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EXPLOSIVE FACILITIES FOR MECHANICAL TESTING OF MATERIALS AND CONSTRUCTIONS

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RESUME : Une brève description est faite sur quelques dispositifs expérimentaux par explosifs qui sont destinés aux essais de résistance dynamique des déformations 10^{-2} - 10^3 . S^{-1} . Divers états de contraintes de chargement mécanique des structures de dimensions différentes sont décrits dans cet article en fonction des paramètres de chargement impulsionnels.

Abstract - A brief description of some existing experimental explosive devices for material dynamic strength tests at strain rates of 10^2 - 10^3s^{-1} and different stressed states and for mechanical loading of structures, of different overall dimensions, with loading pulse parameters, varying in a wide range are considered in this report.

1.- Methods of pressure pulse formation of the specified shape.

The main problems in the development of explosive devices are:

- 1 - pressure pulse extension (pressure reduction at the wave front, increase of pulse duration),
- 2 - localization of explosion effect that is significant for stationary devices in laboratory conditions.

Method of pressure pulse "extension" by means of crashers (dumpers), applied in impact tests, is successfully used in impact loading [1]. To achieve impact impulse of a trapezoidal shape, the dynamic diagram of dumper compression must correspond to perfectly plastic body. Some porous materials and tubular crashers have the dyagram of nearly the same shape {2,3,4}. Pressure pulse, corresponding to trapezoidal (or rectangular) is shaped, when dumper is compressed within the constant pressure region.

Test stands of the type are best suited, as they are simple in fabri-

cation, however increasing pulse duration a substantial increase in HE charge mass is needed, that is not always possible. These difficulties can be avoided when the whole system (loading device and test sample) is mounted in a barrel with one end being closed. Such device is described in the work [5]. When HE charge is detonated, the initial pressure peak is "cut" by damper, while shock wave being spread through it, and acceleration of the moving system is realised mainly due to explosion products (EP) residual pressure effect on the striker. This provides similar loading regimes of a test sample with the explosive charge mass being lesser than in the first method of loading here described, and which is approximately half as the damper deformation.

The residual EP pressure, used for impact impulse generation, made it possible to carry out comparatively easy the tests of structures on the effect of the mechanical pulses with decreasing in time load.

Test stand consist of an explosion chamber, shock-wave attenuator made in the form of a plug with throttling slots, accelerating section, pressure release and decelerating sections.

Experimental-calculation technique, based on the experimental load versus time dependences and on fitting of the corresponding analytic dependences and integration of the test sample equation of motion has been developed for calculation of the loading impulse parameters [6]. Discrepancy between calculated values and experimental ones is not more than 10%.

2.- Devices for dynamic testing of structural materials.

The split-Hopkinson-bar method (SHB), is used in dynamic tests of materials at uniaxial compression and tension in the strain rate range $\dot{\epsilon}=10^2 \dots 10^4 \text{s}^{-1}$. For the first time this method, used in explosive loading was applied in work [7]. According to this method, used in compression tests, a sample in the form of short cylinder is placed between the ends of two measuring bars (transmitting and supporting) and is exposed to a stress wave, generated in transmitting bar by means of the mentioned loading device (explosive loading by the damper). The sample, used in tension tests, had a form of a cap and the supporting bar had a tubular form. Similar experimental procedure is used in materials crack resistance tests [8], where specific wedge samples are used, the end of the loading bar has a wedge form. The diagram of experimental configuration, used in these tests, are shown in Figs. 1a,b,c. Where 1...4 are the elements of the loading device, 5, 9-

Fig.1

are transmitting and supporting bars, 8 -is the sample, 6 -are tensometers. Some experimental test results are given in work [9].

The scheme of a device for dynamic compression tests, disposed in close proximity to reactor active zone, is given in Fig.2. Localization of the explosion effect is provided by a steel chamber 1. The results of practical application of such devices are considered in work [10]. Besides, a series of devices for dynamic materials in combined stress test has been developed, constructions of these devices and investigation results are reported in works [11,12].

Fig.2

3.- Compact impact test stands for mechanical overload tests of structure components.

Two constructions of compact impact test stands for testing structure components subjected to comparatively small overloads to 10^3 units, trapezoidal pressure pulse duration of $5 \cdot 10^{-3}$ s, the test sample velocity

drop up to 50 m/s, are reported in work [12].

Impact test stand of the most simple construction is shown in Fig. 3.

Fig.3

The test stand has a steel casing in the form of a barrel 6 with 140 mm inner diameter and 25 mm wall thickness. The barrel length may be varied. At one end of the barrel there is a throttling plug-shock waves attenuator. The test stand is provided with four explosion chambers 4 of 30x13 steel with 70 mm outer diameter, 18 mm wall thickness and 500 mm length. Explosive charge in the form of a tube is made of steel-TEN-based explosive. A piston-striker 8, a loading dumper 10 and a test sample 11 are mounted inside the barrel. To reduce gas leakage the piston is provided with a self-sealing gasket 7. As the piston-striker passed through the throttling slots 9 and EP are removed from the accelerating section, the loading process is over. Test sample deceleration is performed by cellular polystyrene damper 12, forced through the tapered bush 14 (with the given force). Tolerable chamber charge density is 200 kg/m³, initial loading force is 250 t. (The test sample and piston mass was 50 and 40 kg respectively).

4.- Impact test stands for generating intense mechanical pulses.

For testing large-scale test samples there has been developed and used a series of impact test stands, in which impulses forces up to several hundreds of tonnes and duration up to 10⁻²s are generated by means of explosion chambers.

These test stands as compared to the above mentioned possess considerably larger store of gas and their accelerating and decelerating

sections are longer. The throttling plugs with large level of throttling and opening diaphragms are used in these stands as shock-wave attenuator.

One of the most simple test stands from the point of view of its constructions and fabrication, allowing to test structures having up to 400 mm dimensions is shown in Fig. 4.

Fig.4

The operating chamber volume is $6 \cdot 10^{-2} \text{ m}^3$, tolerable charge density 85 kg/m^3 , that provides the loading force of 1100 tonne. A part of the tube, used as an accelerating section 1 is strengthened by a set of sheet steel rings 2. Pressure release section 4 (0.5 m length) has 6 rectangular slots. That part of the tube, where test sample deceleration takes place, is filled with polyethylene chips 6. Foam plastic damper 7, rested against a massive concrete recoiler 9 is mounted at the end of the decelerating section. Such decelerating system provides gradual deceleration of the test sample of 100 kg mass, accelerated to 300 m/s velocity.

The devices, described in this paper, illustrate only some examples of the operating test stands. Besides, on similar principles there have been developed devices, which made it possible to carry out tests on alternations of stress. Experimental experience gained in these studies, demonstrated extensive application of these devices in different fields of science and engineering. These test stands are less expensive as compared to the corresponding impact test devices with similar parameters.

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