SYNOPSIS

Plasticity is a branch of the mechanics of solids which deals with the deformation of a material produced by the action of stresses greater than those necessary to cause yielding of the material, where the phenomenon of the appearence of permanent strain is called yielding. The propagation of transient disturbances of magnitude large enough to cause plastic deformation to the medium in which the disturbance is travelling is called plastic wave propagation. In dynamic plasticity, the deformation being rapid due to the high rate of loading, the inertia forces are not generally neglected and the process of deformation occurs through the mechanism of wave propagation.

Plastic wave theory has important application in a wide variety of technical problems, such as, the high velocity forming of metals, the rapid deformation due to blast type loading or underground explosions, the dynamic problems for plastics and extensible cables, astroballistics etc. It provides unique opportunity to interpret experimental data at sufficiently high strain-rates. Plastic wave propagation in different media of both rate-independent and rate-dependent work-hardening material is of great interest in dynamic plasticity.

In the present work, the propagation of plastic waves is considered in different media for both rate-independent and rate-dependent work-hardening plastic materials. Small strain theory is employed to analyse the wave propagation in elasto-plastic and elastic/viscoplastic/plastic materials subjected to

compressive and combined stresses with one as well as two space variables. The material considered is assumed to be isotropic with isotropic work-hardening, obeying von Mises yield condition. A general review of the previous work on the subject is presented in Chapter I.

Chapter II represents a study on the simultaneous propagation of coupled dilatational and shear waves, and propagation of torsional waves in a compressible elasto-plastic material. The wave velocities are calculated and the natures of wave propagation are discussed in some special cases.

Chapter III deals with the propagation of plane waves in an elastic-plastic half-space for combined stresses. It is observed that for large stresses plastic wave speeds slowly decrease. However, for combined stresses, there propagate coupled longitudinal and shear waves in the medium. The ratio of plastic wave velocity and ordinary elastic wave velocity is calculated for different longitudinal, shear and also for combined loadings and the numerical results obtained for 0.2% carbon-steel are represented in the form of several graphs. A contour graph of the normal stresses is drawn for various ratios of the elastic and plastic wave velocities.

Chapter IV describes the stress wave propagation in an infinite elastic/viscoplastic/plastic medium. A general constitutive equation represents the medium in which instantaneous plastic properties are coupled and the non-instantaneous properties are also present. From this model, the classical Prandtl-Reuss constitutive equations of plasticity, the constitutive equations of Hohenemser and Prager for an elastic/viscoplastic material, and the constitutive equations for an elastic body can be obtained separately as special cases. Three separate cases, namely, cylindrical plane waves, spherical plane waves, cylindrical shear waves (for corresponding geometrical cavities embedded within the infinite medium) are considered with the general constitutive equation. In each case, the problem is solved by the method of characteristics and finite difference approach. The numerical work for mild steel is done with the help of an EC 1030 digital computer. Particular emphasis is given on the influence of the viscosity coefficient, the strain hardening parameter, and the parameter describing the instantaneous plastic properties. Several graphs are drawn showing the effects of these parameters on the time history of stress, strain, particle velocity, wave velocity, and on the overall shape of the elastic-plastic boundary. It is also observed that at a certain time after the application of the impact load, an elastic region appears within the plastically deforming medium.

Chapter V contains the study of spherical wave propagation in an infinite elastic/viscoplastic/plastic medium. A generalised form of Malvern's idea of dynamic overstress is used with linear viscosity dependence, bilinear static shear stress-shear strain curve, the method of characteristics and the finite difference approach. The numerical results show the influence of strain hardening, viscosity coefficient and the parameter describing the instantaneous plastic response on the time history of the stress, strain, particle and wave velocities except the radius of the yield surface. The effect of these parameters and the magnitude of the impact load (applied at the surface of the spherical cavity embedded in the medium) on the overall shape of the elastic-plastic boundary is also presented.

Finally, the last chapter is concerned with the combined dynamic loading on a thin-walled fixed end tube of elastic/viscoplastic/plastic material with pre-stress condition. The tube is initially pre-stressed statically and then subjected to combined longitudinal and torsional impact. The system of governing equations is solved numerically for mild steel by using difference equations along the characteristics. Stress and velocity profiles are presented as functions of both distance and time, regions of unloading are located. The effects of strain hardening, viscosity coefficient and the plastic parameter (describing the instantaneous plastic response) on the time history of stress, particle and wave velocities and the radius of the yield surface are shown.