



## **ATTRITIONAL STRUCTURES THE MAJOR FACTOR IN INCREASING ENDANGERMENT BY EARTHQUAKES IN CITIES**

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### **ABSTRACT**

*Designed and organized structures show increased resistance compared to organic and compressed ones when facing natural dangers. Based on Islamic indices of the Department of roads and city construction regarding old constructs, the main organic weaves of cities are included in this definition. So, near one eighth of the city population of Iran resides in such structures. This matter has made attention to renovation and strengthening of this immense volume of city structure more necessary. In this planning, attention should be devoted to special design of spaces for safe evacuation, design of public passageways in accord with prevention of blockage at the time of earthquake, and dangerous city facilities such as gas provision networks and the building material of the ground. Only with strengthening of these structures, people can to some extent in case of occurrence of an earthquake have peace of mind and live without fear. In this paper which has been formulated based on an applied and descriptive-analytic method, it has been endeavored concurrently with analysis of past actions to introduce new executive strategies for the purpose of decreasing riskiness in these structures.*

**Keywords:** City, Attrition, Old texture, Identification criteria, Earthquake, Vulnerability, Executive solutions.

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### **Contribution/ Originality**

This study based on the approved urban development plans was conducted to document the dangers of earthquakes and its influence on the damaged area with regard to the specific circumstances of the tissues. Also, this study by analyzing the vulnerability factors provides executive solutions in this field.

### **1. INTRODUCTION**

Now a day, city vulnerability particularly old and aged structures in face of earthquakes has confronted specialists in various fields as a global issue. This situation in countries with a naturally risky construct such as Iran has effaced with more emphasis in the recent decades. The establishment of the city of Tabriz in its current land where earthquake proneness is among its natural threats has confronted this city with dangers resulting from probable earthquakes and its various consequences.

Based on the general census of people and household in the year 2011, more than 54 million people of the population of the country reside in cities and 72 thousand hectares of the present city structure, based on indices announced by the department of road and city construction, are old and near 7 million of city dwellers reside in these structures. The high riskiness of these structures in face of natural disasters, particularly earthquakes, has raised fundamental challenges for public and city officials in stabilizing these perimeters. On this basis, attritional city structures are considered one of the serious problems of our country's cities which is intervened in by three

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approaches rebuilding, improving and renovating by the government and city departments, because if stabilization of these structures is not taken seriously, it is possible that after an earthquake, no old structure will remain and this will be a huge catastrophe. In addition to large human casualty, great financial loss will follow. Also, city identity which has rooted mostly from these structures and reflects the city history will face serious threat.

Economic, social, managerial, skeletal factors, rules and laws, city development plans and some other direct and indirect factors have role in attrition of city structures. When city life in the city limits stagnates for some reason and no attempts are made to reinvigorate it, the city structure in that perimeter faces an attritional trend (Adibi, 2010).

Up to a few years ago, necessity for improving and renovating old structures was not sensed. Yet, with unpredicted events including destructive earthquakes in these few years in the country, this reality has become evident that a high percent of people live in the perimeter of old city structures and are at risk and the scar of old structures is sensed in the corpus of the city. Yet, it should be noted that in general improvement and renovation of old structures is not a simple task but very complex and multidimensional (Andalib, 2008). Identification of the reason for attrition is a necessity for presenting an appropriate plan for decreasing risk. Yet, what we will tend to more in this discussion is the skeletal and city development issues related to decreasing risk in face of earthquakes. Although, we strongly believe that attending the problem of eroded structures is not just a skeletal and city development issue and economic, social, cultural and other topics have fundamental position in this discussion. The method of research in this study was descriptive-analytic and it is applied. Statistical population includes the cities of Iran and the city of Tabriz is evaluated as a case study. Pathology of old structures in the context of confrontation with dangers of earthquakes and problems arising from it are among the goals of this study. Executive strategies for decreasing riskiness of old structures in face of earthquakes are evaluated. The concepts and definition of vulnerability are numerous in number and different literarily. Yet, in its simplest and most applied form, it means the level of harm incurred from a phenomenon that is potentially harmful. Now a day, this description of vulnerability is a limited, technical, shorter and mostly physical conceptualization. Vulnerability is the level of damages to a particular element at risk or a collection of such elements in case of occurrence of the dangerous factor and is generally described on a scale of zero (no damages) to one (total damage). Vulnerability is not a static phenomenon but is considered a dynamic and comprehensive process that changes the probability of losses and harms incurred by the mentioned factors and influences them (Sotoudeh, 2001). In fact, vulnerability in face of an earthquake is the degree of harm and loss resulting from the earthquake and in various societies; it differs based on the level of development and progress of the society (Chardon, 1999).

Earthquake risk is the result of interaction between its dangers and some vulnerable human activities such as city development and it can refer to the number expected of casualties, injured, financial losses and economic gaps resulting from natural phenomena. Therefore, elements in risk can be divided into human population, buildings, engineering works, public service applications, other sub structural facilities and environmental values in the region under consideration. Due to weakness in planning, inappropriate building design, carelessness in foundational implementation of developmental projects, lack of sufficient care regarding repair and maintenance and residence in lands at risk, they have turned into vulnerable locations in face of earthquakes (Sayah and Sahfi, 2010).

## 2. ATTRITIONAL STRUCTURES

The ratification by the higher council of city development and architecture in Iran has clearly identified what is meant by structure and attrition. On this basis, structural weave is an interaction of a spectrum that has formed with different morphologies during the period of city life history in the perimeters of the city or its outskirts in persistence and connection with the city. This spectrum can be formed from buildings, complexes, roads, spaces, facilities and city equipment or a combination of them. By attrition, it is meant loss of function or decreased use of one structure relative to the function of other city structures. Attrition of structures and their internal elements

happen either due to antiquity or lack of development and supervision plans based on the formation of the structure. The most important consequence of aging of a structure is the loss of its status in the minds of citizens (Zivyar, 2010). In general, old and eroded structure is one that has formed and emerged in the process of a long time and has now a day become surrendered to this age's technology. In other words, in the past and by virtue of time period, it has had logical and hierarchal functions. Yet, today it has become inflicted with deficiencies in terms of construct and function and cannot respond to the needs of the residents the way it should or must (Hanachi, 2003)

With these definitions, we understand that old structures are among the most vulnerable city regions in face of natural dangers particularly earthquakes. If we carefully evaluate the earthquakes that have occurred in recent years, we will become aware of the highlighted and increasing riskiness of aged structures in the face of earthquakes. Figure 1 represents the perimeters of the aged structures in the city of Tabriz and Figure 2 represents the ratio of area of the aged structure to the city department regions of the city of Tabriz.

### 2.1. Indices of Attrition or Criteria for Identification of Aged Structures

The Ministry of Roads and City Development has identified three important indices for identification of aged structures in Iran which are:

- Blocks where more than 50% of the buildings are unstable.
- Blocks where more than 50% of the public passages have a width less than 6 meters.
- Blocks where more than 50% of their buildings have areas less than 200 meters squared.

Off course, these indices are not reflective of all characteristics of attritional structures and with this regard, precise identification of aged city structures just based on these criteria has had problems associated with it. This matter has led to most cities including the expansive city of Tabriz to request for reevaluation of the perimeter of attritional structures ratified from the Ministry of Roads and City Development. Other factors that can be considered as criteria for identification of aged structures are as follows:

- Skeletal attrition
- Lack of access to inside the structure
- Environmental problems and high volume of pollution
- Deficiency in facilities for spending recreation time
- Poverty and exclusion
- Vulnerability in face of earthquake
- Low per capita of services
- Supra normal population (high population density)
- High density of low stability buildings
- Insecurity and social problems (Jahanshahi, 2003)

These matters describe most characteristics of aged structures. Yet, what we will attend to most is vulnerability in face of earthquakes which is considered the main reason of increased risk based on the three indices of instability, small granularity and lack of access.

### 2.2. The Method of Intervention in Aged Structures

- Improvement

In this intervention, the principle is fidelity to the past and protection of identity giving constructs. In activities related to improvement, significant intervention in corpus does not happen and help is provided for improvement of the conditions of the structure mostly by way of repair, strengthening and replacement of functions.

- Renovation

In renovation, there is emphasis on permanent activity of the space and with changes in the corpus, it is up to dated and will lead to creation of appropriate city spaces.

- Reconstruction

In this kind of intervention, not only there is no requirement for protecting the past, but also the purpose is creation of new biological and skeletal and spacial conditions and it is performed by way of destruction, elimination and rebuilding. In this situation, city spaces express totally new relationships with new faces or in their original appearance (Faraji, 2010).

Considering the above three interventions, the following actions have been taken by the government during the past years:

- Financial actions including financial exemptions and granting of discounts and subsidies
- Preparation of reform plans with identification of applications that have added value and determination of encouraging construction rules and laws
- Provision of land
- Collaborative methods of intervention

### 2.3. Earthquake

Earthquake is among natural factors that along history has brought along numerous harms and has taken the lives of thousands of humans. Yet, the results obtained from attention to the earthquakes that have happened in the past shows that it is not the earthquake that takes human lives, but collapse of building blocks on individuals is the main factor of morbidity and mortality in earthquakes, such that countries like Japan that are located in earthquake prone areas have been able with advanced technologies to increase the resistance of structures against earthquakes and by this way save human lives and turn earthquakes from a natural disaster to a natural incidence. The reason is that earthquake is in fact evacuation of energies stored in earth which shows increased intensity in fissures and faults.

Our dear country, Iran, due to being located on the Alp-Himalaya earthquake line is considered among earthquake prone countries and must like the experience of other developed countries, acquire multilateral policies for changing threat by an earthquake to a natural occurrence and this will not be possible except with serious effort by all individuals in society.

## 3. RESEARCH BACKGROUND

Various studies have been performed regarding riskiness of attritional city structures in face of earthquake. Safar *Ghaed et al. (2013)* studied the evaluation of variables influential on vulnerability of city residences in face of earthquake in Broujerd. *Monzavi et al. (2010)* examined the vulnerability of aged structures in the central region of the city of Tehran against earthquakes. *Ghadiri et al. (2011)* studied the explanation of the socio-spacial centrality of vulnerability to earthquakes in the city of Tehran.

### 3.1. Analysis of Past Endeavors

Interventions in the cities of Iran begins in 1932 with ratification of the law of founding and developing passageways and roads that city development based on destruction reaches its height in 1940. In the first developmental program of the government in 1947, a budget is allocated to old structures but does not get implemented due to occurrence of the Second World War and war issues. In the second developmental program, the law related to land ownership for implementation of developmental plans is ratified in 1969. In the third program also city well fare and revision of management of city matters becomes among the major goals of city development. Governmental city policies alongside with other policies in the years 1940 to 1965 leads to huge city population increase. Revision of the law of city departments and formation of the higher council for city development and architecture in Iran intensifies city innovation and improvement activities.

In the fourth development program (1967-1971) the law of city renovation and development was passed. For important cities, a comprehensive plan was ratified and ultimately the law of change of name of Ministry of Development and Housing to Ministry of Housing and City Development was accepted each of which had numerous positive and negative influences on cities and old structures.

In the fifth program for development (1972-1976) a special budget is allocated to city improvement and renovation which needed to be implemented in the framework of comprehensive, enlightening and detailed plans.

#### **- Actions Taken After the Victory of the Islamic Revolution**

The most actions and interventions in cities after the victory of the Islamic revolution occurred in the framework of policies with regards to plans for economic, social and cultural development of the Islamic Republic of Iran.

#### **- First Plan for Development (1988-1992)**

Plans for renovation and improvement with founding of the office of improvement of city structures was prepared in 1986 and in the year 1989 with the foundation of the «home builders» company, executive duties of development and improvement of city structures is delegated to this company and in 1990, the office of improvement of city structure is formed in the Ministry of Housing and City Planning.

#### **-Second Plan for Development (1993-1997)**

In 1995, the development and improvement company with the purpose of preparation and implementation of improvement plans for city structures is founded and this company begins plans of improvement of old structures and cultural axes with first priority.

#### **-Third Plan for Development (1999-2003)**

Attraction of collaboration and investment of private sectors and cooperatives is the most important goal of this plan in renovation and improvement of old structures.

#### **-Fourth Plan for Development (2004-2008)**

Identity allocation to the appearance and skeleton of cities, reviving of old and inappropriate city structures is among the main goals of this plan in the context of city development. Additionally, in the law of the fourth plan, it has been emphasized that the government is responsible for rebuilding and renovation of old city and village structures and strengthening of existing buildings against earthquake with use of internal and external resources.

#### **-Fifth Plan for Development (2009-2013)**

Based on the title 171 of the law of the fifth plan for development, the higher council of city development and architecture of Iran is dutiful to explore regions in need of improvement and renovation in old structures and classify plans in these regions with prioritization of plans that are implementable with collaboration of the people and support of the government, city departments and village departments in time. Additionally, the Ministry of Housing and City Development and city departments are dutiful each year along the program to revive and renovate at least 10% of old city structures and the government is responsible to allocate 50% of credits and granted facilities for the housing sector for implementation of various plans of housing provision in the perimeter of old city structures.

Ultimately, the global policies of the system, notified by the supreme leader, has emphasized securing and improving governmental, public and important buildings, detrimental vessels and sub structural facilities against shakes and rebuilding and improving old structures in at most 10 years.

#### 4. DISCUSSION

Executive strategies for decreasing riskiness of old city structures against earthquakes

Decreased riskiness of old structures against earthquakes requires that part of plans for city development be allocated for attainment of persistent city development.

If we do not have a correct understanding of dangers of earthquakes for old city structures, we will not be able to plan comprehensively and correctly for decreasing vulnerability of these structures against earthquakes. The reason is that “analysis and evaluation of riskiness are necessary prerequisites for aware decision making, determination of project prioritization, planning for actions for decreasing riskiness and identification of regions in great, moderate or low danger with attention to their vulnerability and advantageousness of potential interventions” (Crisis Management Mashad City Department, 2012). Correct implementation of national building laws and the 2800 guideline for earthquake, performance of detailed micro-zonation studies and utilizing it and correct design of old structures regarding provision of appropriate substructures and secure evacuation spaces, revision and strengthening of the accessible, city management responsive to persistent city development are considered main priorities and participation of people in this management, use of modern technology and ultimately practical strategies and effective actions after the incident can have deep effects on decreasing vulnerability of old structures in face of earthquakes.

##### 4.1. Micro Zonation Geotechnical Shaking Studies of the City of Tabriz

Figure 3 represents the situation of the Tabriz faults with demonstration of buffer zone regions. Micro zonation Geotechnical Shaking Studies of the City of Tabriz were performed in 2009 by consultant engineers in Tehran Padir with management by the department of housing and city planning of the province. Table 1 represents the estimation of human casualties of the city of Tabriz in these studies.

Additionally, according to these studies, near 16% of the surface area of the city of Tabriz is located in the region with higher than average risk. The latter holds while if we subtract large empty of resident regions such as 9 and 7 from the total surface area of the city, the ratio of surface area with high and very high risk relative to residential and constructed city areas will be significantly more than the values in the Figure 4 (Tehran Padir Consultant Engineers, 2009).

Table-1. Human casualties in the city of Tabriz

Intensity (MMI)	Day	Night
8	22653	53299
9	117265	250490
10	117245	426673

\*Microzonation studies of Tabriz (TPCE, 2009)

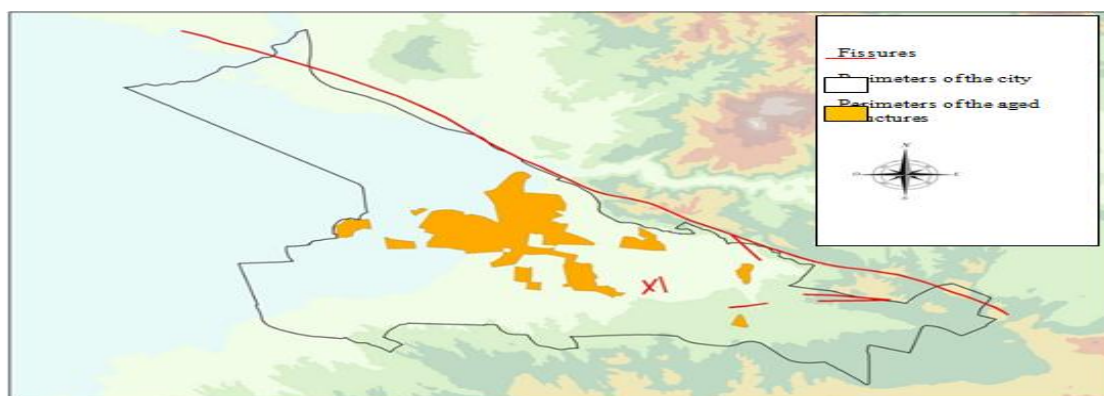


Figure-1. Map of perimeters ratified as aged structures in the city of Tabriz

(Source: Figure by author)

#### **4.2. Revision of the Network of Passageways of Old City Structures a Factor in Decreasing Riskiness of Earthquakes**

Passageways are considered as detrimental vessels in a city. In the time of disasters, their role becomes doubled. In old city structures with consideration of expanded need of citizens, now a day, and these passage ways are not functionally responsive to the needs of the residents. This matter in a crisis situation and particularly occurrence of an earthquake doubles the problems. For this reason, the department of roads and city development considers one of the characteristics and indices of identification of old structures lack of penetrability and defines them as blocks where more than 50% of the passage ways have a width less than 6 meters. After appropriate design and revision of these passage ways, in addition to increased penetrability, due to the major role of this passage ways in the construct, economic reinvigoration occurs and this economic booming is a factor that prevents more structural aging. Additionally, in cases of occurrence of disasters such as earthquakes and fires when obstruction of the passageways increases casualties and damages, accessibility and possibility of easy passage and access to secure spaces will decrease level of riskiness.

#### **4.3. Renovation of City Facilities and Equipment of Aged Structures**

Attrition is among inseparable parts of all human productions and it occurs with passage of time and due to long term usage often without repair and maintenance. In the city facilities and equipment sector, attrition occurs more often and leads to their decreased function. In addition to city facilities and equipment being required and necessary for all city complexes and today's livelihood, they are also stimulants to structure development. In the event of incidents particularly earthquakes, these factors themselves transform into factors leading to increased risk. Experience of various countries shows that gas provision networks at times of earthquakes lead to fires and create increased casualties and damages. If these facilities and equipment are aged due to little resistance, danger will be increased. Therefore, renovation of these networks and their appropriate repair and maintenance alongside with necessary training for the employees occupied in this area for rapid repair in case of outbreak of an incident and use of up to date technology leading to appropriate automatic reaction to them at times of danger will be able to decrease risks in disasters. Simulation of scenes relevant to crisis and periodic and persistent exercises by specialist groups in various areas including water, electricity, telecommunication, gas and evaluation of the results for identification of defects and deficiencies will be useful and in this way it is possible to train personnel with high ability for rapid repair and rebuilding of lines and facilities (CMMCD, 2012).

#### **4.4. Special Attention to Design and Creation of Public Spaces and Buildings**

Plans intervening in old city structures to some extent need to be able to increase per capita city public spaces in these structures. These spaces in addition to positive effect on life prosperity in the structures and increased public well fare, at times of crisis, will act as spaces for secure evacuation.

City circles, parks and regional green spaces, public parking's, fire stations, emergency, paramedic and rescue bases, inter city transportation stations, alongside with education centers, health and treatment centers, public offices and other public spaces will decrease riskiness due to earthquakes to a large extent. Considering the principle role of these centers in crisis situations, special attention is needed to their design and construction. The reason is that in times of crisis, these centers will provide the most services to injured people and if they face crisis themselves, in fact, risks and depth of the incident will be increased and we will face catastrophe. Additionally, these centers after containment of the crisis need to restart their activities for prevention of social and psychological issues in the least time interval possible. The latter also holds for students being able to resume their education and health and treatment centers being able to return to their daily activities. Even trade and shopping centers as buildings with public thoroughfare need to be able to provide for public needs and this is very important in revival of society psychologically.

#### 4.5. Strengthening of Residential Buildings in Old City Constructs

For strengthening residential building existing in old constructs, collaboration of residents has special importance. Participative renovation when interests of residents are considered in the plan will happen with confidence building and acculturation. The post incidence period, due to focus of public opinion, is the best time of acculturation. Yet, unfortunately in a few days post incidence, the issue of strengthening is forgotten. After creation of motivation in people for renovation and strengthening and their interest in this matter and performance of appropriate programs, financial support by way of granting of facilities and other economic plans, accurate supervision on the abundance of reconstruction is needed. The reason is that renovation is not necessarily equal to strengthening and decreased riskiness. Evaluation of earthquakes in the past in our country and other countries in the world shows that renovated buildings due to lack of observance of technical principles in design and implementation have been destructed. The history of studies and formulation of earthquake guidelines in Iran goes back to approximately 40 years ago. In the early sixties decade and after the earth quake in Boen Zahra, the first earthquake guideline was formulated in the technical office of the Planning Department(Management and Planning) and Iran was placed among 22 countries that up to that time had earthquake guidelines. These regulations were mandated for public buildings and during various periods they evolved and ultimately led to the guidelines named 2800 and since then, their observance became mandatory for buildings constructed by the private sector. Hashemzadeh (2004-2005). After formulation of an appropriate guideline, control of design and implementation of buildings and observance of regulations in this sector becomes important such that lack of correct supervision will neutralize the effect of the regulations. In this section, the role of supervising, designing and computing engineers, engineering system organizations, city departments and department of roads and city development and following organizations is important. Yet, the role of owners, expert engineers and workmen as the real executors of buildings is a lot more important than other groups and organizations. With creation of awareness in people and their familiarity with the problems of insecure construction, we will encourage them to observe rules, regulations and guidelines. Yet, these regulations need to agree with realities present in society. In other words, plans should be prepared for these structures that promote use of low cost building materials without undesired effects on decreased building resistance. Alongside with the latter, special specialized forces should be trained for periodic inspection.

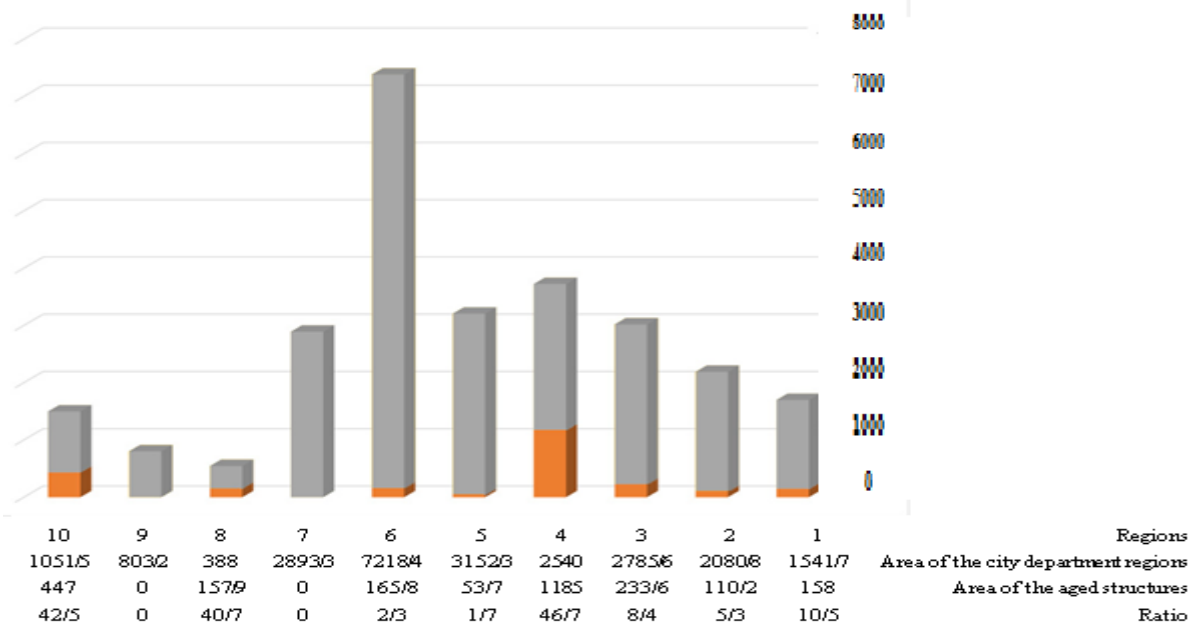


Figure-2. Ratio of area of the aged structure to the city department regions of the city of Tabriz

(Source: Figure by Author)



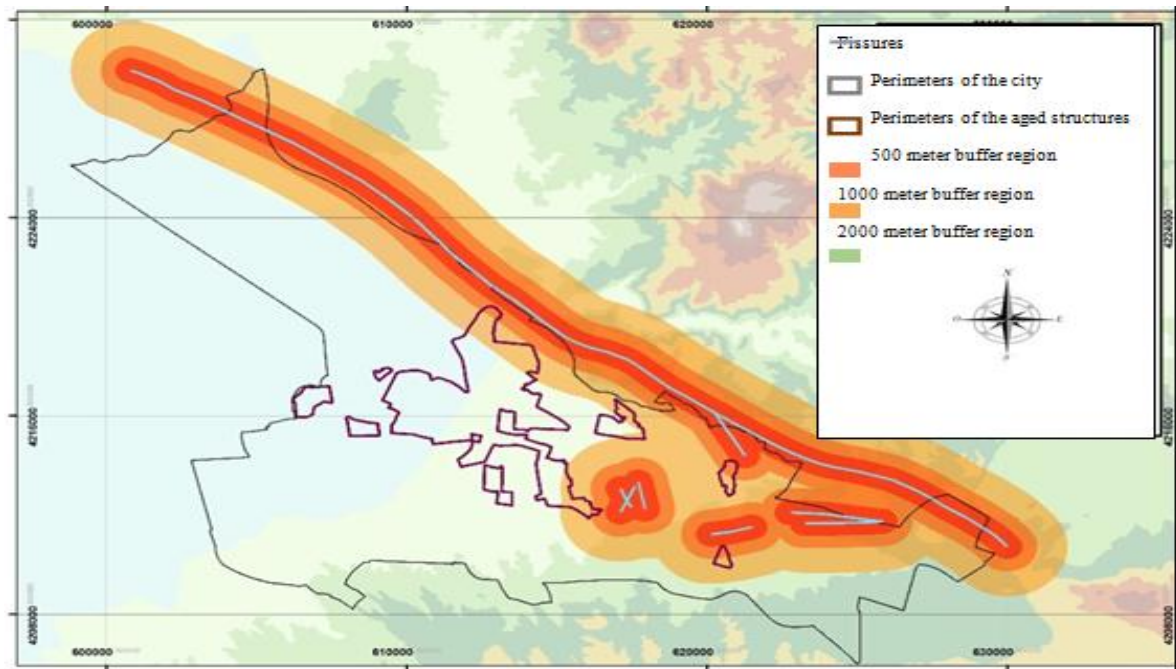


Figure-3. Map of the situation of the Tabriz faults with demonstration of buffer zone regions

(Source: Figure by Author)

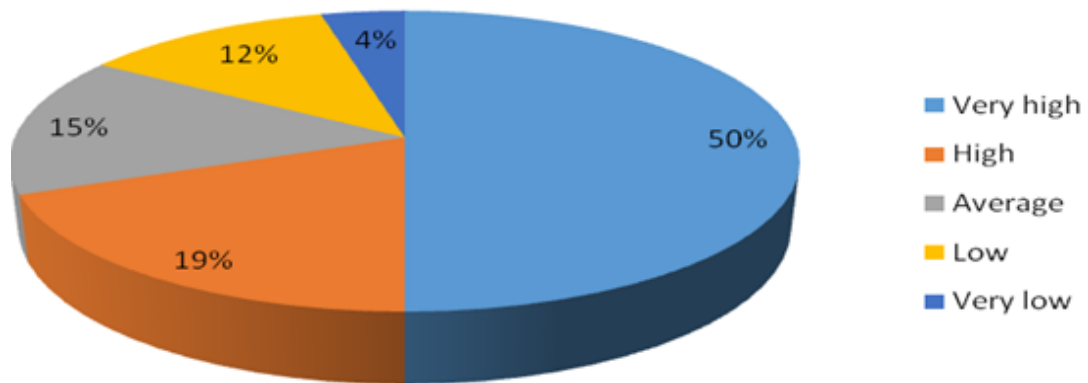


Figure-4. Risk level of the Tabriz Microzonation studies of Tabriz

(Source: Tehran Padir consultant engineers, 2009, Personal Communications)

## 5. CONCLUSION AND SUGGESTIONS

Earthquake is a natural incidence and we can decrease its dangers by planning and observing technical and engineering principles. Meanwhile, old city structures due to excessive vulnerability against this natural occurrence require special attention. To decrease risks of earthquakes in these constructs, multilateral social, cultural, economic actions alongside with appropriate city development, technical and engineering plans are needed and necessary. Educational centers and public organizations will help in decreasing risks with acculturation and implementation of technical and research plans. City development and building rules and regulations that are realistic also have fundamental role in decreasing riskiness of old constructs. Plans of decreasing riskiness in old constructs should be prepared and with allocation of appropriate budgeting, they should be implemented. Alongside with the latter, special planning for responsiveness to needs after occurrence of an earthquake with appropriate financial procurement should be available so we can quickly show the appropriate reaction in facing an earthquake.

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