Professor Sergey S. Vyalov is a founder of the Russian school of soil rheology

Specially for Time Capsule Project

Sergey Stepanovich Vyalov

Sergey Stepanovich Vyalov is an outstanding Russian scientist in the field of frozen soil mechanics and permafrost engineering, the founder of a new branch of soil mechanics - rheology.

His father, Stepan Efimovich Vyalov, was a Major General of the General Staff of the Russian Imperial Army. Being a hero of the First World War, he was wounded to death in a battle, in 1916. His Mother was Maria Feoktistovna Gorizdro.

Sergei Vyalov was born in Petersburg in 1910. His childhood he spent in Tashkent. At the age of 10, he went to work at the Shredor's experimental agricultural station, where he worked for 5 years. Having finished the school, he moved to Leningrad, where he worked as an electrician. He entered the Leningrad Construction Institute and graduated in 1936.

SHORT BYOGRAPHY

After graduation, he was sent to the city of Magadan to construct docks and civil buildings. The features of permafrost, which had to be taken into account when designing, impressed him, and his first constructive proposals for improving foundation engineering were published in Dalstroy's magazines "Kolyma" and "Kolymproekt" in 1940.

Since 1941, he worked in the Construction Department of the Yakutsk Dockage, where he became fully aware about his main future activity, namely, the study of permafrost.

In 1945, S. Vyalov moved to Moscow and became a member of the Permafrost Institute. In the same year, he entered the postgraduate course.

In 1950 S. Vyalov left Moscow for Igarka, where he carried out unique in scope and novelty comprehensive studies. Totally, he performed about 1300 laboratory and dozens large-scale field experiments. Some of them lasted over 20 years.

In 1956, he took part in the Second Antarctic Expedition, where he conducted research in the field of ice mechanics and developed the theory of viscous flow of ice domes.

In 1959, S. Vyalov published his monography "Rheological properties and bearing capacity of frozen soils". In the same year, he defended his thesis for the degree of the Doctor of Technical Sciences and became the head of the Laboratory of Frozen Soil Mechanics and Foundation Calculation Methods at the Gersevanov Research Institute of Bases and Underground Structures (NIIOSP).

In 1961, he published the article "Viscoplastic flow of Glacial Sheets".

In 1978, he published the monography "Rheological Fundamentals of Soil Mechanics".

In 1986, he became a professor at the Department of Soil Mechanics, Basements and Foundations of the Kuibyshev Moscow Construction Institute and replaced the departed Prof. N.A. Tsytovich in the position of a scientific director of the Research Laboratory of Permafrost Engineering for Energy Construction.

Prof. S. Vyalov was awarded the title of laureate of the State Prize of the USSR, Honored Worker of Science and Technology of the Russian Federation.

Prof. S. Vyalov's developments were often awarded medals of Exhibition of Economic Achievements of the USSR.

In 1990, Prof. Sergey Vyalov was awarded a first-class medal of the Order of Merit for the Motherland for outstanding scientific and economic achievements.

He took an active part in construction of BAM (Baikal-Amur Mainline) South-Yakutsk coal complex, Norilsk mining and processing plant, northern hydroelectric power stations, and in development of the Russian Arctic cities. (Yakutsk Severobaikalsk, etc.).

CONTRIBUTION TO SOIL MECHANICS AND GEOTECHNICAL ENGINEERING DEVELOPMENT

Professor Sergey Stepanovich Vyalov is a founder of the research area – soil rheology. He is an author of fundamental research on permafrost engineering.

In Igarka, in a deserted mine in permafrost conditions, he studied the long-term strength of frozen soils for three years. The results of the experiments radically changed the approach to the estimation of the bearing capacity of frozen soils with respect to rheological soil properties. Some of his key studies are worth remembering:

- Evaluation of the frozen soil cohesion and the cohesion behavior over time;
- Study of the compression, tension and shear resistance of frozen soils, as well as soil rheological scenario under a simple stress conditions;
- Description of the received dependence of the frozen soil strength on the load duration, confirmed by numerous experimental data:

$$\tau_{д.л} = \frac{\beta}{\ln\left(t_{пр}/B\right)}$$

where $\tau_{\partial л}$ – conditional long-term strength; t_{np} –sufficiently long time interval ; β, B – constsnts.

- Evaluation of the long-term cohesion on the base of Ishlinskyi's solution for perfect plastic continuum, based on results of the ball bearing test:

$$c_t = 0{,}18\frac{P}{\pi d s_t}$$

Where P – ball loading; d – ball diameter; s_t – settlement over time.

Prof. Nikolay A. Tsitivich and Prof. Sergey S. Vyalov suggested considering the c_t value a complex characteristic – equivalent cohesion ($c_{экв}$). This approach allowed one to assess bearing capacity of the frozen soil foundations as bearing capacity of the "equivalent" ideally plastic continuum with equivalent cohesion $c_{экв}$. This was applicable for the following types of foundations:

- Strip: $P_{пр} = (\pi + 2)c_{экв} + \gamma_{гр} h_{ф}$
- Square in plane: $P_{пр} = 5{,}71 c_{экв} + \gamma_{гр} h_{ф}$
- Circular in plane: $P_{пр} = 5{,}65 c_{экв} + \gamma_{гр} h_{ф}$

where $\gamma_{гр}$ – soil unite weight; $h_{ф}$ – foundation depth.

Results of the unique large-scale research on the contact stress of the foundations-frozen soils interaction, described in the monograph, are still significant. The important conclusions drawn from the results of these experiments are worth paying attention:

- In contrast to thawed soils, diagram of contact stress transforms from "double-humped" or "uniform" to "saddle-shaped" when load increases, but "parabolic" diagram is not observed;
- Contact pressure scarcely transforms under a constant load over time .

After his participation in the Antarctic expedition in 1961, Prof. S.S. Vyalov published his most interesting article "Viscoplastic Flow of Glacial Sheets", in which he predicted a contour of the glacial sheet. Field observations, he undertook in East Antarctica along the Mirny-Pionerskaya-Vostok-I-Komsomolskaya profile, confirmed the contour of the glacial sheet theoretically predicted by him.

The house where Prof. Sergey S. Vyalov spent his childhood, in Tashkent

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PROFESSOR SERGEY S. VYALOV'S CONTRIBUTION TO THE DEVELOPMENT OF SOIL MECHANICS, GEOTECHNICAL ENGINNERING

In the early 1960s, the development of the richest iron ore deposit of the Kursk magnetic anomaly was set up. Shaft drilling was required to strip the deposit occurring at a depth of 600 m. Geological profile comprised layers of Batbayoss saturated clay and Callovian floating silty clay at a depth of 400-500 m. It was decided to strip the deposit by drilling 9 meters wide and 700 meters long shafts with freezing the surrounding rock, thus forming a temporary frozen support around the shafts. Besides technological problems, namely, a choice of low-temperature coolant (–60 °C), verticality of shafts, in which freezing columns were to be lowered, it was necessary to substantiate the most important design parameters by computational analysis :

– Thickness of the temporary frozen support;

– Allowable size of the non-frozen part of the shaft during sinking.

These substantiations had to be based not so much on the strength conditions of the frozen rock support, but on its ultimate deformation. The reason was that the metal of the freezing columns became cold-short at a temperature of –60 °C, and could not withstand large bending deformation. The rupture of the columns would have triggered off a breakthrough of the coolant into the surrounding frozen rock mass and cause a very rapid defrosting followed by the destruction of the support. Therefore, the optimal dimensions of the frozen support (its thickness and the size of the "entry-way") should provide the resistance to the radial movement exceeding a certain specified value, which realized over the period from the start of the sinking to the installation of reinforced concrete fastening tubbing (minimum time 24 hours).

Professor S. Vyalov developed the most adequate algorithm of the assigned technical problem. He divided the problem into component parts and launched investigation. This work manifested him as a talented scientist, engineer and a very good organizer.

He developed a new rheological approach to assessment of the behavior of the frozen soil barriers. The approach was used in the design of sinking and fastening deep mine shafts. For the development and introduction of the mineshaft construction technology with using low-temperature freezing of rocks, a team of scientists, engineers and workers, which included Prof. S. Vyalov, as well as his students and closest associates Yu.K. Zaretsky, S.E. Gorodetsky, was awarded the State Prize of the USSR in the field of science and technology (1988). The results of the research were summarized in the well-known collective monographs by Prof. S. Vyalov and his collaborators and students: "Strength and creep of frozen soils and calculations of frozen soil barriers" [1962], "Method for determining the characteristics of creep, long-term strength and compressibility of frozen soils" [1966], "Calculation of strength and creep of artificially frozen soils" [1981]. These monographs have become the main guide for specialists dealing with frozen soil engineering.

Prof. S. Vyalov examined in detail the common factors of long-term soil destruction and interpreted the physical sense of the parameters included in the long-term strength equation. He showed that the collapse of clayey soil was in good agreement with the ideas of the kinetic theory, which considered collapse a thermal fluctuation process of breaking and restoring bonds, activated by the action of an external force.

Prof. S. Vyalov announced the developed thermodynamic approach to soil mechanics at the Third All-Union Symposium on Soil Rheology (Leningrad, September 1979). He even earlier expressed the idea that thermodynamics could combine physics, thermal physics and mechanics of frozen soils. Perhaps, that would be the "general" theory of the permafrost engineering. S. Vyalov was well aware that thermodynamics could bypass difficult problems of many bodies or particles; it did not need a specific model of the internal structure of the investigated bodies, and at the same time gave the opportunity to use molecular and microscopic data, if any.

In the late 1980s and early 1990s, Prof. S. Vyalov, together with his student V. Razbegin, deriving the long-term strength equation with respect to entropy phenomenon. According to this approach, a collapse occurred when a certain critical value of the entropy density was reached. In this case, the deformation at failure depended on the acting stress and was determined by the critical value of the viscoplastic deformations.

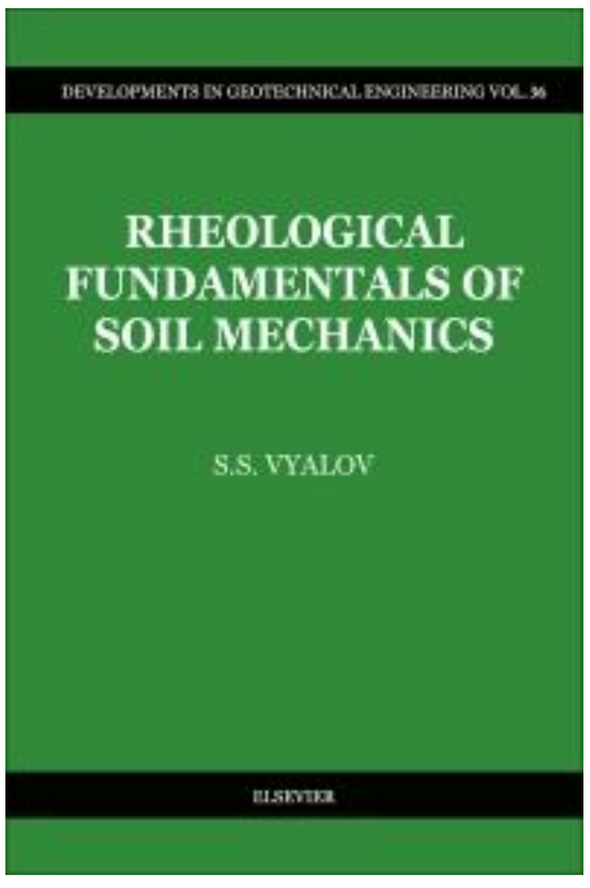
The thermodynamic approach in soil mechanics, apparently, has great prospects, and one can hope that constitutive relations of the theory of viscoplastic flow of soil will be obtained with its help.

The scope of scientific interests of Prof. S. Vyalov was very wide. He solved a number of problems in soil mechanics, studied a physical nature of the deformation process at the microstructural level, developed a kinetic theory of strength and creep of soils, and applied the rheological approach to nonlinear soil mechanics. The results of these works he summarized in the monograph "Rheological Fundamentals of Soil Mechanics" [1978]. The monograph "Rheological Properties and Bearing Capacity of Frozen Soils" [1959] was the first work, in which S. Vyalov summarized the experimental and theoretical results of his work at the Igarka testing site of the Institute of Permafrost. It presented an excellent overview of the general theory of strength, creep and relaxation.

Prof. S. Vyalov developed and took an active part in developing regulatory documents devoted to design and construction of foundation in permafrost.

Prof. Sergei Vyalov established an outstanding school of soil mechanics and was active in teaching. Under his leadership, many graduate students, including those from foreign countries, successfully defended their thesis. Many students and closest associates of Prof. S.S. Vyalov deserved to be mentioned: A.G. Brodskaya, K.F. Voitkovsky, S.E. Gorodetsky, Yu.K. Zaretsky, V.N. Ivanov, N.N. Kolesov, Ya.A. Kronik, N.B. Kutvitskaya, R.V. Maksimyak, S.R. Meschyan, A.L. Mindich, Yu.S. Mirenburg, N.K. Pekarskaya, G.V. Porkhaeva, V.N. Razbegin, L.T. Roman, M.E. Slepak, Yu.O. Targulyan, S.B. Ukhov, L.N. Khrustalev, E.P. Shusherin and many others.

Prof. S. Vyalov in the Antarctic expedition



Prof. Sergei Vyalov lost his sight by the end of his life. Even being blind, he decided to realize his dream - to write a monograph that would summarize the results of his research on the rheology of frozen soils. He had dictated the book to his relatives and students for 3 years. Finally, the monograph "Rheology of frozen soils" was published in 2000. It comprised 464 pages. The book was translated into Chinese. The scientific editor of the monograph was V. Razbegin.

Although Prof. Sergei Vyalov published about 300 monographs, which included 9 books, he once said that he had written not so much monographs and cited Aesop's fable: "The boastful fox said to the lioness that she could give birth to several cubs at once, and the lioness only has one cub. "But on the other hand, I give birth to a lion - the king of animals," the lioness answered. Prof. S. Vyalov passionately served the cause of science. His last book, which he wrote being absolutely blind, was a real scientific feat.