International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

EARTHQUAKE HAZARD MITIGATION IN IRAQ: Recommendations to Decision Makers

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Abstract - *The people of Iraq have experienced economic loses and stagnation consequent of the human and natural induced hazards. The 7.3 magnitude earthquake that hit the Iran and Iraq border in November 2017 is one of the deadliest seismic activity that was witnessed by the two Asian countries based on the tremendous destruction of property and loss of lives that was brought by the earthquake. The earthquake led to extensive damages on the Iraq side of the border especially in the town of Halabjah where there was a high number of injuries as a result of the violent earthquake. The earthquake brought about the disruption of normal operations in the towns close to the border where the earthquake occurred. There was a disruption of the power supply which left some of the emergency services helpless since nearby hospitals were unable to provide treatment of patients since there was a disruption of power to the facilities. There was a level of confusion among specialists in the field of earth sciences since the quake did not adopt a typical, predictable characteristic since it did not occur along a known major fault as similar earthquakes of that magnitude. The purpose of this paper is to introduce Iraq's situation in earthquake hazard. It tries to provide an insight into the achievements that may be gained by implementing a proposed program of earthquake hazard mitigation. The program should be implemented with co-operation specialized identities and universities and other community beings. The program aims to reach better understanding of seismic hazard, strong monitoring network, better built geotechnical testing facilities, increasing knowledge in earthquake field, changing in the education toward earthquake engineering and increasing in the public awareness. A plan is proposed here and the main objective of this plan is to achieve a seismically safe Iraq. This paper provides 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 needed before the program could actually be implemented.*

Key Words: Hazard mitigation, earthquake engineering, earthquake monitoring, earthquake network station in Iraq, seismic activities, Halabjah.

1. INTRODUCTION

Disaster mitigation refers to a detailed guideline for all the actions taken before, during, and after the disaster to reduce its impact and intensify by facilitating recovery. The first strategy of mitigation is the improvement of risk assessment. As such, the government should invest in scientific research, to identify the frequency, severity, and possibility of occurrence of an earthquake before it happens. Technology should be mobilized to send forewarnings and mend the propagation and reaction to warnings. Prior information prepares people for a prospective earthquake, thus reducing the impact of earthquakes. For instance, if the people are informed beforehand, and they can vacate the threatened zone significantly reducing the mortality rate caused by the earthquake. The threatened area should be insured against catastrophic loss. This can be achieved through the formulation of a disaster policy that would reduce the risk arising from the disaster. Therefore, Iraq should invest in technology and scientific studies to identify and manage possible earthquake outbreaks in the future [1],[2].

Iraq is located in an active seismic belt and hence is an earthquake country that has experienced many strong earthquakes in the past decades. In this century, large earthquakes have claimed much lives, destroyed many areas and caused extensive economic damages [3].

Figure 1: seismic zoning map of Iraq

Figure 1 [10] shows the seismic hazard map of Iraq and indicates that many major cities of Iraq have been located in high hazard zone.

Figures 2 [6] and 3 shows earthquakes maps of Iraq and adjacent countries respectively.

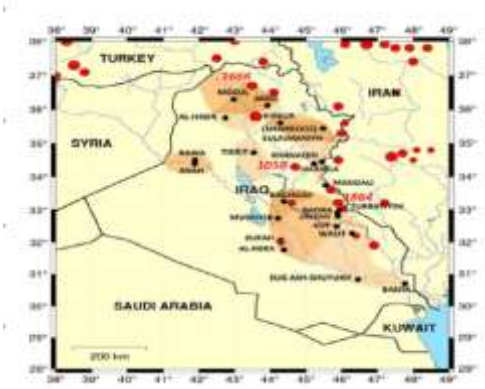

Figure 2: Historic Earthquakes map in Iraq

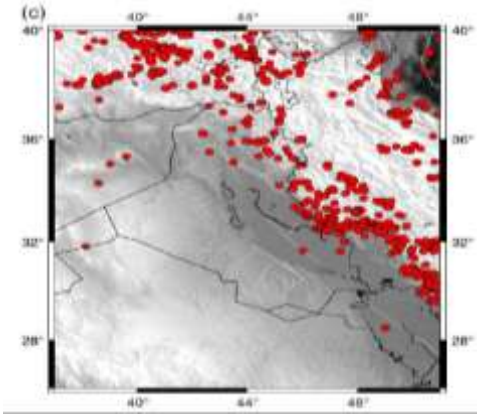

Figure 3: Earthquakes map around Iraq country

With the past occurred earthquakes, human and economic losses have been due to failure of structures that for the most part were incompatible with the level of earthquake hazard in Iraq. To control the seismic risk a comprehensive earthquake hazard reduction program should be launched. This program which will be described in next section aims to good achievements and impacts on earthquake hazard mitigation and public awareness as well as on the earthquake research programs in Iraq [4], [5].

2. Iraq Earthquake Hazard Mitigation Program

The Iraq Earthquake Hazard Mitigation Program which is proposed here aims to the following objectives:

1- Increasing the scientific knowledge

2- Reduction of risk of failure in constructions

3- Increasing public awareness of seismic hazards

4- Plans for post-earthquake actions.

Based on the above objectives, the detail program with **six** main components was designed and to be implemented with the co-operation of various institutions in Iraq. The outlines of the program have been shown in Table 1. The description column in this table gives the various requirements included in the proposal and the initial situation column is representing the existing nowadays situation in Iraq regarding the requirements. It is very difficult to reach the real data that describe the actual situations in Iraq. The percentages shown are approximated and just suggested to be the start point of the proposed program. These percentages are extracted in most cases from the few information available in the global internet web. A brief history of earthquake monitoring in Iraq can be shown in Table-2

Regarding earthquake catalogue, the catalogue encompasses the region between 36E-51E longitudes and 26N-40N latitudes, and includes about 16,000 events of magnitude 3.0 and larger, and about 4,000 events of magnitude 4.0 and larger between the years 1900 2009 inclusive. The geographic extent of the catalogue's coverage is intended to include sources of seismicity beyond Iraq's borders, but may be damaging inside the territory of Iraq. The catalogue is harmonized to M_w[6].

The completeness intervals for the entire catalogue are as follows: Mw6.5 and above are complete since 1900, Mw6.0 and above since 1924, Mw4.2 and above since 1965, Mw3.4 and above since 1995, and Mw3.2 and above since 2006.Roughly 90% of the earthquakes in the catalogue have a depth of between 0 and 35km.This indicates that majority of earthquakes in the region exhibit shallow crustal seismic activity.

Table 1. Proposed Earthquake Hazard Mitigation Program

No.	Description	Initial Situation
1	**Research on Seismic Zoning and Micro zoning**	
1.1	Seismic Network : Existed stations covers only 50% [7],[8],[9]	60%
1.2	Motion Network : Lack of national strong motion network and the existed is few compared with the needed [8],[9]	20%
1.3	Seismological Studies a. Source mechanism estimation: recently active but it is influenced by the political conditions of the country. b. Earthquake catalogue: There is one in term of moment magnitude [6]	45%
1.4	Monitoring faults and studying their activity and study the seismic gaps : not periodical , they are in the form of (researches) rather than continuous monitoring and studying	30%
1.5	Geotechnical Studies and Investigation: Narrow band budget that allocated to hazard and disaster risks like ones of earthquakes. Weak effort in this direction	10%
1.6	Seismic Hazard Studies: Estimate activity of seismic sources and their probabilistic models , develop seismic hazard maps , study the influence of local soil	30%

	conditions at selected cities and updating hazard maps.	
1.7	Seismotectonic study of Iraq: geotechnical investigation and amplification analysis	50%
1.8	Seismic Zoning And Microzoning Maps	50%
2	**Research on Seismic Safety of Structures**	
2A	Installations of structural dynamic laboratories and workshops , shaking tables facilities at universities and advance soil dynamic laboratories	40%
2B	Research on Seismic Safety of Structures	10%
2B.1	Assessment of seismic response of actual Structures (at least the important structures)	10%
2B.2	Vulnerability of existing structures a. Formulating an approach for building stocks b. Applying it in the program c. Formulating conclusions and recommendations	10%
2B.3	Vulnerability of Lifelines (observation and analysis)	10%
2B.4	Material Testing and Quality Control a. Common building materials in Iraq for quality control b. Propose recommendations c. Specify acceptable properties	60%
2B.5	New Materials: a. Literature survey b. Selection of new materials to be used in Iraqi construction c. Testing and certification	10%
2B.6	Geotechnical Studies and Zonation	25%
2B.7	Experimental Study of Typical Iraqi Masonry Construction	30%
2B.8	Experimental Study of Typical Iraqi Reinforced Concrete Structure	40%
2B.9	Experimental Study of Base Isolation Systems (BIS) for Small Buildings	30%
2B.10	Experimental Study of Typical Structural Joints	30%
2B.11	Shaking Table Tests and Study of Models of Typical Rural Houses a. Select and design of model b. Develop analytical models c. Shaking table model test d. Shaking Table Model Test of RC Frames with Infill Masonry Walls e. Shaking Table Model of Steel Frames with Infill Masonry Walls	10%
2B.12	Analytical Studies of Structural Response	50%
3	**Building Code**	
3.1	Updating of Building Codes(revision and adjustment)	50%
3.2	Preparation of Written and Graphical Material	50%
4	Education and Training	50%
5	Risk Assessment and Reduction (data , results of study , risk assessment and formulating mitigation strategy)	40%
6	T.V. programs , publication in elementary and high schools and educational campaigns to create consciousness by means of all media	10%

Table 2 A brief history of earthquake monitoring in Iraq [6],[7],[8],[9]

Year	Identity and achievement
1972	• The Department of Geology, University of Baghdad • Mobile 3-component short period analog recording equipment (TELEDYNE SYSTEM) • Most of this recording was for graduate students' research.
1976	• Scientific Research Council-SRC • Seismological Unit as a dedicated independent seismological center to coordinate earthquake monitoring in Iraq.
1980s	• The Iraq Seismic Network (ISN) became operational • Analog short-period stations in Baghdad, Mosul, Rutbah, and Basra . • Monitoring until 1991 after which half of them ceased to operate . • A large gap existed in seismic data collection.
2003	• Project supported by National Science Foundation, US DoE, and UA Little Rock • Installation of two broadband stations in Baghdad and Mosul . • It also included training and capacity building for research and infrastructure.
2007	• University of Duhok in northern Iraq • Install a broadband seismic station (DHK1) on the university campus. • This station located within the seismically active zone, which represents the continental-continental collision boundary between the Arabian and Eurasian plates , see (Figure 3).
2013-2014	• In collaboration with LLNL (Lawrence Livermore National Laboratory) • Seven-element high-frequency three-component array installed • Al-Rifai about 240 kilometres southeast Baghdad • The area experienced a swarm of moderate size earthquakes. • Many of the earthquakes that were strongly felt by the area's residences were not reported by any agency except a few that were strong enough to cause some structural damage.

2014 and 2015	• Five more broadband seismic stations • Two strong motion stations were installed. • Basra (BSR2), Nasiriya (NSR4), Ammarah (AMR2), Karbala (KAR2), and Sulaymaniyah (SYL1). • The 2 strong motion stations were collocated with BSR2 and SYL1 broadband stations. • Figure 3 represents the location map.
2017	• IRIS Data Services provided five Guralp 3ESP broadband seismometers A PowerEdge R815 DELL server • Four broadband stations online. UA Little Rock team fitted three of these seismometers with Guralp DM24 digitizers and GPS antennas to produce three new stations.

The monitoring of seismic activities in Iraq are done by Iraqi meteorological organization & seismology department [9] in the ministry of transportation which provide information and data related to these activities. The distribution of seismic network stations is shown in figures 4 and 5.

Figure.4 Location map of broadband seismic stations

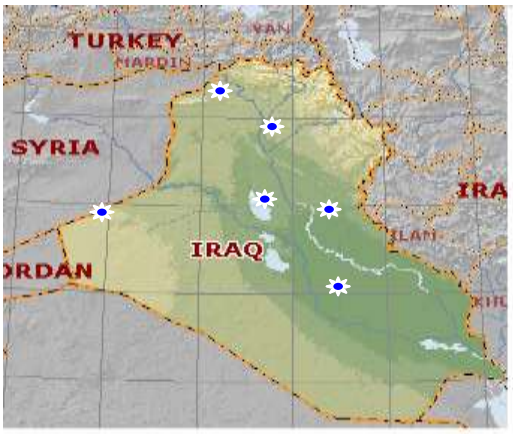

Figure.5 Six Kinemetrics stations with VAST System

3. Main Required Achievements

The main required achievements are as follows:

1- Recognition of hazard, vulnerability and risk in Iraq
2- Focusing on planning
3- Enforcing the technical knowledge and engineering practice
4- Implementation of mitigation actions
5- Reduction of vulnerabilities
6- Testing facilities and laboratories
7- Deeply understanding and assessment of Iraq's seismicity and seismic hazard
8- Treatment of the lack of technical knowledge for the Implementation of risk reduction policy or program
9- Directing engineering education more toward earthquake engineering
10- Establishing graduate studies in the earthquake, MS and Ph.D.
11- Training engineers through courses, seminars and workshops
12- Public awareness
13- Construction quality
14- The long term planning.
15- Co-operation and coordination

4. Effectiveness of Existing Mitigation Plans

According to indexes shown in the Tables 3 the implementation of the program is a significant step toward risk reduction in the country; however, the problem of its use in the society and its overall application still need to be solved.

Table 3: Iraq's achievement during last years (Approximated)

Article	achievement
Public Awareness	Low
Engineering Practice and Knowledge	Moderate
Political Will	Low
Programs Application & implementation	Low
Researches	Moderate
Graduate Students	Low
Seismic Stations	Moderate
Strong Motion Stations	Low
Research Laboratories	Low
Books and Technical Reports	Low
Investment	Low

Today, the public and private investment for aseismic design and construction and mitigation is not compatible with the development. Therefore, questions can be raised about

effectiveness of any mitigation plan and incompatibility of the existing buildings and infrastructures with the level of seismic hazard in Iraq as well as lack of the use of knowledge in application. These represent the causes of the existing vulnerability. Also, following obstacles have made the implementation and reaching a seismically safe environment difficult:

1- Vibrated level of seismic risk in Iraq
2- Strengthening and retrofitting lifelines is very expensive and requires very rich economy
3- Lack of the political will in all the governmental level

5. Details of the suggested program

5.1. Program Considerations

Based on Table 3, the plan or program of risk reduction should be more application oriented with the full considerations of the following points in its development:

1- Level of people awareness
2- Economic condition of people
3- Economic capabilities to be used for immediate needs
4- Will of the governments
5- Lack of trend of long term work among the decision makers
6- Lack of law and code enforcement
7- Lack of full use and benefit of the technical knowledge
8- Lack of organization for implementation

5.2. Program Steps

With this consideration, the methods to reach Program requires the following steps:

1- Defining acceptable level of risk
2- Making seismic safety a priority
3- Building changes to existing engineering practice
4- Putting scientific knowledge into a usable format
5- Building public awareness
6- Establishing cooperation framework between government, scientist, engineers, builders and public
7- Close cooperation between developing countries
8- Moving the fund for disaster relief to prevention and risk reduction program

5.3. Main Phase of Program

After reaching the appropriate decision for the above-mentioned eight points and fulfilling the prerequisite, then the main phase of the program 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

6. Conclusion

Good planning and decision by Iraq's became very necessary for implementing an earthquake hazard mitigation program and support of the scientists to make visible achievements toward a seismically safe Iraq. This study suggests that the presented program is an achievable solution for more effective risk reduction in Iraq. Such as this program needs financial and technical support from worldwide organizations which help the development country like Iraq to achieve the target of this program. Further detailed steps should be done from researchers, universities and government to make this briefly paper to be an applicable project and submit it to the authorities and enable the implementation of it.

7. References

[1] Iwan, Wilfred D. "Mitigation emerges as a major strategy for reducing losses caused by natural disasters." Science284.5422 (1999): 1943.

[2] Dehghan, Saeed Kamali, et al. "Iran-Iraq Earthquake Death Toll Climbs to More than 400."The Guardian, 13 Nov. 2017.

[3] ISN , "Report of earthquakes that have occurred north - east Iran , April 2017

[4] Aliev, Telman. "Intelligent Seismic-Acoustic System for Identifying the Area of the Focus of an Expected Earthquake." Earthquakes-Tectonics, Hazard and Risk Mitigation. InTech, 2017.

[5] Mohsen Ghafory-AshtIany , Mohammad-Kazem Jafari and Mohsen Tehranizade"Eathquake Hazard Mitigation Achievement in Iran" , 12WCEE 2000

[6] Tuna Onur, Rengin Gök, Wathiq Abdulnaby, Hanan Mahdi, Nazar M. S. Numan, Haydar Al-Shukri, Ammar M. Shakir, Hussein K. Chlaib, Taher H. Ameen, and Najah A. Abd"A Comprehensive Earthquake Catalog for Iraq in Terms of Moment Magnitude" , Seismological Research Letters Volume 88, Number 3 May/June 2017

[7] Humayun, S., and I. R. Al-Abyadh. "Iraq: country case study Report-How law and regulation supports disaster risk reduction, International Federation of Red Cross and Red Crescent Societies (IFRC)." United Nations Development Programme-Headquarters (UNDP) (2014).

[8] Ammar Mahmood Shakir, Rengin Gok , Hanan Mahdi and Nazar M. S. Numan"Probabilistic Seismic Hazard Assessment for Iraq" , Lawrence Livermore National Laboratory , 2016

[9] Ministry of Transportation in Iraq , Iraqi Meteorological Orgazination and Seismology , "Project of development of Iraqi Seismic Monitoring Network", http:// www.meteoseism.gov

[10] Taha, O. B., & Hasan, A. S. (2018). A Comparative Study of the Seismic Provisions between Iraqi Seismic Codes 2014 and 1997 for Kurdistan Region/Iraq. Eurasian Journal of Science and Engineering, 4(1). doi: 10.23918/eajse.v4i1sip180