Comprehensive research on soil dynamics

Specially for Time Capsule Project

The extensive industrial development that began in Soviet Union in 1930 inspired the construction of heavy industrial facilities equipped with heavy machinery, which imposed dynamic loads on soil basement. This gave start to scientific research on soil dynamics and its application in the field of construction.

FOUNDATIONS OF MACHINES PRODUCING DYNAMIC LOADS

Prof. Dominik Barkan

In 1933, Prof. N.P. Pavliuk suggested treating the system "machine-foundation-soil" as a rigid body on the elastic inertialess basement. The approach became a theoretical framework for vibration analysis of the foundations subjected to dynamic loads. Led by prof. D. Barkan, his colleagues accumulated a great amount of the experimental data: they constructed dozens of experimental foundations in various soil conditions, conducted in-situ instrumental measurements of the vibration generated by hammers, compressors, dynamo and turbo dynamo, crushers and other types of machines producing dynamic loads.

A linear theory was proved to be feasible. It was discovered that coefficients of elastic uniform or nonuniform compression and shear were different. These coefficients were numerically evaluated. It was shown, that elastic coefficients depended on size of foundation bottom, and this dependency did not satisfy both Winkler hypothesis and the hypothesis of uniform elastic half space. New methods for calculating vibration were worked out and tested. The results achieved by D. Barkan and his colleagues were published in the monographs printed in 1938 and 1948. English translation was published in 1962, and it was recognized as a milestone achievement all over the world.

Prof. Olga Shekhter continued theoretical research on soil dynamics. Her publications showed that calculation results obtained from more correct but more comprehensive model of inertial half space could be approximated using engineering methods. Prof. O. Shekhter solved various problems devoted to vibration of homogeneous and non-homogeneous soil foundations, including two-phase continuum model, which helped to solve many problems of the practical value.

Prof. O. Savinov and his followers made a valuable contribution to the study of the dynamic behavior of the machine foundations. Results of the study were summarized by O. Savinov and published in 1955, 1964 and 1979, and by V. Pyatetsky and others in 1993.

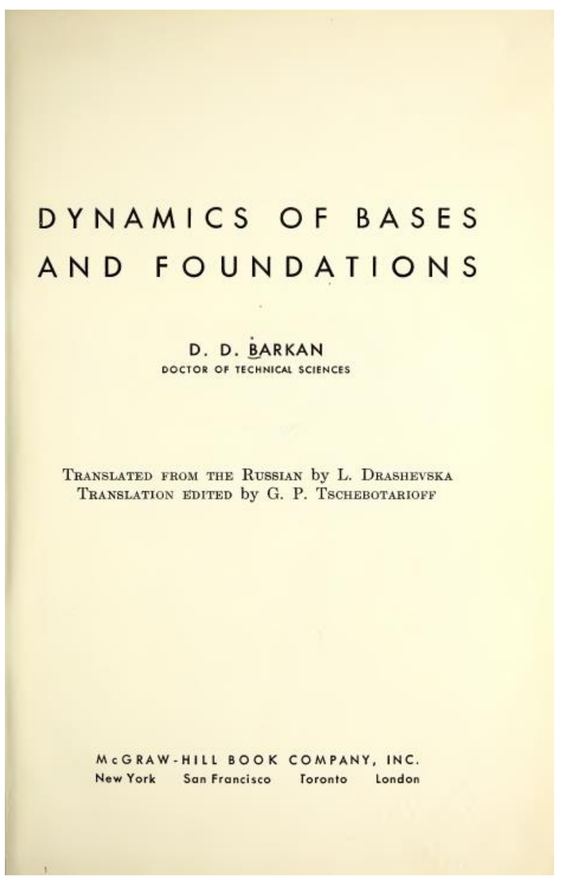
The development of regulatory documents devoted to design of machine foundations subjected to dynamic loads became the most significant achievement.

Dealing with soil dynamics, prof. V. Ilyichev solved important theoretical problems of propagation in soil. Based on results obtained in the field of dynamic theory of elasticity and in engineering analysis, prof. V. Ilyichev developed a dynamic model of foundation with respect to vertical vibration, and treated it as a system with ½ or 1½ degrees of freedom. Damping properties of the foundation were taken into account. Hence, construction regulatory documents adopted a uniform method for determining soil stiffness under all types of loads.

Prof. Olga Shechter

Prof. Vyacheslav Ilyichev

Prof. Vyacheslav Ilyichev analyzed soil behavior under vibration loads caused by industrial machines or transportation, and suggested important equations for calculation.



D.D.Barkan “Vibration method in construction”

APPLICATION OF THE DYNAMIC EFFECTS IN GEOTECHNICAL ENGINEERING

Knowledge of the soil dynamic behavior opened up an opportunity to use vibration load or impact to drive single piles or sheet piles, or to compact soil mass.

Prof. D. Barkan discovered the soil feature to behave like a viscous liquid under vibration impacts. This triggered a large-scale research on vibration piling. The technique found a wide application in construction practice, especially in hydraulic engineering. The work received high accolades and was awarded the State Prize. Prof. D. Barkan summarized and published results of the study in his monography "Vibration method in Construction" (1959).

Another way to use vibrational impacts in construction process is compaction of cohesionless soil. When soil structure collapses, loose saturated cohesionless soil liquefies and finally compacts. Professor P. Ivanov developed and brought to practical applications the research initiated by prof. N. Maslov and prof. V. Florin in this field.

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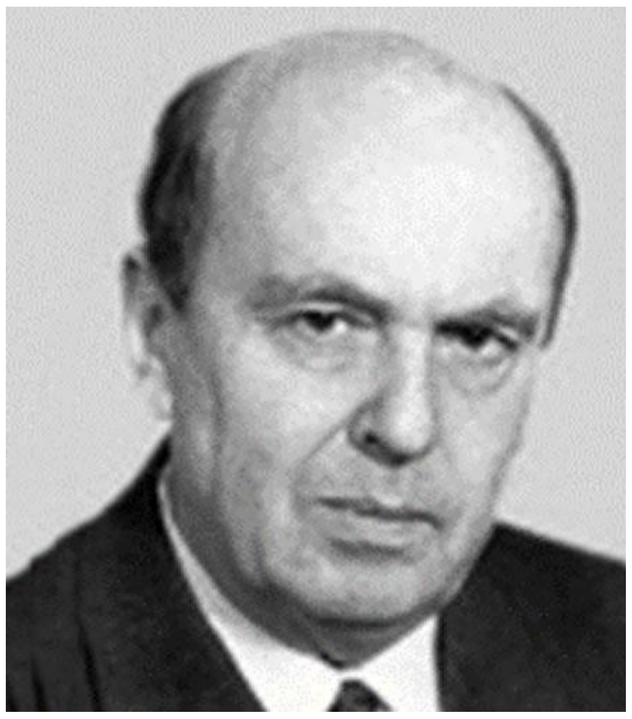
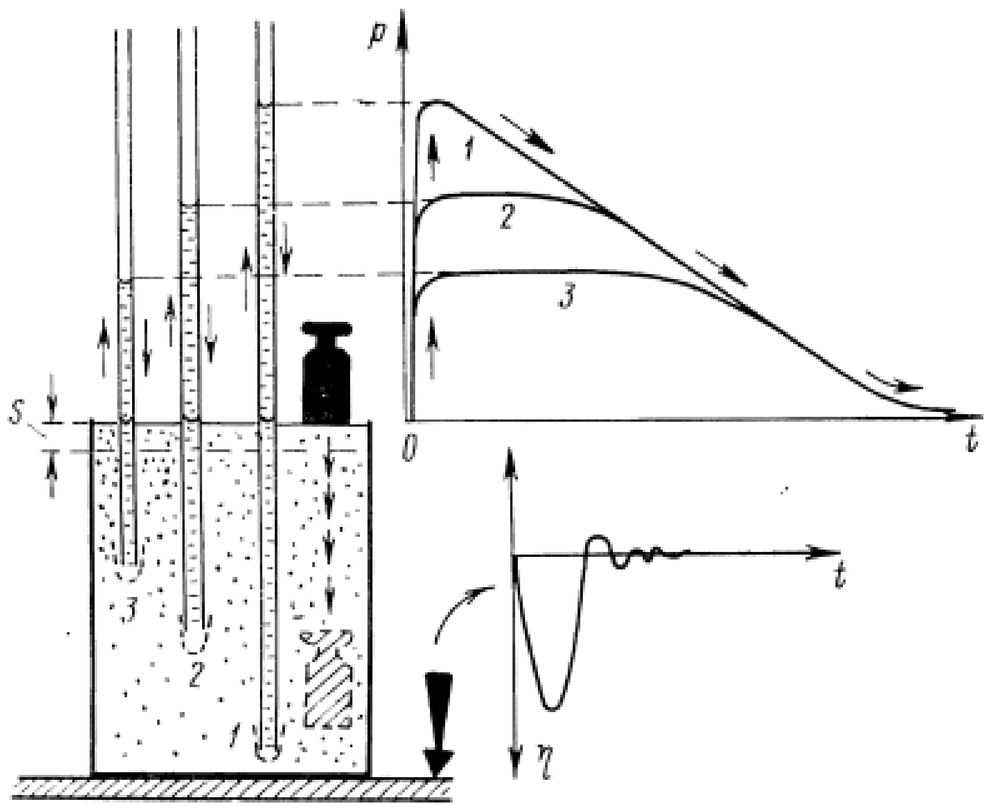


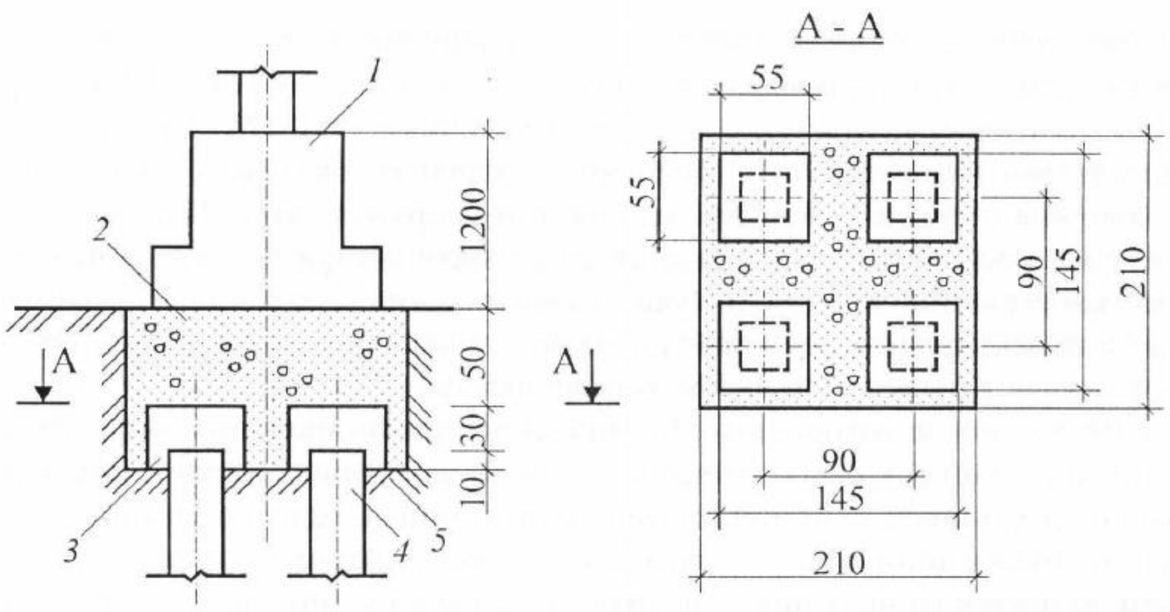
Prof. Oleg Savinov

Prof. Peter Ivanov



Scheme of the E.Kadomsky experiment demonstrating dynamic liquefaction of sand

EARTHQUAKE RESISTANT FOUNDATION



1 - foundation; 2 – seismic isolation layer; 3 – reinforced concrete cap; 4 – reinforced concrete pile; 5 – excavation bottom

Pile foundations with a seismic isolation layer

Large-scale experimental and theoretical research was devoted to seismic resistance of pile foundations. Analysis of the pile response to seismic waves yielded methods for assessing the axial bearing capacity and dynamic pile behavior under horizontal seismic loads. Pile foundations in permafrost, tapered piles, piles with enlarged base, piles integrated with columns for agricultural buildings were studied.

Particular attention was paid to pile foundations with a cohesionless cushion (disconnected piles), which made it possible to exclude the transmission of horizontal seismic loads to the pile head.

Many scientific research results were presented in the monography "Pile foundations in seismic regions" (1983) written by V. Ilyichev, Yu. Mongolov, and V. Shayevich

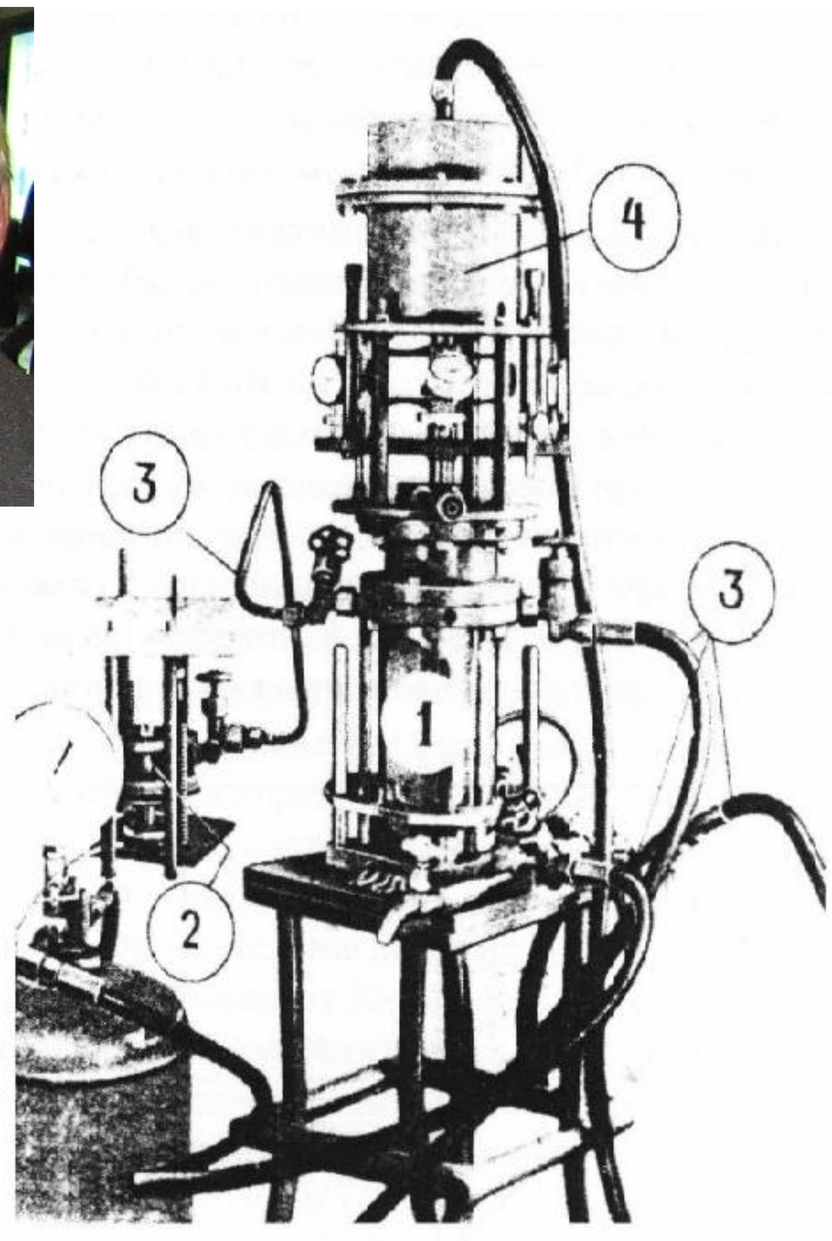
Research on foundation engineering in seismic regions began in the end of the 1960s. That new branch in geotechnical engineering has significantly developed by now.

The most important scientific and technical event was the arrangement of a field test site near the city of Kishinev. The testing site provided an opportunity to perform in-situ experiments, and attracted many skilled specialists.

Prof. D. Barkan headed the research on the influence of soil properties on seismic vibrations, including artificially improved soil. A table designed for approximate evaluation of the increase in seismic intensity with respect to physical soil properties was included in regulatory documents. Accordingly, an approval was given to the method for estimating the design seismicity with respect to the local soil properties, including improved soil. The effect of soil-structure interaction on the dynamic properties of buildings was studied.

Prof. L. Stavnitser and his collaborators both theoretically and by experiments analyzed bearing capacity of spread foundation under seismic loads. Their research devoted to estimation of dynamic properties of soil subjected to triaxial compression under vibration load, as well as other researches on foundation seismic resistance culminated in monography “Foundation seismic resistance”, published in 2010.

Prof. Leonid Stavnitser



1 – testing chamber; 2 – hydropulsator; 3 – pneumatic pipe; 4 – pneumatic press

A device for dynamic triaxial compression test