A NEW MATERIAL FOR DYNAMIC TESTS OF ROCKFILL DAM MODELS

by

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SYNOPSIS

A new material for dynamic tests of rockfill dam models has been developed. This material satisfactorily scales density, stress-strain curves and particle breakage of the rockfills. Several models were constructed and preliminary tests were carried out on a shaking table using harmonic and random input.

INTRODUCTION

One of the principal restrictions found in previous dynamic tests on rockfill dam models has been the lack of similarity in the breaking resistance of the grains, with respect to the prototype, because its consequences in the strain-stress behaviour. The granular material described in this paper reduces this restriction.

By using dimensional analysis the similitude relations were established. Due to the difficulty to comply simultaneously with all the equations, preference was given to the relations between stress, σ , unit weight, γ , and lenght, l , given by the equations (dots are used for model)

$$\sigma/\sigma' = (\gamma/\gamma')(l/l') \quad \text{or} \quad \xi = \rho\lambda$$

The convenience of studying dams of great height and the availability of a 4.7 x 4.7 m shaking table, resulted in a length scale $\lambda = 140$. In order to reduce the stress scale ξ to practical values, a unit weight scale ρ of 0.5 was selected.

MECHANICAL PROPERTIES OF THE NEW MATERIAL

The rockfill of El Infiernillo dam (1), was chosen as prototype for the developed material. A complete reproduction of the behaviour of the prototype was not intended but only to scale its principal characteristics.

Different mixtures were tested, and a material composed by fish-glue and litargirium was found to have adequate properties. It was found that it is practically non sensible to changes of weather conditions, and soluble in water.

Granular material was manufactured by scaling the maximum size of the rockfill used at El Infiernillo dam. The grain-size distribution was such that 100% passed

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sieve No. 4 (4.76 mm), 65% was retained in No. 6 (3.36 mm), and 35% was retained in No. 10.

An experimental program was carried out. 160 triaxial tests of dry material were carried out by using cilindrical specimens with 3.5 cm diameter and 7.0 cm height (2). Confining pressures ranging from 0.028 to 0.140 kg/cm^2 were used, corresponding to the range 2 to 10 kg/ cm^2 in the prototype.

The stress-strain curves shown in Fig. 1 are typical of those observed in all triaxial tests. Some of the features of the material behaviour are as follows:

a) The stress-strain curves are approximatelly parabolic. This fact is in agreement with rockfill behaviour (1).

b) Even for small increments of the confining pressure a different curve is obtained in such a way that the resistance increases as the confining pressure increases.

c) The principal stress ratio ($\frac{\sigma_1}{\sigma_3}$) decreases as the confining pressure (σ_3) increases.

d) The inclination angles of straight lines through the origin and tangent to Mohr circles are 54° and 44°, for pressures of 0.028 and 0.140 kg/cm^2 respectively.

e) Particles breakage is very close related with relative density.

Comparing sample behaviour at the same confining pressure (Fig 2), it was observed that both the resistance and the principal stress ratio were increased when the unit weight of the samples was increased. The modelling of all the above characteristics is practically imposible if natural petreous particles were used (3).

As construction of the models requires a large amount of the material in granular form, it was necessary to design a production device which takes into consideration the low resistance of individual grains. The result was an electro-mechanic system in which the main steps are mixture preparation, drying, cracking and sieving.

DYNAMIC TESTS ON MODELS

In order to develop a model construction technique which takes into account the low strength of the material, four dam models were built, two 50 cm and two 100 cm height (4); the slope was 1.75 and the grain size was the same used in the triaxial tests.

Dynamic tests for the four models were carried out on the shaking table with harmonic excitation applied in the direction normal to the crest. The model response was obtained by simultaneously recording accelerations at its base, crest and other points. The frequency of excitation was gradually increased from 0 to 22 Hz, in steps of 0.1 Hz.

One 100 cm model was tested with random excitation generated through several wooden-hammer shocks, applied to the shaking table. The frequency response function was obtained using the method proposed in ref 5 by means of the cross-correlation function of input and output, and the autocorrelation function of the input.

For the last model quoted the resonance frequency determined in the interval under study was 20.1 Hz for harmonic excitation and 20.0 for random input. Considering that the time scale is equal to the square root of the geometric one, the resonance frequency of the prototype results of 1.69 and 1.70 Hz respectively. The resonance frequency measured in the prototype (6) was 1.64 Hz.

From the above, the approximation reached by the model can be appreciated. It is thought that the difference between prototype and model results is partially due to the fact that the model does not include the effect of impervious core nor that of the reservoir. At the present there is a working programme at the Institute of Engineering, UNAM, aimed for developing models which include these two features.

In order to obtain some information about the failure pattern, the models were tested up to failure, observing at the beginning a gradual sliding of the grains located at the central portion of the crest. This failure extended gradually to lower portions of the models. Failure never started at the interface of the model and the simulated valley slopes. This fact is in agreement with failure observed in dams under earthquakes. This is possibly due to the fact that the material reproduces in an acceptable form the weight of the dam.

CONCLUSIONS

The brittle material here described has a promisory future in the field of rockfill dam modelling because it scales density, and because grain breakage does occur during the tests and has stress-strain curves similar to that of the prototype material.

ACKNOWLEDGMENTS

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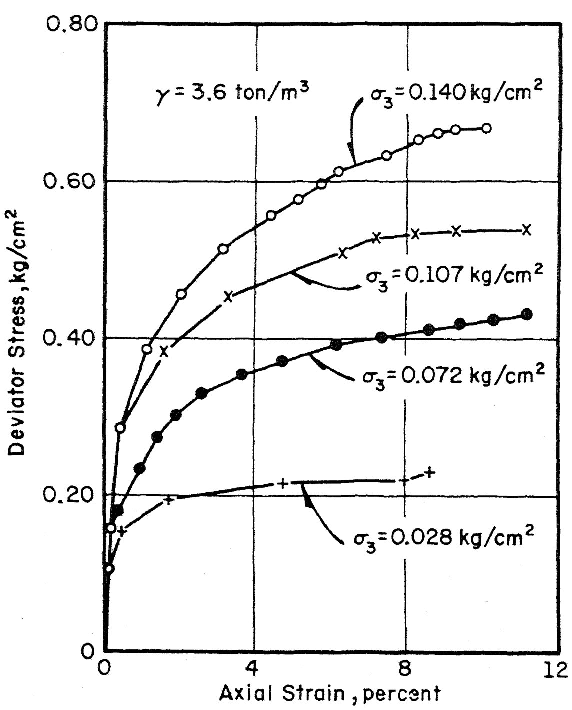

Fig 1 Stress-Strain curves for the material with fixed volumetric weight

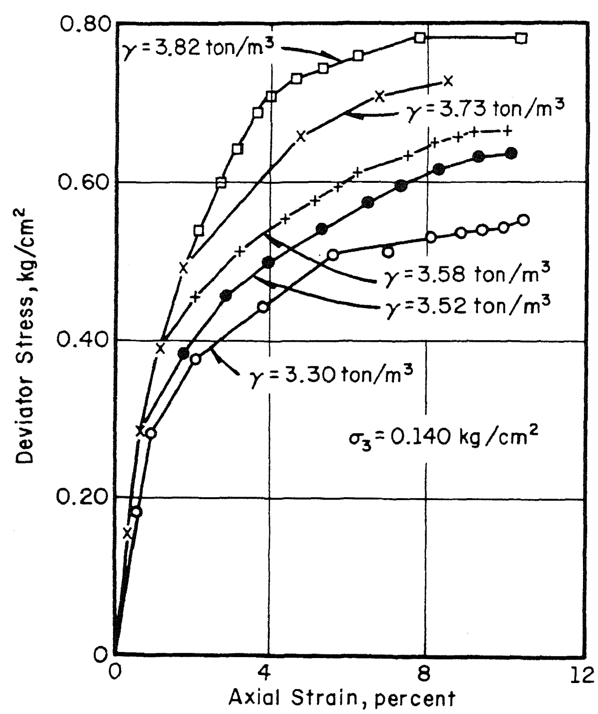

Fig 2 Stress-Strain curves for fixed confining pressure