International Conferences on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics

1981 - First International Conference on Recent Advances in Geotechnical Earthquake Engineering & Soil Dynamics

30 Apr 1981, 1:30 pm - 5:30 pm

Session 7: Moderator's Report

W. F. Marcuson III
Earthquake Engineering and Geophysics Division, USAE, Waterways Experiment Stations, Vicksburg, Mississippi

Proceedings: First International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, April 26 - May 3, 1981, St. Louis, Missouri

Moderator's Report by
W.F. Marcuson, III,
Research Civil Engineer
Earthquake Engineering and
Geophysics Division, USAE
Waterways Experiment Stations,
Vicksburg, Mississippi, on
"Earth Dams and Stability of Slopes Under Dynamic Loads".

During this session, Professor Seed presented an excellent state-of-the-art report addressing the topical area. I briefly reviewed the 22 papers that were submitted to the session. These papers addressed many aspects of dynamic slope stability analyses ranging from shake table tests to field vibration tests on prototype dams; from simplified model analyses to three-dimensional analyses, and from a comparison of soil models to a compilation of empirical data.

Regarding permanent deformation analyses, less progress and technical advancement have been achieved in this area than in the area of liquefaction in the last 15 to 20 years. By and large, the concepts outlined by Newmark (1965) are still the state of the art. I do not mean to belittle the work that has been done in this field, rather, I wish to point out that permanent deformation prediction has not received the attention that liquefaction has. There appears to be good reason for this imbalance of research effort. The principal mode of seismically induced failure is that of a significant loss of shear strength as a result of increased pore pressures. If an embankment and its foundation are well designed and entirely composed of materials that do not undergo significant cyclic strength degradation, then major dynamic instability problems are avoided. Professor Seed makes this point in his Rankine lecture (Seed, 1979). It should not be assumed that such materials will not deform, crack, and/or experience sloughing. Consequently, we must continue to use sound engineering judgement and apply the principle of designing to provide defense in depth, long advocated by Professor Arthur Casagrande. For example, we must design our dams such that cracks are not to be expected, but at the same time, we assume that cracks may develop and so provide drains and filters to prevent a failure by erosion or piping.

Additionally, if the embankment and foundation contain no materials that are subject to significant cyclic strength degradation, then psuedostatic stability analyses using appropriate seismic coefficients are adequate for predicting stability. An appropriate seismic coefficient might be one-third to one-half the maximum acceleration to which the dam might be subjected. This acceleration value should include any amplification caused by the foundation or by the embankment. For example, if the design earthquake was assumed to have a maximum bedrock acceleration of 0.15 g and this motion is amplified through the foundation and embankment such that the maximum acceleration at the dam crest is 0.45 g, an appropriate seismic coefficient might be 0.2 for a psuedostatic analysis. This analysis should use appropriate strength parameters and yield a satisfactory factor of safety. In this case, we can expect satisfactory performance of the dam if the design earthquake occurs.

In the past 15 years, extensive efforts have been devoted to the development of analytical approaches for evaluating the liquefaction potential of cohesionless soils, but there has been a shift toward a more equal balance between the empirical and analytical approaches. This is partly because we are just now realizing the significant influence that sample disturbance has on dynamic strength characteristics of cohesionless material. However, whichever method of analysis is used, the concepts outlined in the Seed, Lee, Idriss method (Seed et. al., 1973) are the current state of the art.

I would say that we have come a long way in evaluating the liquefaction potential of saturated clean fine sands; however, our ability to predict the liquefaction characteristics of silty sands or gravelly sands is deficient. This is partly due to our lack of understanding of the fundamentals of liquefaction and partly because of limitations in our ability to perform adequate laboratory tests.

From a practical point of view, we can analyze existing or imposed embankments and define conditions which are clearly safe and conditions which are clearly unsafe. Between these two limits lie many cases that fall into a grey area. In design, we can usually avoid these cases which fall into the grey areas. In analysis of existing structures, we are not so fortunate and our uncertainty will only be narrowed by further research and new full-scale response data.

Current seismic design methodology does not rigorously account for all cause-and-effect relationships. However, correction factors and compensating errors allow us to "predict" past performance and in this way numerical techniques have been calibrated. More case histories are needed to further develop and refine our current approaches, but our present understanding of the problems involved is vastly improved over the state of knowledge 15 years ago when interest in the problem was first generated in the geotechnical engineering field.

REFERENCES

Newmark, N.M. (1965). "Effects of Earthquakes on Dams and Embankments", Geotechnique, (15), 2, pp. 139-160.

Seed, H. Bolton (1969) "Considerations in the Earthquake-Resistant Design of Earth and Rock-Fill Dams", Geotechnique, (29), 3, pp. 215-263.

Seed, H.B., Lee, K.L., Idriss, I.M., and Makdisi, F. (1973). "Analysis of the Slides in the San Fernando Dams During the Earthquake of February 9, 1971", Report No. EERC-73-2, Earthquake Engineering Research Center, University of California, Berkeley.