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PRODUCTION OF ECONOMICAL CONCRETE BORED PILES WITH HOLLOW SECTION BY VIBRATION AND VACUUMIZING

ВИРОБНИЦТВО ЕКОНОМНИХ БЕТОННИХ ПАЛЬ З ПОРОЖНИСТИМ ПЕРЕТИНОМ ВИГОТОВЛЕНИХ ВІБРОВАКУУМУВАННЯМ

ПРОИЗВОДСТВО ЭКОНОМНЫХ БЕТОННЫХ СВАЙ С ПОЛЫМ СЕЧЕНИЕМ ИЗГОТОВЛЕННЫХ ВИБРОВАКУУМИРОВАНИЕМ

Annotation. The technology of installation thin-walled cast – in – situ piles with the high resistance on a ground of a outside surface which is formed fine grained concrete mix by vibration and vacuumizing is developed.
Keywords: pile, vibration and vacuumizing , concrete, hollow section, bearing capacity.
Анотація. Розроблено технологію, що дозволяє формувати тонкостінні бетонні палі високої міцності з дрібнозернистої бетонної суміші вібровакуумуванням.
Ключові слова: скупчення, вібровакуумування, бетон, пустотіла секція, несуча здатність.
Аннотация. Разработана технология, позволяющая формовать тонкостенные бетонные сваи высокой прочности из мелкозернистой бетонной смеси вибровакуумированием.
Ключевые слова: сваи, вібровакуумирование, бетон, несущая способность.

Introduction. Piles are columnar elements in a foundation which have the function of transferring load from the superstructure through weak compressible strata or through water, onto stiffer or more compact and less compressible soils or onto rock. They may be required to carry uplift loads when used to support tall structures subjected to overturning forces from winds or waves. Piles used in marine structures are subjected to lateral loads from the impact of berthing ships and from waves. Combinations of vertical and horizontal loads are carried where piles are used to support retaining walls, bridge piers and abutments, and machinery foundations. [1-3].

For the first time the technology of the device of ramming piles directly in the soil was proposed in 1899[4]. Kiev engineer AE Strauss. The well was ground in the ground by hand, filled with concrete mix and manually tampered with concrete (reinforced concrete) (Fig. 1) [6]. Due to the considerable manual labor such piles have had limited application.

Abroad (in the USA, Germany, Japan) the field of application of ramming piles covers 40-60% of the foundation works. The works of the Hydro project NIS showed the promise of expanding the use of ramming piles in the near future, and the economic calculations show that the use of short bored piles instead of ribbon foundations reduces the volume of excavation by 2 times and allows reducing the cost of the foundation by 40-50%.

The aim of the study. Reduce the mass of foundations by using concrete bored piles manufactured by vibra-vaccumizing.

Increase the strength and density of fine-grained concrete, providing the possibility of transition from solid to hollow piles.

Materials and methods. According to the standards [5] for concrete bored piles, concrete grade B15 (M200) is recommended. Figure 2a shows the forces acting on a cylindrical pendant pile, the bearing capacity is determined by the force $\Phi_{tot} = \Phi_{fr} + \Phi_b$, where Φ_{fr} is the shear resistance of the pile, as a consequence of its pinching in the ground by a force f directed along the axis and measured by t/ m^2,

$$\Phi_{fr} = Ul_1f, \quad (1)$$

U – external perimeter of the pile section,

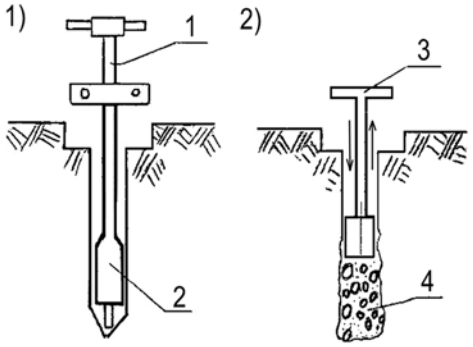
l_1 – the average length of the clamped part of the pile.

$$\Phi_b = S_bR_3, \quad (2)$$

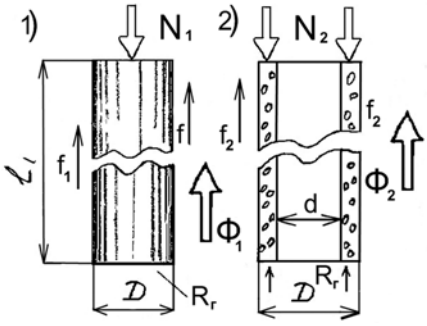
Φ_b – force of bearing capacity,

S_b – area of cross section of pile in the bottom ,

R_3 – strength of soil .



Pic. 1. Bored pile Strauss forces on the 1) hole boring;
2) filling in hole with concrete and seal ramming.
1 – manual boring; 2 – bailer;
3 – manual tamping; hollow section; 4 – con-crete



Pic. 2. The action of external pile
1)pile with solid section 2) developed pile with

The weight of the structure of the pile is loaded with a vertical force N. For the normal operation of the foundation, the condition $\Phi \geq N$.

In addition, that the pile should bear force N without deformation along the ground, the pile material must also withstand the normal stress σ_b of the force N:

$$\sigma_b = N/S_b \quad (3)$$

S_b – the area of the pile on which part of the structure (force N) is supported.

The necessary condition is $6_b < R_b$, where R_b is the design strength of concrete in compression

Consider a pile with a diameter d = 0.3 m in length l_1 = 3.0 m, ground-loam f = 0.25 kg / cm², R_3 = 0.3 kg / cm². Φ_{fr} = 0,25 * 28200 = 7050 kg, Φ_b = 211 kg, Φ_{tot} = 7050 + 211 = 7261 kg.

Under load N = Φ = 7261 kg, the normal stress on the concrete rod is:

$$b_f = \Phi / S \quad (4)$$

b_f = 7261 kg / 706 cm² = 10.3 kg / cm².

Discussion. For the accepted class B15, the design strength of concrete R_b = 85 kg / cm², so only 12 % of the calculated strength «works» in the pile structure, and there is a «designed» overrun of concrete, and for the economical consumption of the material, it is necessary to ensure a full load of concrete. For the recommended class of concrete B15, sufficient strength for concrete piles is provided at its cross-section[6]:

$$S_{дост} = \Phi / R_b \quad (5)$$

For the case under consideration:

$S_{дост}$ = 7261 кг/85 кг/ см² = 85,5 см².

Theoretically, to equalize two indicators of the bearing capacity of piles on the ground and the strength of concrete in the pile, we can use a hollow, thin-walled cylindrical pile (Fig. 2) it will optimum variant in this case . For example, for a pile length of 3.0 m, diameter 300 mm, a sufficient wall thickness of 20 mm.

In accordance with the calculation of concrete strength for the developed piles of the above-mentioned size, the consumption of concrete in comparison with the solid pile can be reduced from 0.21 m³ to 0.05 m³ (developed pile with hollow section), i.e. in 4 times.

A significant reduction in material consumption shows the economic efficiency of the device in the soil of thin-walled piles. That puts forward the relevant requirements for concrete – in particular, on the maximum permissible crushed stone (1/3 of the wall thickness), i.e. Only fine-grained concrete can be used.

The compaction of such a mixture differs from the technology adopted for conventional concrete. For a new type of pile, a new technology for the construction of thin-walled piles has been developed see Pic. 3. The developed method allows:

- the use of hard fine-grained concrete mixtures based on relatively inexpensive aggregates of granite and local sands;
- application for compaction of concrete of pressing, which additionally provides for pressing of concrete into walls of a ground well;
- the use of modified concrete, which ensures, if necessary, a very rapid setting of the concrete mixture, which prevents the destruction under moistening conditions of water-saturated soils.
- use the concrete with a big value of W/C
- it can use steel bar reinforcing

In Pic. 3 shows the pile forming, longitudinal section and core.

Prepared a drill hole in the ground 2 put the bottom of the concrete mix to the bottom. 3. Put a metal or polymer perforated core 1 vertically onto the concrete mixture. On top of which is a filter 4 made of fabric or other material.

The core 1 is made in such a way that the ratio d_1 / d_2 per 1 m of the linear pile is 10-15 mm, i.e. in the form of a truncated cone. Inside of which there are vibrators 5 for compaction of concrete mixture and hose 6 for evacuation of extracted water after evacuation. The hose 6 through the tap 7 is connected to the pump.

Lay the space between the core 1 and the hole in the ground 2 The mobile or cast concrete mixture 3 is sealed with vibrators 5 and evacuated through the tap 8 for 1-5 minutes depending on the thickness of the pile. After evacuation, the water extracted from the concrete mix is pumped by means of a pump through the hose 6. Then the core 1 is taken up vertically by means of lifting devices.

It has been experimentally established by us that the high quality of piles is achieved using the method of forming piles by vibrovacuuming, the essence of which is to remove excess water from a freshly laid concrete mix to 3%. As a result of this treatment, the concrete mixture is compacted, which in turn increases the physical and mechanical properties.

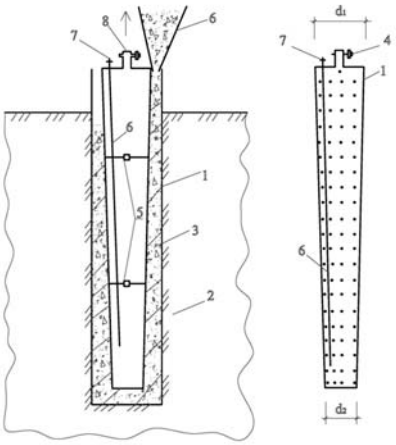
Results. Laboratory studies on the model (d_n = 0.14 m, d_b = 0.1 m) showed that fine-grained concrete on crushed stone screening (f_p = 0.1-5 m) at B / C = 0.38-0.40 corresponds to the class B35 (M400). The bearing capacity of the pile on the soil and on the material was tested [4]. Cubic strength of concrete is 51.57 MPa. In Table. 1 shows the strength value «f» of the lateral surface of piles.

Conclusion. A method for erecting economical foundations has been developed, based on the technology of forming hollow bored piles made of high-strength fine-grained concrete. The use of pile foundations in low-rise construction makes it possible to reduce the construction cost by 50% and reduce the volume of excavation, reduce the consumption of concrete and use local sands and screenings of crushed stone production.

Table 1.

The strength on the lateral surface of piles

Factor	Type of pile		
	SNIP 2.02.0385	pile Strauss	Developed pile
The strength on the lateral surface, f, кg/cm²	0,25	0,34	0,65



Pic. 2. The developed technology of forming the hollow concrete pile

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