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# Vulnerability and Crisis Management of School Buildings in Babol-Iran

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**Abstract:** Due to population growth and increasing urbanization, natural disasters like earthquakes can cause heavy losses and hinder the development of cities and countries. The need to reduce the vulnerability of cities against the earthquake is regarded as one of the main objectives of physical planning, urban planning and urban design. Old and problematic urban textures and suburb and informal settlements are more at the risk of earthquake than other urban areas in developing countries (like Iran). These textures are most at risk due to reasons such as lack of observing engineering and technical standards in construction being located at slopes and inappropriate lands, ineffective communication networks, lack of open space, lack of urban facilities and equipment and so on. This study aims to investigate the vulnerability of school buildings in Babol and to put forward proposals in order to deal with possible damages.

**Key words:** Earthquake, vulnerability, distressed areas, schools, damages

## INTRODUCTION

One of the issues that most major cities of the world including Iran are grappling with due to increased urbanization, population growth, environmental and economic loading on their context is the issue of natural disasters including the earthquake as one of the most important types. Due to its location on the Alpine-Himalayan belt, Iran has been exposed to earthquakes and at risk of serious damages each year. These earthquakes include the historical earthquakes of Bouin Zahra, Manjil and Roudbar, Bam and Saravan. Hence, the natural disasters have put Iran in a crisis every few years (Lantada *et al*., 2008). Due to its geographical and geological position, Iran is considered as of ten worlds' most accident-prone countries and has always been suffering from human and financial losses because of disasters such as floods, earthquakes, fires, droughts and the like. Human life has always been subject to threats and the intensity and weaknesses of dealing with these threats varies among different populations (Beiroudiyan, 2006). Urban areas are likely to be affected a lot of risks due to their large size and concentrated population (Sadri Kia, 2007). Earthquake as a repeatable phenomenon existed throughout the history and there will be in the future too. The occurrence of such a disaster in most cases has left a devastating impact on human settlements and imposed a heavy loss on residents. Although, in the past decade with the progress of human knowledge, scientists have scientifically discovered the reasons for the occurrence of this phenomenon and its consequences, they are still not able to prevent this phenomenon and resist against this natural event and they do not possess the necessary knowledge in many cases in order to accurately and scientifically predict the exact moment of its occurrence and its power (Chen *et al*., 2012). Today, the vulnerability of urban areas and especially old and worn textures against the earthquake as a global problem has been of great interest for scientists in different disciplines. The situation in countries with a hazardous natural structure including Iran, has emerged more acutely over recent decades. Therefore, given that most schools involve old and worn textures of the country, in this study, amount of Babol schools' vulnerability is assessed at earthquake time.

## MATERIALS AND METHODS

### Types of vulnerability in buildings against the earthquake

**Vulnerability caused by materials:** Materials such as mud and adobe, wood and adobe, brick and wood and total wood is of low resistivity and high vulnerability. On the other hand, due to high resistivity of their materials, steel and concrete buildings have the lowest degree of vulnerability.

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**Vulnerability caused by the building lifelong:** In general, the older the building is the lower its quality will be. Hence, they are more vulnerable. The mean of the useful life of Iranian buildings is 30 year. Buildings with a lifelong over 50 year are considered old and of high degree of vulnerability.

**Vulnerability caused by the building quality:** The quality of buildings is also another factor affecting the vulnerability. If the construction quality is the new building blocks, their vulnerability will be low and if the building quality is the dilapidated building blocks, their vulnerability will be high.

**Vulnerability caused by population density (density of persons per dwelling):** Population density is one of the factors contributing to the vulnerability. The higher the population density is the less will be the possibility of providing relief during an earthquake since overpopulation leads to slow and increased traffic. High population density compared to low population density lead to greater vulnerability. In fact, the high density of population is followed by the high density of buildings and lack of sufficient open spaces. Therefore, it can be said that at the same conditions, the region with higher density of population will experience greater vulnerability. Congestion and crowdedness, disruption and hard conditions of escape, refuge, relief and so on are the result of high population density in earthquake (Qanavati *et al*., 2009).

**Natural and social conditions of the studied area:** Mazandaran Province in the North of Iran with an area equivalent to 4/23756 km$^2$ consists of about 1.46% of Iran. In this respect, it is the 18th province in the country. Babol is one of the central towns of Mazandaran Province which is located at a distance of 13 km away from the South of the Caspian Sea and 10 km away from the North of Alborz Mountains.

**Seismicity of the project area:** According to the By-law 2800 (Iranian earthquake By-law), Babol is located on the area of a relatively high seismic risk. The presence of a population of 2,00,000 people in an area of over 35 km$^2$ and the construction of high-rise apartments in this city which is located on two active faults of Caspian (with a length of 600 km) and North of Alborz (with a length of 300 km) have doubled the importance of seismic and geotechnical microzonation studies. Over the years, these faults caused some earthquakes in this province including the earthquakes at Babol with a focal depth of 15 km, Chalous with a focal depth of 6 km, Sari with a focal depth of 7 km, Babol with a focal depth of 10 km (Cutter *et al*., 2003).

**Geographic databases (ArcGIS):** The ArcGIS as an information storage, retrieval and analysis database can be efficient and effective. The ArcGIS systems are able to manage large bulk of diverse information and provide reliable predictions for urban experts and managers with minimal cost and in the shortest time possible.

Shahabi *et al.* (2014) demonstrate the use of GIS models and remote sensing techniques to identify areas which were suitable for reasonable, convenient and administratively transparent waste landfills in Saqqez using Boolean, AHP and WLC in a GIS environment. Stage of the ArcGIS project formation:

- Collecting information
- Integration of information
- Formation of the database
- Transferring data to the ArcGIS Software

In this study, from the beginning, diversified data was collected in the study area. This data was analyzed as basic information in this study. In order to analyze the current situation of the studied area ArcGIS databases were prepared.

**Objectives of the geographic databases:** In order to study the seismic micro-zoning in Babol, a wide range of urban and regional data should be collected and analyzed through using an appropriate methodology (to evaluate the vulnerability of a critical situation caused by the earthquake in the study area).

## RESULTS AND DISCUSSION

**Collecting and entering data:** To develop the geographic databases in this study, a wide range of data containing the conditions of the studied area was collected. The data of the collected maps were analyzed in terms of accuracy, basic scale, date of preparation, methodology and reference organization. After designing the database and carrying out the necessary processing, a complete map was prepared to obtain a thorough understanding of the entire study area. Titles of input data for this study are as follows:

- Topography map
- Boundary map of statistical areas
- Road network map
- Population maps based on statistical areas (2012)
- School buildings based on statistical areas' type of structure (3 groups), age (3 groups) and number of floors

**Structural systems:** Regarding the type of structure, school buildings are divided into three groups:

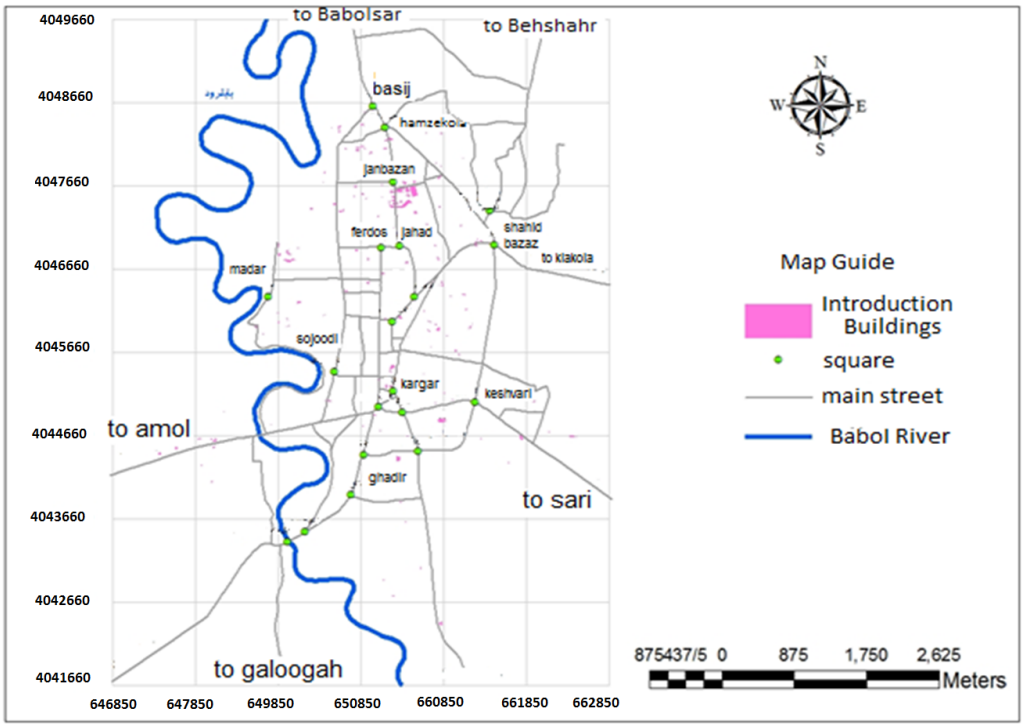


Fig. 1: Current training buildings in the study area

- Steel buildings
- Reinforced concrete buildings

In this study, the reinforced concrete structures are divided into three categories (This classification was made due to the changes in the By-law 2800):

- Concrete buildings constructed after 2005 caused by an earthquake with a return period of 475 year
- Concrete buildings constructed between 1988 and 2005 caused by an earthquake with a return period of 475 year
- Concrete buildings constructed prior to 1988 caused by an earthquake with a return period of 475 year

**Masonary buildings:** After having field studies and collecting information in the ArcGIS Software, the map and location of school buildings in Babol are shown in Fig. 1.

**Floors of the buildings:** In this study, additional data obtained from Iran's Statistical Center in 2012 were used. Observing the existing data prepared by Iran's Statistical Center, it was found that 75% of all school buildings in the region had three-floor height. There were 15-20% 4-6 floor buildings and the rest of the buildings had over six-floor height.

**Age of the buildings:** In this study, data on age were divided into three groups:

- Below 10 year
- Between 10-30 year
- Above 30 year

After collecting information from the field observations and entering data in the ArcGIS Software, it was observed that a large amount of Babol school buildings is over 30 year old. This shows that the probability of vulnerability for these buildings in an earthquake is extremely high.

**Estimating the damage caused by an earthquake:** Databases for residential buildings were provided based on the census 2012. The database contains the following topic identifiers for each building:

- Year of construction
- No. of floors
- Type of structure
- No. of residents

The items year of construction, number of floors and type of structure are the main information aspects describing the structural properties of a building. Risk

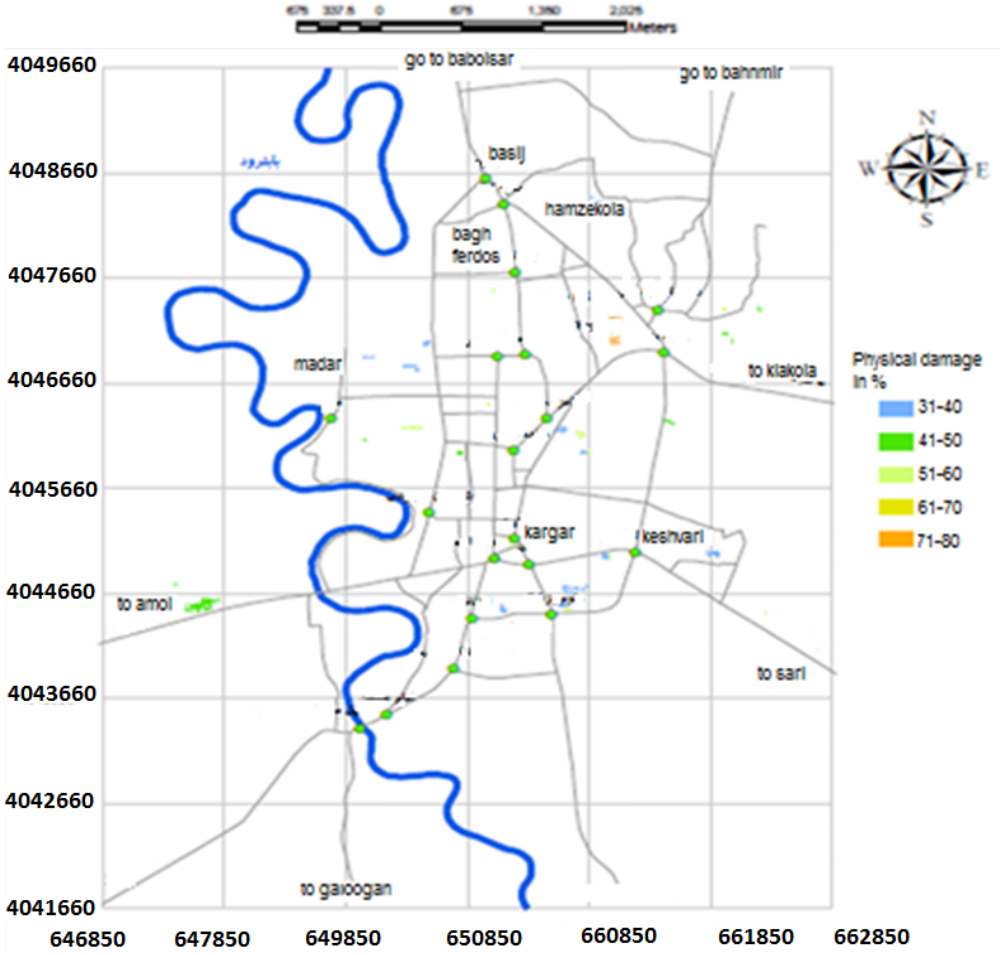


Fig. 2: The potential damage of schools in Babol caused by earthquake

assessment method was selected with regard to the above-mentioned three factors. In general, in order to estimate the damage of school buildings, it is approved that the dynamic parameters such as natural periods of each building relative to the height and type of building structure, i.e., the dynamic response of a building during an earthquake are used. However, in Iran, there are no such parameters available for buildings and they are not taken into account in this study.

**Comprehensive evaluation of vulnerability:** The overall economic vulnerability of the earthquake risk in the study area was evaluated by using the physical and social indicators.

**Risk assessment of each urban area against earthquakes:** The following parameters were considered in the risk analysis: the earthquake risk and its resulting damage.

- Average seismic intensity
- Proportion of structural damage
- Mortality ratio

Social conditions:

- Population density
- Area of open space per capital
- Narrow paths ratio

In this study, in order to estimate the structural damage and obtain the output of the ArcGis Software, risk and vulnerability analyses were performed for the buildings. The vulnerability output is shown in Fig. 2.

## CONCLUSION

As mentioned above, one of the issues that most large cities face is earthquakes which have made the

investigation of features and natural conditions dominant on the urban spaces and the density of peripheral investment and loading and considering proper planning for the safety of urban regions and less damage necessary. On the other hand, any recommendation is realized in an appropriate organizational context. The context of the existing organizations may or may not have some of the essential elements and components. The results of the analysis revealed that 20% of school buildings may have a destruction probability of 80% and because of the importance of this building due to the presence of students, necessary measures should be carried out to improve or retrofit these schools. As a result, in order to prevent irreparable damages or reduce them, the following guidelines are recommended to be used in Babol:

- Reducing seismic vulnerability through immunization and retrofitting urban buildings and facilities
- Designing texture management of the study area
- Providing proper management in the case of risk
- Preparing databases on the close faults or faults involved in risk
- Matching the optimal model of urban land use with the status quo and identifying and modify vulnerable elements and areas
- Hindering traditional and unregulated constructions
- Increased monitoring of municipals and following up the monitoring process until the completion of the construction projects
- Training people to deal with the crisis and the earthquake risk as an important factor of civil defense and performing regular maneuvers throughout the year to get ready to deal with the crisis and the risks of natural disasters
- Raising awareness among the urban population through using the mass media

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