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Results Of Field Tests Of Foundations In Rammed Doun

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Abstract: *The essence of the foundation method in rammed doun is that the pits for individual foundations are not torn off, but the pit is rammed to the calculated depth, followed by embedding with concrete. To increase the bearing capacity of the foundation soil, hard or local soil material is compacted in portions into the bottom of the compacted pit to form a widened part. The load from the foundations along the base and side walls is transferred first to the compacted soil, and then to the soils of natural composition, due to which a higher bearing capacity of the foundations is achieved. This article examines the results of field studies to determine the dependence of the load-bearing capacity on the size and volume of the widened part.*

Key words*: dynamic test, compaction, static test, widened part, crushed stone, silty sandy loam.*

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I. INTRODUCTION

The load-bearing capacity of foundations in rammed foundations (FRD) and pyramidal piles, which are currently used, calculates not only the soil resistance of the frontal part (F_{fr}) and the lateral surface (F_{lat}), but also the soil resistance acting perpendicular to the lateral surface of the foundation ($F_{per.lat}$). The essence of the foundation method in rammed pits is that the pits for individual foundations are not torn off, but the pit is rammed to the calculated depth, followed by embedding with concrete. To increase the bearing capacity of the foundation soil, hard or local soil material is compacted in portions into the bottom of the compacted pit to form a widened part. The load from the foundations along the base and side walls is transferred first to the compacted soil, and then to the soils of natural composition, due to which a higher bearing capacity of the foundations is achieved.

II. METHODS AND MATERIALS

The first study of the bearing capacity of pyramidal pile foundations was carried out at the beginning of the twentieth century by the Russian scientist V.K. Dymokhovsky [1], who made the following conclusion: "... the total resistance of the pile increases significantly when changing from a cylindrical to a conical shape. But this depends to a lesser extent on the angle of lateral inclination≫. He was the first to develop a scheme for calculating the bearing capacity of a pyramidal pile:

$$R = \frac{1}{n}\left(R_s + R_f + R_{pl}\right); \quad (1)$$

In the mid-1930s, V.N. Golubkov [2] examined a pyramidal pile foundation and developed a formula for determining resistance:

$$R_{\text{св}} = \frac{E_{\text{гр.ср}} * V_{\text{св}}}{0.5 * V_a} F_{\text{св.гр}}; \quad (2)$$

N.L. Zotsenko [3] established that there is a direct relationship between the resistance $P_{\text{ск}}$ and the bearing capacity of the soil cone:

$$P = k\ m\ P_{\text{ск}}^{\text{е}} F_{\text{c}}; \quad (3)$$

Bakholdin B.V., Igonkin I.T. [4], Goncharov B.V., Semenkov Yu.V. M.[5] proposed a formula for determining the load-bearing capacity of a pyramidal pile:

$$F_d = RA + \sum u_i h_i \left(f_i + f_{\text{от}.i}\right) \cos\alpha; \quad (4)$$

When determining the value of the force f_oi acting perpendicular to the lateral surface of a pyramidal pile, a method was proposed to include the values of porosity and permissible soil pressure in the calculation. The bearing capacity of a pyramidal pile is determined by the following formula (BNbD 50.01-16 [6]) under the action of a vertical load.

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$$F_d = \gamma_c\left[R\,A + \sum h_i\left(u_i f_i + u_{oi} i_p E_i k_i \xi_R\right)\right]; \qquad (5)$$

Musab Ayed Kissab [7] studied the bending capacity of conical piles with lateral loading in cohesive soils and found that conical piles are more efficient and economical than prismatic piles having the same volume of material.

Fedorov B.S., Kolchunov V.I., Pokusaev A.A., Naumov N.V.[8]проанализировали результаты испытаний многих исследователей и установили корреляционную зависимости между использованием материалов для созыдания уширенной части, длиной и градусов конусного наклона пирамиды.

A design model of a three-layer foundation was used to calculate the load-bearing capacity of FRD with widened rigid soil materials. The FRD performance was simulated using the finite element method (MFE) using the Mohr–Coulomb elasto-plastic model. For calculations to determine the bearing capacity of the soil foundation, FRD is modeled as follows (Nyamdorj Setev [9]):

I layer. Bearing capacity of soil material widening;

II layer. Bearing capacity of compacted soil around the expansion;

III layer. Bearing capacity of the underlying soil taking into account moisture.

The minimum calculated value of these load-bearing capacities is taken as the load-bearing capacity FRD.

III. TEST METODOLOGY

A. Ground conditions: The site for testing the monolithic FRD was selected in the courtyard of the Keramzit plant in the industrial area of the city of Darkhan, Mongolia (Bagdasarov Yu.A., Nyamdorj S. [10]). Soil conditions: a layer of plant roots about 0.3 m thick, underneath is silty sandy loam soil with a thickness of about 4.5 m. Natural humidity 0.05, density 1.65 t/m3, dry density 1.56 t/m3 , thinning coefficient 0.72, degree of humidity 0.20, angle of internal friction 29° with natural moisture, 21° with water saturation, adhesion force of naturally wet soil - 18.0 kPa, with water saturation - 9.0 kPa, relative index shrinkage - 0.012...0.023, deformation modulus - 12 MPa, 4.2 MPa when saturated with water.

The methodology for conducting full-scale field tests to determine the load-bearing capacity of FRD using the dynamic test method, as well as static tests, measurement and processing of results are described in [9].

When testing FRD, the following types of material with corresponding volumes were used and compacted to create widened parts:

a) FRD - 1 with a depth of 2.35 m, 0.78 m3 of gravel was filled in portions and compaction was performed to create a widening;

b) FRD - 2 with a depth of 2.65 m, 2.45 m3 of crushed stone was filled in portions and tamping was performed;

c) FRD - 3 with a depth of 2.65 m, 0.73 m3 of sandy loam soil of the experimental site was filled in portions and compaction was performed.

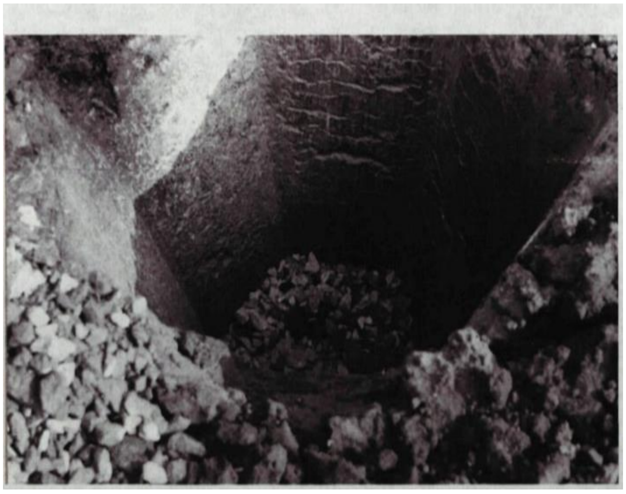

Figure 1. Rammed pit filled with crushed stones

B. Dynamic test results. Work on compacting the compacted pit began after preparations were made for compaction at the central point of placement of the future foundation. After 15...24 single throws of a cone-shaped tamper, a compacted pit was formed at a given depth. Crushed stone with a granular composition of 20...40 mm and silty sandy loam of the construction area were poured into the finished pit to form an expanded part under the foundation using a special dispenser with a volume of 0.5 m3 (Fig. 1). After compacting the previous portion to a depth of 2.8 m or 3 m, the next portion of soil materials was compacted to form an expanded part.

Based on the results of the experiment, a dependence curve Δh=f(n) of drilling a hole in the ground was established for each foundation depending on the number of blows n (Figures 2...4).

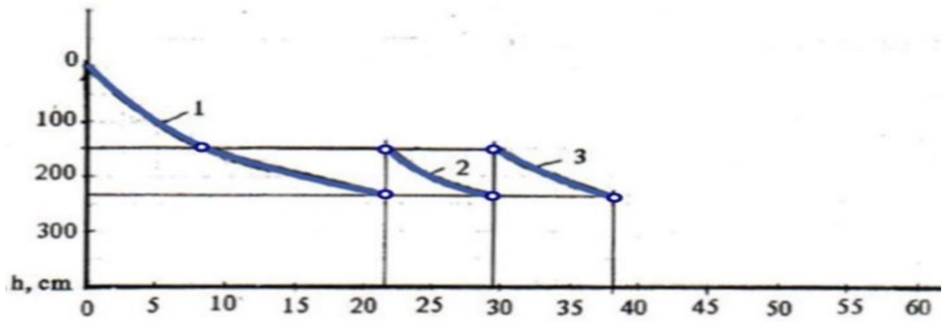

Figure 2. Dependence curve Δh=f(n) of dynamic test FRD No1: 1 – compaction curve of sandy loam foundation soil; 2 – compaction curve of the first portion of gravel for widening; 3...2 – compaction curve of the second and third portions of gravel for widening

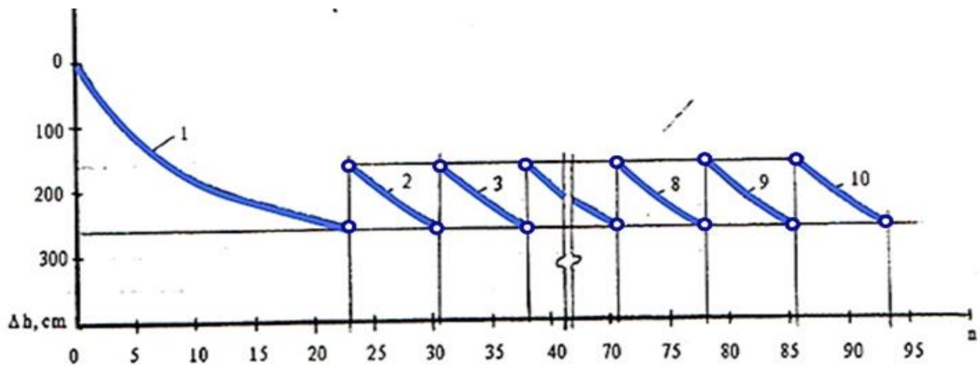

Figure 3. Dependence curve Δh=f(n) of dynamic test FRD No2: 1 – compaction curve of sandy loam base soil; 2 – compaction curve of the first portion of crushed stone for widening; 3...10 – compaction curves from the second to the tenth portions of crushed stone for widening

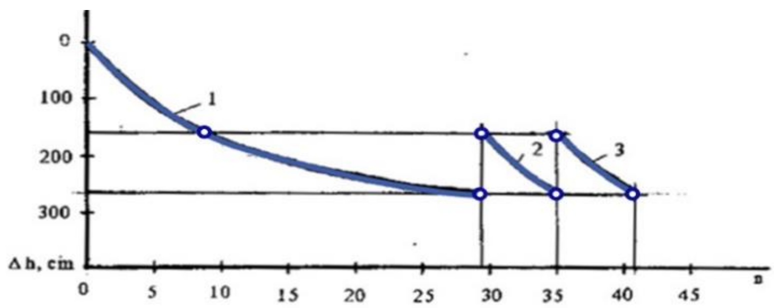

Figure 4. Dependence curve Δh=f(n) of dynamic test FRD No3: 1 – compaction curve of sandy loam foundation soil; 2 – compaction curve of the first portion of gravel for widening; 3...2 – compaction curve of the second and third portions of sandy loam for broadening

B. Static test results. Figure 5 shows calculation schemes for three FRD options prepared after dynamic tests.

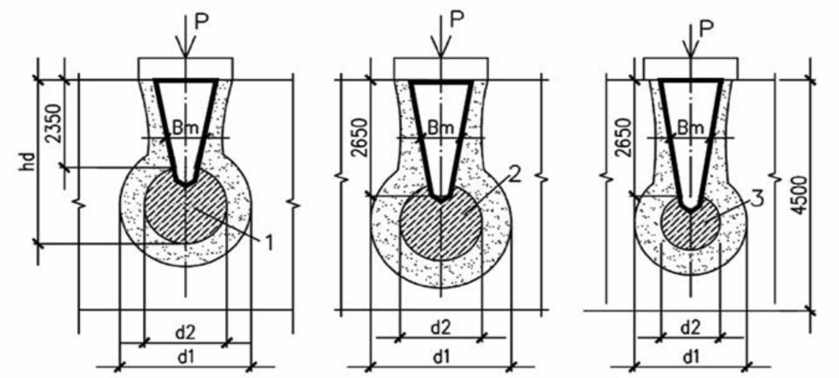

Figure 5. Design diagrams for static tests FRD No1, 2 and 3: 1 – gravel expansion,Vsh=0.78 m3; 2 – widening made of crushed stone, Vsh =2.45 m3; 3 – widening from sandy loam, Vsh = 0.73 m3

Based on the results of static tests, graphs of the dependence S=f(F) were plotted (Figures 6...8) and the load-bearing capacity FRD was determined.

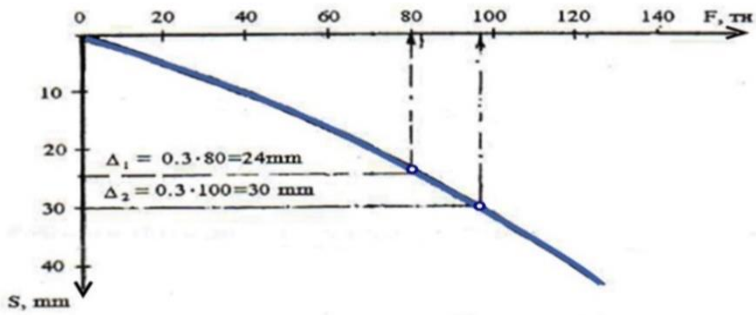

Figure 6. Dependence curve S=f(F) depending on draft FRD (S) and load (F) No.1.

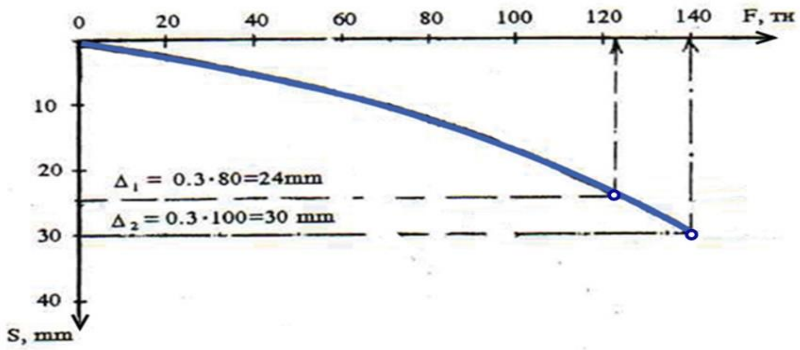

Figure 7. Dependence curve S=f(F) depending on draft FRD (S) and load (F) No.2.

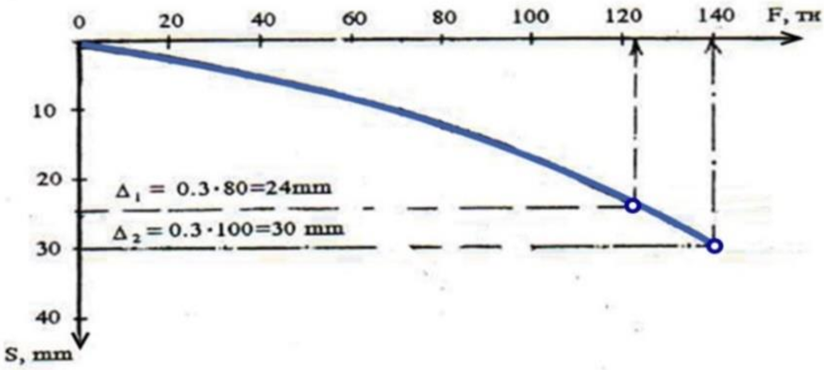

Figure 8. Dependence curve S=f(F) depending on draft FRD (S) and load (F) No3.

Table – 1. Geometric characteristics of the FVC and broadening

Foundation No.	Type and volume of materials for expansion	Diameter of expansion d_1 , m	Diameter of the compacted zone d_2 , m	Marking of the base of the widening,
FRD-1 FRD-2 FRD-3	Crushed stone, 0,78 m^3 Crushed stone, 2,45 m^3 Silty sandy loam, 0,73 m^3	0,53 1,78 0,50	1,10 1,60 1,03	3,2 4,0 3,4

DEPENDENCE RATIO

Based on the test results presented in Table 4.1, a method is proposed for determining the value of the design coefficient $К_h^x$, based on the ratio of the total depth of the compacted zone and the diameter of the expanded part:

$$К_h^x = \frac{h}{d_1} \quad ,(6)$$

where h is the depth of the compacted soil zone, d_1 is the diameter of the expanded part, m.
The value of the coefficient in the case of using crushed stone for the expanded part:

$$К_h^x = \frac{h}{d_1} = \frac{3.6}{1.15} = 3.1$$

Under conditions of using construction sand:

$$К_h^x = \frac{h}{d_1} = \frac{3.4}{0,5} = 6,80$$

It has been established that the value of the calculated coefficient increases in inverse proportion to the indicator. strength of the soil material used in the extended part of the tip.

IV. CONCLUSIONS

Based on the analysis of the results of dynamic and static field tests of the FVK, the following provisions were established:
1. FRD -1 with a depth of 2.35 m and with 0.78 m3 of gravel to form a widened part in the base has a bearing capacity of 98.0 tons, and FRD -2 with a depth of 2.65 m and with 2.45 m3 gravel to form the widened part has a load-bearing capacity of 140.0 tons, or approximately 30% more than FRD -1;
2. FRD -3 has a depth of 2.65 m, is compacted with 0.73 m3 of local silt-sandy soil to create a widened part and has a bearing capacity of 71 tons, which is 27 tons, or 27.5% less than the bearing capacity of FRD -1 . In this case, only the materials used to create the widening are different;
3. FRD -1 has a load-bearing capacity of 42.0 tons, or 1.5 times less than the load-bearing capacity of FRD -2 with the diameter and volume of gravel to create a widening 3 times less than FRD -2.

4. Based on these provisions, it has been established that the bearing capacity of FRD in compacted subsidence soil depends mainly on the diameter of the expansion, as well as on the type and volume of soil materials used to create the expansion.

5. The use of sandy loam soil of a construction site to create an expanded part will reduce the cost of the foundation by 1.5...2.4 times compared to the use of crushed stone and will become a nature-saving green construction technology, since there is no need to develop a quarry for preparing crushed stone.

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