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Seismic Microzonation Study in Tabriz Metropolitan City for Earthquake Risk Mitigation

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ABSTRACT
Azerbaijan is the site of convergent plate collisions along the Alpine-Himalayan active mountain belt. Brittle faults in the Azerbaijan area are mostly Cenozoic in or younger. The data presented demonstrate clearly that geological structures are commonly repeated at all scales from outcrop to regional. Several regional earthquakes have been strongly felt and caused damages in and around Tabriz during history. Urban seismic risk is increasing with population growth and encroachment of vulnerable built in environment into areas susceptible seismic hazard. Seismic -hazard assessment an estimate of ground motion at the site of interest, taking into account instrumental and historical earthquake records, information on tectonics, geology, and attenuation characteristics of seismic waves Tabriz is important industrial city of Iran. It has a very high population density about 2.000000 people in area just 90 km^2. The main objective of the Tabriz seismic instrumentation and microzonation study was to carry out and propose new building in Tabriz and suburbs in order to apply these criteria its development programs and determine the potential for damage to existing constructions during earthquake motions, and finally earthquake risk mitigation assessment.
Keywords: Seismic hazard, seismic microzonation, earthquake risk mitigation.

I. Introduction

Azerbaijan is one of the most active segments of the Alpine- Himalayan seismic belt and marks the junction between the African, Arabian and Indian plate to the south, and Eurasian plate to the North. Historical records of earthquakes in Azerbaijan based on microseismic and macroseismic observations cover a period of 1000-1200 years.

Historical seismicity in the northwest of Iran is mostly associated with the North Tabriz Fault (NTF) and the Bozqush fault (Fig 1).

Tabriz experienced two great Earthquakes in the 18^{th} century (Ambraseys and Melville 1982). There is only convincing historical report about a destructive earthquake (1550 AD), in the south Qaradagh region, Which includes the Ahar- Varzeghan region (11 August 2012, a magnitude $M_W = 6.4$, and $M_W = 6.3$)

A quantitative ground motion prediction is a key for assessing and mitigating the earthquake disaster.

Three major factors that control the level of strong ground motion are Source, path and site effects. Therefore, local geology and soil composition and active faults play an important role in determining have the ground may respond during an earthquake.

- Tabriz city is the fourth largest metropolis in Iran, in the focus of Industrial, economic, social and cultural development and it is the capital of the state of Azerbaijan. Earthquake hazard Zonation for urban areas, mostly referred as seismic microzonation, is the first and most important step towards a seismic risk Analysis and mitigation strategy in densely populated regions (Slob et al, 2002). Tarbiz city displays various building types of wall materials and their percentage, the earthen walls (10%), stone walls (4%) burned brick walls (30-40 %) concrete walls (30%), reinforced concrete masonry and composite structure (30%) etc … .

Earthen, mud and stone walls are vulnerable if shaken by an earthquake of moderate to severe intensity.

II. Methodology

Intensity of ground motion amplification landslide and liquefaction is not only determined by the site conditions such as type, thickness, and shear- wave velocity of soil, topography and hydrology but also by the incoming (Input) ground motion on Rock.

In Azerbaijan context, definition is (Microzonation is subdivision of a region into zones that have relatively similar to variations earthquake related effects). For the present investigation the seismic microzonation has been subdivided into three major items:
Evaluation of the expected input motion.
Local site effects and ground response analysis.
Preparation of microzonation maps.

1- Ground Response Analysis

According to the historical and recorded earthquakes, by instrumentally measured intensities, such as peak acceleration and velocity, are more reliable measures of the severity of strong shaking than seismic intensity seals in Azerbaijan.

The duration of strong ground motion can have a strong influence on earthquake damage.

Many physical processes, such as the degradation of stiffness and strength of certain types of structures and the buildup of porewater pressures in loose, saturated sands, are sensitive to number of load or stress reversals that occur during an earthquake. A motion of short duration may not produce enough local reversals for damaging response to build up in a structure, even if amplitude of the motion is high.

On the other hand, a motion with moderate amplitude but long duration can produce enough local reversals to cause substantial damage (Karmer, 1995).

The principle of one dimensional ground response analysis is bused on the assumption that all boundaries are horizontal and soil and sld.

Bedrock are assumed to extend infinitely in the horizontal direction (Siefko, Robert Hack and outers 2002). The second assumption is that in dined incoming seismic Rays are reflected to a near-vertical direction, because of decrease in velocities of surface deposits. Therefore the response of soil despoil is caused by shear waves propagating vertically from the underlying bedrock (Siefko Slob and outers 2002).

III. Attenuation of ground motion Intensity

Seismic hazard studies, as well as earthquake early warning systems, are usually focused on estimating the distribution of ground shaking associated with earthquake activity in a given region. Usually, ground shaking levels are presented in terms of peak ground acceleration (PGA). Peak ground velocity (PGV) or other recorded parameters (M.B Sorensen, D. Stromeyer and G. Grunthal 2008). The development of this methodology induces three vital steps:

1) Evaluation of distribution of ground motion **Intensity measures** at a site, given certain seismological variables (i.e. fault characteristics, position of site relative to faults etc …).

Intensity measures may consist of traditional parameters such as spectral acceleration or duration.

2) Evaluation of the distribution of system **response** or **damage measures**, given a particular set of intensity measures.

3) Evaluation of the probability of exceeding **decision variables** within a given time period, given appropriate damage measures. Decision variables may include human or collectoral loss, post-earthquake repair time, or other parameters of Interest to an owner. Generally, worldwide earthquakes occur in one of three tectonic Regimes.

a) Active Tectonic Regions b) Subduction Zones c) Stable Continental Regions.

The Azerbaijan and the south **Caspian** Sea basin belongs to the **Alpine- Himalayan** system, an area high geological complication and large scale active tectonic Regions.

The Tabriz area is part of the complex tectonic system due to the interaction between Arabia, Anatolia and Eurasia and comprising the North Anatolian Fault, the East Anatolian Fault, the Caucasus Mountains, and the main recent fault which bounds the Zagros Mountains.

Three measurements of a dense network located around Tabriz between 2002 and 2004 (Musson et al 2007) confirm that most of the motions is concentrated on the right- lateral at rate of 8 mm/year.

This Rate is consistent with the long- term geological rate deduced from geomorphological observations (Hessami et al 2003; Karakhanian et al 2004). Historical earthquakes destroyed the city of Tabriz several times. The last sequence of 3 event during the 18th century ruptured the total length of the NTF, and since that time, no large magnitude earthquake has been located on this fault. However, about 20 smaller earthquakes have been felt by the habitant of Tabriz since 1900 (Berberian and Arshadi 1976),

3) Characteristics of Near- North Tabriz Fault Ground Motion)

The Near North Tabriz Fault Zone is Typically assumed to be within a distance of about 20-40 km from a ruptured fault. Within this near fault Zone, ground motion are significantly influenced by the rupture mechanism, the direction of rupture propagation. Relative the site, and possible displazoment ground displacement, resulting from the fault slip (Fig. p64)

These factors result in effects termed herein as (rupture directivity) an fling step. (Jonathan p. Stewart and Shyn- Jeng Chiou, Janathan D Bray 2001).

If a site is located near the epicenter, i.e., rupture propagates away from the site, the arrival of seismic waves is distributed in time. This condition, referred to as backward directivity, is characterized by motions with relatively long duration and low amplitude.

Modern digital recordings of near fault ground motions, for example from the August 17, 1999 Turkey earthquake, contain permanent ground displacement due to the static deformation field of the earthquake. These static displacements, termed "**fling step**" occur over a discrete time interval of several seconds as the fault slip is developed.

4- Geologic setting of Azerbaijan (Case study North Tabriz Fault = NTF)

According to some authors, the northeastern corner could be included in Alborz and southeastern part in Sanandaj- Sirjan. Some believe that most of Azerbaijan lies in a zone culled Azerbaijan-Alborz, and as they indicate, this zone is bounded in the north by Alborz fault. In the west by Tabriz- Mianeh fault, and in the south Semnan fault. Organic episode generated the North Tabriz orogenic episode generated the North Tabriz Fault (NTF), extending in a northwest- southeast direction from Zanjan depression to the northern mountains of Tabriz (Moro- Mishow) and northwest of Azerbaijan and the Caucasus.

The NTF is the most prominent tectonic structure in the immediate vicinity of Tabriz city. It can be followed almost continuously at the foot of the northern mountions (Eynali- Moro dagh) near Tabriz about 100-120 km, from Mishow mountain in the west to Ujan (Bostan abad) in the east (Fig …).

NTF forms a well- marked between the rocks of border folds and Quaternary alluvial deposits of the Tabriz piedmont zone, Up thrusting the Miocene Rocks against the alluvia deposits west of Khajeh-Marjan village and northeast of Tabriz Airport (Fig …) (Berberian, M 1976).

5- Necessity of seismic Microzonation and seismic vulnerability Assessment of Existing Building At the city of Tabriz- Azerbaijan- Iran.

- Seismic microzonation and seismic vulnerability assessment of building stock at a certain location is of Importance in order reduce the potential from future earthquakes. The assessment of seismic hazard and risk involves first determining the expected level of shaking by accounting for seismic sources in the region, past history of earthquakes, and local soil and rock characteristics, and then incorporating structural inventory and the associated fragility relationships (i.e., ground shaking versus level of damage curves) into seismic hazard. The special characteristics of pipelines require modifications to the standard seismic hazard and risk analysis that are typically done for buildings. In most general terms, seismic microzonation is the proven of estimating the response of soil layers under earthquake excitations and thus the variation of earthquake characteristics on the ground surface.

However, it is also very important to select appropriate ground motion. Parameters for microzonation that correlate with the observed structural damage as well as which could be implemented in engineering design of the man made structures (Finn 1991).

A vulnerability assessment needs to be made for a particular characterization of the ground motion, which will represent the seismic demand of the earthquake on the building. The selected parameter should be able to correlate the ground motion with the damage to the buildings.

The evolution of vulnerability assessment procedures for both individual buildings and building classes is described in the following section, wherein the most important references, applications and developments pertaining to each methodology are reported (Culvi. G. M. and outers 2006).

IV. Results and Discussions.

Seismic microzonation requires multi-disciplinary contributions as well as comprehensive understanding of the effects of earthquake generated ground motions on man- made structures. It can be considered as the process for estimating the response of soil layers under earthquake exaltations and thus the variation of earthquake ground motion characteristics on the ground surface. Microzonation should encompass the variation in

- Earthquake hazard parameters.
- Ground Shaking Intensity
- Surface faulting and tectonic deformation.
- Liquefaction, ground spreading and settlement susceptibility.
- Slope stability problems like landslides or rock falls, ground settlements.

Main aim of this study is to put forward the combined use of geophysical and geotechnical data in integrated form I context of seismic microzonation.

For this aim, firstly, seismic hazard analysis of region was carried out by deterministic and probabilistic hazard analysis techniques. Lastly microzonation is an efficient tool to mitigate earthquake risk by hazard- related land use management. However, microzonation does not replace the existing building and construction codes. Are for this weakness is the necessity for interdisciplinary interpretation.

Unlike seismic microzonation, seismic macrozonation requires input from civil engineering and engineering geology, especially in the field of geotechnical engineering.

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