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No. M-4 SOIL CONSOLIDATION WORKS EFFECTED NEAR ELNE, FRANCE ON A BRIDGE OVER THE TECH RIVER
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The bridge, which forms the subject of the present report, is a stonework construction thrown over the river Tech between Perpignan and Port Vendres.

Its length of 143 yards, is composed of five arches, having an average span of 23 yards between the supports and thus reposes upon four piers laid out on the river-bed.

The abutments and two piers nearest the banks rest upon old foundations, executed in 1786 and laid out on pileworks whose points are enforced into a layer of soft limestone (thickness $1 \frac{1}{4}$ to $1 \frac{1}{2}$ yards) situated at about 26 feet beneath the present river-bed.

The two central piles rest on a foundation of lime-concrete, executed in 1877 and 1881, and which itself reposes upon the older pilework, with a slight tendency towards the right bank; this foundation was sunk into an enclosure of wooden stakes and piles, constructed at the same time as the foundation concrete at a depth superior to that of the soft limestone.

Already in 1893 cracks had been noticed above each of the bank piers. In 1895 these were repaired while reinforcing the abutments. Outliers were attached and this state of things continued until December 1932, between the 14th and 21st of which month a dangerous and prolonged rising of the Tech undermined the pier-foundations in an alarming manner.

A dangerous sinking of one of the piles followed and this sinking accompanied by a slight sliding of the whole pile toward the downstream caused the cracking of the two arches supported by it.

All access to the bridge by traffic was at once strictly forbidden, and a temporary road established over the river-bed upstream from the bridge, so as to permit of traffic circulation between Perpignan and Port Vendres.

Various methods for repairing the bridge were then studied and the one which was finally adopted as being the most practical consisted in a strengthening process by means of cement-injections under pressure.

Plan of Injections repairs: The problem created by the repairs necessary to the Elne bridge, comprised as already stated:

- 1) The strengthening of the two pier foundations which had subsided.
- 2) The consolidation of the fractured arches, in order to give them their initial resistance.

This double purpose was very economically attained by concrete injections into the pier foundations on the one hand, and into the brickwork on the other.

Bore-hole tests were carried out, first of all on the river-bed from the bridge downstream, so as to make certain as to what was the average elevation of the layer of soft limestone and the nature of the ground which had to be pierced in order to reach it.

The samples obtained during the tests showed that the ground to be passed through first consisted of alluvia, comprising relatively fine sand and shingle, then one or two layers of thin mud and silt and finally more compressed and rougher-grained sand and shingle, lying at a depth of between 21 and 25 feet on the layer of soft limestone.

These results and the laboratory tests tried on the samples made it possible to establish the following program.

- 1) At three yards from each pier-surface a circular series of bore-holes was to be pierced by means of vertical drillings and injected under feeble pressure by means of Lafarge's artificial liquid cement, in the general proportion of one part cement to one water.

These bore-holes would have to be begun by means of a rotary drill for piercing enrockments and continued through the gritty marl by bore-holes of the so-called instantaneous variety, worked by steel tubings with perforated lower sections, which are driven by a power hammer down to the point of resistance.

- 2) Inside the tubing thus obtained and under the pier itself, higher pressure current injections would have to be made by bore-holes of the same type, started likewise by the rotary drill so as to pierce through the foundation stonework, the object of these injections being to impregnate the sub-jacent sands and gravels with cement, so as to form a concrete prolonging the old foundation down to the good soil.

The Carrying out of repairs. These repairs were carried out according to plan. The outer drillings formed very satisfactorily an impermeable ring of bore-holes and allowed of high pressure injections under the piers themselves. The average depth of the drillings was from 20 to 26 feet; the injections were made at a pressure of 11 pounds by sections 3.2 feet high. Once the outer buckle was accomplished bore-holes were pierced through the cement foundation of the pier so as to inject the sub-jacent soil zones. The bore-cores obtained during the piercing of the stonework showed moreover that the old foundation was reduced to a concrete, all of whose pliancy had gone. Thus an injection into the foundation itself became necessary in order to replace by cement the old limestone pliancy which had been decomposed.

With this reserve the method applied was the same as for the execution of the outer buckle, though the injection pressure was raised from 11 to between 33 and 44 pounds. In order to assure the proper bonding of the pier foundations and stonework, a belt of oblique bore-holes, pierced by a perforating hammer, was injected by perforated tubes penetrating 7 feet below the stonework. The result of the above repairs was verified by check drillings and appeared highly satisfactory. The bridge has since undergone very violent floods without showing any trace of movement or cracking.