



SHOCK SIMULATION UNDER CONDITIONS LOCAL SHORT-TERM STRETCHING

¹Bozorov Nosirzhon, ²Mamadaliyeva Nargiza

KSPI. Cand. physical-mat.Sciences, KSPI.PhD

Bozorov 1970 @ mail. Ru, mamadaliyeva.nargiza@inbox.ru

ANNOTATION

This article examines the mechanism of destruction of a heterogeneous system, experiments were carried out with the simplest form of loading with a short-term tensile (impact) of a heterogeneous body - a high modulus fiber in a relative plastic matrix. Based on the study conducted in a direct experiment, it was shown that in a heterogeneous material not only under static loading, which researchers have long and well known, but under dynamic loading the principle of joint deformation is realized. Therefore, high-modulus crystals (“inclusions”) even at a large distance from the center of the explosion can be damaged (microcracks can form in them) and at minor stresses in the crystal of the host rock as a whole.

Key words: heterogeneous body , fiber, epoxy channel, elasticity, methacrylate.

INTRODUCTION

In the framework of studying the mechanism of destruction of a heterogeneous disordered system, such as rock in general and granite, in particular, it seemed interesting to conduct an experiment with the simplest form of loading during short-term tension (impact) of the simplest heterogeneous body - a high-modulus fiber in a relative plastic matrix. This interest was due to the very first results of studying the damage of crystals in granite using luminescence microscopy. It turned out that the highest modulus quartz crystals are damaged (microcracks are formed) first of all.

MAIN PART

It is well known from the literature [1] that short-term stretching can be easily organized, as shown schematically in Fig.1, in a reflected wave. Our model sample is a plexi glass washer (PMMA) with a diameter of 50 mm and a thickness of about 1 cm. A hole with a diameter of about 1.5 mm was drilled along the axis of the washer, which was filled with epoxy resin. Characteristic impedance — acoustic stiffness (r_s) for PMMA and epoxy resin are the same, as shown by measurements of the spall strength of the washer in the initial state and with a channel made of epoxy resin. In both cases, the spall strength was 16-18 kg / mm².

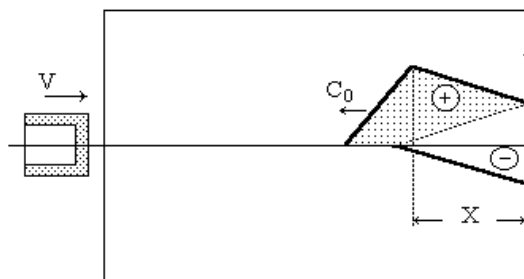


Рис.1. Эпюра напряжений в зоне откола

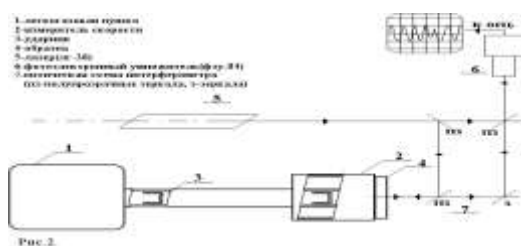


Рис.2

A model sample of the simplest heterogeneous body was obtained by introducing one or another fiber into the epoxy channel, the modulus of elasticity and strength of which were much higher than the material of epoxy resin and polymethyl methacrylate (PMMA). The installation [2], schematically shown in Fig.2, was used as the loading system. In our case, the interferometer was not used. The accelerating part was used to determine the speed of the impact of the duralumin glass on the duralumin target, against which our washer, the sample, was

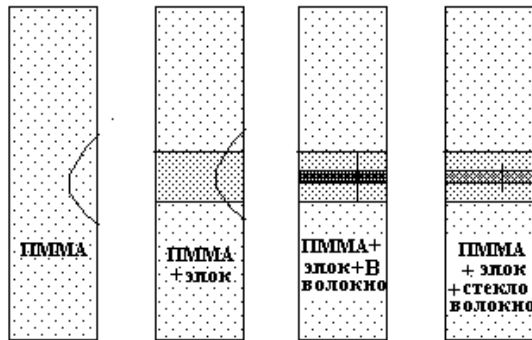


Рис. 3..

tightly pressed. The presence or absence of spallation damage was determined using an optical microscope.

As the simplest, elementary model of a heterogeneous body, a sample was chosen from traditional (in physical modeling) organic glass PMMA (polymethyl methacrylate) in the form of a washer 50 mm in diameter and 10 mm thick, in the center of which a channel 1.5 mm in diameter was made, filled with cured epoxy resin. Four series of samples were made (Fig.3.). Samples of the first series were the original, homogeneous material from PMMA. Samples of the second group are the same washers, but with an epoxy resin channel. In the third group, a single boron fiber with a diameter of 100 μm was glued into the channel, and in the fourth group of samples, a single glass fiber, also 100 μm in diameter, was glued into the channel. With the help of a light-gas gun, a schematic representation of which is shown in Fig.2, dynamic loading was carried out by collision of a duralumin cup with a duralumin target tightly connected to our sample - a PMMA washer.

Experience shows [3] that it is precisely such a complex design of the target and striker that makes it possible to obtain a plane wave at the exit from the sample under study.

The fact is that the initially flat front of the pulse under the influence of unloading waves arising on the free surfaces of the body degenerates into a curvilinear one on a path equal to approximately the diameter of the impacting or explosive charge [4]. Therefore, if it becomes necessary to keep the pulse front flat over a long path, it is necessary to use loading devices of correspondingly large diameter, which is always associated with certain technical difficulties. Interferometric measurements [5] of the velocity of the free surface of the target, in which the pulse was excited by the impact of such a glass, showed that the pulse front in a zone with a diameter of 15 mm remains flat on the way up to three diameters of the glass. In [6], the effect of using a striker of this shape was illustrated by the example of studying the phenomenon of rear spalling, the surface of which remained flat even in a target 40 mm thick. This aspect seems to be important, since it is necessary to have a guaranteed single place in our composite specimen with the maximum value of the load under shock loading, shown schematically a view of such a composite specimen and a stress diagram. The maximum tensile stresses

for a given geometry of the experiment should occur at a distance of about 3 mm from the back side of the sample washer.

The experiment showed that at a collision velocity (220 m / s, a sample made of pure PMMA undergoes so-called spall fracture [7] and, at the same time, its dynamic (spall) strength is (16-18 kg / mm²). The pulse duration

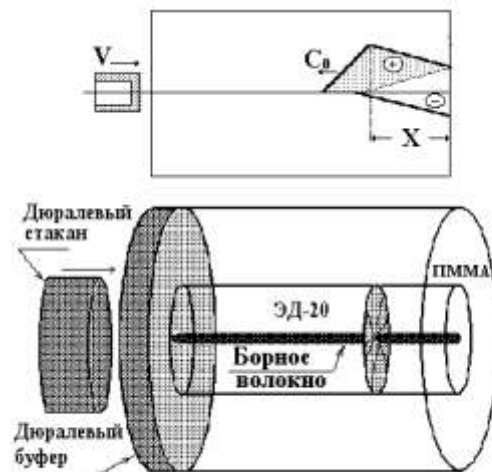


Рис. 4.

was 2 (3 μs, geometrical pulse length 6 mm.

In the case of the sample, when creating a foreign channel in it only with epoxy resin, the dynamic spall strength did not change (16-18 kg / mm²).

In an experiment with samples of the third type, a high-modulus boron fiber is destroyed, as it turned out already at a collision velocity 109-120 m / s. In this case, the dynamic load on the Plexiglas's was at the level of

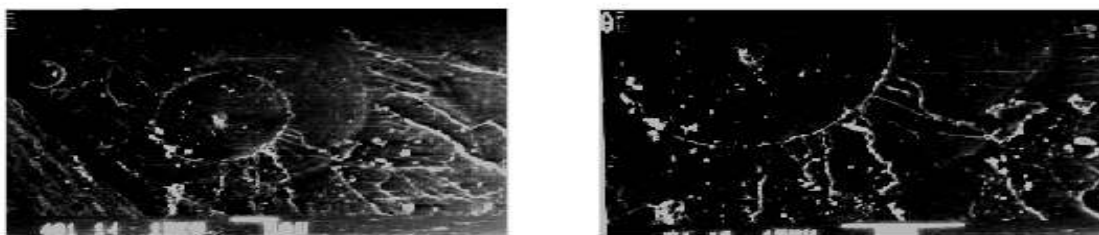


Рис. 5.

8-9 kg / mm², and the main body of the sample (PMMA) remained intact, i.e. traditional spalling destruction of the main body of the washer did not occur. Analysis of the fracture surface of the extracted boron fiber using a scanning electron microscope shows (see Fig. 5.) that the fiber fracture was initiated from the inside,

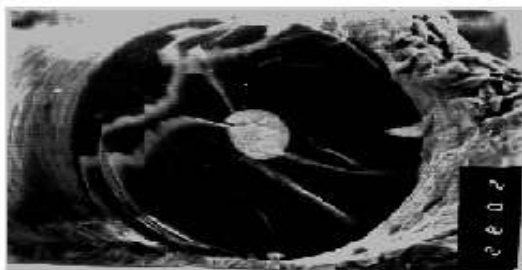


Рис. 6.

those. it happened as if the fiber was stretched by two ends, therefore, the fiber rupture was not a consequence of the development of a crack from the plexiglass - epoxy resin interface. For example, in the case of initiation of fracture from the lateral surface in the Al-B composition [7], the fracture thane is significantly different - the

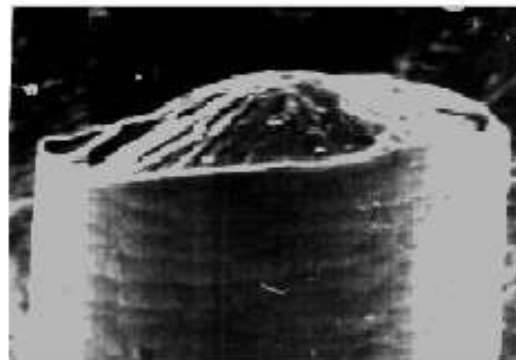
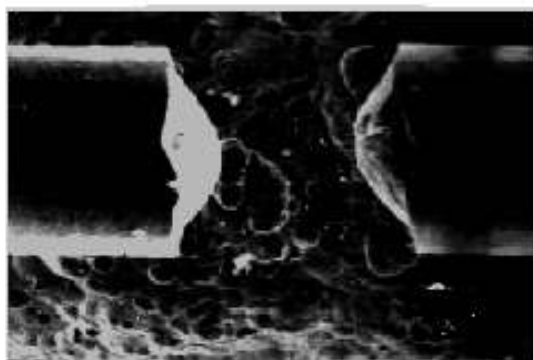


Рис. 6а.

crack start point is revealed quite definitely (see Fig. 6.).

Figure 6a. an example is given in the case of initiation of destruction from the inside.

In the case of a specimen with glass fiber, its destruction occurs at a significantly higher dynamic load at the level of 12-13 kg / mm², i.e. greater deformation of the system as a whole, but less than in the case of the original Plexiglas sample.

Thus, in a direct experiment, it was shown that in a heterogeneous material, not only under static loading conditions, which has long been well known to researchers, but also under dynamic (including explosive) loading, the principle of joint deformation is implemented.

CONCLUSION

Therefore, high-modulus crystals ("inclusions"), even at a great distance from the center of the explosion, can be damaged (micro crack scan appear in them) and at low stresses in the crystal of the host rock as a whole.

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