EARTHQUAKE HAZARD MITIGATION ACHIEVEMENT IN IRAN

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SUMMARY

The purpose of this paper is to present Iran's achievement in earthquake hazard related risk mitigation as a successful experience during International Decade for Natural Disaster Reduction (IDNDR). In the beginning of IDNDR on June 20,1990, the north of Iran has experienced its most devastating earthquake in the recent century causing 16,000 death and the loss of 2.5% of GNP. This event due to its heavy socio-economic impact became a turning point in earthquake hazard mitigation activities in Iran. This paper provides an insight into to the 9-years achievement and lesson learned from the implementation of the Iran Earthquake Hazard Mitigation Program (IEHMP) from different aspects for the purpose of planning for future activities. After the Manjil earthquake the IEHMP was developed by IIEES. The first phase of the program was implemented during 1991 to 1997 with the co-operation of IIEES, IGUT, BHRC, GSI, SUT and other universities with the support of Earthquake Committee of Iran Research Council (EC-IRC) and National IDNDR committee. The distinguished achievement of this phase were: Better understanding of Iran seismicity and seismic hazard; expansion of the seismic and strong motion monitoring network; establishment of required geotechnical testing facilities along with performing many geotechnical microzonation with regional and local scale; increasing the earthquake engineering knowledge and performing many research on aseismic design as well as vulnerability assessment of important structures and retrofitting the vital ones; changing the university education of structural engineer toward earthquake engineer, substantial increase in public awareness, etc. Today we can claim that the seismic safety has become an important issue in the country, structures are build much better than before, eventhough there is a long way to achieve a seismically safe environment.

Based on the experience and achievement of the first phase of the program as well as increased knowledge of our expert a new program called "Doable Initiative and Momentum for Earthquake Hazard Reduction-DIMEHR" has been proposed for "Iran 1400" which is "Iran in year 2020". The main objective of this plan is to achieve a seismically safe Iran in Year 2020 or 1400 in Iranian Calendar. This paper will provide the outline of this proposal, which is more applied mitigation oriented than research with the consideration of socio-economic situation of the country as well as the steps need to be taken before the program could actually be implemented. This proposal with some modification can be implemented in many developing countries, definitely with international support. Meanwhile up to the approval of the above mentioned plan a 3 year (1997-2000) complementary program to the first phase have been developed by EC-IRC which is now under implementation by more than 20 research institutes and universities under 78 project title.

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

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thousands villages, and caused extensive 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) and Kazeroon (May 99, mb=6.0) have shown Iran's seismicity as well as its vulnerability to earthquakes. Figure 1 shows the location of recent earthquakes as well as major seismotectonic provinces of Iran. Figure 2, which shows the seismic hazard map of Iran, indicates that most major cities of Iran have been located in very high hazard zone. In all the past-occurred earthquakes, human and economic losses have been due to failure of structures

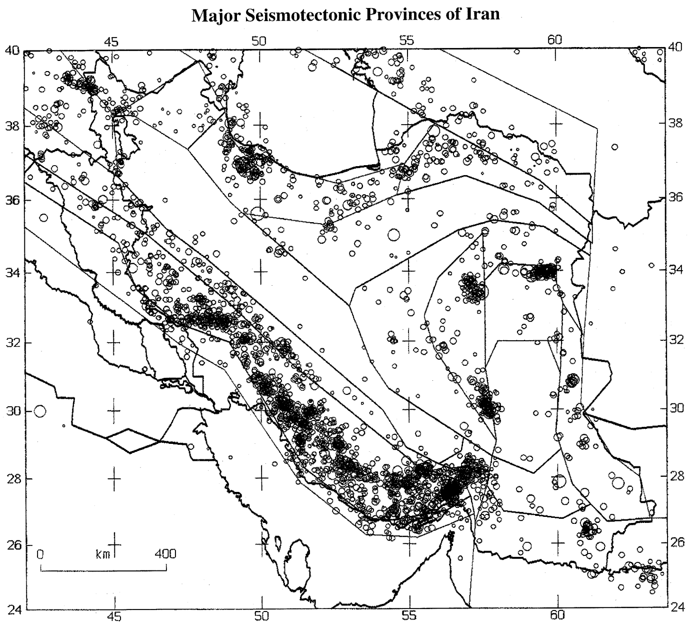

Figure 1: Seismicity and seismotectonic provinces of Iran

Figure 2: Seismic hazard zonation map of Iran

that for the most part were incompatible with the level of earthquake hazard in Iran. To control the seismic risk, a comprehensive earthquake hazard reduction program has been launched in Iran since 1991. This program which will be described in next section had a good achievement and impact on earthquake hazard mitigation and public awareness as well as on the earthquake research programs in Iran [Ashtiany, etal, 1990].

IRAN EARTHQUAKE HAZARD MITIGATION PROGRAM

With the presence of a constant threat from major earthquake in Iran, In 1991 (after the Manjil earthquake and in the beginning of IDNDR) the government decided to implement a multidisciplinary strategic research and mitigation plan entitled “Iran 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.

Based on the above objectives, the detail program with 6 main components was designed by IIEES and implemented with the co-operation of various institutions in Iran. The outline of the program and the level of its achievement have been shown in Table 1. To follow up the above mentioned program, after 1997 a three year program was designed by EC-IRC which is now under implementation. The main topic of this program and number of the approved projects are shown in Table 3.

The main achievements of the past 9 years of activity and in the last year of the IDNDR are as follows:

- Recognition of hazard, vulnerability and risk in Iran by decision-makers, engineers and public.
- Move toward planning 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
- Reduction of vulnerability in some specific area
- Appropriate testing facilities and laboratories have been established. Also the seismic Network and strong motion network has been expanded. In other word the minimum requirement for research studies have been provided, eventhough there is more which need to be added
- Better understanding and assessment of Iran’s seismicity and seismic hazard through seismotectonic studies, development of seismic catalogue, seismic monitoring, and hazard analysis.
- Improvement of technical knowledge and reaching the know-how for seismic safety and strengthening the country against earthquake. Today there is no lack of technical knowledge for the implementation of risk reduction policy or program in the country
- The Civil-structural engineering education has been directed more toward earthquake engineering and aseismic design and construction.
- Graduate studies in the earthquake relate fields were established in different universities. The MS and Ph.D. thesis were oriented toward solving the technical problems related to the earthquake hazard mitigation.
- Familiarization of engineers to the latest know-how and information related to aseismic design and construction through extension courses, seminars and specialized workshops.
- Public awareness: Through the extensive educational camping in school system and through all type of media, it can be claimed that people are more knowledgeable about earthquake and 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.
- Disaster management: In past 10 years 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 and excellent. In recent year the view to Disaster management has been changed toward a long term planning. A comprehensive Disaster management program with the view of prevention, preparedness, rescue operation, reconstruction has been developed for sustainable development.
- Co-operation and coordination: EC-IRC not only had played an important role in the coordination of research activities in Iran but with its support and approval of the IEHMP have helped all the institution and avoided duplicate work. Also national IDNDR committee had played an acceptable role in the coordination of the applied work and risk reduction program.

In conclusion as several indexes and comparisons shown in the Tables 3 and 4 the implementation of the program was a significant step (but not enough) toward risk reduction in the country; however the problem of its use in the society and its overall application still exists and need to be solved. Today, the public and private investment for aseismic design and construction and mitigation is not compatible with the development investments [Ashtiany 1999]. Therefore this question can be raised that “Why the level of technical knowledge and the know-how is not compatible with the implementation and why Iran is still highly vulnerable to earthquake?". Long term effectiveness of any mitigation plan and incompatibility of the existing buildings and infrastructures with the level of seismic hazard in Iran as well as lack of the use of knowledge in application are the causes of the existing high vulnerability. Moreover following obstacle have made the implementation and reaching a seismically safe environment very difficult:

- High level of seismic related risk in Iran or any developing countries;
- Strengthening and retrofitting, specially the lifelines, of the existing system is very expensive and requires very rich economy and financial resources;
- Socio-economic problem and lack of the political will in all the governmental level.

Table 1. IRAN Earthquake Hazard Mitigation Program (IEHMP)

	DESCRIPTION OF ACTIVITIES	Achievement %
1.	**Research on Seismic Zoning and Microzoning**	
1.1	*Seismological Network (Expansion of existing one and Establishing the INSN)*	45
	a. Design of network; Site survey; and Site preparation	100
	b. Installation; maintenance; and operation	30
	c. Data acquisition; Processing; Interpretation; and Cataloging	50
1.2	*Strong Motion Network (Expansion)*	90
	a. Site survey and site preparation	100
	b. Installation of 1000 accelerometer, maintenance and operation	100
	c. Data Acquisition, Processing and Interpretation	80
1.3	*Seismological Studies*	70
	a. Source mechanism estimation	60
	b. Earthquake catalogue (Historical and 20th century)	80
	c. Development of attenuation laws	100
1.4	*Seismotectonic* Maps	60
	a. Monitoring faults and study their activity	60
	b. Study the seismic gaps	60
1.5	*Geotechnical Studies and Investigation*	95
	a. Compile existing geological and geotechnical data of Tehran into zoning maps	100
	b. Conduct additional geotechnical study in 10 other important location	90
1.6	*Seismic Hazard Studies*	100
	a. Estimate, activity of seismic sources and their probabilistic models	100
	b. Develop seismic hazard maps on firm ground	100
	c. Correct the SHA for influence of local soil conditions at selected cities	100
	d. Develop methods for updating hazard maps	100
1.7	*Earthquake Amplification Study*	90
	a. Seismotectonic study of Tehran	90
	b. Geotechnical investigation planning and study of Tehran	100
	c. Amplification analysis of Tehran alluvium	100
	d. Develop geotechnical microzonation map of Tehran	85
1.8	*Seismic Zoning And Microzoning Maps*	80
	a. Revision of seismic design coeff. And spectra on the basis of past earthquake	100
	b. Develop new seismic hazard zonation maps of Iran	100
	c. Microzonation maps for the cities of Tehran, Tabriz and Mashad	60
	d. Revised seismic design coefficients and spectra	90
2.	**Research on Seismic Safety of Structures**	
2A	*Projects for Development and/or Improvement of Installations*	75
	a. Structural dynamic laboratories and workshops at IIEES	90
	b. Completion of shaking table facilities at Sharif University of Technology	45
	c. Advance soil dynamic laboratories	100

	DESCRIPTION OF ACTIVITIES	Achievement %
2B.	**Research Projects on Seismic Safety of Structures**	
2B.1	*Seismic Response of Actual Structures*	85
	a. Ambient and forced vibration study of structures	100
	b. Installation of accelerograph on important buildings	55
	c. Perform system identification and formulate conclusion and recommendation	

		100
2B.2	*Vulnerability of existing structures* a. Formulating an approach for evaluating vulnerability b. Applying it to a number of pre-selected existing structures c. Formulating general and specific conclusions and recommendations	100 100 100 100
2B.3	*Vulnerability of Lifelines* a. Develop data bank for the most vulnerable lifelines in Iran b. Safety evaluation of structures and other components of existing lifeline c. Design and commissioning of measuring instruments for lifeline monitoring d. Vulnerability and risk assessment of lifeline based on observation and analysis	28 40 30 20 35
2B.4	*Material Testing and Quality Control* a. Collection and testing the common building materials in Iran for quality control b. Propose recommendations for improving of the material quality and its control c. Specify acceptable properties of building materials suitable for Iran climates	57 55 60 60
2B.5	*New Materials for Structural & Nonstructural Memb., Energy Dissipation Devices* a. Literature survey on building material that can be used in Iran b. Selection of new materials to be used in Iranian construction c. Testing and certification	20 90 10 5
2B.6	*Geotechnical Studies and Zonation* a. Landslide Studies: Development of methodology for landslide zonation and detail studies of landslides in Gilan. b. Liquefaction studies: Development of zonation methodology and preparing	100 100 100
2B.7	*Experimental Study of Typical Iranian Masonry Construction* a. Select typical masonry structural components for testing b. Develop Analytical Models for the Selected Structural Components c. Study the Strength and Ductility Characteristics of Unreinforced and Reinforced Brick Masonry Walls with Different Layout of Brick Units c. Study the Behaviour of Brick Masonry Infill Walls in RC and Steel Frames d. Study the Behaviour of Brick Masonry Floors e. Study Various Schemes for Improving the Integrity of Masonry Structures f. Verify or Rectify Analytical Model Studies for Various Kinds of Masonry Construction in Order to Develop Guidelines for Proper Design and Construction	75 75 55 80 85 85 70
2B.8	*Experimental Study of Typical Iranian Reinforced Concrete Structure* a. Select Typical Reinforced Concrete Structural Components for Testing b. Develop Analytical Models for the Selected Structural Components c. Study the Strength and Ductility Characteristics of Commonly Used and Joints with Stay-in-place Clay Forms and their Connections to the Framing System d. Study the Behavior of RC Shear Walls for Low-rise Buildings and its use in Iran	55 50 65 60 40
2B.9	*Experimental Study of Base Isolation Systems (BIS) for Small Buildings* a. Develop Several Low Cost Schemes for BIS b. Develop Analytical Models for the Selected Schemes c. Testing Reduced Scale Small RC Frame Buildings with Selected (BIS)	20 40 40 10
2B.10	*Experimental Study of Typical Structural Joints* a. Develop Analytical Models for the Selected Joints b. Improve the Behaviour of Various Shear and Moment Welded Connections c. Test Various Schemes to tie Infill Masonry Walls to Steel or RC Frames	65 100 80 80
2B.11	*Shaking Table Tests and Study of Models of Typical Rural Houses* a. Select and design of model structural components and assemblage for testing b. Develop the necessary analytical models c. Shaking table model test of adobe & RM construction w/ strengthening schemes d. Shaking Table Model Test of RC Frames with Infill Masonry Walls e. Shaking Table Model of Steel Frames with Infill Masonry Walls	5 20 20 0 0 0
2B.12	*Analytical Studies of Structural Response*	80

	DESCRIPTION OF ACTIVITIES	Achievement %
3.	**Building Code**	

3.1	*Updating of Building Codes*	40
	a. Revision of seismic zonation and design spectra based on the lessons learned	100
	b. Detailed revision of building codes	10
	c. Adjustment of Detailed Revision Using Further Research Results	10
3.2	*Preparation of Written and Graphical Material*	55
	a. Manuals and design aids for easy application of revised building codes	100
	b. Booklets about Adequate Structural Framing Details and Connections	80
	c. Handbooks of Quality Control of Different Materials and Connections	30
	d. Booklets for Non-skilled Workers and for Builders of Low-cost Housing	30
4.	**Education and Training**	85
	a. Specialized education in advance topics	80
	b. Extension courses in practical aspects of Earthq. Eng. for C.E. and Architecture	100
	c. Fellowships and scholarships for Master and Ph.D. programs	100
	d. Skilled workers education	20
5.	**Risk Assessment and Reduction**	85
	a. Collect and compile basic data of the selected facilities	80
	b. Compile the results of studies of seismic zoning and microzoning maps	80
	c. Hazard, vulnerability and risk assessment of Tehran and the selected facilities	100
	d. Formulate strategies and priorities to reduce seismic risk for Tehran and the selected facilities including actions before and after earthquakes	100
6.	**Public Awareness**	80
	a. T.V. special program for children (cartoons)	70
	b. Preparing publication for children in elementary and high schools	100
	c. Developing country-wide educational campaigns to create consciousness about seismic risk condition, by means of all media	100
	d. Preparation of pamphlets for the general public, teaching them what to do before, during and after an earthquake in their houses, schools, hospitals, etc.	100
	e. Helping the emergency management authorities to prepare disaster preparedness plans for future earthquakes	100

Table 2: National earthquake research plan in Iran 1997-2000

	Research Area
1.	Crustal study of Iranian plate
2.	Seismicity study of Iran and the expansion of broadband seismic network
3.	Establishing strong motion dense array and geotechnical study of the SM
4.	Seismic hazard assessment of important cities of Iran
5.	Completion of earthquake data bank and establishment of the earthquake
6.	Development of intelligent systems for seismic hazard and seismic risk
7.	Micorzonation of important cities
8.	Vulnerability and seismic safety evaluation of structures
9.	Development of strengthening methods for building in rural areas
10.	Development of light weight earthquake resistant structures adaptable to
11.	Vulnerability and safety evaluation of lifelines safety and the development
12.	Implementation of strengthening program of Tehran against earthquakes
13.	Retrofitting of important structures and lifelines.
14.	Conducting effective measures in public education for earthquake hazard
15.	Development of a comprehensive disaster management plan

Table 3. Iran's achievement during IEHMP

	Before IEHMP&IDNDR	End of IEHMP
Public Awareness	None	Good
Preparedness	None	Low
Engineering Practice	Very Poor	Average
Engineering Knowledge	Average	Good
Political Will	None	Acceptable
Application & Implementation	None	Low

Table 4. IEHMP achievement

	Before the SHMRP	1999
Researchers	<40	More than 260
Graduate Students	<20	350
Seismic Stations	15	43
Strong Motion Stations	270	~1000
Research Laboratories	2	7
Books and Technical Reports	<100	More than 450
Budget	10 Years<700 MRials 1989: 104 MRials	10 Years>128,000 MRials 1999: 24,000 MRials
Investment for Laboratories	$3,100,000	$11,500,000

DOABLE INITIATIVE AND MOMENTUM FOR EARTHQUAKE HAZARD REDUCTION (DIMEHR)

Based on the above analysis, the future plan or program of risk reduction should be doable and usable by the people and authority and it should be more application oriented than pure research with the full considerations of the following points in its development:

1. Level of people awareness and their capabilities
2. Economic condition of people and lack of having luxury economy
3. Economic capabilities are used for immediate needs rather than for long-term application: seismic safety
4. Will of the governments and that the priorities are set for rapid development and sometimes without consideration to seismic safety issues
5. Lack of patient for long term work among the policy makers
6. Lack of law and code enforcement in small cities and rural area.
7. Lack of full use and benefit of the technical knowledge in everyday life.
8. Lack of strong and authoritative organization for implementation of the risk reduction programs.

The answers to these requirements as well as a solution to the future, especially in the developing countries, based on the experience gained from the past and authors' evaluation of IDNDR achievements, is in the DIMEHR program. DIMEHR is a "Doable Initiative and Momentum for Earthquake Hazard Reduction" which has been presented by the first author in SEE3 Conference [Ashtiany, 1999].

Before the DIMEHR's implementation, several decisions should be taken in the national level. With this consideration, the methods to reach DIMEHR requires the following steps:

- Defining acceptable level of RISK
- Making seismic safety a priority by a strong legislation and changing public policies
- Building internal mechanism for changes of existing engineering practice
- Putting scientific knowledge into a usable and doable format and utilization of practical knowledge to promote risk reduction
- Building public awareness and motivation
- Establishing partnership and cooperation framework between government, scientist, engineers, builders and public
- Close cooperation between developing countries and international organizations or a developed country for implementation of RISK REDUCTION program
- Divert the post earthquake fund for disaster relief to prevention and risk reduction program.

After reaching the appropriate decision for the above-mentioned points and fulfilling the prerequisite, then the main phase of DIMEHR should be started which consist of:

1. Expansion of public education program by the use of active Earthquake Information System.
2. Make the full benefit of active participation of the public in prevention and mitigation activities.
3. Promotion as well as active enforcement of codes, quality control and inspection for all type of construction.
4. Provide a system for rapid vulnerability assessment of structures and easy, simple and inexpensive strengthening solution.
5. Provide financial incentive and rapid cost-benefit analysis for those interested in upgrading their existing vulnerable structures.
6. Move toward industrialization of the construction practice for better quality control.
7. Promoting the use of simple and easy do-it-yourself construction of simple dwelling in the rural area.
8. Reducing risk of vulnerable structures and lifelines.
9. Reducing technological disasters (Na-Techs) by strengthening industrial and chemical facilities against earthquake.

CONCLUSIONS

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. The authors also believe that DIMEHR is a new achievable solution for more effective achievement of risk reduction in Iran. It is hoped that with the support of international agencies, it can be expanded to other countries.

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