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Basic Methods and Principles of Solving Contact Issues

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Abstract: This article presents the main methods, tools and their laws and their solutions for solving contact problems that are important in the theory of elasticity.

Keywords: Elastic half-plane, deformation, stress, displacement components, boundary conditions, contact area.

In solving contact problems, the stress state of the elastic half-plane under the influence of the forces placed along the cross section of the straight line is of great importance.

When we study the problems of the interaction of elastic bodies whose outer geometric dimensions do not match, we consider that the dimensions of the impact surface are much smaller than the dimensions of the bodies. In this case, taking into account the size of the bodies, the stresses on the interaction surface at points far from the boundaries of the bodies do not depend on their configuration, but one of the bodies can be considered as consisting of semi-elastic media. This formulation of the problem is commonly used in "contact problems" found in the theory of elasticity. Simplification of boundary conditions allows the use of mathematical methods of the theory of elasticity. We study the stress state of the elastic half-space under stresses acting on a plane with a finite width and a sufficiently large length.

In the adopted coordinate system, the *0xy* plane is considered to overlap with the boundary of the elastic half-space, and the *0z* axis is directed towards the inside of the half-space. Let's take the width of the voltage space equal to $a+b$ and consider it directed along the 0y axis. In addition, the semi-elastic space is considered to be in the state of plane deformation.

$$\varepsilon_y = 0 \tag{1}$$

So, the transverse part of semi-elastic space *z=0,* $-b \le x \le a$ *p(x)* normal and q(x) are acting on it, and it is required to find $\sigma_x, \sigma_z, \sigma_{xz}$ stresses, deformation U_x, U_z tensor components and displacement components at its internal points.

As we mentioned, this issue is borderline

$$\begin{cases} x < -b \\ x > a \end{cases} ,\{ \text{x<-b x>a} \quad \overline{\sigma_z} = \overline{\tau_{xy}} = 0, \tag{2}$$

and $-b \le x \le a$ in the field $\overline{\sigma_z} = -p(x), \quad \overline{\tau_{xz}} = -q(x)$ biharmonic containing conditions

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial z^2}\right)\left(\frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial z^2}\right) = 0 \ , \tag{3}$$

satisfying Eq $\varphi(x,z)$

$$\sigma_z = \frac{\partial^2\varphi}{\partial x^2},\ \sigma_x = \frac{\partial^2\varphi}{\partial z^2},\ \tau_{xy} = -\frac{\partial^2\varphi}{\partial x \partial y}, \quad (4)$$

is brought to define the function. Moreover, as the case may be, at a sufficiently far distance from the "contact area" $(x \to \infty, z \to 0)$ voltages $\sigma_x \to 0, \sigma_z \to 0, \tau_{xy} \to 0$ must satisfy the conditions.

To solve similarly precise problems, in most cases (stamp problems) using stamp geometry instead of boundary stresses $\overline{U_x}\ (x)$ and $\overline{U_x}'\ (x)$ displacements are given, or if there is no slip under the stamp,

$$q(x) = \pm\mu p(x) \quad (5)$$

(μ - coefficient of friction in sliding) if there is sliding.

$$q(x) = 0 \quad (6)$$

Conditions are taken into account.

In the case of a stamp, depending on the setting and essence of the problem, the following border conditions are mainly imposed:

In the above-mentioned general theory, we considered the state of stress under stresses applied to some areas of the half-plane. But in most cases, in contact problems, displacements are also given along with stresses at the boundary, that is, a mixed boundary problem is considered. Such a situation can be found mostly in stamp issues.

In most cases, mixed boundary conditions have the following forms.

- Normal and compressive stresses are given at the boundary of the half-plane $p(x)$, $q(x)$.
- At the boundary of the half-plane u_z *(x)* normal migration, attempt $q(x)$ voltage or u_x (x) trial displacement and normal stress are given $p(x)$. These boundary conditions are appropriate in the absence of frictional forces between interacting surfaces and are derived from the geometrical profile of the surfaces.
- At the boundary of the half-plane u_z (x), u_x (x) normal and shear displacements are given and the sliding of the two surfaces relative to each other is not taken into account. In this case, the frictional forces between the two surfaces will be large enough, and it is necessary to determine the normal and tensile stresses at the boundary.
- The normal stress at the boundary is between the given normal and test stresses $q(x) = \pm\mu p(x)$ connection is taken into account. This is the coefficient of friction.

Thus, in the matter of interaction of elastic bodies with inconsistent external geometry, the dimensions of the impact surface are considered to be much smaller than the dimensions of the bodies. Taking into account that the dimensions of the bodies are quite large, the stresses on the interaction surface at points far from the boundaries of the bodies do not depend on their configurations, that is, one of the bodies can be considered as a semi-elastic medium. This formulation of the problem is mainly used in the "contact problems" of the theory of elasticity and allows the simplification of boundary conditions and the application of mathematical methods of the theory of elasticity.

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