Paper No. 26

A LARGE SHEAR - BOX FOR DYNAMIC TESTS ON SOILS

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SYNOPSIS

The paper describes the design of a 30 cm × 30 cm strain controlled shear box machine for dynamic tests on soils. Any rate of loading from 0.004 cms/sec to 6.4 cms/sec can be achieved by the unit. The performance of machine is judged by tests on sand.

INTRODUCTION

Designing of dams in seismic zones stresses the need to study the stress deformation and strength charateristics of pertinent soils under dynamic loads. Besides that, in the conventional type of shear machines sample size of 6 cm × 6 cm × 2.5 cm is generally tested. These dimensions are so small that soils over a certain grain size cannot be tested accurately. Moreover, in case of high rock-fill dams the soil is subjected to high normal stress at base, and to correctly estimate the value of shear strength it is necessary that the soil is tested under corresponding load in the laboratory.

A 30 cm × 30 cm sample size strain controlled shear box is designed and fabricated, for carrying out dynamic shear tests on gravels and sand-gravel mixtures. The machine is designed for a maximum normal stress of 4.4 kg/sq. cm on the sample. The movement of the box is by the advancement of a lead screw which is driven through a gear box. The gear box reduces speed in ratios of 1/1000, 1/100 and 1/10. The speed of motor, driving the gear-box is controlled by a "speed control unit". The flexibility of the speed control unit affords to attain any rate of strain within limits of 0.004 cms/sec (0.1 in/min) to 6.4 cms/sec (150 in/min). The recording of load displacement is through proving frames with electric resistance strain gauges pasted on it.

DESIGN OF MACHINE

The machine can be devided into following four units:

SHEAR-BOX

The 30 cm × 30 cm box is made in two halves from 2 cms thick mild steel plates joined by allen screws. The box is provided with top plate with grid on one of its faces for proper

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transmission of load, the plate weighs 20 kg. The bottom plate is also provided with grids. Four spacing screws are provided with steel balls at the ends. During preparation of sample the two halves of the box are pinned together with two removable but locking screws. The box is housed in a water jacket, mounted on two trains of ball bearings, which consist of 10 steel balls 1.875 cm (3/4") diameter in each train. Stops, guides, are provided to prevent the derailment of water jacket. Figure 1 shows the various components of box.

LOADING UNIT

The normal load on the sample is applied by means of single lever system with lever-ratio 1 : 15. The lever beam is made of I–Section weighing 13.785 kg. The loading hanger made up of (7.5 cm × 15 cm) I-section and (7.5 cm × 3.75 cm) channel section weighing 30 kg. rests on top-plate on sample. The weights are placed on the pan attached to one end of the beam.

DRIVING UNIT

The application of shear load is through a lead screw coupled to the put shaft of a gear box with gear ratios 1/1000, 1/100 and 1/10. The input shaft of the gear box is fed by

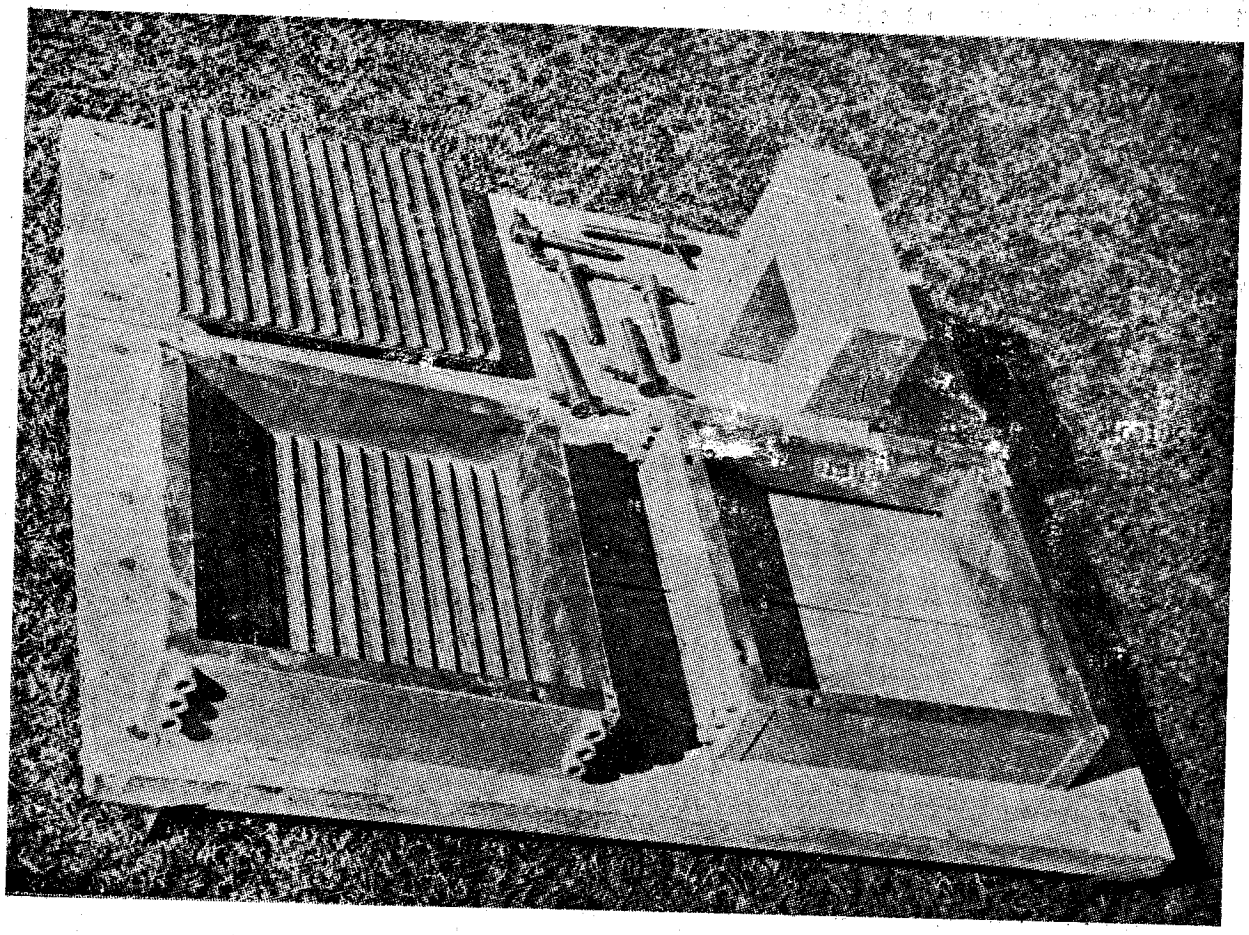

Figure 1 Components of Shear Box

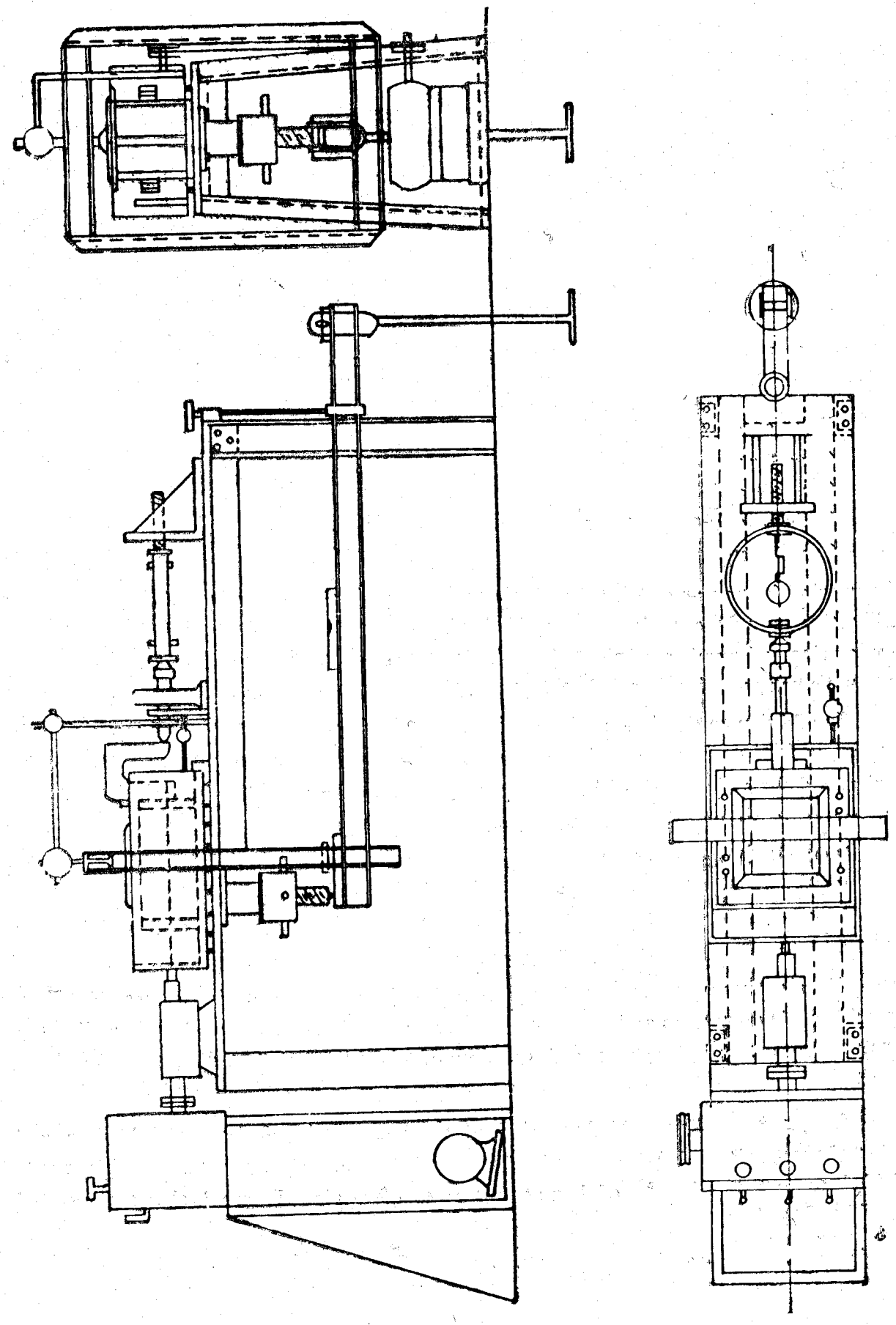

Figure 2 Assembly of Shear Box Machine.

a D.C. motor (1500 r.p.m., 440 volts) through a "speed control unit". Figure 2 shows a detailed drawing of the assembly of the machine.

INSTRUMENTATION

For measuring the load, the load-gauge is designed based on the criterion suggested by Casagrande and Shannon (1947). The proving frame used had the following dimensions :

External diameter	=	20 cms
Internal diameter	=	16 cms
Thickness	=	6 cms

Four SA-10 Rohits electric resistance strain gauges were pasted. Specifications of gauges :

Type	SA—10
Pattern	Flat
Overall size	24 × 12 mm.
Gauge length	10 × 5 mm.
Resistance in Ohms	122 ± .025%
Gauge factor	2.05

The proving frame was calibrated under compression in a 2-ton Universal Testing Machine. Calibration was done under progressive loading between deflection of 0.002 mm. dial of proving ring and number of chart lines deflected as recorded by a Universal Amplifier and Automatic pen recorder (Brush Oscillograph)*.

In addition to the design criteria of load gauge it was necessary that the deformation gauge should take minimum load so that effective shear load is not reduced. Moreover for maximum deformation it should not loose its initial geometry. With these points in view a ring was made from clock spring with these specifications:

Internal diameter	=	18.5 cms
Thickness	=	0.0356 cms
Width	=	0.87 cms
Weight	=	11.75 gms

The ring was provided with four SA-10 electric resistance strain gauges pasted on it, comprising of two tension and two compression gauges. It was calibrated using a dial extensometer to measure displacement and number of chart lines deflected as recorded by pen recorder.

A micro-switch is provided to switch off the motor under fast rates of loading and to protect the motor from being damaged. The switch is mounted on the table and is properly shielded against the inertia of box at fast rates of strain. Figure 3 shows the complete assembly of the box.

* For details, refer to manufacturer's catalogues

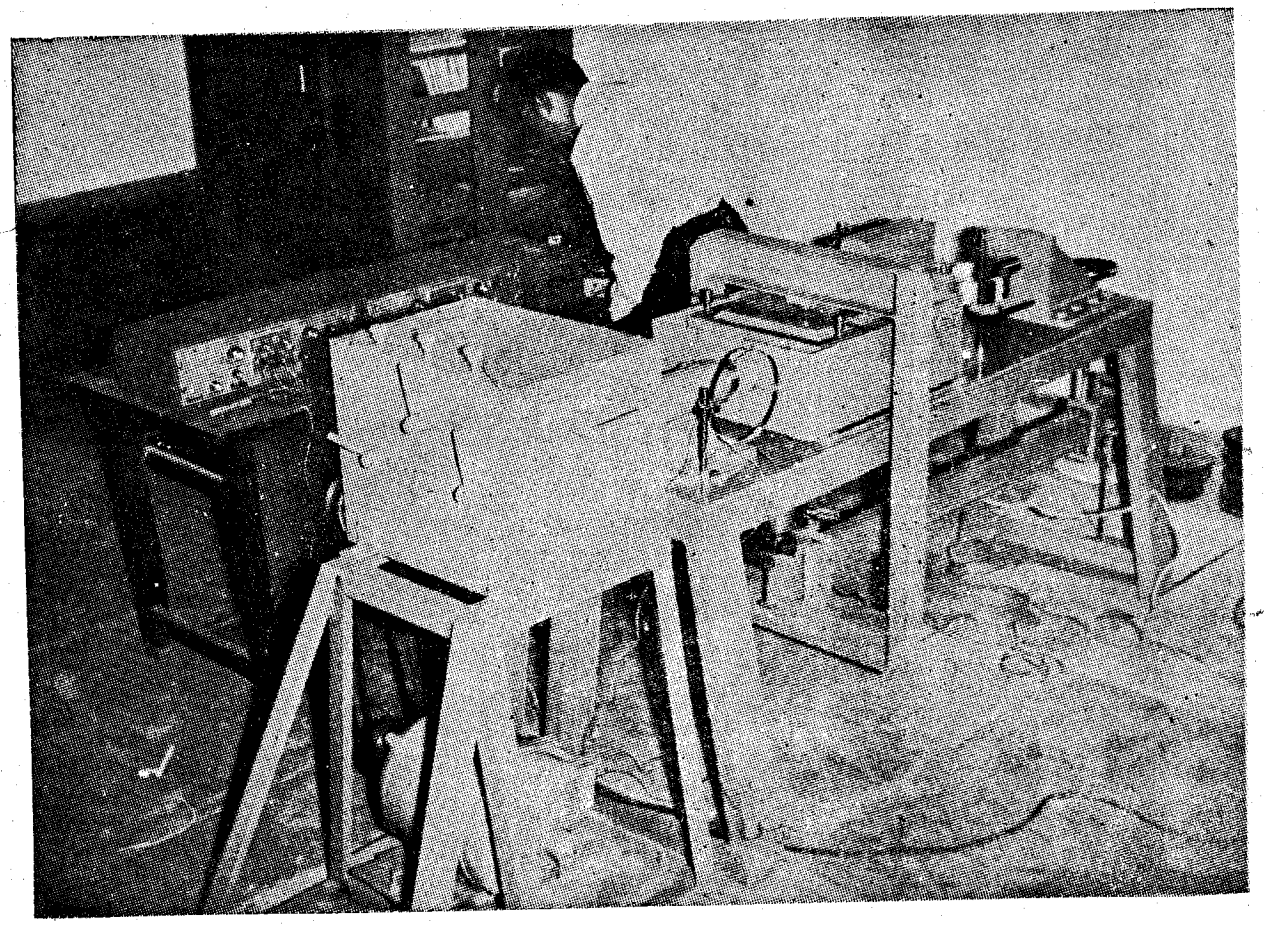

Figure 3 Dynamic Shear Test in Progress

PERFORMANCE OF MACHINE

From the tests carried out on the sand from Obra Dam site (Ranjan 1965) it was observed that the machine functioned satisfactorily for the time of loading upto two seconds. Tests on this sand were performed for rates of loading from 0.0062 cms/sec to 0.36 cms/sec. Tests on rates of loading faster than 0.36 cms/sec could not be performed due to some difficulty.

COST ANALYSIS

The large scale shear box for dynamic tests was fabricated in the workshop of the School. The box along with its components, table on which it is mounted and with loading arrangement for normal load and gear-box was fabricated at an approximate cost of Rs. 3000.00. The speed control unit along with the D.C. motor was designed and assembled at an approximate cost of Rs. 5000.00. The proving ring used for measuring load was purchased from Associated Instruments Manufacturers India Ltd. for about Rs. 1000.00.

SUMMARY AND CONCLUSIONS

The machine functioned satisfactorily for the time of loading upto two seconds. I was observed that U-frame attached to the upper half of the box causes eccentricity which results in the tilting of the upper frame and the top plate. To minimise tilting the U-frame should be replaced by a solid rod attached to the upper frame and abutting against the proving ring.

ACKNOWLEDGEMENTS

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REFERENCES

Associated Instruments Manufacturers (India) Ltd. Operating Instructions For Large Shear Box.

Brush Operating Instructions—Oscillograph Models R.D. 232100 and R.D. 232200.

Brush Operating Instructions—Amplifier model R.D. 51200.

Casagrande and Shannon (1947), "Research on Stress Deformation and Strength Characteristics of Soils and Soft Rocks under Transient Loadings", Soil Mechanics Series No. 31, Harvard University.

Ranjan, G. (1965), "Design and Performance of a Large Shear Box for Dynamic Loads", M.E. Thesis, Deptt. of Civil Engineering, University of Roorkee, Roorkee.