REINFORCED PILE FOUNDATIONS FOR BLAST FURNACES.*

By Armand Baar.

THE question of foundations often plays an important part in iron and steel works, where engineering skill requires to be exercised with special care, in view of the responsibilities which devolve upon the engineer when erecting heavy plant on a poor subsoil. The frequency with which such poor subsoils occur in works is due to three causes: (1) The price of land often compels the utilization of certain areas hitherto undeveloped, owing to their unsuitability for building purposes. (2) The need of a water supply for steam engines often necessitates a works being installed close to a river, which by the gradual shifting of its bed, may have undermined the adjoining areas. (3) Lastly, the production of dump heaps for the embankment of railway junctions require constant filling up with debris either as simple ash-shoots, or by the tipping of slags from blast furnaces into mounds which often attain a height of 65 ft., and upon which it is dangerous to install machinery in motion owing to the lack of stability of the foundations.

In Belgium in particular, as well as in the North of France, and in the Grand Duchy of Luxemburg, a new system of foundations known as Franki piles is being employed with considerable success in most of the big works. The principle is, briefly, as follows: A conical perforator armed with a hard steel point is driven into the ground by the help of a pile-driver. This perforator carries with it telescopic tubes which serve as tubbing, and have an average diameter of 2 ft. The perforator thus passes through the hardest ground. An instance may be adduced at Ougrée, where the process has been applied on a slag tip 30 ft. in height, and consisting entirely of slag blocks from a basic steel works, of a size extending to about 80 cu. ft. each. Reference may also be made to instances where the ground has been exceedingly soft and highly water-bearing, as at the Courrières Collieries, where the soil consists of peat and water-bearing sands, and where three bridges have been erected. The object of the system is to bore through the overlying ground until a solid foundation of clay or gravel is encountered.

The perforator is then withdrawn and replaced by concrete, which is rammed down by degrees as the tubes (commencing with the lowest) are withdrawn. By means of the ram the concrete is compressed so as to press against the sides of the bore-hole and to consolidate them, until ultimately the bottom is enlarged and a cone obtained, pressing against the side walls of the cavity.

Amongst applications of this process which may be referred to, one of the most interesting was the strengthening of No. 2 blast furnace at the Esch-sur-Alzette works of the Société des Aciéries Réunies de Burbach-Eich-Dudelange in the Grand Duchy of Luxemburg, and its supercession by a furnace of twice the size.

The masonry batter of this furnace rested on gravel 14 yards below the level of the soil, and the ground had been packed up entirely with goaf of an inferior description. Several break-outs from the furnace had, however, penetrated the packing at different times, and it was feared that lumps of metal might be encountered at several points, which actually happened later.

Forty-one piles were driven, each calculated to sustain a load of 70 tons, and in order that the concrete arch, which had to rest simultaneously on the batter and on the pile itself, should distribute its load uniformly, there was placed, above the masonry, a layer of granulated crystalline slag 4 in. thick, mixed with a little cement, so that if, under pressure, the fresh cement should spread, any further increase in the load would bear upon the crystalline slag and further compress the latter by crushing it, after which the injection of water at the bottom would finally mortar the arch to the masonry, by the action of the cement originally introduced as an addition, with the dust of the powdered slag.

The furnace is in full working order, and the method of construction has been perfectly successful, and shows no sign of settlement.

Another interesting application of Franki piles was made in erecting the rolling mills of the Ougrée Marihaye Company. On a tip composed entirely of slag blocks to a height of 30 ft., resting on 15 ft. of bad subsoil, these mills work 35 ft. above the level of the Meuse gravels. The whole plant, including mills, buildings, gas producers, etc., rests on 180 piles, which were driven through this thick layer of slag. Not a single pile had to be left unfinished during boring, and the whole of the work proceeded without interruption.

The Athus-Grivegnée Company has erected a similar plant at Athus, under analogous conditions, but in this instance the piles are only 30 ft. long. Franki piles have also been most satisfactorily employed as foundations for gas engines at the works of the Société Métallurgique de la Basse Loire, at Trignac (St. Nazaire), at the Aciéries de Micheville in Meurthe-et-Moselle, and at the works of the Société des Hauts Fourneaux de la Chiers at Longwy.

It may also be interesting to add that before constructing the foundations of the Ougrée Marihaye rolling mill plant, the company carried out a test on a Franki pile, which was loaded with a charge of 473 tons.

Discussion.—Mr. Andrew Lamberton, Coatbridge, said that the subject was a very interesting one, but he would like the author to give some additional information with regard to the stiffening up of insecure foundations. It was largely a question of cost. He would like to know what was the time taken to put down a pile of about 3 ft. in diameter through 30 ft. of solid basic slag, and what was the cost; also whether there was any difficulty in withdrawing the tubes, which he would expect to find was the case. The paper contained a cross-section of a pile which had been put down, and it was obvious that the tubing was much less in diameter than what the slag pile was depicted as being, that diameter being reached by filling in concrete in the metal tube and hammering it down till it expanded. There seemed to be some difficulty about that, and in getting a section resembling that shown in the illustration. A good deal appeared to depend upon the porosity of the material and the number of fissures present, while the concrete might get out of the true line of the pile. The method described was certainly ingenious, and if it could be done satisfactorily and was commercially sound the author would have accomplished a smart thing in engineering.

M. Baar, in reply, said that the cost of driving was about $10.00 per yard in hard soil and about $5.00 in easy soil. With regard to the time element, they had put down one pile per day of 12 hours to a depth of 49 ft., and in the case of one big contract a thousand piles had been put down.

Later, by letter, he replied in respect to a suggestion of simply consolidating the ground by an injection of

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