Abstract— The well-known micro plane theory is extended to account for micro rotations and couple stresses in the framework of the micro polar Cosserat continua. The main purpose is to obtain reliable macroscopic constitutive equations and models for engineering materials like concrete and other composites based on available and precise information of their complex microstructure. The proposed macroscopic descriptions account also for anisotropic material response behavior by means of the well-developed micro plane concept applied within a micro polar continuum setting. For the formulation of the micro polar-based micro plane theory a thermodynamically consistent approach is considered, whereby the main assumption is the integral relation between the macroscopic and the microscopic free energy as advocated by Carol et al. (2001) and Kuhl et al. (2001). Thereby, the micro plane laws are chosen such that the macroscopic Clausius-Duhem inequality is fully satisfied. This theoretical framework is considered to derive both elastic and elastoplastic micro polar micro plane models. Numerical predictions of the uniaxial tensile and simple shear tests in plane strain conditions obtained with a micro polar micro plane elastoplastic model are also presented and contrasted to the corresponding predictions of the classical micro polar elastoplastic model.

Keywords— plasticity, micropolar, microplane, localized failure.

I. INTRODUCTION

One of the most successful constitutive theories for the analysis of the engineering materials is the micro plane theory which is characterized by three relevant features. On one hand, it incorporates microscopic information in the macroscopic material formulation in a natural way. On the other hand, very simple constitutive equations at the micro plane level lead to highly accurate macroscopic predictions of material behaviors. The third relevant aspect of the micro plane theory is its capacity to model anisotropic material behaviors. Actually, this was one of the most important objectives of the original proposal by Taylor (1938) which is based on the definition of fully independent uniaxial stress-strain relations on several planes of the material.

Based on Taylor's idea the micro plane theory was then pioneered by Bazant and Gambarova (1984), Bazant (1984) and Bazant and Oh (1985, 1986).

For the formulation of the uniaxial stress-strain relations on the micro planes, two different approaches may be considered, whereby the static or the kinematic constraint require that either the stresses or the strains on each micro plane are the resolved components of their macroscopic counterparts. The static constraint was extensively used until the first application of the micro plane theory to continuum damage mechanics and to cohesive-frictional materials by Bazant and Gambarova (1984) and Bazant (1984). It was in those works were the name micro plane appeared for the first time instead of the original terminology slip theory which was related to the plastic behavior assumption on slip planes by Taylor and other authors like Batdorf and Budianski (1949). The potentials of the micro plane theory for describing non linear response behaviors of engineering cohesive-frictional materials like concrete were extensively demonstrated in the first contributions by Bazant and coauthors related with the micro plane theory and, more recently, in the works by Bazant and Prat (1988), Carol et al. (1991, 1992) and Carol and Bazant (1997), among many others.

Recently, the lack of a thermodynamically consistent approach for deriving micro plane-