BASIC REQUIREMENTS FOR MICROZONATION

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SUMMARY

In this paper the authors briefly summarize the main geologic, seismologic, and geotechnical parameters that enter into microzonation considerations of an area. A short remark is also made regarding financial incentives for microzonation.

INTRODUCTION

Microzonation involves the determination of geologic, seismologic, and geotechnical properties of a site and the incorporation of these site characteristics in the design and construction of earthquake-resistant structures to reduce damage to human life and property resulting from earthquakes in seismically active regions.

The above relevant site properties should be incorporated in a microzonation map to aid the design engineer in assessing the damage potential of existing as well as anticipated future structures in the region. Microzonation maps are not intended to provide design information for important structures such as hospitals, school buildings, dams, nuclear reactors, and the like. These important structures deserve and should have in-depth site-specific studies.

DEFINITIONS AND BASIC CONSIDERATIONS

Geologic and Seismologic Considerations for Microzonation

One of the most important geologic considerations relates to mapping and locating seismic faults within a radius of approximately 50 miles from the outer boundaries of the region in question. Since the type of faulting and its distance from the site affects the seismically induced acceleration and velocity levels at the site, these fault-line features should be clearly identified as to whether they are of the strike slip, normal slip, or reverse slip type.

Other important information needed for microzonation includes the occurrence rate and spatial distribution of earthquakes, together with their magnitudes, during the entire seismic history of the site. This information is especially relevant because it enables the engineer to intelligently choose the design earthquake for the structures to be built at the site. Equally important concerns of seismicity relate to undertaking seismic field studies. This latter activity should preferably involve detonating explosive charges (whenever feasible) and recording the seismic signals generated over a base rock and over soil deposits at

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selected critical locations at the site. To conduct such field experiments one needs two sets of three-component seismometers, one set to remain as a base station on a nearby rock outcrop, the other to serve as a portable station to be moved from one locality to another within the candidate region. The seismic data generated by the explosion should be recorded on either digital or analog magnetic tapes at exactly the same time at both the base and the portable stations.

From this set of field data the following useful information can be ascertained:

1) Attenuation of seismic signals (both p and s waves) as a function of distance and as a function of explosive size.

2) The relative amplification of the soft ground with respect to the rock base and the predominant frequencies of the soft geologic deposit as a function of explosive-energy input. By varying the size of the explosives it should also be possible to learn about the nonlinearity of attenuation of seismic signals as well as of ground response.

The relative amplification of the soft ground could be obtained by dividing the resultant of the N-S, E-W, and vertical peak accelerations or velocities on the soft ground, by the resultant of the three-component peak signals at the base station. Alternatively, the ratio of the resultant of the peak Fourier spectral curves obtained over the soft soils and the rock can be used for amplification and predominant frequency distribution. This latter information can be summarized in tabular form as shown in Table I. This table shows that the given area has been divided into eight subregions in terms of their amplification and predominant frequency distribution. Based on the magnitude of the design earthquake and its distance from the site and the amplification factors associated with each subdivision, a design acceleration for each of the regions can be recommended as indicated in Table I.

GEOTECHNICAL CONSIDERATIONS

The most pertinent geotechnical parameters that enter into microzonation concerns are soil liquefaction, soil densification, loss of soil strength, and dynamic soil properties such as shear moduli and damping.

Soil Liquefaction

Sandy soil deposits that fall within certain grain-size-distribution ranges (Japan Society of Civil Engineers, 1973) and lie below the water table are most susceptible to liquefaction. In assessing soil liquefaction potential, however, the magnitude of the anticipated earthquake plays a very important role. A rigorous analytical procedure for determining soil liquefaction potential is given in Sherif et al. (1980). This method uses only the actual earthquake-induced shear stress-time history and two basic soil constants which are functions of volume-decrease potential ($e_{max} - e$).

The boundaries of liquefiable areas within the given region should be delineated for potential damage assessment as well as for land-use-planning purposes. It may be desirable to designate liquefiable areas within the area in question for parks and recreational purposes.

Loss of Soil Strength

Most cohesive soils lose a certain amount of their in-situ strength when subjected to dynamic excitation. If the region to be microzoned has hills and slopes composed of clayey soils, the strength loss of these soil deposits in these hilly parts should be studied. In assessing the stability of these slopes in the region, the post-dynamic-excitation strength of the soil should be used. The procedure for assessing loss of soil strength is outlined in Sherif and Wu (1971).

Dynamic Soil Properties

One of the important aspects of microzonation is the estimation of the dynamic forces to which structures may be subjected in the event of an earthquake of given magnitude in a region. The accurate estimation of these forces depends on the engineer's ability to predict the ground response as precisely as possible. The analytical procedures used in the estimation of ground response, however, rely heavily on the shear moduli and damping characteristics of soil deposits at the site. It is important, therefore, that these two soil parameters be determined for microzonation purposes.

The methods for calculating the ground response are discussed in Seed and Idriss (1969), and the procedures for estimating the shear moduli and damping of the soil are outlined in Sherif and Ishibashi (1976) and Sherif et al. (1977).

Regarding the densification characteristics of the soils, as yet there are no reliable procedures available for this purpose, and until such information is forthcoming, we suggest that the soils directly beneath foundations, slabs, and highways be compacted to a reasonable depth (from one to three feet) to increase the soil density above its critical void density.

Insurance and Building Cost Concerns

One of the inhibiting factors to microzonation is the fear of land and property owners that they will be financially penalized in terms of increased insurance premiums or by the imposition of rigid design requirements that will increase the cost of structures if they are determined to lie in seismically more damage-vulnerable areas. This of course is a legitimate concern and one that should be remedied before a viable and effective microzonation program can be implemented. One suggested solution is that the added insurance premium costs for existing buildings be absorbed by the government or by other public-interest-oriented agencies, and that the developers of new construction be compensated for their extra expenses in terms of future tax benefits.

TABLE I

Zone	Predominant Frequency in Hz	Amplification Factor	Recommended Average Design Acceleration Values (g)	No. of Building Stories (N)
I_1	$0.5<f<2.5$	$1.0<A<1.5$	0.12g	for all N
I_2	$0.5<f<2.5$	$1.5<A<3.0$	0.12g 0.17g 0.25g	for $N\geq16$ for $4\geq N$, $15\geq N\geq12$ for $11>N>5$
I_3	$0.5<f<2.5$	$3.0<A$	0.2g 0.35g	for $N\geq16$ for $N\leq15$
II_1	$2.5<f<5.5$	$1.0<A<1.5$	0.15g	for all N
II_2	$2.5<f<5.5$	$1.5<A<3.0$	0.28g	for all N
II_3	$2.5<f<5.5$	$3.0<A$	0.15g 0.20g 0.25g 0.35g	for $N\geq11$ for $10\geq N>5$ for $2>N$ for $5\geq N\geq2$
III_1	$5.5<f<8.0$	$1.5<A<3.0$	0.12g 0.2g 0.15g	for $N = 1$ for $10\geq N>1$ for $N\geq11$
III_2	$5.5<f<8.0$	$3.0<A$	0.25g 0.15g	for $N = 1$ for $N\geq2$

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