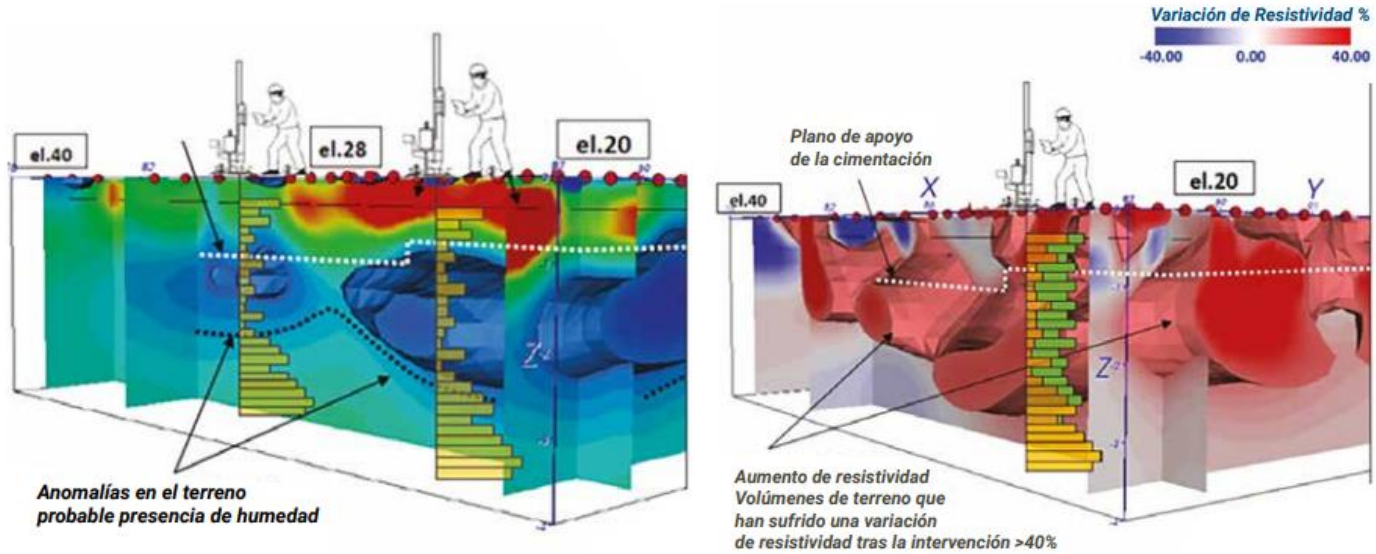

Fig.19-20: Examples of analysis with ERT tomography, before and after the intervention. ©GEOSEC.ES

Fig.21: Constant monitoring of the behavior of the soil and the injected resins. ©GEOSEC.ES