

Seismic Power and Safe Areas of Qazvin

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ABSTRACT

Due to the existence of plentiful dynamic faults e.g. Ipak, in north of Qazvin, Eshtehard and Musha and also devastating earthquakes happened during last century like; Buinzahra's 1962 earthquake with a magnitude of 7.2 Richter and historic earthquakes in the region like; Qazvin's 5.4 Richter earthquake in 1901, Qazvin is considered as an active area from tectonic and seismic power point of view. Considering seismic power and according to statistical studies about the earthquakes happened in the region and also with an investigation on kind, length and activity of faults in the area, three independent seismic fields are distinguishable: Buinzahra with a high velocity and seismic power, Qazvin with moderate to high velocity and seismic power and Takestan with weak to moderate velocity and seismic power.

KEYWORDS: earthquake, fault, Qazvin, Takestan

INTRODUCTION

Earthquake is a proper form of transformation of stone masses where breakage happens in different scales [7]. There is a mutual relation between fault and earthquake i.e. excess of breakage and fault in an area results in earthquake to happen and this earthquake causes new faults to be made as well, eventually the number of breakages increase and seismic power of the area goes higher too [7].

With a short look on the map of faults existing in the area studied, it can be noted that Qazvin as a field, and its neighboring environment are considered as active tense field regarding seismic power.

Additionally, due to the existing major faults e.g. north of Qazvin, Ipak, Eshtehard and ..., there will happen dangerous earthquakes in Qazvin with 6.5 Richter magnitude which can result in huge devastations and disastrous deaths.

Some brief studies on historic earthquakes happened in Qazvin during 20th century show that, regarding seismic point of view, this area is strongly active which has passed a highly dynamic history like the 6.5 Richter earthquake in 1119, 7.2 Richter earthquake of Buinzahra in 1962 and Roodbar and Manjil's 7.3 Richter earthquake in 1990.

Seismic power and prediction of earthquake in extended faults of Qazvin and the environment around

a) Extended faults of Qazvin and the environment around

As is defined, the breakage in earth's crust along which relative displacement happens, is called fault and an exact knowledge of extended faults of Qazvin and the environment around is the first step to investigate land-made vibrations and earthquake risk.

Principal characteristics of seismic faults of Qazvin are briefly mentioned below:

1) Pressure fault of north of Qazvin

The fault of north of Qazvin is a pressure fault with a relative east-west direction, 60 kilometers length and inclination toward north which passes 10 kilometer far from north of Qazvin and 38 kilometers far from north and northeast of Takestan. A sudden altitude difference between city of Qazvin and its northern area is one of the most outstanding topographic characteristics of Qazvin resulted from kinesis of this fault [2].

Qazvin's pressure fault is a seismic fault but due to lack of information about the history of its seismic power is not clear enough. There is the possibility that the earthquake of December 10th in 1119 with 6.5 Richter and 8 Merchali degree magnitude has happened as a result of this fault's kinesis [1].

2) Ipak pressure fault

Ipak is a pressure fault with east-west direction, inclination to south and 85 kilometers length which passes 43 kilometers far from southeast of Takestan. Ipak pressure fault gained a new kinesis after the earthquake of September 1st, 1962 and made an earthquake with 7.2 Richter and 9 Mechali degree magnitude [2]. The potential of secondary kinesis of this fault at the time of third millennium earthquake A.D. in Sagezabad is high [1].

3) Eshtehard fault

This fault, with 63 kilometers length and east-west direction, is located 4 kilometers far from north of Eshtehard and 60 kilometers far from southwest of Takestan. It is inclined to north. Kalledareh village which was destroyed after the earthquake of October 20th, 1876, was located 2.5 kilometers from southwest of Eshtehard [2].

4) South Eshtehard fault

This fault contains an east-west direction and 52 kilometers length located parallel to and in south of Eshtehard fault, 52 kilometers from southeast of Takestan. It is inclined to south with no exact data about its age [2].

5) Qeshlaq Pressure fault

Qeshlaq pressure fault with east-west to southeast-northwest direction and 33 kilometers length passes 52 kilometers far from east of Takestan and 5 kilometers from south of Abyek [2].

6) Alamootrood pressure fault

This fault with northwest-southeast direction and southern inclination and 53 kilometers length passes 70 kilometers far from northeast of Takestan and 20 kilometers far from north of Taleghan [2].

Alamootrood pressure fault had a major role in the earthquake of Roodbarat-Taleghan in April 20th, 1608 with 7.6 Richter magnitude and Heryan earthquake happened in September 27th, 1945.

7) Shahrood pressure fault

This fault is located in west half with east-west direction and in east half with northwest-southeast direction and an inclination toward south-southwest, 60 kilometers long in a distance of 30 kilometers from Qazvin and 57 kilometers from north and northeast of Takestan [2].

There is a possibility that eastern part of this fault had an important role in the earthquake of April 20th, 1608 in Roodbarat-Taleghan with 7.6 Richter and 10 Merchali degree magnitudes [1].

8) Aftabro fault

Aftabro is a fault with northwest-southeast inclined direction and is 50 kilometers long which passes 44 kilometers far from south of Takestan, there is no exact data about the age or seismic power of this fault [5].

9) West part of Musha pressure fault

This part with a length around 200 kilometers reaches Abyek in eastern part of Qazvin. This seismic fault is located 45 kilometers from Qazvin and 85 kilometers from east part of Takestan, there is no data about kinetics of western part of this fault [2].

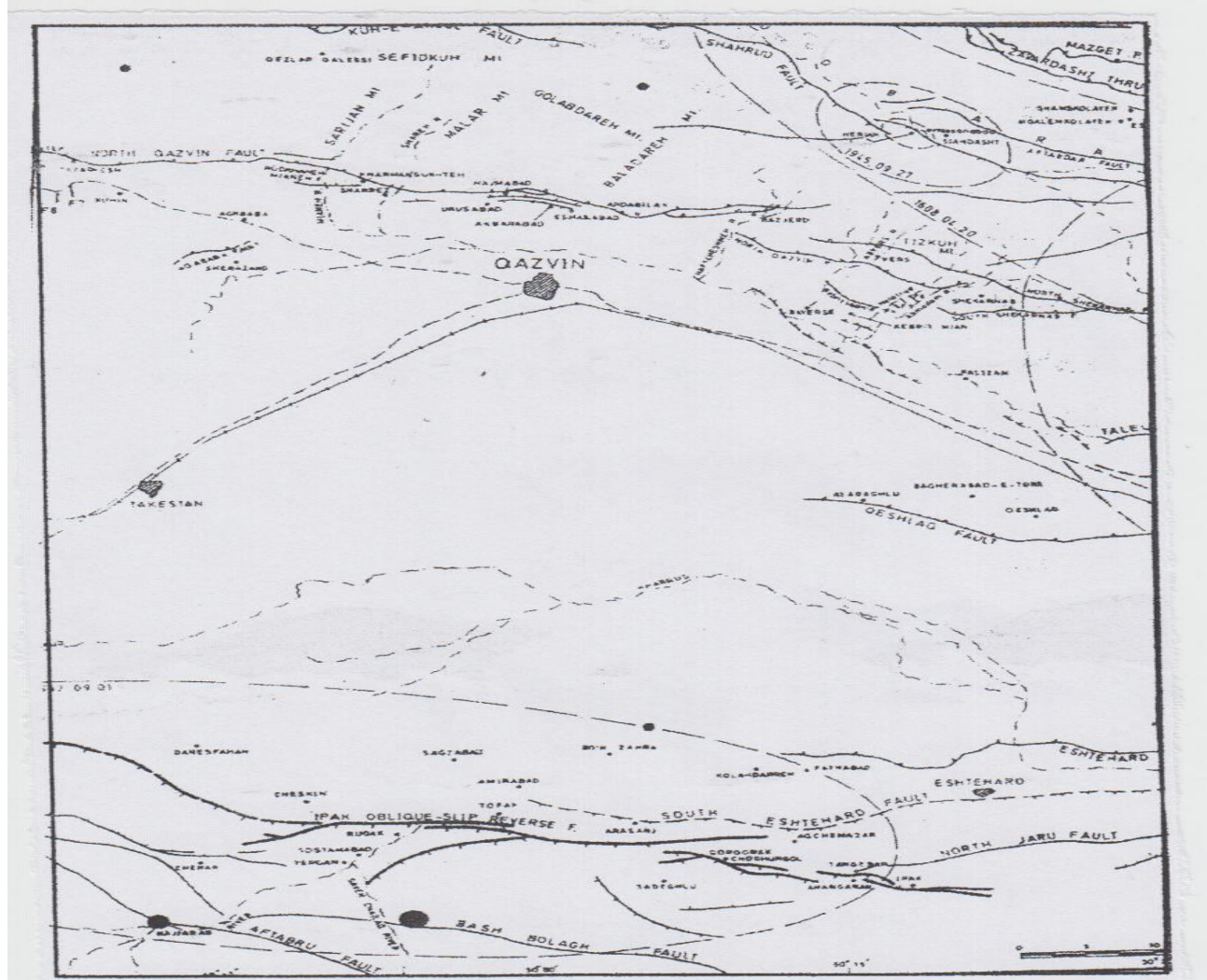
10) Taleghan pressure fault

This fault, with east-west direction and an inclination toward south and 60 kilometers length, is located 45 kilometers from northeast of Qazvin. There is a possibility that the earthquake happened in September 8th, 1966 with 5 Richter magnitude and also the earthquake of December 16th, 1808, 5.9 Richter, in Taleghan, were related to this fault [5].

11) Soltaniyeh fault

This fault, with northwest-southeast direction and 138 kilometers long, is located 43 kilometers from east and northeast of Takestan and 75 kilometers from east of Qazvin. There is no data about the age and seismic power of this fault [6].

In addition to the faults mentioned in Qazvin, there are many other faults like; Klishum, Fashand, Qezelozan, Keshachal, Najmabad, north of Shekarnab, Zavardasht, Alamootrood and ...



Map 1. position of Qazvin's fault

b) Historic earthquakes (before 1900) and major earthquakes of after 1900 happened in Qazvin and the environment around

The data about historic earthquakes of Iran gained from historical literature have not been gathered or studied systematically (at the moment, the best reference for studying such earthquakes is the book “history of Iran’s earthquakes” translated by Abolhasan Radeh). Our knowledge about earthquakes happened before 1900 is limited to historical books, travel accounts and little literature on this issue and unfortunately, there is little knowledge about the center of historic earthquakes. In the following, historic earthquakes of the area being studied are investigated:

1) Third millennium A.D. earthquakes of Saghezabad

Saghezabad is located 11 kilometers from west part of Buinzahra, 8 kilometers from north of Ipaq live fault and 24 kilometers from Eshtehard fault. There is a great possibility that the activity of Ipaq or Eshtehard fault during third millennium A.D. resulted in this devastating earthquake to happen [1].

2) 10th of December, 1119, earthquake in Qazvin

This devastating earthquake happened in Qazvin and lots of people were injured and a huge destruction appeared. This earthquake had a magnitude of 6.5 Richter and 8 Merchali degrees and ended in massive number of deaths and wide devastation.

The whole wall around Qazvin, with one third of city, was totally ruined and Abuhanifah mosque was largely damaged. Aftershocks continued for almost one year [1].

Because nothing mentioned about other cities or big areas around, except Qazvin, it is possible that the reason for this earthquake has been the fault passing 10 kilometers away from north of Qazvin. In author’s point of view, the earthquake happened in 1119 with this magnitude, resulted in wide devastations in Takestan as well.

3) The earthquake of May 1177- Rey, Qazvin

This devastating earthquake ruined the field within Rey, Karaj and Qazvin and made wide damages. It had 7.2 Richter and 8 Merchali degree magnitudes [1]. It is not clear if this field was destroyed due to one or two earthquakes in 1177 or not. Due to lack of seismic data it is not possible to determine which fault; north of Qazvin, Eshtehard, faults around Rey or Ipak, was the reason for this.

4) The earthquake of April 20th, 1608- Roodbarat, Taleghan

A 7.6 Richter 10 Merchali degree earthquake around 12 p.m. destroyed Roodbarat Alamoot (north part of Shahrood river) and Taleghan.

Alamootrood and Shahrood pass from middle of damaged field and it is possible that kinesis of them or one of them has been the reason of this earthquake [1].

5) The earthquake of December 16th, 1808- Taleghan

A 5.9 Richter earthquake destroyed western part of Mazandaran and Taleghan at 6 p.m. on December 16th, 1808. Some houses were destroyed in Qazvin and almost all public places like Abbasi mosque were damaged seriously [1].

It is possible that this earthquake has been a result of Alamootrood or Taleghan faults kinesis.

6) The earthquake of 20th of October- Kalledareh village, Buinzahra

Kalledreh is located 11 kilometers from east part of Buinzahra. This village exists 11 kilometers from Ipak and 2.5 kilometers from southwest of Eshtehard faults. The magnitude of the earthquake happened in this village in 1876 was estimated to be 5.7 Richter. Iran newspaper, no 300, November 5th 1876, wrote: "the earthquake has been severe in Qazvin as well and some walls were destroyed and some rooms of Qazvin's chief mosque had cracks but the city was not totally damaged" [1].

7) The earthquake of Monday, 20th of May, 1901- Qazvin

At 12:29 p.m. a 5.4 Richter 7 to 8 Merchali degree earthquake happened in Qazvin. There is no machinery-recorded data for that [1].

8) The earthquake of Saturday, September 1st, 1962- Buinzahra

7.2 Richter, 9 Merchali degree earthquake destroyed Buinzahra at 10:55 p.m. on September 1st, 1962. It ruined 91 villages and killed 1220. 300 villages were damaged among which 180 had deaths. Some important villages destroyed were: Buinzahra, Danesfahan, Arasanj and Roodak.

Some historical buildings belonging to Saffavid and Qajar era as Shah Soleyman Hosseinieh (house of worship) and shrine on Karaj-Eshtehard route were damaged due to this earthquake [1].

9) The earthquake of June 20th, 1990- Roodbar, Tarom

At 00:38 a.m. local time, a devastating earthquake happened in western Alborz which ended in death of over 30000 people and injury of 60000. Roodbar, Manjil and Loushan and 700 villages were seriously damaged and 300 others had partial ruins. The magnitude was estimated at 7.3 Richter and 10 Merchali degrees. This earthquake was recognized in Takestan and some villages were damaged badly there as well [1].

c) Mathematic relations to determine earthquake parameters

Since seismic power of faults is related to the length of detached and displaced part at the time of earthquake, a straight relation between the earthquakes happened and length of active faults is achievable.

In order to estimate seismic power of each fault, we have to assume part of fault length peripherally. In existing relations, it is assumed that at most, 50% of a fault length is displaced during an earthquake [3].

$M_b = 1.256 + 1.244 \log LR$ (Nouroozi relation, 1985)

$M_b = 2.021 + 1.142 \log LR$ (Salmons relation, 1982)

$\log L = 0.7M_b - 3.24$ (Ambersiz and Melville relation, 1982)

$M_s = 1.61M_b - 3.71$ (Ambersiz and Melville relation, 1982)

$I_o = 1.3M_s - 0.09$

L: Half of fault length on the basis of kilometer

LR: Half of fault length on the basis of meter

M_b: Magnitude of earthquake wave on the basis of Richter

M_s: Magnitude of surface waves of earthquake on the basis of Richter

I_o : Intensity of earthquake on the basis of Merchali adjusted scale

In table 1, seismic power of major faults in the area considered is provided based on researchers' relations: [5]

Table 1. faults in Qazvin and environment around and determination of expectable seismic power

Fault name	Fault length (Km)	Size estimation (Ambersiz and Mellvile relation)	Size estimation (Nouroozi relation)	Size estimation (Salmons relation)	Average estimation (Richter)	Intensity estimation (adjusted Merchalli estimation)
North of Qazvin	60	6.8	6.8	7.1	6.9	9
Ipak	85	6.8	7	7.2	7	9
Eshtehard	65	6.8	6.9	7.2	7	9
Qeshlaq	33	6.4	6.5	6.8	6.6	7
Alamootrood	53	6.7	6.7	7.1	6.8	9
Taleghan	60	6.8	6.8	7.1	6.9	9
Soltaniyeh	138	7.2	7.3	7.4	7.3	10
Musha	200	7.4	7.5	7.7	7.5	10

CONCLUSION

With a brief investigation on the area and historic earthquakes of the field considered, seismic power of Qazvin, Buinzahra and Takestan are explained as followed:

1) Qazvin: among the faults existing in the area, we can note to the role of faults of northern Qazvin, as the first step, and then the role of Qeshlaq, Alamootrood and etc :

Maximum horizontal acceleration of earthquake, delivered to the city by seismic power of north of Qazvin's fault is around 49 % which equals with 8 to 9 Merchalli degrees.

The effects of this possible earthquake in Qazvin is as the following: considerable damages will be made on buildings with special designs, well-designed skeletal buildings will be slanted, normal buildings will be ruined and weak buildings will be seriously damaged.

2) Takestan: among faults existing in the area, Ipak and North of Qazvin faults will have more influence on Takestan compared to other faults.

Maximum horizontal acceleration created by possible earthquake through these faults is around 21 %. This acceleration equals with maximum 7 Merchalli degrees i.e. damages in buildings with special design will be little, skeletal buildings with good design will have little damage, normal ones will collapse inconsiderably and weak buildings with weak materials like; inappropriate mortar will receive serious damages.

3) Buinzahra: among faults existing in the area, Ipak and Avaj faults have more influence on Buinzahra compared to others.

Maximum horizontal acceleration caused by possible earthquake through these faults is around 52 % which equals with 10 Merchalli degrees. The effects of this earthquake on Buinzahra are: normal and weak buildings will collapse completely, serious damages will be made in specially-designed buildings and a real disaster will happen.

Generally speaking, compared to other cities of Qazvin, as a province, regarding seismic power and due to distance from major faults of the area and also absence of known earthquakes happened, during recent centuries or this century, Takestan is considered as a constant area. With maximum areas, especially; Qazvin, Buinzahra and Avaj located near dangerous faults, there is a great need of care and immunization of the structures.

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