DEVELOPMENT OF NEW TYPE DYNAMIC SHEAR TESTING APPARATUS OF BULK SOLID*

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Abstract  The functions and system structure of DSA-1 Type direct shear apparatus were described, which is noted for its various functions, advanced techniques of multi-disciplines. The apparatus adopted advanced measuring system and has high accuracy of testing data. It provide a new technical measure for the study of dynamic characteristics of bulk solid.

Key words  dynamic direct shear apparatus; structure; bulk solid; dynamic characteristics

Various types of vibrating machines are widely applied in numerous national economy departments for compacting, loading, unloading and transporting bulk solid. DSA-1 type dynamic direct shear apparatus is mainly designed to simulate mechanic vibration. It is usually used to investigate the dynamic characteristics of the bulk ore and rock.

Most of traditional apparatus load shear force with either the hand wheel or hoisting jack, which is difficult for manual hand wheel to get the uniform strain rate. Its loading velocity is unstable and limited. At the same time, the intense labor and difficult operation cause the subjective experimental results. With the rapid development of science and technology, computer and sensor techniques are widely adopted in many subjects and fields, and have taken the place of many surveying tubes, percent gauges, measuring force-ring and other manual work involved in recording, graphics and calculation. The apparatus can automatically collect, calculate and treat the experimental data.

The multistage electrical automatic loading system has substituted hand wheel or jack loading, and can automatically shear the sample material at uniform strain rate. Thus it can greatly improve the experiment precision, speed up the data management and reduce the manual work and labor intensity.

The main body of the apparatus is designed to be assembled to meet the needs of various experimental conditions. Some of its parameters can be conveniently regulated according to the change of experiments. The apparatus can produce the horizontal and vertical vibration of either the whole shear cell or only top shear cell, and possess the dual function of both static and dynamic DSA. With the shear cell demolished, it can do the vibration liquefaction of bulk solid or other model experiments as a multifunction vibration platform, meeting the need of many kinds of experiments.

1 THE WHOLE FUNCTION OF THE DSA-1 APPARATUS AND THE CRITIC TECHNICAL PARAMETERS

As a device for vibration direct shear test of bulk solid, the stress-strain relationship of bulk rock and changing regularity of r.c.p values can be approached. The influence on the dynamic shear strength of bulk solid by amplitude, frequency, moisture content, solid size can also be analysed and studied.

The main technical parameters of DSA-1 are as follows:
1) The maximum vertical stress: 1.0 MPa;
2) The minimum vertical stress: 0.01 MPa;
3) The maximum horizontal shear thrust: 10 kN;
4) The sample size: d95 mm x 60 mm, d185 mm x 100 mm;
5) The shear velocity: 0.0025 - 25.00 mm/min;
6) The shear displacement range: 0 - 20 mm;
7) Exciting style: horizontal or vertical excitement;
8) Frequency range: 5 - 500 Hz;
9) Amplitude range: 0 - ± 5 mm;
10) The wave type: sine wave.

2 SYSTEM STRUCTURE

The direct shear apparatus is made up of five subsystems, namely, shear system, exciting system, vibration measuring system, measuring system of shear force and shear displacement, vertical loading system.
2.1 Shear System

The shear system, including electrical-motor, gearbox, propeller, shear cell, etc, is the main part of the device and is installed on the platform. Fig. 1 shows its structure.

1) Shear cell. The sample of bulk solid, d95 mm or d185 mm, is put into the shear cell. The two kinds of shear cells are laid on the same chassis. It is easy to change the shear cell to suit the variable conditions. Shear pattern: There are two shear patterns, one is stress-control pattern, which is to control a certain stress increment within certain time, and measure the corresponding strain of the sample; the other is strain-control pattern, the sample displacement will be controlled with the experimental procession, and the corresponding stress is measured along with the strain. The strain-control pattern, which is widely applied, can accurately measure the maximum strength and the final strength, so we have selected it as the shear pattern.

2) Arrangement of the shear direction and the exciting direction.

Three arrangements are listed in Fig. 2. Assume the shear direction S as the fundamental direction, the exciting force direction lies in three relationships to S: paralleled ($F_1$); vertical ($F_\perp$); angled ($F_\alpha$). The exciting force $F'$ is alternative, 

$$F' = P \cos \alpha t$$  

where $P$ is the exciting force amplitude of the exciting device.

Provided the composite force $F$ is along the $S$ direction:

- Paralleled: 
  $$F = S + P \cos \alpha t$$  

- Angled: 
  $$F = S + P \cos \alpha t \cos \alpha$$  

- Vertical: 
  $$F = S + P \cos \alpha t \cos (\pi/2) = S$$

According to the analysis, the exciting force and shear force will interact if (1) or (2) is adopted. The sensor is applied to measure the composite force which includes alternative part, so it's difficult to accurately survey the shear strength. If $F'$ direction is vertical to $S$ direction, the sensor only measures shear force, so the shear direction is mostly vertical to exciting direction.

3) Shear force loading.

The motor drives the gearbox via the shaft coupling, then drives the propeller which exerts the shear force on the shear cell via the force sensor and the thrust top, and pass the shear force on to the joint face between the two cells.

The switch on the control panel controls the electrical motor revolving clockwise and counterclockwise, which causes the propeller to move forward and backward. It's critical to grasp the propeller's thrust velocity that can ensure a shear at uniform strain rate. It not only makes the shear force stable, uniform and making less noise, but also changes the velocity widely to suit the various experimental conditions.

4) Seaming way and pneumatic counter-force apparatus.