GLOSSARY

INTRODUCTION

The terms in this glossary are provided to facilitate communication on the scientific, technical, and policy issues of seismic zonation. Because seismic zonation is linked with the hazard, built, and policy environments, the terms are organized in these three categories. (See Attachment in Appendb(C).

<u>Seismic Zonation</u>-Seismic zonafion is the division of a geographic region into smaller areas or zones based on an integrated assessment of the hazard, built, and policy environments of the Nation, a region, or a community Seismic zonation maps, which can be constructed on scales ranging from national to urban, provide decisionmakers with a scientific and technical basis for selecting prevention, mitigation, and preparedness options to cope with the physical phenomena generated in an earthquake (i.e., ground shaking, ground failure, surface fault rupture, regional tectonic deformation, tsunami run up, and aftershocks). Seismic zonation contributes to risk reduction and sustainabiiffy of new development. Seismic zonation maps are the result of a process that integrates data, results of research and postearthquake Investigations, and experiences on the hazard, built, and policy environments. The maps are used to answer questions decisionmakers and end users are asking about their communities, such as:

- **Which part(s) of the geographic area under consideration is (are) safest for a single-family dwelling? A high-rise building? A government building? Commercial buildings? A school? A hospital? A dam? Short bridges? Long span bridges? Utility pipeline systems?** A port?

Which part(s) of the geographic area Is best for avoiding ground shaking above a certain threshold (such as 20 % of gravity, or 20 cm/sec, or 100 cm)? Soil amplification that enhances a particular period band of the ground motion (e.g., 0.2 second, 1.0 second, or 2.0 seconds)? Liquefaction? Lateral Spreads? Large volume landslides? Surface fault rupture? The "killer **pulse" generated by the fling of the fault? Source directivity? Regional uplift or subsidence? Tsunami wave run up?** Seich? **Aftershocks?**

- **Which part(s) of the geographic area is(are) most vulnerable in a damaging . earthqu_a_ke? Which element(s) at risk is (are) most vulnerable?**

HAZARD ENVIRONMENT

<u>Acceleration</u>-Acceleration is a force having the units of gravity that denotes the rate of change of the back and forth movement of the ground during an earthquake. Velocity (the rate of the ground motion at a given instant of time with units of cm/s) and displacement (the distance the ground has moved from it's rest position with units of cm) are derived from an accelerogram.

Accelerogram-The record or time history obtained from an instrument called an accelerometer showing acceleration of a point on the ground or a point in a building as a function of time. The peak acceleration, the largest value of acceleration on the record is typically used in design criteria. The velocity and displacement time histories and the response spectrum are derived analytically from the time history of acceleration.

Active Fault-A fault is active if it exhibits physical characteristics such as historic earthquake activity, surface fault rupture, geologically recent displacement of stratigraphy or topography, or physical association with another fault system judged to be active. When these characteristics are suspected or proven, it is classed as active and judged to be able to undergo movement. See Fault.

Attenuation-A decrease in the strength of seismic waves and seismic energy with distance from the point where the fault rupture originated. Also referred to as Seismic Wave Attenuation Function.

Duration-A description of the length of time between the onset and the departure of a natural hazard. Also, a measure of the length of time the ground motion exceeds a given threshold of shaking, such as 5 % of the force of gravity.

Earthquake Hazards-The physical effects generated in an earthquake (e.g., ground shaking, ground failure, surface fault rupture, regional tectonic deformation, tsunami run up, seiches, and aftershocks).

Epicenter-The point on the earth's surface vertically above the point where the fault rupture originated.

Exceedance Probability-The probability (for example, 10 %) that an earthquake will generate a level of ground motion that exceeds a specified reference level during a given exposure time.

Exposure Time-The period of tine (for example, 50 years) that a structure or a community is exposed to potential earthquake ground shaking, ground failure, and other earthquake hazards.

Fault-A fracture or a zone of fractures in the earth along which displacement of the two sides relative to one another has occurred as a consequence of compression, tension, or shearing stresses. A "blind fautt" is the term used to describe a fault system that is not visible at the surface of the ground and cn only be detected by using geophysical techniques such as drilling, seismic reflection profiles, gravity profiles, or magnetic profiles. A fault may rupture the ground surface during an earthquake, especially If the magnitude Is greater than M 5.5. The length of the fault is related to the maximum magnitude, with long faults able to generate larger-magnitude earthquakes than short faults. See Active Fault.

Focal Depth-The vertical distance between the point where the fault rupture originated and the earth's surface. See Epicenter.

Ground failure-A-term_referring to the permanent, Inelastic deformation of the soil and/or rock triggered by ground shaking. Landslides,_the most common and wide spread type of ground failure, consists of falls, topples, slides, spreads, and flows of soil and/or rock on unstable slopes. Liquefaction, which results in a temporary loss of bearing strength, occurs mainly In young, shallow, loosely compacted, water saturated sand and gravel deposits when subjected to ground shaking. Surface fault rupture occurs in some earthquakes when the fault breaks the surface. Reaional tectonic deformation,_changes in elevation over regional distances, Is a feature of earthquakes having magnitudes of 8 or greater. Tsunami run up results when the long period ocean waves generated by the sudden, Impulsive, vertical displacement of a submarine earthquake, reaches low lying areas along the coast. Seiches are standing waves induced in lakes and harbors by earthquake ground shaking. Aftershocks refer to the long, exponentially decaying, sequence of smaller earthquakes that follow a large-magnitude earthquake for months to years, exacerbating the damage.

Ground shaking-This term refers to the dynamic, elastic, vibratory movement of the ground in response to the arrival and propagation of the elastic P, S, Love, and Rayleigh seismic waves. Ground shaking is characterized In terms of amplitude, frequency composition, duration, and energy, and is indicated in terms of Modified Mercalli Intensf , ground acceleration, ground velocity, ground displacement, and spectral response. Ground shaking can be Increased by soil amplification, source directivitY, topography,_anonomalously shallow focal depths, surface fault rupture,_and the fling of the fault. The "killer pulse" is a longduration acceleration pulse that is generated close to the causative fault and is thought to be related to the fling of the fault as It ruptures. All structures are vulnerable at some level of amplitude, frequency, and duration of ground shaking.

Hazard-A potential threat to humans and their welfare.

Hazard Assessment- An estimate of the range of the threat (i.e., magnitude, frequency, duration, areal extent, speed of onset spatial dispersion, and temporal spacing) to humans and their welfare from natural and technological hazards.

Intens' -A numerical index denoted by Roman numerals from I to XII describing the physical effects of an earthquake on the earth's surface, man, or on structures built by man. These values are determined subjectively by individuals performing postearthquake investigations to determine the nature and spatial extent of the damage distribution, not by Instrumental readings. The most commonly used scales throughout the word are Modified Mercqlli Intensity (MMI), developed fn the 1930's by an Italian, and the MSK scale, developed in the 1960's by scientists in the former Soviet Union, which are essentially equivalent for intensities VII to X. Intensity VI denotes the threshold for potential ground failure such as liquefaction. Intensity VII denotes the threshold for architectural damage. Intensity VIII denotes the threshold for structural damage. Intensity IX denotes intense structural damage. Intensities X to XII denote various levels of total destruction. See MaAnitude.

Magnitude-A numerical quantity, devised by the late Professor Charles F. Richter in the 1930's and denoted by Arabic integers with one decimal place accuracy (for example 7.8) to characterize earthquakes in terms of the total energy released after adjusting for difference in epicentral distance and focal depth. Magnitude differs from intensity in that magnitude is determined on the basis of instrumental records; whereas, intensity is determined on the basis of subjective observations of the damage. Measured on a logarithmic scale, magnitude Is open ended theoretically, with the largest earthquake to date being the M 9.5 Chile earthquake of 1960. Moderate-magnitude earthquakes have magnitudes between 5.5 and 7.0; large-magnitude earthquakes have magnitudes between 7.0 and 8.0; and great earthquakes have magnitudes of 8.0 and greater. The - energy Increases exponentially with magnitude. For example, a magnitude 6.0 earthquake releases 31.5 times more energy than a magnitude 5 earthquake, but (31.5) (31.5) or approximately 1,000 times more energy than a magnitude 4 : earthquake.

Natural Hazard -A potential threat to humans and their welfare caused by rapid and slow onset events having atmospheric, geologic, and hydrologic origins on solar, global, regional, national, and local scales (e.g., floods, severe storms, earthquakes, landslides, volcanic eruptions, wild fires, tsunamis, droughts, winter storms, coastal erosion, and space weather).

Response Spectrum-The response spectrum is a graph of the output of a mathematical model which shows how an idealized ensemble of lightly damped simple harmonic vibrating buildings respond to a particular ground motion accelerogram. The accelerogram Is used to excite them into vibration in the 0,05-10 seconds period range, the range of Interest to engineers. The concept of the response spectrum is used in building codes and the design of essential and critical structures.

Seismodenic Structure-A geologic structure such as an igneous pluton dike, or sill that has earthquake activity associated with it.

Soil Ampllficaflon-Solls have a perlod-dependent effect on the ground motion, increasing the level of shaking for certain periods of vibration and decreasing It for others as a function of the "softness" and thickness of the soil relative to the underlying rock and the three-dimensional properties of the sofi/rock column.

Soil/Structure Resonance-A physical phenomenon Increasing the potential for destructiveness that results when the input seismic waves causes the underlying soil and the structure to resonate, or vibrate at the same period.

Source Drectivity A phenomenon that increases ground shaking at a site. It results from the directional aspects of the fault rupture that cause most of the energy to be released in a particular direction instead of in all directions,

Surface Fault Rupture-A phenomenon that increases ground shaking at a site. Refers to the physical phenomenon of the rupturing fault breaking the surface of the ground, instead of stopping beneath the ground surface, and releasing more energy on the side of the fault that (s moving than on the stationary block.

BUILT **ENVIRONMENT**

Earthquake Resilient Buildings-Buildings that are sited, designed and constructed in such a way that they are able to resist the ground shaking from largemagnitude earthquakes without collapsing and from moderate-magnitude earthquakes without significant loss of function and with damage that is repairable.

Elements at Risk-People, ecosystems, natural resources, the environment, buildings and infrastructure, essential facilities, and critical facilities that are voluntarily or involuntarily exposed to natural and technological hazards.

Infrastructure-These_structures and facilities provide the essential functions of supply, disposal, communication, and transportation in a community. They are also called Community Lifelines.

Risk-The probability of loss to the elements at risk as the result of the occurrence, physical and societal consequences of a natural or technological hazard, and the mitigation and preparedness measures in place In the community.

Risk Assessment-A_risk assessment Is an objective scientific assessment of the chance of loss or adverse consequences when physical and social elements are exposed to potentially harmful natural and technological hazards. The endpoints or consequences depend on the hazard and include: damage, loss of economic value, loss of function, loss of natural resources, loss of ecological systems, environmental impact, deterioration of health, mortality, and morbidity. Risk assessments Integrate hazard assessments with the vulnerability of the exposed elements at risk to seek reliable answers to the following questions:

1. What can happen?

2. How likely are each of the possible outcomes?

3. When the possible outcomes happen, what are the likely consequences and losses?

Loss – A range of adverse consequences impacting communities and individuals (e.g. damage, loss of economic value, loss of function, loss of natural resources, loss of ecologlcal system, environment impact, health deterioration, mortality, morbidity).

Technological Hazard-A potential threat to humans and their welfare caused by technological factors (e.g., chemical release, nuclear accident, dam failure). Earthquakes and other natural hazards can trigger technological hazards.

VulnerabilitY-The_potential loss in value of each element at risk from the occurrence and consequences of natural and technological hazards. The factors that influehce vulnerability include: demographics, the age and resilience of the built environment, technology, social differentiation and diversity, regional and global economies, and political arrangements. Vulnerability is a result of flaws in planning, siting, design, and construction.

POLICY ENVIRONMENT

Acceptable Risk-The probability of occurrences of physical, social, or economic consequences of an earthquake that is considered by authorities to be sufficiently low in comparison with the risks from other natural or technological hazards that these occurrences are accepted as realistic reference points for determining design requirements for structures, or for taking social, political, legal, and economic actions In the community to protect people and property. See Risk.

Disaster-hazardous event which adversely affects a community to such a degree that essential social structures and functions are disrupted. Disasters represent policy failures.

Public Policies-Public policies are designed to manage the potential risk from being exposed to one or more of the earthquake hazards. The policy options encompass: a) stop Increasing the risk to elements that will be exposed in the future to natural and technological hazards, and b) start decreasing the risk to existing elements already at risk from natural and technological hazards. They Include: Mitigation- A range of policies, legislative mandates, professional - practices, and social adjustments that are designed to reduce or minimize the effects of earthquakes and other natural hazards on a community. Mitigation measures implemented over the last 20 years have included: 1) land use planning and management, 2 engineering codes, standards and practices, 3) control and protection works, 4) prediction, forecasts, warning, and planning, 5) recovery, reconstruction, and planning, and 6) Insurance. Preparedness refers to a range of policies, legislative mandates, professional pract(ces, and social adjustments that are used by Individuals, businesses, organizations, communities, and Nations to plan for emergency response, recovery, and reconstruction .after a damaging earthquake.

Risk Management-The public process of deciding what to do when risk assessments Indicate that risk, or the chance of loss, exists. Risk management encompasses choices and actions for communities and individuals (i.e., prevention, mfffaatlon, preparedness which are designed to: a) stop increasing the risk to future elements that will be placed at risk to natural and technological hazards, b) start decreasing the risk to existing elements already at risk, and c) continue planning ways to respond to and recover from the inevitable natural and technological hazard, including the imponderable extreme situation or catastrophic event.