



EARTHQUAKE RISK MANAGEMENT IN HISTORICAL AND OLD URBAN FABRICS, CASE STUDY OF TEHRAN BAZAAR

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ABSTRACT

Iran as a historical country located in a seismic prone region in the world and has been affected by several destructive earthquakes during its history. These seismic events have affected a lot of old urban fabrics and historical places in this country including Bam Citadel and Tabriz Kabood Mosque, both known as world cultural heritages. In this paper, having a look on the impacts of earthquakes in historical places of Iran, the potential seismic risk in Tehran Bazaar and its surrounding old urban fabrics as well as adjacent cultural heritages sites will be introduced. Furthermore, the potential activities that can be implemented to reduce the earthquake risk and improve emergency response capacities in the region will be discussed. These measures can be implemented in other historical sites all around the world by making some adaptation based on the local conditions.

INTRODUCTION

Iran is located in an active part of the Alpine-Himalayan Orogenic belt and is considered as one of the seismic prone countries in the world. In this line, several active faults exist in different parts of the country, some shown in Figure 1 (Hessami et al, 2003). Seismicity studies and investigations of historical earthquakes show that the country has been continually affected by earthquakes of different sizes and will undoubtedly experience large earthquakes in the future. The records show that annually in Iran one seismic event with magnitude higher than 6.0 and every ten an event with magnitude of at least 7.0 can be expected (Amini Hosseini et al., 2009). Irregular growth of Iran's cities during the last decades has gradually increased the vulnerability of the built environment to potential earthquakes. This may cause considerable damages and casualties in earthquakes, similar to what observed in the Manjil (1990) and Bam (2003) earthquakes.

On the other hand Iran is a historical country with a lot of old urban and rural fabrics as well as historical buildings and monuments. Considering the high risk of earthquake in Iran, it is expected that in any potential earthquakes, some of the existing cultural heritages may be affected. Amongst the historical sites damaged by earthquakes in Iran recently, Kharaghan Twin Towers (damaged by Avaj Earthquake of 2001), Bam Citadel (damaged by the Bam Earthquake of 2003) and Imam Mosque (Damaged by Silakhor Earthquake of 2006) are good examples that show the importance of paying necessary attention towards the safety of old urban fabrics, historical buildings and cultural heritages sites in earthquakes and making necessary earthquake risk mitigation and management plan for them. In preparing such plans, different elements of risk reduction and management including prevention and mitigation as well as preparedness and emergency response and even reconstruction and rehabilitation of the sites should be considered in order to assure the safety and security of these sites against potential earthquakes. Such elements should be evaluated and integrated into a master plan for protecting these sites.

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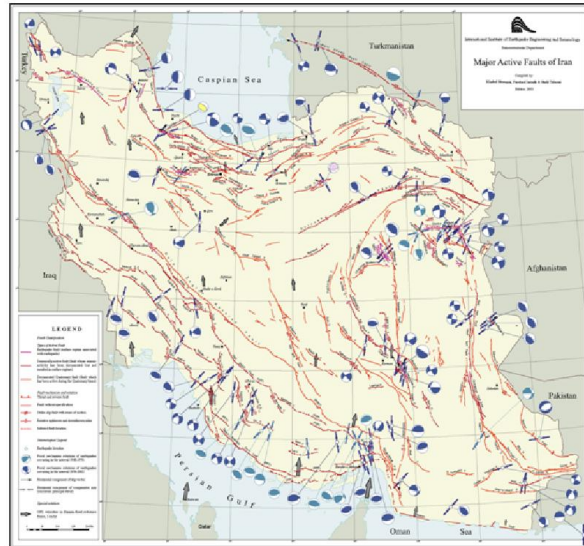


Figure 1. Map of active faults and location of some strong earthquakes in Iran

IMPACTS OF EARTHQUAKES IN HISTORICAL SITES OF IRAN

Among the historical sites affected by earthquakes in Iran, Kabood Mosque that was collapsed by 1778 Tabriz Earthquake (as one of the World Heritages), can be considered as an important case (Figure 2). The city of Tabriz at the time of that earthquake was also completely destroyed and ten thousands of resident were affected by the event.



Figure 2. Damages to Kabood Mosque by the Tabriz, Iran Earthquake of 1778

In the recent seismic events of Iran, Bam city can be considered as the most important old urban fabric and historical site that were damaged by Bam, Iran Earthquakes of 2003. More than 26,000 peoples lost their lives in that event and most parts of the city that was covered by mainly old adobe structures were destroyed, including the Bam Citadel that is known as a world cultural heritage with more than 2500 years history (Figure 3-A). The other important historical buildings that were affected by recent earthquakes in Iran are Kharaghan Twin Tower near Qazvin city that was damaged by Avaj, Iran Earthquake in 2002 (Figure 3-B) and minaret and entrances of Imam Mosques in Broujerd city that were destroyed by Silakhor, Iran Earthquake of 2006.

These examples depicts the vulnerability of most historical fabrics as well as cultural heritages sites in Iran to potential earthquakes and reveal the necessity of conducting appropriate measures for protecting these assets and managing the potential consequences of an earthquake in these sites. Considering the variety of historical buildings in Iran and their differences, it would be necessary to study each sites separately to prepare an appropriate integrated earthquake risk management plan based on their local conditions. In this paper the results of the studies carried out for Tehran traditional bazaar and its surrounding old urban fabrics will be presented.



Figure 3. Damages caused by the earthquake to: (A) Bam Citadel in Bam Earthquake of 2002; (B) Kharaghan Twin Tower in Avaj Earthquake of 2002

TEHRAN BAZAAR AND ITS SURROUNDING OLD AREAS

One of the most important cities of Iran, which is in high danger of earthquake, is Tehran, the capital of Islamic Republic of Iran. The city is surrounded by several active faults and experienced numbers of strong earthquakes in its history. Seismologists believe that a strong earthquake could be expected in Tehran in near future (JICA and TDMMC, 2004). However, the vulnerability of the city to a potential strong earthquake is estimated to be quite considerable. Some parts of this city are covered by vulnerable and old structures, located in narrow road with insufficient emergency response facilities. These parts are in higher risk of earthquakes, and urgent intervention is necessary to reduce potential loss and damage in these areas.

Tehran Bazaar is located in the central part of the city in old urban areas. By now several activities were carried out by Tehran Municipality and other relevant authorities to reduce the vulnerability of this part. However, the results were not reduced the risk to an acceptable level due to complex socio-economic and physical condition of the site. Many important historical buildings and monuments (including Golestan Palace as a world cultural heritage) are located inside these urban fabrics that made it difficult to conduct a general plan. In Figure 4 some of the most important parts of Tehran Bazaar and its surrounding areas are depicted.



Figure 4. Location of Tehran Bazaar and its surrounding old and historical urban fabrics

Figure 5 depicts some views of Golestan Palace and Tehran Bazaar. As it can be seen, Tehran Bazaar is covered by vulnerable buildings, narrow roads and high density of visitors especially during the day time.

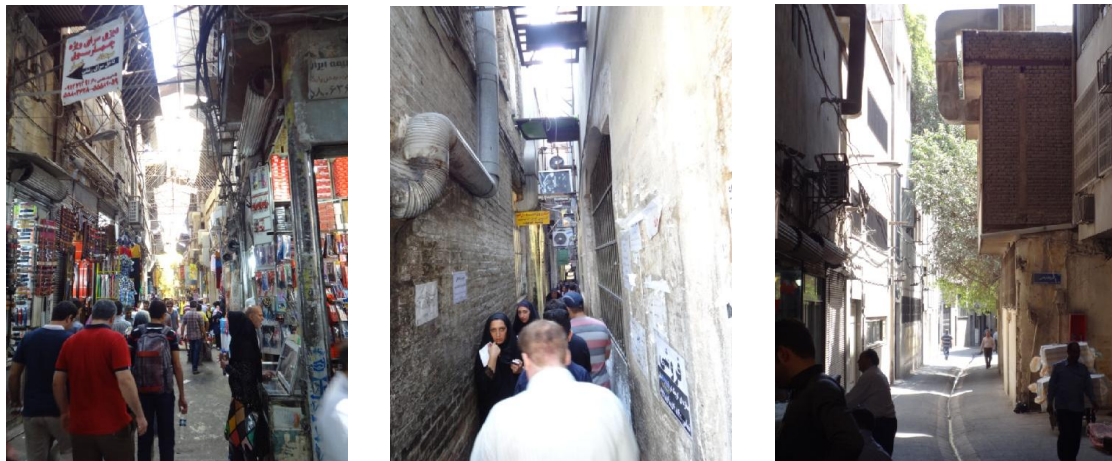


Figure 3. Golestan Palace and Tehran Bazaar

In Table 1, the most important vulnerability types and the potential impacts of earthquakes on the mentioned areas are presented.

Table 1. Different aspects of vulnerability in Tehran Bazaar and their results

Vulnerability	Results
Physical: Vulnerability of historical buildings, old urban fabrics, vulnerable lifelines and transportation systems, etc.	Casualties, damages to buildings and infrastructures, road blockages, interruption of necessary services, etc.
Economic: Accumulation of unprotected assets and properties, lack of appropriate insurance, etc.	Loss of properties, financial loss, unemployment, interruption in distribution of goods, second losses, etc.
Social: Unpreparedness, lack of appropriate awareness, lack of social cohesion, delinquency, etc.	Riot, robbery, suicide, addiction, etc.
Response capacity shortages: vulnerability of firefighting, medical care and security centers	Lack of capability to provide necessary services in time, further casualties and damages

EVALUATION OF EARTHQUAKE RISK

Based on what approved by the Iranian Council of Architecture and Urban Planning, the vulnerable urban fabrics should have one, two or all of the following characteristics:

- Size of the building ground: Less than 100 m²;
- Building age: More than 50 years;
- Width of adjacent roads: Less than 6 m.

In order to improve the condition of the places having the above conditions, some policies have been adopted by the government to renovate such fabrics (i.e. setting back from the adjacent roads and merging small units as well as opening some spaces). For this purpose, up to now relevant authorities provided low profit loans, permits for additional storey without payment to the municipality for reconstruction old buildings and proposing some discounts in providing urban services (gas, water,

electricity, etc.). However, the above criteria do not pay sufficient attention to the risk of natural hazards such as earthquake; while the first target for renovation of old urban fabrics, was to reduce their impacts. Furthermore, there is about one decade that the Iranian government started to work on renovation old urban fabrics based on above mentioned criteria and polices, while the results is not satisfactory. In addition, many important buildings and structures with cultural or historical values exist among the old urban fabrics, but there is no clear distinction between them and their adjacent buildings. Therefore, the traditional methods for assessment and renovation of old urban fabrics and historical sites in Tehran may not lead to acceptable results, and it is necessary to consider more applicable methods for this purpose.

In order to prepare an appropriate earthquake risk management plan for the study area, in this research and at the first stage a scenario of the impacts of an earthquake in this area has been prepared. For this purpose, based on existing vulnerability, the consequence of a seismic event was estimated for 24 hours after the earthquake in different aspects. The results are shown in Table 2.

Table 2. Earthquake scenario for the first 24 hours

	Disaster Situation	Urban area conditions	Cultural heritage conditions	Emergency response condition
Outbreak	<ul style="list-style-type: none"> - An earthquake of magnitude 6.7 occurs by the Ray Fault at 11 a.m. - Some fires ignite due to damages of gas pipelines. 	<ul style="list-style-type: none"> - It is visually observed that a huge number of buildings have been collapsed. - A lot of people are dead or injured. - Several traffic accidents take place on roads around the site. 	<ul style="list-style-type: none"> - Golestan Palace and Imam mosque severely damaged and a lot of visitors have been died and injured. - Many visitors are trapped in the collapsed buildings of the palace and mosques. 	<ul style="list-style-type: none"> - Only about 30% of staff remains safe at the emergency bases. - Emergency facilities have been partially or totally destroyed. - Communication of response bases to their headquarters has been interrupted.
2 to 3 hours later	<ul style="list-style-type: none"> - Several aftershocks occurred and it made more difficulties for rescue and relief activities. - Fire spreads in some commercial centers and due to damages to water network and hydrants, it cannot be extinguished easily 	<ul style="list-style-type: none"> - It is estimated that more than 50% of buildings collapsed and hundreds of peoples instantly died in and around the site. - Damages of lifelines take place in the whole area and only satellite system is working. - District Mayor orders to establish EOC. - Almost half of medical centers and fire fighting bases are heavily damaged. 	<ul style="list-style-type: none"> - Some of the visitors start to assist others, but due to lack of tools, it is difficult. - The staffs of sites are requesting assistance from the relevant organization, but due to large scale damages in whole city, no rescue team is available. - Most of the roads are blocked around the sites due to debris or abandoned cars. 	<ul style="list-style-type: none"> - Order of evacuation is issued, but few residents can take note. - Emergency operations start by available facilities and staff. - Most of offices, hospitals, fire-stations and facilities are damaged, unable to function properly. - Huge number of injured are rushed to hospitals, but they are unable to function. - People try to recover those buried under debris.
1 day later	<ul style="list-style-type: none"> - Fire extinguished in most places as the flammable materials already burnt. - Aftershocks decrease and it make better conditions for response activities. 	<ul style="list-style-type: none"> - MOI declares a state of emergency and rescue and relief teams arrive from national and international resources. - Wireless system and mobile telecommunication become partially available. However they are not easily accessible. - Data of damage come in. - Emergency transportation route is determined and opened. 	<ul style="list-style-type: none"> - All the visitors and trapped people inside the sites have been evacuated. - Great confusion takes place at the sites, as they are not assured how to keep security of the sites. - Some security forces are arriving to secure the national treasures. 	<ul style="list-style-type: none"> - The situation of evacuees is not clear as the places are not ready. - A lot of heavily injured victims are left untreated. - The survivors' needs cannot be provided appropriately. - It becomes clear that damages totally overwhelm the rescue resources. - Field care teams start to partially deploy at some evacuation places.

DEVELOPING DISASTER RISK MANAGEMENT PLAN FOR THE STUDY AREA

In the study area, there are a mixture of old urban fabrics that may not have considerable historical values with important cultural heritages and buildings. This made it difficult to make a sound decision for renovation of the area by a unique methodology. Therefore, in this research a new approach for risk mitigation and management of the site has been proposed that combines different methods that may be appropriate for relevant aspects. The main scopes of this approach are as follows:

- Reducing damages and casualties of potential hazards in Tehran Bazaar and its surrounding old and historical fabrics;

- Developing necessary measures for identifying, improvement and protecting historical fabrics of Bazaar;
- Promoting awareness of owners and local residents as well as local authorities in disaster management, cultural heritages and public services about the potential impacts of earthquake and fire in the area;
- Preparing and implementing integrated disaster risk management plan for the areas;
- Promoting resiliency of the local communities against potential disasters.

For applying this approach, there are some core members and supporting bodies. The main core members include representative of owners and merchants, local residents, local municipality, cultural heritages authorities, local emergency response organizations, local religious leaders, urban planners and construction experts and representative of public services organizations. The supporting bodies include NGO's and CBO's, media, socio-economic experts, research centres and in some cases national and international relevant organizations. The main components of the prepared risk mitigation and management plan are as follows:

- Mitigation: Preparing and enforcing necessary rules and regulation for protecting cultural heritages sites against potential disasters, retrofitting the existing buildings of Golestan Palace, existing mosques in the area and the tradition fabrics of Bazaar considering their historical background, protecting objects of the palace as well as bazaar against potential damages and fires, allocating sufficient open spaces for evacuation in appropriate places, opening two main corridors (NS and WE directions) in the middle of Bazaar for improving access to the central parts, developing firefighting bases and emergency water reservoirs around the Bazaar and making redundant emergency water network systems with necessary amount of hydrants and hoses, developing some warehouses inside the area and keeping necessary tools for conducting rescue and relief activities by the local people, removing the flammable material from the internal parts of the Bazaar, development of fire detection and extinguishing system in the area.
- Preparedness and Response Measures: To make an Incident Command System (ICS) for the site, increasing public awareness and knowledge about the risk of earthquake in the area, organizing workshops and seminars for local people as well as relevant authorities, preparing diagnosis and evacuation maps by participating local people and distributing them among the local residents, strengthening community based disaster management groups, conducting Disaster Imagination Games (DIG) and on site drills for local residents, establishment of volunteer groups and training them for conducting response activities, developing and enforcing appropriate insurance system, preparing security plan to protect the sites and its objects after a disaster.
- Recovery: Preparing necessary plans for damage assessment aftermath, preparing necessary reconstruction plan for the old urban fabrics and cultural heritage sites in advance, preparing temporary operation plan of the sites, estimating the socio-economic impacts of earthquake to local communities and supplying necessary measures to recover these aspects, considering the necessary resources for financial supports of the activities.

CONCLUSIONS

In this paper, the importance of paying attention to the vulnerability of historical buildings and old urban fabrics to earthquakes has been discussed and relevant parameters in mitigation, preparedness, response and recovery aspects were introduced. Based on what presented here the priorities for risk mitigation and management can be determined to be implemented in short to long terms programs. Accordingly the most important projects to be implemented in short term include: making necessary plans for disaster risk reduction at historic and old urban fabrics, organizing some workshops for local communities and relevant authorities for introducing the risk and potential measures for risk mitigation and management, classification of the study area based on vulnerability and other elements of risk, determining best places for evacuation, establishment of cooperation between the relevant authorities and local communities for strengthening response capacities, etc.

In mid-term the projects need to be implemented in around five years. Therefore, in this period of the time, the most important activities are: retrofitting the existing cultural heritages sites in the area, establishment redundant systems for fire extinguishing inside the Bazaar and cultural heritages sites and developing fire fighting bases around them, changing the land use in some hazardous sites, implementing the prepared master plan in the pilot site and making necessary changes according to the feedbacks and results, analyzing necessary changes and their costs to reform urban structure from economic point of view, and planning for developing the potential emergency roads network that can be constructed into the site for assuring the safe evacuation and emergency response.

Finally, retrofitting or renovating of old buildings, developing emergency roads and open spaces inside the Bazaar fabric, etc. are those projects that can be implemented in long term plans (about 12 years). It seems by implementing the above mentioned plan and projects, the earthquake risk in the site can be reduced to an acceptable level.

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