3D REHABILITATION

3D electrical resistivity tomography is proving to be a fundamental tool in the identification of the effective causes of settlement of a structure for the planning, control and verification of expansive resin injections.

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3D electrical resistivity tomography has been one of the main tools used in the works carried out in the Ciudad de Los Ángeles Integral Rehabilitation Area (ARI) in Madrid.

With a surface area of 59.6 hectares, in which there are 7,996 dwellings, with 441 buildings that could potentially be rehabilitated, its problems derive, on the one hand, from the poor state of conservation of the public spaces with which the urbanisation was provided and, on the other, from the structural problems, lack of thermal insulation and difficulties of access, 52% of which lack lifts.

The geology of the area is not suitable either. It is made up of materials belonging to the intermediate facies of the Madrid tertiary basin, i.e. plastic clays, generally expansive (peñuelas) and, occasionally, detritic levels that form authentic sandy lenses covered by materials of alluvial origin resulting from the sedimentation in a diffuse stream regime of waters of pluvial origin or, due to an- trophic action, fillings with deficient and highly variable geotechnical characteristics.

The building that has been intervened using tomography dates from an initial project in 1960. It was conceived as a linear block of open construction, being

On the right, on the other page, figure 1 (elevation) illustrates the injuries to the building, which can be seen in this image: Vertical cracks between lintels and window sills. Vertical cracks between lintels and window sills. 45° sloping cracks starting from the corners of the windows. The arches are facing towards the party wall where there is an opening in the joint of up to 8 cm on the roof.

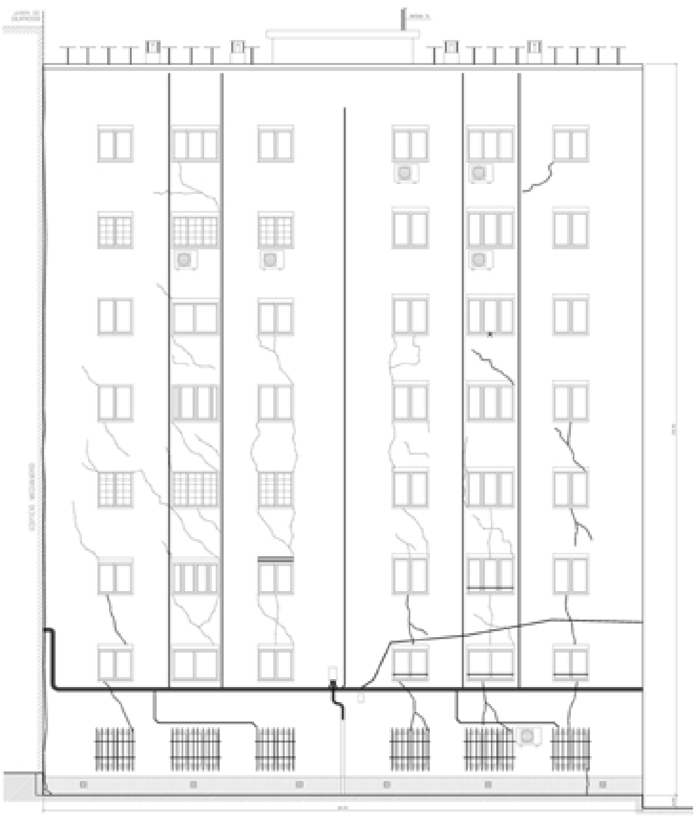


Figure 2: Test plan; test projection, E.R.T. 3D and D.P.M. 30.

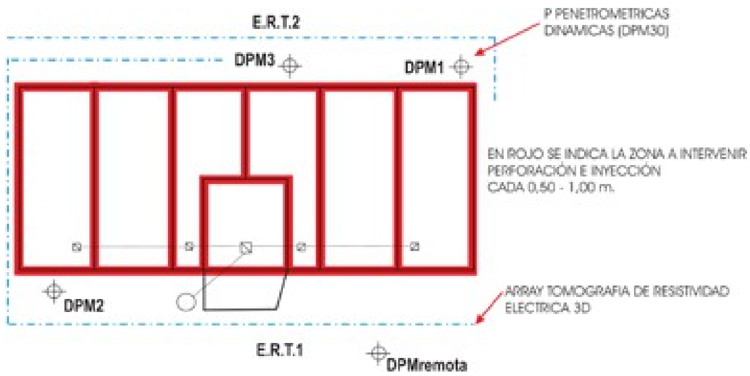


Figure 3: Implantation and performance of diagnostic 3D E.R.T. tests.

A corner building with three façades facing onto a public road and a single party wall. Access is from a single doorway consisting of a single storey building, free-standing and centred on the façade, leaving a dwelling on each side of it. I t consists of eight storeys above ground level (including the ground floor), all of which are for residential use, with two dwellings per storey. The building has a linear, rectangular lozenge shape with dimensions of 20.40 x 7.85 m, occupying a floor area of 160.14 m^2 . On its larger sides it borders on landscaped areas, with the head of the block facing the public road and the other side of the block forming a dividing wall with an annexe building. This separation between the block is produced by means of a dividing wall of a thickness of 30 cm, with an expansion joint that makes the two structurally independent. This building is included in the so-called Integrated Rehabilitation Zone of the City of Angels of the PGOUM.

CONSTRUCTION SYSTEM

The structural typology of the building is formed by six bays parallel to the minor façade and 30 cm thick, unreinforced concrete load-bearing walls. The stairwell is located on the main façade (access from the entrance) and is also formed around its perimeter by 30 cm thick mass concrete walls. On top of the load-bearing walls and in the direction of the main façade (smaller side), the floor slabs are supported in continuity and with

The staircase has an approximate span of 4 metres, formed by joists and vaults. The staircase is Catalan style, with three leaves of rasilla, the first one with plaster and the other two with cement. Originally, the foundations consisted of continuous mass concrete trenches, measuring approximately 0.90 x 1.80 m, located under the load-bearing walls. The building did not have a sanitary chamber and the ground floor was separated from the natural ground by a mass concrete slab. Subsequently, in 1986, work was undertaken to consolidate and stabilise the foundations and structure, which consisted of underpinning all the load-bearing walls, increasing the depth of the trench supports.

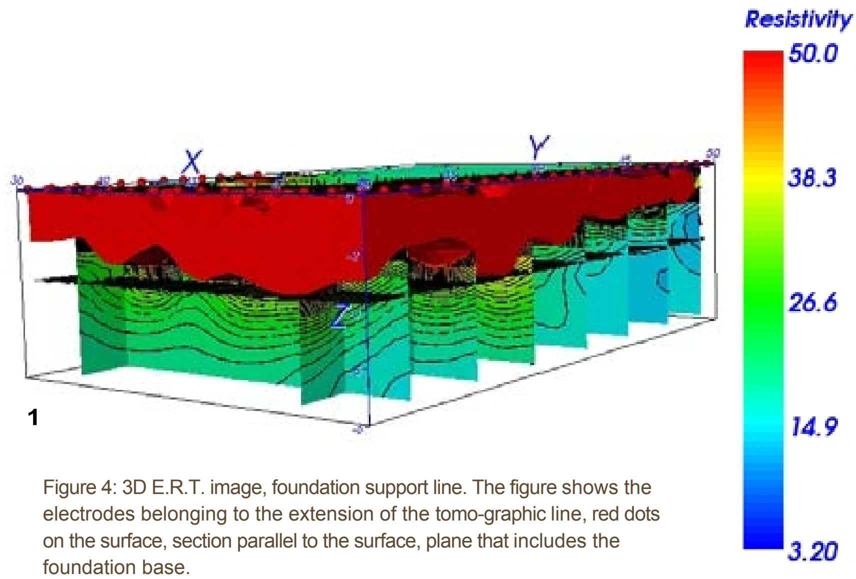


Figure 4: 3D E.R.T. image, foundation support line. The figure shows the electrodes belonging to the extension of the tomo-graphic line, red dots on the surface, section parallel to the surface, plane that includes the foundation base.

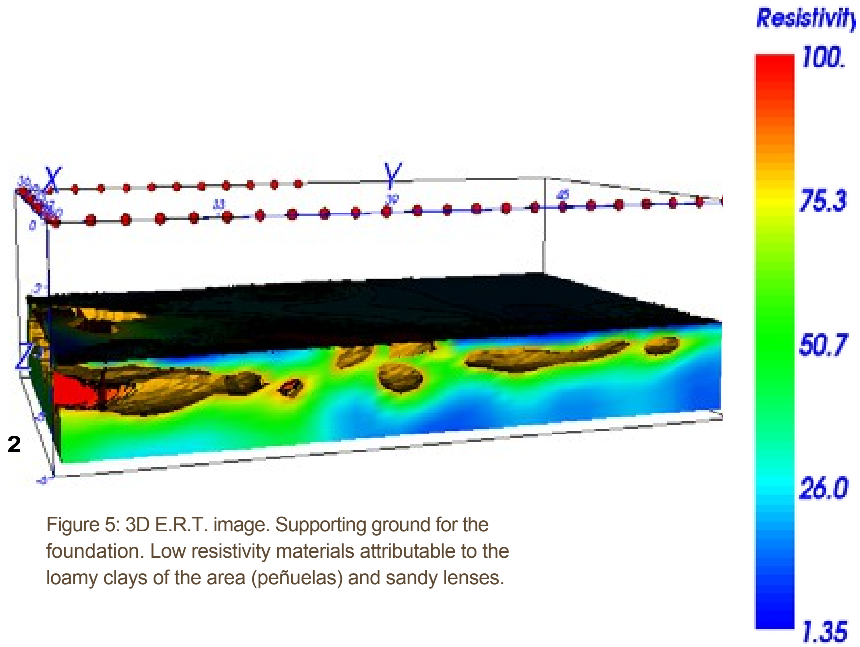


Figure 5: 3D E.R.T. image. Supporting ground for the foundation. Low resistivity materials attributable to the loamy clays of the area (peñuelas) and sandy lenses.

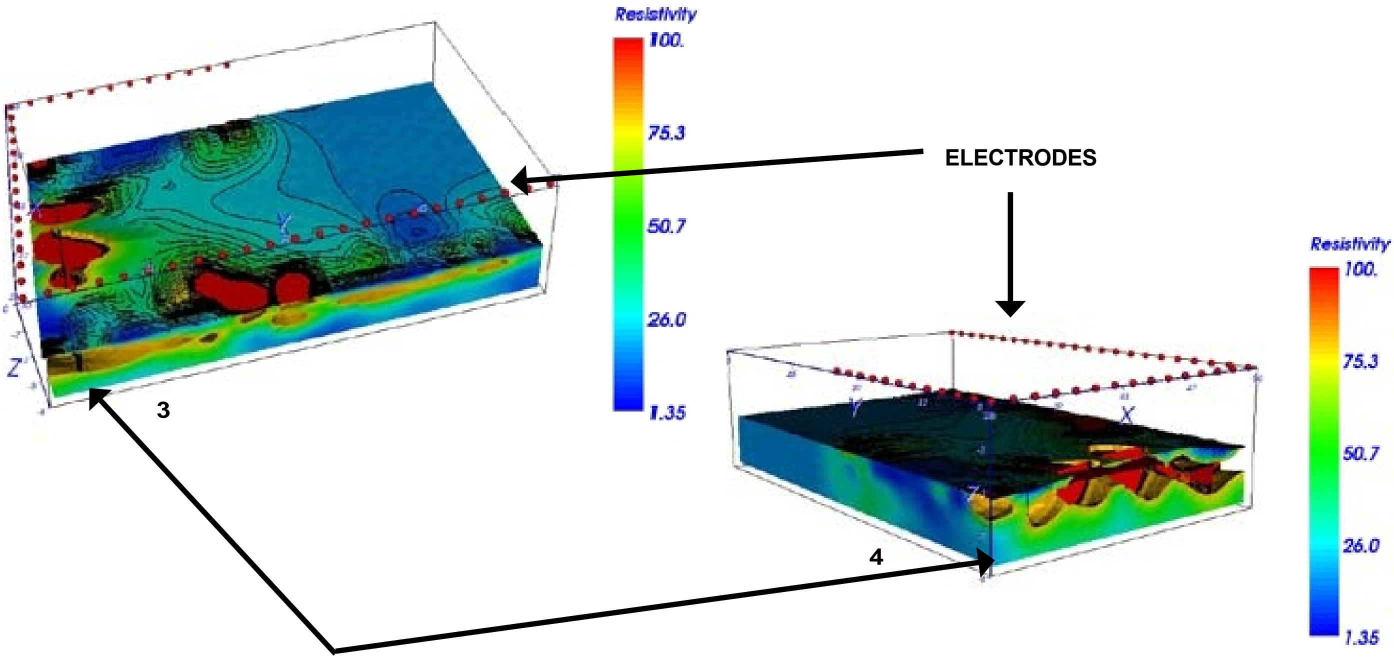
The road is made up of concrete-filled potholes up to a depth of four metres from the street level.
While the aforementioned works were being carried out, a floor slab was built on the ground floor to replace the initial floor slab, which formed a sanitary chamber without access and prevented damp pathologies in the ground floor dwellings. This sanitary slab rests on one-foot brick walls located next to the main concrete walls and resting on the same trenches. According to the documentation provided, the small annexe that forms the entrance doorway was re- sourced in 2002 by means of micro- piles manufactured in situ with an external diameter of 114 mm reinforced with ST-37 steel pipe, to a depth of 15 metres.

PATHOLOGY

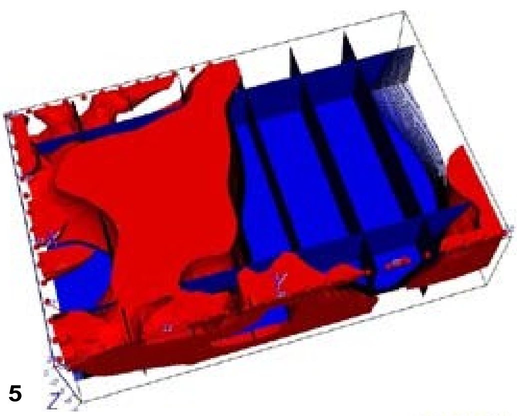
- Widespread cracks and fissures of various trajectories in enclosures and stairwells at ground floor level and above.
- Cracks in the rendering of the different façades, due to manifestations of the pathological process of the previous point and the deficient quality of the materials, causing leaks.
- Peeling asphalt membrane, deteriorated drains, broken floor tiles, degraded parapets and chimneys on the Catalan roof, due to lack of maintenance.

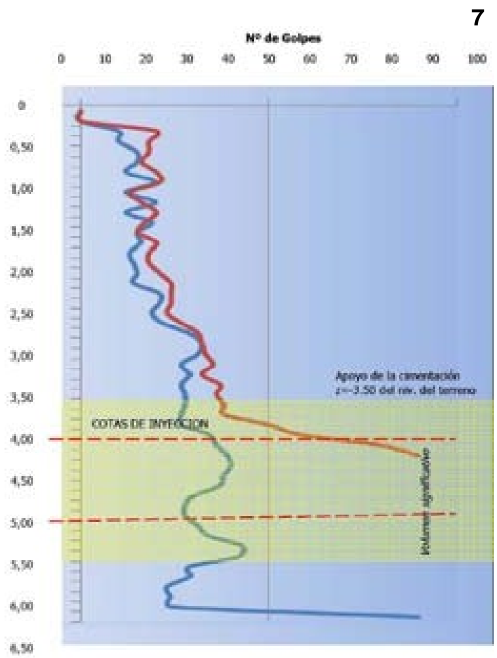
CHOSEN SYSTEM

Due to the construction system of the building, the possibility of carrying out a low-invasive intervention that would avoid the demolition of the sanitary wrought ironwork, speed of execution (given that the intervention would be carried out inside occupied dwellings) and low economic cost was considered.
Once the deadlines and execution procedure had been agreed with the project management, the soil was characterised according to protocol by means of dynamic penetration tests and 3D ERT (see figures 2 and 3). The 3D electrical resistivity record shows the level of the building foundations and the underlying materials composed of clays and sand lenses (identifiable in figure 5).
Tests were carried out on the expansivity of the samples collected, showing moderate to high expansivity. The lack of homogeneity of the soil, its expansivity and the possible washing of the sands, as shown by the high electrical resistance records, are considered to be effective causes of the destabilisation of the structure.
The injections of expansive resin at two depths, four and five metres, allowed the homogenisation of the terrain, decreasing the presence of The water in the building, filling excessive cavities and porosities in the sands, consolidating the pressure bulb generated by the building's foundations.
The comparison between the pre- and post-intervention geophysical and geotechnical study of the ground under the footprint of the target building, carried out using the 4D electrical resistivity tomography method f(x,y,z,t) in near real time and dynamic penetration tests, confirms this, allowing a significant increase in resistivity and tip resistance to be verified compared to the initial values measured before the injections (see figure 8).



Above, figure 6: 3D E.R.T. image at foundation level showing high resistivity records attributable to lava in the sand lenses detected.
Figure 7. Below, 3D E.R.T. image of the soil below the foundation at level h=3.50 m, showing the homogenisation and 25% increase in electrical resistivity of the soil.
Right, intermediate 3D E.R.T. image, during the execution of the injections, showing the interaction of resin with the treated soil, allowing for modifications/repetition of the injections if the results obtained are not as expected.





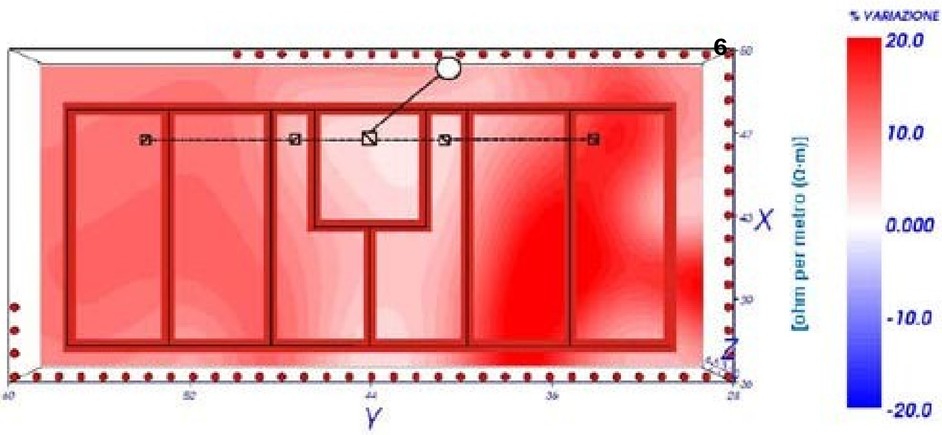


Figure 8: Tapping record of one of the DPM 30 dynamic penetration tests performed before (blue) and after the intervention (red).
There is a clear increase in mechanical strength at the tip with rejection at almost the first injection level.