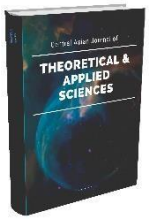

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Seismic Maps in the Iraqi Seismic Codes and their Impact on Buildings

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Abstract: *The seismic maps used in the Iraqi seismic codes have a significant impact on buildings and the way they are analyzed and designed, as they affect the seismic parameters and be an important factor in determining the results and their accuracy due to the seismic analysis's dependence on them. Many seismic maps were issued before 1997, until our study was limited to the period from (1995 to 2020) AD, where the first Iraqi seismic code in this period is the Iraqi seismic code for the year 1997, and it was a map dividing Iraq into four seismic zones, followed by the Iraqi seismic code for the year 2017, which It was in a seismic map that depends on the modern division of the regions, which is considered a map with high coefficients, after which the 2019 edition of the same version was issued (the Iraqi seismic code 2017 edition 2019)which had less coefficients than the previous one, the results showed that the least code affecting the buildings is 1997, followed by the 2019 code, where it was Code 2017 leads in the highest results in impact on buildings*

Keywords: *seismic maps, buildings, Iraqi seismic code, Earthquake.*

I. INTRODUCTION

All over world, there is high demand for the construction of tall buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damages to those tall structures. Reinforced concrete multi-storied buildings are very complex to model as structural systems for analysis. Usually, they are modeled as two-dimensional or three-dimensional frame systems using finite beam elements. Since earthquake forces are random in nature and unpredictable, the engineering tools need

to be sharpened for analyzing structures under the action of these forces. Earthquake loads are required to be carefully modeled so as to assess the real behavior of structure with a clear understanding that damage is expected but it should be regulated. Analyzing the structure for past earthquakes of different intensities and checking for multiple criteria at each level has become essential and pivotal these days."

II. Iraqi Seismic Codes

Iraq seismic code requirements for buildings (ISC1997) [1]

According to ISC 1997, the zoning map of Iraq is four zones; as shown in Fig. (1), Baghdad City is classified as zone I. The total horizontal design seismic force (V) was calculated in accordance with the Iraqi Seismic Code Eq. (1).

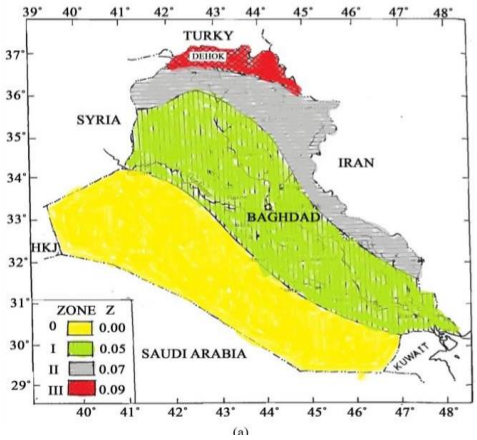


Figure (1) Iraqi seismic zone map (ISC 1997). [1]

the total horizontal seismic design force acting on building and structures shall be determined according to the following formula but shall not be less than (0.02 W):

$$V = Z.\ I.\ S.\ K.\ W \quad (1)$$

V – total unfactored horizontal seismic design forces

Z – seismic hazard zoning coefficient

I - importance factor related to the use of structure

S – dynamic coefficient related to soil category

K – structural system coefficient, specified for various types of structures

W – total weight of the structure, including permanent and probable live load

A- Lateral forces distribution

The total horizontal seismic design force V should be distributed over the height of the building in

accordance with the following formula:

$$Vi = V \frac{Wi\, H_i}{\sum_{j=1}^{n} W_j H_j} \ldots \quad (2)$$

Where:

Vi – horizontal seismic design force in i-th level

Wj, Wi – the weight of i-th and j-th floor

Hj, Hi – the height of i-th and j-th floor from the top of the foundation

N – total number of levels

B- Factors and Coefficients:

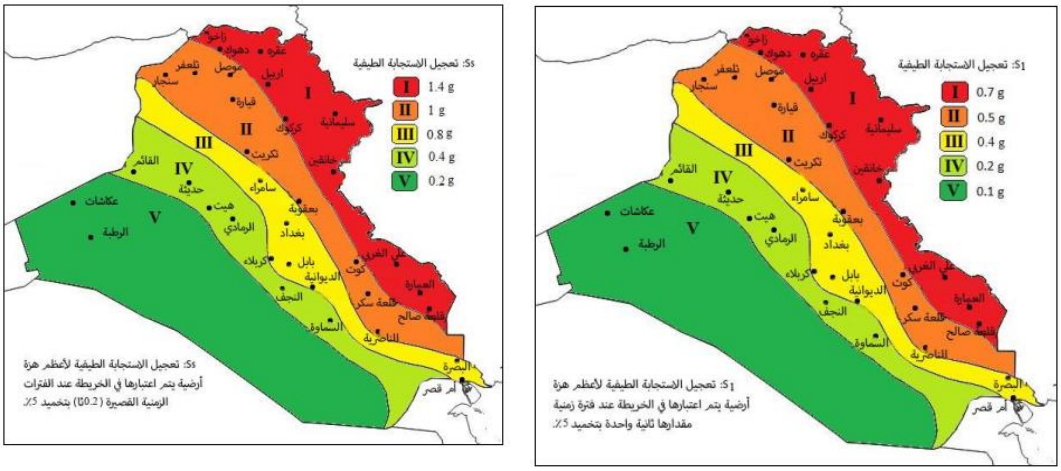
The Structural system coefficient (K) is specified in Iraq seismic code requirements for buildings (1997) Table 3-4, and equal to 1

Importance factor (I) is specified in Iraq seismic code requirements for buildings (1997) Table 3-2, and equal to 1

The seismic hazard and zoning coefficient (Z) specified in Iraq seismic code requirements for buildings (1997) Table 16-I, for zone 2, Z = 0.05

Iraq seismic code (ISC2017) [2]

Iraqi Seismic Code 2017 present the seismic coefficients for all regions of Iraq and the calculation method for calculating the total horizontal design seismic force. Fig. (2-a) shows the Iraqi map of spectral response acceleration at 0.2 sec, and Fig. 2-b shows the Iraqi map of spectral response acceleration at 1 sec. The spectral response, acceleration at 0.2 seconds Ss, and acceleration at 1.0 seconds S1.



A- 0.2 second acceleration (ISC 2017) **B- 1 second acceleration (ISC2017)**

Figure (2) Map showing spectral response acceleration in Iraq (ISC2017)[2].

equivalent lateral force procedure is based on chapter 3, section 3.9 of the Iraq seismic code requirements for buildings (2017)

Seismic Base Shear.

The seismic base shear, V, in a given direction shall be determined by the following equation:

$$V=CsW \quad (3)$$

where

Cs = the seismic response coefficient

W = the effective seismic weight of a structure shall include the total dead load and other loads

seismic response coefficient, C, shall be determined in accordance

with Eq. (4):

$$C=s\frac{S_{Ds}}{(\frac{R}{I})} \quad (4)$$

Where:

SDs= the design spectral response acceleration parameter in the short period range as determined from Section 2.2-4

R = The response modification factor in Table3.2-1.

I = the occupancy importance factor determined by Section 2-3

The value of Cs computed by Eq. (5) need not exceed the following

$$Cs = \frac{S_{DS}}{T\,(\frac{R}{I})} \quad (5)$$

CS shall not be less than the following:

$$CS = 0.044\ SDS\ I \quad (6)$$

where:

S_{D1}=The design spectral response acceleration parameter at a period of 1 sec.

T = The fundamental period of the structure.

For the regular building of five floors or less in height and has a T= 0.5 sec. or less, both values are 1.5g and are used when calculating the seismic response coefficient S1 and S2

Lateral forces distribution

Formulas for determining seismic force at any level (kip or kN) may be found in the following sections:

$$Fx= (Cvx*W) \quad (7)$$

$$C_{vx} = \frac{w_x\ h_k^x}{\sum_{i=1}^{n} w_i\ h_k^i} \quad (8)$$

Where:

$C_{v^{\times}}$ = vertical distribution factor

V = total design lateral force or shear at the base of the structure (kip or KN)

Wĭ and $W^{\times}$= the portion of the total effective seismic weight of the structure (W) located or assigned to Level (ĭ) or (^{x}).

h, and. h, = the height (ft or m) from the base to Level i or x

k. = an exponent related to the structure period as follows:

for structures having a period of 0.50 s or less, k. = 1

for structures having a period of 2.50 s or more, k. = 2

For structures having a period between 0.50 and 2.50 s, k. shall be two or shall be determined by linear interpolation between 1. and 2.

The factors and coefficients can be determined according to Iraq seismic code requirements for buildings (2017). The soil profile type is specified in sections 7-1; for stiff soil profile, use D profile.

The spectral response acceleration parameters SS and S1 are 0.8g and 0.4g, respectively.

The Site Coefficients Fá and Fv are defined in Iraq seismic code requirements for buildings (2017) Tables 2.2-1a and 12.2-1b, respectively, and equal to1.1 and 1.6, respectively.

The response modification factor (R) is specified in Iraq seismic code requirements for buildings (2017) Table 3.2-1, and equal to 5

Occupancy Importance Factor (I) is specified in Iraq seismic code requirements for buildings (2017) Table 2.3-1, and equal to 1

Iraq Seismic Code (2019) [2]

In 2016 and 2017, some Iraqi researchers, in cooperation with Iraqi researchers in the United States of America in the laboratories of the US Department of Energy, compiled and unified them over 116 years (1900-2016) AD.

Therefore, after publishing this research, which contains solid information and a comprehensive seismic catalog for Iraq, the authors of the Iraqi code for the year 2017 updated their map and replaced it in the year 2019, but it is unofficial as it is not published in the Iraqi Ministry of Housing and Construction, considering the latest issue of the Iraqi seismic code is the one that was issued in 2017.

It is an exact copy of the 2017 code; the difference in it is only the seismic map so that it will be taken into account and the study of its impact on multi-story buildings,) figure (3). Table (1) Coefficient Seismic and year.

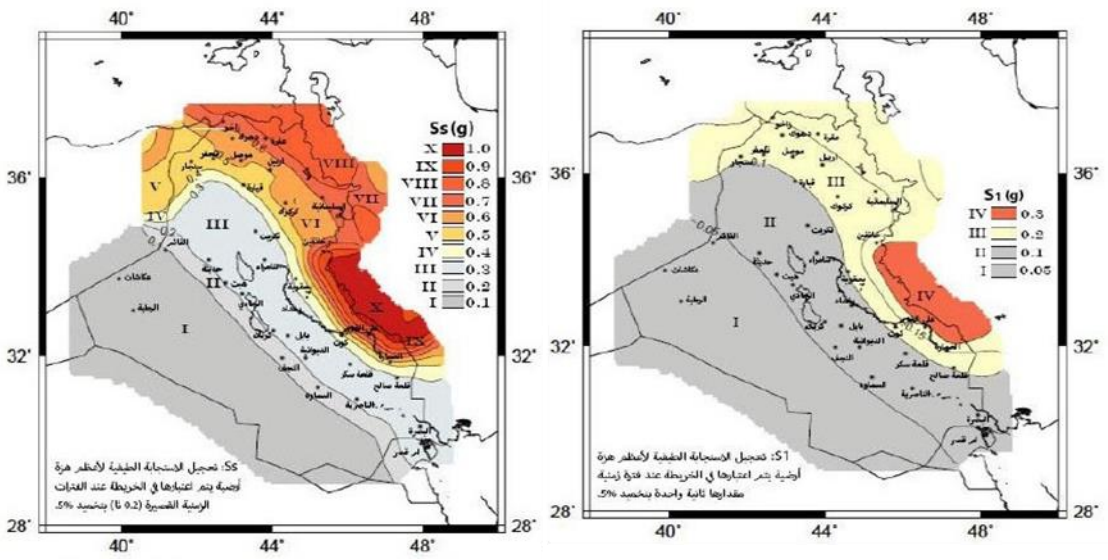


Figure (3) Iraqi Map of spectral response acceleration (ISC2019)[2]

III.Seismic Hazard Maps in Iraq

The most important axis that can have a significant impact on the structural design of structures under the influence of earthquakes is the seismic map adopted by the special code in the design

Most of the old local codes depend on seismic maps that were prepared with the help of devices that are not accurate as at the present time and the development taking place in this field

It is also worth noting that after the year 2003 and the openness that occurred to Iraqi researchers and the comprehensiveness in the tremors of neighboring countries and the whole world. Including Fahmi and Al Abbasi (1989)[3], Which divided Iraq into a zone on oval shapes overlapping with some, which gives two or specific numbers for each studied area, without relying on the tectonic borders in Iraq, Also, if you relied on your CATALOG, it contains only a thousand earthquakes

(Tuna Onur et al., 2016) [4]They compiled an earthquake catalog for Iraq containing 28,000 earthquakes from the year 1900 to 2010 and it was working with the seismic moment magnitude system (MW). Which gives a value for the energy released from the earthquake, which is very accurate and was comprehensive for all tremors, which is based on a compilation of several global and local indexes, including (International Seismology) (ISC), and the regional (ESE) and the Iraqi Seismic Network (ISN), which by means of which a new and modern seismic map was issued (the latest so far) for Iraq,

Active faults were relied upon, the most important of which is the Mandali - Badra Al-Amarah fault, which extends from the city of Al-Kut to the city of Al-Tayeb in Al-Amarah.

They divided Iraq into 12 seismic zones. This map will be adopted as it is the latest and will also be compared with the codes in our study and find the differences between them and the old maps, Figure (4) shows the distribution of the earthquakes that occurred in Iraq from 1995 to 2020, Which was collected by us from the Iraqi seismic monitoring center of the Meteorological Authority (Figure (5).

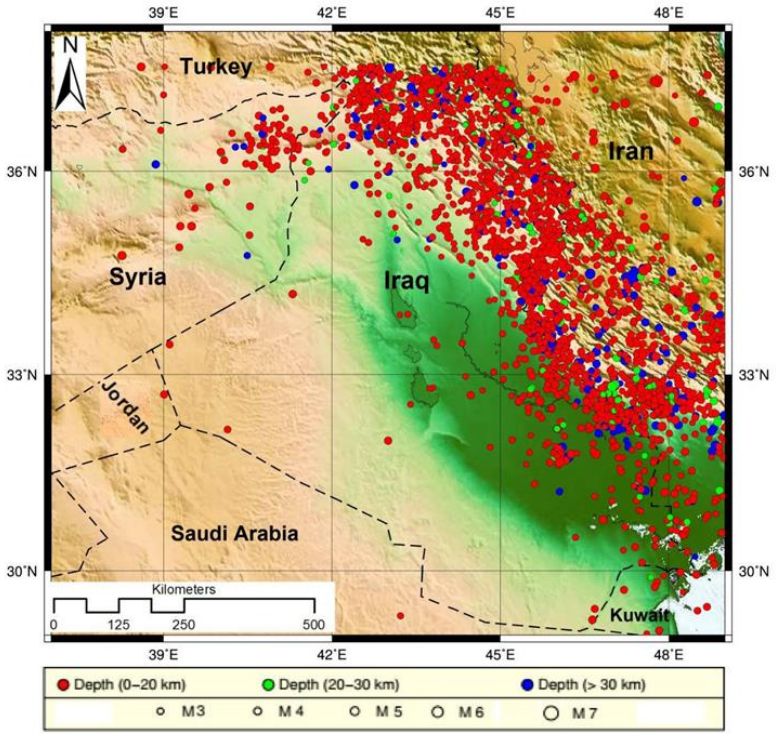


Figure (4) shows the distribution of earthquakes that occurred in Iraq from 1995 to 2020

the detailed seismic information that was drawn on the seismic map of Iraq is explained in (figure 4) and as stated in the graph shown below (Figure 5), which cannot be organized in a table because of its large number (4362).

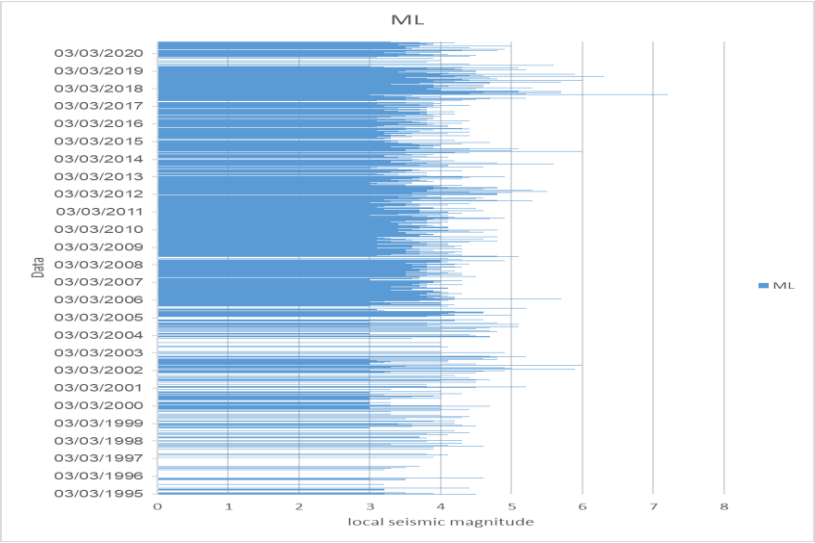


Figure (5) seismic information that was drawn on the seismic map of Iraq

Table (1) Coefficient Seismic and year

No.	Code	Year	Seismic coefficient
1	Iraqi Seismic code	1997	Z= 0.05
2	Iraqi Seismic code	2017	S_s= 0.6 , S_1=0.2
3	New Map Iraqi	2019	S_s=0.3 , S_1= 0.1

IV. General Description of the Test Building

The reinforced concrete building with 10 floors and the dimensions of floors are 20x30 m. The thickness of the slabs is 0.2m. All the supports of structures are fixed. The dimensions of the beams are 0.4x0.6 m. The height of the ground floor is 4.6m and all the other floors have a height of 3.6m. The studied buildings were analyzed with structural system (columns), Modeling and analysis of the structure are done on ETABS software

Beam size =600(mm)*400 (mm)

Column size =600(mm)*800 (mm)

Slab = 200 mm

Beam length and column c/c spacing =5m

Duplicate Story height = 3.6m

Ground story height = 4.6m

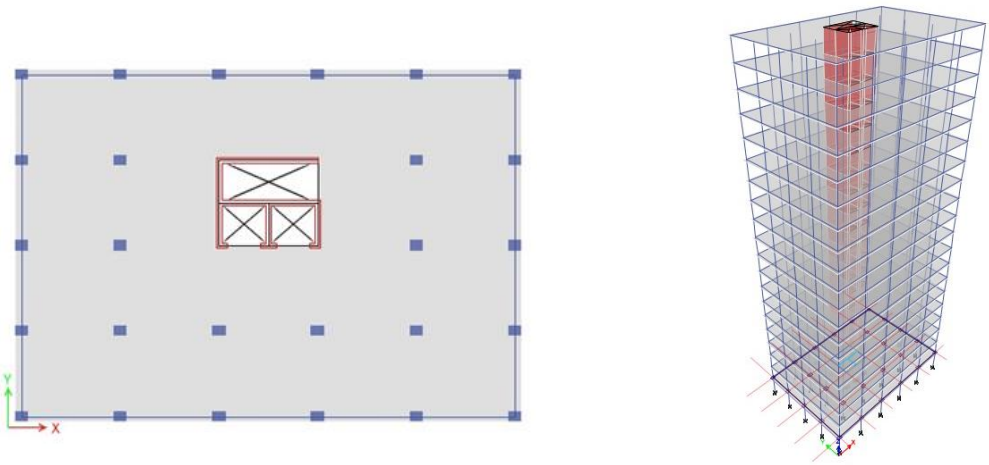


Figure (6) 3D Model in ETABS Program [5]

V. Results

Lateral forces distribution

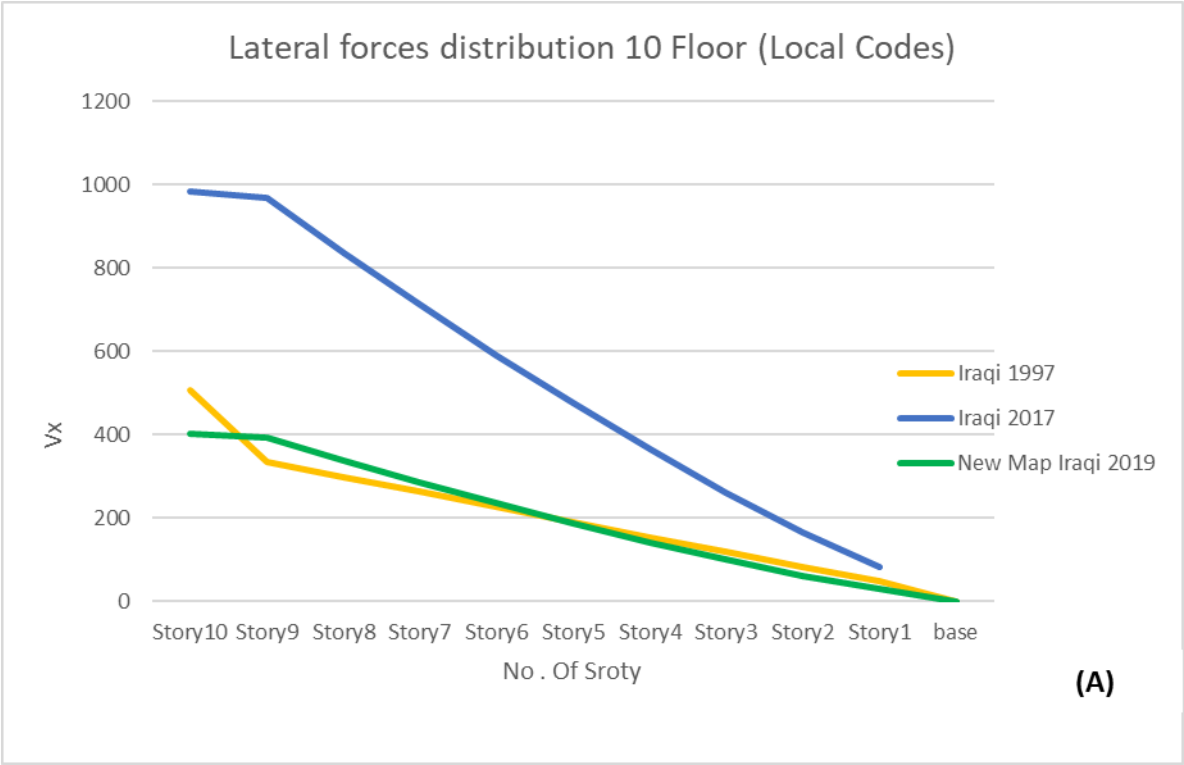


Figure (7) Lateral forces distribution for (10 floors 34 m) a structural system consisting of columns Iraqi code

When applying seismic forces to the studied structure according to the three selected codes, its noted that the code 2017 in blue color is the highest number up to (980 KN) at the top of the tenth floor, while the result in the code 2019 was (410 KN), and the code 1997 was (550 KN), and this is a large discrepancy in the results that must be taken into account

CONCLUTION

When discussing the results in general, we should praise the latest Iraqi code for the year 2019, which simulates reality and applies what was stated in the earthquake distribution in the form Figure (5) taken from the Iraqi government seismic monitoring center, where it can be noted that the Iraqi code for the year 2017 was twice as much as the other codes, the results of the code came 2019 (40%) and the 1997 code (56%) of the Iraqi code issued in 2017. This difference in results is due to the different seismic coefficients in the seismic maps, which are indicated in Table 1.

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