Preface

Studies of stress and displacement fields in solids with crack-like defects play the key role in fracture mechanics. Such defects include both cracks or thin notches themselves and sharp V-shaped notches, which originate infinite stresses in their tips in the frames of linear elasticity theory, as well as rounded notches with small radii of tip curvature. In the tips of such notches, even small loads generate stresses higher than the ultimate strength of material that precludes application of classical criteria to the estimation of carrying capacity of structural members. To date, solution schemes for fracture mechanics problems are best developed for solid bodies with cracks. Fracture problems for solid bodies with sharp V-shaped notches are studied to a much lesser extent. This situation can be explained by analytical difficulties arising in solving problems of elasticity theory for bodies with rounded notches. To solve problems of such class starting from data on stress concentration in the rounded notch tip with a significant radius of curvature, approximate methods are therefore of great importance. To find a solution, one must know how stress concentration factor for rounded notch tip with a small radius of curvature asymptotically depends on stress intensity factor for similar sharp stress concentrator. The authors had obtained such dependencies by solving singular integral equations that describe the singular boundary value problem of semi-infinite rounded V-shaped notch in elastic isotropic or orthotropic plane under ordinary boundary conditions, and assuming the respective asymptotic behavior of stress field at infinity. Obtained solutions demonstrated the asymptotic behavior for finite notched bodies, i.e., the smaller relative radius of curvature the notch tip has, the more precise they are. Based on the developed unified approach to determining stress concentrations near sharp or rounded V-shaped notches in elastic bodies, stress concentration factors near rounded V-shaped notches were derived and stress intensity factors for respective sharp V-shaped notches were found using a limit transition. The approximating functions were built for stress concentration factors near a rounded notch with arbitrary tip curvature radius and stress intensity factors for sharp notches in specimens of different configurations. Along with original achievements of authors, the book contains most established results from the world literature in the field. The book is partially based on translated Ukrainian edition entitled ‘Stress Concentration in Solid Bodies with Notches’ by M.P. Savruk and A. Kazberuk issued in 2012 by the SPOLOM Publishing House, Lviv, Ukraine. Present edition contains extra chapters concerning stress concentration near notches in anisotropic bodies. The book consists of 12 Chapters.

Chapter 1 outlines the method of singular integral equations in application to two-dimensional problems of elasticity theory for multiply connected regions with holes and/or cracks. Basics of quadrature method for numerical solution of the singular integral equations along either open or closed contours are considered.

Chapter 2 presents analysis of stress fields in elastic plane with a semi-infinite notch under condition either of plane stress state or plane strain state. Well-known boundary value problem solutions for eigenvalues of a wedge in the plane elasticity theory are considered at first. Then the same solutions are constructed for the semi-infinite rounded V-shaped notch and the relation between stress concentration and stress intensity factors in elastic bodies with rounded or sharp V-notches have been established.

Chapter 3 is devoted for the solutions to elasticity problem for a plane weakened by a sharp or rounded V-notch with edge cracks propagating from the notch tip. The relationship between stress intensity factors in the sharp tip of V-notch and the crack tip has been derived.

Fracture criteria for notched solid bodies are discussed in the Chap. 4. The most attention here is focused on the deformation criterion. The model of plasticity bands in fracture mechanics was adopted as a basis. Under this model, the solutions to elastic–plastic problems for a plane with sharp or rounded V-shaped notches have been obtained.

Chapter 5 comprises results of studying stress concentration around the curvilinear openings in an elastic plane. A well-known analytical solution for the elliptical hole is presented and discussed. The limit transition to the parabolic notch is performed. Numerical values of stress concentration factors in the tips of a slot, oval, or rectangular openings with rounded vertices are calculated by solving respective singular integral equations. Using the limit transition to zero tip rounding radius, we derived stress intensity factors for respective sharp-angled holes.

Chapter 6 proceeds with the periodic elasticity theory problem for a plane weakened by an infinite row of closely spaced identical curvilinear holes. Stress concentration factors in the tips of bilateral parabolic or rounded V-shaped notches were found for the limit case of infinitesimal holes spacing. These results are compared with known expressions for hyperbolic notches. Using the limit transition the solution for bilateral sharp V-shaped notches was derived.

Edge notches in elastic half-plane are studied in the Chap. 7. Analysis is given to single sharp or rounded V-shaped notches as well as periodic systems of such notches. A solution to periodic elasticity theory problem for a half-plane with sinusoidal boundary is presented. The case of edge notch with a crack growing from its tip is included as well.

In Chap. 8, we quote stress concentration factors and stress intensity factors for rectangular specimens with edge rounded or sharp V-shaped notches. Unilateral and bilateral edge notches are included. Widely known interpolation Neuber formula for stress concentration factors is generalized to sharp and rounded V-shaped notches.

Chapter 9 is devoted to the disc specimens with notches. Calculations were made for tensile disc specimen with edge U-shaped notch either without crack or with crack growing from the notch tip. Analysis was made also for compression disc specimens with the slots or rhombic holes. The solution was obtained for ring-shaped specimens with inner edge U-shaped notches as well.

Antiplane deformation of elastic bodies with notches or cracks is studied in the Chap. 10. The elastic problem solution for eigenvalues of a semi-infinite rounded V-notch in the antiplane theory of elasticity was constructed. Based on this solution, the relation between stress concentration factor and stress intensity factor for rounded or sharp V-shaped notches under longitudinal shear had been established. The longitudinal shear of elastic wedge with cracks or notches was analyzed. Elastic–plastic interaction of sharp V-notch with a circular hole was examined. Solutions were found for stress concentration near curvilinear holes (including narrow slot, oval, rhombic, and rectangular holes) with either sharp or rounded vertices under antiplane deformation.

Chapter 11 covers results of studying stress concentration near notches in an anisotropic body. The method of singular integral equations in application to plane anisotropic elasticity problems is presented. Based on known closed form solutions to problem of anisotropic plane with elliptical hole under tension, stress distribution in the plane with stress-free parabolic notch is determined for the case when the stress field is asymptotically given at infinity through the stress intensity factor in the tip of respective semi-infinite crack. A solution to plane eigenproblem for an orthotropic wedge with the bisecting line parallel to orthotropy axis is ensured. Using method of singular integral equations, the similar solution was obtained for a rounded V-shaped notch in the orthotropic plane. The relation between stress concentration factor and stress intensity factor in orthotropic plane with rounded or sharp V-shaped notches was established.

Chapter 12 concerns with studying stress concentration near notches in quasi-orthotropic bodies, that is, bodies with the special type of orthotropy when the characteristic equation has multiple roots. Basic relationships of plane elasticity theory for such media are presented and singular integral equations of first basic problem of theory of elasticity for a region containing curvilinear cracks are stated. Solutions for eigenvalues of a quasi-orthotropic wedge were obtained. Corresponding solutions for quasi-orthotropic plane with a rounded V-shaped notch were constructed. The relation between stress concentration factor and stress intensity factor in quasi-orthotropic plane with rounded or sharp V-shaped notches had been established. On this basis, the stress intensity factors in V-shaped tip of two-sectional kinked crack using the superposition technique were derived.

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Bialystok, Poland; Lviv, Ukraine — Mykhaylo P. Savruk
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