Sediment," U.S. Waterways Experiment Station Vicksburg, Miss.
6) "Recent Developments in Soil Testing Apparatus," Philip C. Rutledge, Bulletin No.165, Graduate School of Engineering, Harvard University.
7) "The Soil Mechanics Laboratory at Harvard University," Philip C. Rutledge, Paper No. A-25, Vol. II. Proceedings of the International Conference on Soil Mechanics and Foundation Engineering.
8) "Notes on Soil Testing for Engineering Purposes," Arthur Casagrande and R.E. Fadum, Bulletin No. 268, Graduate School of Engineering, Harvard University.
9) "Improved Soil Testing Methods," Glennon Gilboy, Engineering News-Record, May 21,1936
10) "A Comparison Between the Results of Loading Tests, Settlement Analysis Based on Consolidation Tests and Observed Settlements," Raymond F. Dawson, Proceedings of the Purdue Conference on Soil Mechanics and its Application, July, 1940.
11) "Research on Consolidation of Clay," Donald W. Taylor, Serial No. 82, Department of Civil and Sanitary Engineering, Mass. Institute of Technology, August, 1942.
12) "Influence Charts for Computation of Stresses in Elastic Foundations," Nathan M. Newmark, Bulletin No. 338, Eng. Experiment Station, University of Illinois, No., 1942.
13. "Theoretical Soil Mechanics," Karl Terzaghi, John Wiley and Sons, Inc., New York, 1943.
14) "Undisturbed Clay Samples and Undisturbed Clays," Karl Terzaghi. Journal of the Boston Society of Civil Engineers, July, 1941.
15) "Foundation Problems in Texas," Willard E. Simpson, The Texas Engineer, November, 1934.
16) "Settlement Records of the Gulf Building," Willard E. Simpson, Proceedings of the Seventh Texas Conference on Soil Mechanics and Foundation Engineering, 1947.
17) "Settlement Studies on the San Jacinto Monument," Raymond, F. Dawson, Proceedings of the Seventh Texas Conference on Soil Mechanics and Foundation Engineering, 1947.

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SUB-SECTION VI b

MEASUREMENTS OF STRESS DISTRIBUTION IN THE CONTACT FACE

VI b 2 FULL SCALE MEASUREMENT TEST OF PRESSURE ON THE SUB-SOIL OF A BRIDGE PIER

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SUMMARY OF THE FRENCH REPORT

This paper gives an account of the tests made in 1942, during re-building of the BRENIER-CORDON bridge over the Rhone, for previous measurement of the actual pressure exerted on the sub-soil by the piers, and the resulting settlement.

The nature and characteristics of the compressible marl of practically indefinite depth, composing the foundation, were determined by soundings and systematic tests.

Had it been assumed that the load would bear entirely on the base of the piers, the settlement, calculated by conventional methods, would have been so important as to be inacceptable; but the marl was covered by a very thick layer of sand and gravel. On the one hand it was legitimate to assume that Archimedes' upward thrust principle would hold good throughout the marl and unburden the foundation soil.

To estimate the importance of these two factors, it was decided, when one of the piers was rebuilt, to load it with a weight equal to that which it would have, in future, to bear and to maintain this load during a sufficient length of time. The test was carried out and the load was left in place during 18 months.

When the pier was constructed two contrivances were put into position; the first to measure the upward thrust (Archimedes' principle) exerted through the sub-soil on the base of the foundation. The second, composed of two cells filled with water, in contact with the marl and connected to gauges for the measurement of vertical and horizontal pressure sustained when the structure was in place.

The cells used had rubber envelopes similar to those of the cells used by the Laboratoire du Batiment et des Traveux Publics, for tests in clay, in the neighbourhood of Provins.

Once the cells had been put into position at the bottom of the caisson used to build the pier, their proper working was checked by causing the pressure of the compressed air in the chamber to vary. This test showed that the cells faithfully reproduced the pressure values.

During the eighteen months of the load bearing test, the sinking was measured to with-

in one half of a millimetre. Instead of the settlement of 33 cm. (13 inches) given by calculations, leaving out of account the Archimedes' principle and the lateral friction on the pier the registered settlement was in the neighbourhood of 3 cm. (1 1/4 inches).

The piezometer placed at the base of the structure showed that the Archimedes' upward thrust was wholly exerted through the clayey layer. Meanwhile the cells made it possible to measure the load transmitted by the pier to the ground. This load was in agreement with the settlement of a few centimetres, as registered. Finally it was possible to compare the load transmitted to the ground by lateral friction (difference between the total load applied and the maximum load transmitted by the base of the pier) with the ultimate resistance to lateral friction given by the conventional formulae; the values arrived at were much lower.

Generally speaking, the results of the different measurements and observations agreed satisfactorily and gave every assurance as to the future behaviour of the structure.

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SUB-SECTION VIc

INFLUENCE OF GROUNDWATER

VIc 4 THE SINKING OF SHAFTS AS A CAUSE OF SETTLEMENT

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It is evident and a well-known fact that the lowering of the piezometric level of underground water causes settlement within the sphere where this process takes place, because the ground layers emerging from the underground water increase in weight owing to the lack of uplift. There are cases, where the lowering of the underground water level takes place unnoticed, so that the settling process is also not noticeable, and its causes are not properly recognized and therefore contested in practise. This is the case particularly with such clay layers, where an actual piezometric underground water level does not exist as capillary rise is considerable, and there is nothing but a surface along which the tension in the pore water are Nil. However, a change of the altitude of this theoretical water level, which might be called "No-Pressure-Surface", also causes locally a lack of lift as is the case when lowering the piezometric level proper, and this takes place immediately and within a wide sphere, because in this case we have to deal merely with an alteration of the tensions in the pore water. The following case, which the author has experienced himself, may serve as an example: In the coal district of Morasvska Ostrava a conveying shaft having a Ø of 8 m was sunk through entirely homogenous and "dry" clay without the necessity of any mine-drainage. Under the clay, and in a depth of about 100 m there was a thin layer of quicksand, which had been prospected with 4 boreholes in the immediate neighbourhood of the shaft. The boreholes had to be telescoped twice so that only the innermost tubing reached as far as the quicksand, thus forming a sort of "depth gauge". Before work in the shaft was begun, pumping tests were carried out in the quicksand for which purpose the inner tubing was somewhat raised and connected with the outer tubing by means of a clamp.
In the course of the work in the shaft the innermost tubing was raised from within the outer

tubing, so that in the course of 6 - 8 months the clamp was 40 to 50 mm above the upper edge (see illustration). This very considerable settlement is caused by the fact that the "No-Pressure-Surface" performs a downward movement together with the bottom of the shaft, which amounts to a lowering of the underground water level, and it causes very considerable axial strain upon the walling of the shaft, which is not taken into consideration. Mine surveying operations carried out within the district showed that cones had formed in the neighbourhood of the already existing shafts, which shows that the shaft walling absorbed the frictional forces of the settling ground layer, thus preventing settlement in the neighbourhood of shafts at least to some extent.
The question relating to the sphere within which the lowering of the "No-Pressure-Surface" is