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Dynamic Tests of Foundations with Explosives

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SYNOPSIS The dynamic tests results of bearing capacity of bases disposed of foundation on the tampered out trenches in subsiding soils fulfilled by means of explosions are represented. The main principles are stated which concern the dynamical lasting methods of the "soil-structure" system in subsiding soils by the modelled seismic load fulfilled by means of explosions; the principles concern the analysis of results of dimensions. The functional scheme and the description of work of the device for automatic controlling the seismic explosive load are represented.
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INTRODUCTION

Full-scale soil investigation of experimental foundation fragments fulfilled by means of seismic-explosive loads is one of the methods of investigation of functioning of building and construction foundations during the earthuakes. An imitation of seismic influences may be developed in two principle trends in dependence on aims being pursuing during the experiment. The first trend is to reach the maximally full initiation of seismic influences characterizing the given region seismic regime.

The second trend of seismic influence modelling consists in trying to get the strictly limited number of firmly assigned parameters of such an influence for more reliable revealing the dynamic properties of the system "soil-foundation-construction" being investigated.

Second-trend investigations were carried out by authors in Tajikistan during the dynamic trials of foundations on the tampered out trenches in collapsible soils. Because of the necessity to conduct the above mentioned trials at different plots of building the problem of comparing the various experiment results arose on the reason that an explosive load is the most complicated type of dynamical influence and its character influences onto experiment results. Therefore the method of conducting investigations and of accepted data processing has been worked out.

The following matters are represented in the article:

—methods and results of static and dynamic investigations of bearing capacity of foundations on the tampered out trenches in loess collapsible soils;

—dynamic characteristics of basis (for vertical foundation vibration) which have been accepted at a base of model with 1.5 degree of freedom;

—the scheme and work principle of the device worked-out for automatic controlling seismic-explosive loads

FOUNDATIONS ON THE TAMPERED OUT TRENCHES

The essence of arrangement of foundations on the tampered out trenches consists in following: the trench is being tampered out on 2.0-3.5 *m* in depth by rammer of conic form with acute on the end. Then reparate portions of rigid concrete or crushed stone are layed on the tampered out trench on given depth with compacting of each portion by the same ramzone around the ramming . The result of this operation is in extending of dimensions of soil compacted zone around the ramming (Fig.1).

Application of this method in high seismic regions is limited by insufficient extent of studying of influences of seismic effects on bearing capacity of foundation different types and modifications on the tampered out trenches.

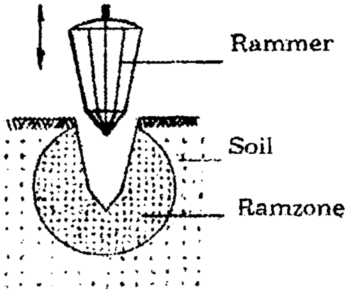

Fig. 1. Tampeved out trench.

METHODIC OF TESTS

Static and dynamic tests of bearing capacity of foundations were carried out on the loess collapsible soils. Experimental tampering out was carried out at the trenches preliminarily wetted until their optimum moisture arrived to 0.17-0.19.

In order to determine the density and sizes of compacted zone the trenches were uncovered by digging of a pit-trench and the samples were taken from. The tests of foundations were carried out in two stages. The first stage included the static trials of one pair of foundations in order to determine their bearing capacity. At the second stage the changing of bearing capacity of another pair of foundations has been studying during the dynamic (seismic-explosive) influence.

The static tests were carried out by loading the foundations with concrete blocks which were layed on the loading platform installed on the two foundations. The load setting on the foundations was being applied by stages which composed primary specific pressure on soil equal 0.3 *MPa* and the load after each following stage - 0.05 *MPa*.

During the foundation tests being carried out by seismic-explosive effects the load (the static one) applied to foundations was also passing through the loading platform with the help of concrete blocks . In order to decrease the foundational mutual influences coming through the loading platform during seismic explosive effects, the above-mentioned platform was arranged in such a way that one of its edges would be disposed directly on one of the foundations and the metal rollers would lay on the second foundation under the platform.

As well as during the static tests, the soil was brought to the optimum degree of moisture around the foundations and under their foot. The static load given to the foundations was also transmitted by stages with maximum load having been brought to 0.8 from the foundational bearing capacity.

The seismic effects were simulated by short slow explosions of charges placed at a definite distance from the foundations (Fig.2).

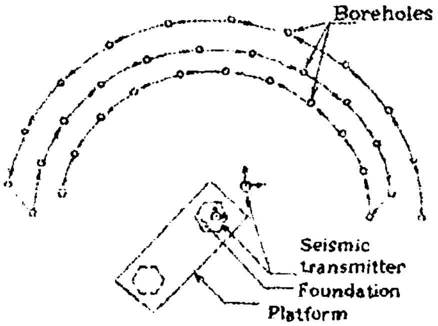

Fig. 2. Arrangement of boreholes, foundations and apparatus.

The calculation of seismic-explosive effects consisted of picking out the mass for an individual explosive charge in order to secure the essential soil vibration intensity and was carried out by formula:

$$\mathbf{Q} = \mathbf{V}^{2} \cdot \mathbf{K}^{-2} \cdot \mathbf{R}^{2.4},\ kg, \qquad (1)$$

where: $\mathbf{V}$— soil vibrational speed,10^{-2} m/s; $\mathbf{K}$— empirical coefficient, equal to 50-60; $\mathbf{R}$— distance between point of blasting and point of observation, m.

The depth ($\mathbf{H}$) of placing explosive charges secured the unthrowing-up of blasting and was determined by condition: $\mathbf{H} > 1.5\ \mathbf{Q}$, m. The distance ($\mathbf{L}$) between boreholes eliminated the neighbor charge detonation and was determined by condition: $L > 2/3\ H,\ m$.

The explosive charges were lowered into the boreholes having the diameter of 0.22 *m* and were covered with soil. The control individual bursting of each charge were carried out before the tests. In consequence of this the characterized period of soil vibration was determined which permitted to choose the compulsory time of slowing between separate blasting. While our experiments it was equal to 0.16-0.20 *s*. To secure seismic-explosive effect continuity and stationarity the time of slowing between separate blasting was established with seismic-explosive process automatical manage device worked out especially for this purpose.

The registration of vibrations of soil and of experimental foundations was fulfilled by the standard seismometric apparatus; it was conducted towards the three mutually perpendicular directions. The subsidence of foundations was recorded by the tensometers of transferences in the process of dynamic effects and it was verified by the level before the experiment and after it.

DEVICE FOR AUTOMATIC REGULATION THE SEISMIC-EXPLOSIVE INFLUENCE

The functional scheme of the foundation vibration intensity automatic regulation and controlling seismic-explosive influences is represented at Fig.3.

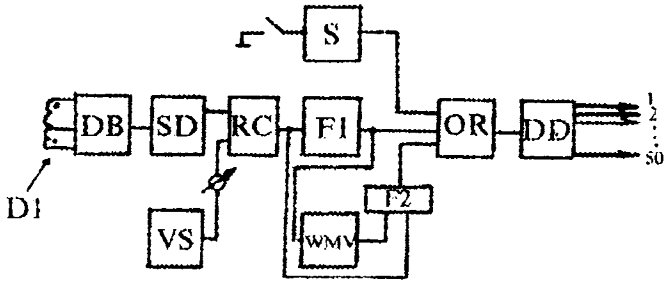

Fig. 3. Functional Scheme of Device

All the system may be put into operation by a single impulse arising **S** with a press of button stationed at the front panel. During its passing through the logical **OR**-scheme and entering the distributor the impulse calls the explosion of the first charge of explosive matter (**EM**). After them have been called by the explosive wave, the foundation vibrations are transforming themselves into electric signal with a seismometer **DI**; the signal is directly proportional to the speed of foundation vibration. The seismometer consists of the two seismic receivers switching opposite in phase. The electric signal goes from the seismometer to the entrance of the differential booster **DB**. At the outlet of booster the amplitude of concentrated signal must reach the value enough for switching the supersensitive detector **SD** supplied with an integrator. The constant voltage apices at the outlet of integrator; the voltage is a function of speed of vibration of the foundation having been tasted. The voltage enters one of the entrances of regenerative comparator **RC**. The voltage source **VC** produces the comparative voltage and sends it to the entrance of the second comparator. The value of comparative voltage is regulated by in the units of measurement of accepted scale of seismic fluctuation intensity.

At the very moment when both the voltage entering the comparator from the integrator and the voltage coming to it from the comparative voltage source are equal one to another, the comparator is re-switching itself into the opposite state; thereby it is fixing the certain intensity of the foundation fluctuation. Thus in such a way if becomes possible to record the development of speed of fluctuations in their certain significance by means of requlation of the comparative voltage. Re-switching of the comparator is taking place in the moment of equality of comparative and entrance types of voltage and serves as a signal for the former **F1** to develop the short electric impulse; the last one carries out the two tasks. The first one is that the impulse secures **EM** regular charge explosion while entering the distributing device **DD**; the second is that the impulse starts the waiting multivibrator (**WMV**). **WMV** produces the single impulse from the starting impulse; the single impulse duration may be regulated fluently within rather wide limits: it may be from 50 to 600 *ms*. The **WMV** impulse comes also across the **OR**-scheme and enters the distributing device and can serve for the **EM** regular charge explosion. But this becomes possible only in the case when for definite reasons the foundation fluctuation intensity haven't reach the established level during the previous **EM** charge explosion.

The element named "forbid" **F2** is called to control the observance of conditions mentioned above; the voltage comes from the comparator outlet and enters the controlling entrance of the element. Hence if any **EM** charge explosion appearing to be inadequate for supporting the fluctuation intensity at a definite fixed level the signal for the **EM** regular charge explosion is formed with **WMV** after the time interval fixed beforehand; these time intervals must be estimated from the previous explosion first moment. By means of these operations we create all the conditions sufficient for securing the unbroken seismic-explosive influence owing to be applied onto the foundation and taking place during the whole process of the dynamical influence.

METHODS OF PROCESSING INFORMATION AND RESULTS OF TESTS

Bearing capacity of foundations under dynamic influences must be determined by the coefficient **M** which is a multiplicational amendment for static calculations of bearing capacities of foundations:

$$\mathbf{M} = \left(\frac{S_s}{\mathbf{S_s} + \mathbf{S_d}}\right) . (1 + \mathbf{Z_f} / \mathbf{g}) \qquad (2)$$

The formula (2) first factor counts up the reduction of bearing capacity of foundation towards the vertical load while changing of soil intensive state is taking place in the process when seismic waves are passing through: $\mathbf{S_s}$-subsiding of foundation under the static load; S_d-supplementary subsiding of foundation under the seismic-explosive influence of rated duration (t_d).
At the seismic-explosive influence duration being less than the rated one (**t**) the value of the S_d'measured must be brought to some rated duration by formula:

$$S_d = \frac{t_d}{t} \cdot \mathbf{S_d'} .\ m \qquad (3)$$

The second formula factor (2) counts up the vertical load increasing during the tests on account of inertia, where: $\mathbf{Z_f}$ — average value of vertical component of foundation vibration increasing; **g** — easy fall increasing = 0.98 *m/s*.

The results of several experiments after being summed up are represented below. The tests illustrated that the increment of foundation subsidences under seismic-explosive influences tolalled 0.08-0.18 (Fig.4)

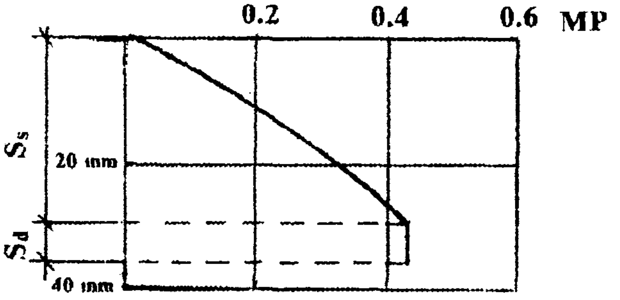

Fig. 4. Subsidings of Foundation under the Static and Dynamic Loads

M-dependence of the seismic-explosive influence may be considered as a linear one at range of (0.1-0.6) g (Fig.5) and as affording to insert corrections into the seismic load calculation. Studying of the system "soil-foundation" dynamic interaction was carried out at the base of the system of integrodifferential equalations:

$$\left.\begin{aligned} (\mathbf{m} + \mathbf{m_i}) \cdot \ddot{\mathbf{Z}}_f\,(\mathbf{t}) + \mathbf{R_z}\,(\mathbf{t}) &= 0 \\ \mathbf{Z_f}\,(\mathbf{t}) - \mathbf{Z_s}\,(\mathbf{t}) &= \int_0^{t_1} \mathbf{R_z}\,(\mathbf{t}-\mathbf{t_1}) \cdot \mathbf{Z_{itf}}\,(\mathbf{t_1})\, \mathbf{dt_1} \end{aligned}\right\} \qquad (4)$$

where: **m** — mass of a foundation; $\mathbf{m_i}$ — mass of an above-foundational construction; **R**z(t) — interaction between soil and foundation; $\ddot{\mathbf{Z}}_f$ **(t)** — foundation shifting; $\mathbf{Z_s}$**(t)** — soil shifting; $\mathbf{Z_{itf}}$ **(t)** — impulse transition function (ITF) of the "soil-foundation" system.

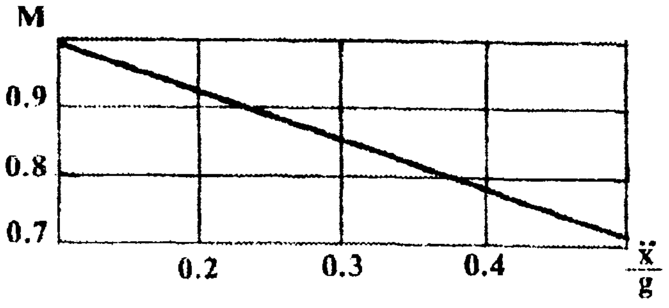

Fig. 5. **M**-dependence of the Seismic Load

The system of equalations (4) was solved by one