

THE EFFECTS OF HIGH INTENSITY EARTHQUAKES ON THE  
STABILITY OF THE CHIRA PIURA SPILLWAY, PERU  
- A NONLINEAR FOUNDATION/STRUCTURE ANALYSIS

by  
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The Poechos Dam, part of the Chira Piura irrigation scheme, incorporates a large reinforced concrete spillway and associated radial gate. The response of the structure under the loads imposed by a high intensity earthquake, including hydrodynamic forces, was calculated in combination with the static response due to self weight and seepage forces. Design specifications required that the structure withstand, undamaged, peak accelerations of 0.2g. In the advent of higher intensity earthquakes the onset of foundation yielding would allow the dam to slide without excessive tensile forces being induced in the structure with a resulting savings on the reinforcement. However, an accurate nonlinear response analysis is required to assess these stresses.

A nonlinear finite element analysis of the system was carried out and some of the pertinent features of the mesh are shown in Figure 1. The foundation/structure combination was subjected to the Parkfield earthquake record, scaled to a maximum of 0.4g, with the solution being obtained by a time stepping process. Nonlinearities in the analysis were introduced by restricting the solution to a non-tension condition in the vertical direction of the foundation and by adopting a limiting shear condition of the form

$$\tau = \tau_0 + \sigma_v \tan \phi ,$$

for horizontal planes. Such a solution required an iterative approach with the vector of modified forces being updated until convergence was reached for each time step.

The inclusion of fluid-structure coupling permitted the direct calculation of the applied hydrodynamic pressures on the radial gate of the spillway.

The analysis showed that at earthquake levels of 0.4g maximum acceleration, extensive foundation yielding would occur. The yield zone is, however, confined to a relatively narrow region underneath the dam structure which would act as a lubricated surface on which the dam could slide. The zone of yielding is also shown in Figure 1.

Currently, at the University of Bristol, an experimental research programme is underway to study the effects of high intensity earthquakes on structures similar to the Poechos Dam. A 23kN shaker is being used to generate earthquake forces for models. The modelling material is a sand/wax mixture which can be varied to allow for different cohesive properties to simulate prototype materials. A general view of the test rig is shown in Figure 2.

The earthquake acceleration history is stored in a dedicated mini-computer and output to the shaker amplifier whilst simultaneously monitoring the responses of the model. Analysis and final preparation of the collected data is performed by the computer. Such tests provide a means of validating the finite element program and indicating possible failure mechanisms.

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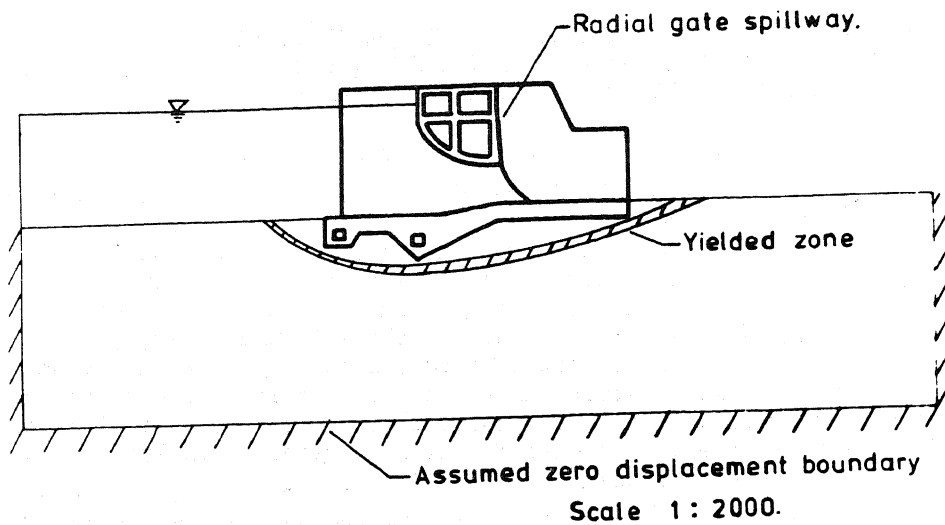


FIG. 1 POECHOS DAM

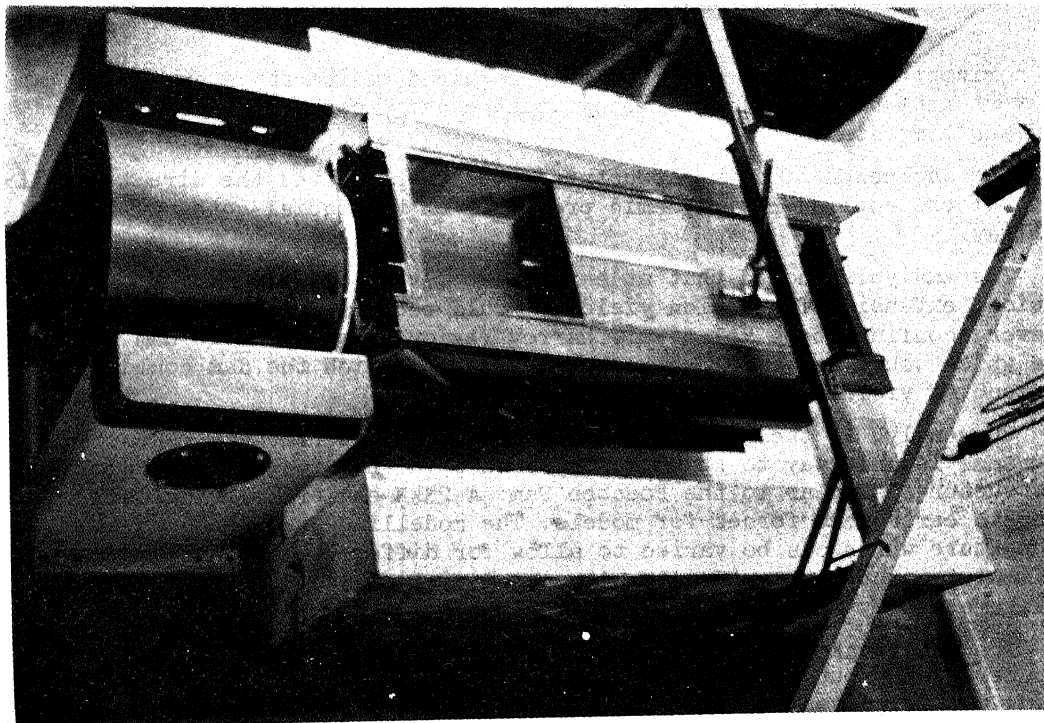


FIG. 2 EXPERIMENTAL RIG