SECOND EUROPEAN CONFERENCE ON EARTHQUAKE ENGINEERING
AND SEISMOLOGY, ISTANBUL AUG. 25-29, 2014

LESSONS LEARNED FROM THE 28 NOVEMBER 2013 BORAZJAN, SOUTH OF IRAN EARTHQUAKE

Ahmad NADERZADEH[1], Ehsan NADERZADEH[2] and Masoud NADERZADEH[3]

ABSTRACT

On November 28, 2013 at 17:21 local time (13:51 UT) an earthquake of magnitude M 5.6 (Mw 5.7) occurred in south of Iran, which caused moderate damage in Bushehr province. The total casualty was 7 deaths and 210 injuries. About 4,800 residential units suffered with different levels of damages. The epicenter was located at 29.31°N and 51.31°E. In total 11 strong motion accelerographs recorded the earthquake. The nearest and the furthest stations to the epicenter were Dalaki (about 11 km) and Bandar Ganaveh (about 86 km), which recorded peak ground accelerations of 0.23g and 0.017g, respectively. The nearest urban area to the epicenter is Borazjan which experienced a relatively strong shaking, but serious damages were not observed in this city. Maximum intensity on the MSK scale was VII at the epicentral area and it was VI− in Borazjan. Other than buildings with reinforced concrete and steel structures in Borazjan and villages, there are many homes with unreinforced cement block and stone masonry in the earthquake stricken area in which earthquake effects on these types of buildings was considerable.

There were also important structures in the area which were affected due to the earthquake. For instance, a newly built hospital building in Borazjan suffered extensive non-structural damages which temporarily disrupted its services to ordinary as well as injured people due to the earthquake. Main damages were settlement of the floor in a couple of rooms on the ground floor, damage at the separation joint area, separation of infill walls from the frame, falling of tiles and false ceilings, and falling of facade stones.

Although the Borazjan earthquake is categorized as a moderate earthquake but it offered many useful lessons. Among others are, the importance of site selection of important and vital structures, treatment of the ground soil where there is a possibility of settlement, paying more attention to the separation joints and the filling materials between them, proper fixing of all the tiles, false ceilings, facades, etc. This report presents the result of post earthquake visit of the earthquake stricken area and its effect mainly on different types of buildings and in particular a newly built hospital building. It also discusses the learned and relearned lessons due to the earthquake.

INTRODUCTION

On Thursday, 28 November 2013, at 17:21 local time (13:51 UT), a relatively strong earthquake occurred in northeast of Borazjan city in south of Iran. A relatively large area of the Bushehr and parts of the Fars Provinces were shaken due to this earthquake. Although the epicenter of the earthquake

[1] Technical director, Imensaze Zelzeleh Company, Tehran, Iran, naderzadeh@dpi.net.ir
[2] Expert, Imensaze Zelzeleh Company, Tehran, Iran, e_naderzadeh@yahoo.com
[3] Graduate student of civil engineering, Amir Kabir University of Technology, Tehran, Iran, naderzadeh.masoud@gmail.com

was located in a relatively low populated area but some districts and villages sustained damages due to this earthquake. According to official figures 7 lives were lost and more than 210 people injured. Also, in total about 4800 residential units experienced damages with different degrees. This event was occurred one day after the first anniversary of the flooding in the area.

According to the Institute of Geophysics of Tehran University (IGTU), the magnitude of the earthquake was M 5.6 and the epicenter was in northeast of Borazjan. The nearest urban area to the epicenter was Borazjan city which was shaken with a moderate intensity but no destruction or serious damages was observed in this city. Other than reinforced concrete and steel buildings in Borazjan city, many buildings with stone masonry bearing walls are constructed in the earthquake affected area of Borazjan and surrounding villages which earthquake effect on those buildings were considerable.

The most important building which experienced extensive non-structural damages was the newly built Borazjan hospital which disrupted its continuous services following the earthquake.

This paper presents the earthquake, its causative fault, and its effects on the ground and the structures located at the earthquake macro-seismic area, and finally highlights the lessons learned and re-learned due to this earthquake.

BACKGROUND SEISMICITY OF THE REGION

The earthquake affected area is located at the southern Zagros area and has been exposed to small to moderate earthquakes since ancient times. Historical background shows that small to medium size earthquakes have caused destructions in this area from time to time. More than 26 historical (prior to 20th century) earthquakes with magnitudes greater than M 5.5 within a radius of 200 Km from the epicenter are documented mainly by Ambrasys and Melville (1982). In the 20th century, generally moderate earthquakes have been recorded in the vicinity of the recent earthquake epicenter which is an indication of the moderate to relatively strong seismicity of the area. Some of these earthquakes within a radius of 100 Km from the recent earthquake epicenter have been destructive and their magnitudes have relatively been moderate. More than 60 earthquakes with magnitude greater than M 5.0 within 100 Km radius are reported since 1925 up to the recent earthquake. Figure 1 shows the instrumental epicenter of the earthquake reported by the European-Mediterranean Seismological Center (EMSC). It also shows the earthquakes occurred in the region since 1960 up to the 28 November 2013 earthquake.

SEISMOLOGIL DATA

Various institutions reported different data for the 28 November 2013 earthquake. Magnitudes reported by IGTU, IIEES, NEIC, EMSC were M 5.6, while Building and Housing Research Center (BHRC) which derives the earthquake data directly from the recorded strong motion accelerograms, reported the magnitude as Mw 5.7.

According to most reports, the epicenter of the earthquake was concentrated in the northeast of Borazjan city (east of the road between Borazjan to Dalaki near Rahdar village). IGTU reported the epicenter at 29.31°N and 51.31°E. Local investigation confirmed the reported location for the epicenter.

The reported focal depth for the earthquake was between 8 to 16 Km. Evidences on the ground surface, intensity, and the relative low damage distribution were also an indication of the shallow focal depth of the earthquake.

The 28 November 2013 Borazjan earthquake was felt in a relatively large area of the Bushehr and parts of the Fars Provinces. Maximum intensity at the epicenter (on mountain heights with no residents) is estimated as VII in MSK scale. Rahdar village, the nearest residential area to the epicenter which suffered the most damage, experienced the intensity VI+ and the Dehghayed village located in the north of Borazjan city which had also experienced a relatively significant damage had the intensity VI. Finally, the maximum intensity in Borazjan city was estimated as VI-.

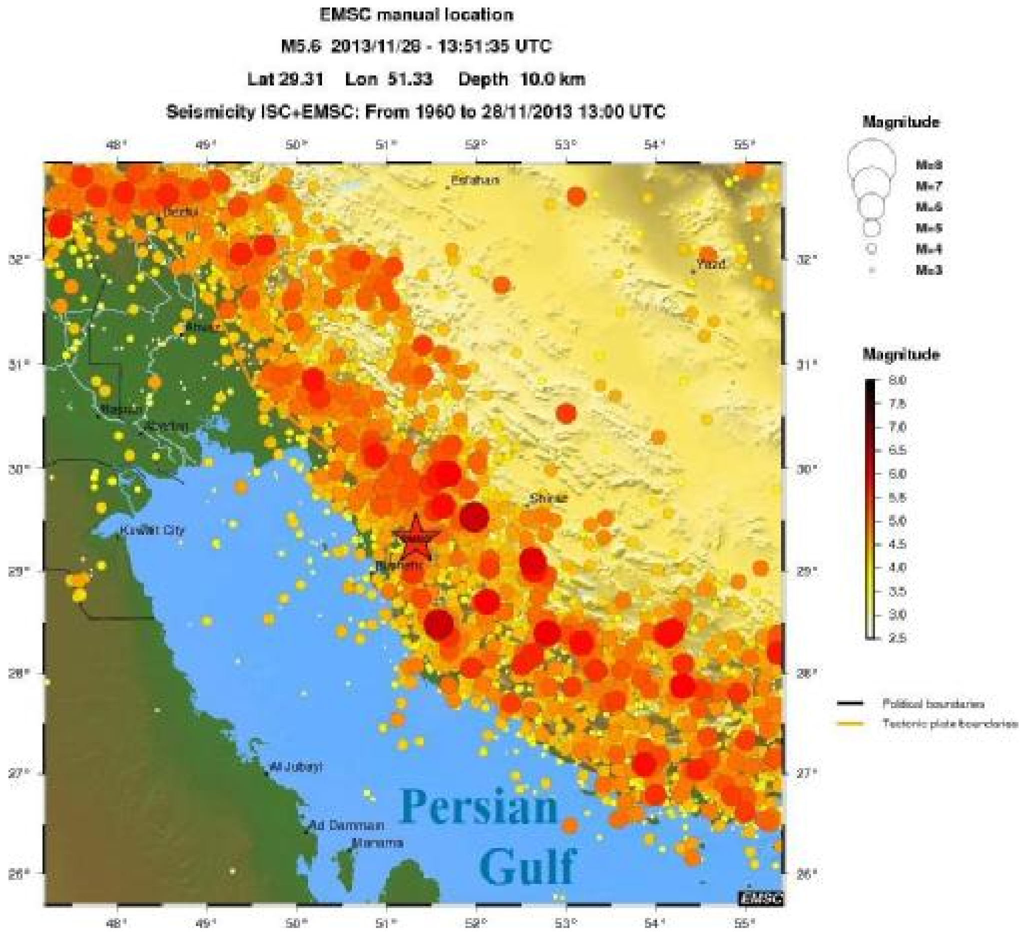

Figure 1. Epicenter of the Borazjan earthquake (red color star) reported by EMSC. Other earthquakes occurred in the region since 1960 up to the 28 November 2013 earthquake are also shown.

STRONG MOTION RECORDINGS

Several strong motion accelerographs were located at the earthquake stricken area at the time of the earthquake. The nearest instrument to the epicenter was the accelerograph installed in Dalaki (about 11 Km to the northwest of the epicenter) which recorded a Peak Ground Acceleration (PGA) of 232 cm/s^2. In total the earthquake motion was recorded by 11 strong motion instruments in the area. Recorded PGA's of the 28 November 2013 by the Iranian Strong Motion Network (ISMN) are shown in Table 1.

Unfortunately, some of the accelerographs, among others the instrument installed in Borazjan city were out of service during the earthquake and therefore, there is no recorded motion available from this city. As a result, in order to study the behavior of the structures in this city, the ground motion acceleration of the city was estimated by carrying out local investigation, the observation of overturned objects, and damage distributions on structures which concluded that the maximum horizontal peak ground acceleration in this city must have been a little over 0.10g. This estimate was confirmed after the average distribution of the horizontal acceleration map was prepared based on the recorded accelerations in the earthquake stricken area (Figure 2). According to the Building and Housing Research Center's report, the effective duration of this earthquake in Dalaki station was about 5 seconds and its dominant period was about 0.1 second. Acceleration, velocity, and displacement time histories, and also response spectra of the recorded accelerograms (transversal component) at the Dalaki station from the same report are shown in Figure 3.

Table 1. Peak Ground Accelerations (PGA's) recorded by Iranian Strong Motion Network

	Station	Epicentral distance (Km)	Recorded PGA's (cm/s²)		
			Longitudinal component (L)	Vertical component (V)	Transversal component (T)
1	Dalaki	11	212	111	232
2	Tang-e Eram	27	130	76	136
3	Shabankareh	38	118	38	58
4	Konar Takhteh	20	79	53	100
5	Faryab	51	80	59	52
6	Abad	38	48	41	72
7	Chehel Zarei	51	44	16	24
8	Ali-Hosseini	67	12	5	21
9	Bandar-e Ganaveh	86	17	5	12
10	Ahram	52	11	11	13
11	Booshkan	66	11	6	9

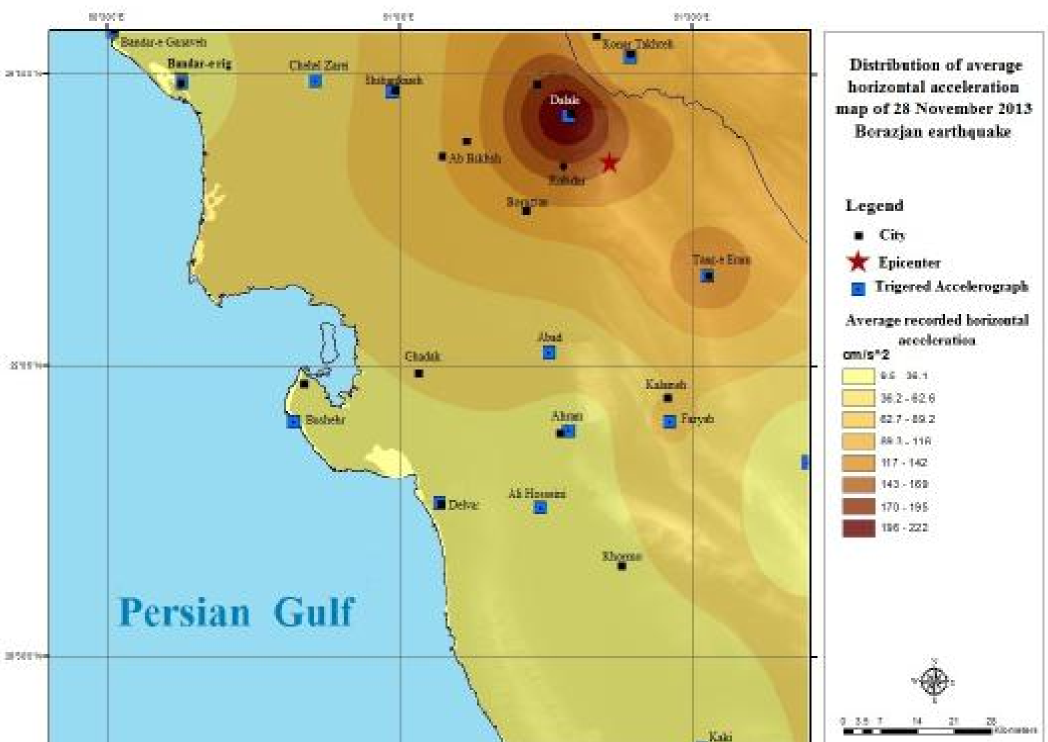

Figure 2. Distribution of average horizontal acceleration map based on the recorded accelerations in the earthquake stricken area.

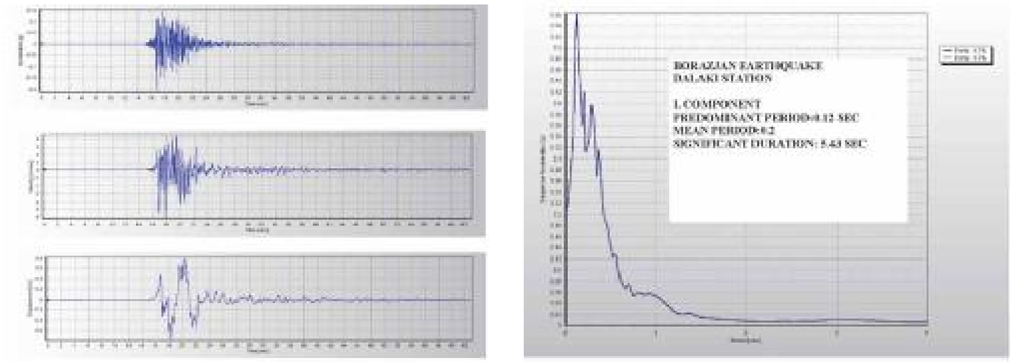

Figure 3. Acceleration, velocity, and displacement time histories of the transversal component recorded at Dalaki station (left), and response spectra of the same accelerogram (right).

EFFECTS ON THE GROUND AND THE CAUSATIVE FAULT OF THE EARTHQUAKE

Some limited surface deformation were developed due to the earthquake, among others were the lateral spreading of the ground and local settlement of the road between Borazjan and Dalaki (Figure 4a, b). Also, some changes were observed on the underground water level following the earthquake. These changes caused blockage of a spring and opening of another spring near the epicenter. At the entrance road to Rahdar village which is the nearest residential area to the epicenter, a sulfur smell was spread around, which according to local people had been created after the earthquake.

According to reporting agencies, the magnitude of the earthquake was M 5.6. Most likely, with an earthquake with this magnitude, an accompanying surface faulting is not expected. In addition, it is not generally expected to have a surface faulting even in the case of earthquakes greater than this in the Zagros fold belt. The main reason for this is related to the presence of evaporative and thick ductile sediments of infra-Cambrian, Jurassic, and Miocene which has caused detachment in different layers. Thus, the primarily seismic ruptures in the earthquakes of the Zagros region are rarely reached to ground surface.

The coordinates of the epicenter of the 28 November 2013 Borazjan earthquake shows that this event has occurred in the southwest boundary of the tectonic sub-units of the Zagros fold belt belonging to the Zagros tectonic unit. Zagros Mountains are introduced as the separating deformation of the Arabian and the Eurasian plates. Jackson and McKenzie (1984) described the relative movement between the Central Iran plate and the Arabian plate with the Euler polar coordinates of 14.6°N and 34°E and with the rate of 6.42 mm/yr. The position of this pole with consideration to structural elements boundary is a justified reason for presence of oblique convergence following the plates' collision. This means that in addition to the compressive components, the presence of the right lateral component in Zagros is also a natural phenomenon.

(a) (b) (c)

Figure 4. Lateral spreading (a), and a local ground settlement and the poured Asphalt after the earthquake (b) on the road between Borazjan and Dalaki. Borazjan fault which is a portion of Kazerron-Qatar fault (c).

The fault plane solution of the recent earthquake shows that there is a strike-slip mechanism of its causative fault which is the Borazjan fault (Figure 4c). The Borazjan fault is a portion of the Kazeroon-Qatar basement fault which extends from the Dinar Mountain in the north toward south to the east of Bushehr and the Persian Gulf. This fault has been existed since the pre-Cambrian period and its creation is the production of the Katangan Orogeny. Many earthquakes confirm the recent activity of this fault. In the Zagros geological literature, this master fault determines the boundary between the northwestern Zagros (Lorestan Zagros) and the southeastern (Fars Zagros).

However, Talbot and Alavi (1996) have defined the boundary of the eastern and western Zagros with a strike-slip zone which is in turn introduced by the presence of two right lateral strike-slip lineaments namely Mengharak-Mazrook in the east and the Kazeroon-Qatar in the west. More precise investigation shows that the Mengharak-Mazrook lineament corresponds with the Ardakan, Karebas, and Firoozabad faults which earthquakes of Dadenjan, Firoozabad (1994), Ghir (1972), and Karebas (1989) correspond with them. To this end, all relevant segment faults to this lineament are earthquake faults. The Kazeroon-Qatar lineament corresponds to Dena, Noorabad, Kazeroon, and Borazjan faults.

There are reports of digging a trench on the Borazjan fault near the epicenter of the 1929 Ahram earthquake which shows a clear displacement of lower Holocene and Quaternary. The causative fault of this displacement was again experienced in this trench during the 1999 Ahram event with magnitude Mw 5.2. This is an evidence for accepting a low probability of surface faulting in the Zagros earthquakes.

One solution to estimate the probability of earthquake occurrence in the future is to know the faults slip rates, earthquake related to this slip rate, and comparison of its results with real earthquakes of the instrumental and historical periods. In the lack of accurate information from the age determination of ancient earthquakes, more appropriate information are obtained from the return period of earthquakes of certain magnitudes or earthquake occurrence rate from the faults slip rates. Estimation of the long term behavior of the earthquake sources with estimation of their slip rate can facilitate the prediction of place and time of the events in the long term intervals.

EFFECT OF THE EARTHQUAKE ON BUILDINGS

New buildings in Borazjan city are constructed in accordance with modern construction technology. However, in most cases long yard walls of the buildings are constructed by unreinforced cement blocks. This type of walls is generally vulnerable against the lateral seismic forces of even moderate earthquakes. Figures 6 and 7 show cases of damages to buildings in Borazjan due to the earthquake which are generally falling of the cement block or stone walls and also damage or fall of the building facades.

Residential buildings in villages have a relatively more hazardous situation. This is because firstly they generally lack tie beams and tie columns, and secondly they use unreinforced stone or block walls as bearing walls. In some cases, mud mortar is used in stone walls which make them vulnerable to even small or weak earthquake motions. It is interesting to note that the stone walls, especially in bearing walls are constructed in double layers and in some cases even thicker. It was observed in many cases that one of the layers in these walls is collapsed while another layer is still remained (Figure 8- left). The roofs of these buildings are mostly jack arch type.

Due to the earthquake, especially in the villages, buildings sustained damages to different degrees. Most damages were observed in stone and cement block walls and buildings which had used stone walls as bearing walls. Figure 8 (right) shows the collapsed cement block wall of the school yard of Rahdar village. This school was closed during the visit, and according to local people, another building was temporarily used as school. Figures 9 show typical damaged buildings in Rahdar village due to the earthquake.

It was noted in the village that significant number of the newly built houses or under construction houses with reinforced concrete frame had not sustained any damages.

Figure 6. A yard wall of a vocational school made of cement block is fallen in Borazjan city.

Figure 7. Part of a fallen wall and façade in a building in Borazjan (left), and developed cracks on a brick façade in Borazjan (right).

Figure 8. Failure and collapse of one of the layers of the wall while the other layer is remained (Rahdar village) (left), a fallen wall of the Rahdar village school made of cement block. The debris had been removed at the time of the visit (right).

Figure 9. Damages in Rahdar village. Partial collapse of the jack arch roof (left), and the fall of yard wall (right).

EFFECT OF THE EARTHQUAKE ON THE BORAZJAN NEW HOSPITAL BUILDING

The Shahid Ganji newly built hospital building of Borazjan city which is located about 20 Km to the epicenter is one of the most important buildings in the recent earthquake stricken area (Figure 10). This building which has different floors up to 4 story sustained several non-structural damages due to the earthquake which caused relocation of the hospitalized people to other hospitals (e.g., the old Borazjan hospital which had not sustained any damage and the hospitals in Bushehr city, the capital of the Bushehr Province).

Although the recent earthquake had neither a relatively high intensity nor a high acceleration in Borazjan city but imposed the following damages to the new hospital:

- *Observed damages from outside*

What had exposed the hospital to the public eyes more than anything else, was the fall of façade stones from the external walls. This type of damage could be seen in different parts with different degrees (Figure 11-left). Also some cracks and damages to the walls near the ground level were evident (Figure 11-right).

- *Observed damages from inside*

One of the obvious damages was observed in the separation joint areas of the upper floors. At the time of the visit, these locations had been repaired in such a way that new gypsum boards on the walls (Figure 12a) and new mosaics on the floor had been replaced (Figure 12b). In addition, separation of partitions from the frames and as a follow up breaking of brittle materials such as tiles were among the non-structural damages which had taken place in several places (Figures 12c and d). False ceilings had fallen down in several locations which had been replaced before the visit.

In addition to above damages, what seemed to be more impressive was the ground settlement in parts of the ground floor of the new hospital building. These settlements were observed with different degrees, from a small vertical displacement at the floor of the corridor to large settlements in some of the rooms on the ground floor. According to the hospital authorities, signs of settlements had been seen in those rooms before the earthquake. The earthquake occurrence caused large settlements in those rooms to a degree that it was necessary to fill the floors and bring them to the normal level. For this reason, during the visit, the floors of those rooms had been reinforced by steel bars to rebuild the floors (Figures 13a and b). The hospital site location on satellite images shows that the site is located on a fluvial basin (Figure 14). Therefore, if the ground is soft sediment, it can magnify the earthquake acceleration in the site. In this case, a comprehensive geotechnical study must be carried out and if necessary, special measures (e.g., soil consolidation and inclusion of the acceleration magnification factor in the structural design) have to be taken into consideration so that these problems are avoided in normal conditions and during the earthquakes. An important point in this regard is the study on the site selection of important and vital structures which as much as possible should be selected in places that are far enough from geological hazards such as faulting, landslide, liquefaction, settlement, etc.

Figure 10. A view of the Shahid Ganji new hospital in Borazjan city.

Figure 11. A view of the fallen façade stones (left), and a long horizontal crack near the floor of the Borazjan new hospital building (right).

(a) (b) (c) (d)

Figure 12. Non-structural damages to the Borazjan new hospital building. Rapid installation of new gypsum boards (a), and replacement of new mosaics at the separation joints (b) following the earthquake; detachment of partitions from the frames (c), and breaking and falling of tiles on some of the ground floor rooms (d).

Figure 13. Large settlements took place on some rooms of the ground floor of the Borazjan new hospital building. Reinforcements are placed to rebuild the floors and bring them back to normal level.

Figure 14. Satellite image shows that the Borazjan new hospital building is located on a fluvial basin.

LEARNING FROM THE EARTHQUAKE

The 28 November 2013 earthquake in the Borazjan region offered many lessons. Although most of these lessons are relearning of the past lessons but it is important to highlight them here as an emphasis on the principle aspects of earthquake resistant design in earthquake prone areas.

In essence, a moderate earthquake occurred in an area with a relatively low population and caused some human casualties and significant damage losses. The main repeated lesson is that those buildings which had implemented the basic earthquake engineering principles sustained their stability and others which had not used the primary engineering concept such as integrated structural performance -even in this moderate earthquake- sustained damages and imposed casualties and losses to their residents.

Surely, besides the damages and losses, occurrence of this type of events can have positive aspects as well. This type of earthquake creates an opportunity to reconstruct or retrofit many damaged buildings through the technical and financial assistance of the government. However, the important point is that this reconstruction and retrofitting process should be done in such a way that structures gain a relatively more safety compared to the past. Another words, occurrence of the earthquake and the follow up casualties and damages can be converted to an opportunity for a stronger and safer construction so that we do not confront with the repetition of casualties and loses in similar events in the future.

IMPORTANT LESSONS ON NON-STRUCTURAL DAMAGES

There is not an accurate figure in Iran on the amount of non-structural damages, but through performance of the buildings due to earthquakes, especially in recent years, it can be concluded that this figure is not low. The recent Borazjan earthquake clearly showed the share of non-structural damages in comparison with the total losses. Anyhow, taking into consideration of a relative improvement in the building industry in Iran, it is essential that through necessary measures to reduce the damages to non-structural elements. This measure along with prevention of losses provides the assurance for continuous services especially in important and public buildings. Considering the above points, the most important lessons of the Borazjan earthquake and in particular related to non-structural damages are as follows:

Lesson 1. Necessity of appropriate site selection for important buildings

The main reason for the significant non-structural damages of the Borazjan hospital building is related to the building site. This building is constructed on the fluvial basin. The soil of the fluvial land is a soft sediment type and can intensify the earthquake waves and as a result increases the motion acceleration at the foundation. The soft soil of the site intensifies the building blocks vibration. If this phenomenon is not accurately investigated in advance and during the design process, and if necessary technical measures are not taken into account to prevent it, then it will result to the damages that were actually observed. These damages were in particular as follows:

- Strong pounding of the two blocks of the hospital building at the separation joints
- Falling of façade stones from external walls and tiles in the rooms.
- Occurrence of local large settlements on the building floor.

Thus, in selection of appropriate site for important projects more attention should be paid and necessary technical measurers have to be implemented, if it is compulsory to build in hazardous or potentially hazardous places.

Lesson 2. Necessity of appropriate construction of separation joint and its filling materials

The main objective of separating two building blocks from each other is to provide the possibility of independent vibration for each one of the two blocks adjacent to each other. An appropriate separation joint prevents the pounding of the two building blocks during an earthquake. According to the Iranian seismic code (Standard 2800), the minimum separation joint is specified as 1/100 of the building height. However, it is sometimes observed that this joint is less than the minimum requirement of the code, especially in small towns or remote areas. If the distance between the two blocks is not enough, a complicated vibration response is resulted during the earthquake; neither of the building blocks can have its own independent vibration. As a result, pounding is occurred between the two blocks and cause damage. The amount of the damage is generally depends on insufficiency of the separation joint, the height of each one of the buildings, and the filling materials at the joint.

It did not seem that a minimum separation joint was adapted in the Borazjan new hospital building. Noting that this building has 4 stories and its minimum height should be at least 12 m, the minimum joint between the two blocks should be at least 12 cm. This amount of joint did not seem to have been implemented, at least from what could be seen from inside of the building (Figures 12a and b). Anyhow, taking into consideration that the vibration in this building blocks has been intensified during the earthquake, the two adjacent blocks have strongly pounded each other and have caused significant local damages.

These types of problems may seem minor but they represent their negative impacts during and after the earthquakes. Damages which seem minor but large enough to cause damages and losses, and even more important than it, they can disrupt the services of the hospital exactly at the most needed time.

Another case which is more important with regard to separation joint and has to be taken into consideration during the building construction is the filling materials in the joint. According to Standard 2800, the filling materials of the joints shall be brittle. This type of material is immediately broken during the earthquake and does not prevent independent vibration of the building blocks. If the separation joint is filled with non-brittle and flexible materials, the joint will not have the expected performance.

Lesson 3. Necessity of appropriate installation of stone facades, tile works, and false ceilings

Fall of the façade stones from the external walls, and tiles and false ceilings in the rooms inside the building are among the damages that even in moderate earthquakes are observed in Iran. Besides the financial losses due to these damages, these types of fallings can be dangerous and threatens the life safety. A clear sample of this type of damage was observed in the Borazjan new hospital building which clearly showed its negative impact. Although these damages are not considered as structural but their occurrence coupled with other non-structural damages had caused panic in the hospital in such a manner that the hospital authorities and personnel evacuated their pre-earthquake hospitalized people to other hospitals, and the new hospital could not offer medical assistance to the injured people at the vital hours following the earthquake. Anyhow, the reason for falling of the façade stones and tiles in a large volume in the Borazjan new hospital is related to two main factors: Firstly, a relatively intense vibration of the building due to its sitting on the soft soil, and secondly, lack of implementation of the technical measures such as proper anchoring the stones to the walls. This event represented more concerns to installation of façade stones and tiles and their fixing to the walls. Test of different types of facades' performance on shake table and examining different kinds of fixing methods can introduce more reliable fixing methods whose application can contribute to more stable façade stones.

Lesson 4. Necessity of implementing appropriate measures to prevent fall of yard walls

Falling of yard walls during the earthquakes has been hazardous in Iran since the past. Fall of the self supporting walls is among the damages that occur and causes casualties and damages. This type of damage is more evident in school buildings because it can thread the life safety of numerous students. In the recent Borazjan earthquake, the walls of many houses were fallen down. It was observed in this earthquake that even walls with buttress (e.g., the wall of the Rahdar village school near the epicenter) also fell down. Of course, part of these fallings, especially in the areas near the epicenter can be justified because these walls are usually constructed with cement block, brick, and stone without any reinforcement, and the mortars used do not have the required quality. Application of vertical bars in certain distances inside the walls can considerably reduce the walls from falling down. Obviously, taking any measure on this requires tests on shake table or other similar tests. The positive results of the tests can be published as approved guidelines, criteria, and codes in a manner that their implementations become compulsory. This could significantly reduce the fall of walls during the earthquakes.

CONCLUSIONS AND RECOMMENDATIONS

The November 28, 2013 Borazjan (south of Iran) earthquake of magnitude M 5.6 caused some casualties and moderate damages in Bushehr Province. Although the earthquake did not offer very significant new lessons, but relearning and repetition of the previously learned lessons can also guide us to a safer construction in the future. The most important lessons and relearned lessons of the Borazjan earthquake outlined in this paper can be summarized as the following recommendations:

- It is recommended that through an appropriate plan to accelerate the ongoing strengthening of non-resistant houses in the rural areas and renovation of old fabrics in the urban areas with priority to the areas with higher vulnerability. This will help to safeguard the residents in these areas during the earthquakes. This will also help the national budget to be spent in retrofitting and strengthening in the normal condition, rather than spending them for reconstruction of the houses that are damaged and have caused casualties during the earthquakes.
- It is recommended that more attention is paid for site selection of vital buildings and as far as possible to avoid sites which are exposed to geological and other probable hazards. If there are not better alternatives and it is compulsory to use hazardous prone sites, especial technical measures should be taken into consideration.
- It is recommended that necessary measures are taken in order to prevent or to minimize the non-structural damages which -other than causing financial losses- can disrupt non-stop performance of important buildings such as hospitals.
- It is recommended to take advantage of qualified and experienced consulting engineers and contractors in the design, construction, and inspection process of buildings with high and very high importance factors such as hospitals. This type of buildings requires more sever controlling systems to be implemented in different aspects of their construction. This will ensure the resistance and safety of these buildings and can continue their services without disruption following the earthquakes.

ACKNOWLEDGEMENT

Authors are grateful to Dr. A.A. Moinfar for his contribution and fruitful comments on the final manuscript of the paper. Authors are also grateful to Iranian Society of Consulting Engineers who sponsored this study. Participation and cooperation of Dr. A. Saneinejad and Dr. G. Etemad during the visit to the earthquake stricken area is highly appreciated. Mr. R. Madani and Dr. A. Beitollahi's contribution to the paper is acknowledged. The authors are also thankful to the Borazjan Municipality and the Shahid Ganji Hospital authorities who assisted the study group during their visit to the earthquake stricken area. Finally, authors acknowledge the Earthquake Watch Group's support.

REFERENCES

Ambrasys NN and Melville CP (1982) A History of Persian Earthquakes, Cambridge University Press. 219 PP.
Jackson JA and McKenzie DP (1984) "Active tectonics of the Alpine- Himalaya Belt between Western Turkey and Pakistan", Geophy. J. Astr. Soc.**77**-185-264.
Institute of Geophysics of Tehran University (IGTU) website: www.geophysics.ut.ac.ir.
Building and Housing Research Center (BHRC) website: www.bhrc.ac.ir. Farzanegan E, et al (2013) "Borazjan, Bushehr preliminary immediate report of the 28 November 2013 earthquake" (in Farsi).
International Institute of Earthquake Engineering and Seismology (IIEES) website: www.iiees.ac.ir
National Earthquake Information Center (NEIC) website: www.neic.usgs.gov.
European-Mediterranean Seismological Center (EMSC) website: www.emsc-csem.org.