# A PROPOSAL FOR

# SITE RESPONSE EFFECT AND MICROZONATION

# مشروع مقترح لدراسة

# التمنطق الزلزالي الدقيق وتأثير استجابة الموقع

# Summary


It is well known that the ground shaking site effect caused by an earthquake can vary significantly within a small distance. This is because at sites having soft soil or having undulations, seismic energy gets trapped, leading to amplification of vibrations that may increase damage to manmade structures. Theoretical analysis and observational data have shown that each site has a specific resonance frequency at which ground motion gets amplified (***Bard, 2000***). Man-made structures having resonance frequency matching that of the site have the maximum likelihood of getting damaged. Here, in order to construct seismically safe structures, it is important to know the site response of a particular location. It is important to note that such resonance and amplification of ground motion is not observed on relatively flat sites where hard rock is exposed.

Since damage from an earthquake may vary even within a few tens of meters because of variation in the local site conditions such as thickness of the soil layer, type of soil and variation in elevation, it is necessary to carry out seismic microzonation. Damage due to ground shaking site effects are caused by amplification of ground motion at certain frequencies. The level of amplification and the frequencies at which such amplification occurs are called site response parameters. One of the ways of carrying out seismic microzonation is to estimate the site response parameters at a number of closely spaced sites in the area under investigation. Consequently, the main objectives are:

1) Estimation of the fundamental frequency and the corresponding amplification factor throughout acquiring and analyzing of microtremor (ambient noise) data.
2) Differentiation of surface soil pattern from the calculation of shear wave profile to 30 meters depth ($V_{s\,(30)}$).
3) Assessment of seismic hazard level for the area.
4) Dividing the area into small zones depending on the surface soil distributions and local site response parameters.
5) Conducting seismic microzonation maps for new the buildings design.

# Methodology

There are three major components of seismic hazard assessment and risk mitigation: (1) assessment of seismic hazard, (2) assessment of seismic risk and losses, and (3) development of loss reduction strategies. Assessment of seismic hazard involves determining the expected level of shaking by accounting for seismic sources in the region, past history of earthquakes, and local soil characteristics. Assessment of seismic losses is accomplished by incorporating structural inventory and the associated fragility relationships (i.e., ground shaking versus level of damage curves) into seismic hazard. Loss reduction strategies include retrofit, demolition, land use planning, monitoring systems, training, and education. Ultimate products of a seismic hazard study are a series of digital GIS maps (i.e., seismic hazard maps, site amplification maps, microzonation maps, structural inventory maps, structural damage maps, and loss estimation maps), and a software package to manipulate and modify the maps to assess seismic hazard and risk. Figure 1 gives a flow chart, which summarizes the steps in seismic hazard assessment and risk reduction. Seismic hazard assessment and risk mitigation includes (3) components:

1. Probabilistic seismic hazard maps
2. Deterministic seismic hazard maps
3. Site amplification and microzonation maps

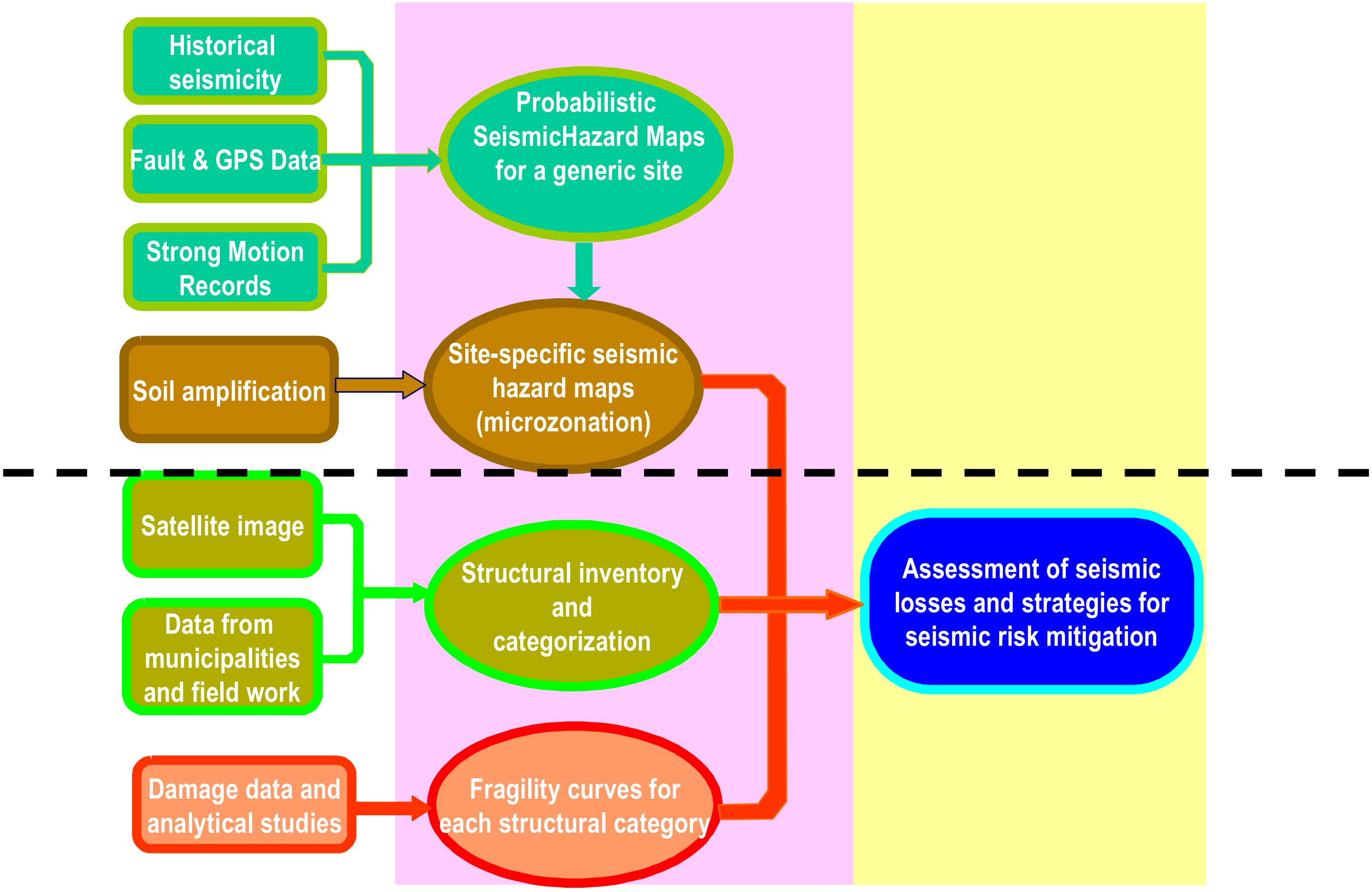


FIGURE 1- Components of seismic hazard assessment and risk reduction.

# Assessment of Seismic Hazard

Assessment of seismic hazard involves development of tools and techniques to predict the intensity of ground shaking for likely earthquakes in the region. In any proposed study , an accurate probabilistic seismic hazard maps, will be developed using the USGS (United States Geological Survey) methodology, which is used to develop official seismic hazard maps for the United States. The detail is presented below.

The probabilistic assessment of seismic hazard involves calculation of the expected value of ground shaking for a specified probability of exceedance within a specified time period (e.g., peak ground acceleration that has a 10-perecent probability of being exceeded within the next 50 years). Figure 2 presents schematically the steps of probabilistic hazard assessment. To calculate seismic hazard, we will utilize the methodology recently developed by the USGS (Frankel, et al., 1996). This methodology has been reviewed extensively by the scientific and the users communities in several workshops convened by the USGS, the Building Seismic Safety Council, and the Applied Technology Council in the United States. The seismic hazard and design maps that resulted from this methodology have now officially been published by FEMA as National Earthquake Hazard Reduction Program Recommended Provisions for Seismic Regulations for New Buildings in the United States (FEMA, 1997). The USGS methodology for the probabilistic assessment of seismic hazard includes the following steps:

1. Produce comprehensive earthquake catalogue with uniform magnitude scale.
2. Produce database of active faults with slip rates, estimated recurrence times, and estimated maximum magnitudes.
3. Assess appropriate attenuation relations for ground motions as a function
4. Integrate (1)-(3) into probabilistic calculation of seismic hazard curves with uncertainties.

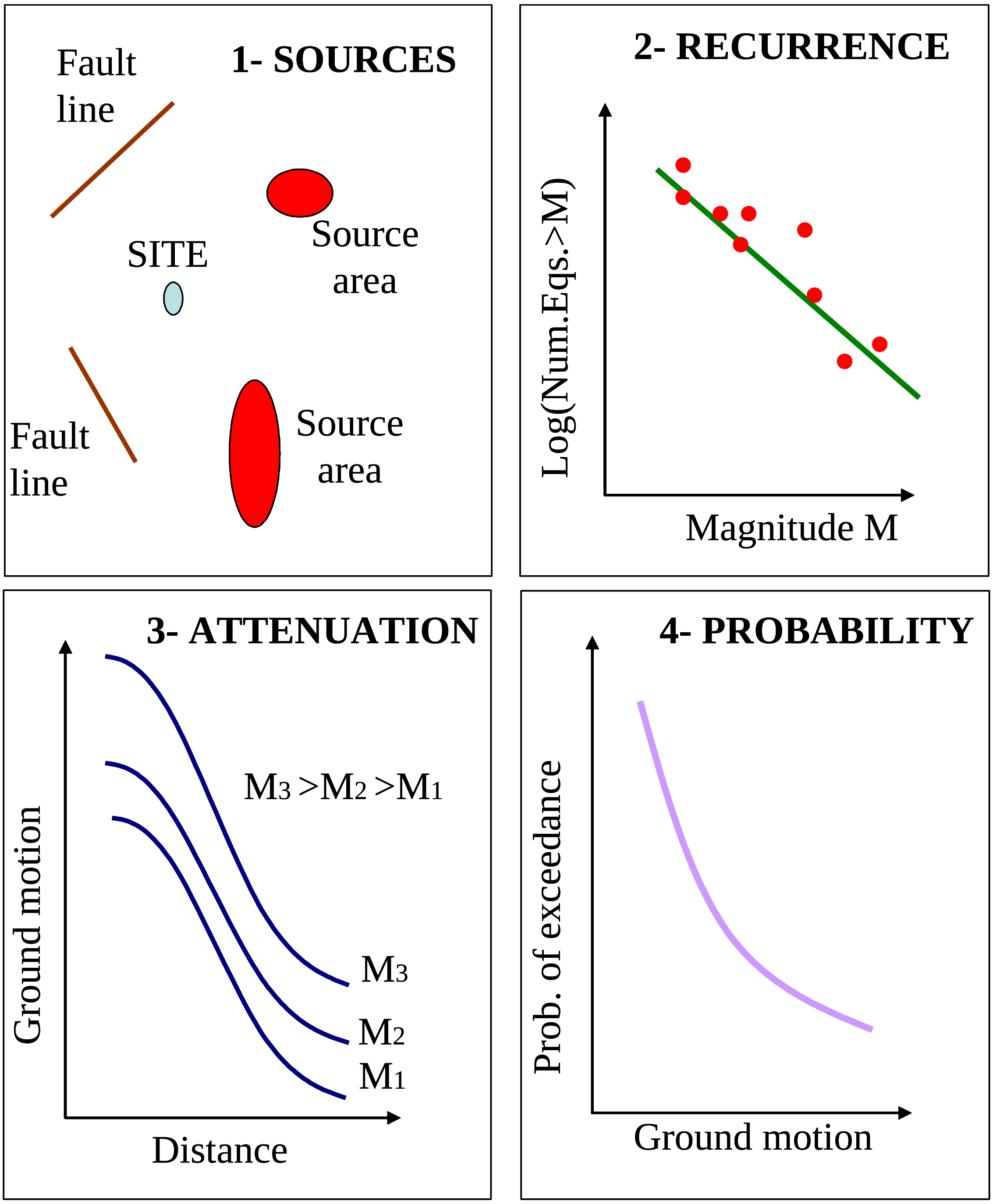


FIGURE 2- Steps of probabilistic seismic hazard analysis for a given site: (1) definition of earthquake sources, (2) earthquake recurrence characteristics for each source, (3) attenuation of ground motions with magnitude and distance, and (4) ground motions for specified probability of exceedance levels (calculated by summing probabilities over all the sources, magnitudes, and distances).

The calculations give the numerical values of various ground motion parameters (e.g., peak acceleration, peak velocity, root-mean-square acceleration, response spectra, spectral intensity, etc.) for any given probability of exceedance or return period. The products from this task will be a set of probabilistic seismic hazard maps showing peak ground accelerations and pseudo-acceleration response spectra at 0.2, 1.0, 2.0, and 4.0-sec. periods for 10% probability in 50 years, and 2% probability in 50 years. The maps will be presented in a digital format compatible with commonly used GIS software packages.

## Site Amplification and Microzonation

The term “site amplification” refers to the increase in the amplitudes of seismic waves as they propagate through the soft geologic layers near the surface of the earth. Site amplification is a critical factor influencing the damage in structures during earthquakes. Soft soil layers can cause five to ten fold increase in the amplitudes of seismic waves.

The probabilistic and deterministic seismic hazard maps, discussed above, are developed for a generic soil type. To determine the actual ground shaking at a specific location, the shaking values given in seismic hazard maps should be multiplied with the local site amplification factors. The resulting maps are known as Microzonation Maps. These are the maps that are used to design and evaluate structures because they represent the actual ground shaking in that location. The most accurate way to determine site amplification factors is to use field measurements.

Figure 3 shows a schematic of such excitation sources. If the objective were to locate earthquake sources, such noise would be detrimental, because it interferes with waves generated by the earthquake. That is why seismologists do not want to locate their instruments in urban areas. However, when the objective is to determine site amplification factors, such noise are very useful because they incorporate a lot of information on the characteristics of sub-surface soil layers. It can be shown that by proper analysis we can extract site amplification factors from ambient ground vibrations (Safak, 2005; Safak, 2006).

We will deploy sets of portable broadband seismic recorders with built-in three-component sensors, record ground noise continuously. The results presented in the form of a site amplification values, and charts for microzonation.

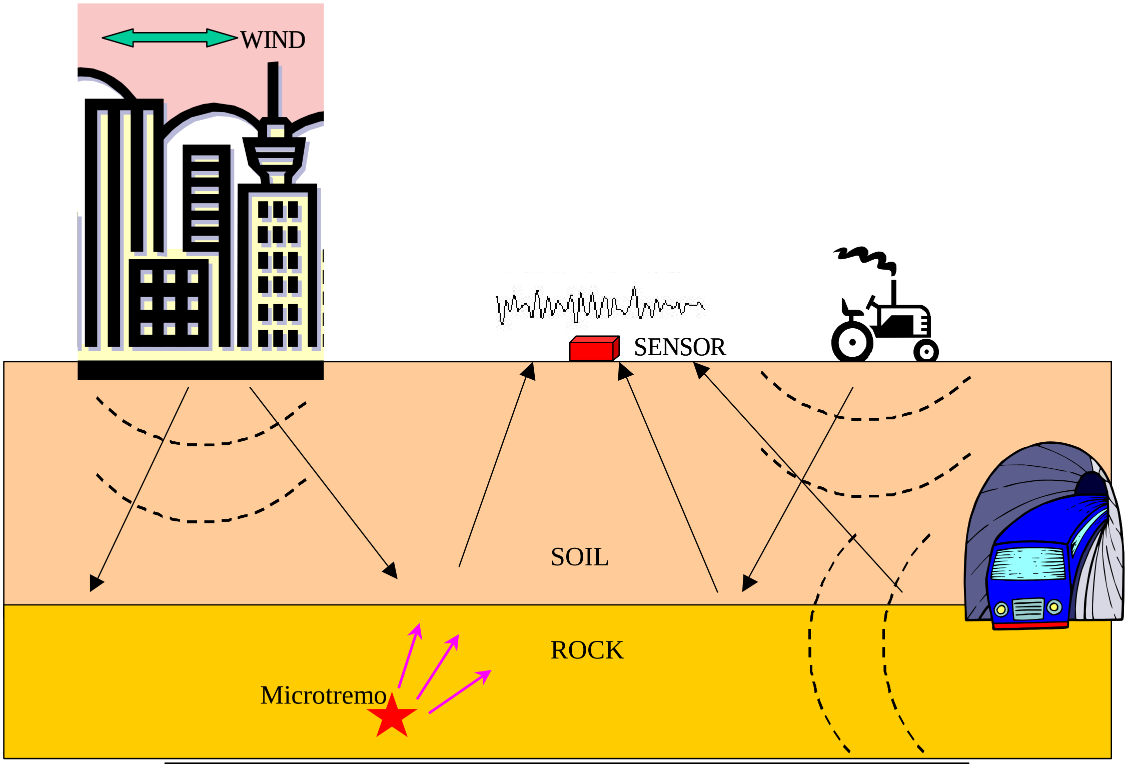


FIGURE 3. Sources for ambient ground vibrations.