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Uniformly moving screw dislocation in strain gradient elasticity

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Abstract

In the present paper, Mindlin's strain gradient theory of elasticity (form II) is utilized to determine the deformation and strain fields due to a straight screw dislocation that moves uniformly at a subsonic velocity in an infinite isotropic body. The theory employed herein, in addition to the effect of strain gradient, is capable of accounting for that of acceleration gradient through the incorporation of the micro-inertia term into the analysis of the problem. Integral representations are obtained for the displacement and strain fields, and it is shown that the utilization of the strain gradient theory for the continuum description of a moving screw dislocation leads to discarding the discontinuity of the induced displacement field, consequently resulting in the removal of the classical singularities of the associated strain and stress fields.

Keywords: moving screw dislocation, strain gradient elasticity, micro inertia.

1 Introduction

From the viewpoint of micromechanics, it has been proved that dislocations play an important role on the mechanical behavior of crystalline materials. In particular, plastic deformations of such materials are considered to be the result of the collective dynamics of dislocations present therein [1, 2]. Among the pioneering studies in this realm, one encounters the contributions of Eshelby [3] and Frank [4] who dealt with the uniform motions of screw and edge dislocations, respectively. The continuum description of dislocations and their motions has thus far been the subject of numerous studies. A brief review of some related studies is provided in the following.

Eshelby, subsequent to the aforementioned study, in one of his other contributions [5], determined the elastic field around a screw dislocation accelerating from rest and asymptotically approaching the velocity of sound. Mura [6] extended the solution of the deformation field induced by a single moving dislocation to the problem of a time-dependent continuous distribution of dislocations. Kiusalaas and Mura [7] derived an expression for the elastic field around an edge dislocation moving with an arbitrary velocity and applied the obtained results to the problem of an edge dislocation oscillating with a small amplitude. Weertman [8] obtained general solutions for screw, edge, and mixed dislocations traveling uniformly at velocities in the transonic and supersonic ranges. Markenscoff [9] addressed the problem of transient subsonic motions of a non-uniformly moving screw dislocation starting from rest. Likewise, Markenscoff and Clifton [10] treated the same problem but for the case of an edge dislocation. Lazar and Pellegrini [11] derived the full analytical solutions for non-uniformly moving screw and edge dislocations using the theory of generalized functions. Payton [12] obtained an expression for the elastic field induced by an

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