CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Earthquake Induced Ground Motions
ASCE Continuing Education Seminar
06002.01.011.399

DATE/PLACE: September 25–26, 2003
Sacramento, California

AUTHORS: Sarah Gonzalez

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PERSONS PRESENT:

The seminar was attended by 28 engineers and geoscientists.

BACKGROUND AND PURPOSE OF TRIP:

The purpose of the seminar was to provide participants with a better knowledge of the characteristics of earthquake ground motions and their effects on soil deposits and structures. The lecturer was Dr. Praveen K. Malhotra, a Senior Research Scientist with FM Global Research in Norwood, Massachusetts.

SUMMARY OF PERTINENT POINTS:

The seminar was divided into eight sessions. A brief summary of the main topics discussed in each session is provided below. A copy of the course manual is available by request from Sarah Gonzalez.

Session 1: Basic Geology and Seismology

A brief description of the structure of the earth, plate tectonics, and types of faulting was provided along with a description of types of seismic waves and their measurement.

Session 2: Characteristics of Ground Motions

Earthquake strong-ground-motion records may be characterized in terms of amplitude, frequency distribution, and duration of shaking. The frequency distribution of a particular ground motion record is shown from the Fourier amplitude spectrum. However, the amplitude parameters PGA (peak ground acceleration), PGV (peak ground velocity), and PGD (peak ground displacement), also provide information about the respective high, medium, and low frequency content of a particular ground motion time history. The duration of the strong motion, or significant duration, may be determined from the acceleration time series.

Session 3: Response Spectrum

The response of structures and soils to a particular ground motion may be approximated by one or more single-degree-of-freedom (SDOF) systems. The response spectrum is a plot of the peak response of an SDOF system to ground acceleration, as a function of the system's natural period. The response spectrum is an important means of quantifying the response of a structure or soil, with known period and damping, to a particular ground motion.

Session 4: Ground Motion Prediction Relationships

Ground motion amplitude parameters (PGA, PGV, and PGD), spectral values and significant duration depend on site to source distance and earthquake magnitude. Attenuation relationships for both soil and rock sites are developed by regression analysis of recorded strong-motion data, as functions of distance, magnitude, and type of faulting. These relationships are then used to estimate future levels of ground motions at sites of interest. Examples of attenuation relationships for the Western, Central, and Eastern United States and Hawaii were provided.

Session 5: Site-Specific Response Spectrum

In order to establish a site-specific response spectrum it is necessary to conduct a seismic hazard analysis (SHA). The SHA can be either deterministic (DSHA) or probabilistic (PSHA). A DSHA considers a suite of scenario earthquakes (from various nearby potential sources) and utilizes attenuation relationships to compute response spectra. In comparison, a PSHA takes into account the combined probability of certain PGA values being exceeded by these potential sources. A uniform hazard response spectrum is comprised of spectral values at all periods having the same probability of being exceeded. The advantages and disadvantages of both methodologies were also discussed in this session.

Session 6: Site-Specific Ground Motions

In order to perform dynamic analysis of structures and of soil deposits, time histories are required. Time histories may be developed from existing earthquake recordings. These time histories are then scaled to the site-specific spectrum (target response spectrum) and bracketed duration. Alternatively, time histories may be generated synthetically to match the target spectrum.

Session 7: Effects of Local Geology on Ground Motions

The local geology (soil deposit) can affect the amplitude, duration, and frequency-distribution of the ground motion. For example, impedance effects may result in an increase in amplitude of ground motion when seismic waves travel from bedrock to soil. Also, resonance effects may result in the amplification of certain frequencies. Ground motion amplitudes may be reduced by viscous damping effects (soil damping). The transfer function shows how various frequencies in bedrock motion are affected by the soil deposit. Computer programs such as SHAKE determine the transfer function numerically and perform a frequency domain analysis.

Session 8: Near-Field Effects and Soil-Structure Interaction

Ground motions experienced at sites located close to ruptured faults may be significantly enhanced due to near-field effects. Near-field "fling" and directivity effects, and how they influence the amplitude, frequency, and duration of ground motion were discussed in this session.

The motion experienced by the foundation of a structure will be different from the free-field motion, which is the motion of the ground surface in the absence of the structure, due to soil-structure interaction. The damping of a soil-structure changes due to radiation effects and nonlinear soil behavior (hysteretic effects).

IMPRESSIONS/CONCLUSIONS:

The seminar was very comprehensive, covering a large number of relevant topics in two days. Because of the limited amount of time available, some of the topics were not discussed in great detail. However, a very useful list of references was provided in the course manual for further research.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None

SIGNATURES:

Sarah Gonzalez — 10/27/03
Research Scientist
Date

CONCURRENCE:

H. Lawrence McKague — 10/27/03
H. Lawrence McKague, Manager
Geology and Geophysics
Date

10/27/2003
Budhi Sagar
Technical Director
Date