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ON THE INFLUENCE OF PLATE PROPERTIES OF THIN-WALLED BEAMS, MODELED BY THE SYSTEM OF RELATED PLATES, ON THE NATURAL FREQUENCIES AND MODE SHAPES

Thin-walled rods are widely used in construction and other industries. In the design of bridges, crane beams, gas-producing constructions there are cases when flange width is greater than the height profile of its wall. The currently used V.Z. Vlasov's beam approximation in the process of determining the dynamic characteristics, is based on a set of assumptions, which do not allow to take into account the plate properties of thin-walled rods. In this paper the torsional vibrations of thin-walled beams modeled by a system of related plates with different geometrical characteristics are studied using finite element method. Also the case of an asymmetrical I-beam is studied. It was revealed that the transition from the uniaxial system to spatial structure with appropriate geometric parameters of the rod significantly thickens the frequency spectrum and can lead to more complex (mixed) modes of vibration. The author identified the cases when neglect of inertial forces in the wall and flanges and the assumption of non-deformability in the plane of the profile cross-section can lead to errors in determining the frequencies and modes of torsional vibrations. The application limits of the Vlasov's theory are investigated and practical recommendations are given.

Key words: thin-walled beams, modeled system related plates, torsional vibrations I-beam, plate properties, flexibility elements inertia shelves.

References

1. Vlasov V.Z. *Tonkostennye uprugie sterzhni* [Thin-walled Elastic Rods]. Moscow, Fizmatgiz Publ., 1959, 568 p.

2. Timoshenko S.P. *Teoriya kolebaniy v inzhenernom dele* [Theory of Oscillations in Engineering]. Leningrad-Moscow, Gosudarstvennoe tekhniko-teoreticheskoe izdatel'stvo Publ., 1932, 345 p.

3. Korbut B.A., Lazareva G.V. (Kucha G.V.) O dinamicheskoy teorii tonkostennykh krivolineynykh sterzhney [On the Dynamical Theory of Thin-walled Curved Bars]. *Prikladnaya mekhanika* [Applied Mechanics]. 1982, vol. XXIII, no. 5, pp. 98—104.

4. Beylin E.A., Lazareva G.V. (Kucha G.V.) *Opredelenie chastot svobodnyh izgibno-krutil'nykh kolebaniy tonkostennykh krivolineynykh sterzhney s uchetom deformatsii vrashcheniya secheniy* [Determination of the Frequencies of Free Flexural-torsional Vibrations of Thin-walled Curved Bars Taking into Account the Deformation of Sections Rotation]. Leningrad, Leningradskiy inzhenerno-stroitel'nyy institut Publ.,1985, 13 p.

5. Taranukha N.A. Matematicheskoe i eksperimental'noe modelirovanie kolebaniy sterzhnevykh sudovykh konstruktsiy s uchetom soprotivleniya vneshney sredy razlichnoy plotnosti [Mathematical and Experimental Modeling of Ship Bar Systems Oscillations with Account for the Resistance of the Media of Different Densities]. *Uchennye zapiski KnAGTU* [Scientific Notes of Komsomolsk on Amur State Technical University]. Komsomolsk on Amur, KnAGTU Publ., 2010, vol. 1, no. 4, pp. 81—91.

6. Taranuha N.A., Zherebko K.V., Petrova A.N., Petrov M.R. Matematicheskoe modelirovanie bezmomentnoy sterzhnevoy sistemy pri bol'shikh peremeshcheniyakh [Mathematical Modeling of a Membrane Core System in Case of Substantial Displacements]. *Izvestiya vuzov. Stroitel'stvo* [News of Higher Educational Institutions. Construction]. 2003, no. 3, pp.12—18.

7. Gavrilov A.A., Kudina L.I., Kucha G.V., Morozov N.A. Vliyanie geometricheskikh kharakteristik secheniy na znacheniya chastot svobodnykh izgibnykh kolebaniy tonkostennykh sterzhney [The Influence of the Cross Sections Geometric Characteristics on the Frequencies of Free Flexural Vibrations of Thin-walled Beams]. *Vestnik OGU* [Proceedings of Orenburg State University]. 2011, no. 5, pp. 146—150.

8. Arpaci A., Bozdag S. E., Sunbuloglu E. Triply Coupled Vibrations of Thin-walled Open Cross-section Beams Including Rotary Inertia Effects. Journal of Sound and Vibration. 2003, vol. 260, no. 5, pp. 889—900. DOI: 10.1016/S0022-460X(02)00935-5.

9. Li J., Shen R., Hua H., Jin X. Coupled Bending and Torsional Vibration of Axially Loaded Thin-walled Timoshenko Beams. International Journal of Mechanical Sciences. 2004, vol. 46, no. 2, pp. 299—320. DOI: 10.1016/j.ijmecsci.2004.02.009.

10. Prokic A. On Fivefold Coupled Vibrations of Timoshenko Thin-walled Beams. Engineering Structures. 2006, vol. 28, no. 1, pp. 54—62. DOI: 10.1016/j.engstruct.2005.07.002.

11. Senjanovic I., Catipovic I., Tomasevic S. Coupled Flexural and Torsional Vibrations of Ship-like Girders. Thin-Walled Structures. 2007, vol. 45, no. 12, pp. 1002–1021. DOI: 10.1016/j.tws.2007.07.013.

12. Kim J.S., Wang K.W. Vibration Analysis of Composite Beams with End Effects via the Formal Asymptotic Method. Journal of Vibration and Acoustics. 2010, vol. 132 (4), 041003, pp. 1—8. DOI: 10.1115/1.4000972.

13. Senjanović I., Tomašević S., Vladimir N., Tomić M., Malenica Š. Application of an Advanced Beam Theory to Ship Hydroelastic Analysis. Proceedings of International Workshop on Advanced Ship Design for Pollution Prevention. Taylor & Francis, London, 2010, pp. 31—42. DOI: 10.1201/b10565-6.

14. Senjanović I., Tomašević S., Vladimir N. An Advanced Theory of Thin-walled Girders with Application to Ship Vibrations. Marine Structures. 2009, vol. 22, no. 3, pp. 387—437. DOI: 10.1016/j.marstruc.2009.03.004.

15. Senjanović I., Grubišić R. Coupled Horizontal and Torsional Vibration of a Ship Hull with Large Hatch Openings. Computers & Structures. 1991, vol. 41, no. 2, pp. 213—226. DOI: 10.1016/0045-7949(91)90425-L.

16. Pavazza R. Torsion of Thin-walled Beams of Open Cross-sections with Influence of Shear. International Journal of Mechanical Sciences. 2005, vol. 47, no. 7, pp. 1099—1122. DOI: 10.1016/j.ijmecsci.2005.02.007.

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