Increasing the bearing capacity of driven piles

Augmenter la capacité portante des pieux entraînés

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ABSTRACT: Increasing the bearing capacity of driven piles is possible due to the increase of the lateral surface of contact with the ground. Among geometrically correct transverse sectional shape to satisfy this requirement section in the form of a triangle and a shortened hypocycloid, provides both the highest value at the lowest values of the perimeter of the transverse sectional area, limited to the perimeter. Replacing existing standard series of precast concrete piles with a square cross-section, acting as a friction pile on the pile with a cross section in the form of an equilateral triangle or a shortened hypocycloid will increase the specific load-bearing capacity of the pile Hanging Drop by up to 14%.

RÉSUMÉ: L'augmentation de la capacité portante des pieux entraînés est possible en raison de l'augmentation de la surface latérale de contact avec le sol. Une forme de section transversale géométriquement correcte pour satisfaire à cette section d'exigences sous la forme d'un triangle et d'un hypocycloïde raccourci fournit à la fois la valeur la plus élevée aux valeurs les plus basses du périmètre de la section transversale limitée au périmètre. Remplacement des pieux en béton contre-carrés de la série standard existante de conduite sur la section transversale sous la forme d'un triangle équilatéral augmentera leur capacité spécifique de charge jusqu'à 14%.

KEYWORDS: precast pile, load bearing capacity, side surface, transverse section, shortened hypocycloid.

1 INTRODUCTION

In Kazakhstan, the dynamics of the input pro-industrial facilities, civil and residential destination in recent years, characterized by stable growth.

Along with the use of modern building technologies in the construction of buildings is not used in the hollow as possible to reduce costs in the performance of the zero cycle works, particularly in the foundations of the device driven piles.

One way to increase the bearing capacity of driven piles is to provide them with an enlarged side surface in contact with the ground as compared with conventional piles of square cross-section [1, 2].

Among geometrically regular cross-sectional shapes to satisfy this requirement in a cross section of a regular triangle, while providing the largest perimeter at the lowest magnitude values of the cross-sectional area bounded by the perimeter of this [3].

2 ANALYSIS OF THE CARRYING CAPACITY HANGING DRIVEN PILE

A comparative analysis of cross-sections of the piles criterion accept their equality geometrical moments of inertia of the square and triangular cross-sections of cross-sections of driven piles in order to ensure equal performance pile resistance to horizontal forces during their operation.

The choice of this criterion is due to the need to provide equal stability characteristics of piles with a triangular and square sections to the horizontal load action.

Equality of geometric points of cross-sections of piles in the form of a triangle and the square allows you to calculate the proper length of the side of an equilateral triangle:

$$b = a \cdot \sqrt[4]{\frac{8}{\sqrt{3}}} \cong 1{,}466 \cdot a, \qquad (1)$$

where b - triangle side length, a - square side length.

The existing regulations are installed cross-sectional dimensions of square piles [4]. On the basis of the available range of sizes of driven piles with a square cross-section with the help of equation (1) we can calculate the required size of the cross section of the part of the corresponding triangle (see Table 1).

Table 1. Comparative analysis of parameters of driven piles

	The length of the sides of the square cross-section of the pile, м	The length of the sides of the triangular cross-section of the pile, м	Geometrical moment of inertia of the pil, $м^4$
а)	0,300	0,328	0,000675
б)	0,350	0,383	0,001251
в)	0,400	0,438	0,002133

In order to determine the effect of cross-sectional shape on the bearing capacity F_D of friction pile Drop the existing procedure were performed corresponding calculations for piles with a square and a triangular cross-sections [5].

As the foundation soil were appointed silty-clay soils with a melt flow index $I_L = 0{,}2; 0{,}4; 0{,}6$. The calculation results are presented in Figure 1.

From these graphs show that the use of suspension of driven piles with a triangular cross-section instead of traditional piles with a square cross-section provides a further increase in their bearing capacity.

For example, replacement of the square pile length of 15 m with a side of 0.30 m on the pile of the same length with a corresponding triangular cross-section allows to increase the load capacity by an amount from 4.5% to silty clay soil with melt index of 0.2 to 6, 1% for the same soil with melt index 0.6.

As seen from the above graphs, the relative increase in the bearing capacity of the pile Hanging Drop with a triangular cross-section in comparison with the traditional pile increases:

- to increase the length of the pile,
- to increase the geometric dimensions of the pile section,
- with an increase in turnover silty clay soil.

It is obvious that such an increase in load-carrying capacity (up to 7%), and thus the work forces of resistance during pile piles will have no significant impact on the choice of pile-driving equipment. Thus, there are a number of diesel hammers can be used as standard equipment with the pile foundation of the device driven piles triangular section.

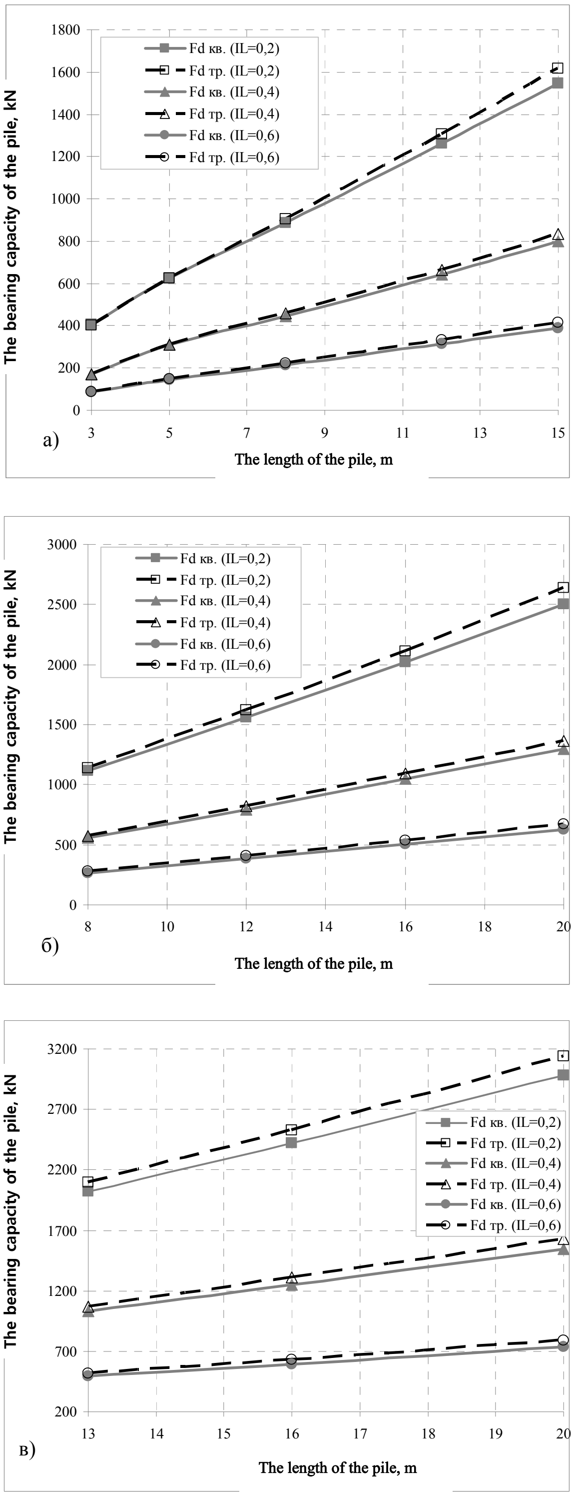

Figure 1. The dependence of the load-bearing capacity of driven piles hanging square and triangular cross-section of the length: а), б), в)

Comparison of cross-sectional areas corresponding to the triangular and square piles showed that at equal geometrical moment of inertia of the cross-sectional area smaller than a square triangle area by 7.5% (see Table 2).

Thus, in the manufacture of driven piles with a triangular cross section can predict reducing material consumption by approximately 7.5%. The development of specific designs of piles will clarify this value.

Table 2. Comparative analysis of cross-sections of driven piles

	Geometrical moment of inertia of the pile, м^4	The length of the sides of the square cross-section of the pile,м	A square cross-sectional area of the pile, м^2	The length of the sides of the triangular cross-section of the pile, м	The cross sectional area of the triangular piles, м^2
а)	0,000675	0,300	0,0838	0,328	0,0900
б)	0,001251	0,350	0,1140	0,383	0,1225
в)	0,002133	0,400	0,1489	0,438	0,1600

Thus, in the manufacture of driven piles with a triangular cross section can predict reducing material consumption by approximately 7.5%. The development of specific designs of piles will clarify this value.

In view of the above, for the integrated assessment of the impact of the replacement of square section driven piles on triangular encouraged to use this characteristic as the specific load-bearing capacity:

$$F_D^{уд} = \frac{F_D}{V_{св}}, \qquad (2)$$

where F_D - pile bearing capacity; $V_{св.}$ - the volume of the pile.

The use of such features as the specific load-bearing capacity $F_D^{уд}$, will allow not only to estimate the change in load-carrying capacity F_D, but also to take into account at the same time the volume of spent material $V_{св.}$, and therefore in the long term and the cost of the pile. The results of the calculations of the specific load-bearing capacity of driven piles hanging from a cross-section in the form of a square and a triangle in a silty-clay soils with a melt flow index $I_L = 0{,}2; 0{,}4; 0{,}6$ shown in Figure 2.

From these graphs show that the use of suspension of driven piles with a triangular cross-section instead of traditional piles with a square cross-section provides a significant increase in their specific load-bearing capacity $F_D^{уд}$. For example, replacement of the pile of square section with a side of 0.30 m corresponding to the pile with a triangular cross-section, depending on its length allows to increase the load capacity by an amount ranging from 6.1% to 12.2% for silty-clay soil with indication of the flowability $I_L = 0{,}2$, an amount from 6.7% to 12.2% for silty-clay soil, and a melt flow index $I_L = 0{,}4$ by an amount ranging from 7.1% to 13.9% for the same lot to flow index $I_L = 0{,}6$ (see Figure 3).

Substitution pile square with a side of 0.35 m corresponding to the pile with a triangular cross-section, depending on its length allows to increase the load capacity by an amount between 8.9% to 12.3% for silty-clay soil with melt flow index $I_L = 0{,}2$, the value of 8 , 9% to 12.4% for the silty clay soil with a melt flow index $I_L = 0{,}4$ and the value of 10.7% to 13.9% for the same soil with a melt flow index $I_L = 0{,}6$.

In turn replacement square with a side of the pile of 0,4 m corresponding to the pile with a triangular cross-section, depending on its length allows to increase the load capacity $I_L = 0{,}2$ by the amount of 10.0% to 11.6% for silty-clay soil with melt index at value from 10.1% to 11.7% for the silty clay soil with a melt flow index $I_L = 0,4$ and the value of 12.0% to 13.3% for the same soil with a melt flow index $I_L = 0,6$.

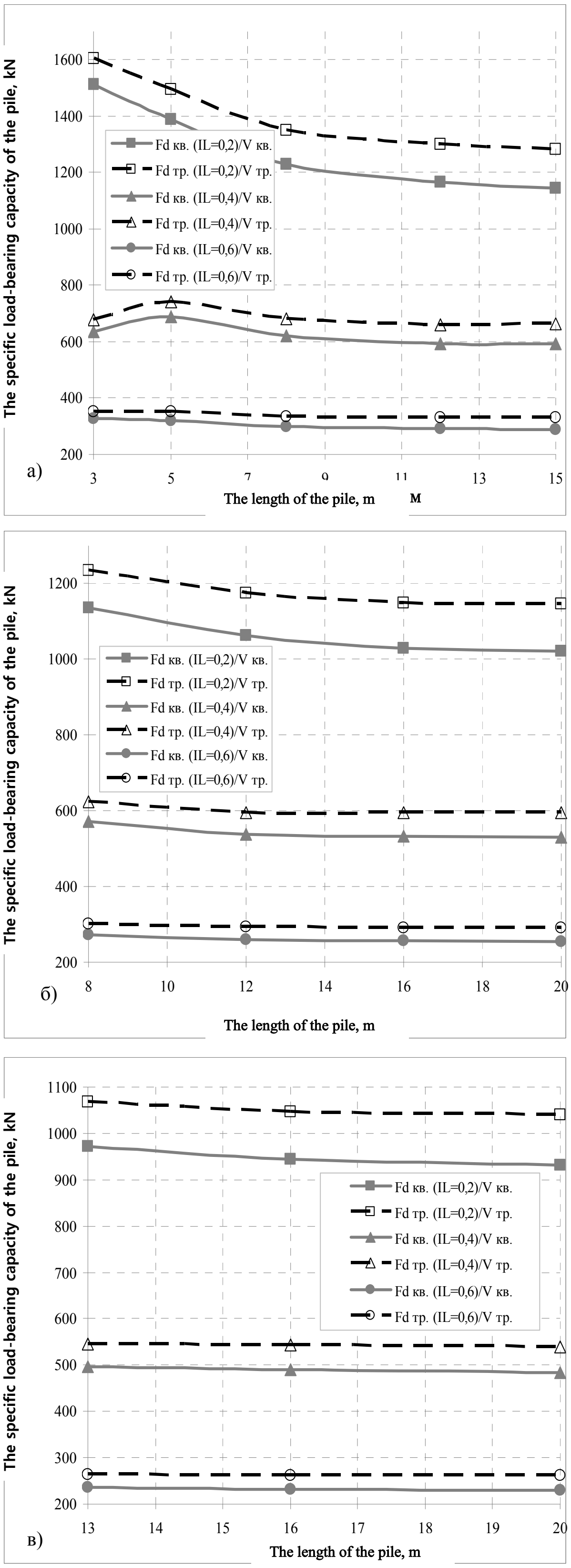

Figure 2. The dependence of the specific load-bearing capacity of driven piles hanging square and triangular cross-section of the length: а), б), в)

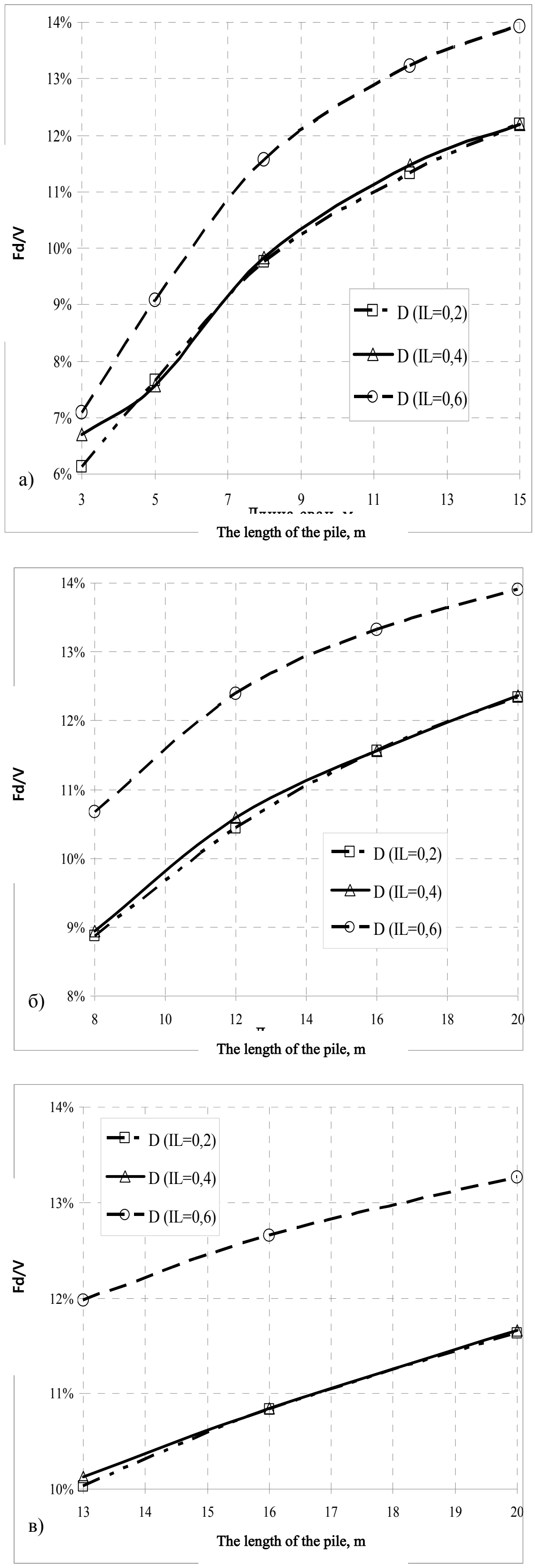

Figure 3. Increasing the specific load capacity of the triangular cross section compared with piles according to the square of the length: а), б), в)

To determine the economic benefit from the use of prismatic suspension of driven piles with a triangular cross-section instead of piles with a square cross-section rough estimate of the total load on the foundation soil with a recalculation of the planned housing construction in the area of structural weight was carried out.

For example, a result of implementation of the program "Affordable Housing-2020" in Karaganda is planned by 2021 to put into operation more than 3.2 million square meters of housing, or more than 37 thousand apartments at the expense of all sources of funding.

Practice construction of housing in previous years shows that the total volume of trade-housing is usually up to 20% (640 thousand sq. m.) of individual housing construction.

The remaining share of housing (2.56 million sq m) is a high-rise building, clearly require the device of pile foundations.

When performing approximate calculations we make the following assumptions:

– 1 sq. m of housing is equivalent to 12.5 kN load on the foundation soil,

for foundations device used precast piles CH12-35 GOST 19804.2-79 * and the corresponding triangular section,

– in the calculations do not take into account "bush" effect by working together hanging driven piles,

– as the foundation soil appointed silty clay soil with a melt flow index $I_L = 0{,}4$,

– the reliability factor on the ground $\gamma_k = 1$.

Calculations show that in view of the assumptions made the weight equivalent of 2.56 million sq m planned for delivery in 2021 of property equal to $32 \cdot 10^6$ κH.

The bearing capacity of square piles CH12-35 GOST 19804.2-79 * taking into account the assumptions equal to 793 kN. Massa square pile is 3.73 t. Thus, the total number of square piles suit of the same total weight of 40353 pieces 150515 tonnes. At the cost of one square piles order 49100 KZT total cost of the necessary number of piles will be about 1982950000 KZT

In turn, it is seen from the above graph that the corresponding hanging precast pile with a triangular cross-section has a bearing capacity of 822 kN. Its weight is 3.46 tons. The total number of such needful tre-coal piles equal to 38929 pieces total weight of 134696 tons. The approximate cost of a triangular pile will be about 45950 KZT. The total cost of the necessary number of piles will be about 1788960000 KZT.

Thus, the effect of the suspension of driven piles with a cross section in the form of a triangle in the construction of housing in the city of Karaganda in 2021 may reach 193.99 million. KZT. In addition, the use of this technology further allows for all the construction time to reduce loads to 15821.16 tons.

Speaking about the production technology driven piles triangular section, their storage and transport, it may be noted that the introduction of the proposed changes in the cross-sectional shape is not con-quires considerable financial and material costs for the modernization of production.

Previous studies had demonstrated the possibility of use as a cross-section of a driven pile shortened hypocycloid, providing an additional increase in the specific load-bearing capacity in comparison with the corresponding correct N-gon [6].

In this case, the maximum value of the specific bearing capacity has three beams $(n = 3)$ shortened hypocycloid with sliding coefficient $\lambda = 1$ [7].

Preliminary calculations show that the replacement of the existing standard series of precast concrete piles with a square cross-section, working as a hanging piles on piles with a cross section in the form of a hypocycloid $(n = 3, \lambda = 1{,}0)$ will increase the specific load-bearing capacity of the pile Hanging Drop by from 22 to 41%

3 CONCLUSION

1. Replacing existing standard series of precast concrete pile with a square cross-section as the working hanging piles on the pile with the cross section in the form of an equilateral triangle will increase the specific load-bearing capacity of the pile Hanging Drop an amount from 6% to 14%.
2. As standard equipment with pile foundation device of driven piles with a triangular cross-section can be used by an existing standard series diesel hammers.
3. In the production, transportation and storage piles with triangular cross section may be used by the existing production equipment and trucks with minimal changes to their design features.
4. According to the program "Affordable Housing-2020" in Karaganda g according to plan housing development until 2012 at the device of driven pile foundations on stilts hanging with a triangular cross-section can be saved up to 194 million. KZT.
5. The use of driven piles of hanging with a triangular cross section in the housing Karaganda to 2012 would reduce trucking to 15821.16 tonnes.
6. Performed calculations do not include an assessment of the volume of industrial construction and private housing construction in the period under review the use of driven piles with triangular section.
7. One promising area is the use of a more detailed study of the possibilities of driven piles with a cross section in the form of a shortened hypocycloid with parameters $(n = 3, \lambda = 1{,}0)$.

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