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Estimation of Seismic Parameters and Shear Waves Velocity from SPT for the Site of Construction Project of Multi Stories Building in Holy Karbala City-Iraq

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Abstract: Shear wave velocity is an important parameter with respect to geophysical investigation, site classification and microzonation studies. Standard penetration test is very important test in geotechnical works and it spread in all the world. This study had been carried to calculate of shear wave from SPT test for site of construction project of multi stories building in Sacred Karbala Center in Alsadiyah District, Holy Karbala, Iraq. Research methods included field, laboratory and office works. Soil section show sandy soil layers with values of N range between (26) to (50/2"). The value of shear wave velocity calculated as (396 m/sec).

Key words: Standard penetration test, soil, shear wave velocity, methods, Karbala, project

INTRODUCTION

Estimation of seismic parameters for the sites of different projects in Iraq is very important in the last years because of many earthquakes effected of the large areas from Iraq with values range between (5.4-7.3) on Richter scale. However, the soil investigation described in this report consists of drilling the boreholes, securing representative samples, testing these samples and analyzing the soil properties and calculate shear wave velocity in studied site. Ohta and Goto (1978) were the first to correlate Vs to N-value, depth, geologic age and soil type. They developed different empirical Vs correlation equations considering these four index properties worldwide, Hanumantharao and Ramana (2008) had measured shear wave velocity using multi channel analysis of surface wave for 80 site to a depth range between of 20-32 m. And correlations Vs with N value. For Ganga Basin, Maheshwari *et al*. (2013) calculated MASW and SPT for soil in two sites. Many studies developed correlations between Vs and N and these studies take in consideration the geological age and the soil types. Jafari *et al*. (2002) studied correlations for Tehran., another studies were done by Seed HB, (Idriss and Boulanger, 2008) which correlated between (Vs) and (N) using uncorrected (N) values In USA and Taiwan.

Study area: This study will discus the seismic parameters of Karbala city which represent a very important Holy city around the world and millions of peoples visit this city every year and the study area represent a very important district in this city because large numbers of hotels and tourism apartments located in this site.

This study was carried in site of multi stories building in Sacred Karbala Center in Alsadiyah District, Karbala, Iraq. In general, the site is regular area, the area of the land about (300) m^2 as shown in Fig. 1 and 2.

The geological history: The proposed site in Sacred Karbala City which is located on the boundary separate between stable shelf (Al-Salman tectonic zone) and unstable shelf (Mesopotamian zone) and the stratigraphy of Karbala Province characterized by sedimentary rocks from tertiary and quaternary and its included Injana and Dibdiba formations and quaternary deposites. While the surface of the ground in the city of Karbala and nearby areas featuring quaternary sediments consisting of sand, silt and clay and sometimes some gravel. The eastern and northern parts of the city located over the quaternary sediments either western parts located above the sandy sediments Dibdiba.

Fig. 1: Explain the site flatness and boreholes locations

Fig. 2: The drilling machine which was used in boreholes drilling

Site exploration

Drilling and sampling: Drilling was done by using drilling machine provided with wash rotary drilling method according to the requirements of the specification (ASTM D 1452-03) (ASTM, 2003) for boreholes and (Disturb Samples) (DS) and (Split Spoon) (SS) samples were obtained from standard split spoon while (US) didn't obtained by Shelby tubes due to nature of soil is friable.

Number of boreholes: Two boring points were assigned by our representative and located by surveying team in the site which are shown in Fig. 1. The No. of each borehole with it is depths as shown in Table 1.

Field testing (S.P.T): Penetration resistance of the underground strata in drilled boreholes, obtained by S.P.T according to (). The corrected N can be estimated by using (McGregor and Duncan, 1998) and are referred to (0.7) value of N recorded and represents the standard penetration resistance N 60 according to Eq. 1 (Table 1-6):

$$N60 = \left(N^{*}{}_{\eta H}{}^{*}{}_{\eta B}{}^{*}{}_{\eta S}{}^{*}{}_{\eta R}\right)/60 \quad (1)$$

Where:

N = Measured SPT blow countered

η_H = Hammer efficiency (%)

η_B = Correction for borehole diameter

η_S = Sampler correction

η_R = Correction for rod length

Table 1: Boreholes depths

BH	Depth (m)
BH (1, 2)	30

Table 2: The correction factors for standard penetration (Variation of η_H)

Country	Hammer type	Hammer release	η_H (%)
Japan	Donut	Free fall	78
	Donut	Rope and pulley	67
United States	Safety	Rope and pulley	60
	Donut	Rope and pulley	45
Argentina	Donut	Rope and pulley	45
China	Donut	Free fall	60
	Donut	Rope and pulley	50

Table 3: Variation of η_B

Diameter		
mm	in.	η_B
60-120	2.4-4.7	1
150	6	1.05
200	8	1.15

Table 4: Variation of η_S

Variables	η_S
Standard sampler	1.0
With liner for dense sand and clay	0.8
With liner for loose sand	0.9

Table 5: Variation of η_R

Road length		
m	ft	η_R
>10	>30	1.00
6-10	20-30	0.95
4-6	12-20	0.85
0-4	0-12	0.75

Table 6: Relative density of sand according to results of standard penetration text

SPT N-values	Relative density
0-4	Very loose
4-10	Loose
10-30	Medium
30-50	Dense
Over 50	Very dense

Table 7: Soil lab test

Class	Lab. test	Standard specification
Classification and physical properties	Moisture content and density	ASTM D2216
	Liquid and plastic limits	ASTM D 4318
	Sieve analysis	ASTM D(422)
	Sieve analysis and hydrometer	
	S.G.	ASTM D(854)
Strength tests	Direct shear test	ASTM D 3080
Chemical tests	Sulphate content, gypsum content, organic matter and Total Soluble Salts (TSS)	BS 1377:1990 part 3 and earth manual

Laboratory works: In general, different laboratory tests were carried out on samples as and these testes illustrated in Table 7.

Ubsurface stratification: According to the test results and soil profiles as shown in Fig. 3 and by adopting unified soil classification system and textural classification obtained from two boreholes. The stratification of layers was described independently for each borehole according to the test results and summerized: the upper layers of soil in the project site which extended to depth 1.0 m. Below the ground surface consist from fill materials of compacted layers of boulders and subbase with pieces of broken bricks and various stone fragment, these layers overlaying dark gay SILT layer overlaying medium light yellow poorly graded SAND with silt layers overlaying very dense light yellow well graded SAND with silt layers overlaying very dense light yellow well graded SAND with gravel layers overlaying dense light yellow silty SAND layers which contain slightly gypsum and soluble salts (T.S.S) overlaying very dense light yellow poorly graded SAND with silt layers overlaying very dense dark gray poorly graded SAND with silt layers which extended down to end of drilling at (30.0) m details of soil stratification for the boreholes are shown in the "Bore logs" appended.

Underground water table: The underground water table was (1.0) m (BSI and BSIS, 1990) after the drilling termination at the time of insitu investigation in january 2018, the WTL may be fluctuated due to effects of construction in the future.

RESULTS AND DISSCUSSION

Field tests (standard penetration test): Standard penetration test were conducted at different depths for soil samples. From SPT test results obtained for all boreholes as shown in Fig. 3-5, N recorded values were range between (26-50/2") blow while the N corrected values were range between (20-105) blow which indicated in non-cohessive layers as medium to very dense in granular soil as shown in Fig. 3.

Laboratory tests results: The summary of laboratory tests results was concluded in the Table 8 and 9 as the next.

Site seismic parameters: Peak Ground Acceleration (PGA) is equal to the maximum ground acceleration that occurred during earthquake shaking at a location. PGA is also known as an intensity measure for earthquake engineering (Moss *et al*., 2006).

During 2014, the committee under the auspices of Lawrence Liver Rmore National Laboratory in USA and presence with concerned authority representatives from Iraq was studying the Probabilistic Seismic Hazard Assessments (PSHA) form the basis for most

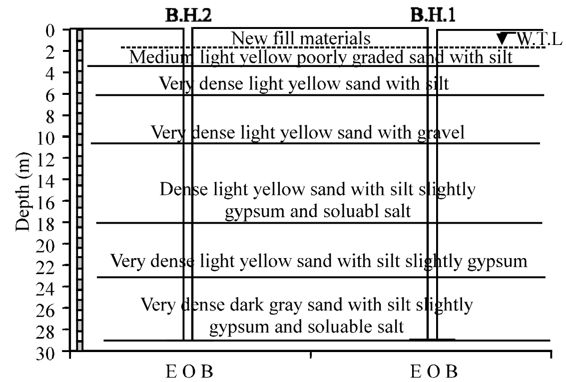

Fig. 3: For soil stratification in the site

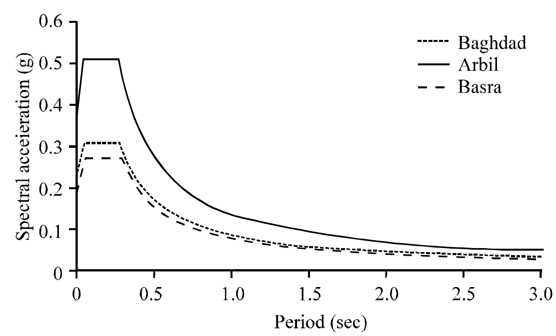

Fig. 4: Design spectra for selected cities

contemporary seismic provisions in building codes around the world. The current building code of Iraq was published in 1997.

An update to this edition is in the process of being released, however, there are no national Probabilistic Seismic Hazard Assessments (PSHA) studies in Iraq for the new building code to refer to for seismic loading in terms of spectral accelerations. Then the ground motions ere calculated for 10% chance of being exceeded in 50 years, the results in Iraq are presented in hazard maps of PGA.

Design spectra for selected cities Arbil, Baghdad and Basrah as constructed according to the provisions in the draft building code of Iraq are plotted in Fig. 4. Based on (Iraqi Seismic Code/97), the study area found in zone I, zone I assimilate east middle parts in Iraq. Last four years show great changes in seismic zones (Fig. 5). And it recommend to use UBC code for seismic analysis and take into account to the soil types and field tests results.

With regards to shear wave Velocities (Vs), various researchs have considered different empirical correlations between N_{spt} and Vs based on soil type and geological age of the deposits. A correlation by Bolton (1985) can be considered as follows:

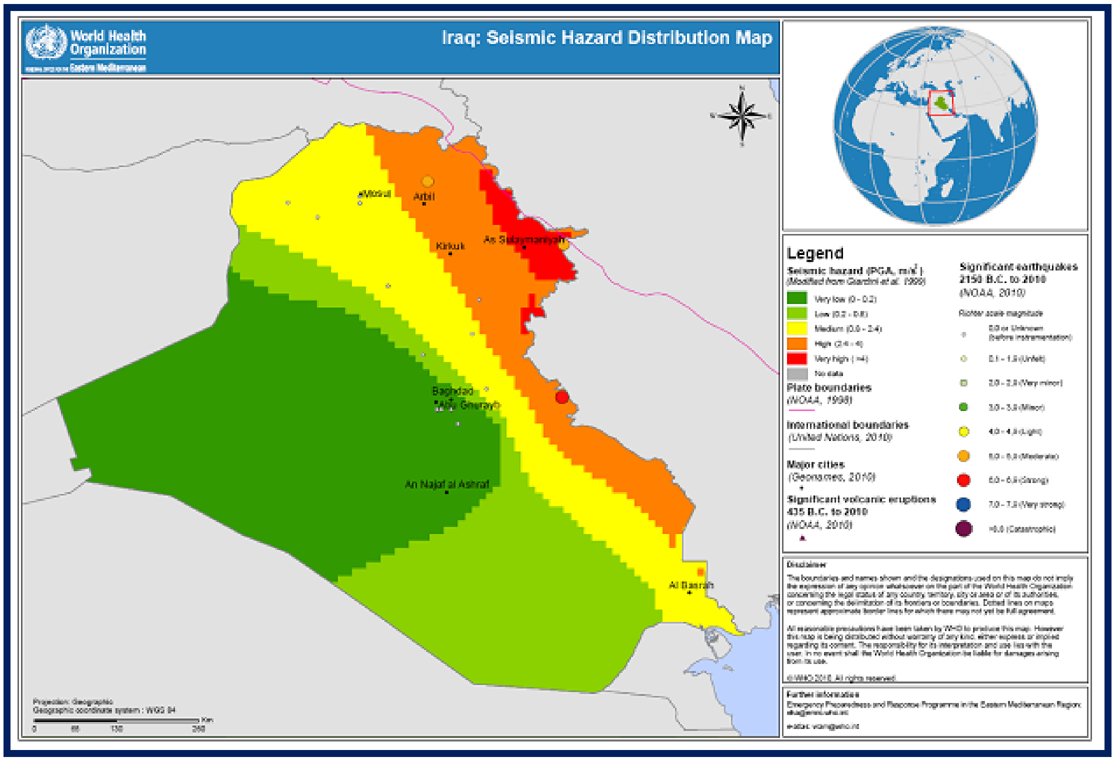

Fig. 5: Seismic hazard distribution on map of Iraq (WHO, 2010)

Table 8: Laboratory tests results for BH1

Hemical tests				Strength tests					Index properties			Location of specimen		
OM	TSS	SO_3	Sieve analysis passing No. 200	Cohesion (kPa)	Friction angle	Unconfined compressionk (kPa)	Specific gravity	Bulk density (g/cm^3)	PI (%)	PL (%)	LL (%)	Sample type	Depth (m)	SampleNo.
0.03	8.4	3.5	6	0	29	--	2.65	1.75	--	--	--	SS	1.5	1
0.03	8.3	3.4	7	0	39	--		1.98				SS	3.0	2
			3	0	41	--	2.65		--	--	--	DS	4.5	3
0.08	7.2	2.9	4				2.65	2.11				SS	6.0	4
			2	0	38	--			--	--	--	DS	7.5	5
							2.65	2.15				SS	9.0	6
0.06	11.5	4.7	8	0	38	--			--	--	--	DS	10.5	7
			9				2.65					SS	12.0	8
				0	36	--			--	--	--	DS	13.5	9
0.08	8.8	3.6	6				2.65					SS	15.0	10
			6	0	36	--			--	--	--	DS	16.5	11
0.03	9.1	3.8	7				2.65					SS	18.0	12
				0	40	--			--	--	--	DS	19.5	13
			6				2.65					SS	21.0	14
0.03	10.2	4.1	3	0	37	--			--	--	--	DS	22.5	15
							2.65					SS	24.0	16
			8	0	36	--			--	--	--	DS	25.5	17
							2.65					SS	27.0	18

$$V_s = 56N_{spt}^{0.5} \text{ (m/sec)} \quad (2)$$

Where:

N_{spt} = Average blows for 30 meter's depth ≥50 blow

Vs = $56*(50)^{0.5}$

Vs = 396 m/sec

Based on seismic activity according to Iraqi seismic code requirements for building code (Anonymous, 1997) Karbala city under zone I with seismic zone factor (Z) = 0.05 as define by ICBO, (1997), UBC (1997). Considering the shear wave velocity equal to 396 m/sec. The soil profile type can be defined as S_c. According to Tables 11

Table 9: Laboratory tests results for BH_2

Chemical tests				Strength tests					Index properties			Location of specimen		
OM	TSS	So_3	Sieve analysis passing No. 200	Cohesion (kPa)	Friction angle	Unconfined compressionk (kPa)	Specific gravity	Bulk density (g/cm^3)	PI (%)	PL (%)	LL (%)	Sample type	Depth (m)	SampleNo.
0.08	3.2	1.2	9	0	26	--	2.65	1.73	--	--	--	SS	1.5	1
0.05	3.2	1.3	4	0	45	--						DS	3	2
			3				2.65	2.05	--	--	--	SS	4.5	3
0.03	7.5	3.2		0	41	--						DS	6	4
			3				2.65	2.13	--	--	--	SS	7.5	5
0.05	91.0	3.7	4	0	39	--						DS	9	6
			13				2.65	2.15	--	--	--	DS	10.5	7
0.1	9.0	3.6	14									SS	12	8
				0	38	--	2.65		--	--	--	DS	13.5	9
			14									SS	15	10
			9	0	40	--			--	--	--	DS	16.5	11
0.03	9.5	3.9					2.65					SS	18	12
			7	0	40	--			--	--	--	DS	19.5	13
0.03	9.5	2.6					2.65					DS	21	14
			1						--	--	--	SS	22.5	15
			3	0	35	--						DS	24	16
0.03	9.5	3.8					2.65		--	--	--	SS	25.5	17
				0	37	--						DS	27	18

Table 10: The soil profile type

		Average soil properties for top 25 m of soil profile		
Soil profile type	Soil profile name/generic description	Shear wave velocity (m/sec)	Standard penetration test N 60	Undrained shear strength (kPa)
SA	Hard rock	>1500	-	-
SB	Rock	760-1500		
SC	Very dense soil of soft rock	360-760	>50	>100
SD	Stiff soil profile	180-360	15-50	50-100
SE	Soft soil profile	<180	<15	<50
SF	Soil requiring site specific evaluation			

Table 11: Seismic parameters

Seismic coefficient (Ca)	Seismic coefficient (Cv)
0.09	0.13

and 12. (16-Q) and (16-R) of UBC 1997 the following seismic parameters can be considered (Table 10 and 11).

CONCLUSION

From geotechnical evaluation of the study area the following conclusions were obtained:

- Soil section consist of sandy soil
- Values of N from SPT range between 26-50/2"
- Shear wave velocity is 396 m/sec^2 and the soil profile Type can be defined as S_c according to UBC1977
- Value of horizontal seismic Coefficient (Ca) was (0.09)
- Value of vertical seismic Coefficient (Ca) was (0.13)

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