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Explaining the Effective Measures in Decreasing the Vulnerability of Urban Area against Earthquake Using AHP Model (Case study: Tehran, a Metropolis)

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ABSTRACT

Earthquake is one of the natural disasters. If it happens, it creates in compensable troubles and losses in the human environment. Tehran, as a metropolis, is always apt to earthquake due to lying on the belt of Alps-Himalaya which is prone to earthquake and the existence of fault in its north and south area. The specialists and authorities in the field have always presented ideas and measures to reduce the probable losses. In the he present article, attempt has been made to recognize the measures and analyze to see to what extent they are practical. The idea and impractical measures do not meet the needs of Tehran with the undeniable characteristics such as being populated, having compacted dwelling texture, lacking per head and standard observance. The research methods used are descriptive–analytical and statistical. AHP model and expert choice 2000 software have been used to evaluate the measures. The result showed that material resistance and the width of lattice work, among the reducing measures of vulnerability, are the most important ones respectively. The regions 8, 22, and 1 have possessed a better status respectively regarding the investigated measures related to the extent of vulnerability.
KEYWORDS: earthquake, AHP model, Tehran as a metropolis, vulnerability.

1. INTRODUCTION

Earthquakes have caused the most devastating natural disasters in the 20th and 21th centuries (Bryant, 1993; Marcuson et al, 2003). Unlike many other types of disasters, originating primarily from natural forces, there is no warning. For many victims the experience of an earthquake is one that causes inexpressible, sudden and seep shock, often with long–term ongoing psychological consequences, and the impact is often widespread (for instance, see: Akason, 2004; Bo dvarsdo ttir and Elklit, 2004; Cannon, 2003; Basog lu et al, 2002; Durkin, 1993). The vast area of Iran, because of its special geographical status (fault and climate condition), has always faced various natural disasters, particularly earthquake which has caused a lot of financial and mortal damages. Moreover, the correct technique against earthquake not being applied by human, as a factor of disaster, has doubled the damages. Tehran with the area of some 700 kilometers is one of the biggest cities of the world which owns particular characteristics. The faults surrounding its north and south regions and the buildings built on the faults necessitate more attention to be paid to recognize dangerous points and provide measures to reduce the probable dangers. To fight with the damages which occur during and after earthquake, the specialists in the field have designed some measures. Of these measures we may refer to lattice work or grid, the number of storeys of the building, the use of the lands etc. So, the main purpose of the article is the recognition of the measures for evaluating the degree of urban vulnerability against earthquake. The sample for this case study is the northern regions of Tehran, for these areas are closer to the brake and potentially are apt to receiving the danger of earthquake.

2. The background of earthquake in Iran

Due to resting on the Alps–Himalayan belt, Iran is one of the five countries which are prone to earthquake (Golabchi & Taiebat, 2011). During the last century, Iran has experienced 130 earthquakes as large as more than 7.5 Richter (Ghafari – Ashtiani, 1992). 17.5 percent of the devastating earthquakes of the world happen in Iran (Baiat, 2003). As the map of the width of earthquake shows the two–third of the country's area rests on the axis of dangerous earthquake (Asgharimoghadam, 1999). In the regions located between Alborz and Zagros mountains, the alternate occurrence of earthquake is less. Thus, strong and devastating earthquakes are expected there. (Memari & khandani, 1993). Based on the officially known statistics in the last 25 years, six percent of the mortality of the country has been due to earthquake (Zangiabadi & Tabrizi, 2005). Studies concerning the statistics of earthquakes larger than 6.5 Richter imply that some forty earthquakes have happened in Iran during the last century. Therefore, it should be noted that an intense earthquake happens every 2.5 years, as an average, in our country (Arian, 2003). Tehran has been built in south skirt of central Alborz Mountains and on the deposition of quarter, and its south is located on north – west of the vast desert of central Iran. The sudden and

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intense difference of height between Tehran (with average altitude of 1300 meters) and the closest (less than 10 kilometers) peak (Toochal with the height of 3933 meters) is one of the photographic features of expansion (Manovil, 1992). Two active faults in the north (or south of Alborz Mountains) and the south (around it belt) of Tehran have surrounded it and have changed it into one of the dangerous area of the country.

3. Human factors influencing vulnerability against earthquake

3.1 Urban population growth

Urban population has been 2 percent in 1800, 30 percent early in 1940, 47 percent in 2000, and more than half of world's population in 2008, and it is expected to be raised to 60 percent in 2030 (Nagle, 2005). Citizenship has always been ascending so that its share has increased from 30 percent in 1956 to 64 percent in 2001 (Abdollahi, 2004). The mere growth of population is not increase, but it is inappropriate distribution of population in different geographical areas of the city, especially in the regions with low income and rather, height compression of the building with low quality, which has increased vulnerability.

2.3 Unsuitable urban house

The imbalanced economic and social conditions in the developing countries have caused only a limited social class to possess suitable house (with scientific and technical requirement) and others suffer it (Ahri et al, 1991). Therefore, many citizens in third world countries unavoidably and increasingly choose to live in the outskirts of the cities. According to pourmohammadi (2000, 7-8). This constitutes 25 to 35 percent of regions of the cities. Iran also is not an exception. In the second populated city of this country, Mashhad, 650000 people have been living in the outskirts in 2000 (Mosaiebzade, 2000). In addition to this, 7.2 out of 12 million houses throughout the country enjoy little resistance (Negresh, 2005).

3.3 The activity of laymen in land and house market

The financial poverty of the citizens, the intervention of land and house agents (official or not), the activity of irrelevant and laymen in the land and house market (Moatamedi, 2003), the insensitivity of the city management toward city development in the natural hazardous area and sometimes being close to faults have imposed deformity and a vulnerability bed on the houses (Pourmohammadi & Mosaiebzade, 2008).

4.3 Urban planning and the framework structure of the town

The study of damages resulting from earthquake in the cities implies that the direct or indirect damages originate from the undesirable planning and designing of the cities. The important distribution of the structure of elements, city usages, inefficient lattice work, compressed city texture, high density, unsuitable establishment of the underlying installations of the city, and the shortage of play ground play a crucial role in increasing the damages the city receive from earthquake (Abdollahi, 2003).

5.3 The texture and the form of the city

City texture, as one of the important elements of the city structure resisting damages due to earthquake, plays an essential role. The regular and disconnected textures are safer than the irregular and the connected ones (Aahmadi, 1997). The shape of the city may also minimize the earthquake dangers. Singer and Lynch (1960) believe that the open forms of cities are more flexible than the closed and packed ones (a cited in Habibi, 1992). While now a days the horizontal development of the big cities of the country is limited due to geographical characteristics and … .

6.3 Land usage and urban densities

Planning to improve the usage at the city lands plays an important role in reducing vulnerability against earthquake. When deciding about the usage of the lands of city, if the adjacent elements and agreeing principles among them are taken in to account, it will be possible to easily empty the area and prevent the next event which may occur as a result of disaster. Some places such as hospitals, the fuel warehouses of the aid centers and fire fighting stations, and accessible networks are termed special usages which need special care so that they could be used in the case of natural disasters (Abdollahi, 2004).

7.3 The underlying installations of the city

Being damaged, the underlying installations such as water, electricity, gas, and telephone can increase the losses intensely. Diffusion of gas causes great fires like those occurred, due to earthquake, in Kube and Sanfransisco (Abdollahi, 2004). Water network of the city is of high importance as far as individuals' consumption and fire fighting are concerned. The central control network of these installations, if well–located and made resistant based on the scientific and technical principles as well as being replaced by a suitable system, decreases the hazards of the earthquake (Pourmohammadi & Mosaiebzade, 2009).

4. Research method

Focusing on systematic attitude, in the present study analytical and library methods of study have been used. To achieve the purpose of the study, first the effective measures for evaluating the degree of earthquake damage were recognized. Next, four measures, emphasized in the literature, were selected. Finally, evaluating

the chosen measures via Analytical Hierarchical Process (AHP) and the paired comparison of selected regions of Tehran, the desirable choices as the main priorities of vulnerability were taken in to account.

5. The scope of the study

The scope of the study has been the north of Tehran including the regions of 1, 2, 3, 4, 5, 6, 7, 8 and 22. These regions were chosen because of being close to the fault in the north of Tehran and the slope in their south. The characteristics of the applied measures are shown in the following table.

Table (1): The characteristics measures applied for comparing the regions

Material resistance	Number of storeys	The area of paths by percent	The mean of the area of pieces by m²	regions
83	2	20	498	1
85	2.8	29	336	2
85	2.9	23	441	3
85	2.5	24	252	4
82	3	24	285	5
85	3.2	28	321	6
87	2.5	23	355	7
89	2.7	36	280	8
88	2.4	4	233	22

Sources: Detailed plan of Tehran

6. Analysis and discussion

Concerning the evaluation of vulnerability against earthquake, different measures have been present. In the following Table the measures and the degree of the vulnerability of each against earthquake have been introduced.

Table (2): The matrix of measures and sub measures and their coding based on the degree of vulnerability

Very high vulnerability	High vulnerability	Average vulnerability	Low vulnerability	Very low vulnerability	sub measures	Main factors and measures
9	7	5	3	2		
				•	Iron skeleton	**Type of material**
			•		concrete	
		•			Brick & iron	
	•				Brick & wood	
	•				Brick, adobe & wood	
•					Brick & wood	
•					Before 1952	**Antiquity**
	•				1952-1972	
		•			1972-1982	
			•		1982-1992	
				•	1992-2002	
				•	After 2002	
				•	new	**The quality**
		•			Repair	
•					Destructive	
•					Ruin	
				•	1 storey	**Number of Floors**
			•		2 Floors	
		•			3 Floors	
	•				4 Floors	
•					5 Floors	
			•		0-25%	**The occupancy level**
		•			25%-50%	
	•				50%-75%	
•					75%-100%	
	•				Residential	**Land use**
		•			Commercial	
			•		Education and Clinical Centers	
				•	Facilities and Equipment	
				•	Administrative and military	
•					Less than 100 square meters	**Parts area**
	•				250 to 100 square meters	
		•			500 to 250 square meters	
			•		500 square meters	

Sources: (Aahadnejad Roshti, Gharakhlu, Ziari, 2011) (Monzavi et al)

As it was mentioned earlier, among the measures investigated concerning the evaluation of vulnerability, 4 measures referred to in different studies have been evaluated. They are: material resistance, the area of the paths,

the number of storeys, and the area of the piece of land. The following table shows the result of a paired comparison of the regions based on each of the measures mentioned. The comparison has been done via Expert Choice software, version 2000, with measurement error less than 0.02. The numbers related to each region are indicative of final weight of the city.
The final results of comparing the regions based on the determined measurs are shown in Table 3.

Table (3): The final result of paired comparison of the regions based on the intended measures

The area pieces	The area paths	Number of storeys	Material resistance	Regions
0.367	0.054	0.232	0.045	**Region1**
0.090	0.161	0.081	0.079	**Region2**
0.198	0.081	0.070	0.079	**Region3**
0.035	0.054	0.128	0.079	**Region4**
0.050	0.104	0.060	0.045	**Region5**
0.072	0.138	0.042	0.079	**Region6**
0.105	0.081	0.128	0.139	**Region7**
0.048	0.313	0.095	0.247	**Region8**
0.035	0.015	0.164	0.210	**Region22**

Figure (1): The final result of paired comparison of the regions based on the number of storeys in Expert Choice software

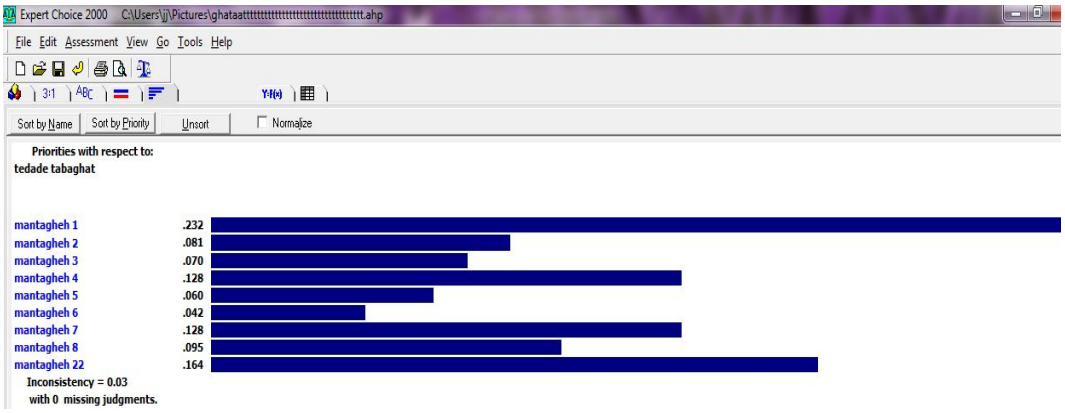
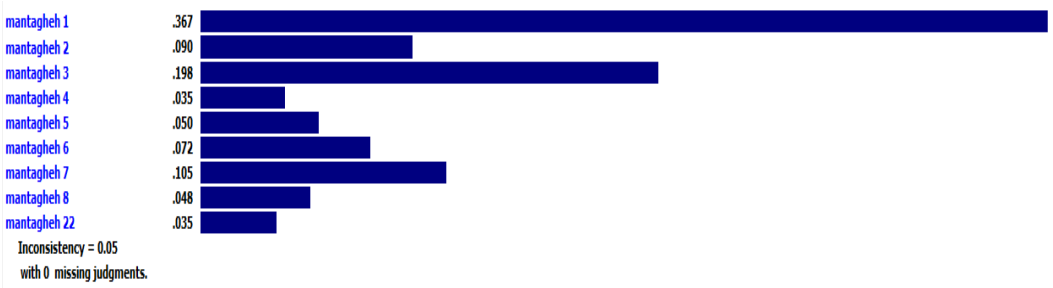


Figure (2): The final result of paired comparison of the regions based on the area of paths in Expert Choice software

Figure (3): The final result of paired comparison of the regions based on the material resistance in Expert Choice software

Figure (4): The final result of paired comparison of the regions based on the individual area of pieces in Expert Choice software



In the next stage (Figure 4), one of the main stages of AHP model, which is paired comparison of the measures and determining the coefficient importance of each of them, has been introduced. The final result of paired comparison of the measures shows that measures of the material resistance is the most important (0.467 out of 1) one among the other measures.

Table (4): The final result of paired comparison of the measures

	Material resistance	Number of storeys	The area of paths	The mean of the area pieces	Final result
0.467	1	2	3	4	0.467
0.277		1	2	3	0.277
0.160			1	2	0.160
0.095				1	0.095

Figure (5): The final result of paired comparison of the measures in Expert Choice software

The final result of AHP model has been shown in Table 5. The final result in the very ranking determined based on the weight coefficient of each city across the measures. The regions 8, 22, and 1 are ranked as first and second and enjoy less vulnerability compared with the other regions. Region 5 stands last and is, based on the measures investigated, the most vulnerable region in the north of Tehran.

Table (5): The final result and the ranking of the cities

Rank	Final weight	The area pieces	The area paths	Number of storeys	Material resistance	Regions
3	0.128784	0.034865	0.00864	0.064264	0.021015	**Region1**
5	0.09364	0.00855	0.02576	0.022437	0.036893	**Region2**
6	0.088053	0.01881	0.01296	0.01939	0.036893	**Region3**
7	0.084314	0.003325	0.00864	0.035456	0.036893	**Region4**
9	0.059025	0.00475	0.01664	0.01662	0.021015	**Region5**
8	0.077447	0.00684	0.02208	0.011634	0.036893	**Region6**
4	0.123304	0.009975	0.01296	0.035456	0.064913	**Region7**
1	0.196304	0.00456	0.05008	0.026315	0.115349	**Region8**

7. Conclusion

The recent earthquake happened in the country has caused a lot of mortal and financial losses indicating the vast vulnerability and weaknesses in the urban buildings. Since our country is the one which is prone to earthquake most of the entire world, more studies should be conducted in the area of the evaluation of the building vulnerability (as the first step in reducing the effect of the hazards) against the phenomenon (of earthquake). The present article has dealt with the evaluation of the degree of the vulnerability of the regions located in the north of Tehran taking into account the measures such as material resistance, the area of the paths, the number of storeys, and the area of the individual pieces. The results obtained imply that the regions 8, 22,

and 1, compared with the others regions, enjoy a more suitable status concerning vulnerability against earthquake; while region 5 is the worst. Thus, to minimize the degree of the vulnerability regions, the following guidelines are suggested:

1. Providing low income classes (people) of the regions with facilities to build secure houses and building houses, where there are deteriorated textures of suitable size for each family under the control of engineering system organization
2. Preventing the establishment of the new dwellings which do not use resistant material and do not follow the engineering principles
3. Observing the proportion of the number of the building storeys to the width of neighboring paths to minimize the damages resulting from earthquake
4. Improving and reconstructing the established dwelling in the areas apt earthquake, and
5. Reducing the number of the building storeys in the areas close to the fault.

REFERENCES

1. Abdollahi, M. (2004). The management of crisis in urban areas. Preceding of the Symposium of Iran urban planning, Art Faculty, Shiraz University

2. Abdollahi, M. (2004). The management of crisis in urban areas (earthquake and flood. Tehran: Municipality publication (second edition).

3. Ahadnezhad Roushani, m et al (2000). Modeling of building vulnerability from earthquake. The proceedings of the first international conference of natural disasters in urban areas. Tehran: The office of urban planning studies.

4. Ahari, z. et al (1991). The minimum house. The Ministry of housing and urban planning, second edition, No 101, Research Center Press of Building and House.

5. Ahmadi, H. (1997). The role of urban planning in reducing the vulnerability of the city. Maskan va Enghelab, the Specialty Quarterly of Housing Organisation.

6. Akson, j.b,2004. Perceived earthquake-include effects and their relation to recorded strong ground motion as well as structural and none-structural damage. Earthquake Engineering Research Center, Engineering Research Institute at the University of the Island, Selfoss.

7. Arian, m. (2003). Iran and geological reasons of earthquake. Monthly Journal of Municipalities, Special Letter, no 12.

8. Asgharimoghadam, m.r. (2000). Natural geograohy of cit (1), geomorphology. Masa, 1, Tehran.

9. Barbarian, m. (1992). Research and investigation of construction land and investigation of the new depth of construction land, and danger of earthquake-breaking in Tehran development. Geology Organization of the Country.

10. Basoglu, M., Salcioglu, E., Livanou, M., 2002. Traumatic stress responses in earthquake survivors in Turkey.Journal of Traumatic Stress 15 (4), 269–276.

11. Bayat, H. (3003). The evaluation of the vulnerability of buildings units and the solutions for metamorphosing. The Symposium of Bam earthquake, national Organization of Land and Housing, Tehran, 36-41.

12. Bryant, E.A., 1993. Natural Hazards. Press Cindicate of the University of Cambridge, Melbourne.Cannon, J.T., 2003. Experiences of the Loma Prieta Earthquake: A Narrative Analysis. UMI-ProQuestInformation and Learning Company, Michigan.

13. Bo¨dvarsdo´ ttir, I´., Elklit, A., 2004. Psychological reactions in Icelandic earthquake survivors.ScandinavianJournal of Psychology 45, 3–13

14. Cannon, J.T., 2003. Experiences of the Loma Prieta Earthquake: A Narrative Analysis. UMI-ProQuest Information and Learning Company, Michigan.

15. Durkin, M.E., 1993. Major depression and post-traumatic stress disorder following the coalinga and chile earthquakes: a cross-cultural comparison. In: Allen, R. (Ed.), Handbook of Post-Disaster Interventions. Journal of Social Behavior and Personality 8 (5), 405–420 (special issue). California: Select Press.

16. Ghafory- Ashtiany,M (1992), " Rescue Operation and Reconstructions in Iran", Disaster Prevention and Management, Volume8,Number 1, MCD University, ISSN0965-3562.

17. Golabchi, M & Taiebat, M (2006). The reasons of village building instability against earthquakes and providing construction model based on the local facilities and abilities: The case study of Zerand, Kerman. The Journals of Fine Arts, 30, 31-42.

18. Marcuson, W.F. et al. (Eds.), 2003. Preventing Earthquake Disasters: The Grand Challenge in EarthquakeEngineering.National Research Council, the National Academies Press, Washington, DC.

19. Mea,ari, A.M. & Khandani, N. (2000). Systems against earthquake in the village building. The housing Institution of Islamic Revelution, Tehran, 63-65.

20. Mohammadi, M. (2000). Housing challenges and building density. The Quarterly of Apartment Buildings, 2 (8)

21. Monzavi, M. et al (2010). The vulnerability of the deteriorated texture of the central area of Tehran against earthquake) Case study of region 12. The Quarterly of research off Human Geography, 73, 1-8

22. Mosayebzade, A. (2000). The way of behaving toward unofficial housing. An unpublished MA thesis of urban planning submitted to the faculty of art and architecture, Shiraz Unversity.

23. Nagle Garret (2005), Urban geography a Global perspective, Routledge, Tylor and francis Group.

24. Negaresh, H. (2005). Earthquake, cities and flouts. The Quarterly of Geographical Research, 19 (4), Ghods Razavi, Mashhad.

25. Pourmohammadi, M. (2002). Housing challenges and building density. The Quarterly of Apartment Builders, 2 (8).

26. Tehran (2005). Detailed Plan.

27. Zangiabadi, A. & Tabrizi, N. (2005). Tehran earthquake and the assessment of spaces vulnerability of the urban areas. The Quarterly of Geographical Researches, 56, 115-130.