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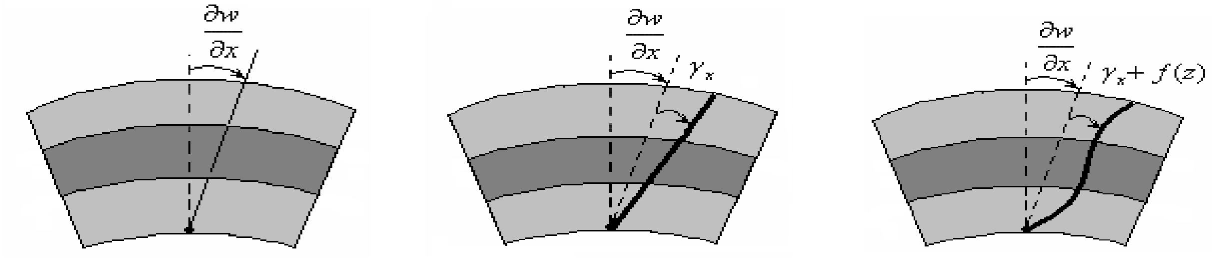
Regular and Chaotic Dynamics of Simply Supported Cylindrical Panels

Abstract: In many cases, while analyzing thin-walled structures, a series of hypotheses is applied allowing for reduction of an input 3D problem to that of 2D. In this paper we study and discuss three hypotheses, which are schematically presented in Figure 1.



a) b) c)

Figure 1. Schemes of the applied hypotheses

In order to construct a mathematical model of a multi-layered beam within the Euler-Bernoulli hypothesis (Figure 1a), we assume that the transversal cross sections perpendicular to the beam axis before bending remain non-deformed after bending, i.e. they are not changed in their planes. Observe that within this approach an order of a system of differential equations does not depend on the layers number and is equal to six. On the other hand, neglecting of a layer shear effect in many cases, and in particular in multi-layered composite beams (having various layers characteristics) may yield large errors in computations in comparison to a real beams behavior. A part of errors can be omitted using the so-called hypothesis of a normal rotation on angle γ_x, which belongs to Timoshenko (Figure 1b) [2]. In this case the system of ODEs order is eight. However, this hypothesis does not allow taking into account layers shear effects separately. Finally, applying the Sheremetev-Pelekh theory (Figure 1c) we allow the normal to rotate on an angle as well as to curve. This approach allows to include, at least partially, the layers shifts separately (note that the curving is defined through the function $f(z)$). In this case the order of the system of differential equations is eight.

During construction of the mathematical models within the applied hypotheses we assume that each layer material is elastic, and also that the all layers are governed by the same (one of the three mentioned) hypotheses. In addition, the beam is subject to sign-changeable load action. The obtained differential equations govern the object behavior inside and outside solutions boundary for each of the applied models and for arbitrary initial conditions. We are aimed at the analysis of influence of different types of the boundary conditions on the system dynamics. In order to reduce the system of PDEs to that of ODEs we apply the method of second order of finite differences regarding the spatial coordinate, FEM as well as the Bubnov-Galerkin method with higher approximations. The obtained systems of ODEs are solved via various Runge-Kutta methods of orders of h^2, h^4, h^6, h^8. The convergence of the applied method is rigorously monitored, and a priori estimations are formulated. The analysis of nonlinear vibrations of multi-layered beams is carried out with a help of time histories, Poincaré maps, Fourier spectrum, wavelet transformations, autocorrelation functions and the Lyapunov exponents. One problem is solved via different methods in order to get validated and reliable results since the systems with many degrees of freedom are studied.