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Feasibility for the implementation of cement piles

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Abstract. The article considers the technical and economic efficiency of the construction of pile foundations by the mixing method with mechanical activation of soils. Various designs and technologies for the construction of pile foundations are analyzed. The main most promising technological processes for the manufacture of pile foundations are described. The advantages of constructing pile foundations by a mixing method with mechanical activation of soils are substantiated. The results of calculations of comparing technical and economic indicators for the construction of types and designs of foundations are presented. Conclusions and recommendations on the construction of foundations of low-rise buildings are given.

1. Introduction

The durability and trouble-free operation of buildings and structures are largely determined by the design and production technology of foundations and foundations in the construction of industrial and civil construction. A variety of options for the construction of foundations and foundations expands the possibilities of optimizing construction on the "zero cycle" [1 - 7]. Significant cost reduction in the development and construction of foundations of buildings and structures allows the use of pile foundations, the implementation volume of which is increasing every year.

The construction and construction of pile foundations depend on the type of soil, the shape and size of construction sites. It is very important to have reliable and complete information about the properties of soils at construction sites. For the construction of pile foundations, it is most advisable to use local building materials reinforced with binders, for example, cement. However, a variety of climatic, soil, and hydrological conditions place increased demands on the physicomaterial properties of cement-reinforced soils. In addition, low frost resistance is another drawback of cement primers, which significantly reduces the operational reliability of the upper part of the foundations and foundations of buildings and structures. The strength characteristics of cement soils are also affected by the degree of grinding of the soil component before adding it to the cement and soil mixture and obtaining a new binder for cement pile installation using the mixing method [8 - 13].

Only a comprehensive study of the processes occurring in cement soils will increase the manufacturability of the construction of pile foundations made on the basis of cement soils. The choice of the optimal composition of the cement-soil mixture in the interests of increasing the manufacturability of pile work taking into account the increase in their frost resistance requires complex studies. Improving the technology of the construction of cement piles using mechanical activation allows us to meet the needs of the construction industry in cheap building materials based on local soils.



2. Materials and methods

When developing land under construction sites that were not previously built up due to the complexity of engineering and geological conditions due to heterogeneity of soils. Design organizations are increasingly using piles in the construction of foundations of buildings and structures.

Recently, various designs and piling technologies have been used. Factory-made piles were widely used: screw, driven, and other designs.

There are various technologies for making piles directly at the construction site. Consider one of these technologies in Figure 1.

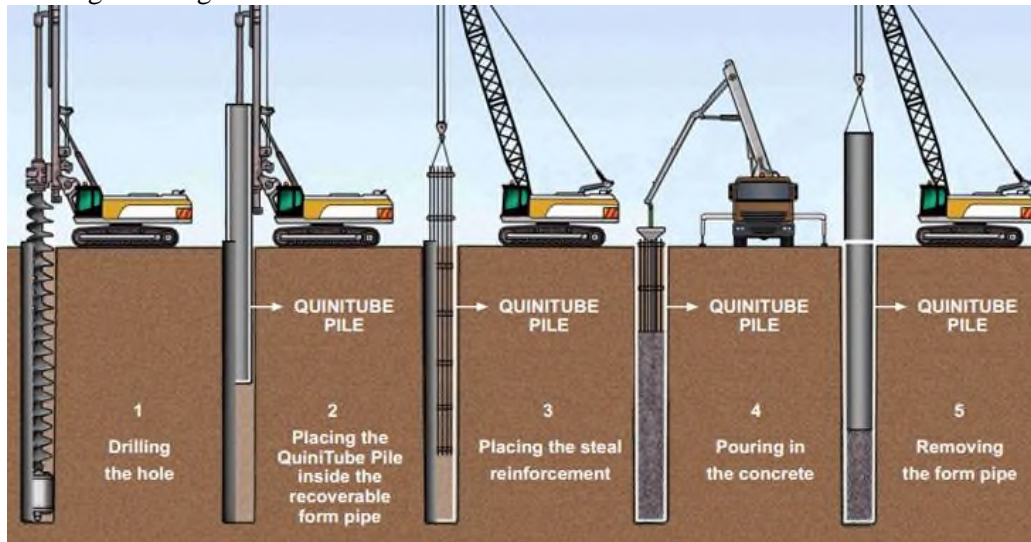


Figure 1. Manufacturing technology of the pile foundation at the construction site.

The manufacturing process of the pile foundation at the construction site, shown in Figure 1, consists of five stages. At the first stage, the drilling rig forms a well in the ground under the future pile. At the second stage, a pipe of the corresponding diameter, which serves as the formwork, is immersed in the well obtained at the first stage of the technological process. At the third stage, a steel reinforcing cage is placed in the pipe. At the fourth stage, the steel reinforcement cage is poured with concrete mixture. The concrete mixture is sealed with a vibrator. Without waiting for the curing of the concrete mixture, not the fifth stage, a pipe is removed from the raw concrete solution. After curing the concrete mixture, the resulting pile is ready for the further construction of the foundation.

The advantages of the considered technology for manufacturing a pile foundation include:

- the ability to build the foundation of a building under construction or structures near existing buildings, as this technology belongs to the category of unstressed;
- the foundation obtained by this technology has a large bearing capacity;
- there is the possibility of building the foundation for this technology in any soil conditions.

The disadvantages of the considered technology for manufacturing the pile foundation are the need for heating the concrete mixture in winter, so concreting occurs in the field, and the complexity of controlling the quality of well formation.

However, during the construction of buildings and structures, especially on heterogeneous soils in difficult engineering and geological conditions, pile foundations account for approximately 25% of the total volume of constructed foundations. Therefore, research to improve the technology of their construction today is very relevant. Especially technologies that, while ensuring the strength and reliability of pile foundations, reduce the complexity and cost of manufacture.

One of the most promising methods of constructing pile foundations is the mixing method [1]. The drilling mixing method of constructing pile foundations allows fixing all types of structurally unstable

and weak soils regardless of their moisture and the location of the groundwater horizon. The mixing method is quite economical, thanks to:

- the use of local soil piles as part of the material;
- low cost of the process;
- a high level of mechanization of work;
- the prospect of fixing soils under the object under construction, such as filler soils of any moisture and activity, clay flowing and fluid-plastic soils, as well as loose water-saturated sands.

This method is characterized by environmental cleanliness and the possibility of application, both for the construction of foundations of new buildings and structures, and for the reconstruction of existing ones.

Many years of experience in strengthening soil confirms the need to improve methods for improving the properties of cement-soil pile foundations [1]. One of them is the method of mechanical activation of soils, which allows to reduce cement consumption and increase the strength of cement-pile foundations.

A drilling mixing method for constructing pile foundations with mechanical activation of soils can be implemented by using drilling mixing machines, drilling rigs, as well as hollow drill rods providing for the forced supply of the drilling composition (Figure 2).

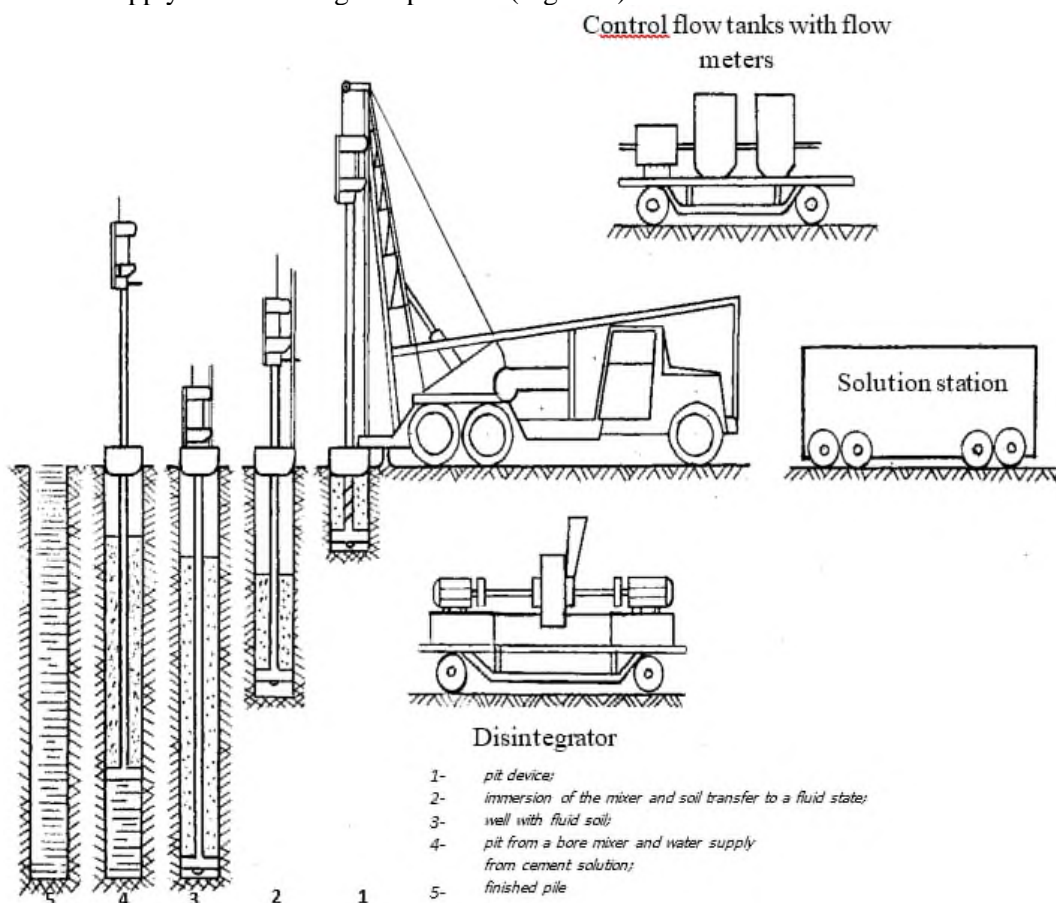


Figure 2. The technological scheme for the manufacture of cement piles by the mixing method using mechanical activation.

The technological scheme for the manufacture of cement piles by the mixing method using mechanical activation of the soil consists of the following operations (Figure 2):

- 1) pit device;
- 2) immersion of the mixer and transfer of soil to a malleable state;
- 3) Filling the well with a soil of viscous consistency;
- 4) Deepening of the mixer and the supply of water-cement mortar.

The pit device is drilled by a receiving well with a diameter of 0.1 meters greater than the diameter of the piles being constructed and a depth of 0.5 - 2 meters, depending on the length of the future pile and the physical and mechanical properties of the soil. The receiving well is designed to receive the excess cement-soil mixture that arose when water and cement were pumped into the ground. The soil extracted from the well is used to prepare a mechanically activated cement-soil mixture. Depending on the physical and mechanical properties of the soil and the amount of binder introduced, determine the depth of the well.

The immersion of the mixer and the transfer of soil into a malleable state is performed by drilling the soil with a paddle mixer and water supply to transfer the crushed soil into a malleable state.

A well is filled with a soil of a viscous consistency by supplying water when the mixer is immersed in the soil. In this case, two processes occur simultaneously: cutting the soil and its moistening to a malleable state.

The boring mixer is deepened and the water-cement-cement mortar is supplied by removing the boring mixer with the simultaneous supply of the water-cement mixture in the required volume for the estimated amount of cement to enter the ground mass.

The construction of a pile foundation in fluid mixtures, compared with plastic ones, reduces the immersion and removal times of the mixer by three times by increasing the speed to 130 rpm and reduces the cutting force of the soil by two to three times. And also, the development of the soil with a mixer with the supply of a given volume of water to the well to transfer the soil to a malleable state allows you to get the soil of the required degree of grinding.

The main advantages of the drilling mixing method for constructing pile foundations with mechanical activation of soils are the use of local soil extracted directly from the well as the material of the piles, and the possibility of installing piles near existing foundations and other underground structures without damaging them.

3. The results of the research

As mentioned above, the main reason for the high efficiency of the construction of pile foundations by the mixing method with mechanical activation from cement soils is the use of local soils as the main material, from which it is possible to obtain materials with high strength characteristics. This is especially true for areas poor in stone building materials, and such areas make up 15% of the territory of the Russian Federation. Therefore, the use of local soils as the main material for pile foundations in the formation of cement gives a real practical advantage.

The production of cement piles by a mixing method based on a mechanically activated binder ensures high economic efficiency due to the consumption of cement, which is the main expensive component.

At the first stage of research, a comparison was made of technical and economic indicators for the construction of strip foundations from precast concrete blocks and foundations on cement mixing piles with a precast grillage. Calculation diagrams are presented in figures 3 - 7.

When performing the calculations, the technical and economic indicators are given per linear meter of the walls of low-rise buildings with strip foundations of precast concrete blocks and foundations on cement mixing piles with precast grillage at a load of ten tons per linear meter.

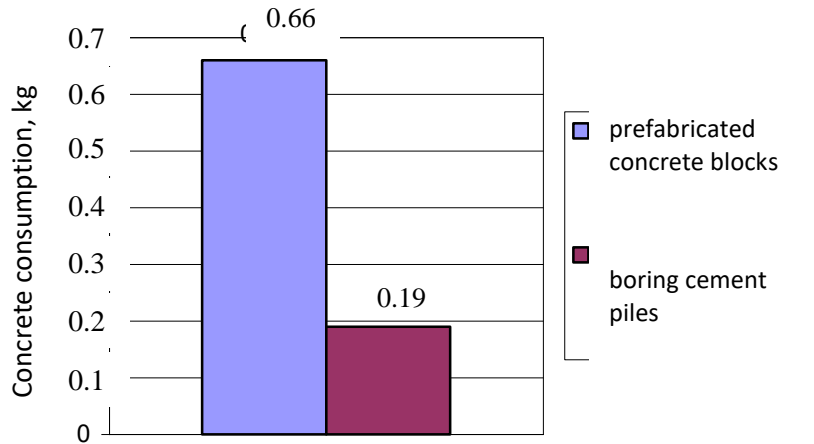


Figure 3. Concrete consumption during the construction of strip and pile foundations.

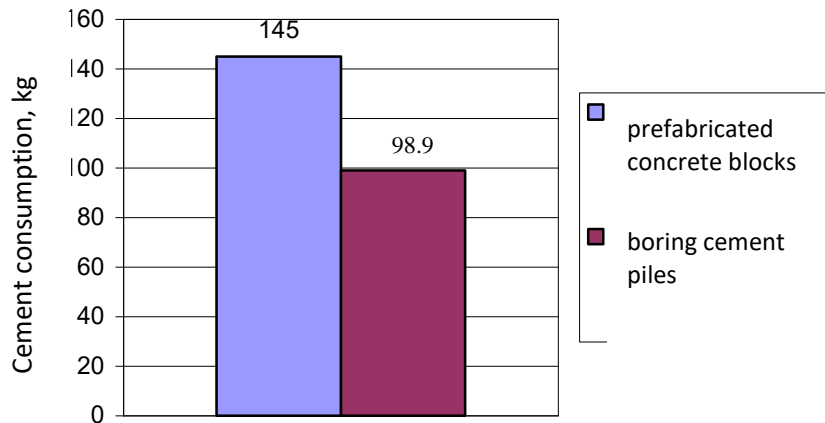


Figure 4. Consumption of cement during the construction of strip and pile foundations.

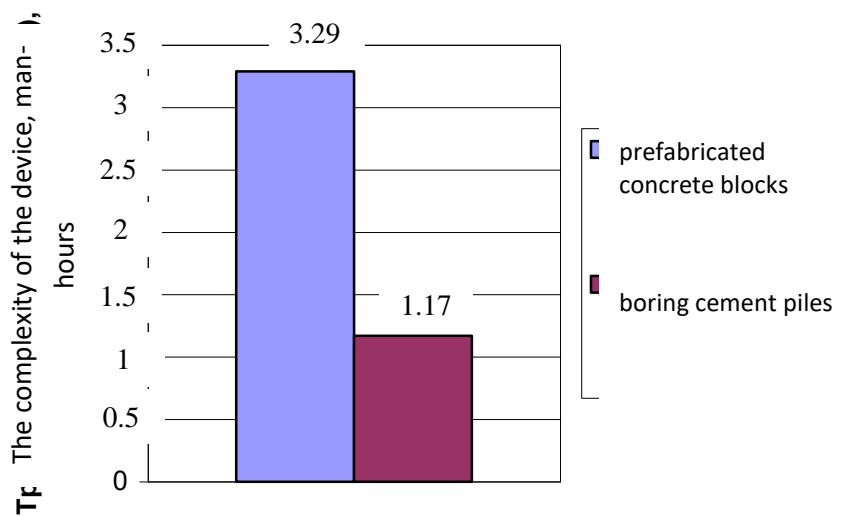


Figure 5. The complexity of mounting the tape and pile foundations.

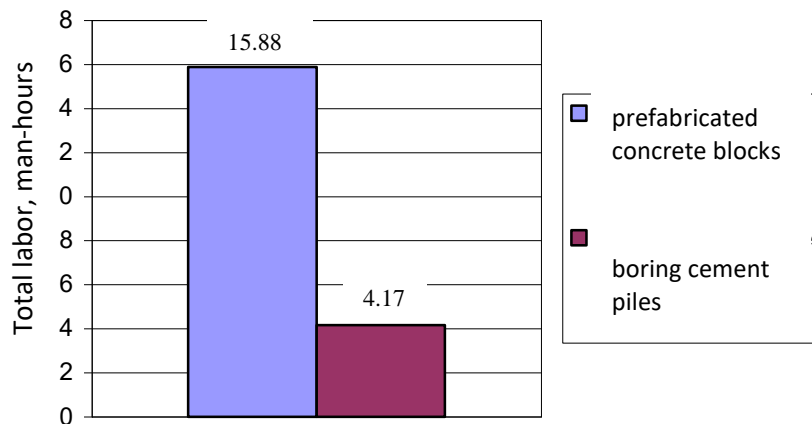


Figure 6. The total complexity of the construction of tape and pile foundations.

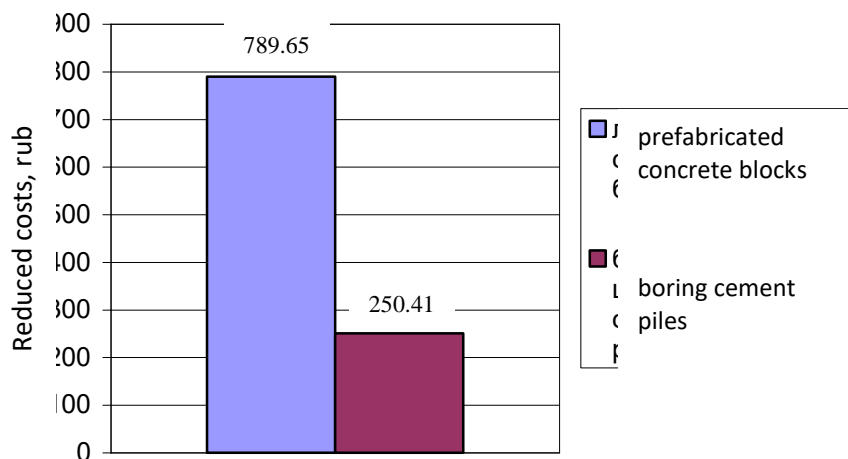


Figure 7. The above costs for the construction of strip and pile foundations.

For clarity, the results of studies of the first stage are summarized in table 1.

Table 1. Results of studies of the first stage.

| Name of the indicator | Foundation type | |
|------------------------------|-------------------------------|---------------------|
| | Prefabricated concrete blocks | Boring cement piles |
| Concrete consumption | 0.66 Kg | 0.19 Kg |
| Cement consumption | 145 Kg | 98.9 Kg |
| The complexity of the device | 3.29 man-hours | 1.17 man-hours |
| Total labor | 15.88 man-hours | 4.17 man-hours |
| Reduced costs | 789.65 rub | 250.41 rub |

As a result of the comparative calculation of technical and economic indicators for the construction of strip foundations from precast concrete blocks and foundations on boring cement piles with precast grillage. it can be argued that the foundations on boring cement piles with precast grill are significantly superior to strip foundations of precast concrete blocks (Table 1). Concrete consumption during the construction of foundations on cement mixing piles with precast grillage is more than 3

times less than when constructing strip foundations from precast concrete blocks. Cement consumption during the construction of foundations on cement mixing piles with precast grillage is almost 1.5 times less than when constructing strip foundations from precast concrete blocks. The complexity of installation during the construction of foundations on cement mixing piles with a precast grill is almost 3 times less than with the construction of strip foundations from precast concrete blocks. The total laboriousness in the construction of foundations on cement mixing piles with a precast grill is more than 3 times less than in the construction of strip foundations from precast concrete blocks. The above costs for the construction of foundations on cement mixing piles with precast grillage are also more than 3 times less than for the construction of strip foundations from precast concrete blocks.

At the second stage of research, a comparison was made of technical and economic indicators in the construction of foundations from prefabricated solid blocks, bored concrete piles and blended cement soil piles. Calculation diagrams are presented in figures 8 - 11.

The conditions for the calculation of technical and economic indicators at the second stage of research are the same as at the first stage, namely, per linear meter of the walls of low-rise buildings with strip foundations of precast concrete blocks and foundations on cement mixing piles with precast grillage at a load of ten tons per linear meter.

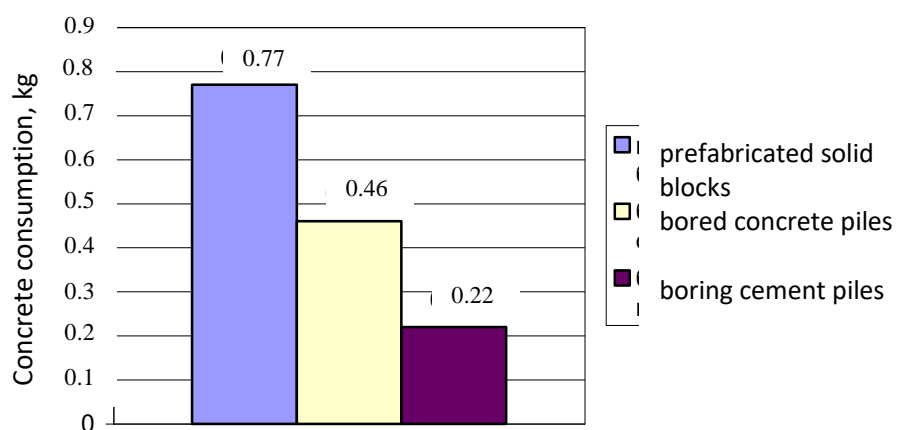


Figure 8. Concrete consumption during the construction of various types of foundations.

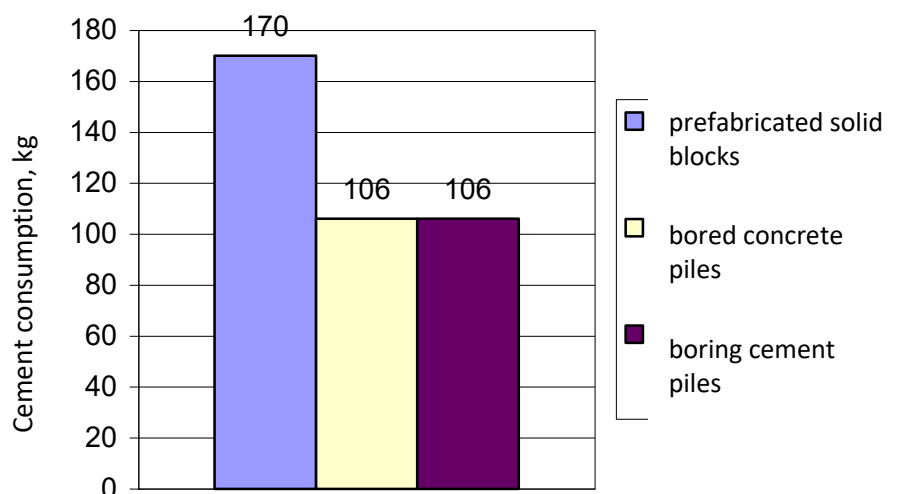


Figure 9. Consumption of cement during the construction of various types of foundations.

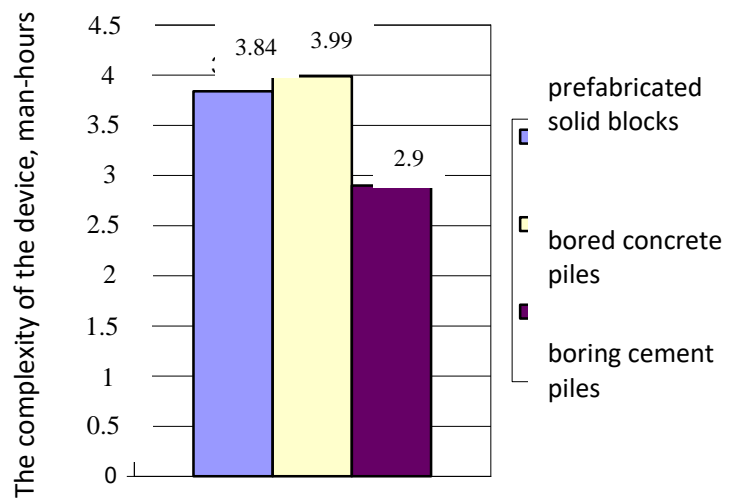


Figure 10. The complexity of installation during the construction of various types of foundations.

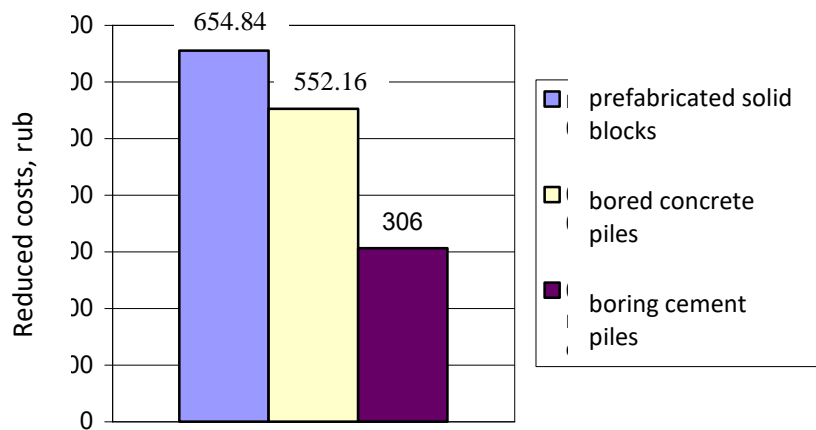


Figure 11. The above costs for the construction of various types of foundations.

For clarity, the results of studies of the first stage are summarized in table 2.

Table 2. Results of studies of the first stage.

| Name of the indicator | Foundation type | | |
|------------------------------|----------------------------|----------------------|---------------------|
| | Prefabricated solid blocks | Bored concrete piles | Boring cement piles |
| Concrete consumption | 0.77 Kg | 0.46 Kg | 0.22 Kg |
| Cement consumption | 170 Kg | 106 Kg | 106 Kg |
| The complexity of the device | 3.84 man-hours | 3.99 man-hours | 2.9 man-hours |
| Reduced costs | 654.84 rub | 552.16 rub | 306 rub |

As a result of the comparative calculation of technical and economic indicators for the construction of foundations from prefabricated solid blocks, bored concrete piles and boring cement piles, it can be argued that the foundations on cement mixing cement piles have a significant advantage over the foundations of prefabricated solid blocks and bored concrete 2 piles. Attention is drawn to the equality of the values of the technical and economic indicator of cement consumption during the construction of foundations on bored concrete and boring concrete cement piles 106 kilograms. However, this does

not diminish the advantages of foundation construction on boring cement piles over foundations on concrete bored piles. Since, the construction of foundations on bored concrete piles is not permissible next to existing buildings or structures. This is due to the shock effects that are necessary when installing foundations on bored concrete piles, which can cause damage to the foundations of nearby buildings or structures.

4. Conclusions and recommendations

1. As a result of the comparative calculation of technical and economic indicators for the construction of strip foundations from precast concrete blocks and foundations on boring cement piles with precast grillages, it can be argued that the foundations on boring cement piles with precast grill are significantly superior to strip foundations of precast concrete blocks.

2. As a result of the comparative calculation of technical and economic indicators during the construction of foundations from prefabricated solid blocks, bored concrete piles and boring concrete cement piles, it can be argued that the foundations on cement mixing cement piles have a significant advantage over the foundations of prefabricated continuous blocks and bored concrete.

3. The use of bored instead of reinforced concrete driven piles helps to strengthen the soil and increases the technical and economic efficiency of the construction process.

4. Production by a mixing method with mechanical activation of piles from cement soil reduces the need for large aggregate, does not require the removal of soil from the construction site.

5. When constructing the foundation, together with cement, primer is used as a mechanically activated component.

6. The production of piles from cement soil by the mixing method with mechanical activation minimizes the fleet of construction machines and mechanisms, reduces the number of construction workers and reduces the cost of the zero cycle.

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