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INVESTIGATING THE PRINCIPLES OF PASSIVE DEFENSE IN WORN-OUT STRUCTURES IN ISFAHAN: A CASE STUDY OF THE RESISTANCE OF THE MONUMENTS OF QEYSARIE BAZAAR AGAINST EARTHQUAKES

***Nima Goudarzi¹, Mahdieh Ghaem Maghami², Nazanin Omrani³, Javad Abdedi⁴, Hossein Soltani⁵, Moein Garag Yaraghi⁶, Alireza Shafie⁷, Safieh Shariati⁸ and Nasimeh Nasr Esfahani⁸**

1-Islamic Azad University, A Member of the Young Researchers Club

2-Isfahan University of Art, MA Student of Urban Development

3-Islamic Azad University, Khorasgan Branch, MA Student of Architecture

4-Islamic Azad University, Khorasgan Branch, BA in Architecture

5-Kashan Vocational University, BA in Architecture

6-University of Tehran, MA Student of Civil Engineering: Specializing in Road and Transportation,

7-University of Tehran, MA Student of Project and Construction Management,

8-Islamic Azad University, Khorasgan Branch, MA Student of Architecture

**Author for Correspondence*

ABSTRACT

The use of passive defense in the historical and valuable monuments in the Iranian metropolises could promote the safety, security and the quality of the cities. Employing the principles of passive defense holds a long history worldwide. Considering the natural threatening events or those by the humans, Iran has found the usage of these strategies very necessary. By investigating the different samples and the general principles governing the country, appropriate actions could be taken so as to preserve the principles of passive defense. Earthquakes are among the significant natural events in Iran. Improving the resistance of the buildings and the right arrangement in them could decrease the losses and damages resulted from earthquakes. Building on library research and the filed observation, we tried to study the Qeysarie Bazaar in the Isfahan metropolis. The investigations illustrated that susceptibility of the market to the earthquake is considerable. Thirty percent of the structures used in the monument lack sufficient resistance, and the access routes also carry many limitations. Appropriately and scientifically by reforming the access routes and also making the monument more strong more, it is possible to perform the principles of passive defense in the market so that the losses and damages resulted from earthquakes are reduced.

Keywords: *Principles of Passive Defense, Worn-out Structures, Qeysarie Bazaar in Isfahan, Earthquakes*

INTRODUCTION

Iran has been placed on the Alp-Himalaya earthquake belt and has experienced around 130 large earthquakes with a magnitude of 7.5 or more (Ghafory, 1999). The return period of these large earthquakes was passed some long time ago in Iran's metropolises, and no new large earthquake has been occurred. As there has no record of minor earthquakes, it shows the probable occurrence of a devastating earthquake (HosseinZadeh, 2004). Isfahan has experienced many earthquakes, and according to the surveys, some earthquakes with a magnitude of 2 to 5 occurred in 1976 to 1978 (MohajerAshjai, 1981). Around the city of Isfahan, there are some important faults with different stretches; thus, this could increase the possibility of occurring a larger earthquake (Safai, 2004).

MATERIALS AND METHODS

Methodology

This research was conducted using library and field survey research methods. Utilizing the different and up-to-date sources and information related to the topic at hand, interviewing with the experts and

Research Article

receiving the expected strategies and also employing the field research approaches in the Isfahan's market are the notable approaches used in this study.

The objectives of the study revolve around:

Understating the state of the Isfahan's market and examining it against the dangers of the earthquake,

Identifying the susceptibility of dwellers and users of the market during the crises,

Presenting urbane planning strategies when facing with the earthquake,

Examining the principles of the passive defense and its necessities for the old market of Isfahan,

Passive Defense Criteria in Designing the Architecture of the Public Buildings

Iran holds special conditions due to its diverse geographical position. These conditions have caused to see the different climates and temperatures in different regions. This country, however, has been located in the dry and low water regions with many deserts. The only reason which could be stated for such diversity is the presence of different lengths and the mountains in this country. This could bring about challenges for the dwellers. The faults, different water flows in rivers and streams and other geological builders could bring more problems for the people. If these potential problems are appropriately identified, they could be predicted; as a result, it reduces their damages.

The active faults are among the significant problems and threats in the country. The faults are the places where different layers slip under or over each other. Based on the theory of plate tectonics, which is wildly accepted by many geologists, whenever the plates move over each other a mountain range is produced and this case has happened in Iran leading to the generation of Zagros and Alborz mountain ranges. The slip and movement of the place of the faults are the main reasons of the earthquake occurrence which could be devastating, causing many losses and damages.

Another issue, which is generated due to the altitude differences, is the water flow and watercourse which at last create river basins. The river basin initiates with the heads of the watercourses in the mountains and after their connections with each other a bigger flow is generated, and finally the flows enter the basin. This movement of flow brings about floods in the region.

Earthquakes and floods are two issues which demand an urban and regional planning so that they could be defeated. In case there is no suitable preparation or there is a lack of planning, huge crises may happen. To defy such crises, the cities could be prepared in a way that they would have much resistance towards this crisis. To achieve such aims, the collaboration of the responsible people in different sections seems necessary.

The major aim of passive defense is to make the buildings and equipment stronger against any kind of invasion. When they are strong, the level of susceptibility is reduced and at the same time it increases the capability of reforming and the system capability of guarantee. At last, by employing this approach, we could reduce the amount of the problems and weaknesses in the emergencies and operational situations and to cover them in the optimal state.

Averting the generation of crisis and avoiding the conditions generating crises is of necessity. In the case of crisis occurrence, creating conditions for the quick control of situation and restoring the conditions to their previous good state are among the effective strategies in this regard (SavadkouhiFard, the analysis of the urban space based on the principles of the passive defense, 2013).

Definitions and Concepts in the Scope of Passive Defense

Security: It literally means freedom, peace, no fear and no invasion of others. In another typology, security has been divided into concrete and mental. The concrete security means not threatening or not being threatened, and the mental security implies the feeling of the lack of threat. The mental security is not observable and the internal understating of it for people is not different. The security of a country means that it is not faced with dangers and is free from any threat and fear. The security of a country is related to its stability that a country enjoys.

The security is the most fundamental need of each country and the most significant factor for permanence of the social life. The countries determine their security areas in the international, regional, and national sections based on the objectives, interests, and fundamental values and the level of power. Different

Research Article

aspects of security can be regarded as social, economic, political, religious, national and environmental. From an architectural and urban development perspective, the security could be regarded as an urban security (Safavi, 2002).

Threat: It is opposite to security. Therefore, in case the threats are expanded, the security level of the country decreases. There are different types of threats, and in one classification they can be divided into hard and soft threats. The hard threat is violent and is accompanied with common devastating equipment, demolition, annihilation and massacre. The soft threat is not violent and is mainly in the form of software programs but can bring much damage. Being legal is a feature of this threat.

Susceptibility: If a threat successfully happens, the susceptibility occurs in the region. The susceptibility could be physically, economic, social, spiritual, psychological, scientific, cultural, managing, technological and the like.

Danger: It is a source, situation or act which has a capability to damage either in forms of injury or diseases or a combination of the two. Any type of situation; the potential source of loss and damage either in the form of injury or diseases or damage to the properties and equipment or any damage to the environment of a combination of these are called a danger.

Defense: It means to save the life of people, to guarantee the people's security, to preserve the territorial integrity and the national government against any kind of situation, conditions or any attacks at any time. Defense is generally associated with the protection of the ground.

Active Defense: The direct use of different weapons or electronic warfare to nullify or reduce the attract effects of the enemy which is conducted either through the air, sea or ground (Ahmarloui, 2010).

Passive Defense: All the precautionary principles and acts which are conducted without weapons and arms, and by means of them the possible damages to the facilities, vital, martial and civil installations and human damages are prevented and/or these damages are minimized (Ahmarloui, 2010).

The principles of the passive defense in vital or sensitive projects are conducted by considering its culture or the public belief in the necessity of using them. All the people require a series of preliminary activities of which mentions could be made of the most important ones:

Providing a continuous and dynamic ground to conduct the passive defense

Putting the principles of the passive defense in the project text

Generating the guarantees and in the highest level of executing position in each system about employing the passive defense

Determining the indexes of prioritizing, fitting and sensitivity according to the goal (buildings, installations, equipment and the main roads of the country which might be attacked)

Determining the levels of security, criteria and regulations of the passive defense corresponding to the spots of the goal and type of the threat

Reducing the susceptibility of human force, buildings, the vital and sensitive centers which are available or still being conducted or in the phase of proposal and study through carrying out the passive defense projects (SavadkouhiFard, the analysis of the urban space based on the principles of the passive defense, 2013).

Review of the Related Literature

Each time the urban planning is conducted appropriately; three key concepts are studied, investigated, and analyzed (Hiraskar, 1989). Security in different texts of urban planning is not the ultimate goal. It has been employed as an optimal criterion in determining the right positions for the activities and urban uses alongside other factors such as compatibility, peace, efficacy and desirability (Saeednia). Protecting the life of humans and installations and urban equipment against the natural and human dangers is of necessity and should be considered as a fundamental aim in urban programs. The natural dangers are the most important parts of the interactions between the nature and humans, and the relation between the humans and nature should be regarded both positively and negatively. When the humans utilize the environment, they exploit it to achieve their goal which is a positive relation. But if they damage to the environment, the exploitation is negative (Adkalan, 2000).

Research Article

Natural Dangers

According to the UN strategic program of reducing the natural dangers, all the dangers hold two origins which are natural and technological (because of the human activities) (Mou *et al.*, 2006). The natural danger is a reality which happens in the humans' place of residence and threatens their life. These dangers are due to the structure of the earth, pathogen, regional and territorial factors which have entered the humans' life and would affect it (Smith, 2012).

Earthquakes are of these natural dangers which could release the energy blocked in the shell in the short period of time and brings about much demolition (Gibson). The scholars of the urban design regard earthquakes as destroying the life of humans who desperately built the houses with low price and or with the low level of security.

Therefore, the susceptibility of the city is considered as a tool to show the extent and amount of the possible damages which have been the results of the natural dangers. The determination of the susceptibility of the present buildings is predicting their loss and damage against the possible earthquakes (Zahrai and Ershad, 2007). The effective factors in this susceptibility are many and each affects the other and has a systematic effect, and they are associated with the susceptible groups and their factors like age, minority, poorness, literacy and the like (Paton and Footstone). Different variables which affect the susceptibility can be seen in Table 1.

Table 1: The Variables Affecting the Susceptibility of the Cities during the Earthquakes (with Change and Optimization, 2008)

Variables	The Description of the Factors Affecting that
Natural	<ul style="list-style-type: none"> - The feature of the earthquake which involves depth, magnitude, duration, and time of occurrence, - The geological conditions and the structural morphology of the infrastructures which contain the distance to the active fault, features and the quality of ingredients of the shell, and the features of the bedrock, -Topography and slope of the city.
Physically and Structural	<ul style="list-style-type: none"> -The amount and quality of urban passageway, - The way uses are distributed and observing the adjacency among them, -The degree of density of houses and the number of floors and its extent, -The type of building design.
Social and Economic	<ul style="list-style-type: none"> -Population density in each level, -The mechanism of crisis management and its utility, - The level of peoples' knowledge and culture, -The level of welfare and the financial situation of the dwellers.

The Challenge of the Earthquake

One of the challenges of the human beings throughout the history of its habitat on the earth has been their confrontation with natural events and to protect their life and properties against them. With the development of the civilization, the consequences of the events increased. This was the reason to call the years between 1990 to 2000 as the reduction of natural events, and many important steps have been taken towards finding the applied and efficient thoughts in the management of the crisis (JICA, 2000).

Iran has been among the eleven countries which most suffer from the natural events due to its geographical and political position. As out of 40 introduced natural events in the world, more than 30 happen in Iran so the occurrence of some like the earthquake is inevitable. As a result, Iran has been confronted with many natural events like earthquakes for such a long time. Unfortunately, Iran has endured many financial and physical damages (JICA, 2000).

Research Article

As alluded to earlier, Iran is among the countries suffers from natural events. For example, 90% of Iran has been located on seismic zones. The natural and human dangers threaten the construction of metropolises in Iran. Earthquakes are among those natural events which could create a very complicated crisis for Isfahan if it happens. The monuments of the old market of Isfahan could not stand this crisis and this is because of the lake of risk management and the old age of the monument (JICA, 2000).

Appropriate Actions Taken to Reduce the Effects of Earthquakes in Isfahan's Market

Attempts to reduce the effects of earthquakes should be prioritized over other actions in each area, employing guaranteed and efficient actions would reduce the effects of the events or could excluded them in some cases. These actions are divided into:

Immunizing Structural Components Against Earthquakes: Elements such as pillars, legs, and diverse roofs, major and minor shafts, cross braces, bearing walls, and different foundations against the gravity force, wind, and other lateral forces standing against the loads are called structural components. To build the structure, these regulations have been stated in the building regulations and by observing and respecting them it is possible to make the buildings strong against the earthquakes (MaziarHosseini, Saeed Montazerolghaem, AbdolrezaAminiai, 2008).

Immunizing the Non-Structural Elements The non-structural elements are related to sections of buildings which contain all the elements expect for the structural parts. The common non-structural elements in buildings are: patio roofs, windows, office supplies, computers, bookcases, drawers and things in it, heating equipment, ventilation systems and air-conditioning, electronic supplies, the furniture, lights andlusters. The reason for the importance of the non-structural components in the buildings is that earthquakes directly and indirectly affect them. These effects are classified into three categories

Human Damages: Injury or killing of people because of falling or damages of the non-structural components are very significant. The sudden falling of things like frame of the light, window break, collapse of the bookcases heavy wardrobes, gas pipelines which have not been well fitted could bring more damages as a result of the earthquakes.

Financial Damages: In most cases of the commercial buildings, building the foundation can take around 21 to 25 percent of the whole costs and other costs are devoted to the mechanical, electronic and architectural blocks. Unfortunately, these components are largely damaged by the earthquakes.

Reducing the Efficacy of Building Operating: In addition to what mentioned earlier, massive and serious damages of the non-structural elements could decrease the efficacy of building operation (MaziarHosseini, Saeed Montazerolghaem, AbodlrezaAminiai, 2008).

To reduce the susceptibility of non-structural components, we could conduct building inspections, taking simple actions to reduce the dangers, employing refinement details, building programming and the necessities of the building regulations for the non-structural components (MaziarHosseini, Saeed Montazerolghaem, AbodlrezaAminiai, 2008).

Investigating the Qeysarie Bazaar in Terms of Passive Defense

Qeysarie Bazaar is the main center for trading in Isfahan. The dense structure and a great deal of goods in it can bring more potential threats. These dangers are discussed from different perspectives.

As to firing, the main problem is the lack of sufficient access ways to the worn-out structures. In the market, millions flammable materials have been stored while nothing has been considered for the firefighting equipment. The reason of this event and its subsequent problems is to disregarding the safety fundamentals (Firefighting Centre and Safety Services of Isfahan's Municipality, Isfahan, 2011).

Qeysarie Bazaar, due to its significance, was always an attack target during the Iran-Iraq-eight-year war. The economic significance and the dense structure of the population could cause more damages. The enemy would attack the economic and human targets. Based on the said conditions, Tehran's market holds a high degree of risk and it can be considered as one of the most significant parts of the city. The other problem is the collapse of the worn-out parts of the buildings of the market. The worn-out structures carry many problems because of their density among which we can refer to the way cities are built and how they are structured. This problem is solved by the bodily interferences and with an emphasis on the

Research Article

economic and human needs. In this area, since the soil is rich, it is possible to make some changes and promote the access ways. If the access ways are promoted, it could increase the incomes of the people; consequently, a circle with shared interests is achieved. The analysis of the said sections illustrate that Qeysarie Bazaar is confronted with some threats in terms of passive defense. To understand these threats, different functions have been proposed. The simple, understandable method is to weigh the said different criteria. This weighing could be seen in following table.

The Possible Damages Which would be Introduced by these Threats in Isfahan's Market

Among the different sections which might be damaged by the earthquake, the transportation network is subject to more damage (Hosseini, 2002). In this regard, the factors produce crisis could be classified as follows. It is clear these factors could be generalized and covers other worn-out and historical structures around the country. The market and the region around it are very significant, and the collapses could affect the health and life quality of many people.

The collapses of the high-rise buildings located near the roads could hamper the roads and make them unsafe,

Damage to the infrastructures of the city like water, gas and so on would threaten the main roads as well as the subway tunnels,

The falling of the electric masts not only hamper the roads, but also could bring fierce firing,

Leaving the cars in the blocked roads could lead to more problems,

Disruption in the activities of the traffic police due to the power outage and heavy traffic (SavadkouhiFard, the analysis of the urban space based on the principles of the passive defense, 2013).

Important Notes about City Building and Architecture of the Worn-out and Historical Structures

The importance and value of the historical structures: These structures and different parts of the city are considered as the beating heart of the city and the center of city formation. The significance and value of these structures have many reasons such as: the presence of many valuable and important architectural structures, the impressive structures created in the past which are taken as a live school for the students of the architecture, the cultural values which reflect the life style of the past, market building values introducing the styles and urban patterns of the past that continue the collective memories.

The effective factors in destroying the monuments: These factors could be potential threats involving the factors like: the lack of recognition of the soil type and building foundation, the lack of attention to the water flow in this section or watersubside in the transportation pipelines, non-standard structures, disregarding the regulations and guidelines, environmental pollution and the effects of the disasters and natural events.

Conscious interferences in the urban city to prevent the demolishing and modernizing the present structure with the least costs, strengthening the present structures and respecting the principles of passive defense are vital and effective steps towards the survival of and saving the lives. In this regard, we can refer to the following recommendations:

Identifying and the close examination which are the pre-study phase in the scientific scrutiny to the forthcoming attempts for strengthening, reforming, and preserving the monuments and buildings.

Transferring the sections of the storerooms of the buildings which carry a high risk to the region, here, it is possible to achieve the low rate of traffic which is generated in the structure due to different situations alongside reducing the amount of damages in the case of any event like firing.

Equipping all the sections with alert systems and fire-extinguishing system,

Training the dwellers at regular times to increase the culture of passive defense and familiarity with how to face with different crises,

Transferring people to the predicted sections for the temporary settlement in parks and green spaces and equipping these areas,

Strengthening and equipping the hospitals of the region so that it appropriately addresses the needs,

Hampering some streets in order to have access to the temporary settlements by considering the fact the area is blocked,

Research Article

Organizing and transferring drainage systems and the water around this area,
Presenting comprehensive practical maps to utilize more contexts and potential utilities of this region based on the tourism industry and its benefits to increase the incomes and the welfare of the dwellers,
Building smart parking around the given structure to utilize the ground more efficiently,
Averting trafficking of transport means which use petrol, and advertising using bicycles and electronic devices so that the noise pollution is reduced and promoting the feeling of life in the area,
Using the urban elements to promote the movements and to avert stopping the visitors which could enhance trafficking,
Zoning to avert expanding probable firing and its optimal control with the consultation of fire and safety services,
Building shelters with multiple user interfaces to efficiently utilize the area in common and ordinary situations (SavadkouhiFard, the analysis of the urban space based on the principles of the passive defense, 2013).

The Case Study of the Big Market of Isfahan

Markets are the most important channels of communication of cities that not only people have been present in that and the goods and investments are circulated in that but also the information, news and advertisements would be notified to the citizens.

This major element which has found a proper place in the Islamic architecture includes two series of shops which are located in front of each other, and are connected to each other through a pretty roof. Markets have been very important in the urban constructions as after mosques, they are the main components of a neighborhood.

Big cities have one or several shopping malls or a big and main market which provides the needs of the people.

Isfahan holds many very famous and old markets and the Big Market is the most important of them. Nasir Khusraw, a traveler, who traveled to Isfahan in 1052, described some markets of Isfahan and spoke of a special market in that 200 money-changers were working. The current markets of Isfahan date back to the Dailamites and the Seljuq dynasties and in particular to Safavid dynasty. Throughout history like the other monuments and artworks, the monuments and artworks in Isfahan have seen many ups and downs. This antiquity, in many cases, has caused many threats to be regarded in terms of passive defense. Qeysarie Bazaar is the most important market in Isfahan relating the Imam square to Atigh (old) square and Isfahan to Seljuq dynasty.

It is also called Soltani Bazaar which was one of the most impressive and magnificent markets and trading centers in the Safavid dynasty. In this market, pricey cloths and different goods were being sold. Qeysarie Bazaar was built in 1619 and its impressive gate was named Qeysarie. This market due to domed roofs was always in the attention of the travelers. In the center of the market which is round and wide space, a dome was built that André Godard described it as domes in Spain which were once built by the Arabs (Hassanzendedel *et al.*, 2010).

The Analysis of the Strength of Materials in Isfahan's Market

The recognition of the strength of materials is a factor with which we can study the strength of materials in the market. In Qeysarie Bazaar, by regarding its development and also its historical oldness, a wide variety of materials were used. These materials are classified into no durability, low durability, average durability and good durability.

Field surveys results show that 28.9 percent of the materials used in the buildings in the study had no durability, low durability and average durability, and the rest, that is, 71.1 percent of the buildings used materials with good durability.

It should be noted that this issue is in terms of the quality and its processing and protection of the used materials especially concrete affecting their life time and strength but they were not taken into consideration in this study.

The general classification of these four groups can be seen in Table 2.

Research Article

Table 2: The Strength of Materials used in Isfahan's Qeysarie Bazaar

The Strength	Percentage	Total Percentage
No Durability	4.6	4.6
Low Durability	9	13.6
Average Durability	15.3	28.9
Good Durability	71.1	100

To complete the study, the skeleton of the building was also investigated, and here similar results were achieved. The reconstructed buildings with a metal and concrete skeleton formed 90 percent of the total buildings and the rest of the materials formed 10 percent. All these, by reporting the year of construction and the strength of the materials were classified in Table 3.

Table 3: The Relation Between Oldness of the Building and its Strength Materials

The Oldness of the Building	Strength of Materials				Total (Percentage)
	No Durability	Low Durability	Average Durability	Good Durability	
Before 1921	1	1.5	1	0.8	4.3
1922 to 1941	1.2	1	0.7	1.1	4
1942 to 1961	0.6	1.8	1.9	3.2	7.6
1962 to 1981	0.9	2.3	5.5	27	35.6
1982 to 2001	0.7	1	3.5	16	21.2
2002 to 2015 (Now)	0.2	1.4	3.7	23	28.3
Total Percentage	4.6	9	15.3	71.1	100

For the defined indexes in the strengths of materials, it can be concluded that the studied buildings have a good condition in terms of the type of materials, the type of skeleton and the oldness of the building. But by considering the danger of earthquakes in the area, the buildings should be examined and inspected time to time.

Conclusion and Discussion

In terms of the studied indexes the buildings of Isfahan's Qeysarie Bazaar are in a good condition. This condition, however, is not remained stable and it demands more close and detailed investigation of the material processing.

The analysis showed that around 30 percent of the studied buildings hold a low durability which shows that they are subject to the danger of many factors like earthquakes.

Some buildings hold a good durability but the structure and formation the equipment and facilities and also the internal architecture have been conducted without regarding the passive defense principles and it generates more dangers for the users.

Access to the rescue centers have a very bad condition in Qeysarie Bazaar. This issue can be seen in the inappropriate access ways as well as the distance from the rescue centers. In case a critical even occurs, a quick and acceptable reaction for rescuing the people cannot be seen.

If appropriate training in terms of passive defense is offered to the employed people in the market, it is possible to avoid deteriorating the situation through the personal abilities and performing the first aids with a great pace. It is worth stressing that such activities should be conducted under the supervision of the municipality and other responsible persons to reform the worn-out structure and access ways to

Research Article

Qeysarie Bazaar. Consequently, it can be expected that one of the big and crowded markets to be remained in a good condition in terms of passive defense.

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