

SEISMIC ZONING AND OTHER SEISMIC PARAMETERS
CONSIDERATION FOR IRAQ

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SUMMARY

The available data on the macroseismicity of Iraq for the period 1900-1975 was utilized to consider the main seismic parameters for Iraq.

The seismic zoning map for the country is constructed which shows the distribution of seismic intensity between V-IX on the MM scale.

Seismic Risk analysis which includes seismicity index map, quake sensitivity and seismic activity maps are constructed.

Seismic design regionalization map for Iraq is presented with statistical evaluation for the probability of occurrence of seismic intensities.

It is hoped that the present findings will contribute to the efforts to establish a seismic code for Iraq.

Seismicity of Iraq

Iraq has a rather long well-documented history of seismic activity, where 79 events of major and/or minor effect on the community are documented for the period 1260 B.C. through 1900 A.D.

The historical seismicity follows a well-defined pattern and fits with the boundaries of the major tectonic units of Iraq, as well as with the recent seismicity of the country (1).

Iraq is part of the Alpine belt, located at the NE boundary of the Arabian Plate, and is thus marked by a line of epicenters along the Tauroz-Zagros mountain ranges.

The seismic history reveals annual seismic activity of different strength. The northern zone depicts the highest seismic activity with strong diminution of earthquakes in the southern and southwestern parts of the country. A detailed account of the seismicity and seismotectonics are given by (2).

A number of microearthquake studies were carried in various parts of Iraq showing good correlation between micro and macro events, (3)(4). Other seismic field investigations covered investigations of induced seismicity around Mishraq sulphur mine (5) and near Derbendikhan dam area (6).

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New investigations near Hamrin dam area and Mosul dam area are in progress.

In this investigation, a compiled catalogue of earthquake epicenters for the period (1900-1975) is used. It covers (91) event (7). The most important ones are marked in Figure (1).

Seismic Risk Evaluations

(a) Seismicity Index (S_T): It is defined by equation (1)

$$S_T = \frac{\sum_{m \geq x} N(M)}{T} \quad \Delta \leq 100 \text{ km} \quad \dots (1)$$

where: N = number of earthquakes of magnitude $\geq x$;
T = period in years and Δ = epicentral distance.

For this investigation ($x \geq 4$) was chosen and Figure (2) was constructed; from which the following points may be drawn (8):

- (i) The eastern parts of the country have a frequency of occurrence that ranges from (2) to (10) years.
- (ii) Mesopotamian area has a frequency of occurrence of (5-20) years.
- (iii) The southern and southwestern parts has a frequency of occurrence of (≥ 20) years.
- (iv) The frequency of occurrence ranged from 0.05 upto 0.5 (earthquake in the year).

(b) Quake Sensitivity (Q.I): This parameter takes regions which are affected by events occurring in neighbouring areas as given by equation (2).

$$Q.I = \frac{N(I)}{S_T} \quad \dots (2)$$

where: N(I) = annual seismic Intensity ($x \leq 1$); where x is the level of quake sensitivity (9).

It is quite significant for Iraq, and using ($I \geq 2$) the following points are drawn:

- (i) The eastern parts of Iraq has the highest seismicity index, even though it has a low quake sensitivity.
- (ii) Mesopotamia has low seismicity index, but its quake sensitivity is high.
- (iii) The southern and southwestern parts has no major earthquakes during the period 1900-1975, so its seismicity and quake sensitivity are very low.

(c) Seismic Activity (R_{km}): It is expressed in units of ($A=A_{10}$), which corresponds to one earthquake in the magnitude range $K = 10 \pm 0.5$ per 1000 Km^2 area per year (10). The values ($A_{10} = 0.01$) refers to the weak activity, ($A_{10} = 0.1$) as moderate activity and ($A_{10} = 1.0$) as strong

activity.

Seismic activity was computed for (M 4.0) and the following points are outlined:

- (i) The majority of Iraqi territories has a low very low activity (0.001 - 0.01).
- (ii) The eastern parts of Iraq near Iraq-Iran borders has a moderate - low activity (0.01 - 0.1).

Seismic risk evaluation may be used to arrive at the following conclusions:

1. The thrust zone has moderate-low activity, relatively high seismicity index and low quake sensitivity.
2. The folded zone has weak seismic activity, moderate seismicity index and low quake sensitivity (except Mosul and Sinjar).
3. The Un-folded zone has very low activity, moderate-weak seismicity index and high quake sensitivity in mesopotamia.

STATISTICAL STUDY

- (a) Of the ninety one earthquakes compiled for the period (1900-1975), 85% are located east of river Tigris, and 52% are located between longitudes 44° - 46° E and latitudes 35° - 37° N. One event of $M = 3.2$ is located near the Iraq-Kuwait borders.
- (b) Eighty four events of the total number have magnitudes ranging from (4.0-6.0). Seventy nine events out of the total events have epicentral intensities ranging between (III-VIII).
- (c) The examination of the recurrence relations was examined according to the following equations (10, 11).

$$\text{Log } N = 4.189 - 0.576 M \quad \dots(3)$$

$$\text{Log } N = 5.471 - 0.32 K \quad \dots(4)$$

where: $K = \text{Log } E = 4 + 1.8 M$; N = number of earthquakes, and M = magnitude.

- (d) The plotting of time (1900-1975) versus magnitude, epicentral intensity and number of earthquakes; was carried plus the consideration of commulative energy released and time according to (12, 13, 14).
- (e) The probability distribution of the maximum possible intensity was utilized to plott the number of event per one year versus different epicentral intensities and to compare the probability of actual maximum intensity distribution with an exponential case (15).
- (f) The seismicity of Iraq has been estimated according to the compound poisson's distribution (Gumbel distribution) for earthquakes of magnitude ($M = 4.0$), during 1900-1975 (16, 17).

The following conclusions may be drawn from the varians statistical techniques applied:

- (i) The general activity is moderate-low seismic, activity of the country increased after 1960.
- (ii) The numbers of earthquakes of ($I = 5$) and below have not completely recorded for Iraq, and for $I = 6$ and above are in general completely recorded.
- (iii) There is a probability of about 40% for the occurrence of earthquakes with the intensity ($I = 6$). And a high probability for the earthquakes of the intensity ($I=5$) or below
- (iv) There is high probability for earthquake occurrence of magnitude ($M=5.5$) during (25) years and 46% for ($I=7.0$) during (100) years.

Seismological Engineering Considerations

(a) The decrease of the mean seismic intensity with the increase of the epicentral distance indicates the magnitude and earthquake characteristic (18). The relation of the magnitude-epicentral distance-intensity, were constructed for 53 events in Iraq to show the relative effected areas and the frequency of occurrence of different seismic intensities (7).

(b) The annual mean of seismic intensity for the range ($I=2 - I=6$) for the period 1900-1975 were plotted. The frequency of occurrence increased in the eastern and north-eastern parts of the country (7).

(c) The first seismic zoning map for Iraq was published in 1975 (19). It is characterized by the following points:
 (1) The seismicity level is low in the middle and south-southeastern regions of Iraq while northern and north-eastern-eastern regions are characterized by intermediate seismic activity level. (2) Seismic intensity (MM) increases from (V) in the south-southeastern regions up to (IX) in the north and northeastern regions, with (VIII) intensity in Ana area west central Iraq.

(d) In fig (1) five degrees of seismic intensities (I) are present in the Iraqi territory ranging from ($I=5$) in the southern and south western parts and increasing in the north and north east direction of the country to a level of intensity ($I=9$), (in the area located around the position of 44E longitude, 37N latitude). There are few changes from the previous map (19) mainly in Karbala area, Ana area, and around the area defined by (36N, 43E).

(e) The engineering seismic risk is defined as the probability of occurrence of critical (design) earthquake during the design period (17).

Fig. (3) shows the probability of exceedance of earthquakes with (0.05)g during a design period of (50) years. The map is constructed for earthquakes in Iraq during 1900-1975. The homogenous distribution in the eastern and northern parts indicates the high frequency of earthquake occurrence, and vice versa for the remanant parts of Iraq.

(f) A seismic design regionalization map fig. (4) has been constructed according to equation given by (20) relating magnitude with distance and acceleration of gravity. Fig. (4) gives the ground acceleration which is needed for design purposes.

(g) In the eastern parts it has a value of (0.1 g), while in the northern parts (44E, 37N) it has the value of (0.2 g) representing the maximum ground acceleration in Iraq. The probability of exceedance of (0.05 g) during 50 years is about 60% in the eastern and northern parts of the country. There is about 15% possibility for exceedance of (0.1 g) in the locations, (44.5E, 37N), (44E, 36.5N), (44E, 37N) and (43.5E, 37N) for the design period of 50 years.

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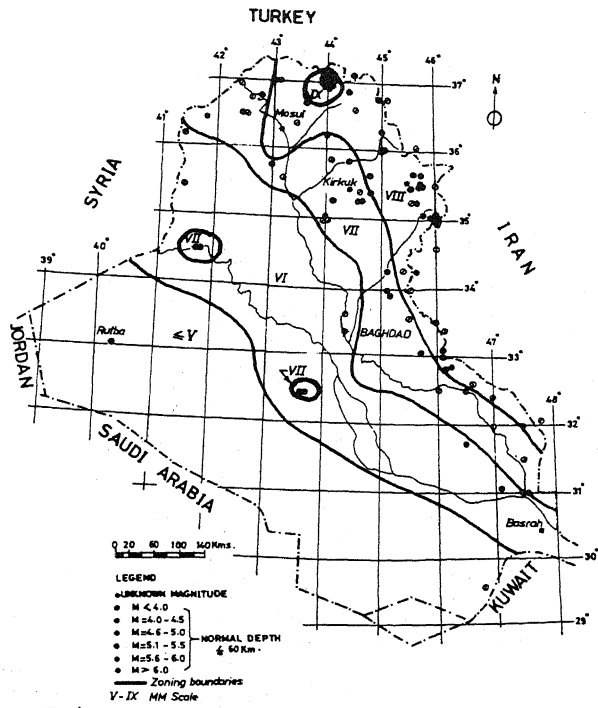


Fig. 1 Seismic zoning map of Iraq with epicentral locations.

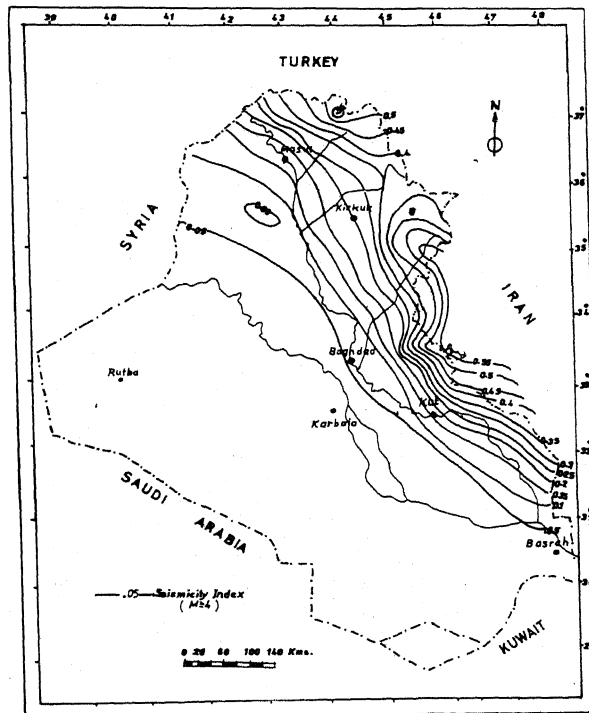


Fig. 2 Seismicity index map of Iraq.

