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Economic Loss Estimation for Earthquake Hazard in Zones 19 and 20 of Iran in 5 Later Years

[1]Yaser Abbasabadi and [2]Reza Toushmalani

[1]Department of Accounting, Hamedan Branch, Islamic Azad University, Hamedan, Iran
[2]Department of Physics, Hamedan Branch, Islamic Azad University, Hamedan, Iran

Abstract: Natural hazards, especially earthquakes, cause disasters when they hit large settlements such as metropolitan areas. After the first shock, the damage is counted by deaths and injuries. In a while, the destroying effects of disaster appear on economic asset of the region. Direct losses including damages in buildings and lifelines can cause non-structural or indirect losses as interruption of business activities and services. Loss estimation techniques have been developed to evaluate losses from earthquakes and other natural hazards. In this paper ,in the first section, the commonly-used articles about economic model in other countries have been introduced, and the parts of such model have been analyzed .then Iran's earthquake capacity, common divisions, and the probability of earthquake occurrence in each area have been mentioned. After that, depending on area scope, each article has studied one or two certain areas. And the resulted damages of each earthquake with a certain size have been analyzed in 5 later years. This article show the earthquake damage in in these areas is the range of $ 30 million to $ 1billion. This is a good guide to crisis management in these areas.

Key words: earthquakes, Loss estimation, Iran's earthquake capacity

INTRODUCTION

Natural disasters, especially earthquakes, can be devastating to human activities, to social organizations at every level and to economic life. After the first shock, the damage is counted by deaths and injuries. In a while, the destroying effects of disaster appear on economic asset of the region (Seda Kundak, 2004). The most obvious consequence of an earthquake is the physical destruction of the built environment. Beside the damages in houses, work places, schools, hospitals, centers of administration and historical buildings, the physical destruction may also extend beyond buildings to infrastructure (lifelines). Transportation systems, power, gas, water and communication lines may be destroyed. As a consequence of this physical damage, economy of the region is disrupted as well. Economic losses by severe earthquakes can cause long-term reductions in the growth of a nation's economy and trigger inflation (Seda Kundak, 2004). Therefore, evaluation of the economic losses can be considered regarding to their share in country's gross national product (GNP). Coburn and Spence (1992) argued that "the poorer nations with lower GNP, tend to be more vulnerable to the economic impact of a costly earthquake, even though in absolute terms, the cost of the damage may not be as high as elsewhere". As seen in Table 1, earthquakes in Nicaragua (1972) and El Salvador (1986) caused $2.0 and $1.5 billions damage respectively. These costs are quite low comparing with those in Italy (1980) and USSR (1988). However, while $45 billions loss is representing 6.8% of the GNP in Italy, in Nicaragua, $2.0 billions loss is equivalent to 40% of the GNP (Table 1).

In order to estimate probable future losses in earthquake-prone regions, loss estimation techniques have been developed. Loss estimation techniques have been studied with every aspects and consequences by engineers, economist, architects, urban planners, sociologists and so on. The sum of all these studies shows that losses caused by disasters are multifaceted (Seda Kundak, 2004).

Table 1. Economic losses by major earthquakes (Coburn and Spence, 1992) Country Year Billions $ damage Loss (%GNP).

In this paper ,in the first section, the commonly-used articles about economic model in other countries have been introduced, and the parts of such model have been analyzed .then Iran's earthquake capacity, common

Corresponding Author: Yaser Abbasabadi, Department of Accounting, Hamedan Branch, Islamic Azad University, Hamedan, Iran
E-mail: Atomicboy_reza@yahoo.com

divisions, and the probability of earthquake occurrence in each area have been mentioned. After that, depending on area scope, each article has studied one or two certain areas. And the resulted damages of each earthquake with a certain size have been analyzed in 5 later years.

Table 1: Economic Losses by Major Earthquakes (Coburn and Spence, 1992).

Country	Year	Billions $ Damage	LOSS (%GNP)
Nicaragua	1972	2.0	40.0
Guatemala	1976	1.1	18.0
China	1976	6.0	1.5
Romania	1977	0.8	3.0
Yugoslavia	1979	2.2	10.0
Italy	1980	45.0	6.8
Mexico	1985	5.0	3.0
Greece	1986	0.8	2.0
El Salvador	1986	1.5	31.0
USSR	1988	17.0	3.0
USA	1989	8.0	0.2
Iran	1990	7.2	7.2
Philippines	1990	1.5	2.7

1-2. Earthquake Risk Estimation:

The most important feature of the new methodology for earthquake loss analysis Lies in estimating the loss by means of macroeconomic indices, such as the gross Domestic product (GDP) and population Chan *et al.*, (1997, 2002, 1996). For a given area, the Estimated loss *L* was given by:

$$L = \sum_{I} P(I) \cdot F(I, GDP) \cdot GDP.$$

where *F(I,GDP)* is a measure of the area's vulnerability for the given GDP value and the earthquake intensity I. Since GDP is one of the many economic and social indicators compiled on a regular basis by various agencies and institutions (for example, World Bank, World Resources Institute), and the GDP data are also increasingly available in digital form, it is suitable to be used as a measure of the national wealth. The GDP data are mostly commonly given for a nation, but in some cases, for individual states or provinces within a nation. Chan *et al.* (1997) shows that the population distribution serves as the most useful basis for the apportionment of GDP to a given geographic unit.

1-3. GDP per Unit Area:

Since GDP is usually provided for a country, it must be apportioned over the nation or province. Chan *et al*. (1997) found a strong correlation between GDP and population density for the States in the United States and the Provinces in China. The GDP of an individual unit is determined according to the following relationship:

$$\text{GDP per unit area} = (\text{GDP of region}) \times \frac{\text{Population in Unit Area}}{\text{Regional Population}}$$

1-4. Vulnerability Analysis in Earthquake Loss Estimate:

A key question that must be addressed in hazard reduction: how much loss might a city or region suffers from future earthquakes? Earthquake loss depends not only on the hazard caused by earthquakes, but also on exposure (social wealth) and its vulnerability. Exposure refers to all man-made facilities that may be impacted in an earthquake. It includes all residential, commercial, and industrial buildings, schools, hospitals, roads and railroads, bridges, pipelines, power plants, communication systems, and so on.

Vulnerability is the expected degree of losses within a defined area resulting from the occurrence of earthquakes and often expressed on a scale from 0 (no damage) to 1 (full damage). The vulnerability in the inventory method varies with the type of buildings. For those buildings with very poor quality, the vulnerabilities of them are almost the same, which represent the vulnerability in the worst cases. On the other hand, for those buildings with high quality and seismic design the vulnerabilities are also the same, which represent the vulnerability in the best cases due to employing the state-of-art-design and construction techniques. The same results obtained by different authors are not strange because they represent the two extreme situations under the contemporary conditions: the best one and the worst one. The intervals between the two situation show the variation ranges of vulnerability for all types of buildings.in this paper we use results of Chen Yong *et al*. (2001) paper for Vulnerability Analysis in Earthquake Loss Estimate.

2)Seismic Hazard Assessment of Iran:

2-1)Introduction:

Iran has been placed on ALP-HIMALIYA geographical bar known as ALPIDE. This geographical bar is very active and unstable area not only in geographical point of view but also in regarding to earthquake accuracies. So, regarding to huge reconstructive projects such as dam constructions, different energy-making centers, refineries, etc, earthquake damages, in addition to economical aspect, will have social, hygienic, and even political and strategic effects, too. The estimation of earthquake in most probable areas, especially for important plants, is really so vital and essential to determine the site of project performance and it should not be taken for granted. There foe, regarding to the risk of earthquake accordance, which has more damages and effects then other natural calamities' in Iran, we can increase the useful life span of resulted constructions. That is, the acquisition of related data on the probability of ear the accordance, as one of the main and effective faction on final risk of a project, can increase the useful life of such projects notably (Barbarian, 1374; Banisadr, 1971).

The relationship between the size of earthquake and the number of its accuracies. The best relationship, which can show the connection between the number of earthquakes and their size, has been determined by Richter and GOTENBERG in 1947. That relationship is a linear relation as follows (Bergi. Khosro, 1379):

$$\log(N) = A - bM$$

N identifies the number of earthquakes which have greater or equal size M. A and b are invariable factors of earthquakes for each particular area. Having the number of above –mentioned earthquakes in a particular span of time, e.g. from one hundred years ago up to now, and/ or more suitable span of time, we can estimate the fixed coefficients of A and b. Such estimation can be carried out by linear Regression or the Least Squares. For example,

$$\log(N) = 5.79 - 0.67M$$

has been suggested for a span of 69 years for Iran earthquakes (Bergi. Khosro, 1379). On the other hand, other assumptions can be appeared about the relationship between earthquake size and its number. Researchers have different views about Iran. For examples, some researchers have divided Iran into 9, 4, 4 areas in their studies (Stoklin, 1968; Takin, 1972). While, some others have divided Iran into 23 areas in their studies (Nowroozi, 1976) In the most recent division, Iran has been divided into 20 areas in 1996 (Tavakoli, 2002) (figure 1). This new division is more preferable because not only it considers the tectonic construction of each area but also it takes the active and important faults of each areas of Iran into account.

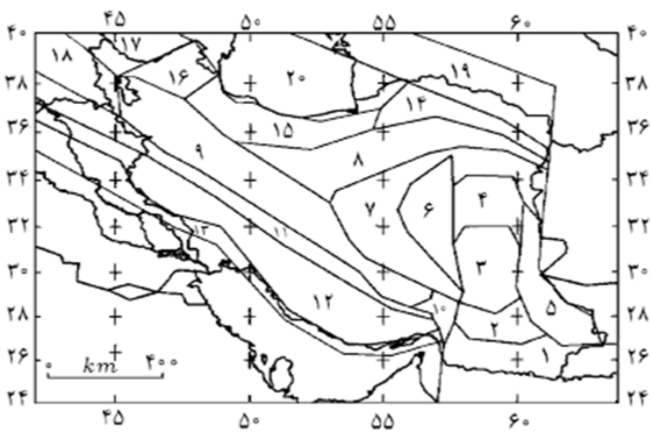

Fig. 1: Seism tectonic provinces of Iran.

In the next stage, a mathematical model is sued for probable earthquake distribution .Such model which is used by most of researchers is called poison model. This model is only used for the accuracy of an earthquake whit size M on a certain time. This is written as follows:

$$P_T(t) = 1 - e^{-N.t}$$

In this formula: P_T(t) Stands for the probability percent of an earthquake with the size M or more in a time distance(t). By the use of such distribution and its generalization to earthquakes, if we want to estimate the probability of accuracy of an earthquake with M-Richter power on M_s scale in a particular city and its effects on a project with a useful life of t years, firstly, it's necessary to keep N number by the formula of the best regional regression line. Then we should divide N number by 100, and place the result in poison relationship to estimate the risk of considered earthquake.

2-2)The Phases of Performance:

1. Using table 2 relations, we calculate earthquake occurrence frequency, in M rishter power (on Ms Scale). Of selected area and acquire the amount of N. then we divide N number of 100 and put it in poason's probability integral to get the probability of earthquake occurrence in that certain area (The duration of probability of earthquake occurrence was thought of being about 10 years)
2. we use the model of vulnerability of Analysis in earthquake bss estimation to calculate damageability coefficient of buildings and after-earthquake stops of economic activities in selected areas.
3. we use loss estimation model to calculate the amount of the earthquake damages to each area. The size of earthquakes are 4,5,6,7,8.

2-3) The formula of best line of regression for Iran's probable areas 19, 20 for earthquake.(figure 1).

Table 2:

zone	best line
Zone (19)	log(N)=4.500-0.717M
Zone(20)	log(N)=4.277-0.587M

2-4) Table of Probabilities of Earthquake Occurrence in Each Area.

Table 3a: probabilities of earthquake occurrence in (a)zone 19 (b)zone 20

Zone19	probabilities
P(4)	1
P(5)	0.97
P(6)	0.64
P(7)	0.25
P(8)	0.08

Table 3b: probabilities of earthquake occurrence in (a)zone 19 (b)zone 20.

Zone20	probabilities
P(4)	0.99
P(5)	0.66
P(6)	0.14
P(7)	0.20
P(8)	0.03

2-5)The Results Gained from Calculating Damages in 5 Years Later(USD Unit)

Table 4: Results gained from calculating damages in 5 years later(zone 19).

Zone19	2011	2012	2013	2014	2015
L4	17966928	304988602/8	574941696	875887740	824767552
L5	18544612/8	314794802/28	593427609/6	904049874	851286035/2
L6	19142424	324942647/4	612557568	933193170	878728416
L7	19760966/4	335442404/64	632350924/8	963347112	907122457/6
L8	20400844/8	346304340/48	652827033/6	994541184	936495923/2

Table 5: Results gained from calculating damages in 5 years later (zone 20).

Zone20	2011	2012	2013	2014	2015
L4	28904295/42	337216779/9	204373806	113865406/2	50259272/7
L5	29833645/842	348059201/49	210944970/6	117526483/62	51875242/77
L6	30795374/61	359279370/45	217745073	121315112/1	53547512/85
L7	31790454/696	370888638/12	224780992/8	125235124/56	55277774/76
L8	32819859/072	382898355/84	232059609/6	129290353/92	57067720/32

Conclusion:

Natural disasters, especially earthquakes, can be devastating to human activities, to social organizations at every level and to economic life. Economic losses by severe earthquakes can cause long-term reductions in the growth of a nation's economy. In order to estimate probable future losses in earthquake-prone regions, outputs of loss estimation techniques are the powerful tools as input of planning process. This article show the earthquake damage in these areas is the range of $ 30 million to $ 1billion. This is a good guide to crisis management in these areas.

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