STRAIN-RATE AND INERTIA EFFECTS IN THE COLLAPSE OF ENERGY-ABSORBING STRUCTURES

Lai Ling Tam

Abstract

This dissertation describes some investigations into strain-rate and inertia effects in two simple types of energy-absorbing structure made of ductile metal: type I has a relatively "flat-topped" static load-deflection characteristic, while type II has an "initial high peak" followed by a sharp decline. The present work addresses the important problem of deriving useful data from a small-scale model of energy-absorbing structures.

Only one size type I specimen made of mild steel has been examined, whereas different sizes of type II specimen made of mild steel and aluminium alloy have been studied. A large number (176) of dynamic experiments performed in a "drop-hammer" apparatus have been conducted on type I and type II structures. This is a continuation of the work of Calladine and English (1984), and a widening of its scope. In these experiments, specimens were subjected to various levels of kinetic energy of impact using different combinations of mass of striker and impact velocity. Having used dimensional analysis to analyse these results, it turn out that the energy-absorbing behaviour of type II structures depends much more strongly on the ratio between mass of striker and ,ass of specimen that on the velocity of impact.

Some investigations have also been made into the collapse mechanism of type II structures subjected to impact loading. There include high speed photography, a study of various forces as a function of time by means of piezoelectric transducers, and a study by means of strain gauges of the time-history of straining at a number of locations on the specimen. In addition, comparisons between the detailed profiles of the specimens formed under both quasi-static and dynamic conditions have been made.

An analytical model for type II structures has been developed using classical impact mechanics on the basis of certain assumptions. This model is a development that of Zhang

and Yu (1989). It comprises two consecutive stages of energy dissipation. In stage I, energy dissipates in the specimen by means of axial plastic squashing, and in stage II, energy is absorbed by means of rotation of plastic hinges.

The analytical model together with the general ideals of dimensional analysis, enable all of the experimental observations to be fitted into a coherent scheme of explanation. For type II specimens, it is now possible with confidence to predict the final deflected form in terms of size, initial imperfections (crookedness), velocity of impact and mass of striker.