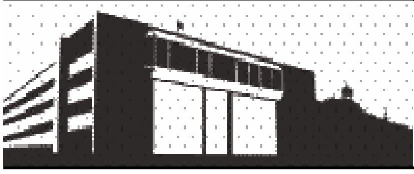

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ТЕХНИКАЛЫҚ ҒЫЛЫМДАР ЖӘНЕ ТЕХНОЛОГИЯЛАР СЕРИЯСЫ / TECHNICAL SCIENCES AND TECHNOLOGY SERIES/ СЕРИЯ ТЕХНИЧЕСКИЕ НАУКИ И ТЕХНОЛОГИИ

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Static load test of unreinforced Franchi (B-4350) soil reinforcement pile

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Abstract. Micro-pile drilling technology is often used today for the reconstruction and repair of buildings whose foundations are heavily loaded. Once installed, the piles take up part of this load. They can also be used to improve the load-bearing capacity of building foundations before the upper floors are built on top of them or before additional underground floors are constructed. Construction of buildings and structures in areas with complex soils is a special case. Buildings constructed in such conditions as a result of underground mining operations, soil movement into the excavated space and formation of a displacement trough on the ground surface are subjected to uneven settlement and horizontal deformations during operation. This paper presents the results of field tests of unreinforced Franki micro-pile (B-4350) unreinforced pile for soil reinforcement. Based on the obtained data, it can be concluded that the use of micro-piles to reinforce the foundations of reconstructed buildings provides a reduction in construction costs, labor costs and construction time, and as a consequence demonstrates their undeniable effectiveness. Application of micro-piles at reinforcement of strip foundations, in comparison with the traditional reinforcement design gives reduction of the estimated cost of construction (by 8 %), mainly due to reduction of the cost of operation of machines (by 46 %) and reduction of wages (by 24 %), though with some increase in the cost of materials (by 28 %), which somewhat levels out the general tendencies of cost reduction.

Keywords: total settlement, bearing capacity, static load test, load-settlement

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1. Introduction

Static tests of soils for bored piles begin after the concrete strength of the pile reaches more than 80% of the design strength or after the resting pile for driven piles. The duration of rest is established by the test program depending on the composition, properties and condition of the cut soils and soils under the bottom end of the pile, but not less:

– 3 days – for sandy soils, except for water-saturated shallow and dusty soils;

– 6 days – for clayey and heterogeneous soils;

The following engineering method of calculating strip foundations on micro-piles with a low basement, based on linear solutions of the theory of elasticity, does not allow to determine the bearing capacity of the foundation with sufficient accuracy for practical purposes at settlements of more than 20 mm. Therefore, for a more complete description of the settlement and stress-strain state of the foundation of single micro-piles and foundations on micro-piles, we used a specialized program for foundation calculation PLAXIS 7.2 Professional.

When investigating the actual performance of micro-piles, strip foundations on micro-piles and the soil foundation, the selected design model plays an important role. The model of the soil foundation, which was used to calculate single micro-piles and strip foundations on micro-piles, was the elastic-plastic Mora-Coulomb model, using the Mnzes-Schleicher-Botkin strength criterion.

The following parameters are required for calculation using this model:

– specific gravity of dry ydry;

– specific weight of wet soil ywet;

– soil filtration coefficient in horizontal kx and vertical ku directions;

– ground deformation modulus Ege/,

– Poisson's ratio g;

– soil specific cohesion sge/,

– soil internal friction angle <r;

– angle of soil volume increase at moistening (dilatancy angle) y/, for clayey soils =0.

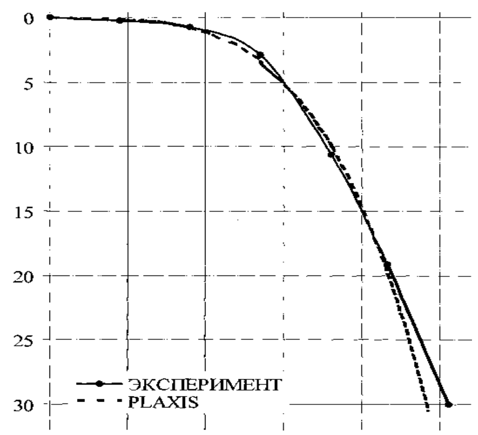

Figure 1. Calculated and experimental load-settlement relationships for single micro-piles

Figure 1 shows the experimental and calculated plots of soil point displacements along the axis of the micro-pile at different elevations. The experimental settlement of the micro-pile was 30.02 mm, while the calculated settlement was 37.6 mm. The character of change of displacements under the heel of the micro-pile in both graphs is the same. However, the attenuation of displacements with depth on the calculated graph is faster than on the experimental one. At a distance of 0.75 m below the micro-pile heel, which is approximately equal to 3 diameters of the micro-pile widening, the experimental displacement is 1.41 mm, while the calculated displacement is 0.63 mm. When analyzing the displacement of soil points, it is seen that the experimental displacement at a distance of 0.5 m above the heel of the micro-pile was 2.58 mm, the calculated displacement was 0.72 mm. In the area of the ground from the heel of the micro-pile and at 0.25 m above there is a break of the calculated graph, corresponding to the rupture of the ground. In the area of 0.25 to Y.5 m above the micro-pile heel, the soil works elastically, and the displacements of soil points with distance from the micro-pile heel are damped.

Table 1. Load on micropipe, kN

Experimental and design bearing capacity, kN	1	2	3	4	5	10	20	30
Experimental bearing capacity, kN	9,6	11,7	13,5	14,3	14,9	17,7	21,7	25,6
Design bearing capacity, kN	9,8	11,6	13,1	13,9	15,1	18	21,9	24,3
Accuracy, %	2,5	-1,3	-3,2	-3,2	1,3	1,7	0,7	-5,2

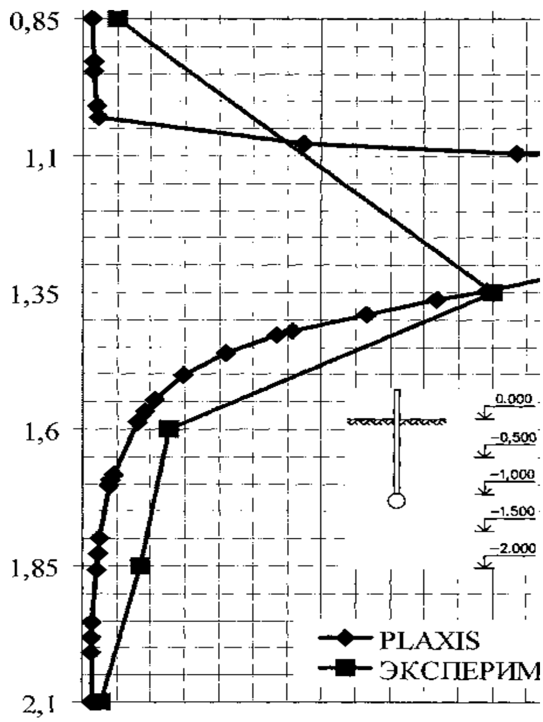

Figure 2. Layer-by-layer displacements of soil points along the axis of the micro-pile at different grades under a load of 25.6 kN

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Figure 2 shows the calculated plots of changes in total stresses and displacements in the soil by depth and width under the heel of the micro-pile. When analyzing the graphs of the stressed state of the base of single micro-piles, obtained by calculation according to the Mora-Coulomb model, the following remarks can be made. The total vertical stresses under the heel of the micro-pile amounted to 382 kPa, and at a distance of 1 m from the heel of the micro-pile - 30 kPa. While the experimental total stresses under the heel were 403 kPa and at a distance of 1 m- 43 kPa. The calculated stresses decay faster with depth than the experimental stresses. This is explained by the higher distributive capacity of soils in comparison with the calculated elastic-plastic model of Mohr-Coulomb.

The installation for testing soils with static indentation loads should include the following equipment: a device for loading the pile (jack), a support structure or platform for reactive forces, a device for measuring the movement of the pile in the process of testing (reference system with izmiritichnymi devices). This paper presents the results of static load test for unreinforced Franki pile (B-4350), which is used under MSE Wall at Gaza Bridge/Baghdad Province for ground improvement. The load test of the pile was conducted by Al-Yasir for Piles Testing office, which carried out all the field work for testing the pile and recording the results as requested by the concerned authority. Details of the tested pile are summarized below:

Table 2. Pile details

Pile No.	Pile Type	Pile Net Length (m)	Pile Diam. (m)	Design Working load (Ton)	Max. Applied Load (Tons)
(B-4350)	Unreinforced Franki pile	13.5	D=0.50	100	200

2. Methods

The Eurocode (EC7-1) defines in clause 7.5 when pile testing should be considered mandatory, namely:

– When using a pile type or installation method for which there is no comparable experience.

– When piles have not been tested under similar conditions.

– When theory and practice are insufficient to provide confidence in the design and when observations during installation show behavior that deviates from what is expected.

The objectives of the load test are:

To demonstrate the stiffness and strength of the pile, which is assumed in the design and can be achieved in reality, and to perform a spot check on the performance of the pile driver, additional pile driving equipment. Accordingly, pile tests were conducted to observe the behavior of the pile under settling load up to 200% of the working load, and to analyze the test results.

A pile shall be considered non-compliant with the design requirements if any of the following conditions occur:

– Maximum settlement exceeds 25 mm at 100% working load

– Maximum settlement exceeds 37.5 mm at 150% working load

– Maximum settlement under ultimate load is greater than the value of settlement = (10%*pile diameter).

– Based on New York City Code criteria, at applied load = 50% of design load, net settlement of the pile is not greater than 5.08 mm.

It is difficult to make a selection of the best axial bearing capacity criterion to use because the preferred criterion is highly dependent on experience and an idea of what constitutes the ultimate fracture resistance of the pile, the following several methods are used to analyze the ultimate resistance of tested piles:-

– Daviss method: it has very wide application and tends to be conservative. It is not suitable for test methods involving loading and unloading cycles.

– De Peer's Method:Use of log - log scale to determine yield strength

– Fung Kee Method: extrapolation methods extrapolate the last part of the load-displacement curve beyond the maximum applied load

– Fuller and Huy Method: using the tangent, find the fracture load (Q)ult on the curve where the tangent to the elastic displacement load of 1.27 mm/ton will have a slope of.

– Mazurkiewicz Method: the ultimate load values are the most conservative results, smaller than values obtained by other methods. It is simple in design and more reliable, especially for piles loaded near failure.

– Method I.S.2911 – Part: safe load = 2/3* (load at which the total settlement reaches 12 mm) or 2% of the pile diameter.

– Decourt extrapolation: Decourt (1999) proposed this method by dividing each load by the corresponding displacement and plotting the resulting value against the applied load, a curve tending to a line intersecting the abscissa.

Compression test procedure per (ASTM-D -1143-2020) Standard Test Methods for Deep Foundations under Static Axial Compressive Loads, paragraph (10.1.3): Apply the test load in increments of 10% of the predetermined required test load as determined by the Engineer. Maintain each increment of load until the rate of axial displacement is less than 0.25 mm per hour, with a minimum time of 30 min and a maximum time of 2 hr. After the axial displacement first exceeds 0.25 mm per hour for the specified maximum time of 2 h and after the load step, reduce the load in decreases of 25% of the maximum test load, keeping the load constant for 10 min, using the same time interval for all load reductions. Considering a longer time interval, not exceeding 1 h, for the final zero load to evaluate the rebound behavior.

Table 3. ASTM-D-2020 -10.1.3 : Procedure B Maintained Page 12

MSE Wall in Gaza Bridge Franki pile test load / Working load = 100 Tons/ Maximum load = 200 Tons

Percent of Maximum Load %	Applied Load Tons	Minimum Time of Load Holding (Min.)	Reading Interval (Min.)	Jack perssure Bar
0%	0			Jack 26 cm
10%	20	1 Hr.	(0, 10,20,30,40,50,60)	38
20%	40	1 Hr.	(0, 10,20,30,40,50,60)	75

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30%	60	1 Hr.	(0, 10,20,30,40,50,60)	113
40%	80	1 Hr.	(0, 10,20,30,40,50,60)	151
50%	100	1 Hr.	(0, 10,20,30,40,50,60)	188
60%	120	1 Hr.	(0, 10,20,30,40,50,60)	226
70%	140	1 Hr.	(0, 10,20,30,40,50,60)	264
80%	160	1 Hr.	(0, 10,20,30,40,50,60)	302
90%	180	1 Hr.	(0, 10,20,30,40,50,60)	339
100%	200	2 Hrs.	(0, 20,40,60,80,100,120)	377
75%	150	10 Min.	(0,2,4,6,8,10)	283
50%	100	10 Min.	(0,2,4,6,8,10)	188
25%	50	10 Min.	(0,2,4,6,8,10)	94
0%	0	1 Hr.	(10,20,30,40,50,60)	0
Total Accumulated Time =750 Min.= 12:30 Hrs.				

However, for the compression test, either the Kent ledge, tension piles or soil anchors can be used as the reactive element. The use of a Kent ledge is preferred because the piles or anchors may affect the result of the test.

Depending on the type of reaction, the following considerations should be taken into account when installing test piles:

– Reaction piles should be placed at least 2.0 m deeper than the test pile.

– The centerline distance between the test pile and any reactive pile shall be a minimum of four pile diameters (largest pile) or 3.0 m, whichever is greater.

– The minimum distance between the test pile and the nearest edge of the support (Kent ledge) shall be 2.5 m, or three times the pile diameter.

The Pile Testing Contractor has arranged for all necessary equipment and supplies for load testing of piles such as Kent ledge dead load, load gauges, deflection gauges, hydraulic jacks, pressure gauges, etc. [see Appendix]. All these instruments have been calibrated for accuracy by the Central Organization for Standardization and Quality. Calibration sheets are attached to this report. All fieldwork and records described herein. All field work and records described herein are the responsibility of the pile contractor and the project owner, who oversees the contractor's work at the site. Tests were conducted using a hydraulic jack, a 600 bar pressure gauge and two dial gauges in accordance with the B.S. Standard Test Methods for Testing Deep Foundations under Static Axial Compressive Loads." The tests were conducted on April 14 and 15, 2024. A continuous record was kept of the pile head displacement at each addition or removal of load during the specified time period, graphs are provided in the Appendix.

3. Results and discussion

The total settlement was (1.64) mm at a load of (100) tons (working load) and the total settlement was (6.46) mm at a load of (200) tons (equal to 200% of working load) in the second cycle, the final residual settlement for the second cycle was (1.62) mm, which is less than 50% of the total settlement equal to (25.08%), The load vs. load plots of vertical pile head settlement, time vs. pile vertical settlement and time vs. load are shown in the appendices.

Table 4. Applied load and final measured settlement

Applied Load (Tons)	
0	0.00
20	0.37
40	0.62
60	0.90
80	1.28
100	1.64
120	2.25
140	2.87
160	3.70
180	4.94
200	6.46
150	6.28
100	5.29
50	3.88
0	1.62

4. Conclusion

By examining the load-settlement curves for the test pile and adopting criteria to ensure the safety of the pile under the applied loads, it is found that:

– The test pile did not show any unnatural behavior in all phases of the test up to the application of load (200) tons with an average total settlement of (6.46) mm, which is within the allowable settlement limits and is approximately (1.29 %) of the pile diameter, which is less than 10% of the pile diameter and the behavior of the test pile is shown in the Appendix.

Consequently, this tested unreinforced Franchi pile with a diameter of (0.50) cm is adequate for the design load of (100) tons with a confident behavior.

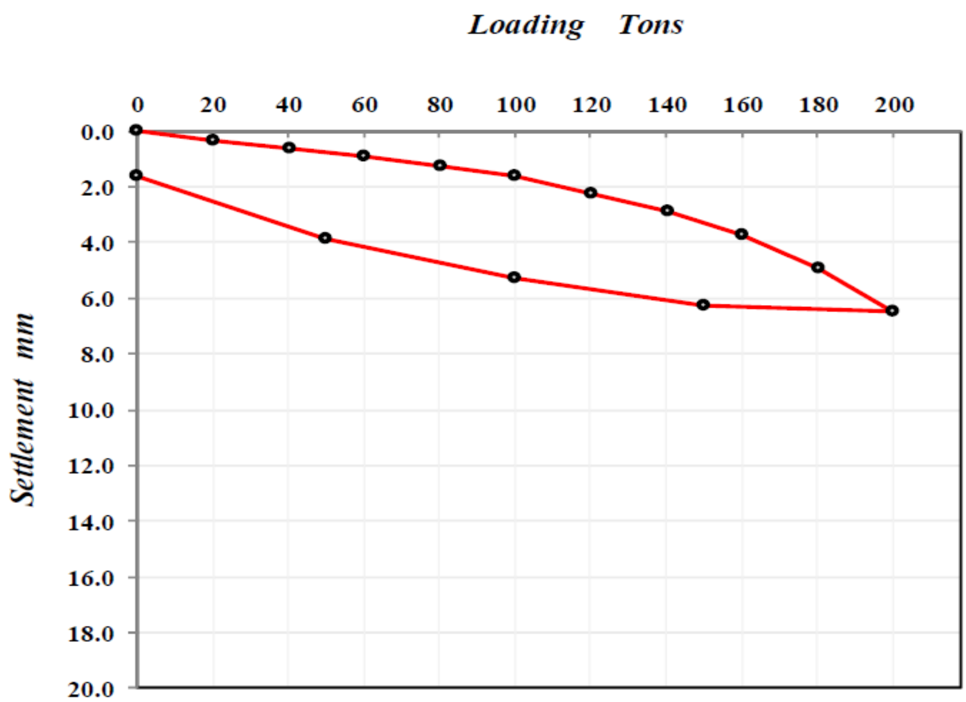
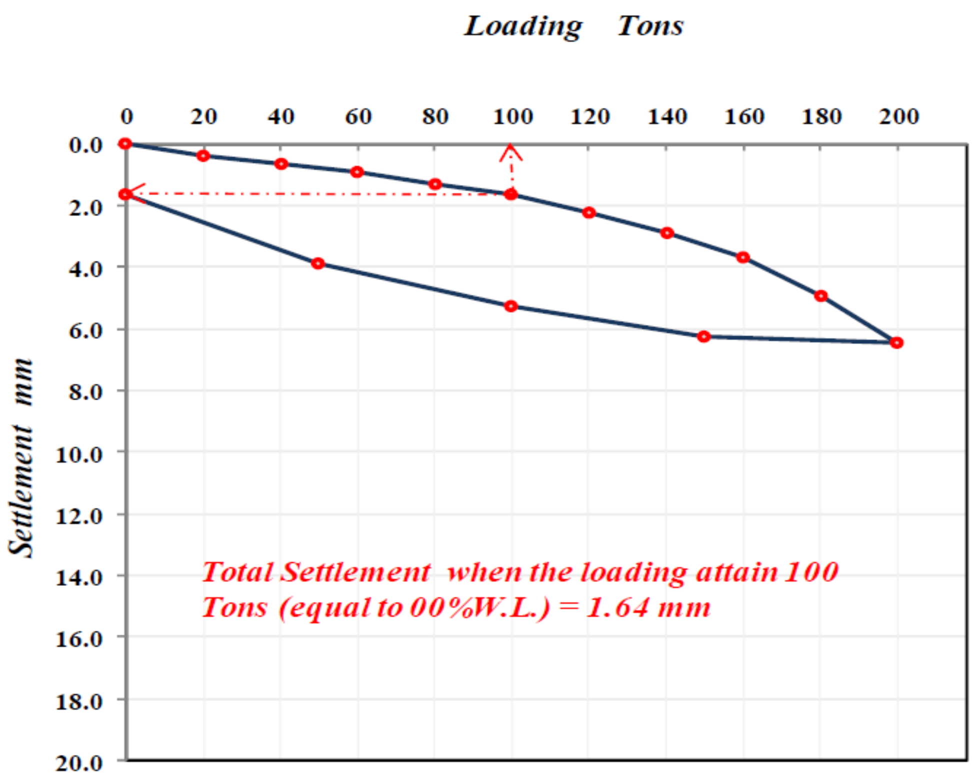


Figure 1. Load – settlement response of the pile Figure



2. Loading versus settlement for 200 % of design load

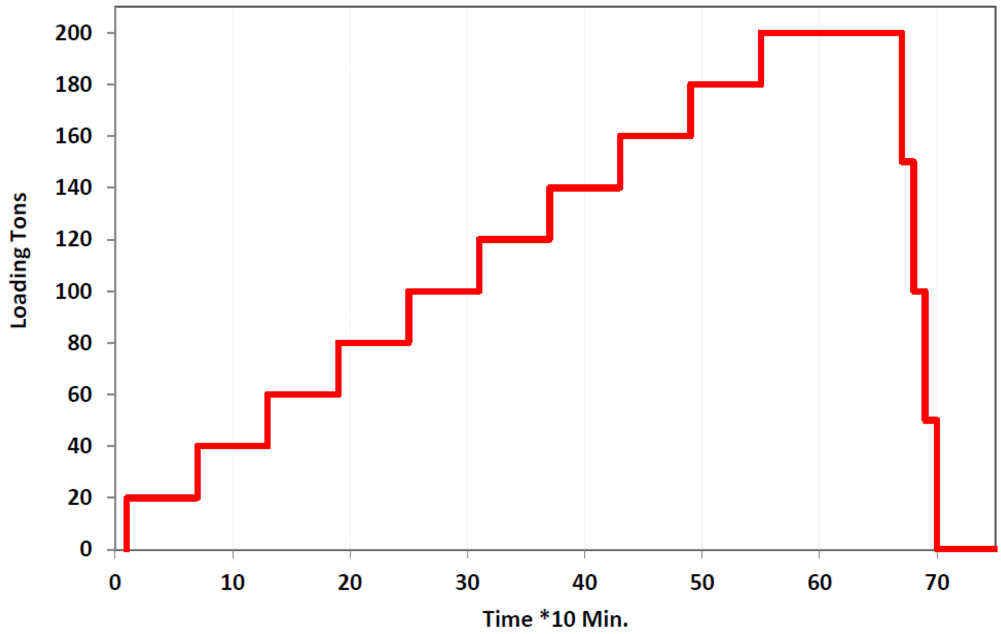
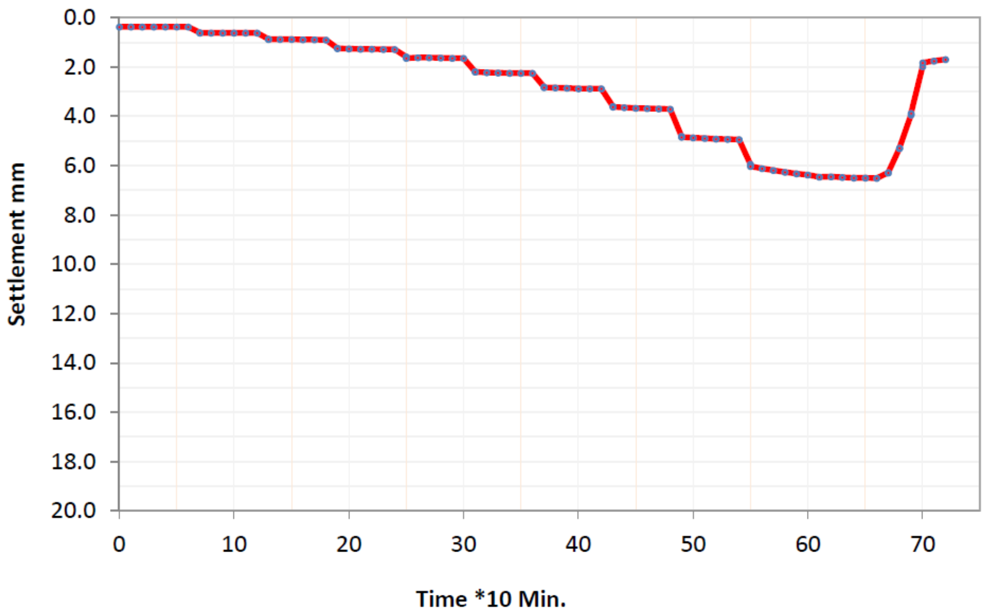


Figure 3. Loading versus time Figure



4. Settlement versus time

Author contribution:

M.Nurgozhina – conceptualization, approving of final version, funding acquisition
A.Zhussupbekov – analysis, writing
D.W. Chang – interpretation of results
D.Yu.Chunuyk – data collection, critical review of content

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Күшейтілмеген Franchi (B4350) топырақ арматурасының қадасының статикалық жүктеме сынағы

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Аңдатпа. Микро қадалы бұрғылау технологиясы бүгінде іргетасы қатты жүктелген ғимараттарды қайта құру және жөндеу үшін жиі қолданылады. Орнатқаннан кейін қадалар осы жүктеменің бір бөлігін алады. Олар сондай-ақ құрылыс іргетасының көтергіштік қабілетін жоғарылату үшін олардың үстіне жоғарғы қабаттар салынғанға дейін немесе қосымша жер асты қабаттары салынғанға дейін пайдаланылуы мүмкін. Күрделі топырақты аймақтарда ғимараттар мен құрылыстарды салу ерекше жағдай болып табылады. Жерасты тау-кен жұмыстарын жүргізу, топырақтың қазылған кеңістікке жылжуы және жер бетінде жылжымалы науаның пайда болуы нәтижесінде осындай жағдайларда салынған ғимараттар пайдалану кезінде біркелкі емес отыруға және көлденең деформацияларға ұшырайды. Бұл жұмыста топырақты нығайтуға арналған арматураланбаған Франки микро қадасының (В-4350) далалық сынақтарының нәтижелері берілген. Алынған мәліметтерге сүйене отырып, реконструкцияланған ғимараттардың іргетасын нығайту үшін микро қадаларды пайдалану құрылыс шығындарын, еңбек шығындарын және құрылыс уақытын қысқартуды қамтамасыз етеді және соның нәтижесінде олардың даусыз тиімділігін көрсетеді деп қорытынды жасауға болады. Жолақты іргетастарды нығайту кезінде микроқадаларды қолдану дәстүрлі арматуралық жобамен салыстырғанда құрылыстың сметалық құнын (8 %-ға), негізінен машиналарды пайдалану құнының төмендеуіне (46 %-ға) және қысқартуға мүмкіндік береді. еңбекақыны (24%-ға) құрады, дегенмен материалдар құнының біршама өсуімен (28%-ға), бұл өзіндік құнның төмендеуінің жалпы тенденцияларын біршама теңестіреді.

Түйін сөздер: жалпы есеп айырысу, жүк көтергіштігі, статикалық жүктемені сынау, жүктемені реттеу

Испытание неармированной грунтоукрепительной сваи Franchi (B4350) на статическую нагрузку

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Аннотация. Технология бурения микросвай сегодня часто применяется при реконструкции и ремонте зданий, фундаменты которых сильно нагружены. После установки сваи принимают на себя часть этой нагрузки. Их также можно использовать для повышения несущей способности фундаментов зданий перед возведением над ними верхних этажей или перед устройством дополнительных подземных этажей. Особый случай – строительство зданий и сооружений на территориях со сложными грунтами. Здания, построенные в таких условиях, в результате подземных горных работ, перемещения грунта в выработанное пространство и образования на поверхности грунта смещающей впадины, в процессе эксплуатации подвергаются неравномерной осадке и горизонтальным деформациям. В данной статье представлены результаты полевых испытаний неармированной микросваи Франки (B-4350) для армирования грунта. На основании полученных данных можно сделать вывод, что применение микросвай для армирования фундаментов реконструируемых зданий обеспечивает снижение затрат на строительство, трудозатрат и сроков строительства и, как следствие, демонстрирует их неоспоримую эффективность. Применение микросвай при армировании ленточных фундаментов, по сравнению с традиционной конструкцией армирования, дает снижение сметной стоимости строительства (на 8 %), в основном за счет снижения затрат на эксплуатацию машин (на 46 %) и снижения заработной платы (на 24 %), хотя и с некоторым увеличением стоимости материалов (на 28 %), что несколько нивелирует общие тенденции снижения издержек.

Ключевые слова: полная осадка, несущая способность, испытание статической нагрузкой, расчетная нагрузка.

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