EXPERIMENTAL AND ANALYTICAL INVESTIGATIONS IN NONLINEAR DYNAMIC SOIL-STRUCTURE INTERACTION

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SUMMARY

Soil compliance effects on the earthquake response of nuclear power containment structures and internal equipment are a significant aspect of nuclear facility design. An analytical and experimental research program to investigate *nonlinear* soil-structure interaction effects on nuclear power plants has been initiated by the Electric Power Research Institute. The primary objectives of this research program include:

- demonstration of the significance nonlinear soil-structure interaction effects on the seismic response of nuclear power plants; and,
- development of experimentally validated analytical options for realistically incorporating nonlinear effects in seismic design of nuclear power facilities.

The research program is ongoing and significant analytical results should be available by February 1977; high level multiple cycle explosive test data and comparison to nonlinear analytical predictions will be available June 1977 and will be presented at the Conference.

The primary motivations for the current research program are:

1. Currently popular methods for incorporating soil-structure interaction in seismic design appear to be very conservative—preliminary studies indicate that the realistic incorporation of soil nonlinear characteristics can reduce in-structure response spectra by factors of two or more below conventional (linear) predictions.
2. Realistic nonlinear methods for treating the nonlinear characteristics of soils may permit the derivation of more realistic site response spectra than those resulting from current regulatory procedures. It is anticipated that generally lowered design spectra will result for a specific site input.
3. Studies in wave propagation and scattering in an elastic media indicates that such phenomena can significantly reduce in-structure response spectra for such large structures as nuclear containment buildings; an experimentally validated numerical procedure for incorporating nonlinear properties in wave propagation in soil may lead to further reductions in equipment dynamic loads.

Objectives include:

- to demonstrate, by experiment and analysis, the significance of nonlinear soil-structure interaction effects on the seismic response of nuclear power systems;
- to obtain high soil strain dynamic soil-structure interaction data for structures and embedments typical of nuclear containment structures;
- to develop fundamentally correct soil constitutive formulations for incorporating soil nonlinear effects in predictive techniques;
- to demonstrate the capability of predicting the salient features of high strain soil-structure interaction;
- to evaluate existing techniques and near-term methods for determining *in situ* the high strain properties of soils; and,
- to develop an experimentally validated procedure for incorporating nonlinear soil-structure interaction in the seismic design of nuclear power facilities.

Realistic treatment of nonlinear soil characteristics may be expected to suppress in-structure response spectra by factors of two or more, depending upon soil and structure characteristics. Reductions in equipment loading are of great significance to future facilities, and perhaps of even greater importance for existing nuclear power plants subject to new seismic design criteria. An experimentally validated method for demonstrating the seismic design margins existing for any given installation (arising from nonlinear interaction effects) could be decisive in the obviating downtime losses and construction costs involved in a retrofit to increased seismic criteria.