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Research paper

Halabjah-Iraq Earthquake, Comparisons and General Review

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Abstract

The collapsed seismic force level depends on region nature where the construction is to be built because of an earthquake released an energy which generated by a sudden randomly movement of earth segments (plate tectonics). Structure geographic location plays a major role in seismic analysis and design of structures because of the global seismicity influenced by the earthquake hypocenter and plate tectonics nature. An earthquake will occur if earth tectonic plate shaft and the mass of earth materials moved with plates stress interface and energy released because of ground vibration which its amplitude reduced with rupture distance. Also the earth vibration generates a large random inertia force that should carried by the structural components safety. In the present study, a comparisons of Halabjah-Iraq Earthquake with many world earthquake is investigated, generally Halabjah earthquake classified as medium risk earthquake

Keywords: *earthquake data compassions; Halabja earthquake; seismic; roh charts; response spectrum.*

1. Introduction

Every year seismic damage building structures around the world and collapse happened due to dynamic loads. The dynamic load can be defined as a load that its value varies with time, therefore, the load, displacements, and many other parameters can be represented mathematically as a function to time. The study of structure responses resulted from these dynamic forces named structure dynamics. Static force happened if the time considered as constant or, when the loads very slowly applied that resulted in a response identical to a static load. When the load applied with high frequency, such load case can be considered as a cyclic load while if the load applied with a low frequency such load can be considered as a repeated load.
Waves and ruptures due to earthquakes was studied by Moczo, P., et- al (2014)[1], using numerical simulation by finite-difference modeling. The authors dealt with a mathematical-physical model of ground motion by derive and solve the ground governing equation of motion. The constitutive law was considered for elastic and viscoelastic continuum, and a various types of earthquake sources were investigated. The part two of the study explained the use of finite-difference (FD) method to solve the time-domain problems numerically. The use of finite element (FE) and hybrid FD –FE methods to get the solutions of ground motion were explained in part three, while part four explained the idea of earthquake motion modeling at real sites using the FD method.
Fundamentals of earthquake engineering were explained in details by Chen, W., and Scawthorn, C., (2003) [2], the authors deal with the seismogenesis, measurement, and distribution of earthquakes. Investigation of the models and simulations of strong ground motion information, and seismic hazard analysis were presented. Statement of the problem of soil-structure interaction analysis and response was illustrated. Historical developments of building code provisions for seismic resistance of steel, concrete, precast and tilt-up buildings, wood, and masonry structures discussed with many other spatial topics were introduced and illustrated.
Structures seismic analysis was explained by Datta, T., (2010) [3]. The author introduced a study of seismology and seismic information input of structures. The response analysis for ground motion as SDOF and MDOF were illustrated. Also, the spectral analysis using frequency domain with method of spectrum analysis for elastic and inelastic response was discussed in details. Other topics were deal like soil-structures interaction under seismic loads, seismic reliability and seismic control of structures.
Chopra, A., (2007) [4] published a textbook illustrated a theoretical dynamics of structures with engineering earthquake applications. The textbook deals with SDOF system as a problem and its solution method. The response to harmonic and arbitrary motions with various excitation type was present. Also the earthquake response of elastic and inelastic systems was explained. In addition, the textbook contained the derivation and solution equations of motion of the theoretical MDOF system, free vibration, damping of structures, linear elastic response, and dynamic analysis of structures. Other topics such as linear elastic earthquake analysis, a structural system with distributed mass and elasticity, and analysis of multistory buildings under the effects of earthquake response were investigated.
Bangash, M., (2011) [5] explained in a published reference dynamic analysis, numerical computations, codified methods, case studies and examples of earthquake resistant buildings. The author deals with an introduction to earthquake with explanatory data. Earthquake design codes with and without seismic devices were discussed. Basic structural dynamics analysis with illustrated examples of framed buildings under various loading and boundary conditions was explained. Furthermore, the reference presented illustrations of response spectra analysis with codes design examples, finite element analysis (FEA) of structures under dynamic loads with numerical solution methods of dynamic equilibrium

equations and advance incremental nonlinear response of multi-degree of freedom systems. In addition, modeling methods of soil structure interaction under dynamic loads, case studies of controlled buildings response, structure seismic design requirements and seismic criteria with illustrated design examples based on American code, structure elements design according to Eurocode 8 specifications, in addition of seismic analysis of adjacent buildings (induced collision, pounding, and pushover) were included.

Iraq earthquake code (2014) [6] essentially considered the seismic engineering conditions to avoid human loss and reduce structures damage by keeping it in a safe state away from failure. The specification depends on contours plans to calculate Iraqi seismic coefficients. Many sciences developments in seismic topics considered preventing structures collapse due to the earthquake.

2. Comparison of Halabjah earthquake with historical world earthquakes.

Said, A., (2010) [7] developed analysis method of linear elastic response spectrum of Baghdad city in Iraq using scaling fit depends on PGA of Baghdad city and comparison concept with El Centro earthquake (California-USA) to prepare response spectrum acceleration (RSA). The calculated scaling factor was 0.75 between Zones 3 and 4 for Baghdad and California respectively (UBC-1997). The estimated PGA for Baghdad city was 0.24g corresponding to that time. The calculated PGA of Baghdad city was approximately agreed with researcher-calculated data.

In bellow, a review of some earthquakes happened around the world were graphed and compared in brief with Halabjah-Iraq (34.911°N, 45.959°E) earthquake (19 km depth) using Seismosoft computer programs (http://www.seismosoft.com/) [8].

Table 1: Compared Earthquakes

No.	Country	Earthquake	Date
1	Iraq	Halabjah	12-November-2017
2	Taiwan	Chi-Chi	20-September-1999
3	Italy	Friuli	6-May-1976
4	USA	Hollister	9-April-1961
5	USA	Imperial Valley	15-October-1979
6	Japan	Kobe	16-January-1995
7	Turkey	Kocaeli	17-August-1999
8	USA	Landers	28-June-1992
9	USA	Loma Prieta	18-October-1989
10	USA	Northridge	17-January-1994
11	USA	Trinidad	24-August-1983

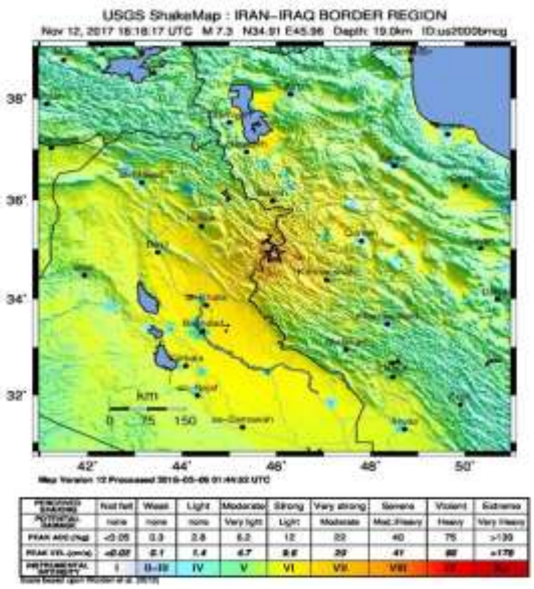

Fig. 1: Shake-Map intensity of Halapjah earthquake (https://earthquake.usgs.gov) [9]

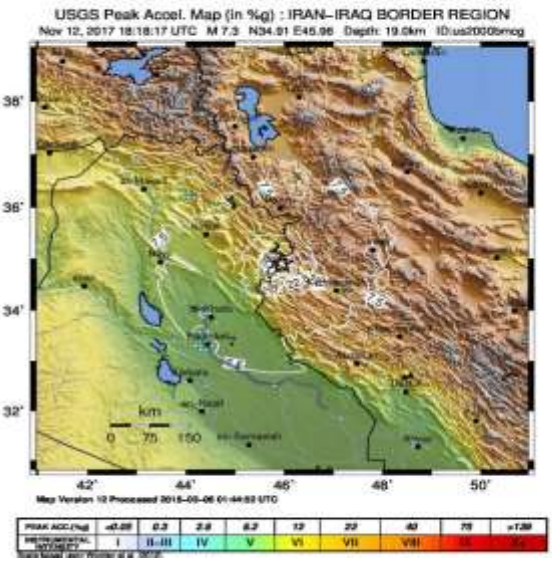

Fig. 2: Peak acceleration map of Halapjah earthquake (https://earthquake.usgs.gov) [9]

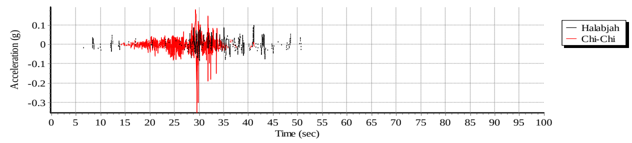

Fig. 3: Roh chart of Halabjah and Chi-Chi earthquake

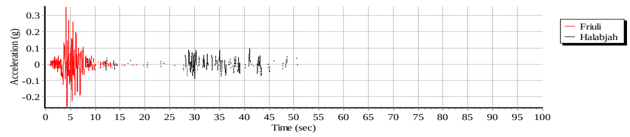

Fig. 4: Roh chart of Halabjah and Friuli earthquake

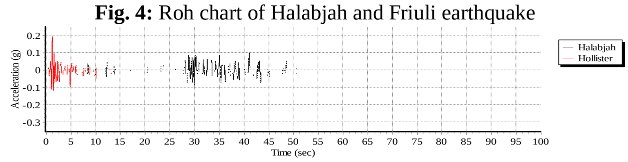

Fig. 5: Roh chart of Halabjah and Hollister earthquake

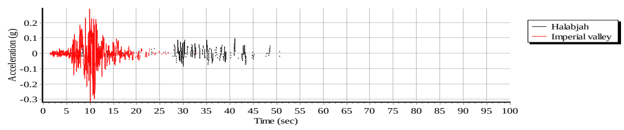

Fig. 6: Roh chart of Halabjah and Imperial Valley earthquake

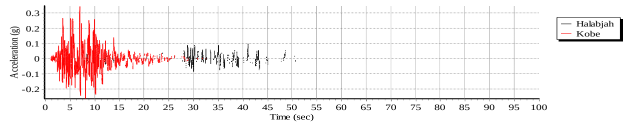

Fig. 7: Roh chart of Halabjah and Kobe earthquake

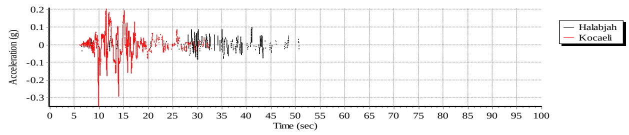

Fig. 8: Roh chart of Halabjah and Kocaeli earthquake

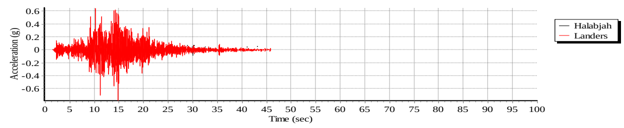

Fig. 9: Roh chart of Halabjah and Landers earthquake

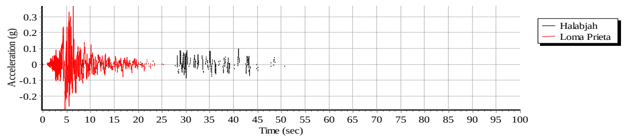

Fig. 10: Roh chart of Halabjah and Loma Prieta earthquake

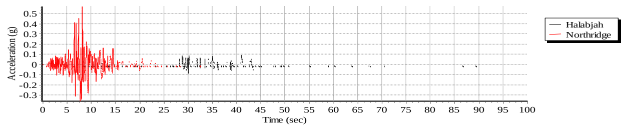

Fig. 11: Roh chart of Halabjah and Northridge earthquake

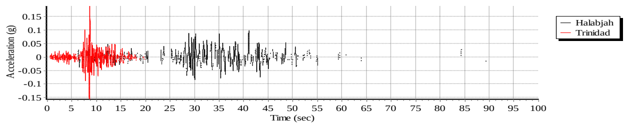

Fig. 12: Roh chart of Halabjah and Trinidad earthquake

Many seismic load sources spatially earthquake loads can be represented by spectral analysis, the response spectrum method used particularly in earthquake engineering because the designer needs the largest response values of acceleration, displacement, or any other dynamic related parameters as a function to natural period or frequency with constant damping ratio to predicate member displacements and forces under seismic effects.

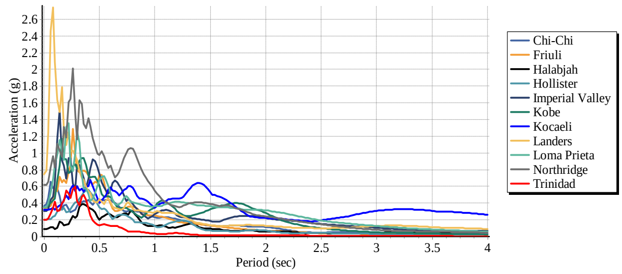

Fig.13: Elastic acceleration response spectrum (Damping 5%) (http://www.seismosoft.com/) [8]

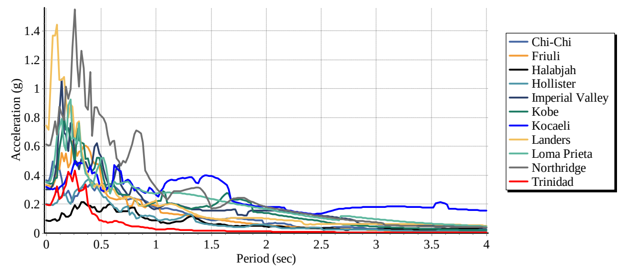

Fig. 14: Inelastic ductile acceleration response spectrum (Damping 5% and ductility factor 1.5) (http://www.seismosoft.com/) [8]

3. Conclusions

By depending on data analysis using seismosoft software [8] (see table 2) and previously mentioned graphs, many remarks can be concluded such as:

- With peak acceleration 0.1g, Halabjah earthquake can be classified as medium risk earthquake.
- It is required to re-update the Iraqi seismic specifications.
- By referring to figures 13 and 14, response spectrum is required to be considered in the building design with (Sa) elastic equal 0.4 g and (Sa) inelastic equal 0.2 g for Baghdad city.
- In Iraq, designers must consider the seismic risk when in the design of buildings because Iraq is located in the Arab seismic tectonic, and the Asian seismic tectonic shafted toward Iraq.

Table 2: Compared earthquakes ground motion parameters

ACCELOGRAME	Halabjah	Chi-Chi	Friuli	Hollister	Imperial Valley	Kobe	Kocaeli	Landers	Loma Prieta	Northridge	Trinidad
Max Acceleration (g)	0.0966	0.36579	0.33279	0.20025	0.30492	0.35216	0.31769	0.74378	0.35131	0.61492	0.19783
Max Velocity (cm/sec)	13.90713	30.96711	24.03628	11.65124	28.02406	28.76710	56.65539	38.34524	38.71087	52.75274	9.15454
Max Displacement (cm)	7.53155	11.47179	4.43841	3.61973	10.02258	7.62300	42.78952	13.04648	13.81016	12.77340	0.85076
Vmax/Amax (sec)	0.16368	0.08630	0.07363	0.05931	0.09368	0.08327	0.18179	0.05255	0.11232	0.08745	0.04717
Acceleration RMS (g)	0.01507	0.02103	0.03734	0.02046	0.04558	0.05175	0.04945	0.09051	0.04673	0.06668	0.02274
Velocity RMS (cm/sec)	3.28764	3.26160	2.87364	2.72659	6.37251	6.28909	16.43434	4.99786	6.74640	7.25526	1.26620
Displacement RMS (cm)	2.59500	3.10051	0.76695	1.10267	4.49871	2.18036	11.80609	2.71611	2.75337	2.15359	0.19880
Arias Intensity (m/sec)	0.34952	0.35967	0.78046	0.25773	1.26416	1.68815	1.31775	6.07183	1.34276	2.73288	0.17053
Characteristic Intensity	0.01849	0.02215	0.04349	0.01850	0.06115	0.07529	0.06503	0.18885	0.06381	0.10874	0.01586
Specific Energy Density (cm2/sec)	1079.77367	561.58345	300.00635	296.92581	1603.64235	1618.09697	9444.96253	1201.47144	1816.45989	2099.76183	34.32606
Cum. Abs. Velocity (cm/sec)	988.27698	489.76588	557.95910	460.11796	897.60297	1152.10649	989.18857	2350.82259	934.66041	1300.48742	281.84253
Acc Spectrum Intensity (g*sec)	0.09914	0.16030	0.30035	0.16254	0.33672	0.32595	0.20600	0.37605	0.33823	0.52496	0.15433
Vel Spectrum Intensity (cm)	48.86697	78.91635	90.18710	55.28086	138.33491	153.16032	172.08936	111.78740	169.58661	205.45663	28.59039
Housner Intensity (cm)	48.32383	73.55659	73.63213	51.44520	125.57205	142.10023	169.56935	92.81710	166.74262	187.91691	18.12946

Sustained Max.Acceleration (g)	0.08283	0.17746	0.25016	0.07589	0.29408	0.28229	0.20470	0.63811	0.32644	0.40832	0.07267
Sustained Max.Velocity (cm/sec)	9.56834	11.55056	15.59905	8.92844	24.37633	23.66189	49.28244	25.72909	32.77552	38.37810	3.76961
Effective Design Acceleration (g)	0.08814	0.26034	0.31517	0.20185	0.32137	0.33662	0.30101	0.48539	0.37379	0.63691	0.18260
A95 parameter (g)	0.08419	0.36487	0.32860	0.19874	0.30109	0.34414	0.31046	0.73065	0.34689	0.60718	0.19634
Predominant Period (sec)	0.34000	0.06000	0.26000	0.40000	0.14000	0.16000	0.42000	0.08000	0.22000	0.26000	0.28000
Significant Duration (sec)	62.99000	11.95000	4.14000	16.52000	9.20000	12.87000	15.87000	13.58000	11.31000	9.07000	7.80000

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