

A Preliminary Reconnaissance Report on August 11th 2012, Varzaghan-Ahar Twin Earthquakes in NW Of Iran

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Introduction

At 16:53 of August 11th 2012 (local time) an Mw6.4 (NEIC) earthquake occurred near cities of Ahar and Varzeghan in the East-Azerbaijan province in northwest of Iran. This event was followed by another event at 17:04 (11 minutes after the first shock) with Mw6.3 (NEIC) that based on precise location of the local seismic network (Institute of Geophysics, University of Tehran; IGUT) is located just below the first event at a depth of around 16km. Following this twin earthquakes, more than 20 villages such as Zangabad, Gourdeh, Dino, Bajebaj, Sarand, and Shahsavar have completely destroyed and cities of Varzaghan, Ahar and Heriss suffered different levels of the damage. The Varzeghan-Ahar twin Earthquakes caused panic among 2 million people in the Azerbaijan province, making many people sleep outside for 2 nights. The earthquake killed 327 people, claimed more than 3000 injuries and left more than 30000 homeless. Buildings in the stricken area experienced different levels of damage. Most of the adobe buildings in villages were collapsed and several masonry and framed buildings were damaged. Some of the roads were damaged due to the surface faulting and geotechnical instabilities. Furthermore some of the bridges suffered damage due to the earthquake but was serviceable after the event. Many of the essential facilities (e.g. hospitals) in stricken areas were damaged and some industrial plants experienced economic loss due to the unsafe shutdown process after the earthquake.

Description of the Event

On 2012 August 11 an earthquake of Mw 6.4 occurred near Ahar and Varzaghan in the Eastern Azerbaijan of NW Iran, approximately 60 km northeast of the Tabriz (Figs 1 and 5). Although of only

moderate size, this earthquake which followed with another large event (Mw 6.3) ~11 minutes later, caused about 327 casualties and destroyed severely more than 20 villages, and damaged many building in two Ahar and Varzaghan cities located around 20 km distance of the main shocks.

Different estimates of the main shocks epicenters have been made (Fig. 1). The most precise location is the estimate from the Institute of Geophysics at Tehran University (IGTU), based on their permanent seismic stations in the NW Iran (Tabriz Seismic Network). Relocation of the main shocks (Dr. Moradi from IGTU, personal communication) indicates that both events have occurred at the same coordinates (38.41°N 46.78°E) located approximately 15 km southeast of Varzeghan and ~25 km southwest of Ahar (Fig. 5). The focal depths of the first and second shocks were determined 9 and 16 km respectively. The focal mechanisms of the both events are consistent with right-lateral strike-slip faulting on E-W trending fault parallel to aftershocks sequence and South Ahar fault (Fig1, 5). However, the second main shock (Mw 6.3) shows a considerable reverse component (CMT solution, Harvard University). The field observation also revealed the existence of E-W trending right-lateral strike-slip surface rupture (Fig. 2).

The strongest SGM acceleration PGAs of the first and the second earthquakes were 0.427g and 0.534g (uncorrected records) respectively, recorded at BHRC-Varzaghan station, see Figure 3[3]. The variation of the recorded PGA in the region is shown in Figure 4. Until Aug 20, 2012 more than 1000 aftershocks have occurred in the region, in which more than 100 had magnitude larger than 3 (Fig 5). This figure shows the E-W trending South Ahar fault which seems to be the causative fault responsible for the Mw 6.4 Varzaghan-Ahar earthquake. Figure 6 shows the daily number of major recorded aftershocks within 8 days after the earthquake.

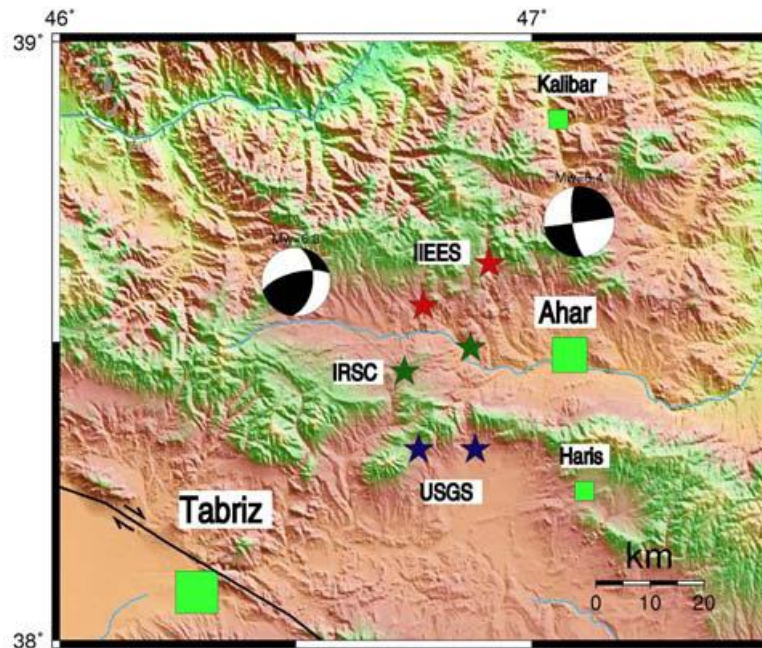


Figure 1. The epicentral area of the 2012 Varzaghan-Ahar twin earthquakes. Main shocks epicenters estimates are the stars in red (from IIEES), green (preliminary location from the Institute of Geophysics at Tehran University), and blue (from the NEIC)



Figure 2. The feature of the surface ruptures indicating on right-lateral strike-slip faulting [2]

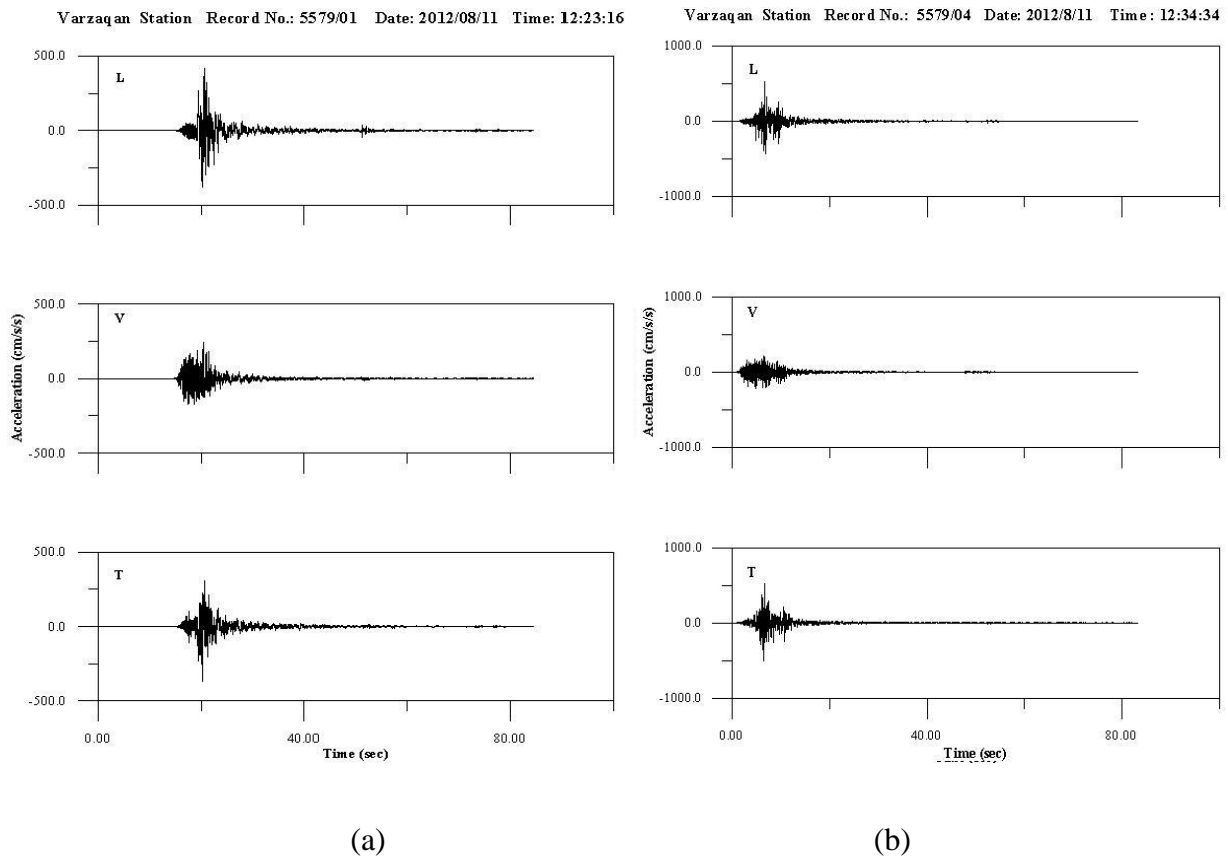


Figure 3. Acceleration time histories of the main events recorded at Varzaghan station (a) the 1st event, PGA=0.436g (b) the 2nd event, PGA=0.544g [3]

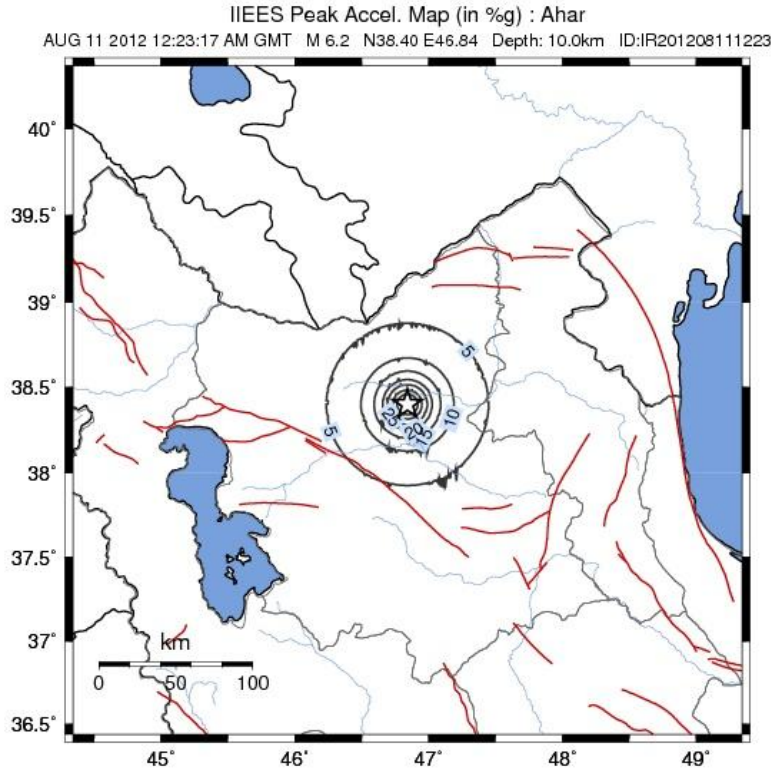


Figure 4. Variation of PGA in the affected area [IIIES]

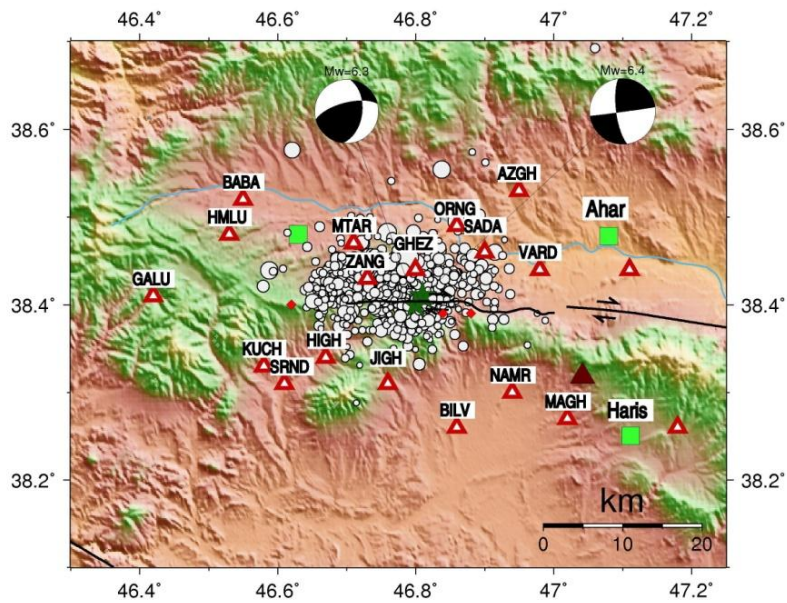


Figure 5. The locations of the aftershocks recorded at local permanent stations of IGTU. A local temporary seismic network of 17 stations, installed by IIIES two days after the main shock is shown as red triangles. The locations of the main shocks based on IGTU relocated epicenters (green stars) and their focal mechanisms (CMT solution) are presented as well (IIIES, Prepared by Dr. M. Tatar).

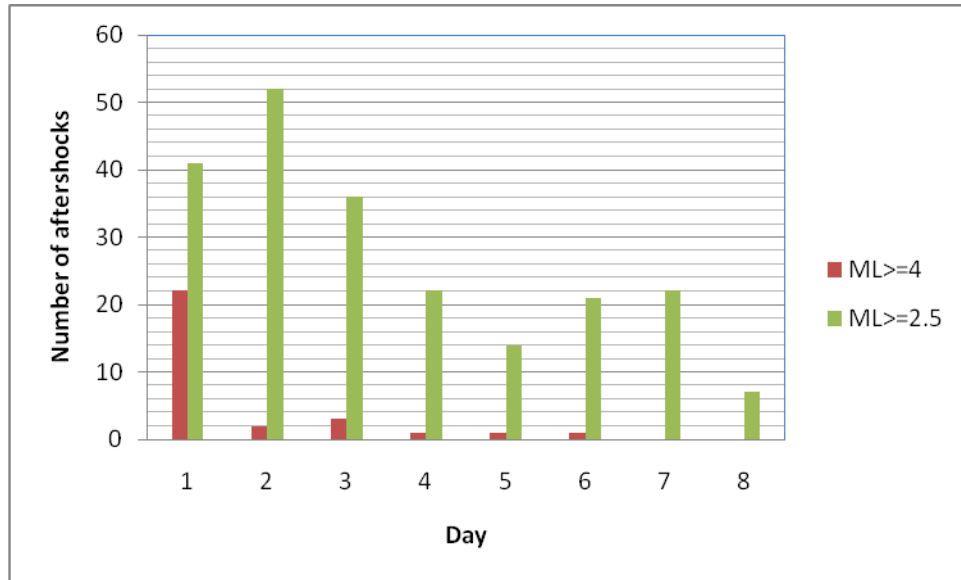


Figure 6. Number of the major aftershocks until August 18th 2012

Geotechnical Aspects

Several landslides and rock falls occurred in the stricken area, as shown in Figures 7. Most of the observed landslides and rock falls were happened next to the Khajeh- Ahar and Khajeh-Varzaghan roads. The distances of the most observed rock falls to the epicenter were less than 20 Km. No evidence of liquefaction and/or sand boiling observed in the stricken area.



Figure 7. Landslide and rock fall near Chaykandi Village [2]

Performance of the Residential Buildings

Most of the collapsed and damaged houses in the effected villages, as shown in Figure 8, were adobe and unreinforced masonry buildings. The main failure modes of these types of building are the failure of heavy roofs, in plane failure of walls and out of plane failure of walls as shown in Figure 9. In general, performance of the brick masonry buildings was noticeably better than of adobe ones. Both framed (steel and RC) structures and brick masonry buildings exist in urban areas. No observable structural damage occurred in residential buildings of the Herris city. Few nonstructural damages observed in these buildings. As shown in Figure 10 residential buildings of different types damaged in both Ahar and Varzaghan cities and villages of stricken area. Infill walls of some of the buildings cracked in northern parts of Tabriz city. It should be noted that buildings with minimum code requirements have survived the earthquake as indicated in Figure 11.



Figure 8. Overall view of the damaged area. It shows that most damages were due the collapse of adobe buildings [Fars News Agencies]



Figure 9. Failure of heavy steel jack-arch and concrete roofs, and walls of UnreinforcedMasonry buildings (Bastami and Mehr News Agency)



Figure 10. Performance of semi-steel frame buildings in villages (Mehr News Agency and Bastami)



Figure 11. Buildings with minimum code requirement have survived the earthquake (Mehr News Agency; Kalantari-IIIES and Bastami-IIIES)

Performance of the Essential Facilities

Hospitals: Performance of Hospitals was not acceptable. Main Heriss hospital with RC moment resisting frame experienced small structural damage due to occurrence of plastic hinge and failure of many columns near to beam-to-column joint, as shown in Figure 12. All of the observed plastic hinges were located in the columns of the first floor. Some of the columns experienced shear cracks next to the openings of the infill walls. In addition to the abovementioned failures, as shown in this figure, diagonal cracks observed in some of the beams net to the column joint. It seems that the main reason for unacceptable performance of the structural system was poor quality of construction and low quality of concrete. Such a performance occurred because of weakness of the cementitious matrix and/or insufficient bondage of cement paste and the aggregates. Figure 13 shows that non-structural damages on the hospital such as diagonal cracking and out of plane failure of infill walls, failure of facades and false ceilings were the major failure modes of the non-structural elements. The hospital was not operable after the earthquake. The Bagher-Al-Oloom Hospital in Ahar city also suffered remarkable nonstructural damages and put out of commission after the earthquake [2]. In plane failure of infill walls, failure of false ceilings and overturning of medical equipment were the major failure mode of non-structural components in this hospital.

Universities: No observable structural damage happened in universities and dormitory buildings in Ahar, Varzaghan and Heriss. Several non-structural failures occurred in educational and dormitory buildings of Varzaghan Islamic Azad University. There were no human losses or injuries have been reported in the universities.



Figure 12. Heriss hospital structural damage to the: Plastic hinges on beam-columns joint and diagonal crack of the column.



Figure 13. Nonstructural damage to Herris hospital:

Dams: Sattarkhan and Herris embankment dam is the most important dam in the affected area, that remained operational, as shown in Figure 14. A crack parallel to upstream-downstream direction was observable in pavement of the crest of the Sattrakhan Dam [2].

Gas stations: No structural damage observed in the gas stations in the affected area. But most of the CNG gas stations went under inspection in order to ensure their safe operation. Only few CNG gas stations were serviceable, and consequently a long queue of cars formed for getting gas.

Roads and Bridges: Although some of the bridges in the affected area suffered structural damage, all of the observed bridges were fully serviceable after the earthquake. Figure 15, indicates a bridge with minor damage. The pavement of some of the roads cracked due to the fault rupture and geotechnical instabilities but the roads was serviceable after the earthquake.

Industrial plants and Factories: Most of the important industrial plants and factories (e.g. Petrochemical plant, refinery, cement facory, etc.) were located near Tabriz and Soufyan cities, more than 45 Km far from the epicenters of the main earthquakes. It is estimated that the PGA of the earthquake in this zone was less than 0.05g. No observable structural damage is reported in the industrial plants. The operation in some of the plants was partially stopped because of the safe shot down operation.



Herris dam (no damage)

Sattarkhan dam (some cracks on its crest)

Figure 14. Sattarkhan and Herris embankment dam with no damage [2]

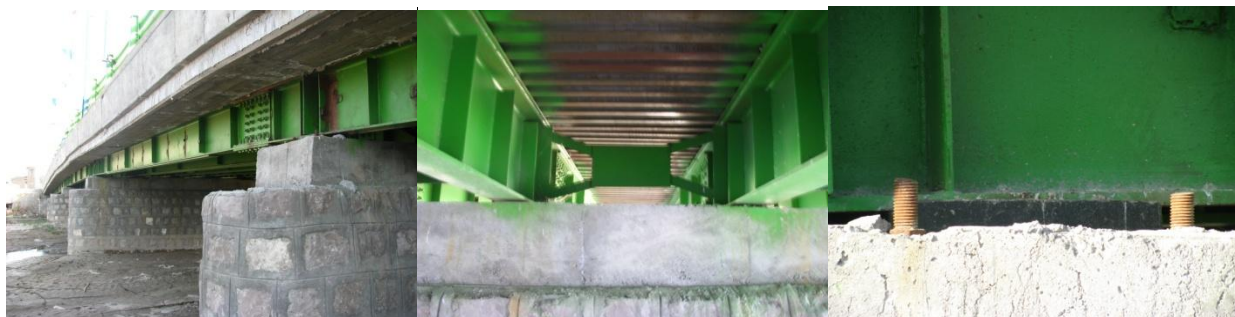


Figure 15. A serviceable bridge after the earthquakes [Bastami, IIEES]

Disaster Response

The search and rescue operation have done by survived people, NGOs and governmental organizations. Just four hours after the earthquake 87 killed and 400 injured people have found by search and rescue teams. The number of killed and injured people reported in 48 hours after the earthquake is indicated in Figure 16, which indicate the effectiveness of the search and rescue operation. As shown in this figure, the lowest performance of the search/rescue teams happened between 7 to 13 hours after the earthquake which was midnight to early morning. Also as it can be seen in Figure 17, most of the killed people reported by hospitals were children and women.

Due to the damages in the hospital, the treatment was done outside in the temporary hospitals setups in the tents, as it can be seen in Figure 12. Rescue teams had to transmit the injured people to the hospitals of the nearby cities.

A remarkable traffic jam in Tabriz-Varzaghan, Tabriz-Ahar and other primary roads of the affected area was one of the most troubles of rescue teams. The main reason for such traffic jams was large remarkable number of volunteers going to the affected areas for helping the rescue teams.

The earthquake caused panic among about 2 million people in the Azerbaijan province; make many people sleep outside for several nights especially in Tabriz, see Figure 18. The earthquakes claimed more than 30000 homeless who had to live in emergency shelters, as shown in Figure 19. Following the earthquakes, the presence of NGOs and self-motivated volunteers was remarkable and noticeable; as they provided essential needs of victims, see Figure 20. Despite all of the suffering, hope and life continues in the stricken area, as shown in Figure 21.

Shortcomings of the crisis management: Disaster managers in this seismic event were not able to control the heavy traffic especially in the first days after the earthquakes. The traffic jam and panic behavior of the drivers caused several car accidents which claimed some victims. Different organizations, presented inconsistent statistics about the consequences of the event (e.g. number of killed and/or injured people). Such a situation made the victims of the event worry and caused panic behavior. The emergency shelters (tents) were not suitable for the climate of the earthquake affected area. Although the earthquake happened in summer, victims of the earthquake had to make fire outside their tents at nights because of the cold weather. Sanitary services in the emergency shelters were important needs of the victims. Lack of psychological counseling and mental therapies was one of the most shortcomings of the crisis management in this earthquake.

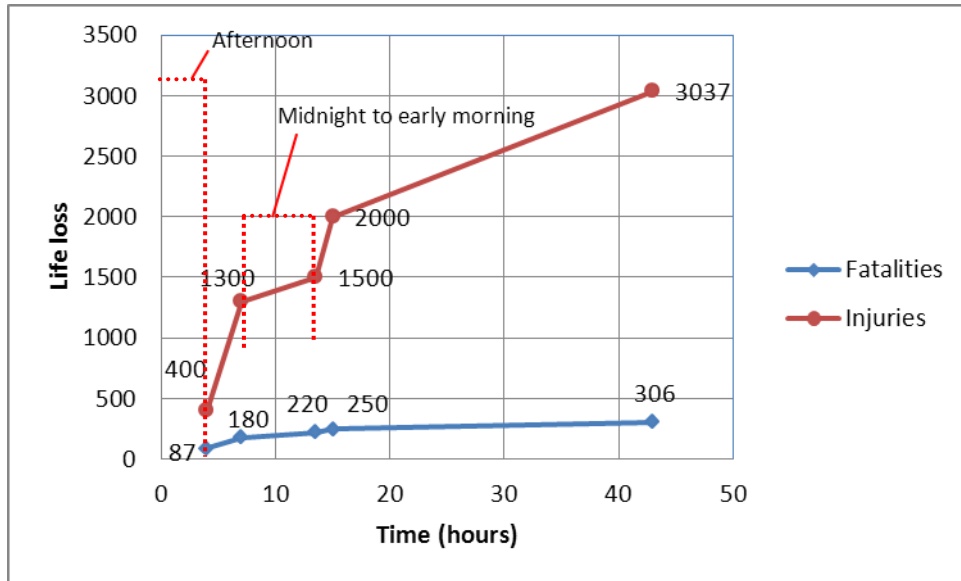


Figure 16. The life loss reported at different stages on search-rescue operation

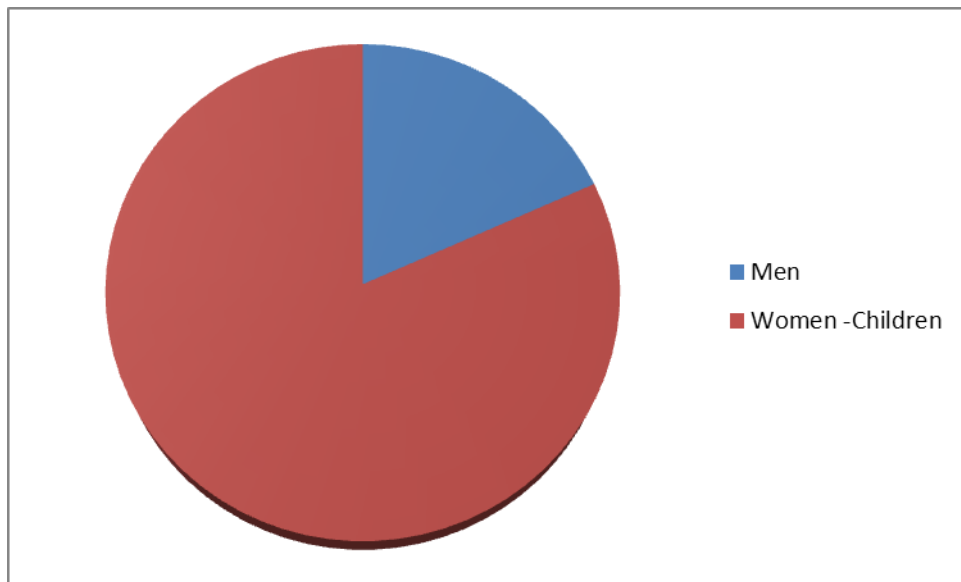


Figure 17. Gender and age of the killed people



Figure 18. The earthquake made many people sleep outside in Tabriz



Figure 19. Victims of the earthquake had to live in emergency shelters



Figure 20. People self-motivated volunteer response (Parsizadeh, Eskandari and Mehr News Agency)



Figure 21. Hope and life continues (Mehr News Agency)

References

- [1] Zareh M., Shahvar M. (2012), An Urgent Report on the 11 August 2012, Mw6.2 and Mw 6.1; Ahar Twin earthquakes in East Azarbayjan Province of NW Iran, www.iiees.ac.ir
- [2] Davoodi M., Kalantari A., Mostafazadeh M. (2012), Urgent Reconnaissance Report on Ahar Earthquake: Reprt No. 1, www.iiees.ac.ir (in Persian)
- [3] Building and Housing Research Center (2012), Ahar earthquakes of 11 August 2012 (East-Azerbaijan), www.bhrc.ac.ir (in Persian)
- [4] ijan), www.bhrc.ac.ir (in Persian)