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INVESTIGATION OF THE OSCILLATIONS AMPLITUDES BASES AND FOUNDATIONS OF THE FORMING MACHINE

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Abstract

Dynamic load equipment is a source of waves that propagate in the ground and affect nearby buildings and structures. Objects with equipment that are sensitive to vibration and operating personnel are not infrequently exposed to vibrations that do not rarely exceed the values set by regulatory documents. The foundations of molding machines from the influence of dynamic loads were studied experimentally, taking into account damage to the foundations. Also, the magnitude of the amplitude was influenced by the above mentioned soil properties, which arose during their operation, the physical and mechanical characteristics of the soil of the bearing layer, as well as the underlying layers.

To measure the amplitudes of oscillations and sediments of the foundations of the molding machines used modern measuring equipment It is determined that the amplitude of oscillation of the base under study when the machine is almost 2.3 times higher than acceptable. And at work of all machines at the same time the amplitude of oscillations of a certain foundation 13.7 times exceeds the allowable one. The reason for the increased fluctuations of the foundations has been identified and substantiated. It was found that the foundations of the molding machines are made with deviation from the design decision (reduced size) and have damage during operation. Recommendations are given to remedy the identified shortcomings.

1. Introduction

It is almost impossible to prevent mechanical vibrations, which cause soil vibration in practice, because they are caused by production processes in enterprises, technology of construction work and other dynamic phenomena. Dynamic load equipment is a source of waves propagating in the ground and affecting nearby buildings and structures, vibration-sensitive facilities and equipment, maintenance personnel and not infrequently exceeding permissible values set by regulatory documents. Low-amplitude mechanical oscillations often cause the resonance of structural elements. Excessive vibrations of the foundations can cause premature actuation of machine parts, affect the growth of deformations and sedimentation of the foundations of machines, structures [1].

2. Basic investigation

2.1 Approaches to determining the characteristics of the foundation oscillations

Analytical methods of calculation are based on the use of some assumptions. There are two approaches to solving dynamic problems. Proponents of the first approach used the Lagrange dynamic method to explain the phenomenon [2]. The calculations were performed using the characteristics of vibrations, materials and soils. This method required preliminary determination of the mechanical energy of the system, which consisted of: kinetic energy of vertical, horizontal displacement and rotational motion, potential energy of deformation of the soil in the plane of the sole of the foundation. If the foundation was designed deep into the soil, then the potential energy of deformation of the lateral compression of the soil was determined, the reduction of potential energy due to the decrease in the center of gravity of the inertia. As a result of the calculations, differential equations of the forced plane harmonic oscillations of the foundation were obtained.

Other authors used the principle of J. d'Alembert [3], that is, in addition to the active forces added forces of inertia, and regarded the system as being in equilibrium. This method is called the method of kinetostatics. This method is simpler, so it is most common. Calculating the foundation in this way, the following assumptions were applied: under dynamic loads, the substrate was assumed to be linearly deformed, perfectly elastic-viscous and devoid of mass (soil inertia not taken into account). The viscosity of the substrate is due to the properties of the damping soil. The foundation was regarded as absolutely solid.

Carrying out a number of transformations, the differential equations of the forced oscillations of the foundation-base system were obtained with one degree of freedom based on them. According to the approach to solving the differential equations of dynamics, the methods of calculating the amplitudes of oscillations of the bases and foundations of the machines are distinguished (Fig. 1). The deformation method was used to calculate the foundations for the machines. Turning to the basic system of the deformation method, I.V. Urban assumed anchoring structures at the center of gravity, and based on this he formulated unknown amplitude displacements that impeded vertical and horizontal displacements as well as rotation. The conditions of symmetry of the structure were taken into account in the calculation, but the deepening of the foundation was not taken into account.

In the works of VB. Shvets [5,6], the dependences for the calculation of the displacements of the foundation and the machine, the system "base - foundation - machine" are proposed, which is considered as two - mass, taking into account the inelastic resistances of the base and the over - base laying. However, dependencies are cumbersome for use in engineering calculations without the use of computers. VB The cobbler is recommended to calculate the foundations for the molding machines, to carry out the hammer taking into account the elastic pads under the shaking part of the machine, which significantly affects the amplitude of the oscillations of the foundation. Yu.O. Kirichek [1], E.O. Lando at Finite element method (FEM) performed the analysis of the interaction of combined solid-plate foundations with the base. Such modeling has advantages in terms of complexity and cost in comparison with full-scale and experimental studies on models. In addition, using this numerical method, it is possible to simulate processes that cannot be experimentally investigated.

A.V. Grishin [7], S.M. Novak noted that this simple and versatile approach worked great. A.V. Grishin [7] investigated with the help of ITU a concrete slab lying on a deformed base under the action of impulse loading, taking into account elastic-plastic properties of concrete and soil base. For the base he used an elastic-plastic model under the condition of Mora - Coulomb. In the numerical solution of the nonlinear elastic-plastic dynamic problem, the sampling of the initial equations was carried out both in time and in the area occupied by the slab and the base.

Eight and five nodal infinite isoparametric elements were used to sample the initial equations. Infinite elements were used to sample the infinite boundaries of the substrate to avoid the reflection of waves. The following is an iterative process. The calculation scheme is shown in Fig. 1.

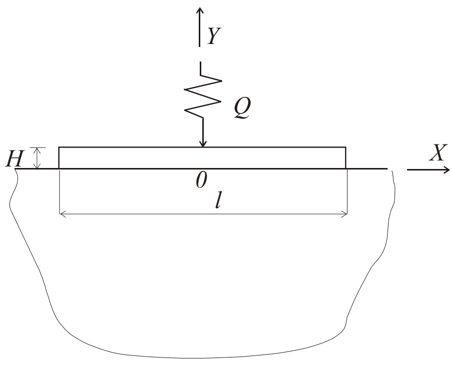

Fig. 1. Calculation scheme of the concrete slab, which is deformed on the basis of the impulse load

A.M. Uzdin [8] used infinite finite element modeling to use “infinite finite elements” (IFE). The base area is divided into two subdomains. The interior adjacent to the foundation of the structure is separated from the outer circle and divided into traditional finite elements. The outer area is divided into IFE limited by the circle and the radii of this circle. This technique can be recommended to calculate the foundations of deep-loading for the action of dynamic loads.

Recently, the market for software for engineering calculations offers a lot of both domestic and foreign developments based on FEM, which allow to carry out calculations of bearing structures fairly reliably. Unfortunately, the area of calculations related to geotechnical engineering which underlies the processes of interaction between foundations and soils is much less developed. Each program has both advantages and disadvantages in terms of solving a specific problem. Multipurpose programs include the following: "Lyra", "MSC.Nastran", "APM Dynamics", "Dynamics - 3", "NONSAP", "Selena", "SCAD", "ABAQUS", "Zenith-95" " VESNA ”and others. These software systems allow you to perform static, dynamic design calculations.

Programs suitable only for the dynamic calculation of any design are "ANSYS LS-DYNA", "LS-DYNA", "MSC / DYTRAN" "T-Flex / Dynamics". Narrow profile software complexes are intended for dynamic calculations of individual types of foundations and foundations. Such programs include "Dynardo". With the Dynardo program you can perform dynamic analysis of foundations (pile and slab) in conjunction with the ground for the effect of wind load. "Dynamics" is a software complex for the calculation of port hydraulic structures, machine foundations.

When calculating the FEM of dynamic problems on the basis of computers, the developers of software complexes are tasked with increasing the accuracy of the calculation of oscillation parameters. However, it is necessary to pay attention to the possibility of taking into account cracks and defects, changing the properties of the soil during operation during the calculation of the foundation. This area needs detailed study in the design and reconstruction of the foundations of machines [9].

Thus, the purpose of the study is to investigate the foundations and foundations of molding machines against the effects of dynamic loads, taking into account the damage to the foundations, the given properties of the soil that arose during their operation, the physical and mechanical characteristics of the soil of the bearing layer, as well as the underlying layers.

2.2. Experimental study of oscillation amplitudes of foundations of molding machines during reconstruction.

The molding and steelmaking workshop of the DniproVagonMash plant in Kamianske was investigated. The territory of the section of the steel-and-steel shop of the DniproVagonMash plant in Dneprodzerzhinsk is located about 200 m from the Dnipro River. Its relief is generally equal, substantially altered by human activity. Absolute Earth Marks: 62.00 - 63.50.

Adverse physical-geological processes and phenomena within the site include:

- thick (10 m or more) bulk soils (IGE - 1 and IGE - 2), which are very heterogeneous both in length and in depth of the massif. In terms of characteristics, such soils should be considered very compact. Very compact soils include litter soils (IGE - 3);
- dynamic impact on soils within individual sections of the site, in particular, the molding department.

The hydrogeological conditions of the territory are caused by the hydraulic connection of the groundwater with the water level in the Dnieper River.

The level of groundwater at the time of the survey (12.04.2005) was 8.60-8.80 m from the surface of the earth. Its fluctuations are fixed within 1.5 - 2 m.

Within the surveyed area the following engineering-geological elements (IGE) are highlighted:

IGE - 1 - bulk soils (industrial waste - slag, ash, ie products of complex thermal transformation of rocks and burning of solid fuel) are loose, from medium degree of water saturation to saturated with water, with sandy filler (sand of medium coarse, non-uniform) and uniform. ;

IGE - 2 - bulk soils (industrial waste - slag, ash and slag) loose, saturated with water, with sandy aggregate (sand dusty, inhomogeneous) and fragments of rocks;

IGE-3 - silt alluvial, greenish-blue-gray (saprolite - the final product of weathering of granites), with the inclusion of small fragments of crystalline rocks, from fluid-plastic to fluid;

IGE - 4 -granite is greenish-gray, medium-grained, slightly stained, non-softening in water, medium to durable.

Soil samples (IGE − 1a), which were passed directly next to and under the sole of the forming machine 3, were also selected.

IGE - 1*a* - bulk soils (industrial waste - slag, ash and slag) of small degree of water saturation, with sand filler (medium size sand, inhomogeneous) and rock fragments, subsidence. The filler content of sand up to 95%, dust content up to 5%. It should be noted that the IGE-1 under the sole of the foundation has been substantially altered by compaction during machine operation. This should have been manifested in significant deformations of the foundations in the past.

According to the values of its characteristics, such soils should be considered as very short [10-12].

To determine the amplitudes of oscillations and depositions of the foundations of the molding machines, measurements were made with the help of a measuring device - the vibrometer 107B (Fig. 2).

Fig. 2. Instrument for measuring oscillation parameters "Vibrometer 107B": *1* - accelerometer; *2* - probe; *3* - the vibrometer

Vibrometer 107V is a stand-alone microprocessor-based vibration measuring device designed to measure vibration parameters (vibration acceleration, vibration speed and vibration displacement).

At the same time, a spectral analysis of the vibration signal was performed. For digital signal processing (DSP), Fourier analysis is used - discrete Fourier transform (DFT), which operates a discrete time sampling of a periodic vibration signal. The exponential averaging was used in the calculation of the mean square value of the measured value. The Hanning weighting function was used to process the input signal. The main element of the device is a processor unit that provides control of measurement circuits, measuring signals, displaying information on the display. The device is operated using the keyboard. Dynamic vibration measurement ranges: 1-5000 microns. Sensitivity of the accelerometer: 0.1 to 500 pcl c^2/m.

The manufacturer of such molding machines is Kamyanske. The main parameters: dimensions in the plan 2730-3500 mm (Fig. 3), height - 2500 mm; weight - 4000 kg; vibrators - 2 pcs; shaking mechanism with an average number of blows: 200-250 beats/min; the course of the table when shaking: 30-60 mm.

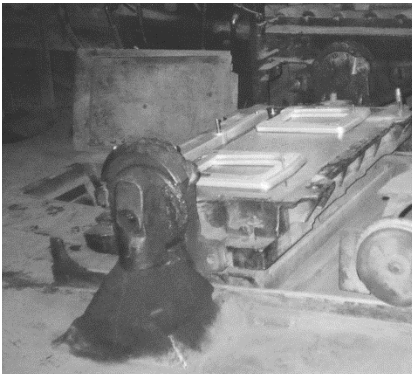

Fig. 3. Model 405 Forming Machine

The hollow folding was carried out by pneumatic hoist, with a load capacity of 1.5 t. from 3.25 to 3.75 m.

Reinforced concrete foundations for molding machines are made jointly with the floor. The condition of the foundation F-3 on the revealed defects indicates the impossibility of its safe operation, therefore, the study of the amplitude of the oscillations of the foundation, taking into account cracks and damage to the foundation during reconstruction. Structurally, the foundation is a massive base (bottom), on which the perimeter wall wall is installed along the perimeter and the base is connected in one. Cracks have been found in the area of connection of the foundation with the floor (Fig. 4).

Fig. 4. Horizontal reinforcement and corrosion of reinforcement in the wall of the base F-3

The lower massive part of the foundation had significant defects and damage during the 2005 survey, namely:

- through horizontal and vertical cracks on the front surface of the supporting part of the foundation;
- the presence of loose soil of the backfill of the foundation;
- destruction of the reinforced concrete base due to the impact of the equipment mounted on it;
- separation due to displacement of the central part of the foundation relative to its side walls.

Such damage is caused by the long operation of the foundations of the molding machines and does not allow full use of the foundation, so it must be reconstructed.

Table 1

Amplitude data of the vertical oscillations of the F-3 foundation for the molding machine of the molding shop

Data	Amplitude	
	mkm	mm
All disabled	17	0,017
Only the first machine is included	67,99	0,068
Only the second machine is included	248,1	0,248
Only the third machine is included	1153	1,153
Only the fourth car is included	136	0,136
The second and third machines are included	1852	1,852
The third and fourth machines are included	1657	1,657
Included are first, second, third, fourth machines	8878	8,878

To evaluate the impact of foundation fractures during operation, measurements of the dynamic characteristics of the foundations of the foundations of the forming machines were measured. The accelerometer sensor, when measuring the amplitude of the oscillations of the foundation, was mounted on the mortar and directly on the concrete surface.

The amplitude of oscillation of the base of the F-3 at the operation of the machine No. 3 was 1.15 mm - 0.5 mm - the value is almost 2.3 times higher than the permissible one [13,14]. And for all machines at the same time, the amplitude of the oscillations of the base F-3 - 8,878 mm - 0,65 mm is 13.7 times higher than acceptable. The foundations of the molding machines are made with deviation from the design decision (reduced sizes); between the foundation structure and the frame of the machine, the elastic gasket is missing or does not meet the requirements of regulatory documents; the wall around the perimeter of the foundation was combined with the floor design of the shop, which contradicts the requirements [13, paragraph 5.10.]. That is, these facts influenced the increase in the amplitude of the oscillations of the foundations, as evidenced by full-scale studies of the foundations.

3. Conclusions

1. The condition of the foundation F-3 on the detected defects indicates the impossibility of its safe operation, therefore, the study of the amplitude of the oscillations of the foundation, taking into account cracks and damage to the foundation during reconstruction.

2. To study the amplitudes of oscillations and sediments of the foundations of the molding machines, measurements were made with the help of a measuring instrument - the vibrometer 107B.

3. The oscillation amplitude of the F-3 foundation when operating the machine was almost 2.3 times higher than acceptable. And at work of all machines at the same time the amplitude of oscillations of the base F-3 13,7 times exceeds the allowable one. This is due to the fact that the foundations of the molding machines are made with deviation from the design decision (reduced size) and have damage during operation. Therefore, it is necessary to carry out the project of reconstruction of the foundation of the machine.

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