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Use of Geophysical Methods to Define the Extension of a Tunnel Roof Failure

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São Paulo City, located in the southeast region of Brazil, is home to a population of 13 million people and more than 3 million vehicles, having enormous traffic problems, with combined daily average traffic jams of about 120 km.

Like in most of the biggest cities of the world, one of the alternatives which has been adopted to minimize such a problem is the construction of urban tunnels connecting important avenues of the city. One of these tunnels, which lies below Ibirapuera Park (the city's main park), links the Juscelino Kubitschek, Sena Madureira and 23 de Maio Avenues.

During the construction of this tunnel, a roof failure occurred involving a volume of about 20 m^3. Despite the stabilization procedures taken by the contractors, there was doubt as to what extent the massive had been compromised. Depennding on the extension, it might be necessary a more intensive support treatment.

It is important to note that the region, where the accident occurred, is located under a small garden of Ibirapuera Park, specifically between the Pedro Alvares Cabral and 23 de Maio Avenues. Both have intense vehicle traffic and, due to the central location, intense ambient, seismic, electric and electromagnetic noise.

In an emergency character (Saturday and Sunday), a geophysical study was conducted with the aim of defining the extension of the affected zone and, eventually, of helping in the proposition of recovering solutions. Due to time constraints (the response should be given on Monday morning), limitation of surface space and mainly the scale and depth of the rupture, high resolution seismic and detailed geoelectric mapping were carried out. To overcome the natural noise of the city, the range of frequencies used by the seismic study was between 200 Hz and 1,000 Hz, and a geophone spacing of 1.0 meter. Three profiles were taken, one on the intact massive, the second on the known disturbed massive and the last crossing the rupture zone.

The geoelectric studies encompassed time domain induced polarization (IP) - resistivity and spontaneous potential (SP). A gradient array was utilized with an AB of 60 and 50 meters and measurements were taken every 2 meters in a grid of 20 x 20 m.

The results allowed for the definition of a 3 m x 5 m zone in which the massive was disturbed, consequently requiring treatment to improve the support. Boreholes confirmed the exactness of the conclusions taken. After the treatment and the reopening of the tunnel excavation, it was possible to observe that the rupture zone had been limited to about 3 x 3 m..