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STRAINING OF LAMINAR COMPOSITE, CONTAINING THE SERIES OF INFINITE CRACKS IN THE MEAN VISCO-ELASTIC LAYER

Abstract

The composite with alternate layers is considered on the base of the model of the piece– wise– homogeneous medium with the help of three–dimensional linear visco-elastic equation. It is supposed that at one of the layers of matrix there are periodic cracks of finite length. And also it is supposed "an infinity" the uniform distributed tension is applied. The influence of rheological parameters of matrix onto the strength–deformed state of composite is investigated.

At long strain loading the mechanical behavior of the composite material containing one or several polymer components depends on time. So in conditions of the long strain loading during investigation of the carrying capability of the composite material it is necessary to consider such an important factor as viscosity of the material of the fiber.

Let us consider the composite with the alternating layers in direction of the axis OX_2 (fig. 1).

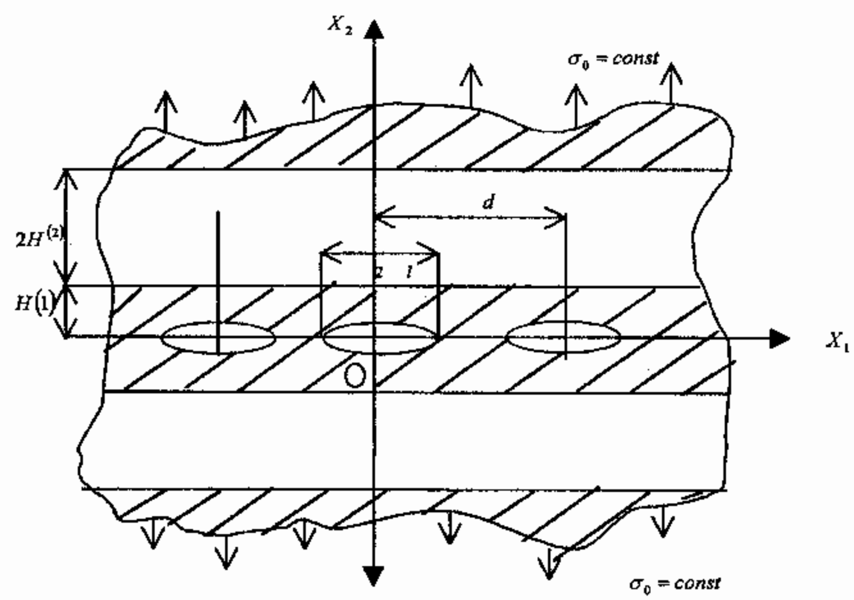

Fig. 1.

Assume, that in one of the layers of the matrix for $X_2 = 0$ the periodic cracks with the finite length 2ℓ are arranged. Also let's assume that at «infinity» the strained uniformly distributed forces are applied with intensivity σ_0 in direction of the axis OX_2. We denote by the upper index (1) the quantities describing the matrix and the quantities describing the layers of the fiber we denote by index (2).

Let's suppose that the materials of the layers of the matrix and the fiber are isotropic and homogeneous. We take the layers material purely elastic with the mechanical characteristics $E^{(2)}$ (Young's modulus), $G^{(2)}$ is the shear modulus, $\nu^{(2)}$ is the Poisson's coefficient, and the material of the matrix's layers is linear viscous-elastic with the operators [1,2,5]:

$$E^{(1)} = E_0^{(1)}\left[1 - \omega_0 Э_\alpha^*(-\omega_0 - \omega_\infty)\right],$$
$$G^{(1)} = G_0^{(1)}\left[1 - \frac{3\omega_0}{2\left(1+\nu_0^{(1)}\right)} Э_\alpha^*\left(-\omega_\infty - \frac{3\omega_0}{2\left(1+\nu_0^{(1)}\right)}\right)\right]; \quad (1)$$
$$\nu^{(1)} = \nu^{(0)}\left[1 + \frac{1-2\nu_0^{(1)}}{2\nu_0^{(1)}}\omega_0 Э_\alpha^*(-\omega_0 - \omega_\infty)\right],$$

where $E_0^{(1)}, G_0^{(1)}, \nu_0^{(1)}$ are immediate values of Young's modulus, shear modulus and Poisson's coefficient, correspondingly; $Э_\alpha^*$ is the fractional exponential kernel suggested by Rabotnov Yu.N. [5]; $\omega_{0,}\omega_\infty, \alpha$ are the reological parameters of the matrix's material. It should be noted that in (1) it was considered that the volume extension and compression of the matrix's medium is linear-elastic.

Let's also note that the analogous problem was investigated in [3,4] in the case when the materials of the layers of the matrix and the fiber were isotropy, homogeneous and linear-elastic.

Let's write the equation of equilibrium and the geometric correlation's within each layer:

$$\frac{\partial \sigma_{ij}^{(k)}}{\partial x_j^{(k)}} = 0 \ ; \qquad \varepsilon_{ij}^{(k)} = \frac{1}{2}\left(\frac{\partial u_j^{(k)}}{\partial x_i^{(k)}} + \frac{\partial u_i^{(k)}}{\partial x_j^{(k)}}\right). \quad (2)$$

Equation (2) contains commonly accepted denotations.

Let's suppose that on the surface of the separation of the mediums of the materials of the matrix and the fiber the conditions of complete enchaining are fulfilled.

For the layer with the crack (for $X_2 = 0$) we have the following boundary conditions:

$$\sigma_{12}(x_1,+0) = \sigma_{12}(x_1,-0) \quad (-\infty < x_1 < \infty);$$
$$\sigma_{22} = -\sigma_0 \quad (dn - l < x_1 < dn + l; \quad -\infty < n < \infty); \quad (3)$$
$$u_1(x_1,+0) = u_1(x_1,-0) \quad (-\infty < x_1 < \infty);$$
$$u_2(x_1,+0) = u_2(x_1,-0) \quad (dn + l \le x_1 \le dn + d - l). \quad (4)$$

Let's investigate the plane deformation. We search the solution in the lieu of the representations by Papkovich-Nayber resign (2) and the expressions for the harmonic functions from the contact conditions we obtain the close system of the non-homogeneous algebraic equations with respect to unknown constants coming into the expressions of the harmonic functions.

Therefore, satisfying the contact and the boundary conditions we determine the distribution of stress in the composite material. Determination of the stress intensity factor in the top of the crack is reduced to the solution of the singular integral equation.

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Received September 15, 1999; Revised December 22, 1999.
Translated by Soltanova S.M.