The Urban Fabric and Its Impact on Reducing the Vulnerability against Earthquake

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Abstract: In spite of human's wondrous advances in technology, the earthquake has still been an unpredictable phenomenon that any negligence to how to deal with it will lead to catastrophic damages to the human habitations. Due to the diversity of its topics, urbanism knowledge can play an effective role in decreasing damages of the earthquake. The main objective of this article is to recognize the current available problems and difficulties in the common patterns of urban fabric and to find a solution for earthquake-related problems. The methodology of this research has been designed according to the results of descriptive- inductive and library surveys; and its analysis method is inductive-modeling. Additionally, modern knowledge of GIS (Geographic Information System) and AHP (Analytic Hierarchy Process) is used along with urbanism criteria to assess the vulnerability of two common patterns of urban fabric including chess and organic fabrics. Results demonstrate that the chess fabric provides better conditions in decreasing earthquake-based damages rather than organic fabric.
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1. Introduction

Although earthquake is considered a natural phenomenon, but it has always another face: catastrophe. Although todays advanced knowledge has realized many aspects of the earthquake occurrence and its consequences, but earthquake is still regarded as an uncontrollable phenomenon whose happening can lead to sever damages in cities, especially in the cities of developing countries. Throughout the 20th century, fatal earthquakes have occurred in 75 countries of the world and have killed at least 1.5 million people, apart from countless material and financial damages. Given the fixed average rate of morality, it is predicted that more than 2 million people will die by the earthquake in 21st century. The result of such a catastrophe is a loss of 5 trillion USD in global economy, and the equivalent loss due to the destruction of buildings (Nicholas, 2005). The evidences show that the threat of the earthquake in urban areas at the global level is being expanded and this increasing threat is indeed a serious problem for developing countries (Tucker et al, 1994: 10). It is estimated that approximately 95% of the global victims of natural disasters- like earthquake- belong to developing countries and the victims of these countries are 20 times more than the victims of similar disasters in developed countries (Kreimer et al, 2003: 2). Linear and unilateral ways to approach the natural disasters that consider such disasters as a static phenomenon have shown that they have failed to reduce the damages of natural disasters in past 25 years. To reform such a process, the planners have to move toward sustainable decrease in the consequences of the natural disasters (Mileti, 1992: 2). What has been neglected in this process is the role of urbanism knowledge that can have a contribution in reducing the damages of the earthquake. In this research, firs the theoretical foundations and global experiences will be proposed, on the basis of which the indexes of the research will be determined. Then regarding the methodology of the research, the analytical model will be explained. Finally, the obtained results on the basis of the research model will be presented for the studied areas.

2. Methodology

This research is a practical one because the use of its results is clear from the very beginning. The main objective of this strategic research is to understand available problems in the current patterns of urban fabric and to think about resolving such problems against the earthquake. In this regard we have used archival and library studies, global experiences, related models for Iran, other research projects especially the researches by the Iranian Center for Encountering Natural Disasters managed by Dr. HoseinBahreini who conducted several researches for the mentioned center on the fabric of Manjil, Loushan, and Roudbar cities (1990). After these researches were studied, the needed indexes were selected on the basis of the analytical model of the research. Besides, to assess the authenticity and precision of these indexes, AHP technique has been used to weight and evaluate the indexes. Then at the next stage, the vulnerability due to each of these indexes was specified in GIS software on the selected zones of Shahrak-e Qarb and Darakeh. Then considering the importance rate as shown in previous stage (AHP), these zones of vulnerability will be studied in more carefulness and precision. Finally, we will obtain a map in which the vulnerability due to the earthquake will be given at the level of the block on the basis of the suggested analytical model.

3. Literature review

Since Iran is located on the Alps - Himalaya belt and its high seismicity, earthquake and its related subjects have always been focal issues in Iran. Although according to the report of United Nations Department of Planning, Iran stands at the first position of the number of earthquakes higher than 5.5 Richter (UNDP, 2004: 35), but still there is not a written and systematic plan for reducing the damages of the earthquake compatible with the local characteristics of Iran. The most ever comprehensive research project in Iran is the project of classification of arenas of Huge Tehran in cooperation with Japanese International Cooperation Agency that was administered during the March to November 2000 (JICA, 2000). As it is obvious from its title, the project is going to evaluate the vulnerabilities of four models of earthquake due to Northern Tehran fault, Rey fault, Masha fault, and floating model for Tehran city. The research plan of the Iranian Center for Encountering Natural Disasters entitled The role of form, pattern, and size of houses in reducing the threats of earthquake is another useful plan that was conducted in 1994 under the administration of HoseinBahreini and MalihehMohammdi in the region of Manjil, Loushan, and Roudbar.

Although JICA researches was systematically engineered, but they have no specific focus on the urban fabric and its outputs are obtained for the suburban scales. Moreover, although the researches of Iranian Center for Encountering Natural Disasters don't lead to providing vulnerability maps and don't offer any technical model, but since these researches have been administered by the experts of urbanism and focus on the urban form and fabric, thus they are useful theoretical sources for this research.

3.1. Studying the global experiences on the planning for reducing the vulnerabilities resulted from the earthquake

In the literature of the earthquake, vulnerability is the scale of tolerance, resistance, or rescue from the effects of a natural disaster in long- term and short-term periods of time (Mileti, 1999: 106). Generally, urban vulnerability against the natural disasters like earthquake is a function of human behaviors and shows the degree of effectiveness or tolerability of urban socio- economic units or urban physical assets against that natural hazard (Rashed and Weeks, 2003: 547). The final goal of this research is to arrive to a solution that can reduce the damages due to the earthquake. Thus it is necessary to firstly study the global experiences in relation to the subject of the research. In this regard, the activities of two developing countries (India and Colombia) and two developed countries (USA and Italy) are studied.

3.1.1. India

India is one of those countries that have a suitable system and planning for their risk and crisis management. This country uses remote sensing (RS) method in its crisis management besides using Geographic Information System (GIS). The main goal of RS is to find hazardous zones on the basis of the location of the buildings, land uses, building inputs, and to provide optimized services of fire fighting for necessary responses management. Necessary responses system collects the geographic- descriptive data and links these data to each other to do the geographic analysis and to overlap the information layers. Geographic data of this system includes the maps of land uses, poor residential zones, firefighting stations, police stations, water reservoirs, and roads network. Risk zones are identified by entering mentioned data to the Geographic Information System and combining the data. Then the accessibility ways to these risk zones are identified by roads data and the speed of the vehicles (Fathi, 2006: 51).

3.1.2. Colombia

Bogota is the capital of Colombia. Due to the sever damages of the earthquake since 1980,the authorities of the city decided to create a model to estimate the risks of the earthquake. The mentioned model was provided in 1955 in which the triple stages of risk reduction and earthquake risk estimation includes the following:

a. Assessing the risk of the earthquake and detailed classification of the urban zones;

b. Estimating different scenarios of earthquake-related damages;

c. Formulizing and applying measures of reducing earthquake- related risks.

After providing the needed data as the inputs of the model, all data are gathered and classified in database. At the first step, the importance degree of each index and the preliminary degree of vulnerability are specified under the natural conditions and their vulnerability degree under the earthquake occurrence conditions to estimate the earthquake risks estimation for the city. In 2003 a more comprehensive model was written for the city that included indexes for vulnerability assessment and disaster risk management. In this new model, a comprehensive approach on the basis of hierarchical multi-criteria model (AHP) is used to determine the relative relationship of the indexes and their weightings; and Delphi method is used to determine the preliminary hierarchy of the indicesso that 19 zones are assessed for their vulnerability and risk estimation (Barbatm 2003). Table 1 shows the indices of this model.

Table 1. Indices and weights used in earthquake risk management of Bogota City in Colombia

<table>
<tr><th>Total Index</th><th colspan="3">Indices</th><th>Symbol</th><th>Variables</th><th>Significance Coefficients</th></tr>
<tr><td rowspan="24">Total indices of risk estimation (IT)</td><td colspan="3" rowspan="5">Physical Indices (I_{ph})</td><td>X_{ph2}</td><td>Probable damaged areas by the earthquake occurrence</td><td>0.30</td></tr>
<tr><td>X_{ph3}</td><td>Number of victims (dead and injured)</td><td>0.30</td></tr>
<tr><td>X_{ph4}</td><td>Interruption of water networks</td><td>0.10</td></tr>
<tr><td>X_{ph5}</td><td>Interruption of electricity networks</td><td>0.20</td></tr>
<tr><td>X_{ph6}</td><td>Interruption of telecommunication networks</td><td>0.05</td></tr>
<tr><td rowspan="19">Other secondary indices (I c)</td><td colspan="2" rowspan="4">Risk Indices (I_{Hc})</td><td>X_{HC1}</td><td>History of earth velocity in time T</td><td>0.05</td></tr>
<tr><td>X_{HC2}</td><td>Areas located in soft soils</td><td>0.44</td></tr>
<tr><td>X_{HC3}</td><td>Areas affected by soil liquefaction</td><td>0.24</td></tr>
<tr><td>X_{HC4}</td><td>Areas capable of landslide</td><td>0.16</td></tr>
<tr><td rowspan="15">Vulnerability Indices (I_{Vc})</td><td rowspan="5">Being exposed (0.25)</td><td>X_{E_1}</td><td>Mean of population</td><td>0.25</td></tr>
<tr><td>X_{E_2}</td><td>Population density</td><td>0.20</td></tr>
<tr><td>X_{E_3}</td><td>Built residential areas</td><td>0.25</td></tr>
<tr><td>X_{E_4}</td><td>Built industrial areas</td><td>0.15</td></tr>
<tr><td>X_{E_5}</td><td>Built official and administrative areas</td><td>0.15</td></tr>
<tr><td rowspan="4">Vulnerability (0.40)</td><td>X_{F_1}</td><td>Urban slum areas</td><td>0.40</td></tr>
<tr><td>X_{F_2}</td><td>Mortality rate</td><td>0.10</td></tr>
<tr><td>X_{F_3}</td><td>Unemployment rate</td><td>0.10</td></tr>
<tr><td>X_{F_4}</td><td>Population dispersal</td><td>0.40</td></tr>
<tr><td rowspan="6">Responsibility (0.35)</td><td>X_{R_1}</td><td>Number of hospital beds in one unit</td><td>0.15</td></tr>
<tr><td>X_{R_2}</td><td>Number of nurses and physicians in one unit</td><td>0.15</td></tr>
<tr><td>X_{R_3}</td><td>Percentage of open spaces to overall spaces</td><td>0.15</td></tr>
<tr><td>X_{R_4}</td><td>Situation of aiding forces and firefighters</td><td>0.15</td></tr>
<tr><td>X_{R_5}</td><td>Rate of development</td><td>0.20</td></tr>
<tr><td>X_{R_6}</td><td>Planning the readiness and emergency aids</td><td>0.20</td></tr>
</table>

Source: Barbat, 2003

3.1.3. Italy

In all used methods in Italy, each of the vulnerability indices is assigned a specific weight which implies high significance, average significance, and low significance in determining the final degree of the vulnerability. The newest and most complete method of estimating earthquake risk in Italy is SERGISAI method, in which the earthquake risks are assessed using a geographical information system and artificial intelligence technique, in two forms, one absolute form and a probable form (table 2). In table 2, A+ means the highest level of vulnerability, A means high level of vulnerability, B means average level of vulnerability, C means low level of vulnerability, and D means the lowest level of vulnerability. Moreover, when the vulnerability degree is "n.r", it means that the vulnerability will be determined for each city separately (Menoni and Pergalani,1996:9-10).

3.1.4. USA

In 1979, US president ordered the aggregation of all responsible centers that are related to crisis management at the national level in a federal agency of emergency management. This agency aimed to reduce the damages to lives and capitals and thus it designed a software program named HAZUS. This model deals with assessing the earthquake- related damages using mathematical formulas, information of buildings resistance, geological information, earthquake center, earthquake magnitude, and other needed information (FEMA, 1997). Using the results of such an assessment, one can rapidly estimates the number of destroyed or damages buildings, the number of the victims and injured people, the scale of destruction of transportation system, the interruption of water and electricity networks, the number of the people who have to evacuate the houses, and the needed budget to compensate the damages of the earthquake. Along with the mentioned model, since 1985, the Supervising Committee of American Constructions suggested a set of rules related to new built constructions and buildings in relation to the earthquake and consequently requested for defining a model of risk analysis at the level of local states. The model that completed in 1991 for California State is able to simulate the earthquake with 12 different methods in 7 different magnitudes. Using this model we can obtain the landslide due to the earthquake from one place to another in the country. Accordingly, for every specific area, some specific rules are regulated in compatible to that area.

Table 2. indices for assessing the vulnerability of Toscana city in Italy

Indices			Significance level	Vulnerability situation
Natural	Landslide		1	D
	Land surface instability		1	D
	Topographical situation (peaks and valleys)		1	D
Artificial	Dangerous land uses		1	A
	Residential uses		0.75	D
	Industrial uses		0.75	n.r
	Historical uses and heritage & valuable buildings		0.50	B
	Public facilities	Schools	1	D
		Police stations	1	D
		Firefighting stations	1	C
	Vital arteries	Electricity	0.75	n.r
		Telephone	0.75	n.r
		Gas	0.75	n.r
		Water and wastewater	0.75	n.r
	Communicative networks	Biological areas	1	n.r
		Residential areas	1	n.r
		Hospitals	1	n.r
		Vital facilities	1	n.r
Social	Population density		1	C
	Family dimension		0.5	C
	Age composition		0.25	C
	Public trainings and public awareness		0.75	C

Source: Menoni and Pergalani,1996: 9-10

In 1997, a research group of earthquake engineering of California provided a model named The Earthquake Disaster Risk Index (EDRI). EDRI model is composed of synthetic indices that can be used to determine the risks of earthquake crisis ate the level of the city, region, or even cross-regional level (Table 3) (Davidson, 1997:112).

Comparing the important factors of the programming and planning of these 4four countries shows that some indices like the type of the materials and building constructions, type of land use, topographical features, communicational networks, and aiding and treatment forces are repeated in the indices of all these countries.

4. A close look at the concept of urban fabric

This research emphasizes on the planning for reducing the damages of the earthquake in the concept of the urban fabric. Thus it is necessary to clearly define urban fabric concept. Following points can be specified in the definition of urban fabric:

A. Aggregation and interconnectedness of the urban spaces and elements that have been replaced due to the environmental characteristics, especially the topography of the urban areas, i.e. blocks and urban zones that have been built in a discrete highly-ordered manner (Tavassoli, 2007: 5).

B. Skeletal form of a zone (Cowan, 2008: 421).

C. The way of separating the elements and the density in space (Lynch &Rodwin, 1958: 201).

D. Buildings, their land blocking, internal subsidiary paths, and open spaces (Hamidi, 1994: 45).

E. Formation of the city and its urban development steps during the history (Soltanzadeh, 1996: 299).

F. Urban fabric is composed of three related elements:

a. Designing communicative networks that specify the array of networks of streets and paths and the pattern of land and building separation and is affected by the life style and culture of the citizens.

b. Patterns of uses that show the space and land uses.

c. Designing the space or skeletal structures on the land that totally form the urban fabric (Amini, 2006: 88).

Thus it is to be said that urban fabric is a set of natural features of earth ground, paths network, and way of building and open spaces.

Table 3. Selected indices in EDRI model

Main factors	Indices	Variables
Risk	Landslide	X_{H1}: earthquakes with return periods of 50 years
		X_{H2}: earthquakes with return periods of 500 years
		X_{H3}: percentage of urban areas that are placed on feeble soils
	Subsidiary risks	X_{H4}: percentage of urban areas that are placed in areas with liquefaction
		X_{H5}: percentage of wooden buildings
		X_{H6}: population density
		X_{H7}: potential for tsunami occurrence
At-risk factors	At- risk skeletal infrastructures	X_{E1}: population
		X_{E2}: GDP size
		X_{E3}: number of residential units
		X_{E4}: percentage of urbanized areas to the whole under- studied areas
	At-risk population	X_{E5}: population
	At-risk economics	X_{E6}: GDP size
Vulnerability	Vulnerability of urban infrastructures	X_{V1}: earthquake codes
		X_{V2}: city income
		X_{V3}: city age
		X_{V4}: population density
		X_{V5}: rate of city development
	Population vulnerability	X_{V6}: percentage of mature population of 4 to 65 years old
External factors	External factors effective on the economy	X_{C1}: economic factors
	External factors effective on the politics	X_{C2}: internal politics situation
		X_{C3}: external politics situation
Prompt actions, responsibility, and programming for improvement	Programming	X_{R1}: programming situation
	Resources	X_{R2}: GDP size
		X_{R3}: rate of emptiness of residential units
		X_{R4}: number of hospitals per each 100,000 person
		X_{R5}: number of physicians per each 100,000 person
	Accessibilities	X_{R6}: climatic situations
		X_{R7}: population density
		X_{R8}: the area of the city

Source: Davidson, 1997: 112

4.1. Organic fabric

Organic fabric is often seen in the regions that have a longer history. In such a fabric, there is no pre-though plan and the paths network is usually based on the walking on foot and the ups and downs of the region and are partially linked to their adjacent areas. Another characteristic of this fabric is the spatial privation and dead-end being of the paths. In many sections the paths are getting narrow to prevent the entrance of the strangers. Additionally, many alleys are dead-end to reduce the high traffic. Moreover, the traffic of the cars is decreased and the internal traffic is usually very low.

Based on its un-designed nature, organic fabric creates some disordered paths. Since the transporting network is an important factor in shaping the masses and the buildings, thus the blocks are formed in a disordered composition. The rate of the destructions in diverse patterns that are obtained in this way will be different. The shape of the occupied floor in every land block is effective on the way of destruction of the buildings. Besides, the order of the infrastructure in combination of the blocks is effective regardless of the building specifications, due to their effect on the adjacent buildings and their reliance on each other. Heterogeneity and disorder of the block pattern will increase the possibility of their destruction due to their destruction pattern on the consistency of the fabric because such factor increases the transmitting forces of any building to other buildings (Hamidi, 1994: 102 & 104). Regarding all these points, the characteristics of organic fabric can be mentioned as shown in table 4.

Table 4. The characteristics of organic fabric

Existential nature	Paths network	Blocks shape	Pattern of building composition
On the basis of ups and downs of the land, its natural features, and the significance degree of the land uses	Disordered, curved, lots of dead- ends, low- width paths, little connection with adjacent areas, being dumb in finding destinations, limited accessible paths	Disorder in the shape and in the area of the blocks	Disordered, non-clarity of the way of placing the arena of the blocks

Source: author

4.2. Chess fabric

In this fabric, network is considered as an absolutely grid- iron geometric shape and it is usually called grid- iron plan. The network is converted to a grid- iron plan when it contains square and equal blocks. In this case, it is given that the map of the chess network can be expanded to all its surrounding dimensions by adding more blocks to its surrounding area (Moutin, 2007: 229). In such a fabric, the ordered and chess pattern of the paths network creates a congruent composition of the blocks. The shape of each block and the way of blocks combination and order is important in the shaping of each fabric type and its vulnerability specifications. The effects of the blocking on the vulnerability are not direct effects, but its consequences can lead to decrease or increase of the damages. Ordered (chess) patterns are effective on the similarity of the building patterns due to their blocking and blocks composition. Ordered building patterns probably decrease the damages due to their uniformity of the force transmissions to the adjacent buildings (Hamidi, 1994: 102). Table 5 summarizes the characteristics of chess (pre-thought) fabric.

Table 5. The characteristics of chess fabric

Existential nature	Paths network	Blocks shape	Pattern of building composition
On the basis of pre-thought pan	Have a specified plan, diversity in accessible paths to the spaces, the congruence between the paths width and the number of the blocks, ordered and direct subsidiary paths, affluence of the intersections	Square or rectangular geometric shapes, congruent composition of the blocks, ease of the repairs due to the ordered shape of the blocks and their adjacency to the paths	Ordered, similar building patterns, clarity of the way of placing the arena of the blocks

Source: author

5. Looking at the methodology of the research

According to the proposed theoretical foundations, the operational indices in assessing the vulnerability of urban fabric against the earthquake that have been selected for this research are as shown in Fig. 1 respectively.

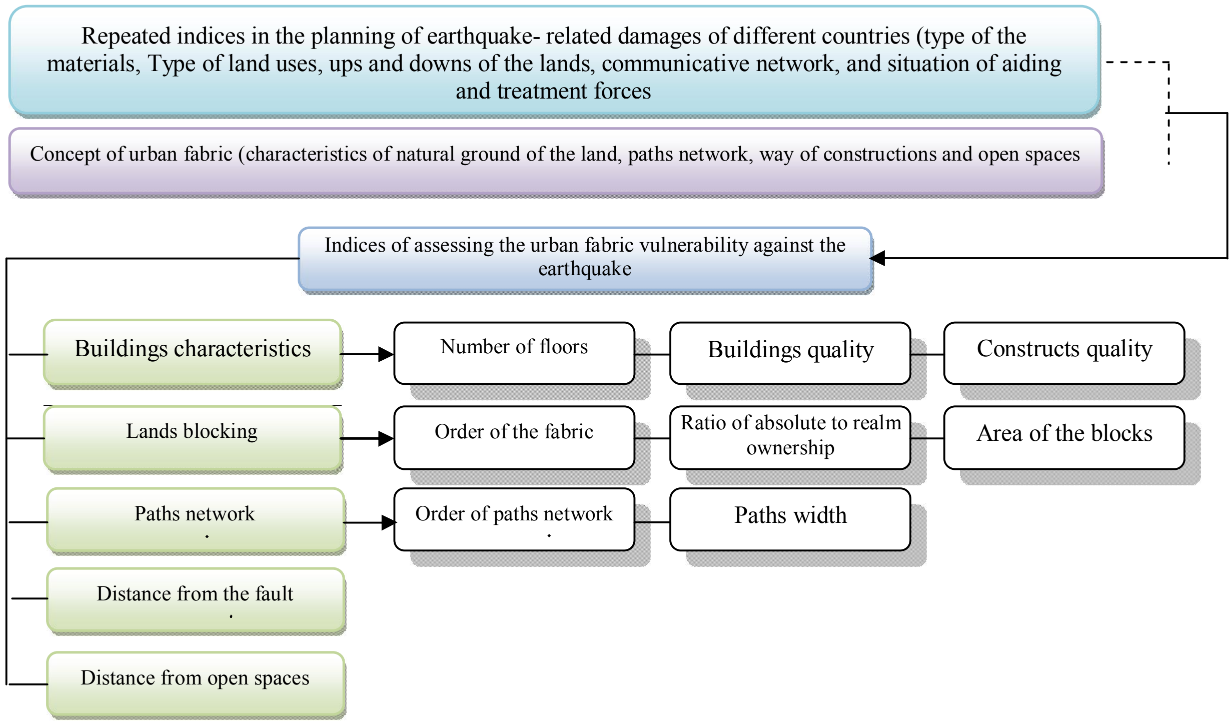

Fig 1. Indices of assessing the urban fabric vulnerability against the earthquake
Source: author

On the basis of research indices, database of two zones in ShahrakeQarb of Tehran have been selected for the chess fabric and Darakeh has been selected for the organic fabric. The maps of these zones have been obtained from GIS software but they are not presented here due to the limitations of the research. At the next step, AHP hierarchical structure was formed whose assessment is being done on the basis of the matrix as shown in table 6.

Table 6. Assessment matrix

Criterion	Buildings characteristics			Lands blocking			Paths network		Distance from open spaces	Distance from the fault
Sub-criterion	Number of floors	Buildings quality	Constructs quality	Order of the fabric	Ratio of absolute to realm ownership	Area of the block	Order of paths network	Paths width		
Limit A	1 to 2	New built	lasting	Suitable	60% and less	201m2& more	Suitable	More than 12m	Less than 50m	More than 1000m
Limit B	3 to 5	Maintainable	Relatively lasting	Relatively suitable	61 – 70%	101 – 200m2	Relatively suitable	6 – 12 m	50 – 100 m	300 – 1000 m
Limit C	6 and more	Destructible	Weak	Unsuitable	71% and more	100m2 and less	Unsuitable	Less than 6m	More than 100 m	Less than 300 m

Source: author

After compiling the hierarchical structure of indices and sub-indices, on the basis of quantitative table 9 in AHP method, the significance coefficients (weights) of the index/ sub-index was calculated and finally the weight of the items were calculated in relation to each of the index/ sub-index. The results are summarized in tables 7 and 8.

Table 7. Significance coefficients of the limits in relation to each criterion/ sub-criterion

Explanation	Number of floors	Buildings quality	Constructs quality	Order of the fabric	Ratio of absolute to realm ownership	Area of the block	Order of paths network	Paths width	Distance from open spaces	Distance from the fault
Limit A	0.637	0.649	0.672	0.735	0.649	0.715	0.722	0.722	0.735	0.649
Limit B	0.258	0.279	0.265	0.207	0.279	0.218	0.227	0.227	0.207	0.279
Limit C	0.105	0.072	0.063	0.058	0.072	0.067	0.051	0.051	0.058	0.072

Source: author

Table 8. final Significance coefficients of the limits in relation to each criterion/ sub-criterion

Explanation	Number of floors	Buildings quality	Constructs quality	Order of the fabric	Ratio of absolute to realm ownership	Area of the block	Order of paths network	Paths width	Distance from open spaces	Distance from the fault
Limit A	0.0210	0.1515	0.1569	0.0054	0.0100	0.0008	0.0259	0.1813	0.1036	0.0311
Limit B	0.0085	0.0651	0.0619	0.0015	0.0043	0.0002	0.0081	0.0570	0.0292	0.0134
Limit C	0.0034	0.0168	0.0147	0.0004	0.0011	0.0001	0.0018	0.0128	0.0082	0.0034

Source: author

At the final step for testing the results, the incompatibility index is calculated that locates in the allowed limit as follow:

Incompatibility index $C.R = \frac{C.I}{R.I} \leq 0.1$

$C.I = \frac{L-n}{n-1} = \frac{5.305-5}{5-1} = 0.076$

$C.R = \frac{0.076}{1.12} = 0.068 < 0.1$

After determining the final significance coefficients of the items (i.e. defined limits of vulnerability) obtained values (with coefficient 1000 to remove the decimals) were inserted to GIS environment and the score of the blocks were calculated to reduce the vulnerability. Since the vulnerability may not be useful in micro scales, the vulnerability of the limits were classified in terms of the minimum and maximum scores of the blocks of ShahrakeQarb and Darakeh into 5 groups. Figures 1 and 2 show the related results.

Fig. 2. Scores of the blocks in the selected limit of ShahrakeQarb (Dadman Blvd.)

Source: author

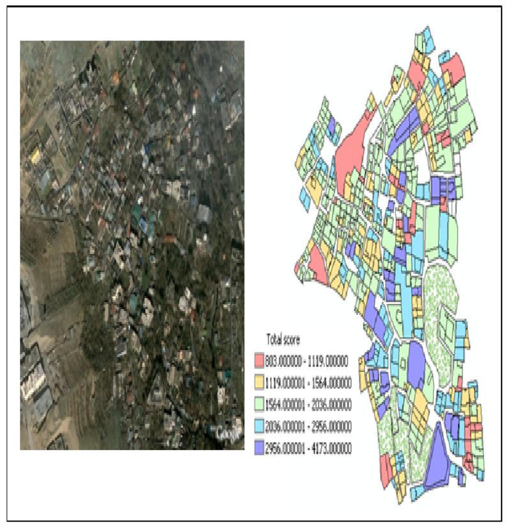

Fig. 3. Scores of the blocks in the selected limit of Darakeh

Source: author

As it is shown in above figures, minimum and maximum scores for the blocks of ShahrakeQarb limit are 2923 and 6679 respectively. The equivalent scores for Blocks of Darakeh limit are 803 and 4173 respectively. The mean of the scores of the blocks in the limit of chess fabric is 4551 and the mean of the scores of the blocks in the limit of organic fabric is 1855. Indeed, the main reason for the difference of the scores of the first and the second limits is that the first limit has the blocks with an ordered and organized fabric and paths network and specially the specifications of its buildings are suitable and their distance from the fault, along with their good location of the open spaces. The results show that the mere focus on each of the indices, especially the mere focus on the specifications of the buildings cannot lead to reduction of the vulnerability of the buildings [1]; but the mentioned indices have to be assessed along with each other. In other words, it has to be emphasized that the totality of the fabric has to be studied with each of its components to have a good assessment of the vulnerability against the earthquake.

6. Discussion and conclusion

In this research, we estimated the rate of vulnerability using an AHP hierarchical method in which the final significance coefficients of the items (i.e. three limits with high vulnerability, average vulnerability, and low vulnerability) were determined. On the basis of the results of this method, the related database was completed in GIS software and the scores of the blocks were obtained in order to reduce the vulnerability against the earthquake. Final results showed a relatively high difference between the blocks of chess fabric and the blocks of organic fabric. On the other hand, there is an issue that has to be paid special attention: although mere focus on some limited criteria (like the specification of the buildings, defined in the scale of each block) can seems very effective, but when we expand our vision to the fabric of a set of blocks, we will find out that such limited criteria are no longer reliable. The evidence of such a claim can be seen in the scores that have been obtained for the blocks of Darakeh limit. Sustainability of a building is the first condition for the survival of the residents during an earthquake, but the problem is not limited to the right time of the earthquake occurrence. This interval is just a small part of a set of disasters that can lead to the death of the residents due to the earthquake occurrence. In post-earthquake conditions, the destruction of weak adjacent buildings of a resistant building can lead to the closure of the paths and consequently, makes the escape impossible or extremely hard. Hence, we have to look upon the post-earthquake steps. Is such cases we cannot merely emphasize on the specifications of the building, but we have to define a broader scope of activity and target the fabric of the whole set. Despite the obtained results, we cannot generalize the presupposition that implies that pre-thought chess fabric is more resistant than the organic fabric or we cannot generalize the presupposition that implies that vulnerability of the former fabric (especially in its social damages and human moralities) is less than the vulnerability of the latter fabric in all regions, because some other indices like geological conditions (like the distance from the fault), demographical features, and many other indices are very important in determining the scale of vulnerability of any urban limit. Indeed, although we just studied the distance from the fault as a geological feature, but such features are well beyond the scope of this research. Additionally, there are so many factors that have been impossible for the researcher to study in this research. By and large, it is necessary to design a model in a completely precise and scientific model to be used in estimating the damages of the earthquake in terms of local characteristics. The researcher believes that the analytical model of this research can be completed by adding some precise indices and leads to clearer results.

Footnote

[1] This is regardless of the conditions where all the buildings of a limit are resistant. Otherwise, the destruction of weak buildings that are adjacent to a resistant building can be very problematic for the residents of that resistant building, especially after the earthquake occurrence.

References

1. Amini, Elham (2006), Explaining the Role and Function of Urban Fabric Planning in Reducing the Urban Vulnerability against the Earthquake, PhD Thesis, Azad Islamic University, Sciences and Research Branch.
2. Tavassoli, Mahmood, (1979), Old Fabric, An Introduction to the Problem, Congress for Survival in Fabric of Iranian Old Cities, Tehran.
3. Hamidi, Maliheh, (1994), The role of form, pattern, and size of houses in reducing the threats of earthquake, Iranian Center for Encountering Natural Disasters.
4. Soltanzadeh, Hossein, (1986), An Introduction to the History of City and Urbanism in Iran, Abi Publications, Tehran.
5. Fathi, Hamid, (2006), Identifying the Relationship between Urban and Regional Planning and Earthquake Risk Management; Case Study: Region 14 of Tehran City, MSc. Dissertaation, Arts and Architecture Faculty, Shahid Beheshti University of Tehran.
6. Moutin, Cleaf, (2007), Green Dimensions of Urban Planning, Publications of Process and Urban Planning, Tehran Municipality.
7. Barbat, Alex (2003), Vulnerability and Disaster Risk Indices from Engineering Perspective and Holistic Approach to Consider Hard and Soft Variables at Urban Level, IDB/IDEA Program of Indicators for Risk Management, National University of Colombia, Manizales.
8. Cowan, Robert (2008), The Dictionary of Urbanism, Streetwise Press.
9. Davidson, Rachel (1997), An Urban Earthquake Disaster Risk Index, The john A. Blume

Earthquake Engineering Centre, report no.121, Stanford, California: Blume Centre.
10. FEMA, Federal Emergensy Management Agency (1997), Earthquake Loss Estimation Methodology HAZUS, Technical Manual, Vol I, II and III, National Institute of Building Science of Federal Emergency Management Agency, Washington.
11. JICA and CEST (2000), The study on microzoning of the Great Tehran area, Tehran municipality.
12. Kreimer, A. Arnold, A. and Carlin, A. (2003), Building Safer Cities, The Future of Disaster Risk, Disaster Risk Management Series, Vol.3, The Worldbank.
13. Menoni, Scira and Pergalani, Floriana (1996), An Attampt to Link Risk Assessment with Land-use Planning: A Recent Experience in Italy, Disaster Prevention Management, Vol 5, MCB UO Ltd.
14. Mileti, Dennis (1999), Disasters by Design: A reassessment of Natural Hazards in the United States, Joseph Henry Press.
15. Nicholas, J. M. (2005), A Major Urban Earthquake: Planning for Armageddon, Landscape and Urban Planning, Vol. 73, Issues 2-3, pp. 136- 154.
16. Lynch.K and Rodwin.L (1958), A theory of urban form, JAIP, Vol. 34, No.4, pp.201- 214.
17. Rashed, K. and Weeks, J. (2003), Assessing Vulnerability to Earthquake Hazards through Spatial Multicritica Analysis of Urban Areas, International Journal of Geographic Information Science. Vol. 17, no.6, pp. 547- 576.
18. Tucker, B., Trumbull, G., and Wyss, S.(1994), Some Remarks Concerning Worldwide Urban Earthquake Hazard and Earthquake Hazard Mitigation, in: Issues in Urban Earthquake Risk, Netherlands Kluwer Academic Publishers.
19. UNDP (2004), Reducing Disaster Risk: A Challenge for Development, A Global report, New York, NY 10017, USA: Breau for Crisis Prevention and Revovery.

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