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RESEARCH AND CALCULATION OF THE LOAD CAPACITY OF THE BASES OF METAL SCREW PILES ACCORDING TO THE TORQUE VALUE REQUIRED FOR DRIVING THEM

ABSTRACT

The results of investigation and improved method of calculation of the load capacity of the bases of metal screw piles under pressing and holding loads from the torque value required for driving them, developed on the basis of the performed investigation are presented. On the basis of literary sources [1-3, etc.] and the data of obtained in theoretical and experimental investigations performed in the Institute BelNIIS Republican Unitary Enterprise, it has been shown that between the torque M_k*, kN·m, required for driving (hereinafter referred to as the torque* M_k*) of the metal screw pile (hereinafter referred to as the MS pile) into soil and its bearing capacity in case of both pressing-in (*F_{dt}*, kN) and pulling out (*F_d*, kN) exists a stable relationship* F_d $(F_{dt}) = k \cdot M_k$*, where k is the transition coefficient, 1/m.*

It has been determined that the M_k *value and MS pile driving speed depend on the soil density, diameter of the pile shaft (*d_p*, m), blade (*D_b*, m), tip shape (either open or closed) and height of soil plug in the open tip, the influence of which on the MS pile driving speed and* M_k *value is bound with the relationship* $n = D_b/d_p$*. If* $n \geq 3$*, the* M_k *value is determined mainly by the soil resistance to driving the blade.*

Provided that, the following factors influencing the M_k *value required for driving the developed MS piles [4] and the typical ones [5] applied in the Republic of Belarus have been revealed. They include:*

1. Driving method: manual, with the MS pile driving speed of 0.5-2 revolutions per minute (V, rpm); or mechanical with the use of mechanisms providing the rotational speed of more than 2 rpm.

2. Blade diameter and pitch. Should the ratio between the blade thickness and its pitch not exceed $m \leq 0.6$*, the direct proportion between the* D_b *and the soil resistance to driving the MS piles (V,* M_k*) is actually observed.*

3. Shape and material of MS piles and relationship between these parameters. In particular, dimensions and construction of the blade (number of threads, their pitch and arrangement).

4. Soil type (its density, dampness, etc.). In case of mechanical driving of the MS piles, the blade immersion depth of up to 6 m affects, as a rule, insignificantly the M_k *value and the blade sinking rate per revolution (pitch "a").*

According to the results of the performed investigations by means of in-place tests of the MS piles with the length of 1.5-8 m for pressing-in and pulling-out loads, the coefficient of transition from M_k *to* F_d *(*F_{dt}*) has been determined for various types of soils with measuring the* M_k *values corresponding to them. For the purpose of monitoring and operational evaluation of the* F_d *(*F_{dt}*) values, the practical calculation method has been developed for the jammed in the soil MS pile of blade diameter* $D_b \leq 800$ *mm and length* $1 \leq 8$ *m, which has ensured the improved accuracy of the existing calculation methods based on torque* M_k*, by at least 30%.*

Keywords: the screw metal pile, tests, bearing capacity, torque of screwing up, method calculation, recommendations.

INTRODUCTION

According to the programme of capital construction of the Ministry of Construction and Architecture of the Republic of Belarus [6 et al.], the mainstay of the development of the construction operations of the country within the period from 2006 till 2020 consists in improvement of its efficiency by creating and introducing new resource- and energy-saving materials, structures and technologies. The metal screw (MS) piles, which have been actively used in recent times as foundations of various buildings and structures correspond to this purpose to the full extent [3, 7 at al.].

Until the present, the wide introduction of them was restrained due to the absence of standard technical base for designing (calculation) of MS piles under the soil conditions of the Republic of Belarus. It has been ascertained that deviations of actual values of the bearing capacity of screw piles in the Belarusian region from their actual values calculated by the known methods [8, 9 et al.] reach 75% and more towards both the underestimation and overestimation [7 et al.].

In this connection, Institute BelNIIS RUE has performed a number of investigations for studying the peculiarities of interaction of MS piles with various types of soil for the purpose of improvement of their construction and adaptation of the existing methods of calculation to the soil conditions of the Republic of Belarus.

Below in the article, the results of one of stages of the performed works for investigation of the bearing capacity of the bases of MS piles and its correspondence to the torque of screwing-in M, establishment of the coefficient of transition from M to F and improvement of the method of calculation of their bearing capacity on the basis of the M value.

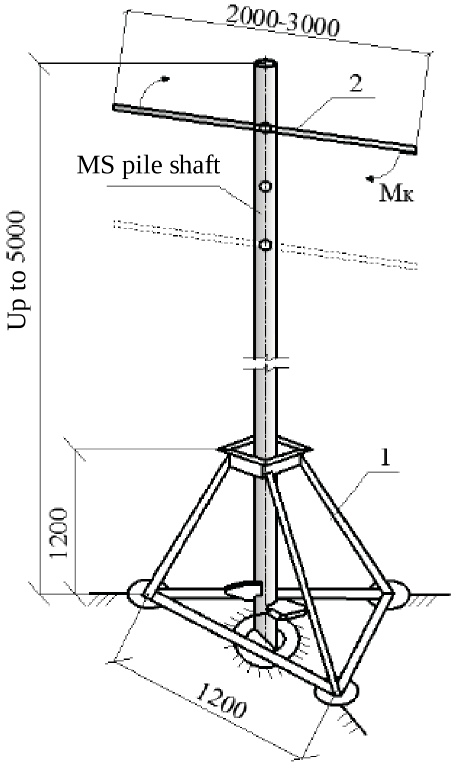
EXPERIMENTAL INVESTIGATIONS, THEIR RESULTS AND ANALYSIS

One of the objectives of the field study of the bases and process of screwing-in of MS piles consisted in establishing the relationship between the bearing capacity F_d (F_{dt}) and the torque value M_k when screwing the piles into various types of soils.

The investigations have been performed: a) by the check test of experimental short MS piles with the length of 1.5 to 3.0 m (for sands, the tests were performed by S.S.H.Al-Tamimi under supervision of the author) screwed in manually at the speed of up to 2 rpm; b) theoretically by acquisition and probability-statistical processing of the experimental data presented by the Centre of Bases and Foundations of Stroikompleks LLC, Promstalkonstruktsiya LLC and from the literature sources [1-3, 9 et al.] screwed in mechanically with the speed exceeding 2 rpm.

To drive the experimental short MS piles into soil, a light portable plant (Figure 1) was applied with the use of the small tools and equipment (winch, crow) and workers' muscular force.

This plant allows screwing-in the short MS piles with the length of up to 3 m with the blade diameter of up to 500 mm into clayey soils and screw in MS piles with the length of up to 5 m into mean-strength sandy soils (the equivalent resistance of the soil to submerging of the probe $P \geq 1.5$ MPa). The plant is not difficult to manufacture in the mechanical workshop of any construction organisation, which solves the problem of wide introduction of MS piles without involvement of difficult-to-obtain heavy equipment oriented to screwing-in the typical long piles [5] with the shaft diameter of as a rule 219 mm and length exceeding 3 m.



1 – light-weight portable plant with a crow (2) for screwing-in of MS piles

Figure 1. Schematic diagram of the light-weight portable plant for screwing-in of MS piles (the dimensions are in mm)

The portable plant (1) for screwing-in of short MS piles is made of metal profile or pipes in the shape of a truncated pyramid with the dimensions of lower base of 1.2 x 1/2 m and height of 1.2-1/5 m. The guiding frame or ring ensuring the vertical fixation of the MS pile shaft at the initial stage of its sinking is made at the centre of the top base. To install the crow (2) creating the screwing torque M_k, the holes for rearrangement of the crow as the pile is sunk into soil are provided at the top portion of the shaft with the spacing of 0.5 m.

The technique of assessment of the relationship between the F_d (F_{dt}) and the M_k consisted in the following. After screwing-in the MS piles under the test, the number of revolutions of MS piles per metre of penetration (screwing-in rate) was counted, and the torque M_k in kN·m required for sinking the pile to various depths z, m, from the soil surface was determined. To do this, the chalk marks are made with the spacing of 50-100 mm on the MS pile shaft, based on which the number of revolutions made during sinking the pile to the specified mark is counted. The torque for the experimental MS piles screwed in manually was determined with the use of a torque wrench while for those screwed in mechanically (by means of a capstan) – with the use of the calibrated gauge of the basic drilling rig or pressure gauge of its hydraulic system.

For short MS piles, the mean values of the required forces applied to the crow when sinking the piles into soil to the depth of 50-100 mm and the number of revolutions around the axis were measured by means of a torque wrench, and the screwing-in torque corresponding to it was determined.

After screwing-in the MS piles, they were tested for pressing in and pulling out loads according to the technique of the STB 2242-2011 "Soils. Method of field tests with piles" that allowed the establishment of the relationship between the bearing capacity F_d (F_{dt}) and the torque M_k when screwing-in the piles as well as determination of the transition coefficient k between the $F_d(F_{dt})$ and M_k; k_{sup}, for pulling out and k_{inf} for pressing in.

The basic processed results of the performed investigations are given in Table 1 and Figure 2.

Table 1

Normative transition coefficients k_i from M_K to F_d (F_{dt}) of the MS piles with the length of up to 10 m with d = 300 mm (with l ≤ 3 m) and d = 500 mm (with 3 ≤ l ≤ 10 m) depending on the depth of penetration of the blade into soil l and torque value M_K

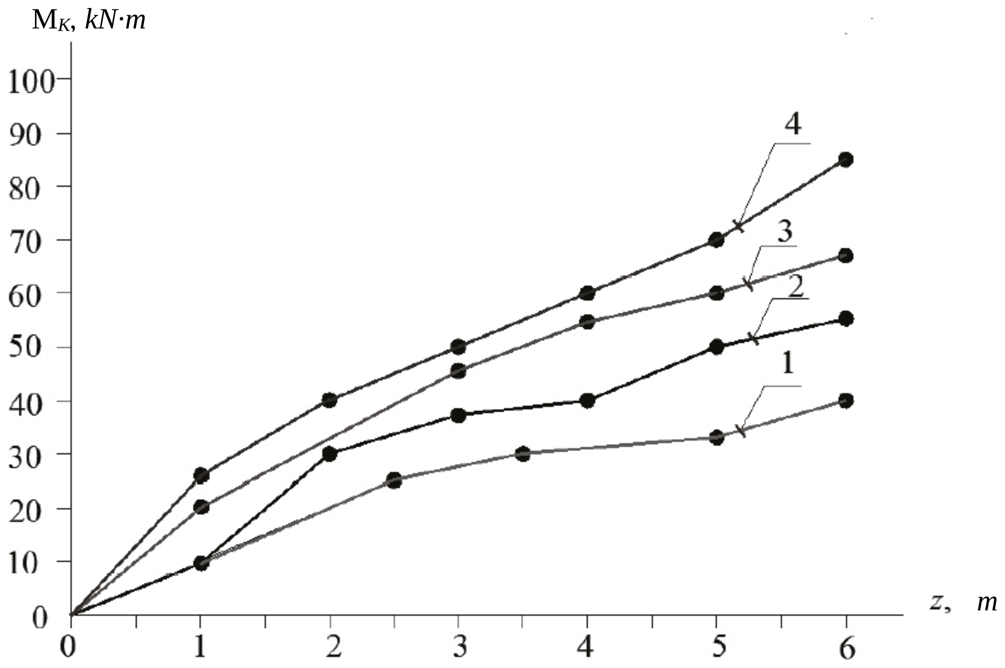
Soil type	Transition coefficient k_i from M_k to F_d (F_{dt}) for the MS pile, 1/m			
	k_{sup} when pulling out, with the blade penetration l, m, and torque M_k, kN·m		k_{inf} when pressing in, with the blade penetration l, m, and torque M_k, kN·m	
	$l \leq 3$, $M_k \leq 50$	$3 < l \leq 10$, $M_k \leq 50$	$l \leq 3$, $M_k \leq 50$	$3 < l \leq 10$, $M_k \leq 50$
Fine medium-strength sand ($p_d \geq 2$ MPa)	3.55	7.1	4.60	9.2

Table 1, end

Soil type	Transition coefficient k_i from M_k to F_d (F_{dt}) for the MS pile, 1/m			
	k_{sup} when pulling out, with the blade penetration l, m, and torque M_k, kN·m		k_{inf} when pressing in, with the blade penetration l, m, and torque M_k, kN·m	
	$l \leq 3$, $M_k \leq 50$	$3 < l \leq 10$, $M_k \leq 50$	$l \leq 3$, $M_k \leq 50$	$3 < l \leq 10$, $M_k \leq 50$
Medium-strength sandy loam ($p_d \geq 1.5$ MPa)	5.63	11.30	7.40	14.7
Medium-strength loam ($p_d \geq 1.5$ MPa)	7.30	14.60	9.54	19.14

Notes:
1. The k_i value for the MS piles with the length of 3 to 10 m is determined by interpolation;
2. With the relationship $D_л/d_c < 3$ the k_i values in the table should be multiplied by the factor 1.1;
3. p_d is the dynamic resistance of soil to driving the probe cone.

The analysis of the results of screwing-in the experimental MS piles allows making the conclusions:
- the increase of the soil density (modulus of deformation) reduces the penetration rate and increase of the humidity, on the contrary, increases the penetration rate and reduces the bearing capacity of the soil.
- the mean depth of penetration of MS piles per revolution is: (0,3-0,5) $D_л$ for fine sand and (0,2-0,3) $D_л$ for medium sand, sandy loams and loams. It corresponds to the optimum pitch between the cutting portion of the MS pile blade and end portion of it, where no additional vertical force is required.



1 – diagram of the dependence $M_k = f(z)$ for fine medium-strength sand (p_d = 2-3 MPa); 2 – the same for medium sand (p_d = 2-3 MPa); 3 – the same for sandy loam and 4 – the same for medium-strength loam (p_d = 1,5-3 MPa)

Figure 2. Results of the investigation. Diagram of the dependence $M_k = f(z)$ of the torque value M_K on the depth of screwing-in of MS piles z with the optimum relationship n = D_b/d_c x 3 and $D_b \leq 500$ mm

It has been determined that the M_k value and MS pile driving speed depend on the soil density, diameter of the pile shaft (d_p, m), blade (D_b, m), tip shape (either open or closed) and height of soil plug in the open tip, the influence of which on the MS pile driving speed and M_k value is bound with the relationship $n = D_b/d_p$. If $n \geq 3$, the M_k value is determined mainly by the soil resistance to driving the blade.

Provided that, the following factors influencing the M_k value required for driving the developed MS piles [4] and the typical ones [5] applied in the Republic of Belarus have been revealed and their bearing capacity that include:

1. Driving method: manual, with the MS pile driving speed of 0.5-2 revolutions per minute (V, rpm); or mechanical with the use of mechanisms providing the rotational speed of more than 2 rpm.
2. Blade diameter and pitch. Should the ratio between the blade thickness and its pitch not exceed m < 0.6, the direct proportion between the D_b and the soil resistance to driving the MS piles (V, M_k) is actually observed.
3. Shape and material of MS piles and relationship between these parameters. In particular, dimensions and construction of the blade (number of threads, their pitch and arrangement).
4. Soil type (its density, dampness, etc.). In case of mechanical driving of the MS piles, the blade immersion depth of up to 6 m affects, as a rule, insignificantly the M_k value and the blade sinking rate per revolution (pitch "a").

DEVELOPMENT OF THE METHOD OF ASSESSMENT OF THE BEARING CAPACITY OF SCREW PILES FOR PRESSING-IN AND PULLING-OUT LOADS FROM THE SCREWING-IN TORQUE VALUE

The proposed method of the bearing capacity of MS piles from the screwing-in torque value is based in the generalisation of the results of their tests by consequentially vertical static pressing in and pulling out loads under various soil conditions (slightly wet and wet sandy and loamy soils) at various blade penetration depth from the surface of the soil with parallel measurement of the torque

M_K according to the technique described above.

When developing the calculation method, we used the results of tests of 86 MS piles (both own data and those from the reported data of various organisations) with the shaft diameters dc = 57 to 219 mm, blade diameters $D_л$ = 150 to 800 mm sunk into soil to the depth of 1,5 to 10 m with placing the blade in sandy or loamy ground for both pressing in and pulling out static loads as the load-settlement $s = f(P)$ and load-output $v = f(P_v)$ diagrams performed on the territory of the Republic of Belarus according to the technique of the STB 2242-2011 with determining the torque M_k required for sinking them.

The analysis of the experimental data has shown that as the MS pile penetrates into the soil, the torque M and bearing capacity of the pile increase when both pressing and pulling out and the stable relationship between them noted in [1, 3, 9 et al.] is observed and expressed by the following dependence:

$$F_d\ (F_{dt}) = k_i M_k, \qquad (1)$$

where $F_d\ (F_{dt})$ is the bearing capacity of the MS pile base under the pressing in and pulling out loads, kN;

ki is the empirical transition coefficient from M_k to $F_d(F_{dt})$ determined from the experience according to results of screwing-in and testing of MS piles, 1/m, on the construction site under consideration;

M_k if the torque value required for screwing-in of MS piles at the final stage of its sinking, kN·m.

To determine the values k_i and assess the factors affecting the accuracy of determining the values $F_d\ (F_{dt})$, the diagrams $P(Pv) = f(s,\ v)$, over 86 existing tests of MS piles in various soils of the Belarusian region tested consequently for the pressing in *(P)* and pulling out *(Pv)* load with measuring the settlement *(s)* and exit from the soil *(v)* as well as torque M_k at the final stage of sinking them were processed according to the dependence (1). To do this, the existing testing diagrams were broken into groups with the identical parameters: construction, type and characteristics of the soil in the active zone of MS piles, dimensions of the blade and depths of its penetration from the base surface. The results of the tests for determining the k_i values (k_{inf} for pressing in and k_{sup} for pulling out) were processes with the use of the probability-statistical method regulated by the GOST 20522-2012 standard "Soils. Methods of statistical processing of the test results" with due account for the main principles of the reliability theory of the STB ISO 2394-2007 standard.

The confidence coefficient (probability) of the design values α is accepted according to the guidelines of the technical code of common practice TKP 45-5.01-254-2012. "Bases and foundations of buildings and structures", α = 0,95.

The regulatory values k_i were determined by dividing the particular values of critical loads perceived by the base of individual MS piles P and P_v by the torque M_k at the final portion of sinking equal to 50 cm, respectively, when pressing in and pulling out, found from the results of the field tests. The regulatory (characteristic) values k_i are assumed to be equal to their arithmetic average values $\bar{k}_{n.\sup}$, $\bar{k}_{n.\inf}$ for each group of diagrams with the design and soil parameters of the same type, with the blades sunk to the equal depth from the base surface.

$$k_{n.sup} = \overline{F}_{dt.m} / \overline{M}_k,\ k_{n.inf} = \overline{F}_{d.m} / \overline{M}_k,\ 1/м. \qquad (2)$$

When processing the data, the particular values failing to meet the following conditions were excluded:

$$\left|\bar{k}_{\sup} - k_{\sup,i}\right| > \nu S^{k_{\sup}},\ \left|\bar{k}_{\inf} - k_{\inf.i}\right| > \nu S^{k_{\inf}}, \quad (3)$$

where v is the statistical criterion assumed depending on the number of determinations n from Table G.1 of Appendix G to the GOST 20522 standard; the design values were determined from the formulae:

$$k_{\sup} = \frac{k_{n,\sup}}{\gamma_g},\ k_{\inf} = \frac{k_{n.\inf}}{\gamma_g}, \quad (5)$$

where γ_g is the safety coefficient for soil to be determined from the formula:

$$\gamma_g = \frac{1}{1 \pm \rho_\alpha} \quad (5a)$$

here $\rho_\alpha = \frac{t_\alpha V}{\sqrt{n}}$ is the factor of accuracy of assessment of the average values, designations and calculation, see GOST 20522.

So, in order to determine $k_{n.inf}$, for piles with the length of 4-5 m and blade with the diameter of 300 mm, located in fine sand, the sample of their particular values of the bearing capacity F_{di} from the results of static tests in the quantity of n = 6 units with the average value of the parent universe sample F_{dm} = 450 kN and standard deviation s = 27.4 MPa was used.
Using the statistical method of coverage for normal distribution of the test results from expression D6 and Table 3 of Appendix D recommended by Eurocode 1990, we find the final regulatory (characteristic) value F_d

$$F_d = \overline{F}_{d.m} - k_p \cdot s = 450 - 3{,}71 \cdot 27{,}4 = 348{,}35 \text{ kN.}$$

Similarly, we determine the regulatory value of the torque M_k, corresponding to F_d, which is equal to M_k = 37.90 kN·m. Then the regulatory transition coefficient k_{inf}, from M_k to F_d for MS piles with the blade having the diameter (D_b = 500 mm) sunk into fine sand to the depth of 4-5 m will be according to formula (2)

$$k_{inf} = F_d / M_\kappa = 248{,}35/37{,}90 = 9{,}19 \approx 9{,}20 \text{ 1/m.}$$

The final results of determination of the k_i values for various kinds of soils and MS piles when pulling out and pressing in them are given in Table 1.

The analysis of the known dependence (1) [1-3, 9 et al.] and available results of the experimental data has shown that the accuracy of calculation of the bearing capacity F_d (F_{dt}) as to the torque M_k with the use of the specified coefficient k_i (see table 1) is also affected considerably by the rate of sinking of MS piles (for the manual and mechanical method of screwing-in), type and properties of the soil (density and humidity) and the blade diameter, which shall be taken into account therein. The effect of the above factors on the values F_d (F_{dt}) is determined on the basis of processing of the experimental data and taken into account by introducing the coefficients of the working conditions of MS piles in respect of soil (γ_{CM}) according to the technology of sinking into soil (γ_{CM1}) into equation (1). The effect of the blade dimensions in (1) is taken into account through the relationship $D_{л.i}/D_{л.500}$ for short MS piles and $D_{л.i}/D_{Л.500}$ for other ones (where $D_{л.i}$ if the diameter of the blade of the used MS pile, $D_{л.300}$ and $D_{л.500}$ are their reference (effective) values equal to 300 and 500 mm, respectively, the k_i values for which are obtained from Table 1).

On the basis of the performed investigations, the calculation method and known dependence (1) from [1-3, 9 et al.] of the assessment of the bearing capacity of the bases of MS piles with the length of up to 10 m and $D_Л \leq 800$ mm, (F_d for pressing in and F_{dt} for pulling out) jammed in soil as to their screwing-in torque M_k of 20 to 400 kN·m on the last fifty centimetres of sinking. With due account for the above transformations, the dependence (*1*) took the following appearance:

where γ_{CM} is the coefficient of working conditions of a MS pile in various types of soil equal to γ_{CM} = 0.9 for loose soils (p_d < 1.5 MPa), γ_{CM} = 0.8 for wet soils (S_r = 0.7-0.9) and γ_{CM} = 0.7 for water-flooded soils (should there be several factors, the coefficients shall be multiplies together);

γ_{CM1} is the coefficient taking into account the technology of screwing-in of MS piles equal to γ_{CM1} = 1 for screwing-in with the torque of up to M ≤ 50 kN·m, and γ_{CM1} = 0,75 for screwing-in by the machines with the torque M_k exceeding 50 kN·m;

k_i is the empirical transition coefficient from the screw in torque to the bearing capacity of screw piles to be determined from the results of the experimental works on the construction site (k_{inf} for the pressing in load and k_{sup} for the pulling out one), 1/m. For the structures of the third level of responsibility and preliminary calculations for the second level of responsibility, it is allowed to determine it from elaborated table 1.

$D_{лi}/D_л$ is the coefficient of impact of the blade dimensions, where $D_{лi}$ is the diameter of the blade of the MS pile to be screwed in, m, $D_л$ is the optimum diameter of the blade equal to 0.3 for short piles with the length of up to l ≤ 3 m and $D_л$ = 0.5 m with *l* > 3 m.

Below is an example of calculation by the developed method.

Example. It is necessary to calculate the bearing capacity of the sand base of a typical MS pile according to [5] for the foundations of a multi-storeyed brick building with the bearing walls at the point of screwing-in according to the torque value M_k when pressing in F_d and pulling out F_{dt} of this pile/

Input data: The geological column of the base with the characteristics of soils and testing diagrams *s = f(P), v = f(Pv)* at the point of screwing-in of the MS pile is shown in Figure 3. The MS pile is screwed in by means of a capstan with penetration of the blade from the planning surface in slightly wet medium-strength sand at the depth of 8,9 m. The maximum torque at the end of screwing-in on the last 50 centimetres (M_k) = 45 kN·m. Geometric characteristics of the pile: shaft diameter: 219 mm, blade diameter: 0.5 m, area (A) = 0.196 m², pile shaft perimeter (u_{st}) = 0.688 m. The nearing capacity of the MS pile according to the results of its testing by the pressing-in load ($F_{d.stat.}$) = 536 kN and by the pulling out load ($F_{dt.stat.}$) = 330 kN (see Figure 3).

Solution: The calculation is performed by the developed method as to the screwing-in torque value M_k (see above).

Now we determine the bearing capacity of the MS pile base in respect of pressing in and pulling out of the MS pile F_d, F_{dt} at the screwing-in point as regards the torque value M_k according to the expression (6).

For a typical MS pile screwed in to the depth of 8.9 m by the mechanical method with M_k = 45 kN·m and blade diameter ($D_л$) = 0.5 m:

γ_{CM} = 1, γ_{CM1} = 1, k_{sup} = 9.2, 1/m, k_{inf} = 12.00, 1/m (see table 1),

we will obtain the bearing capacity of the MS pile base calculated from M_k for pressing in $F_{d.imom}$ and pulling out $F_{dti.mom}$, at the screwing-in point.

$$F_{di..mom} = \gamma_{см}\cdot\gamma_{см.i}\cdot k_{inf}\cdot M_к\cdot\frac{D_{лi}}{D_л} = 1\cdot1\cdot12\cdot45\cdot0,5/0,5 = 540 \text{ кН},$$

$$F_{dti.mom} = \gamma_{см}\cdot\gamma_{см.i}\cdot k_{sup}\cdot M_к\cdot\frac{D_{лi}}{D_л} = 1\cdot1\cdot9,2\cdot45\cdot1\cdot0,5/0,5 = 414 \text{ кН}.$$

Then, according to the TKP 45-5.01-254 and recommendations [10] the allowable load on the MS pile F_u in the case under consideration with due account for the coefficient of accuracy of the calculation method from the results of tests by the static load γ_k = 1.2 and γ_k, as to the screwing-in torque will be:

- according to the results of the static tests:

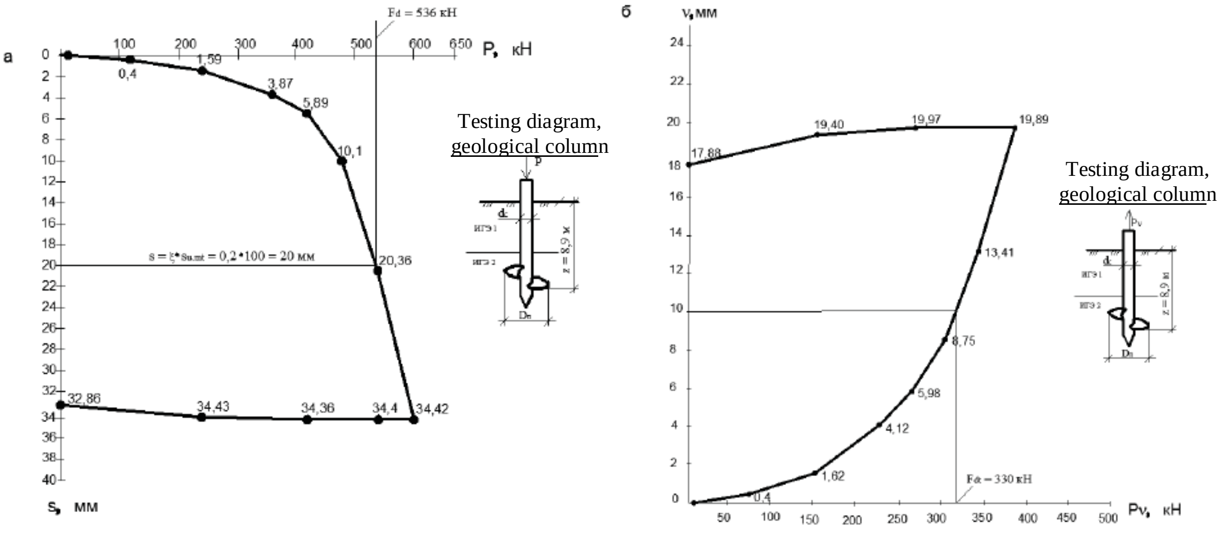
stat $$F_{u.стат} = \frac{536}{1,2} = 446,67 \text{ кН},\quad F_{ut.стат} = \frac{330}{1,2} = 275 \text{ кН},$$

- according to the results of the calculation as to the moment M_k

mom $$F_{u.мом} = \frac{540}{1,3} = 41\ldots \text{ кН} < F_{u.стат} = 446,67 \text{ кН}$$

(deviation from the experimental data i = minus 8%),

$$F_{ut.mom} = \frac{414}{1.3} = 318.46 \text{ kN} > F_{ut.stat} = 275 \text{ kN (i =plus 15.8\%)}.$$



Soil unit 1: Fine medium-strength sand g_{II} = 17.2 kN/m³, C = 0.002 MPa, j_{II} = 33°, E = 22 MPa; Soil unit 3: Medium-size medium-strength sand g_{II} = 17.0 kN/m³, C_{II} = 0.0014 MPa, j_{II} = 36°, E = 35 MPa

Figure 3. The results of testing under the static pressing in *P* and pulling out P_v loads on the MS pile aligned with the geological column (for the example of the calculation).
a is the diagram of the dependence s = *f(P)* of the settlement s on the load *P*; b – the same, *v* = $f(P_v)$ of exit from the soil *v* on the load P_v

CONCLUSION

On the basis of the performed field investigations of the interaction of the metal screw piles with various types of soils, the stable practically proportional dependence between the bearing capacity (when pressing in F_d, and pulling out F_{dt}) and the torque M_k) required for sinking them F_d (F_{dt}) = $f(M_k)$ on the final portion of sinking equal to 50 cm has been confirmed.

According to the results of the performed investigations, the factors affecting the M_k value have been established. Such factors include: shape, structure and material of MS piles (in particular, the blade diameter D_b and pitch), type of the soil and method of sinking the pole into it (either manual or mechanical), with due account for which the coefficients of transition k_{sup} (when pulling out) and k_{inf} (when pressing in) from the torque M_k to the bearing capacity F_d (F_{dt}) were determined and the method of its determination was developed.

The proposed method for assessment of the bearing capacity F_d (F_{dt}) of MS piles according to the screwing-in torque M_k ensures the improvement of the calculation accuracy in comparison with the known solutions [1, 2, 8, 9 et al.] under the soil conditions of the Republic of Belarus and reduction of the primary cost of the foundations by at least 30%. The deviations of the F_d and F_{dt} values calculated by the proposed method do not exceed 20%. The results of the performed investigations were included in the developed recommendations for designing the metal pipes for buildings and structures under the conditions of the Republic of Belarus [10].

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