Preface

This monograph concerns with singular solutions in plasticity and their applications. The source of these singular solutions is the maximum friction surface. The presentation of the introductory material and the theoretical developments appear in a text of six chapters. The topics chosen are primarily of interest to engineers as postgraduates and practitioners but they should also serve to capture a readership from among applied mathematicians. The monograph provides both a description of general approaches to finding the asymptotic expansion of solutions in the vicinity of maximum friction surfaces and the specific asymptotic expansions for several rigid plastic material models. Numerical analysis is restricted to plane stain deformation of rigid perfectly plastic material. The potential of singular solutions to describe the generation of narrow fine grain layers in the vicinity of frictional interfaces in metal forming processes is outlined. The possibility of using singular solutions to build up kinematically admissible fields that account for the behavior of real velocity fields near maximum friction surfaces is discussed. Among the topics that are either new or presented in greater detail than would be found in similar texts are the following:

1. Expansions of singular velocity fields near maximum friction surfaces for several rigid plastic models (rigid perfectly plastic material, viscoplastic material and anisotropic material)
2. An approach to using singular velocity fields for describing the generation of fine grain layers in metal forming processes
3. An approach to using singular velocity fields for constructing accurate upper bound solutions.

Chapter 1 concerns with the constitutive equations for several rigid plastic models (rigid perfectly plastic material, viscoplastic material, and anisotropic material). The models for viscoplastic and anisotropic materials reduce to the rigid perfectly plastic model at specific values of input parameters. Several definitions of the maximum friction law are provided. These definitions are connected to the constitutive equations. The constitutive equations introduced in this chapter and the maximum friction law are used in subsequent chapters.

Chapters 2–4 deal with the asymptotic expansions of solutions in the vicinity of maximum friction surfaces for the material models introduced in Chap. 1. First, in Chap. 2, planar and axisymmetric flows of the rigid perfectly plastic material are considered. The main result for the rigid perfectly plastic material model is extended to a class of viscoplastic models in Chap. 3. It is shown that the constitutive equations for viscoplastic material should satisfy certain conditions for the reducibility of viscoplastic solutions to rigid perfectly plastic solutions when the constitutive equations for viscoplastic material reduce to the constitutive equations for rigid perfectly plastic material. Chapter 4 concerns with plane strain deformation of anisotropic materials. A simple analytic solution is provided in each chapter to illustrate the general theory.

In Chap. 5 a numerical method for calculating the strain rate intensity factor, which is the coefficient of the leading singular term in a series expansion of the equivalent strain rate in the vicinity of maximum friction surfaces, is introduced for plane strain deformation of rigid perfectly plastic material. The method is applied to find the strain rate intensity factor in compression of a plastic layer between two parallel plates.

Chapter 6 includes a brief discussion of two applied aspects of the theory of singular solutions. First, it is shown that there is a correlation between the theoretical strain rate intensity factor and the experimental thickness of a fine grain layer generated in the process of direct extrusion of an AZ31 alloy through a conical die. Second, a general kinematically admissible velocity field that accounts for the singular behavior of the real velocity field near maximum friction surfaces is constructed. This kinematically admissible velocity field is then used in conjunction with the upper bound theorem for analysis of forging inside a confined chamber.

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Sergei Alexandrov

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