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About the oscillatory stability of a simply supported beam under moving load

The theory of moving load dynamic action on elastic structures had arisen long before the completion of the framing static calculation theory and it has more then age-old history. The Chester's Bridge avalanche in 1847 was an immediate reason for the arrangement of the first theoretical and experimental investigations of a moving loads dynamic action. This catastrophe was accompanied by human victims and had aroused the serious alarm at the English civil engineering environment. The question had arisen in front of investigators how the effects which are produced in an elastic structure by a moving load, i.e. deflections and internal forces differ from the corresponding effects which are produced at static loading conditions [1].

At present, the actuality of this theory increases with the increasing of the traverse speed which can be equal to several hundreds kilometers per hour. The moving load influence is very considerable on a bearing structure at such high speed. It can lead to accidents similar to the Chester's catastrophe. The determination of the critical values of the bridge load system parameters is very important at railway and highway bridges designing.

The results of the investigations [2] are presented in the report. These investigations are devoted to the oscillatory stability problem for the structures which experience the moving loads action. The oscillations occur in the linearly elastic simply supported beam which is simulated by the Euler-Bernoulli, Rayleigh and Timoshenko's equations. The beam is subjected to the uniformly distributed moving inertial load which travels with constant speed. The aim of the investigation is determination of the load critical speed values which are associated with the static and dynamic beam instability. There are two cases at a moving inertial load simulation. In the first case, the Coriolis inertial forces are taken into consideration. In the second case, it is not. The nature of the oscillation instability is detected for each of these cases which let the possibility to judge about the Coriolis inertial forces influence. Generally, solution of this task is determined on basis of the two-wave motion representation method [3] which is enclosed in a fact that a required function is presented in the following form

$$y(z,\tau) = \varphi(z)\cos\omega\tau + \phi(z)\sin\omega\tau .$$

The problem of characteristic frequencies finding is solved. Six dependences of the first ten characteristic frequencies on the load motion speed were obtained after the numerical experiment implementation for each model and for each of two concerned cases. The computation shows that the Rayleigh correction gives the incidental quantitative differences against the classical Euler-Bernoulli's model, but the Timoshenko's correction gives the marked differences on the contrary. The taking into account of the Coriolis inertial forces leads to the qualitative differences. It has succeeded in finding the effect which is called the dynamic loss of stability [3]. Also the motion load critical speeds were established. The received results can be used at a design of bridges, pipelines and other structures which experience the moving loads action.

[1] Y. G. Panovko, I. I. Gubanova. Stability and oscillations of elastic systems – Moscow: Nauka, 1967. – 420 p.

[2] D. A. Ievstratenko. About the oscillatory stability of a simply supported beam under moving load / "Applied mathematics and mechanics tasks", XVI Int. scientific and technical conf. papers – Sevastopol, 2008. – P.71-75.

[3] O. O. Goroshko, A. G. Demyanenko, S. P. Kiba. Two-wave processes in mechanical systems – Kyiv: Lybid', 1991. – 188 p.