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Analysis of Steel Multi-storey Building Subjected to Halabja Earthquake Loading

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Abstract. The multi-storey steel building widely used due to its light gravity loads that is very useful for regions of low soil bearing capacity. Also easy of manufacturing and erecting make it a right choice comparing with other structures. In the last years, the Halabja earthquake may classifieds as the largest base excitation that causes a rapid change in the Iraqi seismic map. Therefore, the aim of the study is to investigate the steel building behaviour under Halabja earthquake loading using a non-linear time history analysis and comparing the results with those obtained from linear static analysis depending to the ISC 1997 and the modern seismic standard ISC 2017. A non-linear analysis using a time history approach was carried out for varied steel multi-storey building models. These models were analysed and designed under dead, live, wind and seismic loads using Staad Pro V8i Software. Results shows that the Iraqi Seismic Code (ISC) 2017 is a good approach to predicting the base shear and the story drift comparing with time history analysis under Halabja earthquake loading, while the Iraqi Seismic Code (ISC) 1997 seems to be very conservative approach.

Keywords: Iraqi seismic code, Time history, Steel building, Storey drift, Base shear, and Finite element.

1. Introduction

On November 2017, an earthquake with a moment of 7.3 occurred in the region of the Iraq-Iran border, near to the city of Halabja. The epicentre of the earthquake about 30 kilometres south of the Halabja city. The earthquake was felt across Iraq, including cites of Baghdad, Erbil, Sulaymaniyah, Kirkuk and Basra. Records of acceleration (m/sec2) are available for Baghdad were used in the dynamic time history analysis to investigate the structural behaviour of multi-story steel building.

There are many studies involved with time history analysis of modelling story building. Bello et al., 2017 presents a dynamic analysis for multi-story reinforced concrete building subject to earthquake. B. Li et al., 2008, presented dynamic analysis of regular multi-storey building. Both of steel and reinforced concrete buildings with unsymmetrical configuration under dynamic load were presented by Pralobh S. & Kanhaiya K. (2015), they are study the time history analysis of multi-story building subjected to earthquake loading using Staad Pro structural software [7]. A dynamic time history analysis of the steel frame was presented by Peng et al., 2015 using the finite element method by the structural software SAP2000. The results of the study show that the steel frame composite steel shear wall has a higher strength than the traditional structure. Al-Nuaimi et al., 2016 present an investigation of the effect of capacity spectral method for multi-story building according to Iraqi seismic load. This study measured the story drift, displacement and shows the capacity curves for the steel building results from pushover analysis. Sangle et al., 2012 presents a time history analysis under dynamic loads, G+25 stories were modelled by Staad Pro V8i structural software [7].

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2. Properties of steel building models

In order to study the dynamic effect of Halabja earthquake loading, three models of three-dimensional multi-story steel building having six (6), nine (9), and twelve (12) stories. The first story height is 4.5m to investigate the effect of the first soft-story case. The height of all other floors are 3m, the plan of the building is symmetrical in tow direction with a dimension of (15x15) m in plan with 5m bay in each direction as shown in Fig. (1). Bracing systems of X-type are used in middle bay in each floor at exterior frame to increase the structure ability against the side-sway. The building is designed in accordance with Iraqi Seismic Codes (ISC) [10, 11] and AISC UNIFIED 2010 [13]. The steel frames weights are introduced as a self-weight, while the composite concrete slab in addition to flooring loads, false ceiling and mechanical loads are considered to be 5 KN/m^2. However, natural fibers composites are highly recommended in structure materials composites [12]. The lightweight partition is assumed to be 4.5 KN/m for each beam in both directions. The live load is assumed 3 KN/m^2 according to ASCE 7-10 for residential building [13]. The lateral loads based on limitation of ISC for earthquake loads and according to ASCE 7-10 for a wind load of speed 120 km/hr. The columns and beams section results from the final design are listed in Table (1).

Table 1: Properties, Stories, and section of steel multi-story builds models

Model	Floor	Corner Column	Edge Column	Interior Column	Interior Beams	Exterior Beams	Bracing
6 Stories	GF & 1	IPEA 220	IPEA 240	IPEA 270	IPEA 200	IPEA 180	UPE 100
	2 & 3	IPEA 200	IPEA 220	IPEA 240	IPEA 200	IPEA 180	UPE 100
	4 & 5	IPEA 180	IPEA 200	IPEA 220	IPEA 200	IPEA 180	UPE 100
9 Stories	GF & 1	IPEA 270	IPEA 300	IPEA 330	IPEA 200	IPEA 180	UPE 100
	2 & 3	IPEA 240	IPEA 270	IPEA 300	IPEA 200	IPEA 180	UPE 100
	4 & 5	IPEA 220	IPEA 240	IPEA 270	IPEA 200	IPEA 180	UPE 100
	6 & 7	IPEA 200	IPEA 220	IPEA 240	IPEA 200	IPEA 180	UPE 100
	8	IPEA 180	IPEA 200	IPEA 220	IPEA 200	IPEA 180	UPE 100
12 Stories	GF & 1	IPEA 300	IPEA 330	IPEA 360	IPEA 200	IPEA 180	UPE 100
	2 & 3	IPEA 270	IPEA 300	IPEA 330	IPEA 200	IPEA 180	UPE 100
	4 & 5	IPEA 240	IPEA 270	IPEA 300	IPEA 200	IPEA 180	UPE 100
	6 & 7	IPEA 220	IPEA 240	IPEA 270	IPEA 200	IPEA 180	UPE 100
	8 & 9	IPEA 200	IPEA 220	IPEA 240	IPEA 200	IPEA 180	UPE 100
	10 & 11	IPEA 180	IPEA 200	IPEA 220	IPEA 200	IPEA 180	UPE 100

3. Methods of analysis

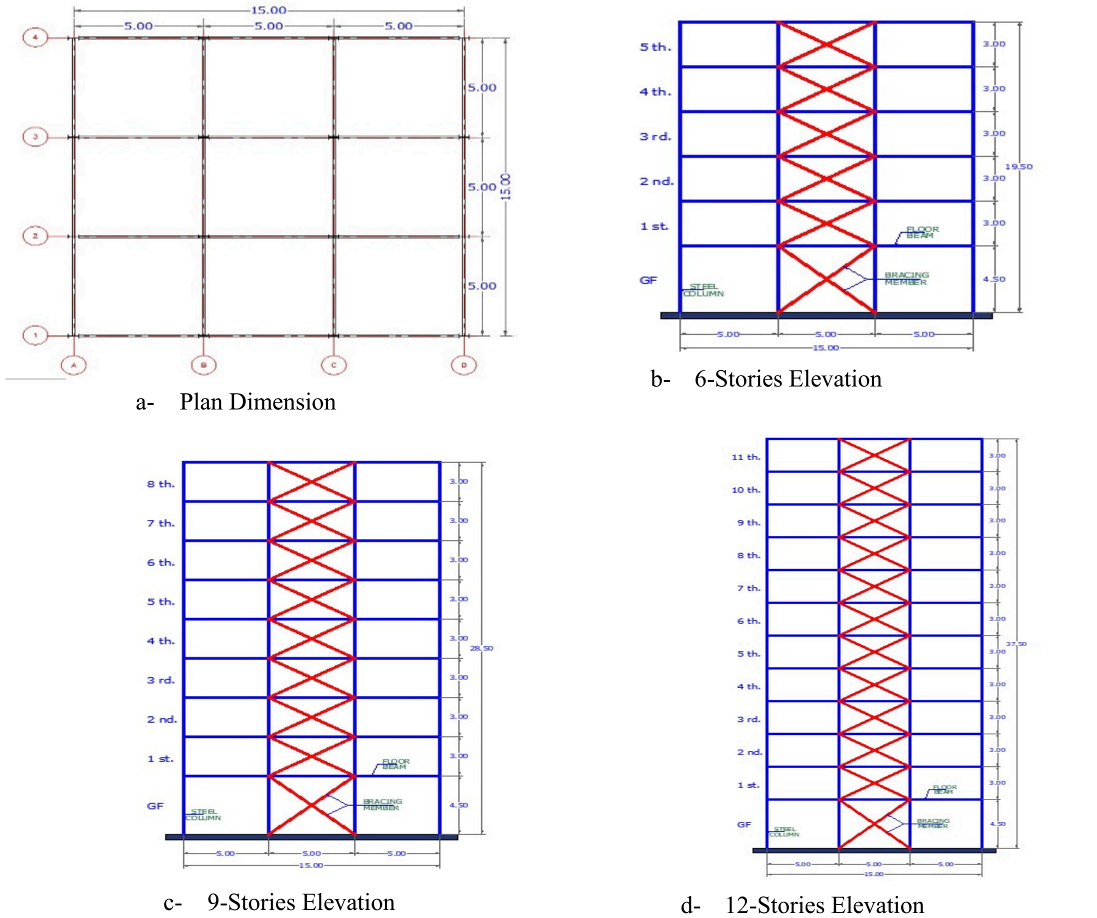
There are three methods adopted in this research for analysis of the Steel Multi-Storey building, Time history analysis depend on the real earthquake data of Halabja earthquake (acceleration-time) history and two other methods depend on the principle of equivalent static method proposed by Iraqi Seismic Codes presented in 1997 and 2017 [10, 11].

3.1 Time History Analysis

This type of analysis gives the dynamic response of the structure over time during and after the application of the load by solving the structure equation of motion [9].

$$mu^{\circ\circ} + cu^{\circ} + ku = mg \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

In which m, c, and k denote, respectively, the masses, damping and stiffness of the structure. In the time history analysis, the structural response is computed at several subsequent time instant. The generated acceleration (m/sec^2) corresponding to the time (sec) in Baghdad due to Halabja earthquake are adopted in this research for time history analysis of multi-story steel building. Table 2 shows the maximum and minimum acceleration in X, Y and Z direction and their corresponding times.



a- Plan Dimension

b- 6-Stories Elevation

c- 9-Stories Elevation

d- 12-Stories Elevation

Figure 1: Plan and elevation of steel building models.

Table 2: Halabja earthquake maximum & minimum acceleration versus times.

	X-Direction		Y-Direction		Z-direction	
	Max.	Min.	Max.	Min.	Max.	Min.
Acceleration (m/sec2)	0.96932	-1.0975	1	-0.9853	1	-0.7976
Time (sec.)	50.4	41.5	48.7	42.3	47.8	49.2

3.2 Equivalent Static Analysis

It is a simplified technique to represent the dynamic's load effect of expected ground motion by a lateral static force distributed laterally on the structure. In this approach, a seismic response design spectrum will be defined and the building responds in its fundamental mode. This type of analysis is adopted in this research under limitation of Iraqi Seismic Code (ISC) 1997 and 2017.

3.2.1 Iraqi seismic code 1997 requirements

According to ISC 1997, the zoning map of Iraq is four zones as shown in Fig. 2, Baghdad City is classified as zone I. The total horizontal design seismic force (V) calculated in accordance with Iraqi Seismic Code as:

$$V = Z.I.S.K.W \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \text{(2)}$$

Where V is the total horizontal design seismic force, Z is the zoning map factor, I is the importance factor, S is the dynamic coefficient, K is the structural system coefficient, and the W is the total vertical load consist of structure self-weight, superimposed dead load and permissible live load in accordance with the standards. Table 2 shows the height, story number, plan dimension, fundamental period of the structure, dynamic coefficient (S). The zoning map factor (Z), importance factor (I), Structural system coefficient (K), Soil Profile Type (SPTY) and the structure period factor (CT) are 0.05, 1, 4, 4, 0.07 respectively.

Table 3: Fundamental structure period and daynamic coefficient factor.

Model	No. of stories	H(m)	D(m)	$T = 0.90H/\sqrt{D}$	S
M1	6	19.5	15	0.453	1.0
M2	9	28.5	15	0.662	1.0
M3	12	37.5	15	0.871	0.90

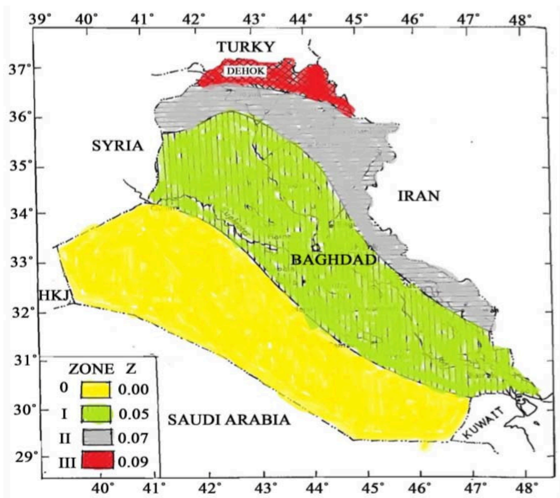
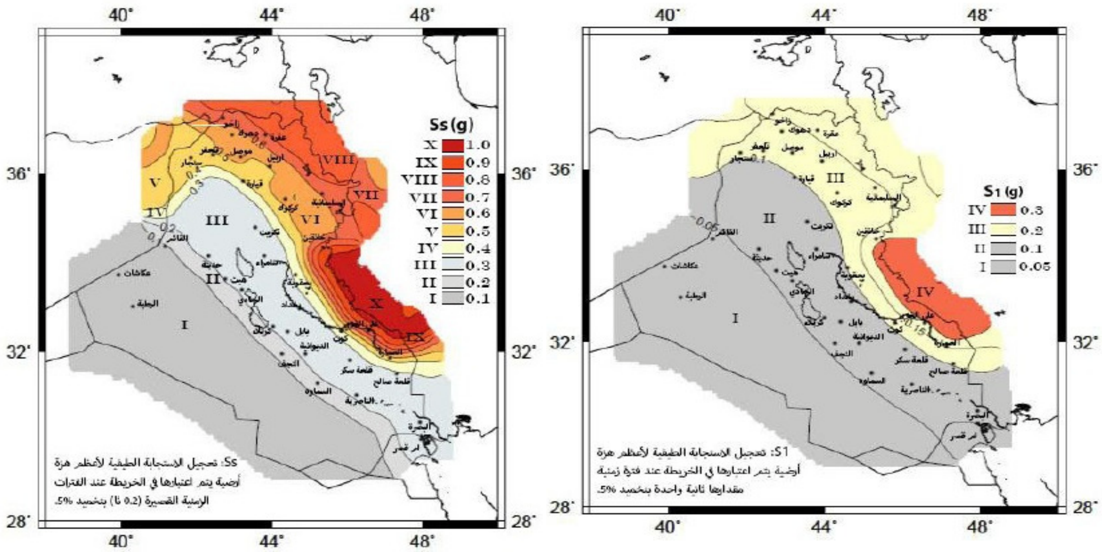


Figure 2: Iraqi seismic zone map (ISC 1997).

3.2.2 Iraqi seismic code 2017 requirements

Iraqi Seismic Code 2017 present the seismic coefficients for all regions of Iraq and the calculation method for the calculating the total horizontal design seismic force. Fig. 3-a shows the Iraqi map of spectral response acceleration at 0.2 sec and Fig. 3-b shows the Iraqi map of spectral response acceleration at 1 sec. The spectral response, acceleration at 0.2 sec $\mathbf{S_s}$, spectral response acceleration at 1.0 sec S_1, Transition period T_L, Importance Factor I, Response modification factor R, Short period site-coefficient at 0.20 sec period Fa, long -period site-coefficient at 1.0 sec period Fv, Structure period coefficient C_T, exponent factor in equation of the structure period formula x are 0.60, 0.2, 1, 4, 4, 1.1, 1.6, 0.07, and 0.75 respectively.



a- Acceleration at 0.2 sec (ISC 2017)

b- Acceleration at 1 sec (ISC 2017)

Figure 3: Iraqi map of spectral response acceleration (ISC 2017).

4. Distribution of horizontal seismic forces

The Horizontal seismic forces distribute over the height of the structure to predict the effect of the earthquake on the structure. The distribution should be in accordance with the following formula:

$$V_i = \frac{W_i H_i}{\sum_1^N W_j H_j} V \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where: V_i is the horizontal seismic design force in the ith level, $W_i \& W_j$ are weights of ith and jth floor, $H_i \& H_j$ are the heights of the ith& jth from the top of the foundation and the N is the total number of stories.

5. Finite element modelling

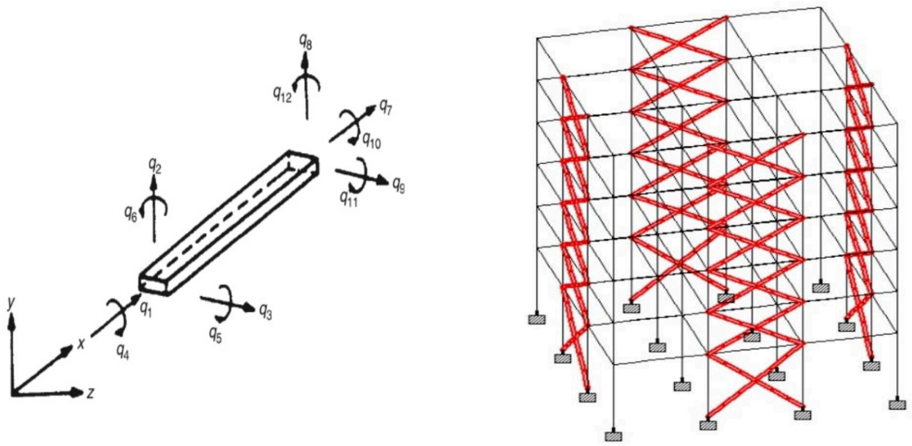
The finite element method is classified as numerical method used to overcome the experimental limitation to demonstrate the behavior of the structure. A useful technical finite element model must be used to demonstrate the real structural behavior.

5.1 Geometry Idealization

Staad Pro V8i SS6 software was used to perform the time history using the Finite Element Method. Columns and beams are idealized using Space Frame Element which has a six degree of freedom per node as shown in Fig. (4-a). A rigid floor technique is adopted for all floors to represent the effect of the composite concrete slab, this will prevent the distortion of the floor, while all translational degree of freedom along the vertical axis is not constrained. The discretization of elements was carried out to get a good convergence in results. Fixed supports were assumed for all supports. Fig. (4-b) shows the finite element idealization for three models.

5.2 Loading

The loading idealization in a finite element using Staad Pro V8i structural software is defer in Equivalent Static Analysis rather than Time history analysis as follow:



a**:** Space frame element b**:** Space frame modelling

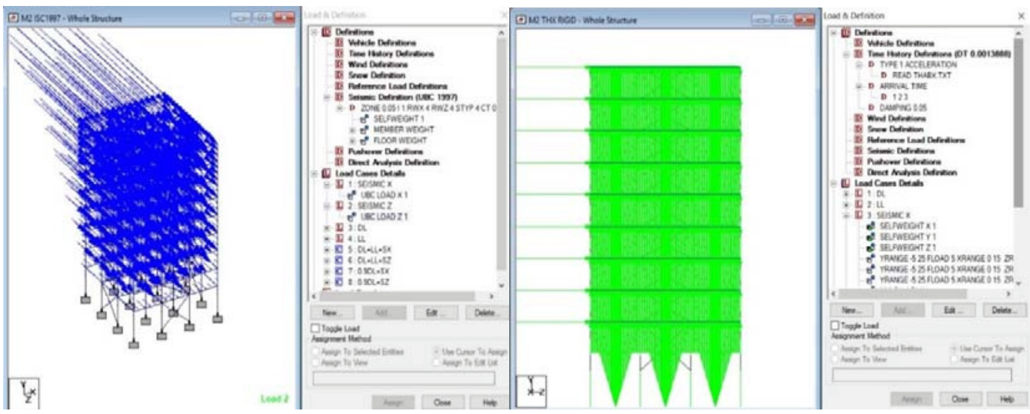
Fig. 4**:** Finite element idealization of building

5.2.1. Equivalent static analysis

In this approach in addition to the seismic definition according to the Iraqi Seismic Codes, self-weight and gravity loads such as superimposed dead loads must be defined. Load cases of seismic load consist of only the seismic loads as shown in Fig. (5-a).

5.2.2 Time history loading idealization

In this approach only the earthquake time history (Acceleration Versus time) must be defined in the definition menu and the self-weight and gravity loads must be defending in three directions X, Y, and Z within the seismic load case in the load cases menu as shown in Fig. 5-b. The loading idealization in a finite element using Staad Pro V8i structural software is defer in Equivalent Static Analysis rather than Time history analysis as follow:



a- Equivalent static analysis-seismic definition **b-** Time history analysis-seismic definition

Fig. 5: Finite element idealization of dynamic loading

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6. Results and discussion

6.1 Mode shapes

Table 4 shows the fundamental global mode shapes with corresponding natural frequencies and the type of each mode per each model.

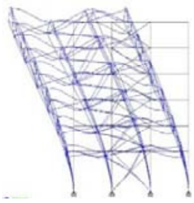
Table 4: Fundamental global mode shapes with corresponding natural frequencies.

Models	Mode No.	Natural Frequency (Cycle/sec)	Type
M1- 6 Stories	1	0.332	1 st Torsional mode
	2	0.572	1 st Lateral mode
	3	0.823	1 st Combined Lateral-Torsional mode
	5	2.264	2 nd Lateral mode
M2- 9 Stories	1	0.186	1 st Torsional mode
	2	0.324	1 st Lateral mode
	3	0.469	1 st Combined Lateral-Torsional mode
	5	1.19	2 nd Lateral mode
	21	2.41	3 rd Lateral mode
M3-12 Stories	1	0.128	1 st Torsional mode
	2	0.224	1 st Lateral mode
	3	0.325	1 st Combined Lateral-Torsional mode
	5	0.850	2 nd Lateral mode
	9	1.755	3 rd Lateral mode
	47	2.702	4 th Lateral mode

Fig. 6 shows the mode shapes of 6 stories steel building M1, Fig. 7 shows the lateral mode shapes of 9 stories steel building M2 and Fig. 8 shows the lateral mode shapes of 12 stories steel building M3. The torsional and combined torsional with lateral mode shapes also accrued for M2 (9 stories) & M3 (12 Stories). Global modes shown in figures 6,7 and 8 has a large effective mass and may be classified as significant contributor to the response of the system. All models have a clear torsional and combined torsional with lateral mode, while the model M1 has only two significant lateral modes as shown in Fig. 6-a and 6-b. The model M2 has 3 significant lateral modes as shown in Fig. 7, while the time history analysis under Halabja earthquake results into four significant lateral modes for models M3 as shown in Fig. 8.

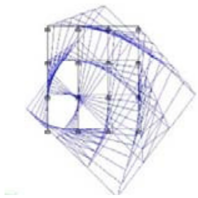
6.2 Maximum base shear

The maximum base shear represents the maximum generated force at the base of the structure due to the earthquake load. Table 5 show the maximum base shear in steel building models and the Fig. 9 and Fig. 10 show the compression of maximum base shear generated in the base of each steel building model due to the applied seismic loads which are even ISC1997 or ISC2017 or by Halabja earthquake loading in X& Z directions. Figures 9 and 10 shows that the equivalent static method proposed by ISC1997 produced a higher base shear in steel building other than that proposed by ISC 2017. Both of ISC 1997 and ISC 2017 have been more conservative in base shear especially for high-rise steel building than the real dynamic analysis under the effect of the latest earthquake in Halabja 2017, while the time history analysis produces a base shear more than ISC 2017. The ISC 1997 approach still produce a higher value as a conservative method.

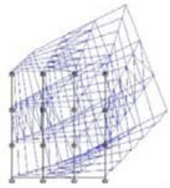


a- M1- 1 st. L

b- M1- 2 nd. L

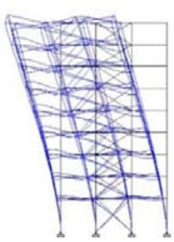


c- M1- 1 st. T

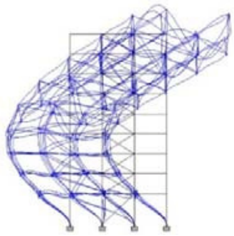


d- M1- 1 st. T+L

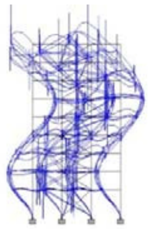
Fig. 6: Modes shapes of 5 stories steel building (M1).



a- M2- 1 st. L

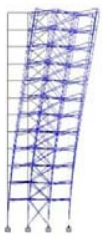


b- M2- 2 nd L

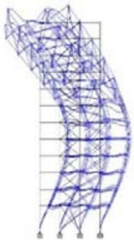


c- M2- 3 rd L

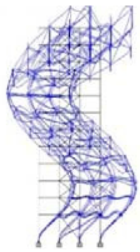
Fig. 7: Lateral modes shapes of 9 stories steel building (M2).



a- M3- 1 st. L



b- M3- 2 nd L



c- M3- 3 rd L

d- M3- 4 th L

Fig. 8: Lateral modes shapes of 12 stories steel building – (M3).

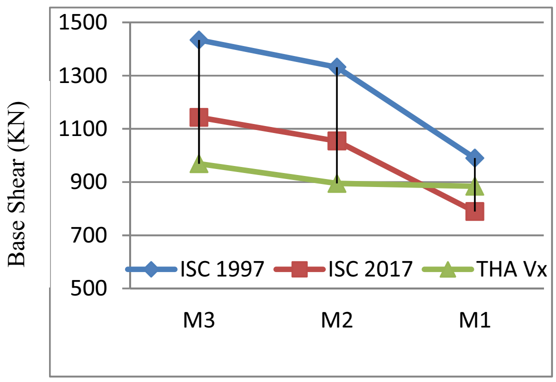


Fig. 9: Maximum base shear Vx.

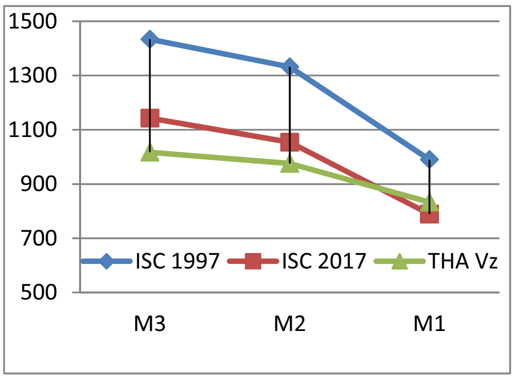


Fig. 10: Maximum base shear Vz.

Table 5: Maximum base shear (KN) in steel building models

	X-Direction			Z-Direction		
	M1	M2	M3	M1	M2	M3
ISC 1997	990	1332	1434	990	1332	1434
ISC 2017	789	1054	1143	789	1054	1143
THA	884	895	969	833	976	1017

6.3 Maximum displacement

The maximum displacement accord in each steel building due to the seismic loads applied by one of the three adopted approaches was mentioned in this research to investigate the behavior of multi-storey steel building and to make a compression between the equivalent static approaches presented in Iraqi codes with the dynamics analysis using time history approach. Table 6 show the maximum displacement in X & Z direction for models M1, M2 and M3 results from analysis carried out according to the limitation of ISC 1997, ISC 2017 and time history analysis (THA) under the effect of Halabja earthquake dynamic loads.

Table 6: Maximum displacement (mm) in X & Z directions.

	X-Direction			Z-Direction		
	M1	M2	M3	M1	M2	M3
ISC 1997	107.8	92	109	122.4	1395	1563
ISC 2017	92	659	813	105	1134	1280
THA	109	265	345	122	281	420

Figures 11 and 12 show a compression between the ISC 1997, ISC 2017 and THA for the maximum displacement for models M1, M2 and M3 in X and Z directions. The ISC 1997 approach still represent a conservative method for predicting the generated maximum displacement and produce higher values rather than those obtained from ISC 2017 approach or THA approach especially for high-rise steel building. In low-rise steel building, all methods yielded close results, as the building elevation increase the result divergence increase. There for a linear and nonlinear time history analysis may be required to predict the actual displacement in the steel building. Figure 13 show the maximum displacement in each model versus the time result from the time history analysis.

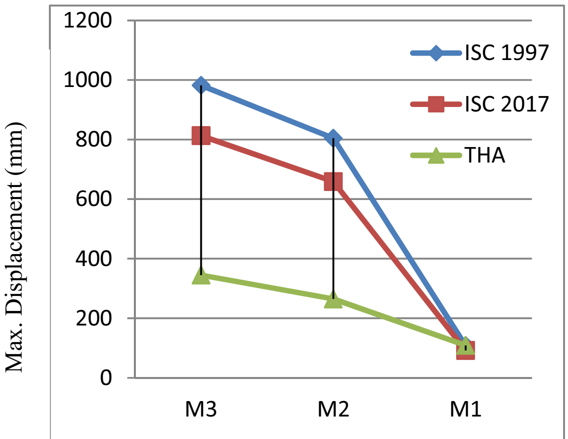


Fig.11: Max. displacement X-Dir.

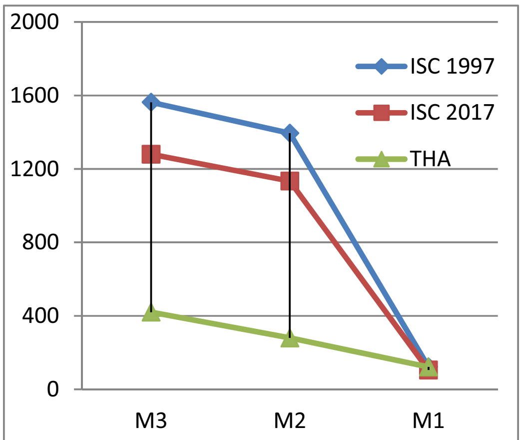


Fig.12: Max. displacement Z-Dir.

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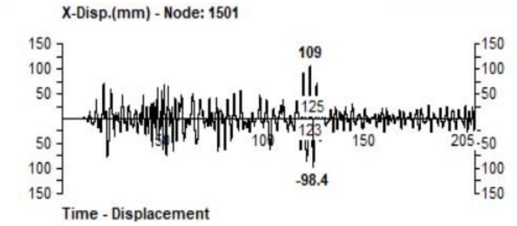
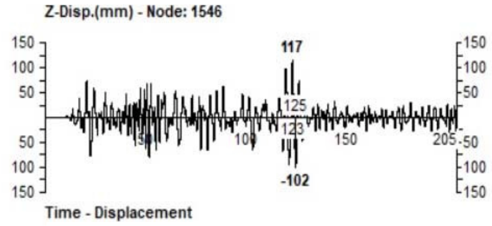
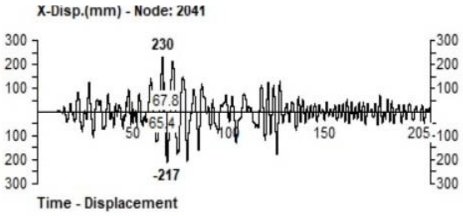


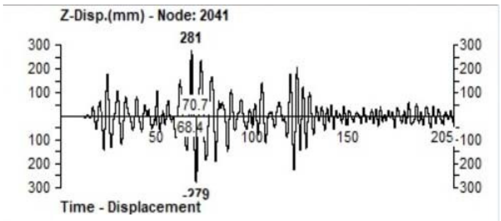
a- M1-Time Disp. X-Dir.



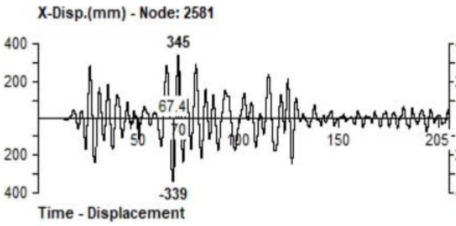
b- M1-Time Disp. Z-Dir.



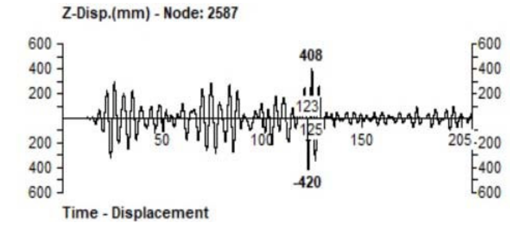
c- M2-Time Disp. X-Dir.



d- M2-Time Disp. Z-Dir.



e- M3-Time Disp. X-Dir.

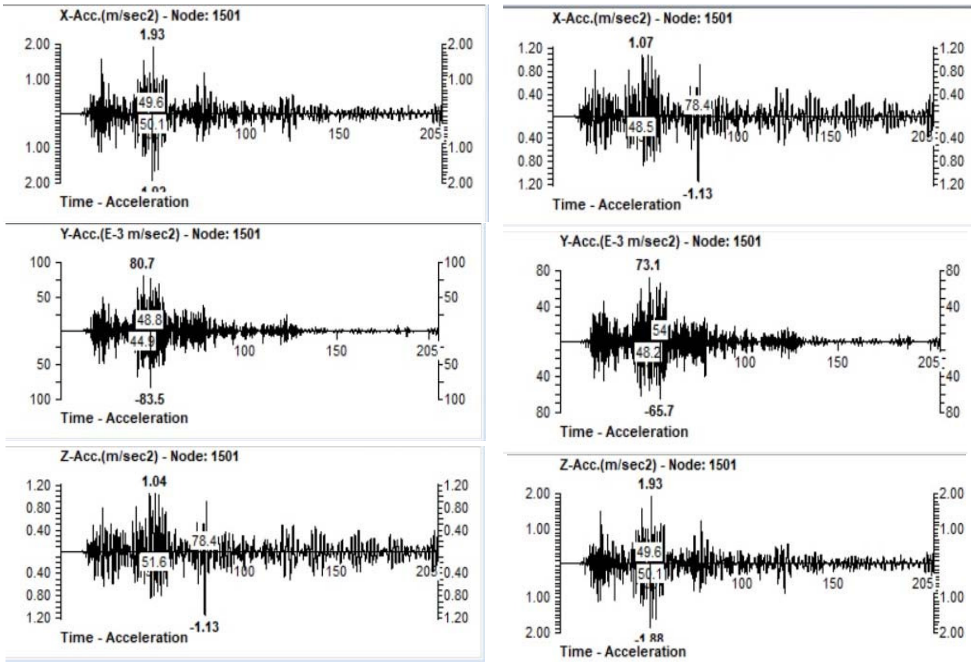


f- M3-Time Disp. Z-Dir.

Figure 13: Maximum Displacement in each building model versus

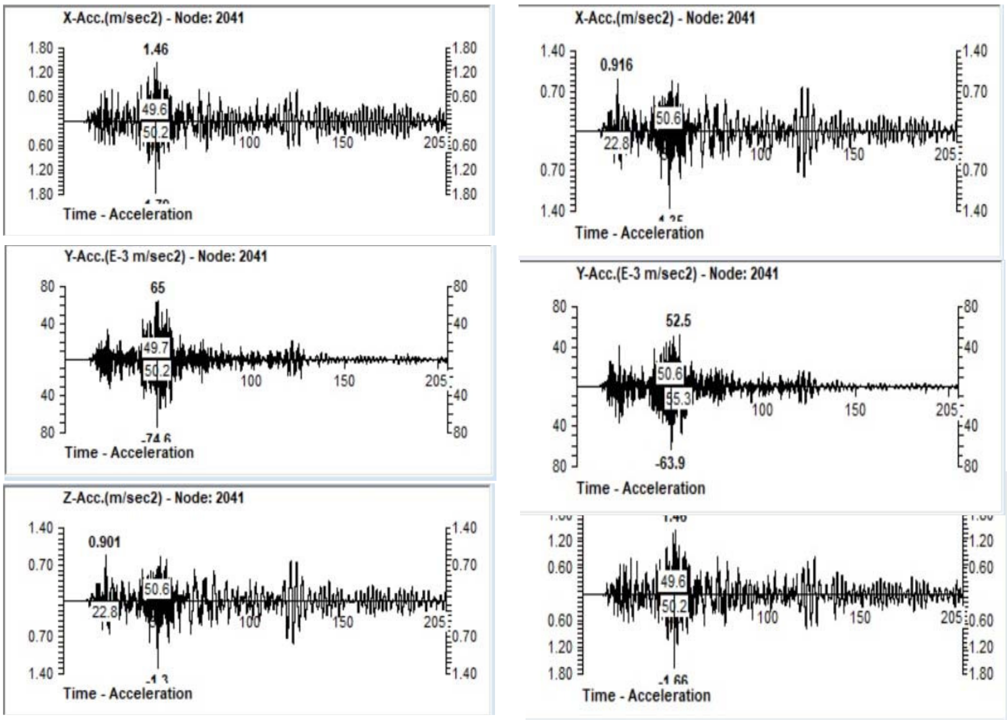
6.4 Corresponding acceleration

The maximum acceleration results from time history analysis in directions X, Y and Z for each node per the direction of the base excitation in X or Z are shown for M1, M2 and M3 in Figures 14, 15 and 16 respectively. The corresponding acceleration for nodes represent the structure energy at specified time. The maximum generated acceleration is 1.93 (m/sec^2) comparing with impute Halabja earthquake records was 0.96932 (m/sec^2), which means the structure mass was contributed the-total energy of the system.



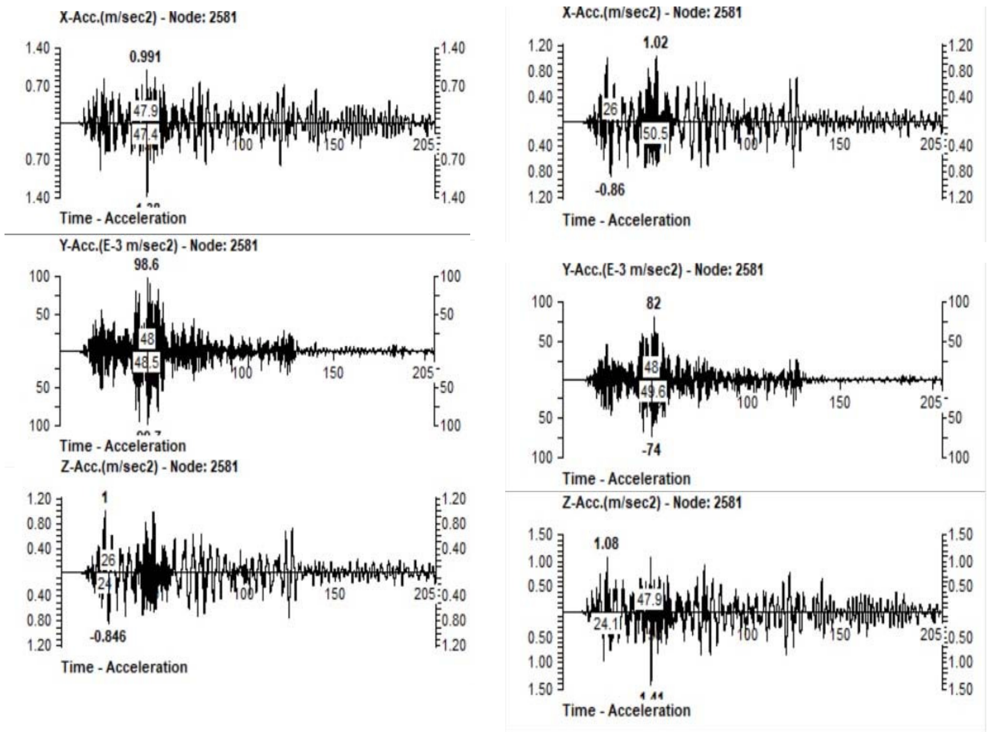
a- M1-Base Excitation X-Dir b- M1-Base Excitation Z-Dir

Figure 14: Maximum acceleration for M1.



a- M2-Base Excitation X-Dir b- M2-Base Excitation Z-Dir

Figure 15: Maximum acceleration for M2.



a- M3-Base Excitation X-Dir b- M3-Base Excitation Z-Dir

Figure 16: Maximum acceleration for M3.

6.5 Story Drift.

The importance of calculation of the story drift in building designs to demonstrate the design of partitions and curtain walls and to avoid the cracks. The ignoring story drift especially in case of structural glazing or brick walls on external surfaces will be to catastrophic. The story drift for story $\boldsymbol{i}$ is calculate as:

$$DR_i = \frac{\Delta_{\boldsymbol{i}} - \Delta_{\boldsymbol{i-1}}}{h_i} \qquad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Where the DR_i is story drift for story i , Δ_i displacement of story i, Δ_{i-1} is the displacement of lower story $i-1$ and the h_i is the story height. Tables 7 & 8 show the stories drift in X & Z Directions of the three steel models results from equivalent static approach (ISC 1997 & ISC 2017) and dynamic analysis due to Halabja earthquake loads. Table 7 and Table 8 shows the story drift in X and Z direction respectively.

Table7: Story drift in X-Direction (cm).

	M1			M2			M3		
Elevations	ISC1997	ISC2017	THA	ISC1997	ISC2017	THA	ISC1997	ISC2017	THA
0	0	0	0	0	0	0	0	0	0
4.5	1.04	0.85	1.22	2.06	1.66	2.05	2.21	1.79	1.67
7.5	1.2	0.98	1.45	2.11	1.72	2.01	2.38	1.95	1.71
10.5	1.46	1.21	1.82	2.52	2.07	2.36	2.91	2.4	2.02
13.5	1.6	1.33	2.06	2.82	2.33	2.61	3.36	2.8	2.28
16.5	1.64	1.37	2.17	3.05	2.53	2.8	3.72	3.11	2.49
19.5	1.59	1.33	2.13	3.13	2.6	2.83	3.94	3.32	2.65
22.5	--	--	--	3.16	2.62	2.86	4.17	3.52	2.82
25.5	--	--	--	3.07	2.5	2.77	4.26	3.6	2.88
28.5	--	--	--	2.91	2.37	2.63	4.33	3.65	2.87
31.5	--	--	--	--	--	--	4.26	3.57	2.77
34.5	--	--	--	--	--	--	4.2	3.5	2.67
37.5	--	--	--	--	--	--	3.89	3.3	2.53

Table 8: Story drift in Z-Direction (cm.

	M1			M2			M3		
Elevations	ISC1997	ISC2017	THA	ISC1997	ISC2017	THA	ISC1997	ISC2017	THA
0	0	0	0	0	0	0	0	0	0
4.5	1.13	0.92	1.31	2.39	1.92	2.31	2.64	2.13	1.96
7.5	1.33	1.09	1.6	2.56	2.1	2.42	2.69	2.21	2.05
10.5	1.63	1.35	2.03	2.9	2.38	2.64	3.39	2.81	2.3
13.5	1.82	1.51	2.31	3.3	2.73	2.97	3.99	3.32	2.64
16.5	1.89	1.58	2.4	3.62	3	3.22	4.48	3.74	2.93
19.5	1.87	1.56	2.44	3.79	3.14	3.34	4.83	4.05	3.15
22.5	--	--	--	3.87	3.2	3.37	5.18	4.35	3.38
25.5	--	--	--	3.83	3.15	3.3	5.41	4.54	3.51
28.5	--	--	--	3.72	3.05	3.17	5.57	4.67	3.55
31.5	--	--	--	--	--	--	5.6	4.68	3.5
34.5	--	--	--	--	--	--	5.57	4.62	3.41
37.5	--	--	--	--	--	--	5.45	4.49	3.31

Figures 17-19 show the compression between the three analysis methods for the stories drift in X-directions, while the figures 20-22 show the compression between the three analysis methods for the stories drift in Z-directions. It has been seen that the story drift increase when the elevation of the building increase except that in the last one or two stories, its trend to decrease versus elevation relatively to the drift of the previous stories.

It can be seen that the THA produce a higher stories drift other than ISC 1997 and ISC 2017 in case of low height steel building (below six stories), while it is in the middle level for moderate height steel building (between six to nine stories) and it produces a smaller stories comparing with ISC 1997 and ISC 2017.

In all cases the ISC 1997 static method produces the stories drift higher than that method presented by ISC 2017, and the deference was increase when the elevation increased.

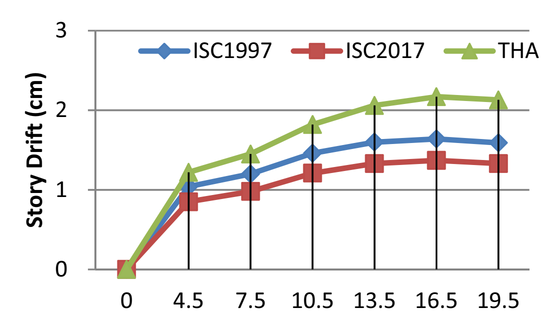


Figure17: Model M1 Story Drift X-Dir

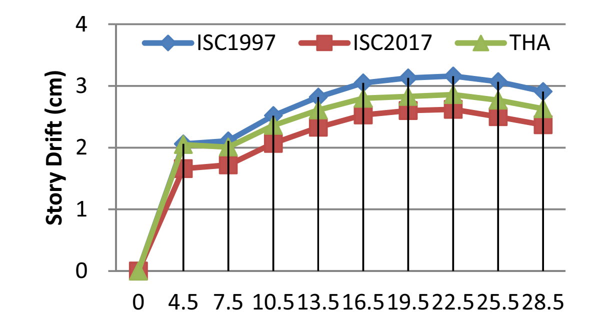


Figure 18: Model M2 Story Drift X-Dir

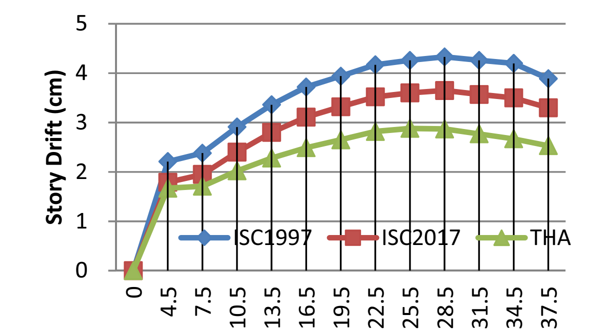


Figure 19: Model M3 Story Drift X-Dir

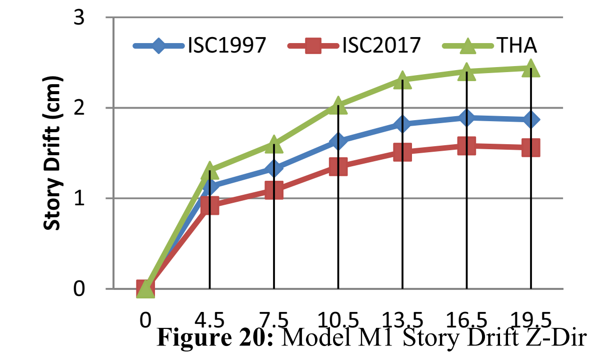


Figure 20: Model M1 Story Drift Z-Dir

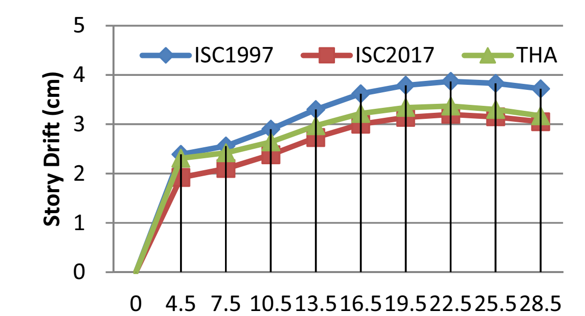


Figure 21: Model M2 Story Drift Z-Dir

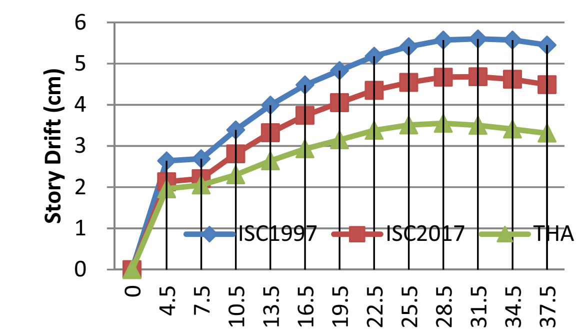


Figure22: Model M3 Story Drift Z-Dir

7. Conclusion

In this study, a finite element analysis was carried out to investigate the dynamic response of multi-storey steel building subjected to Halabja base excitation and to verify the Iraqi seismic codes with the dynamic analysis results, the main conclusion of this study are:

a. A fundamental torsional and combined torsional with lateral modes shape contribute to the global mode shapes of the steel building subjected to the Halabja earthquake loads.
b. The type and arrangement of the bracing system effect the dynamic response of the structure; therefore, the sequence of mode shape type may be changed if the other bracing type will have used.
c. According to the time history analysis, the lateral global modes increased when increasing the steel building height with a fixed plan dimension.

d. The ISC 1997 analysis approach produces a base shear at the base of the steel building more than those obtained from the approaches of ISC 2017 and time history analysis (THA).
e. ISC 2017 seems to be a good approach to predict the base shear at the base of steel building comparing with time history analysis (THA) for the selected cases study of steel building subjected to the Halabja earthquake loading.
f. The maximum displacement results from the ISC 2017 approach is closer to that results from time history analysis under Halabja earthquake loading, while the results of ISC 1997 classified as a very conservative results.
g. ISC has a good predicting the story drift of steel multistory building less than nine stories, while there is a divergence in results for the steel building over nine stories.

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