Behavior of stresses in the vicinity of special points and special lines for cracks in an elastic material

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Cracks are one of the main objects of study in fracture mechanics. As a rule, they are modeled by a surface in the three-dimensional case (or a curve, in the two-dimensional case) on which the displacement field suffers a break. In the elastic formulation, the points of the crack boundary are special. At these points, the stresses are infinite. This feature is characterized by stress intensity factor (SIF). The standard problem of crack mechanics is to determine the dependence of the SIF on the geometry of the problem and the parameters of the external load. This is important because the achievement of critical values by the intensity coefficients determines the stability and directions of possible crack growth.

In this paper, the influence of crack surface geometry features on stress intensity coefficients is investigated. In the two-dimensional case, the characteristic special point for a crack is the point of fracture. In the spatial case, the crack may have a fracture line of the surface. In addition, the crack boundaries in a three-dimensional elastic body may have angular points. The presence of such geometry features leads to a special behavior of stresses in the vicinity of corner points and break points. The point of the crack boundary is already special, and if it is also angular, or belongs to the fracture line, then the already existing feature can both strengthen and weaken.

There are practically no analytical solutions for the problems under consideration, therefore, the only possibility of theoretical research is the use of numerical methods of crack mechanics. The authors have created and verified software packages that allow calculating the displacement and stress field with a sufficient degree of accuracy for systems of arbitrarily oriented cracks of a sufficiently general geometry. With their help, stress and SIF fields were studied in the vicinity of corner points and points (or in the three-dimensional case of lines) of the fracture. For example, for a rectangular crack in the plan, the normal to the boundary is not defined at the corner point. The task of studying the behavior of stresses in the vicinity of such a point is new. According to the classical definition of the stress intensity factor in this problem, its value depends on the choice of the normal by which we approach the boundary. The same problems are important for elucidating the influence of the size of the links and the angle of the fracture on the KIN of the crack in the three-dimensional and two-dimensional formulation. The results of the research of the listed tasks obtained by the authors are the subject of the presented work.