ABSTRACT
An extremely dangerous shallow earthquake occurred in the Qaradagh(Ahar-Varzeghan) NW of Iran. This paper presents damage on buildings and infrastructure plans during the 11 August 2012 strong NW Iran earthquakes. Successively Qaradagh earthquakes (first earthquake was hit by Mw=6.4 at 16:54 local time (12:23 GMT) and about 11 minutes later, Mw=6.3 struck 10km to the west) are the cluster ones or “earthquake grouping”, and involved more than hundreds moderate and small temblors and are centered on Varzeghan area. Initial analysis suggest they were a result of movement along a right-lateral strike-slip fault, were neighboring blocks move horizontally past one another traveling in a roughly east-west direction within the Eurasian plate. The maximum peak acceleration (PGA) of the first event was 478 cm/s/s on horizontal component recorded in Sattarkhan dam and it of second event was 532 cm/s/s on horizontal component recorded in Varzeghan City.

Introduction
Earthquakes occur in narrow belts. Faults play key roles in a variety of processes in the earth's crust. They produce some of nature's most destructive phenomena and accommodate tremendous deformations in the Earth's crust over geological time [9].
On the late afternoon of Saturday August 11, 2012, two of the strong Earthquakes Shook the NW of Iran in Iranian history. The first was hit by Mw = 6.4 at 16:54 local time (12:23 GMT), and about 11 Minutes later an Mw = 6.3 struck 10 km to the west. The maximum peak acceleration (PGA) of the first event was 478 cm/s/s on horizontal component recorded in Sattarkhan dam and it of second event was 532 cm/s/s on horizontal component recorded in Varzeghan city (Figures 1-4).
Figure 1. First records of earthquake at Varzeghan station

Figure 2. First earthquake records at Ahar station
Figure 3. Second earthquake records at Varzeghan station

Figure 4. Second earthquake records at Ahar station
The Qaradagh earthquake was a complex earthquake, paleoseismological data show that for the same regions prior earthquakes have occurred in clusters of ruptures of several faults separated long quiescent periods. Several examples have been chosen that illustrate aspects of the phase locking of faults [3]. Observations along exhumed faults provide information on faulting processes at depth that a difficult to obtain by other means.

Recurring field observations of exhumed faults and predictions of faulting models must be reconcilable if they both are to be used with confidence to understand faulting processes at seismogenic depths or to better predict fluid flow along faults. For example, hydrothermal mineralization and Alteration along secondary fractures near the ends fault traces (for example Ahar- Varzeghan an unknown fault was produced during Qaradagh earthquake) consistently indicate that these fractures form excellent conduits for fluid flow [7, 8].

The two main earthquakes occurred as a result of oblique strike- slip faulting in the shallow crust of the Eurasian plate, approximately 300 km east of the plate boundary, between the Eurasia and Arabian plate many faults have been recognized in the region, from after strong earthquake occurred in August 2012 in this area. Trough analysis of high-quality broad band wave form data from this earthquake [1] determined that the earthquake's occurred at depth of 10 km below grand level continental regions by combining this location with the more than 4000 aftershock until October 20, 2012, which occurred at 10 to 15 km depth (Figure 5).

![Figure 5. The blue ,red, green lines represent the operating field and depth of 11 August, 2012 Qaradagh Earthquake](image)

In the 11 August 2012 Qaradagh earthquake in Azerbaijan area, approximately residential building were destroyed and damaged. It is also estimated that 50%-85% important official building were destroyed and damaged including administration, military buildings etc. Due to ground shaking, most damage to building structures occurred. Because of ground failure also to land sliding, rock sliding and subsidence, a large number of building structures located on or near the slopes were destroyed and damaged (Figure 6). The most concentration of damaged or destroyed building structures was in Varzeghan, Ahar, and most of the collapsed and damaged
houses in the effected villages and depressed areas, as shown in figures 9 and 10, were adobe and unreinforced masonry buildings.

![Figure 6. Surface rupture on roadway Varzeghan area](image)

**Geological setting**

The Qaradagh earthquakes clusters of August 11, 2012 occurred in the low plateau region of northeast of Tabriz City. Geological setting of the area consists of sedimentary, volcanic sedimentary, plutonic and volcanic, and terrestrial deposits embracing almost entire stratigraphic range beginning from early Mesozoic through Quaternary time [2]. The Ahar-Varzeghan area is about 1800 m above sea level and located between two NW-SE trending mountain ranges (Figure 7). To the North, the Sungun- Shivar- dagh mountain with an elevation of 2652 m represents the highest summit among the many mountains in the north and the surrounding of Ahar- Varzeghan area.
Damage to Houses and Buildings

In the 11 August 2012 Qaradagh earthquake approximately residential building were destroyed and damaged. The most concentration of damaged or destroyed building structures was in Varzeghan, Ahar, Heris and in the rural regions. In the main event, estimates tell that 50%-90% of the building structures were destroyed or badly damaged in Varzeghan, Ahar, Heris and entire villages.

In these areas, major concentrations of damage were found in the areas of deeper alluvial deposits along the rivers named Varzeghan and Ahar Chay. In Varzeghan, damage was directly related to Baja-Baj fault rupture (Figure 8).

Figure 8. The failure of earthquake triggered landslide near the hill (Arpazami) at the Chakmakbulagh village Varzeghan area
Several other villages located along the rupture zone suffered significant damage to their building structures. An Aerial survey revealed that a large number of buildings and traditional houses destroyed were in the more rural and mountain areas proximate to the fault rupture. Most of school buildings collapsed due to non-seismic design, low equality construction improper design etc. (Figure 9).

Figure 9. Damage to adobe buildings

Figure 10. Damage to reinforced concrete buildings
The water system was damaged and Varzeghan - Heris- Ahar and other areas was cut off from water supply. The electric power supply to this area was cut off due to fallen transformers and broken transmission lines.

**The Qaradagh Earthquake: Impact on Lifeline, Bridge and Roadway systems**

Reduction of direct and indirect earthquake losses requires that existing public works and utility networks be functional following an earthquake. The Qaradagh earthquake with estimated direct losses of about $80-100 Million, It produced the strongest ground motions ever instrumentally recorded in an urban and rural setting in Azerbaijan area. Most lifelines experienced some damage and disruption. The earthquake was especially to transportation and water systems and cause extensive damage to power systems. In addition, the impact of lifeline disruption or emergency response capabilities of hospitals and fire suppression elements of the emergency response community are discussed. The most significant damage to lifelines and bridges, roadways occurred in the Varzeghan- Ahar and Heris cities of Qaradagh regions both over 20-30 km the epicenter of the earthquake. It is certain that even greater damage to bridges and elevated viaducts these cities would have resulted if this earthquake had been larger or centered closer to the Qaradagh area. Seismic safety is but one of the many problems facing owners and managers of both private and public works and utilities.

Earthquake caused gas network cut off for 20 thousand domestic users in stricken areas. Most of damages to gas distribution network have occurred in residential areas because of building collapse and rest of networks was undamaged. Gas systems back to use for undamaged areas including for 37 out 38 villages of Varzeghan and 60 out of 74 villages of Ahar and 15 out of 18 Villages of Heris county.

Electricity network of 25 villages are totally damaged. Electricity rafts located on fault have fallen rest of them in farther distance from the fault was undamaged. The highest damages to
Tabriz electrical power network relates to Sarand-Kandi Village, located in suburb of Tabriz city. Finally, in the Varzeghan- Ahar and Heris areas, many utility poles were damaged by collapsed buildings, and some underground cables required several days for repair. Another observation about lifeline performance is that electric power is critically important for other lifelines, with power loss reflected directly in reduced serviceability of water supplies, wastewater facilities, telecommunications, and transportation.

Conclusions
The two earthquakes occurred as a result of oblique strike-slip fault in the shallow crust of the Eurasian plate. These earthquakes lay an interpolate type. Due to ground shaking most damage to building structures occurred. Major concentrations of damage were found in the areas of deeper alluvial deposits along the rivers. The maximum pick acceleration (PGA) of the first event was 478 cm/s/s on horizontal component recorded in Sattar-Khan dam and it of second event was 532 cm/s/s on horizontal component recorded in Varzeghan.
Most of the hospitals and schools in the region also suffered severe damage or collapsed. The electric power supply to this area was cut off due to fallen transformers and broken transmission liners. Earthquake caused gas network cut off for 18 domestic users in stricken area.
To lifelines and bridges, roadway occurred in the Varzeghan - Ahar and Heris cities of Qaradagh region both over 20-30 km the epicenter of the earthquakes.
The deaths were more than 350 persons. The significant amount of the death toll and structural damages are from adobe and stone traditional buildings.

References