Professor Vladimir I. Slivker (1937-2011)

Vladimir Isaevich Slivker was born on January 2, 1937, in Leningrad. In 1959 he graduated from the Bridges and Tunnels faculty of the Leningrad Institute of Railway Transport Engineers (LIIZhT) with a degree in engineering of bridges and tunnels. After completing his studies at the university he was sent to work in Krasnoyarsk in the Sibtsvetmetniiproekt institute, where he was researching the designs of bridges of Eastern Siberia for three years. In 1962 he returned to Leningrad and was since continuously engaged in design work (professional activity – structural analysis for strength, stability and vibrations) in LO Proektstalkonstruktsiya Research Institute, Leningrad Promstroiproekt, LenZNIIEP. Since 1998 and until the end of his life he worked as the head of the design of bridges department at the Giprostroymost Institute in St. Petersburg.

Engineering

As a designer, V.I. Slivker participated and led the designs of many important objects of industrial, civil and transport engineering (as an employee of LO Proektstalkonstruktsiya, Lenpromstroyproekt, LenZNIIEP institutes), and participated in the development of software applications aimed at solving problems of automation of structural design (software for the analysis of guyed masts, structures on the elastic subgrade, frame structures taking into account the physical and geometric nonlinearity, development of general algorithms for the analysis of complex structures using the finite element method). Over the last 10 years his engineering activity was focused on solving the applied problems of the analysis of bridges. The department headed by V.I. Slivker performed the analysis of such unique structures as the cable-stayed bridge in St. Petersburg, arch bridge with flexible suspensions over the Large Okhta river in St. Petersburg, the bridge over the Ishim river in Astana (Kazakhstan), cable-stayed overpass over the railroad tracks in the Alexander Farm Avenue (St. Petersburg), a new unique bridge over the Daugava river in Riga (Latvia) – Fig. 1 and many others. The analyses of two cable-stayed bridges in Vladivostok were performed under the guidance of V.I. Slivker: cable-stayed bridge with a central span of 737 m across the Golden Horn bay and the cable-stayed bridge with a record span of 1100 m across the Eastern Bosphorus strait (bridge to the Russian island) – Fig. 2.

Figure 1 Bridge over the Daugava river in Riga (49,5 + 77,0 + 5×111,0 + 77,0 + 49,5 m.)

Figure 2. Bridge over the Eastern Bosphorus strait in Vladivostok (60 + 72 + 84 + 3 × 1104 × 3 + 84 + 72 + 60 m)

Scientific work

As a scientist, V.I. Slivker is known for his achievements in the development and study of various aspects of solid mechanics. The characteristic feature of all scientific works of V.I. Slivker is a very close connection with the specific problems of structural design. In 1971 he defended his Ph.D. thesis "Analysis of Elastic Systems with Nonlinear Constraints" specialty 01.023 (theory of elasticity and plasticity). In 1985 he defended his D.Sc. thesis "Effective Finite Element Method Models in Structural Mechanics Problems Using the New Variational Approaches" specialty 01.02.03 (structural mechanics). In addition to his main design and research work, V.I. Slivker taught at the Structural Mechanics and Theory of Elasticity department of the Leningrad Polytechnic Institute. In 1991 he was awarded a Professor degree.

V.I. Slivker had the following research interests:

• nonlinear problems of structural mechanics;
• finite element analysis;
• stability of equilibrium;
• behavior of structures on the elastic subgrade;
• thin-walled bars;
• computer-aided design.

Nonlinear problems of structural mechanics. V.I. Slivker created special models for the analysis of mechanical systems with nonlinear constraints. These models are based on the concepts he introduced of parallel and serial connection of constraints, one of which has a purely linear characteristic, and the second one represents the remaining nonlinear component of the constraint. In a series of papers on this subject, V.I. Slivker suggested such methods for extracting the linear part of constraints that guarantee the convergence of numerical iterative processes for solving nonlinear problems. A mathematically rigorous justification of the convergence of these processes was given and the theoretical estimates of errors of the approximate solution of both the a priori and a posteriori types based on the contraction mapping principle known in the functional analysis were obtained. Papers [6], [7] are two of the most significant publications on this topic.

Specific applications of the methods for the analysis of systems with nonlinear constraints developed by V.I. Slivker are used: in the analysis of guyed masts (nonlinearity generated by the guys as ideal cables); in the analysis of structures with unilateral elastic supports; in the analysis of foundation structures on the elastic subgrade with a unilateral constraint with the subgrade; in the analysis of frame systems composed of bars with a nonlinear relationship between stresses and strains; in the analysis of floating bridges with non-wall-sided pontoons, and in many other cases.

Finite element analysis. In the theory of the finite element analysis V.I. Slivker considered the finite element method in structural mechanics problems as a specific kind of Ritz method. In this regard, V.I. Slivker proposed a new functional (or rather, a family of functionals) of mixed type generalizing the known classical Lagrange and Reissner functional. These mixed functionals are convex under certain conditions (this is their fundamental difference from the Reissner functional) and thus eliminate the main drawback of the prior mixed functionals. V.I. Slivker also suggested and elaborated the method of two functionals. This method eliminates one of the main disadvantages of the classical version of the FEM, namely a reduced accuracy at the determination of stresses in comparison with the displacements. The central results of these studies were published in [10], [17]. These scientific results were later given in the expanded form in the monograph [2].

Applications of the positive definite mixed functional and the method of two funstionals are not limited to the static problems. V.I. Slivker convincingly demonstrated the applicability of these ideas to the spectral problems as well – to the problems of free vibrations of mechanical systems and to the problems of the stability of equilibrium. In this regard, V.I. Slivker developed rigorous theoretical estimates relating the frequency characteristics of mechanical systems, obtained by applying the finite element method in various variational problem formulations. This scientific result was reflected in the paper [15].

It should be noted that the following effect was observed for the fist time: the possibility of contamination of the frequency spectrum and the critical forces of mechanical systems with parasite numbers, which is typical for the classical mixed variational formulations of problems. Not only does the paper [16] show the possibility of contamination of the frequency spectrum by the so-called “parasite numbers”, but it also indicates the screening algorithm that ensures the screening of these numbers. The conceptual part of this algorithm is based on the method of two functionals.

Stability of equilibrium. Throughout his scientific career, V.I. Slivker repeatedly addressed the problems of the stability of structures. In a series of his works devoted to the complex problems of the theory of stability, he detected and corrected a number of mistakes in the solutions which had been made by well-known scientists and existed for a long time without a proper verification in this field of mechanics. We are talking about the solutions of individual problems of the theory of stability obtained by N.A. Alfutov, S.P. Timoshenko, A.N. Dinnik. The results of these studies were summarized in the three-volume monograph, prepared for publication in collaboration with A.V. Perelmuter [4, 5].

The joint paper written with Yu.G. Ispolov, [29], introduced a new fundamental concept of generalized moment, the so-called "L moment". A more detailed analysis of the L-moments with applications to the problems of stability of spatial structures is given in the above monograph written with A.V. Perelmuter. It turned out that the standard approach previously used for solving spatial geometrically nonlinear problems was incorrect and could lead to qualitatively incorrect results. It was also found that all the published attempts to explain the well-known Argyros paradox, which existed in structural mechanics since 1982, did not have a perfectly logical justification. Introduction of the concept of the generalized moment allowed for the first time in 25 years not only to provide a scientifically sound explanation for this paradox, but also to disprove a number of incorrect assumptions which appeared in the technical literature during the last two decades.

The above monograph also contains other new scientific results, including those which seem paradoxical at first sight. It does not only state the fact of finding new paradoxes, but also provides their full explanation. This book (together with the second volume, which is currently being prepared for publication) is the most complete presentation of the stability problems of all Russian publications and world literature.

Behavior of structures on the elastic subgrade. V.I. Slivker is the author of a number of algorithms for the analysis of the foundation slabs using a two-parameter model of the elastic subgrade. In order to perform the transition from a model of the elastic layer of finite thickness to the two-parameter model a problem of their closest (in terms of energy) approach to each other was solved, which served as a topic of the paper [12].

The method for correcting the stiffness matrices of finite elements of bent plates due to the behavior of the elastic subgrade was elaborated (both for Kirchhoff-Love thin plates, and for the medium thickness plates – Reissner theory). Special semi-infinite finite elements of wedge and strip type were introduced in the theory of finite element method for the analysis of the foundations slabs. These finite elements are included in the finite element library of LIRA and SCAD. Another important achievement was the elaboration of the method for the analysis of the foundation slabs with the consideration of the rigidity of the upper structure. This method was applied to the foundation slabs under the silos, and it was implemented in KORPUS-ES and included in the guide to the design of slab-on-grade foundations of frame tower buildings and structures.

Thin-walled bars. In this very specific field of structural mechanics V.I. Slivker established a general system of resolving equations of the problem invariant to the profile type of the bar cross-section which led to the creation of the semi-shear and completely shear theories of thin-walled bars (author's terminology). These studies lead to the union and generalization of both V.Z. Vlasov theory for thin-walled open profile bars and A.A. Uman theory for thin-walled closed profile bars. The most complete description of the scientific results of V.I. Slivker on the development of the theory of thin-walled bars is given in the three chapters of the monograph [2].

The results of these studies have not only theoretical significance, but they are also essential for the practical needs of the construction design.

Computer-aided design. In the field of the computer-aided design V.I. Slivker focused on the adequacy of the design models of structures, the calculations of which are performed using the software. The set of researches in this field performed by V.I. Slivker is reflected in the monograph [1].

This book had three editions (first edition 2001, second edition 2002) and was very interesting for specialists dealing with strength analysis of structures. Some aspects of computer-aided design problems repeatedly served as a topic of journal publications of V.I. Slivker, which are not considered here. We will only mention the paper [19], which had anticipated the overwhelming number of new software features implemented over the past two decades.

Publications and reports. Scientific advances of V.I. Slivker are well known in the engineering and scientific community, he published more than 100 scientific papers, including 7 monographs, two of which were published by Springer in the prestigious series Foundations of Engineering Mechanics. The most important results of many of these studies were presented at representative international forums in the United States, Poland, Denmark and highly appreciated by the scientific community.

Selected Publications:

1. On a procedure for calculating the stiffness matrix of a prismatic bar. // Analysis of spatial structurea (*Raschet prostranstvennikh konstruktsiy*), issue XVI. — Moscow: Stroyizdat, 1974. — P. 179-189. (with Y.Z. Klempert & V.L. Parikov in Russian)
2. Some peculiarities of the finite element method in the analysis of structures on elastic beds. // Finite element method and structural mechanics. Proceedings of Leningrad Polytechnic Institute, issue, 349, 1976. — P. 69-80. (with K.P. Elsukova, in Russian)
3. Ritz method in problems of elasticity, based ob sequentially minimizing two functional // Mech. Solids, 1982, No 2 — P. 57-64.
4. A mixed variational principle of structural mechanics, generated by a convex functional // Research on theoretical principles of structural analysis. Collected papers of universities. Leningrad Institute of Civil Engineering, 1982 — P. 114-121. (in Russian)
5. Mixed variational formulation of problems for elastic systems // Mech. Solids, 1984, Vol. 20 — P. 1555–1561.
6. On one effect that arises when using the finite element method in its mixed form. // Structural mechanics and analysis (*Stroitelnaya mekhanika i raschet sooruzheniy*). 1984, No.1. — P. 43-48. (with Y.C. Ispolov, in Russian)
7. Optimum approximations in the finite element method. // Structural mechanics and analysis (*Stroitelnaya mekhanika i raschet sooruzheniy*). —1987, No.2. — P. 27-30. (In Russian)
8. Bi-member model of thin-walled member of open cross section // ECCM-2001. 2nd European Conference on Computational Mechanics. Solid, Structures and Coupler Problems in Engineering. Cracow, Poland, June 26-29, 2001.— Abstracts, Vol. 2. — Kraków: Vesalius, 2001. — P. 1048–1049. (with A.O. Kountsevitch)
9. On an error of a mysterious nature that happens in software when analyzing mechanical systems for bukling // Proceedings of the 15th Nordic Seminar on Computational Mechanics, 18-19 October, 2002, Aalborg, Denmark.— Aalborg University, 2002.— P. 229-232. (with A.V. Perelmuter)
10. On one paradox in buckling problems. // Researches in mechanics of structural constructions and materials. Collected topical proceedings. St. Petersburg State University of Civil Engineering and Architecture, 2002. — P. 45-51. (with A.I. Kniga & M.V. Pashkovski in Russian)
11. Problems in matching finite elements having different dimensionalities // 15th International conference om computer methods in mechanics. CMM-2003. Glivice/Wisla, June 3-6, 2003. — Glivice: 2003.— P. 285-286. (with A.V. Perelmuter)
12. Numerical Structural Analysis: Methods, Models and Pitfalls— Berlin-Heidelberg: Springer-Verlag, 2003 — 600 p. (with A.V. Perelmuter)
13. Mechanical models of thin-walled members. // 16th International conference om computer methods in mechanics. CMM-2005. Czestochova, Poland, June 14-24, 2005. Short Papers.— Czestochova: 2005— 201-202 (with D. Maslov).
14. On circulation of tangential stresses // Bulletin of civil engineers, Sanct-Petersburg, 2005, No 1(2) — P.49-52. (in Russian)
15. On a conservative moment load. // Structural mechanics and analysis (Stroitelnaya mekhanika i raschet sooruzheniy), No.1, 2007. — P. 61-67. (with Y.C. Ispolov, in Russian)
16. Mechanics of Structural Elements: Theory and Applications — Berlin-Heidelberg: Springer-Verlag, 2007 — 786 p.
17. On finite element approximations in the Timoshenko bar stability problems. // Bulletin of Civil Engineers (*Vestnik grazhdanskikh inzhenerov*), St. Petersburg State University of Civil Engineering and Architecture, No.4 (17), 2008. — P. 17-26. (with D.V. Derevyankin, in Russian)
18. A generalized Timoshenko problem. // Structural mechanics and analysis (*Stroitelnaya mekhanika i raschet sooruzheniy*). — 2009, No.1. — P. 12–16. (with R.N. Guzeev, in Russian)

19. On two bar models that allow for a shear deformation in equilibrium stability problems. // Structural mechanics and analysis (*Stroitelnaya mekhanika i raschet sooruzheniy*). — 2009, No.5, P. 65-69. (with D.V. Derevyankin, in Russian)
20. Structural models of buildings and their possible analysis.— Moskow.: SCAD Soft publ, ASV and DMK-Press, 2011, 4-th edit — 736 p. (with A.V. Perelmuter, in Russian).
21. Stability of structural equilibrium and related problems — Moskow: SCAD Soft publ., 2011— In 3 Volumes: 704+672+400 p.(with A.V. Perelmuter)
22. Handbook of Mechanical Stability in Engineering — New Jersey, London, Shanghai, Beijing, Singapore ,Hong Kong, New Delhi: World Santific Publ., 2013 — In 3 Volumes: 601+587+401 p.(with A.V. Perelmuter)