ıt. J. mech. Sci. Pergamon Press. 1976. Vol. 18, pp. 543–545. Printed in Great Britain

A NOTE ON TIMES TO FRACTURE IN SOLID PERSPEX SPHERES DUE TO POINT EXPLOSIVE LOADING

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Summary—The internal fracturing of a Perspex sphere due to a localised explosive loading on its surface has been investigated both analytically and experimentally. The locations and times of occurrence of the fractures are predictable from an analysis of stress wave reflection from the free surface based on the methods of geometrical acoustics. High-speed photography was used to measure and note the order in time at which the different fractures occurred.

NOTATION

a	sphere radius
$_d$, c_L	dilatational wave speed
$_s$, c_T	shear wave speed
t	time
E	Young's modulus
P	dilatational wave
S	shear wave
ν	Poisson's ratio
ρ	density

INTRODUCTION

ɴ A previous paper the results of an investigation ıto the point explosive shock loading of a brittle phere of Perspex was reported.[1] For a sphere point"-loaded at one pole, three fairly concen-ated regions of fracture were shown to occur in ıe vicinity of the anti-pole by reference to terminal amage observation and their general location was ıterpreted in terms of geometrical "stress optics"; ıe reason for their separate locations was not lentified.

This paper reports further investigation of this ·acture phenomenon by (i) relating it to the alculated position and shape of the various wave ·onts as time passes and (ii) photographing the ccurrence of the fractures and establishing the me of their appearance after detonation.

Somewhat related recent theoretical work on the ropagation of stress discontinuities will be found ι refs. (2) and (3).

EXPERIMENTAL

Spheres were machined from commercial grade Perspex[4] acrylic stock. The material properties of Perspex are $E = 3 \times 10^9\ \mathrm{N/m^2}$, $\nu = 0{\cdot}35$ and $\rho = 1{\cdot}19 \times 10^3\ \mathrm{kg/m^3}$. From these, the dilatational and shear wave speeds can be calculated as $c_d = 2011$ m/sec and $c_s = 966$ m/sec. The impulsive loading was secured by energizing I.C.I. electrical detonators bonded to the surface of the specimen, as indicated in Fig. 1, and thus producing spherical waves emanating from point A.

To photograph the formation of the fractures which result from the stress waves, the specimen was placed between a camera and a flash tube, as shown in Fig. 1. The camera used was a Barr & Stroud ultra high speed framing camera (type CP5 No. 69), which can be accelerated up to a maximum of 2,000,000 frames/sec. After accelerating the camera up to a pre-selected speed, the explosive charge and the flash tube were then fired automatically, being triggered by the camera itself. When a fracture appeared inside the specimen, the light through it was diffracted and the differential intensity of exposure registered on the film.

Fig. 2 (on the left) shows a sequence of photographs taken at a rate of nearly 670,000 frames/sec (1·5 μsec between frames) for a 7·37 cm (or 3 in.) dia. Perspex sphere subjected to a point explosive loading, i.e., a detonator placed at the extreme left hand end of a horizontal diameter. Apart from the fracture in the immediate vicinity of the loaded region, three other distinct regions of fracture can be observed developing, the photographs showing them appearing at successive times; they are labelled F-1, F-2 and F-3, and can be seen starting in succession, in frames 2, 11 and 26. The latter are shown enlarged in Fig. 2 on the right and rotated through 90°; frame 1 of that sequence occurs 47·5 μsec after detonation.