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EARTHQUAKE RISK IN IRAN AND RISK REDUCTION ACHIEVEMENT FROM MANJIL EARTHQUAKE TO POST-BAM STRATEGY

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ABSTRACT

Iran is an earthquake-prone country with a high density of quaternary faults, located in the active Alpine-Himalayan seismic belt or in a region between the Arabian and Euro-Asia plates. There is a high level of seismic hazard almost in all parts of the country. In the 20th century alone, 22 major earthquakes have claimed over 150,000 lives. Human and economic losses have been due to the failure of structures that were incompatible with the level of earthquake hazard in Iran. Considering vulnerability of the built environment, rapid growth of population, socio-economic values, low level of preparedness, and lack of implementation of knowledge, a multidisciplinary strategic research and mitigation plan entitled "Iran Earthquake Risk Mitigation Program (IERMP)" was developed and successfully implemented by the International Institute of Earthquake Engineering and Seismology (IIEES) with advice from Prof. Luis Esteva after the June 1990 Manjil earthquake. To evaluate the achievement of the IERMP, several indexes have been defined. A comparison of past and present indexes shows that implementation of the program has been a significant step toward risk reduction in Iran. Based on this implementation and the experience of the Bam earthquake of 2003, the "Earthquake Risk Reduction Strategy of Iran" was developed in early 2005. Good planning and decisions by Iran's government after the Manjil earthquake and excellent response by the scientific communities for implementing an earthquake hazard mitigation program have resulted in visible progress toward a seismically safe Iran. We believe Iran's experience can be easily applied to other developing countries.

Introduction

Iran being located in the active Alpine-Himalayan seismic belt is an earthquake prone country that has experienced more than 130 strong earthquakes with magnitude of 7.5 or more in the past centuries. In this century alone, 20 large earthquake have claimed more than 100,000 lives, destroyed many towns and thousands villages, and caused extensive

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economic damages. Recent earthquake in Iran i.e. Manjil-Rudbar (June 90, mb =7.2); Darab (Nov. 90, mb =6.6), Lordegan (March 92, mb =5), Sefidabeh (March 94, mb =6.1); Bojnoord (February 97, mb =6.1); Ardebil (February 97, mb =5.5); Ardekul (May 97, mb=6.6); Golbaf (March 98, mb =6.0; April 98, mb =5.1) ; Birjand (April 98, mb =5.9), Kazeroon (May 99, mb=6.0), Avaj-Ghazvin (June 2002, mb=6.1), Bam (February 2003, Ms=6.5) Kojoor-Baladeh (June 2004, Mw=6.4) and Zarand (February 2005, Ms=6.5) have shown Iran's high seismicity as well as its vulnerability to earthquakes. In all the past-occurred earthquakes, especially in Manjil and Bam earthquake, human and economic losses were high. Figure 1 shows the active fault map and recent major earthquakes in Iran [1]. The seismic hazard map of Iran as shown in Figure 2, indicates that most major cities of Iran have been located in very high hazard zone [2].

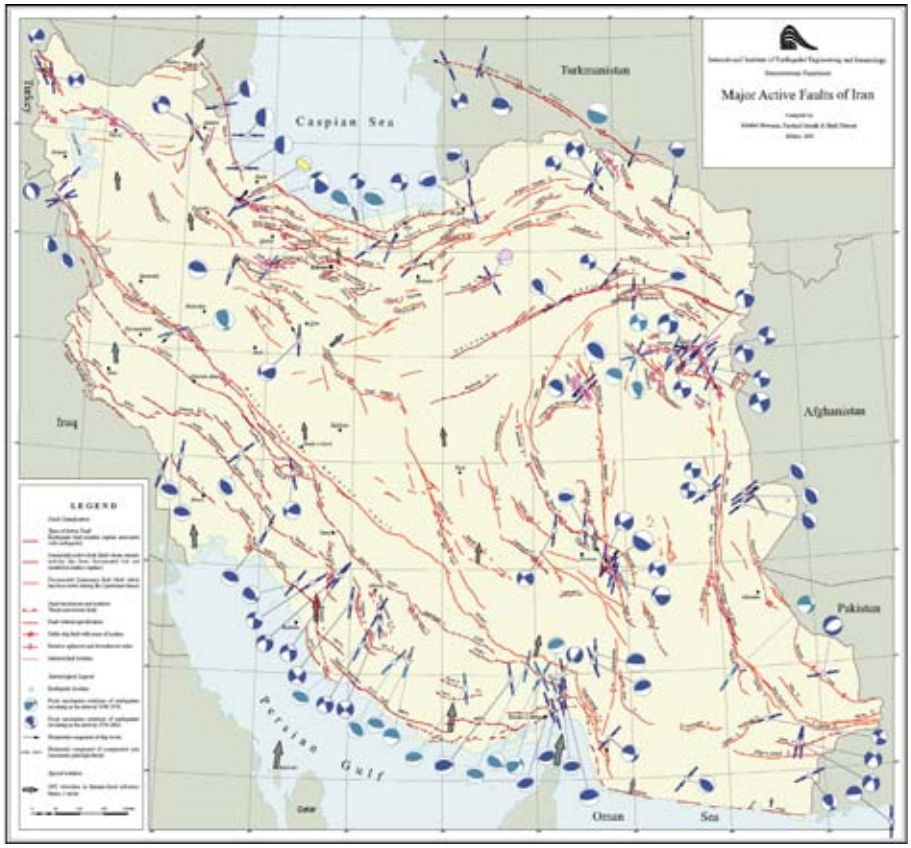

Figure 1: Active fault Map and location of major earthquake in Iran [1]

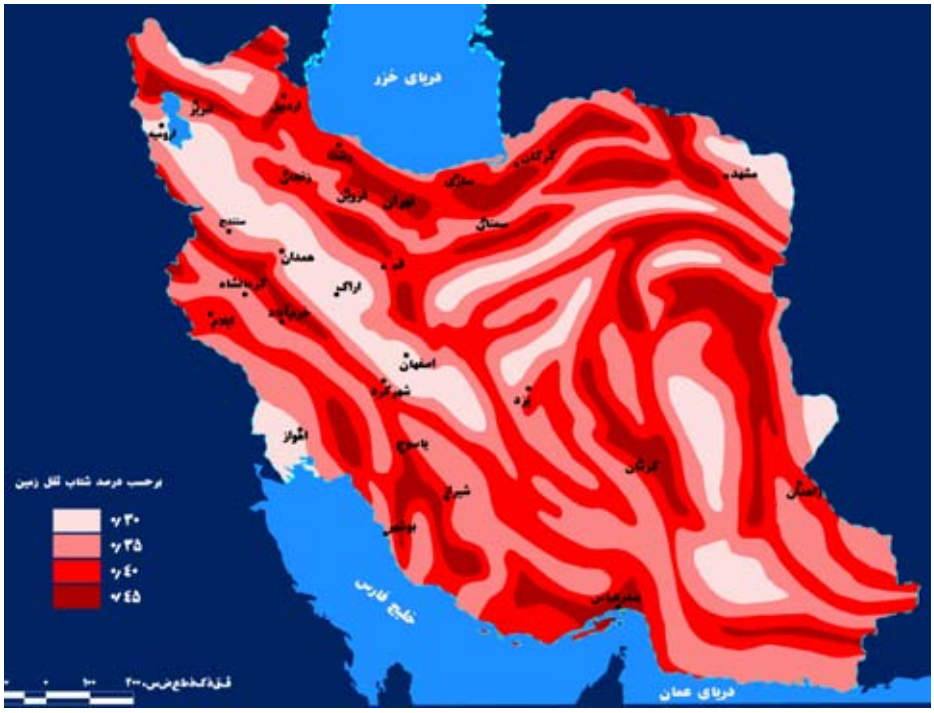

Figure 2: Seismic hazard zonation map of Iran [2]

Earthquake Risk Reduction Program and Achievement in Iran

Considering the following contributing factors to the earthquake risk:

- High seismic hazard in most of the developed cities;
- Inadequate planning and development with respect to the level of seismic hazard;
- Poor code and law enforcement as well as lack of technical supervision and implementation of existing knowledge;
- High vulnerability of the built environment, specially un-reinforced masonry and adobe housing in the rural area;
- High dependency on vulnerable infrastructure and services;
- Rapid growth of human, social, economical, cultural and security values with time and development;
- Lack of preparedness and effective disaster response; and
- Lack of appropriate and integrated Risk Management system;

The earthquake risk in Iran is high based on the following equation:

$$\text{Earthquake RISK} = \frac{\text{Seismic Hazard} \times \text{Vulnerability} \times \text{Value}}{\text{Managemen}}$$

For example Figure 3 shows the expected building damage or vulnerability zonation of the buildings as well as the expected human losses in various cities in Iran for the expected level of hazard.

Considering that the fact that seismic hazard and the value can not be controlled by human; the only and doable approach for risk reduction is to reduce the vulnerability and improve the quality of risk management.

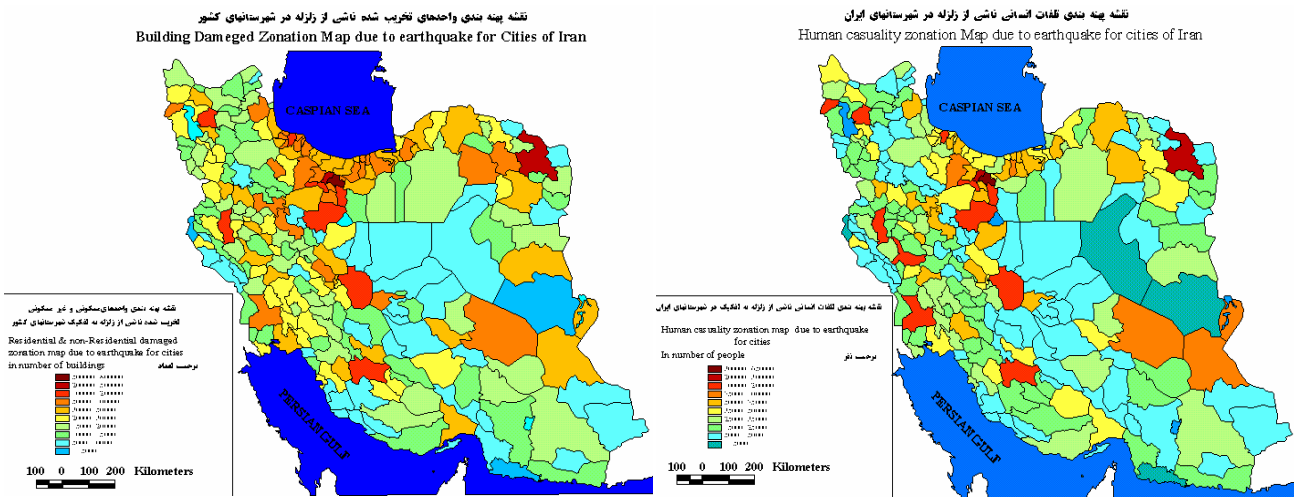

Figure 3: Expected building damage and human loss zonation for expected level of hazard [3].

Manjil Earthquake of 1990 with its heavy socio-economic impact became a turning point for the implementation of the earthquake risk reduction and mitigation activities in Iran. After this tragic event and in the beginning of IDNDR, the government decided to implement a multidisciplinary strategic research and mitigation plan entitled “Earthquake Hazard Mitigation Program” with the following objectives:

1. Increasing the scientific knowledge required for earthquake hazard mitigation.
2. Reduction of risk of failure in different types of constructions and the needs to build safer structures.
3. Increasing public awareness of seismic hazards and promoting a collective prevention culture.
4. Developing plans for post earthquake actions.

The Program had been implemented by IIEES, Building and Housing Research Center (BHRC), Geophysic Institute of Tehran University (IGTU) and Geological Survey of Iran (GSI) with the support of Earthquake Committee of Iran Research council and National IDNDR committee. This program had an acceptable achievement and good impact on earthquake risk mitigation and public awareness as well as on the earthquake research programs in Iran [4].

The main practical achievements of this program, which comprises the Iran’s experience and achievement of earthquake risk reduction, can be summarized as follows:

- Recognition of hazard, vulnerability and risk in Iran by decision-makers, engineers and public;

- Move toward planning and long-term actions in all level of decision-makers.
- Improvement of technical knowledge, capabilities, research, education, engineering practice, etc.
- Improvement of preparedness and helping toward the implementation of mitigation actions.
- Expanding the seismic and strong motion networks as well as establishment of advance geotechnical and structural laboratories;
- Better understanding and assessment of Iran's seismicity and seismic hazard;
- Improvement of technical knowledge and the know-how required for implementation of risk reduction program in Iran;
- Changing the civil engineering curriculum toward aseismic design and construction, as well training the engineers;
- Public awareness: Through the extensive educational camping in school system and through all type of media, it can be claimed that people are more aware of the hazard and risk and consequently are more sensitive.
- Construction quality: Due to the code and law enforcement and construction controls as well as the training program and people awareness, the quality of construction in the urban area has been improved and the trend is toward aseismic construction of public and private buildings. More incentive and encouragement is required.
- Starting the strengthening of public buildings and infrastructures.
- Disaster management: In the past due to the occurrence of many earthquakes and floods as well as the experience of 8-year war, the rescue operation and reconstruction were performed quite acceptable. In recent year the view to Disaster management has been changed toward a long term planning. Reduction of vulnerability in some specific area.

In conclusion as the some of the risk reduction indexes in the Table 1 shows that the seismic safety has become an important issue in the country, structures are build much better than before, even-though there is a long way to achieve a seismically safe environment [5].

Table 1. Iran's Preparedness achievement indexes before and after EHMP

	Before	After
Research	Low	Good
Public Awareness	None	Good
Preparedness	None	Low
Engineering Practice	Very Poor	Average
Engineering Knowledge	Average	Good
Political Will	None	Acceptable
Application & Implementation	None	Low

Post-Bam Earthquake Risk Reduction Strategy

The Bam earthquake disaster, despite its high casualties and losses, provided a unique window of opportunity to raise international awareness on the importance of the effective implementation of a comprehensive earthquake risk reduction program in Iran as well as in hazard-prone developing countries. It gave a challenge to the governments to make the highest use of the existing know-how on earthquakes and its integration into development programs. It also compels the scientific and engineering community to provide more socio-economic-cultural compatible solutions to national needs. Moreover, the public at large should become more concerned about the hazard and increase its own preparedness level. Based on the above mentioned facts, the achievements from the implementation of "Earthquake Hazard Mitigation Program", the experience of the Bam earthquake of 2003, and with considering of following guiding principals:

- Consideration of TOTAL RISK by looking at the causes and all of the effects of earthquake as shown in the diagram of Figure 4.
- Reduction and Control of Seismic Risk in any given area (specially urban are) as a complex problem, requires the integration of knowledge and the collaboration of experts from many disciplines.
- The problem of Seismic Risk Reduction will not be solved just by the acquisition of the required knowledge through research. Research must be accompanied by the necessary technological developments and the implementation of the knowledge and the development in practice; as well as a good management.
- Long term efforts is required for reducing the existing high level of seismic risk;
- Strengthening and retrofitting, specially the lifelines, of the existing system is very expensive and requires extensive financial resources;
- Socio-economic problem and lack of the political will in ***all*** the governmental level.
- Incompatibility between development investments and public and private investment for aseismic design and construction and mitigation;
- Level of people awareness and their economic capabilities;
- Economic capabilities are used for immediate needs rather than for long-term application such as seismic safety;
- Priorities should be put on sustainable development and seismic safety instead of rapid development;
- Lack of patient for long term work among the policy makers
- Implementation and code enforcement in small cities and rural area.
- Lack of full use and benefit of the technical knowledge in everyday life.
- Lack of strong and authoritative organization for implementation of the risk reduction programs.

An action oriented "Earthquake Risk Reduction Strategy of Iran" has been developed and approved at the highest level of decision making body in Iran. The main outlines of this strategy are:

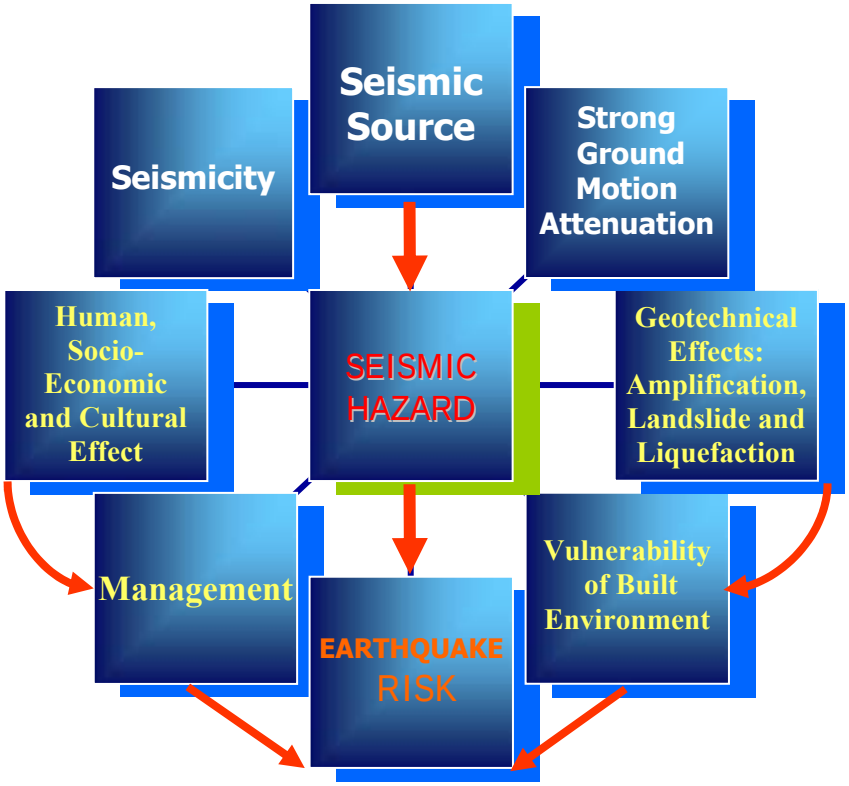

Figure 4: Flow diagram of Total Risk (from earthquake cause to its effects)

1. Increasing public awareness and promoting a collective prevention and safety culture at all level of society (people and government) through an extensive educational program.
2. Increasing the scientific and technical knowledge required for earthquake risk mitigation through the support and expansion of existing research institutions.
3. Creation of united command and management system in order to be fully prepared for an effective disaster response (rescue and relief operation) using all type of civil and military resources.
4. Development of a comprehensive and scientifically sound program for management and implementing an effective plans for post earthquake recovery (mental, social and physical) as well as for rehabilitation and reconstruction of the damaged area.
5. Development of an effective system for financial recovery and compensation through insurance, financial incentives, and supporting funds.
6. Reducing the risk of future construction and developments of urban and rural area through adequate planning and management and making sure that all structures are build safer by full implementation of building codes with “Zero Tolerance” for any type of violation.
7. Substantial risk reduction of existing structures with the main objective of saving human life, especially the public buildings, lifelines and infrastructures within next 10 years; as well as providing special loan and incentive for the private buildings.
8. Improving the quality of city planning and management.

After the development of the plan, in order to seriously manage the risk and implement the program, the policy makers should take following decisions in the national level (some of these decisions were taken).

- Defining acceptable level of RISK, globally and locally.
- Making seismic safety a priority by a strong legislation and changing public policies
- Building internal mechanism for changes of existing engineering practice
- Establishing partnership and cooperation framework between government, scientist, engineers, builders and public
- Divert the post earthquake fund for disaster relief to prevention and risk reduction program.

Even though the work has been done in the past were very important, effective and useful, but they have not solved the problems and have not successfully reduced risk, Thus the "Earthquake Risk reduction Strategy" should be formulated into Doable and Effective Preparedness, Prevention, Response, Reconstruction and Rehabilitation programs through:

- Translation of current engineering and architectural know-how into simplified options which can answer the socio-political and economical concerns. This will require not only a multi-disciplinary approach, but also a comprehensive educational program, not only for the owners and future users but also for all of the different audience that in one way or another are involved in the implementation of the seismic risk reduction measure.
- Good government management and performance which is the key factors in Risk Reduction Program, and therefore is a major controllable factor influencing the impact of a disaster.
- Putting scientific knowledge into a usable and doable format and utilization of practical knowledge to promote risk reduction
- Increasing the public awareness and motivation using active Earthquake Information System.
- Make the full benefit of active participation of the public in prevention and mitigation activities.
- Promotion as well as active enforcement of codes, quality control and inspection for all type of construction.
- Establishing special fund by the government for the strengthening of important public buildings (schools, hospitals, etc.), infrastructures and lifelines.
- Provide financial incentive for private sectors that are interested in upgrading their existing vulnerable structures.
- Establishing a detail and technical data basis and documentation of public building in order to define the priority of strengthening based on the available resources.
- Development of guideline for vulnerability assessment and cost-effective strengthening of common building type (masonry, concrete and steel structures)

- Provide a system for rapid vulnerability assessment of structures and easy, simple and inexpensive strengthening solution.
- Move toward industrialization of the construction practice for better quality control.
- Promoting the use of simple and easy do-it-yourself construction of simple dwelling in the rural area.
- Reducing risk of vulnerable structures and lifelines.
- Reducing technological disasters (Na-Techs) by strengthening industrial and chemical facilities against earthquake.

Good planning and decision by Iran's government after Manjil earthquake for implementing an earthquake hazard mitigation program and excellent support of the scientists has made visible achievements toward a seismically safe Iran. We believe Iran's experience was success and can be easily applied to the developing countries.

An Open Alliance for Earthquake Risk Reduction in Developing Countries

With the objective of earthquake risk reduction in the developing countries and prevention of similar disasters in many cities like "Bam" ; the UNESCO, UNDP, UN/ISDR Secretariat and the IIEES (as the host institute in Iran) have agreed to form an Alliance which will be open to a wider partnership among both Iranian and international institutions and organizations. The objective will be to initiate a series of activities to protect people, building stock, lifelines and critical infrastructure from the impacts of future earthquakes. The Alliance will advocate a shift in emphasis from post-disaster reaction to pre-disaster prevention and risk reduction actions, and stress the importance of preventive approaches through the enhancement of research and knowledge capacities, the design and dissemination of risk mitigation measures as well as increased information, education and public awareness.
The Alliance's vision is: expanding scientific and applied research, technical infrastructures and capacities for implementation of an effective risk mitigation action; reduction of risk in all types of built structures and ensuring that the future constructions are seismically safe; developing initiatives for the mitigation of earthquake risk in the rural areas with emphasis on the provision of realistic, doable, affordable, simple methods and methodologies; and enhancing the level of disaster preparedness by increasing public awareness and promoting collective prevention. In the short term, the Alliance will ensure that post-Bam earthquake scientific and technical studies and investigations are conducive to the production of comprehensive and authoritative compendium on lessons learnt from the earthquake and guidelines for reducing future losses in similar cases. The long-term objective will be to enhance the monitoring of seismic activity, the assessment of seismic hazards, the investigation of geotechnical issues, the improvement of building design, of resilience of important public buildings, lifelines, infrastructure and cultural heritage, and the promotion of earthquake preparedness and disaster management.

Concluding Remarks

Seismic risk is much more than a simple shock. It is a complex combination of the factors that determine the potential for people to be exposed to this type of natural hazard. Scientists, engineers, government officials and the general public must all be involved in finding realistic, achievable and appropriate ways of applying scientific knowledge to everyday life. Only by working together can we mitigate the impact of a natural hazard on human life and society and solve the 'Earthquake Puzzle'.

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