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Foundation Systems in Chicago

Numerical Modeling

Driven Pile Setup

Karst Terrain

Cover photos courtesy Thatcher Foundations

Departments

DEEP FOUNDATIONS
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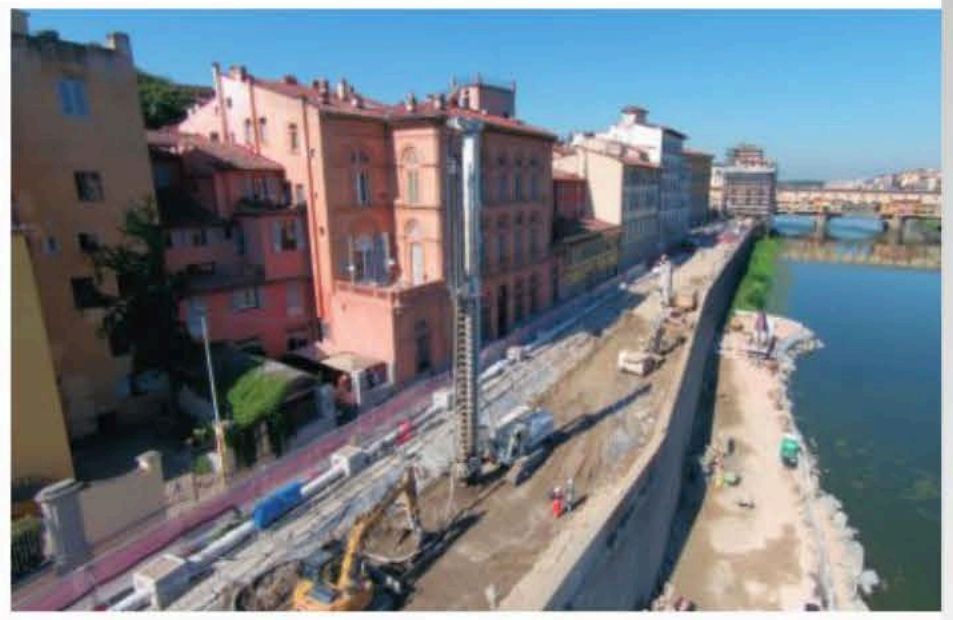
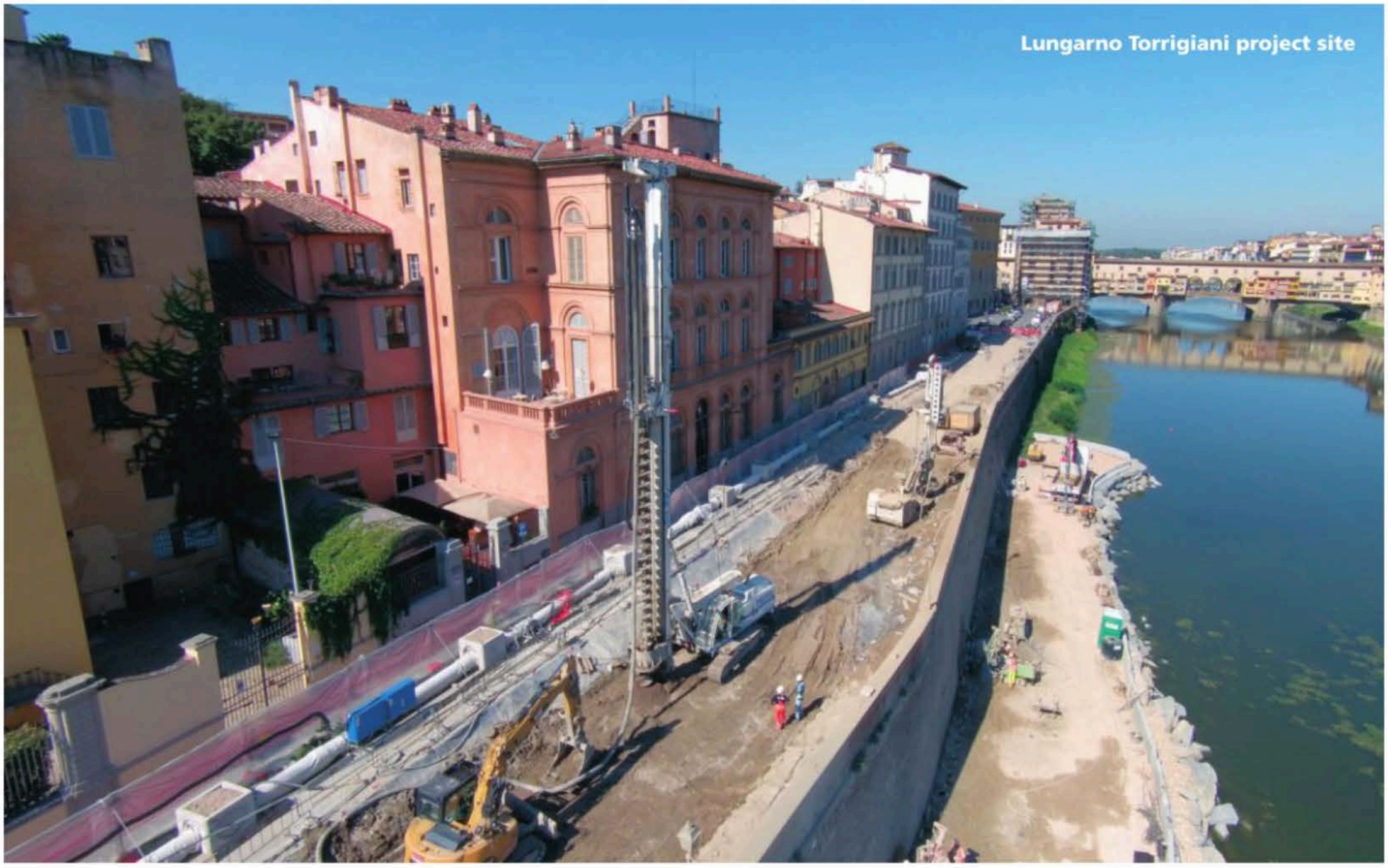



Lungarno Torrigiani project site

Trevi Improves the Lungarno Torrigiani Embankment in Florence

Trevi has completed the first phase of a project aimed at ensuring the safety of the embankment along Lungarno Torrigiani in Florence, Italy, which is adjacent to the Ponte Vecchio and across the Arno River from the Uffizi Gallery. On May 24, the embankment underwent a structural collapse causing a displacement of the riverbank about 10 ft (3 m) toward the Arno River. Consequently, the displacement created a chasm extending about 260 ft (80 m) in length with a maximum depth of 11.5 ft (3.5 m). To avoid any risk of possible river flooding, it was essential to complete the ground improvement, structural restoration and hydraulic protection before winter. As a consequence, there was an urgency to select a contractor and to initiate the work. In addition to its longstanding experience in ground improvement work, Trevi was awarded the contract due to its ability to combine high operating capacity (provide staff for three round-the-clock work shifts and equipment with very short notice) and design capability. Trevi's design, research and development (PRS/DRD) department played a substantial role in the "race against time" as both the jobsite and design activities were carried out almost simultaneously during the first phase of the work. From the start of the project, the PRS/DRD department worked with the client's technicians to create and develop design solutions.

The working operations at this site demanded great care because of the tight schedule and particular location. The project was in the city center, and it was desirable to minimize the impact of construction on the city residents. Moreover, November 4, 2016, marked the 50th anniversary of the Florence Flood,

President Mattarella visiting the site

which was caused by the Arno River when it burst the banks on the Lungarno Torrigiani, and there was a ceremony planned at the location.

The solution consisted of building a structure on the landside of the existing wall that was capable of completely replacing the damaged riverbank wall, which was to be kept in its original position and improved via ground treatment. This work ensured the safety of Galleria Poggi and the existing buildings, reduced pressures and stresses on the existing riverbank, improved hydraulic protection against the flooding of the Arno River, and restored the water pipeline and road traffic along the Lungarno. To operate under constantly acceptable safety conditions, the operating sequence was based on the principle of "progressively increasing structural stability and safety" of both the original and new work.

rods with cement grout injection were installed, (iii) loose soil below the base of the wall was recompacted, and (iv) the cracks in the historical wall were repaired by grouting and plastering using the cut-and-plug technique. For these operations, a service road was used on one side of the Arno River.

Eventually, a large retaining wall will be constructed adjacent to the Poggi Channel, which is a masonry tunnel about 16.5 ft (5 m) in diameter that runs parallel to the Arno River. The proposed wall will serve a double function: (i) it will protect and stabilize the tunnel itself and the buildings located in close proximity to the area affected by the instability, and (ii) it will support the expected 11.5 ft (3.5 m) deep excavation and create a level working platform from which the actual structural works will be performed. These works comprise two walls consisting of adjacent Trelicon piles about 24 in (600 mm) in diameter that will be located opposite from each other and connected to each other at the top with capping beams and cross beams forming a rigid frame. Another wall, which will support the frame in the cusp area, will be installed near the displaced riverbank wall, next to the existing wall supported by old wooden piles. Finally, to restore the road surface, a vertical retaining wall will be built close to the original historical wall to provide support and containment for the soil.

Trevi team with thank you banner

Based on surveys and soil investigations that were carried out soon after the event, the first activity involved constructing rigid inclusions to improve the soil, create a stable work surface for the equipment required for other activities, and consolidate the soil volume that was dislodged and displaced. For the improvement of the soil at the displaced and damaged wall, the following solutions were performed: (i) inclined foundation micropiles were embedded into the wall, (ii) self-drilling

Rigid Inclusions

In general, the word "inclusion" means a type of ground treatment that improves the strength of a soil mass through the insertion of elements that are composed of a material having better characteristics than those of the surrounding natural ground. The intention is to improve the overall mechanical characteristics of the treated soil. Inclusions are "rigid" when the material introduced into the ground has significant and permanent cohesive properties (concrete or cement mortar) and a significantly higher stiffness (500 to 5,000 times) than that of the surrounding natural ground. Typically, small to medium diameters (from 12 to 31 in [300 to 800 mm]) with low percentages of treatment (from 2% to 10% of the volume of soil) are employed, thereby ensuring high quality and consistency of the obtained product in terms of diameter and modulus of elasticity. With regard to execution, rigid inclusions can be constructed using displacement pile (Discrepile) or partial displacement, continuous flight auger technology. PSM-20, SM-405/8 and SM-30 micro drill rigs will be employed for the installation of the rigid inclusions. Soilmec, a Trevi Group company, designs and manufactures these drill rigs and other equipment for special foundation works.

For the work along Lungarno Torrigiani, the treated volume was the soil that was dislodged and displaced by the instability event, and was located between the current post-event ground surface and a depth of about 23 to 26 ft (7 to 8 m) from the original street level. For the elements that were inserted into a reworked, poorly-structured soil, the rigid inclusion columns were constructed using small-diameter drilling rigs that weigh between 22 and 28 tons (20 and 25 tonnes). The columns have a diameter of about 12 in (300 mm), a length of about 24.5 ft (7.5 m), and are made of a premixed mortar with a C30 strength class (4,350 psi or 30 MPa). The inclusions were installed in an almost rectangular grid pattern with a center-to-center spacing of about 3.3 ft by 3 ft (1.0 m by 0.9 m), which corresponds to a percentage of treatment of about 8% of the

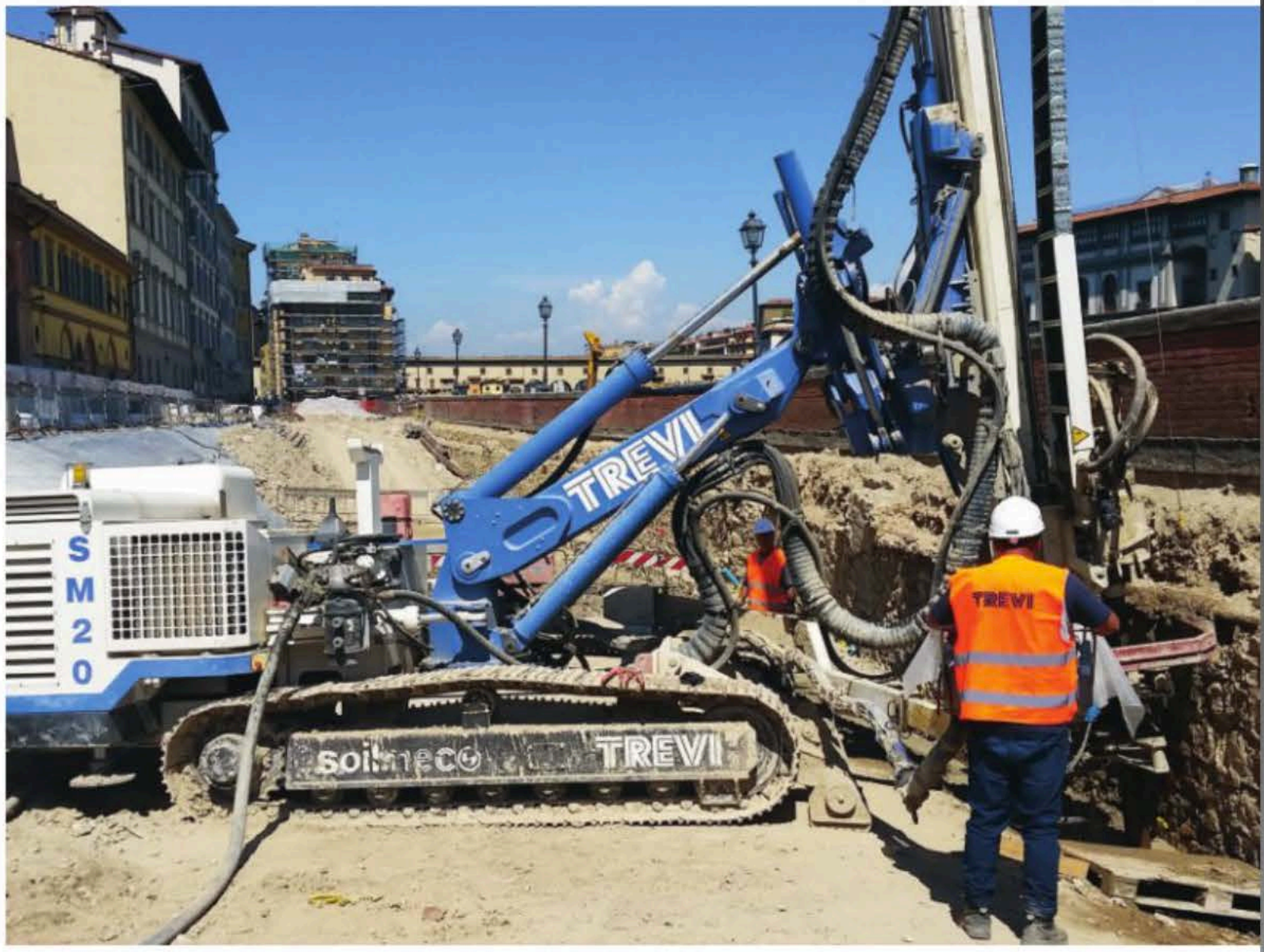
surface area and accounts for the presence of underground structures.

To reduce potential impact on nearby structures and the existing soil, the rigid inclusions were installed using the Trelicon technology, which allows a "dry" rotational drilling without vibrations and avoids the use of water or drilling fluids/muds that may loosen or further disturb the in-situ soil. The rigid inclusion columns were filled with cement grout during the extraction of the drilling rods to avoid decompression of the soil and to ensure constant stability of the borehole wall.

Completion

The work on the Lungarno Torrigiani was completed on November 2 and the inauguration took place on November 4 by the President of Italy, Sergio Mattarella. The President along with the mayor of Florence and a few ministers have visited the stretch of the newly-restored Lungarno and have met the Trevi team that performed the work and offered their compliments.

See a short video about the project at: **https://youtu.be/THpfdg3a_DY**



Wall repair at Lungarno Torrigiani