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Reducing Earthquake Fatalities and Destructions in Iran: A Project Management Perception

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Abstract

Purpose – Appropriate project management knowledge as well as its effective application in the construction industry increase construction quality and, therefore, reduce fatalities and destruction.

Research design, data, and methodology – This study was conducted through a comparative analysis of earthquake fatalities in Iran, Turkey, Pakistan, Indonesia, China, Haiti, Japan, and the United States of America. The data was analyzed using a frequency study. The analysis contrasts the fatalities of some of the strongest earthquakes around the world between 1960 and 2010.

Results – Poor quality construction practices and a lack of effective application of project management knowledge play a major role in the vast destruction, high death toll, and dismal tragedies that are associated with earthquakes, especially in Iran.

Conclusions – Despite the history of tragic earthquakes and their continuing recurrence, this study attempts to make governments, companies, and disaster management personnel aware of the dangers of poor quality construction and the deficient application of project management knowledge and, further, accentuates effective ways to prevent the probability of serious damage in future. This study contains valuable information on the effects of project management application towards reducing earthquake fatalities and destruction.

Keywords: Iran, Earthquake, Project Management, Building Quality, Destruction, Fatalities.

JEL Classifications: H12, H87.

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1. Introduction

Iran being situated in the active Alpine-Himalayan seismic belt, which is one of the most active tectonic regions of the world, is an earthquake prone country that has experienced more than 130 strong earthquakes with a magnitude of 6.5 or more in past centuries (Ghafory-Ashtiany and Eslami, 1997; Mehrabian et al., 2005 Tabassi and Bakar, 2009). According to table 1, in the last fifty years, around 21 huge earthquakes have killed more than 168,000 people, destroyed many towns and thousands of villages, and caused extensive economic damage. Accordingly, the malfunctions of structures for most of the earthquake areas in the country were mismatched with the level of earthquake hazard that caused serious human and economic losses (Ghafory-Ashtiany and Eslami, 1997). Some studies revealed that there were many damages to the buildings, during the past earthquakes, due to low quality construction (Berberian, 2004; Mehrabian et al., 2005; Mehrabian and Haldar, 2005; Tabassi and Bakar, 2009). The causes of the low quality construction mostly stated as the lack of sufficient supervision (Eshghi and Zare, 2003; Mehrabian et al., 2005), low quality materials (Allamehzadeh and Mokhtari, 2003; Berberian and Yeats, 1999; Berberian and Yeats, 2001; Ghafory-Ashtiany and Eslami, 1997) unskilled work forces, and inadequate human resource management and human resource development practices (Tabassi and Bakar, 2009). Same experience has been reported by Ozerdem (1999) through Marmara earthquake in Turkey in 1999.Accordingly, extensive destructions observed in those buildings which were presumed to be earthquake resistant dwellings and infrastructures. Failure in the control mechanisms and supervision of local authorities for inspecting the work of contractors caused many damages to the buildings within the above earthquake in Turkey (Ozerdem, 1999).

<Table 1> A brief history of huge earthquakes of Iran from the last 50 years

No.	DATE	Magnitude (Richter scale)	Location	No. of Dead
1.	09/01/1962	6.9	Buin-Zahra, Qazvin	12,225
2.	08/31/1968	7.3	Khorasan	20,000
3.	04/10/1972	7.1	Southern Iran	5,054
4.	11/24/1976	7.3	Northwestern Iran	5,000
5.	03/21/1977	6.9	Bandar Abbas	167
6.	06/07/1977	6.5	Isfahan province	352
7.	12/21/1977	6.2	Zarand in Kerman Province	521
8.	09/16/1978	7.8	Tabas	25,000
9.	11/27/1979	5.6	Ghaen	1,500
10.	06/11/1981	6.9	Golbaf (Kerman Province)	3,000
11.	07/28/1981	7.3	(Sirch) Kerman Province	1,300
12.	03/141989	5.4	Golbaf (Kerman Province)	5
13.	06/20/1990	7.4	Rasht-Qazvin-Zanjan-Rudbar-Manjil	50,000
14.	06/21/1990	5.8	Lowshan-Manjil	20
15.	02/04/1997	6.5	Bojnoord	100
16.	02/28/1997	6.1	Northwestern Iran	1,567
17.	05/10/1997	7.1	Ghaen-Birjand	1700
18.	06/22/2002	6.5	Western Iran	261
19.	12/26/2003	6.6	Bam	40,000
20.	05/28/2004	6.3	Northern Iran	35
21.	2/ 22/2005	6.4	Central Iran, Zarand	612
22.	11/27/2005	6.0	Southern Iran	13
23.	01/31/2006	6.1	Darb_e_Astaneh (Western Iran)	70
Total people approximately killed during above stated earthquakes				168,467
Total people left homeless following above stated earthquakes				750,000
Total estimated damages				Several billion USD

On the other hand, Lewis (2003) stated that "building construction of any kind takes place under pressures of time; caused by weather or by need to complete by a given date, or both, often with a high penalty or loss of financial incentive for the builder for not doing so. Opportunities to save time, and to save on the cost of materials by reductions in quality or amount, mean that temptations of expediency, shortcuts and omissions, are boundless". However, a large percentage of defects and destructions in buildings, particularly in earthquake prone areas, arise through inadequate management, decisions and/or actions of project teams in design and planning of construction projects (Cornick, 1991 Inan and Korkmaz, 2011; Tiedemann, 1984). As a result, project management, as a body of knowledge, should be more practiced entire the construction process, particularly in earthquake prone areas.

Today's reality is that the construction is a complex and challenging task; and damages and accidents in the industry are more than ever. Accordingly, in order to achieve of the required construction qualities, periodic, even constant, independent inspection of buildings under construction, from phase to phase, would be necessary (Lewis, 2003). Building regulations, codes, standards and guidelines have been developed and published in consistent with the condition of most earthquake prone countries: but legislation is insufficient without effective application of management and supervision to ensure its enforcement.

Hereof, a lack of effective project management knowledge as well as its application in the construction industry, particularly in Iran, seems to be the cause of lots of damages and fatalities. Until now, less attention has been paid to the importance of project management knowledge and its utilization in order to mitigate the earthquake fatalities and building destruction by researchers and practitioners. Therefore, the research aims to explore the problems and deficiencies in the matter of earthquake fatalities and destruction by the project management perspective. The study also makes a comparison between the fatalities of the earthquakes in countries that applied the knowledge of project management in order to mitigate the earthquake disasters such as the USA and Japan with other countries, which are seemed to be not enough developed in project management practices for mitigating the earthquakes' fatalities and destructions such as Iran, Turkey, China, etc.

2. History of Some of the Huge Earthquakes in Iran

Iran is located in a dynamic tectonic region, where shortening takes place due to Arabi-Eurasia convergence and many destructive earthquakes occurred in the past centuries. Seismicity in the region are primarily caused by the continental shortening between the Eurasian and Arabian plates. Seism-o-tectonics of Iran as a part of the Alpine-Himalayan orogenic belt has been the subject of several studies (Jackson and McKenzie, 1984; McKenzie, 1972; Nowroozi, 1972); and the historical earthquakes of the Iranian plateau have also been studied by many researchers (Ambraseys and Melville, 1982 Tabassi and Bakar, 2009). Abrief explanation of the significant historical earthquakes in Iran during the last decades has presented through the followings.

2.1. Tabas Earthquake

On the 1978 September 16, Tabas as was ruined and 85% of its population was wiped out by an earthquake of 7.8 Richter Magnitude (Depth of 33 km) that remains to be as one of the largest instrumentally documented earthquakes in Iran. Most of the buildings were adobe buildings with low quality materials and inadequate design. Low quality construction and poor controlling and supervision through the construction process were also observable in damaged buildings (Walker et al., 2003).

2.2. Golbaf Earthquake

The Golbaf Earthquake in 1981 (6.9 Richter Magnitude and depth of 33 km) wrecked Golbaf city and surrounding villages with 3,000 deaths and more than 4,000 injured. This earthquake was followed nearly one and half months later by the Sirch Earthquake (7.3 Richter Magnitude and Depth of 33 km) with 65 km of discontinuous surface ruptures that destroyed Sirch and the surrounding villages with approximately 1,300 deaths (see Table 1). The lower the magnitude of South Golbaf Earthquake in 1989 (5.8 Richter Magnitude and Depth of 33 km) had much reduced consequences with 4 deaths and 45 injured. Similarly, the Fandoga (north Golbaf) Earthquake (5.4 Richter Magnitude and depth of 31 km) was associated with 5 deaths and about 50 injured and ruptured along a 20km section in northern Golbaf (Beberian et al., 2001; BHRC, 2004; Eshghi and Zare, 2003).

2.3. Rudbar-Tarom Earthquake

During the Rudbar-Tarom earthquake (7.4 Richter Magnitude and depth of 19 km) in northwest, in 1990, more than 40,000 people lost their lives, 500,000 became homeless, nearly 100,000 buildings were destroyed, and three cities and 700 villages were razed to the ground. Such great catastrophe occurred not only because of a large magnitude earth quake at comparatively shallow depth but also due to the fact of the inferior construction practices in vulnerable areas. Reconstruction of the region was estimated to cost at least 7.2 billion USD, by 7.2% in GNP loss. The long-term effects of this devastating event included the disruption of the economies of at least three large provinces, and the human resettlement of at least three large cities and 700 villages. Reconstruction processes conducted based on seismic design code and regulations and procured decades to be completed by immersing a considerable part of the country's budget.

2.4. Ghaen-Birjand Earthquake

On May 10, 1997 an earthquake with magnitude 7.1 (Depth of 10 km)occurred in Ghaen-Birjand region in northeastern in the country. Accordingly, 1,700 people were killed, more than 2,300 were injured and 147 villages had a range of completely destroyed to strongly damaged (Allamehzadeh and Mokhtari ,2003).

2.5. Bam Earthquake

On December 2003, an intensive earthquake shocked a large area of Kerman province in Iran. According to the International Institute of Earthquake Engineering and Seismology (IIEES) in Tehran, the earthquake magnitude was 6.6 on the Richter scale and the depth of 10 km (BHRC, 2003). The earthquake wrecked the majority of Bam city and the nearby villages. Reports indicated on approximately 43,000 death tolls, more than 30,000 injuries and 75,000 left homeless (Akbaria et al., 2004; Fua et al., 2004; Khatam, 2006). The earthquake damages were mostly in Bam where the total number of people directly affected was approximately 200,000. One of the major losses in that earthquake was a popular cultural heritage site and the world's largest mud-brick structure, known locally as Arg-e Bam (Bam citadel), which experienced highly extensive damages. In addition to mud-brick buildings which were suffered ranging from severe damage to total collapsed, many other types of buildings such as steel structures and reinforced concrete structures also exhibited similar degrees of extensive damages. This could be attributed to the poor quality of construction materials, lack of supervision, low quality of construction, weak structural design, etc. Some of the buildings, which stabled during and after the Bam earthquake, benefited from superior design, acceptable construction quality and good supervision (Mehrabian and Haldar, 2005). With reference to other studies (Eshghi and Zare, 2003; Jackson et al., 2006; Mehrabian and Haldar, 2005), the most dominant building structural systems in Bam region were:

- Adobe buildings: built from adobe materials and unfired mud bricks. Most of this type of buildings had vaulted roof systems.
- Masonry buildings: built from fired bricks or concrete block-work as the main load bearing system and normally combined with a jack-arch roof system.
- Steel structures: typical construction includes frame structures with steel beams and columns and sometimes a braced framing system to resist the lateral and shearing loads.
- Reinforced concrete structures: only a limited number of these structures existed in Bam and mostly used for public buildings or government offices.

Outside the city, in the villages and adjacent countryside, adobe and masonry buildings were shaped the main structural form of buildings (Eshghi and Zare, 2003; Jackson et al., 2006).

In all above examples of building destructions in various parts of the country, a lack of proper supervision and project management application may be conceptualized. The following statements in regard to reconstruction experiences in some parts of Iran are also stressed on a lack of proper management of construction projects in different cities and regions of the country.

3. Reconstruction Experiences

From 1978 to 2006 after the asserted destructive earthquakes, the damaged cities and regions of the country were reconstructed with different policies, engineering practices and designs (Allamehzadeh and Mokhtari, 2003; Eshghi and Zare, 2003; Walker et al., 2003). However, in the cases of Golbaf and Ghaen-Birjand, the re-occurrence of the earthquakes in March 1989 and May 1997 (see Table 1), respectively, have brought some factual tests and engineering appraisals on re-construction policies as well as the practices. The tests showed different responses. In case of Ghaen and Birjand, after the earthquake on May 1997, the majority of the ductile moment resisting concrete frame with masonry infill housing units and schools was totally collapsed due to the earthquake with a magnitude of 7.1 Richter and created sorrowful scenes. Ghaen and Birjand are both located in the desert areas; therefore, due to building protection against the high and low temperatures in summer and winter, respectively, the walls and roofs of buildings were built very thick and heavy for insulation purposes. Improper design (strong beam- weak column and heavy roof) as well as poor workmanship, lack of supervision, quality control (Allamehzadeh and Mokhtari, 2003; Ghafory-Ashtiany and Eslami, 1997; Tabassi, 1998), and absence of proper project management knowledge and expertise during the design, construction and re-construction phases caused the tragedy.

In some cases, adobe and masonry buildings had shown less damage than the "so called" engineering buildings. In the case of Ghaen, not only adobe buildings but the steeland reinforced concrete structures, which were supposed to be structured in accordance with the Seismic Design Code for Buildings (Standard 2800) of Iran, was totally collapsed or faced with extremely damages. According to Ghafory-Ashtiyany (1999), the reconstruction of Ghaen after1979 earthquake was a failure and was the key reason of a large number of casualties during the earthquake of 1997. People thought that they were living in safe dwelling units with accurate technical engineering design and construction. As a result, the malfunction behaviour of the buildings after the second earthquake causes that the people did not trust in technical engineering structures and designs; therefore, there were not very well cooperated in reconstruction programs after the 1997 earthquake.

In case of Golbaf, the experience was totally different. Most of the rebuilt constructions, after the earthquake in 1981, stand with minor damages for the March 1989 earthquake. The damages were mostly in adobe and masonry buildings and some exterior walls outside the living units. Regarding the sound reconstruction in Golbaf, 3,000 death tolls in 1981 were reduced to five people in the 1989 earthquake. According to Ghafory-Ashtiany (1999), the design of reconstructed units in both cases of Golbaf and Ghaen was similar. The differences were due to skill workforces, good supervision, quality control (Amini Hosseini et al., 2004; Ghafory-Ashtiany and Eslami, 1997; Tabassi, 1998), consciousness of people of building safer structures, and most likely employment of the project management knowledge and practices through the construction process.

4. Objectives of the Study

In view of the above matters, the main objectives of this research are as follows:

- To investigate the quality of construction projects through the past earthquakes in Iran;
- To make a comparison between fatalities of the earthquakes in Iran and other countries;
- To study the possible role of project management knowledge and application with regard to mitigating in earthquakes' fatalities and destruction by an overview of the previous experiences in other countries, particularly the USA.

5. Methodology

As aforesaid, the primary purpose of this research is to find out the relationship between the applications of the project management knowledge and the level of reduction of earthquakes fatalities and destructions in Iran. The research was conducted through comparative analysis of the earthquakes'fatalities in Iran, Turkey, Pakistan, Indonesia, China, Haiti, Japan, India and the United States of America. However, this study has not considered those casualty of tsunamis since our knowledge of tsunami occurrence is limited and devastating disasters of tsunamis cannot be prevented at present (Scheffers and Kelletat 2003).

Furthermore, this study pays attention to the application of project management knowledge and practices in the United States and tries to find the effects on mitigating the level of fatalities and building destruction in the past earthquakes of California. Finally, some of the crucial damage during the Bam earthquake in Iran, in 2003, with those in the same magnitude and approximately the same date in California has also been explored. Analysis of the collected data was based on the frequency and co-relational study. Discussion on the result of the study is presented through the following section.

6. Results and Discussions

Earthquakes are not new in Iran and there were several powerful earthquakes during the twentieth century claimed more than 168,000 lives (see table 1), and no doubt Iran will continue to be hit by powerful earthquakes in the future. Earthquakes are facts that many of the people in the country now fully influenced by them. Memories of the Buien-Zahra, Dasht-e Bayaz, Tabas, Golbaf, Manjil-Rubar, Ghaen, and Bam earthquakes are still in minds, not only for those who survived from the earthquakes but also many others who have been impressed by the news of the catastrophe. Regrettably, this fact remains to be the country appears incapable in dealing with the earthquake issues since a little sign of improvement in national statistics in terms of seismic fatalities and damages through the last decades (Tabassi and Bakar 2009). The research collected and summarized those information associated with the magnitude and number of death tolls from the earthquakes of last decades in different parts of the country (see Table 1). The results show the seismicity in Iran as well as its vulnerability to earthquakes. Consequently, large death tolls and financial losses should be considered as the key characteristics within the past earthquakes.

As urbanisation process shows development in size and population of the cities, thus the potential for massive destruction and fatality will be increased. That is why the risk of earthquake disaster is higher than at any time in our history, and the risk is growing (Coburan and Spence, 2002).

On the other hand, during the past decades catastrophic disasters occurred in different cities and regions across the world. However, Table 2 summarizes the statistics of the massive earthquakes from 1960 up to the point 2010 throughout the world. Comparison of the records on the impact of earthquake hazards of similar magnitude in countries with varying levels of development is interesting. During the 7.1 Richter Magnitudes with a depth of 19 km of Loma Prieta, California earthquake in 1989, only 63 people were killed, which is a very low casualty figure for an earthquake of such magnitude (Fujita, 2001). Compare this with the 25,000 deaths during the 1978 Tabas earthquake (7.8 Richter Magnitude with 33 km depth) and 50,000 deaths in 1990 Rasht-Qazvin-Zanjan- Rudbar-Manjil earthquake (7.4Richter Magnitude with 19 km depth) in Iran. According to the table, most of the huge earthquakes made a lot of casualties in the countries and regions which may not enough developed on the methods of preventing and mitigating the earthquake hazard. Figure 1 also shows a statistical comparison of the earthquakes'death tolls in Iran, Indonesia, China, Turkey, Pakistan, Haiti, Japan, India and the USA from 1960 to 2010. As a result, China, Haiti, Iran, Pakistan and India have shown the most fatalities during the last few decades'earthquakes, respectively. In contrast, fewer death tolls and destructions have found in developed countries such as the USA and Japan. In this regard, some other countries such as Indonesia and Chile have also shown high death tolls through the earthquakes and tsunamis. However, this study has only focused on the fatalities and damages caused by earthquakes alone; and extensive damages and death tolls of tsunamis have not considered through the investigation. The differences in casualty numbers between these earthquake events are directly related to differences in disaster preparedness, disaster mitigation, and utilization of project management knowledge in the United States of America and Japan. For instance, strict adherence to building codes and employing project management expertise during the past three decades in the San Francisco region undoubtedly saved many lives and kept thousands of buildings from collapsing in the Loma Prieta earthquake (McEntire and Cope,2004). Moreover, a major 6-year program was undertaken by the US Federal Emergency Management Agency (FEMA) during the 1989 Loma Prieta, 1994 Northridge and 1995 Hyogo-ken Nanbu earthquakes. They synthesized and interpreted the results of that research, and conducted additional investigations to develop reliable, practical and cost-effective guidelines for the design and construction of new structures, as well as for the inspection, evaluation and repair or upgrading of existing ones. Topical Investigation Teams of investigators, technical specialists, project managers, and design and construction professionals were assembled to work on the various investigations, to assess social, economic and political impacts, and to develop design guidelines (Mahina et al., 2002) in contrast, no similar step seriously employed in Iran. In California, building codes and geologic site investigations were increasingly accepted; Iran has no comparable public commitment, and many houses have been built with un-reinforced masonry in the small town and villages (Ghafory-Ashtiany and Eslami, 1997; Mehrabian et al., 2005; Tabassi and Bakar, 2009). Accordingly, project management knowledge and its practices have been involved in research and development to assess social, economic and political impacts of decisions, and to develop design guidelines to make the cities and towns safer, particularly, after the earthquakes in USA. Unfortunately, there is less attention on the project management disciplines in design and construction practices in Iran (Tabassi and Bakar, 2009), particularly, in earthquake prone areas.

Despite the frequency of earthquakes in the United States, the number of deaths due to earthquakes has been very low in the past fifty years as compared with losses in Iranian earthquakes. From 1960 until 2010, earthquakes in America have resulted in nearly 208 deaths, while at least 168,467 people have lost their lives during earthquakes in Iran in that period.

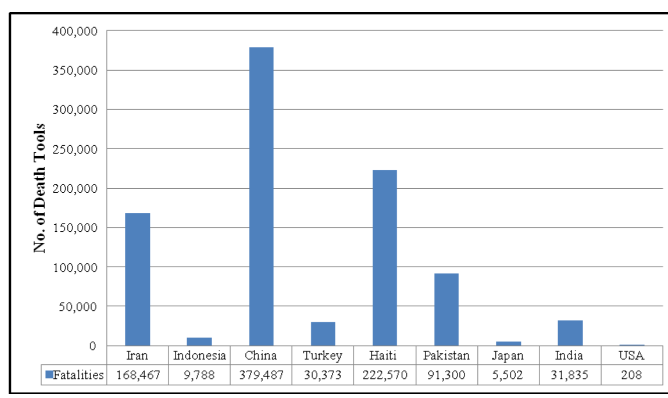
<Table 2> A brief history of high fatality earthquakes in the world between 1960 and 2010

No.	Year	Magnitude (Richter scale)	Location	No. of Fatalities
1.	1960	5.7	Morocco	15,000
2.	1962	7.1	Buin-Zahra, Iran	12,225
3.	1963	6.0	Yugoslavia	1,100
4.	1966	7.0	China	1,000
5.	1966	6.9	China	1,000
6.	1966	6.8	Turkey	2,529
7.	1968	7.3	Dasht-e-Bayaz, Iran	20,000
8.	1969	5.9	China	3,000
9.	1970	7.5	China	10,000
10.	1970	6.9	Turkey	1,086
11.	1970	7.9	Peru	70,000
12.	1971	6.9	Turkey	1,000
13.	1971	6.6	California, USA	65

14.	1972	7.1	Southern Iran	5,054
15.	1972	6.2	Managua	5,000
16.	1974	6.8	China	20,000
17.	1974	6.2	Pakistan	5,300
18.	1975	7.0	China	2,000
19.	1975	6.7	Turkey	2,300
20.	1975	7.2	Hawaii, USA	2
21.	1976	7.5	Guatemala	23,000
22.	1976	6.5	Italy	1,000
23.	1976	7.1	Indonesia	422
24.	1976	7.5	China	255,000
25.	1976	7.9	Philippines	8,000
26.	1976	7.3	Turky-Iran border region	5,000
27.	1977	7.2	Romania	1,500
28.	1978	7.8	Tabas, Iran	25,000
29.	1979	5.6	Ghaen	1,500
30.	1980	7.7	Algeria	5,000
31.	1980	6.5	Italy	2,735
32.	1981	6.9	Southern Iran	3,000
33.	1981	7.3	Southern Iran	1,500
34.	1982	6.0	Yemen	2,800
35.	1983	6.9	Turkey	1,342
36.	1983	6.9	Idaho, USA	2
37.	1985	8.0	Mexico	9,500
38.	1986	5.5	El Salvador	1,000
39.	1987	7.0	Colombia	1,000
40.	1988	6.8	Nepal-India border region	1,000
41.	1987	5.9	California, USA	8
42.	1987	5.6	California, USA	1
43.	1988	6.8	Armenia	25,000
44.	1989	6.9	California, USA	63
45.	1990	7.4	Western Iran	50,000
46.	1990	7.7	Philippines	1,621
47.	1991	7.0	North India	2,000
48.	1992	7.5	Indonesia	2,500
49.	1992	7.3	California, USA	3
50.	1993	6.2	India	9,748
51.	1993	6.0	Oregon, USA	2
52.	1994	6.7	California, USA	60
53.	1995	6.9	Kobe, Japan	5,502
54.	1995	7.5	Sakhalin Island	1,989
55.	1997	7.3	Northern Iran	1,567
56.	1998	5.9	Afghanistan	2,323
57.	1998	6.6	Afghanistan-Tajikistan border region	4,000
58.	1999	6.1	Colombia	1,185
59.	1999	7.6	Turkey	17,118
60.	1999	7.6	Taiwan	2,400
61.	2001	7.6	India	20,085
62.	2002	6.1	Afghanistan	1,000
63.	2003	6.8	Algeria	2,226
64.	2003	6.6	California	2
65.	2003	6.6	Bam, Iran	40,000
66.	2004	6.3	Northern Iran	35
67.	2005	6.4	Central Iran, Zarand	612
68.	2005	6.0	Southern Iran	13
69.	2005	8.6	Northern Sumatra, Indonesia	1,313
70.	2005	7.6	Pakistan	86,000
71.	2006	6.3	Indonesia	5,749
72.	2006	6.1	Darb_e_Astaneh (Western Iran)	70
73.	2008	7.9	Eastern Sichuan, China	87,587
74.	2009	7.5	Southern Sumatra, Indonesia	1,117
75.	2010	7.0	Haiti region	222,570
Total people approximately killed during above stated earthquakes				1,121,784

By comparing Table 1 and Table 2, it has been revealed that approximately 14% of the deaths and fatalities of the earthquakes from 1960 around the world were in Iran. It also indicates seismicity of Iran as well as its vulnerability to earthquakes and approves a low level of supervision and management in construction projects, especially in harmed areas.

As stated before, Iran stands on an active plate boundary that is characterized by strike-slip and reverse faults. This situation in Iran is similar to southern California. It is interesting to note that on December 22, 2003, four days before the Bam earthquake, an earthquake with a magnitude of 6.6 in Richter scale and a depth of 8 km, similar magnitude and depth to that of Bam earthquake, struck California (CSSC, 2004; McEntire and Cope, 2004). The California earthquake did not cause any dramatic damage or destruction with unimaginable death tolls where only a handful of people were killed. In contrast, in the case of Bam, more than 40,000 people lost their lives and caused extensive economic damages. This clearly demonstrates that the knowledge to protect human life against earthquakes exists and the international community needs to focus on applying this knowledge to earthquake prone areas to minimize and mitigate the risks arising from major earthquakes.



<Figure 1> A comparative results of death tools of huge earthquakes in different countries between 1960 and 2010

Comparing California's damages to the buildings and constructions after the past earthquakes with disasters of earthquakes in Iran with the same magnitude are astonishing. Plate 1 shows the differences between some of the structural damage of buildings in California and Bam earthquakes in the year 2003, with the same magnitude and depth. Efforts to reduce the losses from earthquakes have already proven effective in California. California's enhanced building codes; strengthened highway structures; higher standards for school and university, police and fire station construction; and well prepared emergency management and response agencies, reduced deaths, injuries, and damage in earthquakes (McEntire and Cope, 2004).

Unfortunately, in the case of Bam, the buildings which must be built in higher standards and be survived after any occurrence such as hospitals, police and fire stations, highways, and schools were destroyed and out of served during the earthquake. In other words, it is well known that the building construction practices in Iran and more specifically in small cities like Bam has been poorly regulated and monitored. There is clear evidence of this of the Bam Earthquake. Widespread damage to the majority of newly constructed buildings in the both public and private sectors was also observed by the researchers (Amini Hosseini et al., 2004; Mehrabian and Haldar, 2005). This strongly suggests that poor construction quality and lack of effective management of the projects played major roles in the vast destruction, high death tolls and sorrowful tragedies within the cities and small towns in Iran.

Minor damage at column connection to Twin Cities Hospital in Templeton, California, 2003 (Source: RMS, 2003)

Damage to brick façade of the Atascadero City Hal after California earthquake, 2003 (Source: RMS, 2003)

Chimney damage to residential buildings after California Earthquake 2003 (Source: RMS, 2003)

Destruction and out of servicing of fire station after Bam earthquake, 2003

Destruction and of Ferdowsi high school building after Bam earthquake, 2003

Destruction and out of servicing of Hospital after Bam earthquake, 2003

<Figure 2> Comparison of California and Bam buildings destruction in the earthquakes in year 2003

In addition, the research identifies some of the important lessons learnt from earthquakes and management in Californian according to the study of Johnson in 2004. Some of the lessons are as follows:

- A large earthquake in or near a major urban centre in California will disrupt the economy of the entire state and much of the nation. Effective disaster planning by state and local agencies, and by private businesses, have dramatically reduced losses and speed recovery.
- Current building codes substantially reduced the costs of damage from earthquakes, but the codes are intended only to prevent widespread loss of life by keeping the building from collapsing, not to protect the building from damage.
- After a large earthquake, residents and businesses may be isolated from basic police, fire, and emergency support for a period ranging from several hours to a few days. Citizens must be prepared to survive safely on their own, and to aid others, until outside help arrives.
- Maps of the shaking intensity after the next major earthquake will be available within minutes on the Internet. The maps will guide emergency crews to the most damaged regions and will help the public identify the areas that most seriously affected.

According to the above lessons, the use of proper and effective planning and knowledge management can be considered by government and private sectors in order to protect the cities, towns and villages from disasters. The number of earthquakes'fatalities and destructions in California, USA extremely reduced due to the fact of implementing the project management knowledge and expertise in planning, organizing, constructing and managing of the projects by the authorities and practitioners in the construction industry (CSSC, 2004; Johnson, 2003; McEntire and Cope, 2004).

7. Recommendations

For more than forty years, editorials have been written, speeches delivered, reports and books published, funds granted, rules, regulations, and laws promulgated on the subject of earthquakes and their risks, and foreign helps were funnelled into Iran after occurrences of large-magnitude earthquakes. Despite this, the authorities of the country still cannot minimize the death tolls and financial losses of the earthquakes. After almost every earthquake, the call goes out for building construction to be improved. But what the requirements are for improving building construction, how they could be achieved; and are there other strategies for housing in built environments to be considered towards the achievement of earthquake disaster reduction in the even longer-term? Unless serious efforts are made to improve earthquake protection countrywide, we can expect to see similar and greater disasters with increasing frequency in the years to come. On the other hand, the science and methods of how to protect human, buildings and cities from earthquakes have also been developing rapidly during last decades on the globe. A body of knowledge has been built up by engineers, project managers, urban planners, administrators and government officials about how to tackle and reduce the earthquake threats. The earthquake threats' protection is a multi-disciplinary approach with a wide range of measures including well-targeted spending on protection, better building design, better management and supervision throughout the construction process and increasing quality of construction in the areas most likely to suffer an earthquake.

Earthquake protection involves everyone. The general public have to be aware of the safety issues involved in the type of house and of earthquake considerations inside the home and workplace. In some cases such as Ghaen-Birjand and Bam earthquakes, as discussed earlier, many buildings, which were construct ed during the past decades, totally collapsed. Although, the majority of those buildings were in the private sector; in contrast, some of the public buildings and governmental offices, which were obviously benefited from better design, materials, and supervision, were also razed to the ground. Therefore, a lack of awareness of the safety issues as well as insufficient supervision and project management knowledge and practices within general public could be cause of some of the tragedies.

Accordingly, the study presents some recommendations in order to improve the performance and quality of the construction projects in Iran, especially in the area having the highest risks of earthquakes.

I. Seismic design code: The current Iranian seismic design code is published in three chapters and six appendices. The code intent is to provide a level of seismic resistance for buildings such that they can resist in low and medium earthquakes without any considerable damage to their structural system and withstand in strong earthquakes without collapse. The design against earthquake is defined as the one stand with less than 10% probability of occurrence in a 50 year period. For structures with high importance or those higher than 50m or having more than 15 stories a serviceability level earthquake also needs to be considered. This is defined as one stand with more than 99.5% probability of occurrence in a 50 year period (SDCB, 2002). The implementation of the code is a major issue and there are several areas that need to be addressed. Firstly, proper and effective training should be provided for many professionals who are mostly only familiar with general building design and preparation of drawings without any seismic design considerations. Secondly, there are limited official guidelines that accompany the code and clarify the use of the code provisions for civil and structural engineers. It appears that providing background information and examples of the code provisions could greatly improve the successful implementation of the code. Thirdly, a lack of construction management and control leads to poor construction and poor performance under earthquake loading. Therefore, powerful construction management knowledge and expertise are needed for organizing and managing the application of seismic code for building in design, planning and construction phases.

ii. Absence human resource management practices: Many of the workforces which are working in the construction industry are unskilled and with no certificate of fitness for occupation. Some processes should be implemented under project management knowledge and its regulations for training and motivating workers in the construction industry. A lack of human resource management (HRM) practices in the construction industry and the effects onlow quality of construction have shown in the study of Tabassi and Bakar (2009). According to Tabassi and Bakar, one of the essential problems which most of the construction projects in Mashhad, the second largest city of Iran in terms of population, area and construction projects, faced with it, was the lack of expert workforces. Accordingly, just only 20% of the workers in Mashhad construction projects were skilled labour with technical certification of fitness for occupation, and the rest were unskilled (50%) and semi-skilled(30%) workers. Furthermore, it is notable that Mashhad is located in the territory with the highest risks of earthquakes. Since their study was done in the second largest city of Iran, therefore, the results can be considered and developed in the other cities and regions as well. Some profitable results of their study, which can be utilized in HRM practices as a field of project management, are the methods of training the construction labour. Those methods are as follows:

- Short term training courses at a fixed centre;
- Send trainers to the construction sites (on-the-job training); and
- Self-learning and taking part of the standard exam.

On the other hand, some rules and regulations in order to support labour and improving their state of affairs should be legislated by the government. Some of the endeavours, which can be applied by the government in this regard, are:

- Increasing the social security;
- Paying towards of the labour costs of living;
- Requiring the companies to use the workers with certification of fitness of occupation in their projects; and
- Developing social insurance.

iii. Lack of construction control: For many projects, especially for private housing, the architect or civil engineers have the responsibility of supervising and approving the construction processes. However, there is no effective control of this process and often the engineer only takes the role of approving the design drawings (Mehrabian and Haldar, 2005). In other words, lack of project managers as well as project management knowledge and practices can be observed in most of the construction projects in Iran. An effort should be made to increase the awareness among the authorities with respect to legal and professional responsibilities in order to project management knowledge and to include strict control of construction practices.

iii. Lack of quality management: Most of damaged constructions throughout the past earthquakes had shown inadequate benefit of quality construction, which was declared by a number of researchers such as Ghafory-Ashtiany and Eslami (1997), Ghafory-Ashtiany (1999), Mehrabian et al. (2005), and Tabassi and Bakar (2009). As a result, a lack of efficient project quality management in construction projects, specifically in earthquake prone areas, could possibly be concluded. The importance and significance of project management wisdom as well as quality management practices and its application among the construction companies should be considered by the authorities. According to Mc Entire and Cope (2004), after the California earthquake in 1974, government by applying and exploiting effective project management knowledge and practices prevent and reduced the fatalities and economic losses in the future. In order to reduce fatalities, property losses, and increase the quality of construction in Iran, the government requires to set up an organization with professional project managers. This project management organization will be asked to develop the project management knowledge practices in order to enhance quality construction and make the cities and towns safe and sound.

iv. Aside from that, in order to achieve a seismic proof structure following reconstruction of a damaged area, some principles need to be considered and adhered by the Housing Foundation or Ministry of Housing and Urban Development (MHUD), as the in charge organizations on reconstruction of the damaged areas:

a. Planning and organizing the elements affected a correct site selection. To determine an appropriate location for reconstruction buildings in damaged areas, the following aspects should be taken into consideration by project management teams:

- Local geology
- Seismotectonic
- Geotectonic
- Site effect
- Socio-economic and
- Cultural aspects

b. A seismic design and construction. All new structures should be designed against earthquake based on the seismic design code, Standard 2800, of the country. In this regard, MHUD should endorse the project management teams to develop the following forms of dwelling with regard to reconstruction programs:

- Concrete frame with arch roof to be used in the hot climate;
- Concrete frame with flat jack-arch roof to be used mainly in the cold climate;
- Steel frame with flat jack-arch roof to be used in any environment;
- Steel frame with composite roof (steel beam and reinforced concrete slab) to be used in any environment;
- Concrete frame with composite roof (steel beam and reinforces concrete slab) to be used in any environment;
- Concrete frame with sloped timber roof; and
- Timber frame to be used in most of the small towns and villages.

Moreover, construction of building process should be carried out by qualified construction companies, which may be described by the MHUD or Management and Planning Organization (MPO) of the country.

c. Construction material and resources. The quality and environmental availability of construction material and resources are important elements in delivering an earthquake resistant structure. In most cases of the past earthquakes, the damaged areas were situated far from accessible skilled workforces as well as appropriate machinery and equipments. High quality and available construction materials should also be widely used in order to assure safe construction practices. For instance, if good quality concrete material (aggregates, water and cement) cannot be procured locally or is expensive in the environs of the damaged area, the use of a concrete frame structure should be avoided, and the structure should be designed using steel or prefabricated elements. In other words, there should not be any restriction on choosing the most suitable material for the buildings and construction projects in small towns and villages.

d. Retrofitting of old buildings. The Government needs to promote criteria and standard requirements for reinvigorating of old buildings in assorted parts of the country. A lack of effective fortifying of the old buildings in Iran made irreparable damage through the Bam earthquake in year 2003. As stated before, the major cultural heritage site and the oldest and largest mud-brick structure in the world, with approximately 2000 years old, was suffered highly extensive damages through the earthquake.

e. Quality control, supervision and project management. Effective methods of quality control, supervision and managing the projects are the key elements to carry on successfully reconstruction as well as construction practices. The cities and towns can be made safely by developing the knowledge of project management practices in managing resources at all levels of constructions. Consequently, the fatalities and economic losses due to unpredictable events like earthquakes will probably be reduced.

8. Limitations and Future Research

The current study has some limitations that offer an agenda for future research. As this research has been confined to compare fatalities and economic losses during the past earthquakes in Iran and other countries, especially the USA, a large-scale follow-up survey would be useful to find out which of the identified differences have the proposed connection in order to reduce the number of fatalities and economic damages. Although this study found range of methods and recommendations on construction and reconstruction practices, but practical method that is tied up effectively for particular part of Iran is not yet clear. However, it seems unlikely that all practices can be treated as atomistic ingredients that have an additive enhancing effect on idea generation and/or application of quality of construction. In addition, future research should attempt to address the way companies, managers and government adapt to and even form the environmental and organisational settings in such a way that the context optimally promotes project management knowledge and practices to be able to enhance the quality of construction projects.

9. Conclusions

Despite the history of tragic earthquakes and continuing of the recurrence in Iran, and the fact that the knowledge exists to deal effectively with the threat posed it appears that the issue of seismic risk has not to date been addressed effectively. This failing runs through every level of society at individual and company levels and is reflected by local authorities and central government. It is wise to ask why the obvious lessons ofthe earthquakes are being ignored. Perhaps the intermittent nature of devastating earthquakes tends to create a culture of acceptance of the status quo and failure to take responsibility in a society which has mainly focused on short term needs. It is obvious that for any plan to perform successfully this particular culture necessities to be changed, the requirements for fundamental earthquake vulnerability reduction need to enter the national consciousness at all levels of society and then be enforced with minimum tolerance of negligence. Accordingly, the study aims to make the government, companies, and managers of disasters aware of the aftermath in different parts of Iran with low quality of construction, lack of employment of project management knowledge, and make an awareness to apply effective strategies to prevent probable foreseeable future damages. To sum up, this study listed the following recommendations in order to improve the performance and enhance the quality of construction projects, particularly in Iran:

- Designing the buildings according to the seismic design code;
- Applying proper human resource management practices;
- Adopting effective construction control practices for buildings;
- Employing quality management knowledge and practices;
- Managing and organizing the factors affected a proper site selection; and
- Establishing a project management organization in order to apply project management knowledge and expertise in construction projects of the country.

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