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EARTHQUAKE HAZARDS CONSIDERATIONS FOR IRAQ

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ABSTRACT

The seismic hazard for the investigated area outlined by longitudes (30º. 00 –49º. 50') N and latitudes (28º. 50'-38º. 50`) N. Earthquake data for the period 1900-1988 was utilized for the seismicity studies Most earthquakes clustered on the edges of the Zagros-Tauros subduction zones between the Arabian sub continent Plate and the Iranian and Anatolian Plates; in addition to few intraplate type events on the tectonically stable zone to the west. It was found that 95.5% of the events have mb magnitudes range of (4.0-5.5) and that 75.5% of the vents have a focal depth range of (0.0- 50.0) Kms. The (a) and (b) constants of the Gutenberg-Richter recurrence relation gave the values of 6.85 and 0,89 respectively, thus reflecting and intermediate seismicity level. Historical data for the period 1260 B.C. –1900 A.D. were utilized for the historical isointensity determinations.

A seismic zoning map was constructed showing four damage zones ranging between less than (III) and (VIII) on the MM scale. A seismicity index map was also constructed showing the areas east of Tigris River to depict the highest seismicity index.
Seismic sources were also investigated, where five line sources and four area sources were modeled and their locations and parameters determined.
Isoacceleration maps were constructed for the studies area for four return periods of 25,50,100 and 200 years respectively. The acceleration values tend to increase towards the eastern, northeastern and northern direction.
The seismic design parameters were studies and seismic design regionalization map was presented showing a value increase towards the east, northeast and north.

1. INTRODUCTION

This investigation, although was conducted a decade ago, but was not fully published and therefore the results fills an important gap in the ongoing seismic hazard investigations of the Middle Eastern Region.
The geologic and tectonic setting of Iraq is given by a number of investigators amongst which the works of Dunnington (1958), Al Naqib (1967), Al Sayyab & Valik (1968), Ditmar et.al (1971) and Buday & Jasim (1987) are noted.
Iraq has a well-documented history of seismic activity .The historical seismicity follows a well-defined pattern and fits the boundary of the major tectonic elements of the country. The close parallelism between past and recent seismicity, i.e. the historical seismicity provides a relevance to the recent seismicity. An

earthquake catalogue was prepared for the studies area as bounded by longitudes (30º. 00 –49º. 50') N and latitudes (28º. 50'-38º. 50`) N for the period 1900-1988.The Catalogue contains 1031 events ranging in mb magnitudes between 3.0-7.4, and was based on a number of sources available at that time Al Qasrani (1990).
An analysis was carried in this investigation to determine the various magnitudes, focal depths and spatial and time distributions of earthquakes. Seismic hazard investigations were also carried out and seismic zoning map was constructed in addition to the seismicity index map, the seismic source map, the isoacceleration map for four return periods and the seismic regionalization map is constructed.

2. SEISMICITY AND SEISMOTECTONICS

Tectonically Iraq is located in a relatively active seismic zone at the northeastern boundaries of the Arabian Plate .The corresponding Zagros –Tauros Belts manifest the subduction of the Arabian plate into the Iranian and Anatolian Plates .The seismic history reveals annual seismic activity of different strength. The north and northeastern zones depicts the highest seismic activity with strong diminution in the south and southwestern parts of the country. The seismicity and seismotectonics of Iraq is documented by Alsinawi& Ghalib (1975a), and Alsinawi & Issa (1986).
A number of microearthquake investigations were carried out in Iraq, that filled a gap during the period where no permanent seismic stations were operational .The microseismicity background also blend well with the main macroseismic pattern, Alsinawi& Al Ridha (1986).
Figure 1 represents a seismotectonic map of the studied area in which the events of the earthquake catalogue are superimposed on the tectonic framework of Iraq as suggested by Buday and Jasim (1987).
Buday have suggested a six fold tectonic classification of the country that extends from the southwest to the northeast as follows: The Stable Shelf ,The Mesopotamian Zone, The Simply Folded Zone ,T he Imbricated Zone, the Thrust Zone and the Central Iranian Zone .Those tectonic subdivisions are transversly dissected by a number of east west transverse fault systems that were deleniated on stratigraphic subsurface Data amongst other evidences.
The statistical analysis of the event distribution shows that events with magnitudes range of 5.4-4.0 mb constituted 90.95%, while events with mb magnitudes of 5.5-7.4 constitutes 6.03% of the total events.
As for the focal depth, events with focal depths below 50kms constitute 75.75%, while events with focal depth of 90 plus kms constitutes 2.61% of the total events.
As for actual events with magnitudes over 6 five events are documented, only one vent of mb=6.0 is located within the Iraqi territory on Long.42.5 E and Lat. 35.9 N.
Based on the space and time distribution of the events it was possible to distinguish five major periods of activity namely 1900—1930,1931-1960,1961-1970 ,1971-1980and 1981-1988.
The Magnitude Recurrence relationships for the total period of recording and for the five distinct periods are given in Table 1. The average recurrence relation for the region is given by equation (1):

$$\mathbf{Log\ N = 6.85 - 0.89\ m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)}$$

The (b) value is moderate and typical to the Alpine Orogenic Belt (0.7 – 1.0), Miyamura (1962).
It should be noted that in comparing the (b) value from previous investigators in Iraq, Turkey and Iran Reflects a wide range of variation from 1.2- 0.42 in (b) values. This is mainly attributed to the different geographical areas covered by the study, the type of data collected, the duration of recording investigated and the variation in geotectonic regions.

TABLE 1: THE GUTENBERG RICHTER RELATIONSHIP PARAMETERS FOR IRAQ 1900-1988

Recording Period	*Constant (a)*	*Constant (b)*
1900-1930	***4.66***	***0.60***
1931-1960	***5.55***	***0.74***
1961-1970	***6.36***	***0.96***
1971-1980	***7.47***	***1.16***
1981-1988	***8.01***	***1.30***
1900-1988	***6.85***	***0.89***

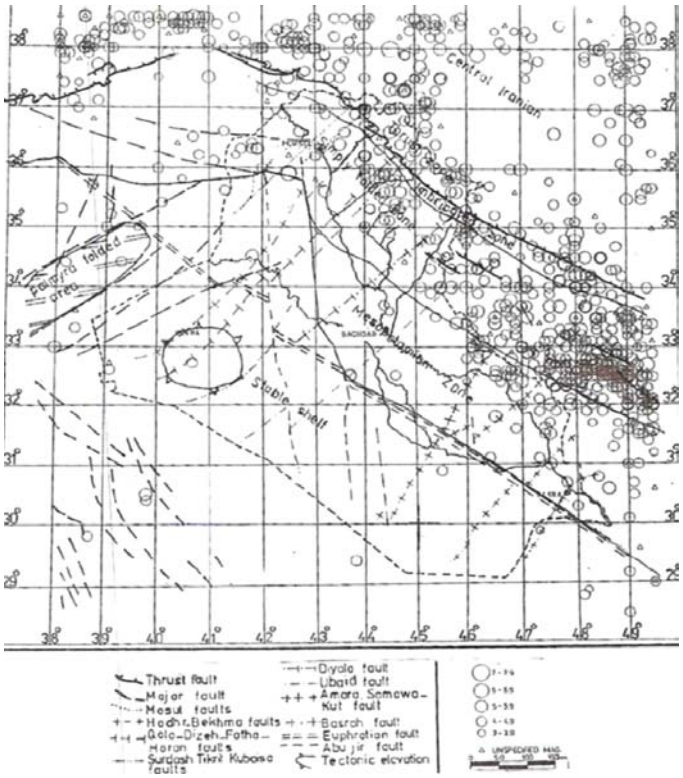

FIGURE 1: SEISMOTECTONIC SETTING OF IRAQ, AFTER ALQASRANI (1990) & BUDAY & JAS

3. HISTORICAL ISOINYTENSITY MAP

The historical seismicity of Iraq was investigated by Ambraseys (1971), Alsinawi& Ghalib (1975b); Poirier & Taher (1980), Alsinawi& Issa (1986) and Alsinawi (1988). The historical seismicity of the region for the period 1260 B.C – 1900 A.D. was investigated and a catalogue of 165 historical events were utilized to construct a historical Isointensity map as given in Figure 2.

4. SEISMIC ZONING MAP OF IRAQ

The main concepts of seismic hazard considerations are given by various investigators amongst which Lomintz (1974), Alsinawi& Ghalib (1975c), Adeli & Nasser (1978), Ambraseys (1978), Alsinawi & Al Moosawi (1982) and Alsinawi & Issa (1986).

Prior to this invesigation Alsinawi & Ghalib (1975c) presented the first seismic zoning map for Iraq where Iraq was divided into five intensity regions ranging between V- IX on the MM scale. Other zoning maps were presented by Alsinawi & Al Moosawi (1980), Alsinawi & Al Moosawi (1982), Alsinawi & Issa (1986), Alsinawi & Al Dilaimi (1993) and Alsinawi (2001).
The seismic zoning map computed for Iraq is based on an attenuation relationship given by Puttonen and Varpasu (1982). But the Ms magnitude in their relationship is replaced by mb relying on Richter (1958) relationship resulting in equation (2).

$$\mathbf{I = 4.671 + 1.51mb - 2.15\ Ln\ (R + 20).\ (2)}$$

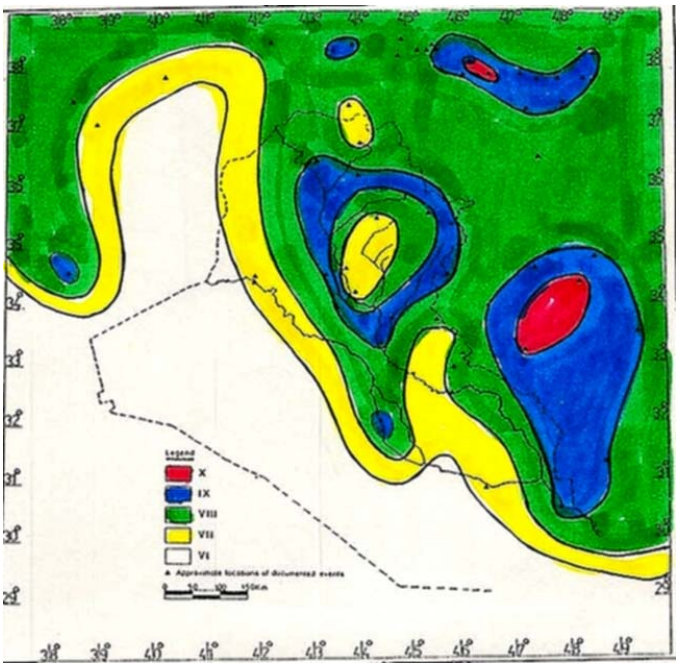

FIGURE 2: HISTORICAL ISOINTENSITY MAP OF IRAQ

Figure 3 represent a seismic zoning map of Iraq, in which it is divided into four zones where the areas of no damage zone of MM = III and less covering mainly the stable shelf region.
Then the minor damage zone follows which covers the intensities IV- V covering the Zagros Foothills and The Mesopotamian Geosyncline. Then the moderate damage zone follows with intensity range of VI-VII which actually covers the Zagros Tauros thrust zones .The major damage zone with intensity of VIII is located on the Zagros thrust outside the Iraqi borders

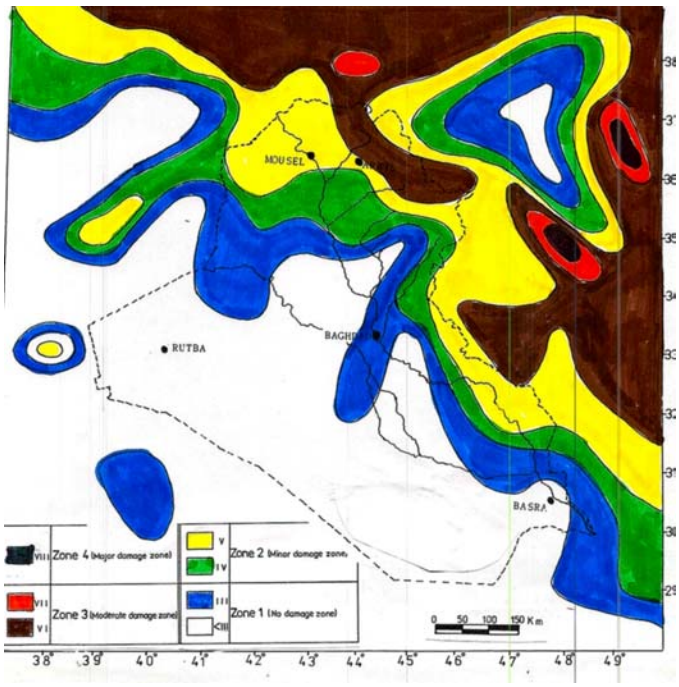

FIGURE 3: SEISMIC ISOINTENSITY MAP OF IRAQ 1900-1988

5. SEISMICITY INDEX MAP OF IRAQ

The seismicity Index **ST** is given by Terashima (1973) in equation (3); where N= number of earthquakes of magnitude ≥X, T = period in years, X= least earthquake magnitude value and Δ= epicentral distance. The seismicity index number (TS) defines the earthquake influence on a region by defining average recurrence period in the studies period and also defining the occurring earthquake magnitudes.
. In preparing this map as shown in figure 4, the value of 4.0 is given to X, as a starting seismic risk value
From figure 4, the region that bears 0.1≤ ST ≥0.2 is a region where there is a possible occurance of an earthquake with M≥4.0 for duration of five to ten years on a 100 km diameter.

$$ST = \frac{\sum_{M \geq x} N(M)}{T} \quad \Delta \leq 100\text{Km.} \quad (3)$$

We may conclude from Figure 4 that the region of SW Iraq depicts a very high seismic number.
The regions east of Tigris River have a high seismic number where an earthquake with magnitude M≥4.0 occurs once every two to five years. The region between Tigris and Euphrates Rivers experiences a low rate of occurrence between five to ten years. The south and southwestern regions have a low seismic index number and low earthquake occurrence for durations of more than ten years.

6. SEISMIC SOURCE MODELING

Figure 5 shows seismic source modeling Roshandel et.al (1981). Of the region where four seismic area sources and five line sources. Table 2 outlines the details of the various seismic sources.

7. ISO ACCELERATION MAPS OF IRAQ

An attenuation relationship given by Esteva (1974) was utilized and the Poissons distribution as given in Table 2 in constructing the isoacceleration maps for Iraq with a contour interval of o.o1g using four return periods of 25,50,100 and 200 years. Figure 6 is an isoacceleration for 100 years return period. These maps reflect the SW NE trend of increase in seismicity and seismic risk in Iraq.

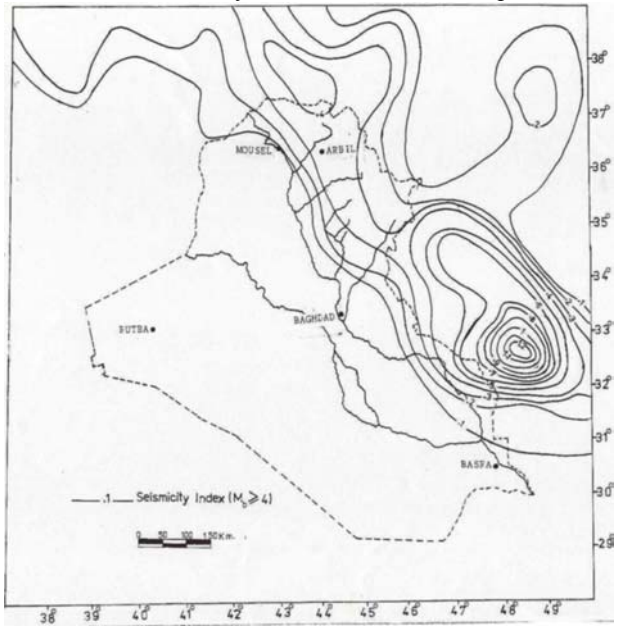

FIGURE 4. SEISMICITY INDEX MAP OF IRAQ

TABLE 2: LINE AND AREA SEISMIC SOURCES IN IRAQ (Figure 5)

Source Type	No. Of Events	Length/Radius	Av. Focal Depth	Highest Magnitude
Line source#1	**72**	**640 km**	**36 km**	**6.7**
Line Source #2	**66**	**367 km**	**32 km**	**7.2**
Line Source #3	**16**	**220km**	**59 km**	**5.2**
Line source #4	**16**	**210 km**	**42 km**	**5.3**
Line Source#5	**8**	**188 km**	**35 km**	**6.1**
Area Source#1	**129**	**80 km**	**44 km**	**5.6**
Area Source#2	**31**	**70 km**	**33 km**	**5.6**
Area Source#3	**31**	**60 km**	**32km**	**6.0**
Area Source#4	**28**	**75 km**	**38km**	**5.5**

8. SEISMIC DESIGNE REGIONALIZATION MAP

The peak ground acceleration relates acceleration, distance and earthquake magnitude as given by Milner & Davenport (1970). The first design regionalization map for Iraq was presented by Alsinawi & Al Moosawi (1980). Figure 6 represents the peak ground acceleration. The value increases towards the east-northeast and north, plus the regions of Ana-Rawa on the Western Desert.

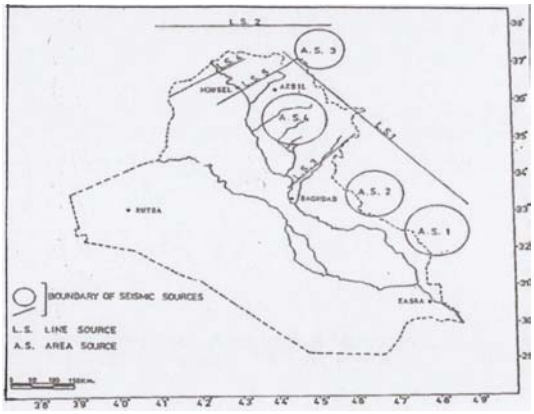

FIGURE 5. SEISMIC SOURCES MAP

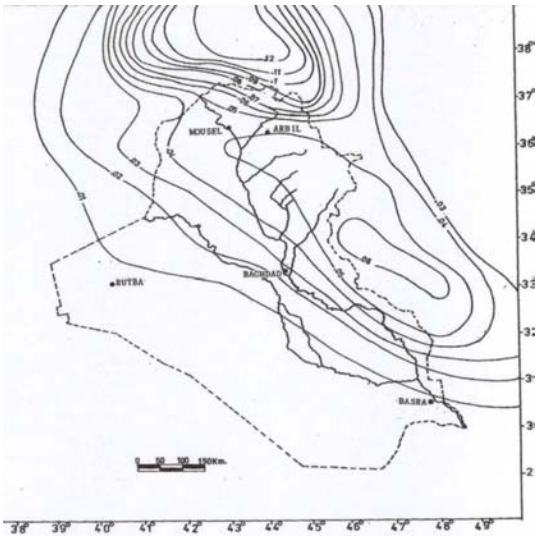

FIGURE 6. SEISMIC ISOACCELERATION MAP WITH DESIGNE PERIOD OF 100 YEARS

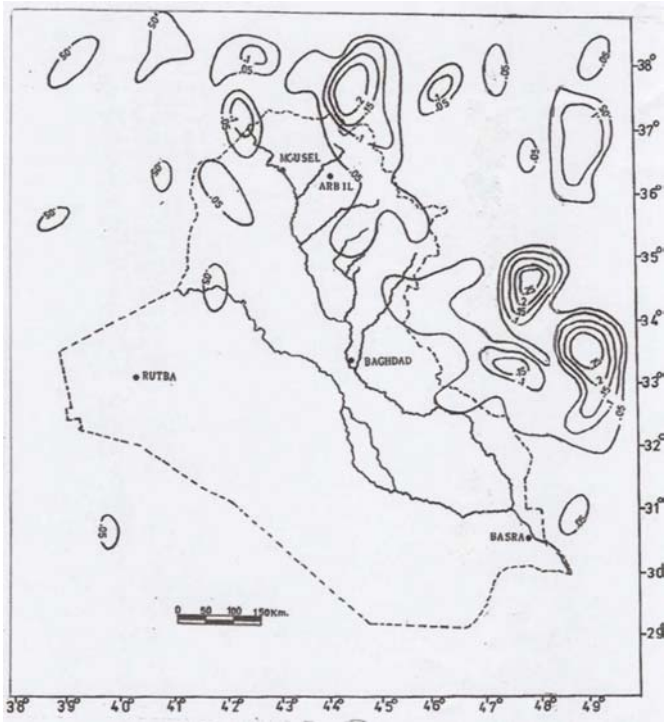

FIGURE7: SEISMIC DESIGNE REGIONALIZATION MAP OF IRAQ WITH EFFECTIVE PEAK ACCELERATION IN % OF g.

9. CONCLUSION

The territory of Iraq, although not directly located on a dense cluster of recent earthquake epicenters; but the geodynamic configurations show a medium to high seismic risk. This will be coupled with the increasing vulnerability of the major highly populated cities .The state of seismological research, seismic monitoring, and seismic hazard awareness have seen better times during the last two decades. It is hoped that the data given in this work would stimulate a more detailed and a state of the art seismic and seismological engineering research on Iraq's seismicity.

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