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# Application of the methods of the theory similarity and dimensional analysis for research the local stress-strain state in the neighborhood of an irregular point of the boundary

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**Abstract**

In this paper, the methods of similarity theory and dimensional analysis analyzes the features of solving the problem of elasticity, caused by a form of boundary or "geometric factor" and the finite break of specified internally strains emerging in an irregular point of the boundary. Given the similarity criteria for the self-similar solution of the elasticity problem in a neighborhood of irregular points on a singular line of the elastic body of the border.

Due to self-solve the elastic problem, stress, strain, displacement in a neighborhood of an irregular point of the boundary admit of the group similarity and functions possess the property of homogeneity, characterized by the fact that these functions can be represented in the form of power complexes. The properties of similarity and homogeneity must have an experimental solution, resulting in the model as the fringe pattern by photoelasticity. Therefore, sequence stripes in some neighborhood of irregular point of the boundary should have the property of similarity, homogeneity as well as stress and be represented in the form of power complexes, $m \sim C\lambda r^{\lambda}$, which is confirmed by research of experimental data.

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*Keywords:* self-similarity solutions, similarity criteria, stress concentration, homogeneity of the stresses, strains, displacements, sequence stripes;

This article discusses the features of solving the problem of elasticity, caused by a form of boundary or "geometric factor" and the finite break of preassigned forced strains emerging in an irregular point of the boundary.

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Such features of the stress-strain states occur in structures and constructions having different variants of design figuration border: special lines, dots, for example, the incoming angle, etc. The active forced deformation doesn't satisfy the compatibility conditions, have a finite break (jump) on line (surface) contact areas, emerging at irregular point (line) border, which gives rise to stress concentration.

The relevance of the research stress from the action such incompatible strain arises in the study of stress-strain state of structural elements by temperature gradients, temperature changes in the joints of dissimilar materials with different coefficients of thermal expansion, the hopping change distortions have a finite break in joints of areas with different mechanical properties, as well as the mounting and fabrication sequence structures, the interference fit and others.

Features of the stress-strain state of buildings and structures, having "structural heterogeneity" and discontinuous forced deformations are determined in the polymer model by methods of photoelasticity [1,2,3] as the stress concentrators, which are the subject of this article.

The geometric stress concentrators, causing features of stress-strained state of an elastic body, determined by the irregular points (lines) of boundary of the following types:

A) the break points (lines) of the first derivatives of the functions defining the boundary lines (surface)of the elastic body, such as the corner points (lines), the polyhedral angles, the conical points;

B) points (lines) of the boundary of composite body owned by line (surface) of contact between two areas on which there is a jump the forced deformation or specified volumetric forces;

C) points (lines) of the boundary of composite body owned by the line of contact of two homogeneous isotropic media with different constant values of the physico-mechanical properties;

D) changes in the character of homogeneous boundary conditions.

In the neighborhood of an irregular point (line) homogeneous boundary conditions are given. Displacements of elastic body are continuous at a singular point (line) and their surroundings. The irregular point (line) of boundary of the body and their neighborhoods arises a feature of the stress-strain state due to factors A) - D), which has a local character, and a distancing by irregular point (line) of the boundary damped. Outside the influence irregular point (line) of the boundary of the body, the solution of the elastic problem is smooth.

Questions behavior of solutions of the Laplace equation, Poisson and elliptic equations for areas with nonsmooth boundaries were studied by Kondratiev V.A., Fufaev V.V., Williams V.L., Uflyand Y. S., Kalandia A.I., Cherepanov G.P., Bogey D.B., Aksentyan D.C., Alexandrov A.Y. [4-11] and others.

Analytical methods of calculation (VA Kondratiev, Williams VL, Uflyand YS [5,7,8], and others. Authors) suggest that in the neighborhood of irregular points of the boundary solution of general elliptic boundary value problem is presented in the form of an asymptotic series and endlessly differentiable function. The terms of this series contain solutions of the homogeneous boundary value problems for model areas: the wedge or cone.

In this paper, using methods of the theory of dimensions [12-14] are studied the orders of stresses changes, deformations and displacements depending on the coordinates of the point at the approach to the irregular point of the boundary.

Consider the resolving a system of equations of the elasticity problem in a small neighborhood of an irregular point $O_\delta(0)$ on a singular line of boundary of the elastic body $V$.

Let us write the equations of initial system to dimensionless form, using the following expression:

$$\xi = \xi_0 \overline{\xi}, \tag{1}$$

where $\xi$ – the considered quantity, $\xi_0$ – the characteristic value of the quantity, $\overline{\xi}$ – the dimensionless value of this quantity. We will consider:

$$\sigma = \sigma_0 \overline{\sigma}; \quad \varepsilon = \varepsilon_0 \overline{\varepsilon}; \quad U = U_0 \overline{U}; \tag{2}$$

$$x = \frac{l_0}{t} \overline{x}; \; y = \frac{l_0}{t} \overline{y}; \; z = l_0 \overline{z}, \tag{3}$$

where $t$ – dimensionless parameter similarity group, is introduced for the analysis of "the degree of approximation to the irregular point".

We obtain a system of equations of elasticity theory problem [3,12-14] in the dimensionless form:

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