COMPUTATIONAL INVESTIGATION OF ELASTICOPLASTIC A SANDWICH BEAM ON THE ELASTIC FOUNDATION

E.I. Starovoitov [1], **Abu Halawa Moh'd** [2]

[1] Belarusian State University of Transport, Gomel, Belarus
edstar@mail.by

[2] AOmar Amukhtar University, Box 919, El-Beida. Libya

The sandwich beam nonsymmetrical with thickness rod with a compressible filler is considered, its external base layers are fulfilled from elasticoplastic material, and a filler is nonlinear-elastic. For description of package kinematics following suppositions are assumed: in base layers Bernoulli hypotheses are fulfilled. in a stiff filler exact relations of the elasticity theory with linear approximation of displacements of its points from cross coordinate z are valid. On contact boundaries continuity conditions of displacements are used. Materials of base layers is compressible in a cross direction, reduction of a filler is considered, strains are low. The distributed superficial loading $q(x)$ simulates the hydrostatic effect of the ambient liquid.

The equilibrium equations of a considered rod follow from variation Lagrange principle. In layers of a beam the physical constitutive equations of the theory small elasticoplastic Ilyushin's strains in the deviator-spherical form are used:

$$s_{ij}^{(k)} = 2G_k(1 - \omega^{(k)}(\varepsilon_u^{(k)}))\epsilon_{ij}^{(k)}, \quad \sigma^{(k)} = 3K_k\varepsilon^{(k)}, \quad (k = 1,2,3; \;\; i,j = x,y,z). \tag{1}$$

Here $s_{ij}^{(k)}$, $\sigma^{(k)}$ — deviator and spherical parts of a stress tensor; $\epsilon_{ij}^{(k)}, \varepsilon^{(k)}$ — deviator and spherical parts of a strain tensor; $\varepsilon_u^{(k)}$ — intensity of strains in k-th layer, $\omega^{(k)}(\varepsilon_u^{(k)})$ — functions of Ilyushin's plasticity; G_k, K_k — modules of a shift and volumetric strain.

Depending on properties of the deformable foundation the interconnection between a response and a sag can be various. In practice often known Winkler model is used, according to which in our case $q_R = \kappa_0 w_2$, where κ_0 — a stiffness factor of the elastic foundation (factor lay).

Proceeding from relations (1) we shall select in stress tensor elastic and nonlinear (with an index "ω") items. Then we shall receive system of the nonlinear differential equations in an iterative aspect

$$a_1u_1^n - a_1u_2^n - a_4u_1^n{}_{,xx} - a_5u_2^n{}_{,xx} + a_2w_1^n{}_{,x} + a_3w_2^n{}_{,x} - 2a_6w_1^n{}_{,xxx} + a_7w_2^n{}_{,xxx} = p_\omega^{n-1};$$

$$-a_1u_1^n + a_1u_2^n - a_5u_1^n{}_{,xx} - a_9u_2^n{}_{,xx} - a_{10}w_1^n{}_{,x} - a_{17}w_2^n{}_{,x} - a_6w_1^n{}_{,xxx} + 2a_7w_2^n{}_{,xxx} = h_\omega^{n-1};$$

$$a_2u_1^n{}_{,x} - a_{10}u_2^n{}_{,x} + 2a_6u_1^n{}_{,xxx} + a_6u_2^n{}_{,xxx} + a_{11}w_1^n{}_{,xx} - a_{12}w_2^n{}_{,xx} +$$

$$+a_{15}w_1^n{}_{,xxxx} - a_{16}w_2^n{}_{,xxxx} + a_8w_1^n - a_8w_2^n = q + \frac{1}{2}p_{,x}h_1 + q_\omega^{n-1};$$

$$-a_3 u_1^n{}_{,x} + a_{17} u_2^n{}_{,x} - a_7 u_1^n{}_{,xxx} - 2a_7 u_2^n{}_{,xxx} - a_{12} w_1^n{}_{,xx} + a_{14} w_2^n{}_{,xx} -$$
$$-a_{16} w_1^n{}_{,xxxx} + a_{13} w_2^n{}_{,xxxx} - a_8 w_1^n + (a_8 + \kappa_0)\, w_2^n = g_\omega^{n-1}. \qquad (2)$$

At the first iteration nonlinear components are assumed to be equal to zero. The received values of displacements correspond to an elastic solution.

Let's accept conditions free leaning of a rod on end faces against static in space stiff support. Boundary conditions in sections $x = 0; l$ (l -- length of a rod) in displacements will assume the form:

$$w^{kn} = u^{kn}{}_{,x} = w^{kn}{}_{,xx} = 0 \quad (k = 1, 2),$$

where k — number of a base layer, n — number of a linear approximation.

We shall assume the solution of system of the differential equations (2) in the form of expansion in trigonometrical series, which automatically satisfy to boundary conditions of leaning against stiff support. After substitution of displacements and loadings in (2) we shall receive system of the linear algebraic equations for required amplitudes of displacements.

In work the problem about curving the sandwich beam laying on the elastic foundation is put and solved. As an example influence of plastic properties of materials of layers of the rod laying on the elastic foundation of an average rigidity is investigated. Convergence of a method of elastic solutions on an example of the foundation of a small rigidity is shown.