I -677 A STUDY OF SOIL-STRUCTURE INTERACTION OF A MODEL STRUCTURE IN HUALIEN, TAIWAN

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INTRODUCTION: To observe soil-structure interaction effects, a 1/4 scale nuclear reactor containment model has been constructed in Hualien, Taiwan in an active seismic zone on stiff soil [1]. The Hualien Large-Scale Seismic Test (HLSST) program is a continuation of the Lotung Large-Scale Seismic Experiment, which has been carried out on soft soil site [2]. The properties of the soil around and beneath the structure have been systematically investigated by in-situ tests which comprise borings, large penetration tests and PS-loggings [4] and laboratory tests which include triaxial tests on frozen undisturbed samples. The present analysis is based on the unified ground model proposed by CRIEPI [4]. Two forced vibration tests of the Hualien model were conducted: in October, 1992 before backfill (FVT-1) and in February, 1993 after backfill (FVT-2). Results of blind prediction and correlation of FVT-1 have already been publicized. (e.g. [5], [6]). This paper presents results from analysis of FVT-2, microtremor observations and earthquake response analysis.

ORIENTATION ERRORS OF THE SEISMOMETERS: The orientation of the accelerometers in the Hualien LSST site was verified using the maximum cross-correlation method [7] using currently available data from three earthquakes, recorded in 1994 (Events 940120, 940530, 940605). The orientation angles of the accelerometers in the backfill and on the structure displayed significant scattering, probably because of the structural response and its feedback on the backfill motion. For this reason, only the orientation errors of the free field accelerometers were determined conclusively.

MICROTREMOR OBSERVATIONS: Microtremors of the structure and the surrounding soil were recorded in October 1994, using simultaneously 8 velocity-type pickups. As a very large peak, apparently due to signal or noise with unknown origin, appeared at frequency 1.5 Hz in the Fourier spectra of all the records, the data were filtered with a band-pass cosine-type filter from 2.0 to 25.0 Hz.

EARTHQUAKE RESPONSE ANALYSIS: Earthquake response analysis for Event 940120 (peak ground acceleration 43 Gal) was performed. The simulation was carried out using a sway-rocking model, according to the methodology described in [8]. The parameters of this model were initially correlated with the results of FVT-2. Figure 1 presents transfer functions between the free field and the top of the structure in the NS-direction. It can be seen, that the predominant frequency of the system as determined from microtremor is around 6.1-6.3 Hz and agrees well with the one, determined by the analysis of FVT-2. This shows, that microtremor observations can be successfully used instead of FVT to study characteristics of low-amplitude vibrations. During earthquakes, there is a weakening of the soil support due to nonlinear effects and possible separation of the soil from the structure. This leads to alterations of the parameters of the soil-structure sys-

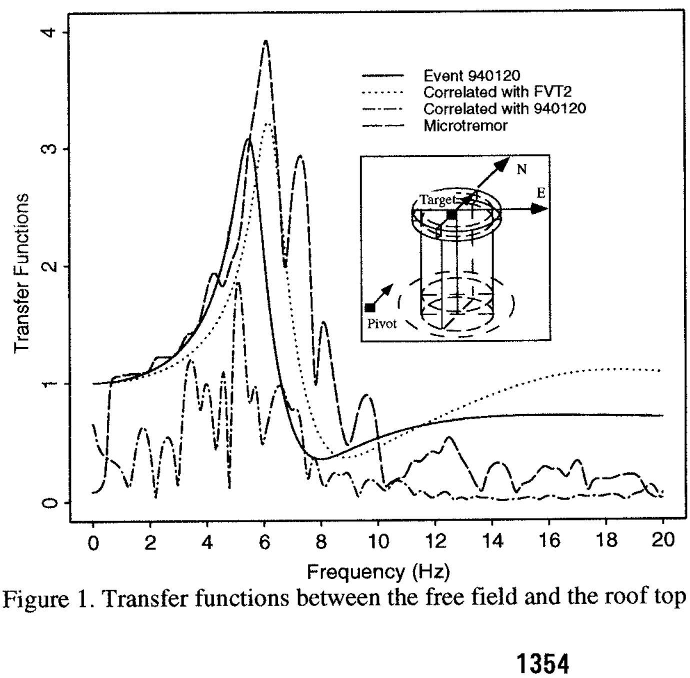

Figure 1. Transfer functions between the free field and the roof top

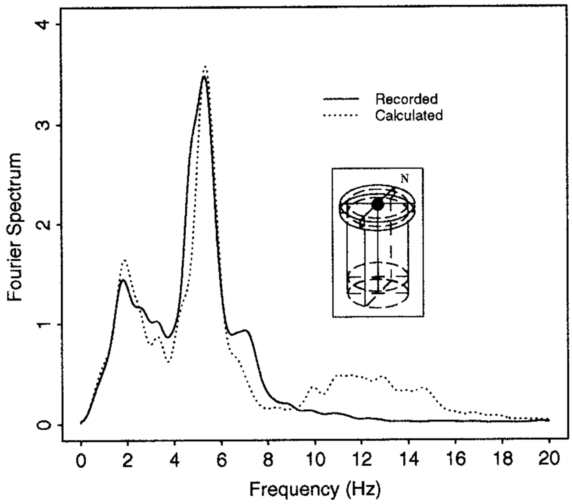

Figure 2. Fourier spectra of response at the roof top

tem. The predominant frequency determined by analysis of earthquake Event 940120 is about 5.6 Hz, 18% less than the one for low-amplitude vibrations. Considering this, the sway and rocking spring and dashpot coefficients were adjusted to fit the recorded response by the trial and error procedure, described in [8]. In Figure 1, the calculated transfer function appears to overestimate the response. The reason is that the transfer function, evaluated from earthquake data, drops around the predominant frequency, due to the low coherence between the records, as shown in [9]. At the same time, the model, being a linear system, has a high coherence between input and output. The actual good agreement between the Fourier spectra of the recorded and simulated response at the top of the structure can be seen in Figure 2. Comparing the model parameters used to simulate FVT-2. and Event 940120, it was determined that during the earthquake, the rocking spring coefficient decreased by 19%, the sway spring coefficient decreased by 52%, the rocking dashpot coefficient decreased by 25% and the sway dashpot coefficient decreased by 78%. This represents a significant weakening of the soil support, even though the soil and the backfill are quite stiff.

CONCLUSIONS: The dynamic behavior of a nuclear reactor containment model in Hualien, Taiwan was investigated, using data from forced vibration tests (FVT), microtremor observations and earthquake records. Microtremor analysis was proven sufficiently precise to understand the behavior of a soil-structure system subjected to small amplitude vibrations. Compared with the forced vibration tests, microtremor observations have the advantage of being easy and inexpensive to perform. Also, from a theoretical point of view, microtremor is very close to earthquake excitation, permits the same type of analysis and allows an easy comparison. The response of the soil-structure system to FVT and earthquakes was simulated, using a linear sway-rocking model. The influence of the interaction phenomena on the soil parameters was determined by a comparative study of actual and calculated structural response. It was found, that although the soil is rather stiff, even during a relatively small earthquake there is a significant weakening of the soil support due to nonlinear effects and probable separation of the soil from the structure.

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