Elastic-Plastic Dynamic Fracture Analysis of Structural Elements
Due to Stress Wave Propagation

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ABSTRACT

The present paper describes a dynamic fracture behavior of structural element under an elastic and elasto-plastic stress wave in two dimensional space. The governing equation of these problems is the type of hyperbolic partial differential equation, which consists of equations of motion and elastic constitutive equation in elastic problem or incremental elasto-plastic constitutive equations in elasto-plastic problem. To solve these problems we use the bicharacteristic method and Zwas’ method based on the finite difference method.

Additionally, in order to deal with the dynamic behavior of some elasto-plastic problems, an elasto-plastic loading path in the stress space is proposed to model the plastic yield phenomenon.

We will show the characteristics of stress waves propagating in elastic medium and calculate the stress intensity factor obtained by numerical simulation using shadow optical caustic to compare the stress intensity factor with the experimentally obtained caustic performed by Kalthoff.

The calculation using the method of bicharacteristic and Zwas method was carried out and their results were compared. The time history of a plastic zone of an elasto-plastic material was obtained by the Zwas method and its results are shown.

KEYWORDS: Stress Wave, Dynamic Fracture.

INTRODUCTION

The study of elastic material behavior under impact loading has been done by using the HEMP code developed by Chen and Wilkins(Chen, 1977). In this case, however, the main concern was on the overall numerical stability rather than the correct modeling of stresses. To model the stresses more correctly and to consider the motion of waves, another important method was proposed, which is the method of bicharacteristic for multidimensional problems in solid. The generating lines of the propagation cones of shear and normal stress disturbances in space and time (Monge-cones) are used to construct the second-order bicharacteristic method which allows the correct treatment of the admissible physical jump of stresses. Using this bicharacteristic method, the interaction between stress wave and crack have been actively studied by Kim(Kim, 1991) and in his more papers.

On the other hand, under the condition of impact loading or loading varies with very high frequencies the model of plastic region around a crack tip has not been known because the material under these loading conditions is dependent on time and exhibits strong non-uniform response. For this reason, the research on how stress waves affect the plastic zone at the crack tip will do an important role in studying the dynamic crack initiation.

In this study, we analyzed the problem of elastic dynamic fracture consisting of two-dimensional linear hyperbolic PDE using the bicharacteristic method. We thereby obtained simulated caustic curve numerically and then compared it with results of experiments performed by Kalthoff.

We also analyze the problem of elasto-plastic dynamic fracture under impact loading. Its governing equation consists of equations of motion and elasto-plastic incremental constitutive equations which also forms hyperbolic PDE. To solve this problem we introduce Zwas, two-step method(Zwas, 1972). When the stress state changes from an elastic one to an elasto-plastic one, the integration of dynamic multi-variable problem in the elasto-plastic solid must be carried out to investigate the stress state of the material. When the stress state is in