ISSN: 2643-6876
Current Trends in
Civil & Structural Engineering
DOI: 10.33552/CTCSE.2022.09.000708
Iris Publishers

Review Article

Concrete for Drilling and Injection Piles ERT

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Received Date: September 26, 2022
Published Date: October 20, 2022

Abstract

The cross-sectional strength of concrete in injection piles is a fundamental indicator for determining its bearing capacity on the ground and on the body. Electric discharge technology allows to increase the strength of fine-grained concrete. At the same time, it can exceed the strength of untreated concrete by the electro-hydraulic method by 40÷50%. An important role in the process of gaining the strength of concrete is played by compliance with the technological regulations for the manufacture of piles-ERT. In geotechnical construction, there are very frequent cases of non-compliance of the strength of concrete of finished piles with design values. Below in the article is a case from geotechnical practice.

Keywords: Strength of fine-grained concrete; Drill piles; Electric discharge technology; Piles-ERT; Fine-grained concrete mixture (BSM); Pavability

Introduction

The construction of any structure involves operational technical quality control of construction, which allows to ensure the safe operation of the object under construction. Of particular concern is the quality of manufacture of drilling piles. It is known that the technology of manufacturing drilling piles is a complex technological chain consisting of drilling, concreting and reinforcing the shaft. If we consider the drilling pile, made by the electro-hydraulic method (piles-ERT), then the electro-hydraulic treatment of the walls of the well in the body of freshly laid concrete is added to the technology of its manufacture. For pile-ERT, the technological circuit looks like: "drilling a well - concreting - electrohydraulic treatment - reinforcement of the shaft". This article discusses the impact of the quality of the concrete construction of the trunk on the bearing capacity of the pile.

Discussion

Below is an example of an algorithm for selecting the composition of a fine-grained concrete mixture (BMS) for the manufacture of pile-ERT. One of the stages of construction design of reinforced concrete shaft structures of a drill-injection pile-ERT is the selection of the composition of a fine-grained concrete mixture (BSM) according to GOST 7423-2010 "Concrete mixtures. Specifications".

The algorithm for selecting the composition of the BSM is presented in the following sequence:

According to the values of the design bearing capacity of piles-ERT Fd on the ground, the class (brand) of concrete for compressive strength is assigned. At the same time, according to GOST 26633-91 "Heavy and fine-grained concretes", the average strength of concrete is laid at a coefficient of variation V = 13.5%, the security of at least 95% of the assigned value. For example, with the design brand of fine-grained concrete M400, the value of cubic strength shall be R= 38.5 MPa (392.5 kg/cm^2).

According to GOST 7473-2010 "Concrete mixtures. Specifications" selects the brand for the pavability of the concrete mixture P and the mobility index (cone sediment).

For example, the symbol P4 means a cone sediment of 20 cm.

Hardening conditions are prescribed. At the base below the freezing depth, the hardening conditions are natural. When carrying out geotechnical work in conditions of negative temperatures, either chemical hardening using sodium formate or an electric method of heating with the help of heating wires is used. It should be noted that electric heating from the experience of work is undesirable. Perhaps the occurrence of shrinkage cracks in the body of concrete as a result of a rapid set of strength and, as a result, the separation of part of the pile-ERT heated from the part hardening naturally.

Components for fine-grained concrete are selected - cement, fine aggregate, additives to concrete and water.

Portland cement, as a rule, is supplied to the site from the nearest cement plant. In the Middle Volga region, cement produced by MORDOVCEMENT OJSC is used. According to GOST 31108-2003 "General construction cements", the controlled parameters are: 1) compressive strength at the age of 28 days R = 50 MPa; 2) normal density of cement dough 27%; 3) setting time: beginning 2 hours 35 min, end 4 hours 25 min; 4) true density ρ = 2.63 g / cm^3.

Natural river sand according to GOST 8736-2014 "Sand for construction works. Specifications (with Amendment)" with a model of size not more than Mk = 2.0. The percentage of fractions larger than Mk2.0 mm and the density of mineral particles ρ≥s are determined.

Additives are used to increase the strength of concrete and increase mobility. For example, the additive EMBELIT 8-100 is a concrete modifier according to TU 5870-176-46854090-04, manufactured by LLC "Enterprise Master Beton" in Moscow, which is both a plasticizer and a modifier.

Water is also subject to special requirements in accordance with GOST 23732-79 "Water for concretes and mortars".

1. In the construction laboratory under the assigned strength, mobility, workability, hardening conditions according to GOST 27006-86 "Concretes. Rules for the selection of the composition of concrete" are designed: 5.1. Water-cement ratio, e.g. V/C = 0.51, where V is the mass of water; 5.2. The ratio of materials by mass, for example, C: P = 1: 2.1, where the C -mass of cement; P – mass of sand; 5.3. The content of additives in % of the mass of cement, for example, the content of EMBELITE 8-100 = 10; 5.4. Consumption of materials per $1m^3$ of concrete mixture; For example, one of the objects used: cement - 850 kg; sand – 810 kg; additive EMBELIT 8-100 – 85 kg; water – 465 kg. In addition to the characteristics of the nominal composition of fine-grained concrete, the composition selection algorithm provides a section of the actual possible consumption of materials per $1m^3$ of the concrete mixture.
2. The physical and mechanical properties of concrete, mandatory to confirm the correctness of the selection of the composition at the facility, are the average density of concrete in a series of samples measuring 10×10×10 cm, ρ [g / cm^3] and the compressive strength at the ages of 7 and 28 days.

Next, a case from construction practice is considered. The project for the ten-storey building of the hotel provided for the installation of drill-injection piles manufactured using electric discharge technology (ERT). This technology includes drilling, concreting, electro-hydraulic treatment, reinforcement and refilling of concrete. Due to the fact that these stages of work were performed by four contractors and there was no proper phased control of the set of strength of concrete, the technological cycle was disrupted and more than 50% of the piles did not reach the design bearing capacity. Therefore, it became necessary to redesign the pile field. The construction of the facility was carried out in difficult engineering and geological conditions in the old channel of the Volga River. The geological section at this site is represented by the following engineering and geological elements (IGE) (from top to bottom) (Figure 1): IGE-1 - bulk soil (undisturbed loam with loam and construction debris); IGE-2 – non-shrinkage tight and soft-plastic loess loam; IGE-3 – non-shrinkage fluid-plastic loess loam; IGE-4 – tight and soft-plastic loam; IGE-5 – hard and semi-solid variegated clay; IGE-6 is a clay polymyctic sand.

The construction site is characterized by a high level of groundwater (non-pressure) water. The construction of the facility was started 5 years before the start of the main construction with the construction of the fence of the pit (9.0 m deep) from two rows of drill injection piles with a diameter of 450 mm with a pitch of 1.0 m. Directly adjacent to the pit is a 10-storey large-panel residential building, built on hammered piles. The disadvantage of the built fence was the lack of a monolithic strapping reinforced concrete belt on top of the drilling piles. This was revealed only by a fragment of the pit. A row of fencing piles on the side of the adjacent building leaned towards the pit (maximum horizontal movement reached 55 mm). As a result of this situation, deformation cracks appeared on the outer walls of the residential building. At the same time, the installed plaster beacons exploded and continued to tear.

The emergency commission established in this regard instructed the lead design organization to urgently develop emergency measures to stabilize the deformations of both the erected retaining wall and the adjacent building. As such measures, a scheme was developed to strengthen the retaining wall in the form of spacer structures made of pipes with a diameter of 1,000 mm, located on two levels in mutually perpendicular directions (Figure 2). These measures made it possible to stabilize the situation. Plaster beacons on the residential building stopped tearing, horizontal movements of the retaining wall were suspended. At the same time, geotechnical monitoring continued.

With the design depth of the pit of 9.0 m, the spacer fasteners were placed at a depth of 4.5–6.5 m. Therefore, in order to avoid negative consequences for the adjacent residential building during the further excavation of the pit, a project was developed for the installation of monolithic reinforced concrete buttresses on additional ERT drill-injection piles with a diameter of 0.35 m and a length of 12 to 19 m, depending on the engineering and geological conditions in one or another part of the construction site. Work on the installation of ERT piles had to be carried out in very difficult conditions between the pipes, and the removal of soil from the pit was carried out only manually. To ensure the safe operation of the retaining wall during the construction of the zero cycle, as well as to create conditions for the dismantling of steel pipes of spacer structures, an algorithm for the installation of buttresses was developed. The implementation of the above algorithm made it possible to gradually dismantle the spacer pipes. No further deformations of the retaining wall and the apartment building were detected. The construction of drill-injection piles-ERT [1–14] for the foundations of buttresses, buttresses, as well as the rostwerks themselves were produced by one contractor. At the same time, monitoring of horizontal movements of the retaining wall and deformations of sedimentary grades of a residential building was carried out daily, so that there were no violations in the technological chain “drilling - concreting - electrohydraulic treatment of walls and the heel of the well - installation of reinforcement frames” at this site. Mandatory stages that confirmed the compliance with the project of the designed ERT piles for the foundations of the buttresses were:

a. strength tests of pre-made cubes of fine-grained concrete intended for the manufacture of piles, according to the algorithm given above.

b. static load testing of experimental ERT piles.

At the test site (within the buttresses manufacturing site), two pile bushes were made using electric discharge technology. In one of them, the piles were made without widenings, and in the other - with multi-seat widenings (see Figure 1 for the vertical binding of piles). The results of tests of the bearing capacity of pile-ERT using a static load are shown in Figure 3. As the spacer structures were removed, a significant part of the pit area was freed up for the pile field. In connection with the reduction by the investor of the construction time of the building, the customer decided to increase the speed of construction of the zero parts, dividing the device of drill injection piles of ERT into stages. At the same time, one construction company contracted to perform drilling operations, another - concreting with fine-grained concrete, the third - electro-hydraulic treatment of the walls and heels of the well, the fourth - the manufacture and immersion of reinforcement frames in finished wells filled with fine-grained concrete and processed by electric discharge technology.

Accordingly, the quality of work at different stages was controlled by different contractors and, as a result, the probability of its reduction increased dramatically. The results of static load pile tests confirmed these concerns (Table 1). For more than 50% of the piles tested, the design load capacity was not achieved. The main reason for this was the low strength of fine-grained concrete due to the lack of proper supervision of its set. It should be noted that one of the contractors responsible for concreting the piles used the RM-750 concrete mixing unit, which saturates the concrete with air at high speeds, which led to a shortage of design strength values. At the same time, the selection of the composition of the BSM was made correctly (Figures 1-3) (Table 1).

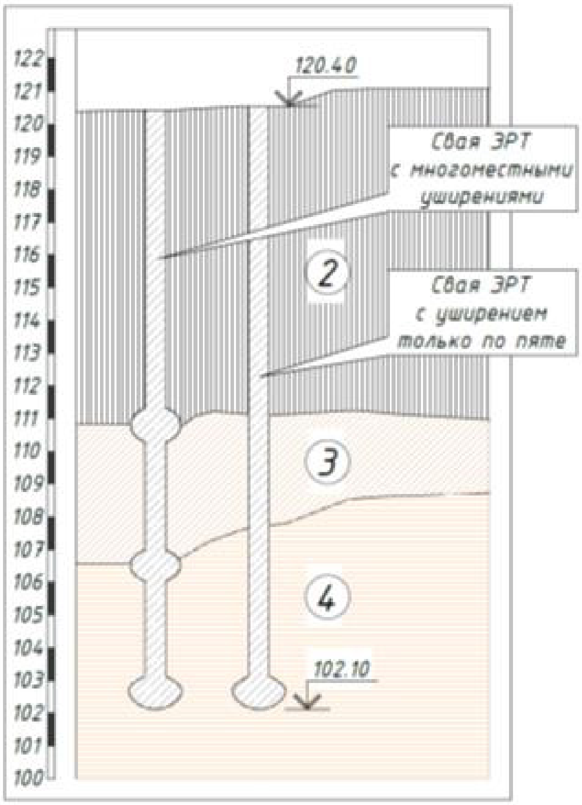

Figure 1: Engineering and geological section of the test site and piles made by electric discharge technology, with multi-seat widenings (left) and only with a widened fifth (right). Vertical left axis - elevation marks, m.

Figure 2: Fragments of the executed buttresses.

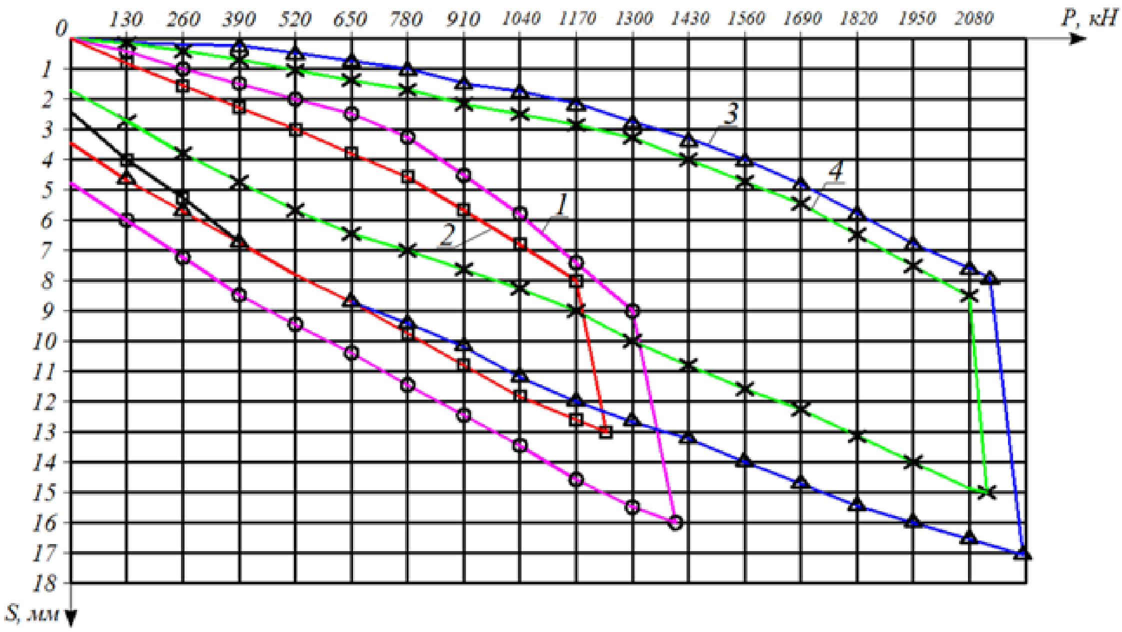

Figure 3: Graphs of the results of static load tests of ERT piles: 1, 2 - only with a widened fifth; 3, 4 - with multi-seat widenings. Letter designations: P – load on the pile; S – vertical movement of piles.

Table 1: Static load ERT pile test results.

№ Piles	Carrier ability F_d, кН	Calculated load N, кН	Strength Concrete body piles, kPa	The reason for the insufficient Bearing capacity of piles
789	62,8	52,3	60	low strength of concrete
710	75,9	63,3	65	
579	95,0	79,1	78	
822	251,2	209,1	1 200	pile breaking
728	565,2	471,0	2 500	
767	376,8	314,0	2 600	
803	251,2	209,3	1 300	

Citation: Sokolov NS*. Concrete for Drilling and Injection Piles ERT. Cur Trends Civil & Struct Eng. 9(2): 2022. CTCSE.MS.ID.000708.
DOI: 10.33552/CTCSE.2022.09.000708.

To ensure the design bearing capacity of rostwerks with defective piles, it was decided to supplement them with piles with multi-seat widenings. The entire pile field (and all the rostwerks) was redesigned taking into account the results of tests of experimental piles for their bearing capacity. Thanks to this, it was possible to ensure the design bearing capacity of the entire foundation of the building as a whole.

Conclusion

In conclusion, I would like to emphasize that due to the implementation of various stages of work on the installation of piles-ERT, four contractors did not ensure the necessary phased control of their quality and additional material resources were spent to correct the negative consequences. To ensure the reliable operation of the structures under construction, customers and contractors should not allow such situations to occur.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

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