04 Apr 1995, 2:35 pm - 3:00 pm

General Report— Session VII: Soil Amplification During Earthquakes and Microzonation

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Proceedings: Third International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics
April 2-7, 1995; Volume III, St. Louis, Missouri

General Report - Session VII
Soil Amplification During Earthquakes and Microzonation

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CLASSIFICATION OF PAPERS

There are two ways to classify the thirteen papers received for this session either by general topic areas or by identifying if the paper is related to a case study or methodology or both. In most cases, there is no clear line between the paper concerned with a specific methodology or a specific case study. Therefore, in reporting the papers, no particular classification is followed. Short report of the papers are presented in the order they appear in the proceedings.

Classification of Papers			
I		II	
Topic	No	Topic	No
Microzonation	5	Case Study	5
Amplification	5	Methodology	5
Methodology	3	Mixed	3

SUMMARY OF PAPERS

Chavez-Garcia, Cuenca, Lermo and Mijares propose (paper 7.01) a zoning map for the City of Pueblo, located 110 km to the south-east of Mexico City. It is noted from historical data dating as far back as 1523 that Pueblo has suffered from several destructive earthquakes and that the population of the city is growing at a fast rate; thus, the need for microzonation maps to reduce earthquake hazard risks since the city is expected to be affected by large earthquakes. In preparing the map, they used geological data as well as ground motions due to microtremors, weak and strong earthquakes. Nakamura's technique (Nakamura, 1989), which is used to compute spectral ratios based on horizontal to vertical motions at one site thus eliminating the necessity for a reference (firm soil or rock) site, has been applied to microtremor measurements from 39 sites within Pueblo to determine dominant site resonant periods. The authors used the same technique on limited strong-motion data obtained from four stations, none on firm ground. They report good agreement between site periods identified from strong-motion recordings and microtremors. In addition, they report recording weak motion data on both soft and firm sites and calculating the standard spectral ratio as well as utilizing Nakamura's technique and good correlation of the results. Detailed information on damage distribution during two events is available (1973 and 1985 events at 90 km and 400 km epicentral distances respectively) and have been used along with geologic data; however, this does not necessarily provide complete insight on the zoning of the city. Therefore, the preliminary map presented is based on dividing the city into four different zones each with specific geology and corresponding dominant site period determined from the various types of motions described.

Bard and Wirgin (paper 7.04) present results of numerical investigations on long-duration effects of soil-structure interaction for buildings on soft soils. Two dimensional models of regular buildings resting on a single, horizontal soft layer overlying stiffer half-space impinged by SH waves are studied. Solutions with varying parameters such as layer thickness and frequency, building size and spacing between buildings show that, wave diffraction related with soil-structure interaction alter the "free-field" surface motion up to a distance of 1 km. In built-up environments, such as Mexico City, presence of tall buildings could affect the distribution, amplitude and duration of ground motion up to significant distances from the location of the buildings considered. Specific examples of this effect have been recently pointed out by Çelebi (1994) who showed that there is significant coherency at structural frequencies between recorded motions of some buildings and their associated free-field sites. In another paper submitted to this conference, Çelebi (1995) summarizes recommendations to implement an experiment to study such effects. The issue raised by Bard is an important one considering the numerous number of tall buildings in many urban areas affected by active seismicity.

Bicker and colleagues present (paper 7.06) a site-specific geologic and seismic hazard zoning map for a college campus in Eureka, California. A 1 km wide thrust fault system passes through the site. Criteria for establishing risk zones are presented. The basic data used include geotechnical borings, fault studies including fault paleo seismic investigations and geophysical survey. Using geotechnical boring logs, simplified profiles of soil type have been developed to evaluate potential responses to settlement, liquefaction and lateral spreading. The profiles have also been used along with potential acceleration and duration of strong ground motion to determine the seismic risk. For each identifiable zone, and response potential, an effect has been assigned (e.g. liquefaction) and a surface cause has been described. Based on such zones, risks are described as "very high" implying site that is not buildable within 50' of fault trace, "high risk" implying site buildable based on futher investigations and "low to moderate" implying site requiring further geotechnical investigations. How potential acceleration and duration of strong motions, mentioned in the paper, are determined and used to determine the risk are not explained.

Use of microseisms to predict soil amplification is revisited by Ferrito (paper 7.09) who describes how system identification techniques can be used to define or calibrate a range of site parameters using microseisms or other site related data as input. Ferrito states that a relationship can be established such that the spectral ratio amplification is inversely proportional to the peak rock velocity. Ferrito provides several case studies to support these approaches.

Zhang and Papageorgiou present a two-dimensional model (paper 7.10) of the Marina district in San Francisco, Ca using a combination of finite element and boundary integral equation methods. They conclude that basin reflection plays an important role in amplifying the motions in Marina district. They state that although the problem is essentially a 3-D problem; nonetheless, they report good comparison between predicted and observed strong-motions.

Ansary, Fuse, Yamazaki and Katayama report (paper 7.12) of stable frequency bands on studies of short period recordings up to 1 seconds at five sites in the Tokyo Metropolitan area of Japan where soil structures are known. The recordings have been made for 2 minute durations every hour for 24 hour period. They found in most cases the period corresponding to the peak of the amplitude ratio of the microtremors corresponding well with the periods calculated from the peak of the amplitude ratio of Rayleigh-wave and transfer function of S-wave. They conclude that in the short-period microtremors, the Rayleigh-wave is thought to be predominant without a general conclusion as to whether microtremors are composed of Rayleigh waves or body waves.

Karkee and Sugimura present a methodology (paper 7.14) to characterize different levels of incident motions with an application at the site of and array in Sendai, Japan. The study is necessitated due to the particular soil types in urban areas of Japan that exhibits stiffness degradation at comparatively low strain levels. Therefore, the long period components of the motions are accepted to play an important role in the non-linear response of such degrading soils. Small motions recorded at one of the Sendai dense array sites during earthquakes are used to characterize the incident wave motion for three levels of excitation (frequent, medium and extreme) by applying Green's function method. Nonlinear response analysis for the designated three levels of motion enveloped by an estimated incident motion response spectra in the period range of 0.02-10.0 are performed for known soil profiles of the array sites. A parameter, SIA (Spectrum Intensity Amplification) is defined and used to represent local shaking hazard to structures (represented by period bands) at each site. For a given spectral damping, SIA, is representative of the ratio of energy in the surface response motion to that in the incident motion within a period band between T1 and T2. For different levels of excitation and for three period bands, 0.2-0.5, 1.0-1.5 and 2.5-3.5, SIA have been calculated for Sendai. Microzonation plots based on this methodology shows for each cell in a gridwork, assigned SIA within four ranges (<1, 1-1.5, 1.5-2 and >2). For wooden structures, with periods ranging between 0.2-0.5 seconds, microzonation maps based on SIA are reported to correspond well with damage distribution of such structures during the 1978 Miyoki Oki earthquake.

Husein (Malkawi), Liang and Nusier present seismic hazard maps (paper 7.16) for Jordan and conterminous areas using probabilistic methods applied to historical data from updated earthquake catalogues. Several seismic sources have been identified. The attenuation relationship presented by Esteva in 1974 have been found to be suitable to determine peak ground acceleration on bed rock chosen as the measure of the ground motion severity. The seismic hazard maps developed are for 90 % probability of not being exceeded for three different assumed life of structures. It is mentioned that the major hazard level in the area is due to the Dead Sea fault for which the computed PGA for 50 year life period of structures in the range of 0.30-0.34 g.

Hosseini has investigated the potential for amplification (paper 7.17) of motions in a generally alluvial area of Tehran, Iran for which geoseismic and geotechnical data are available. The maximum depth to bedrock of the soil layers is 35 m only and based on this study, he concludes that the density of soil layers on the bedrock has no effect on the dominant period of the site but decreases the amplitude of amplification. The paper is a study based on varying the parameters to identify their effect on site frequency and amplitude of amplification.

Sully, Morales, Gajardo, Murria and Saab present (paper 7.20) the methodology for and results of seismic zonation applied for evaluaion and remediation of a 7-km long linear coastal earth structure important for an area of significant economical development in Venezuela. The possible dynamic response variations due to localized subsoil variations have been identified. Additional requisite studies including permanent seismic and strong motion network in the area as well as systematic effort to characterize the site conditions promises to yield data during future events to correlate and improve the current effort.

Loukakis and Bielak visit the subject (paper 7.21) related to seismic response of two-dimensional valleys. Earthquake response of shallow sediment filled valleys are analyzed by finite element method which facilitates the study of effects of layering and geometry. A simple half cycle SV pulse excites the layered media and the horizontal and vertical displacements are found to be significantly affected by valley geometry. Edges of valley are found to play an important role in propogating surface waves into the basins and increasing the responses. The layering influences amplification and duration of the responses.

Tokimatsu and Arai use array observations (paper 7.22) of short period microtremors to estimate the local site conditions in Kushiro City, Japan. Microtremor measurements are made using an array of sensors at two strong-motion stations each located on a different soil profile. Frequency-wave number (F-k) spectra are presented. These are used to develop dispersion curves of Rayleigh waves; and, in turn, V_s profiles down to a depth of 300 m have been estimated. Based on these, shear wave amplification ratio between the two sites computed from the estimated profiles shows good agreement with that observed during an earthquake. The final conclusive statement is that observed microseisms are promising to effectively estimate the influence of subsurface soil conditions on surface ground motions.

The role of rotational shear in site response analysis is studied by Li and Shen (paper 7.24). They point out that, in laboratory tests, change in the direction of shear forces (stresses) has significant impact on the increase in rate of pore pressure. In the field conditions; however, the authors point out that the impact of rotational shear on site response problem may not be as significant as previously thought.

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