Kurdistan Regional Government-Iraq

Kurdistan Engineers union

Calculate horizontal loading from the seismic to 2D six-store reinforced concrete building in Ranya utilizing IBC.

2025-2024

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Abstracte

In Kurdistan, buildings were simply intended to support gravity loads. According to recent research, the Badra-Amarah fault near the border between Iran and Iraq, where our region is located, is active and might sustain significant damage. As a result, the necessity of seismically evaluating older structures is growing. This report's goal is to evaluate the seismic performance of two six-story reinforced concrete buildings—one of which has seismic force design and the other does not. For the analysis, the focused plasticity with nonlinear time history is used. Three time-acceleration data are scaled to the anticipated earthquake level in the area using the spectrum matching approach.

For the investigation, —the International Building Code—2012, IBC—2012, UBC, and ASCE—are employed. In terms of base shear, plastic hinge performance, quantity, and displacements, IBC provided the most cautious findings. Thus, day by day, we must design our structure to be seismically resistant in addition to the other necessary designs.

Introduction

Seismic force is a natural phenomenon that causes motion or vibration of the Earth's surface. It's a dynamic force that shakes the Earth's crust, and it can be caused by tectonic ground motion, landslides, or even human activities. During designing buildings, it's important to consider the lateral forces that earthquakes can generate, following engineering standards and codes. Nowadays, there are multiple codes available for designing buildings, such as IBC, UBC and ASCE. Structural engineers used to enhance lateral behavior of buildings by increasing the dynamic characteristics of structures such as; mass, stiffness and damping. Moreover, avoiding the common mistakes that mostly cause failure of structural members during the disaster.

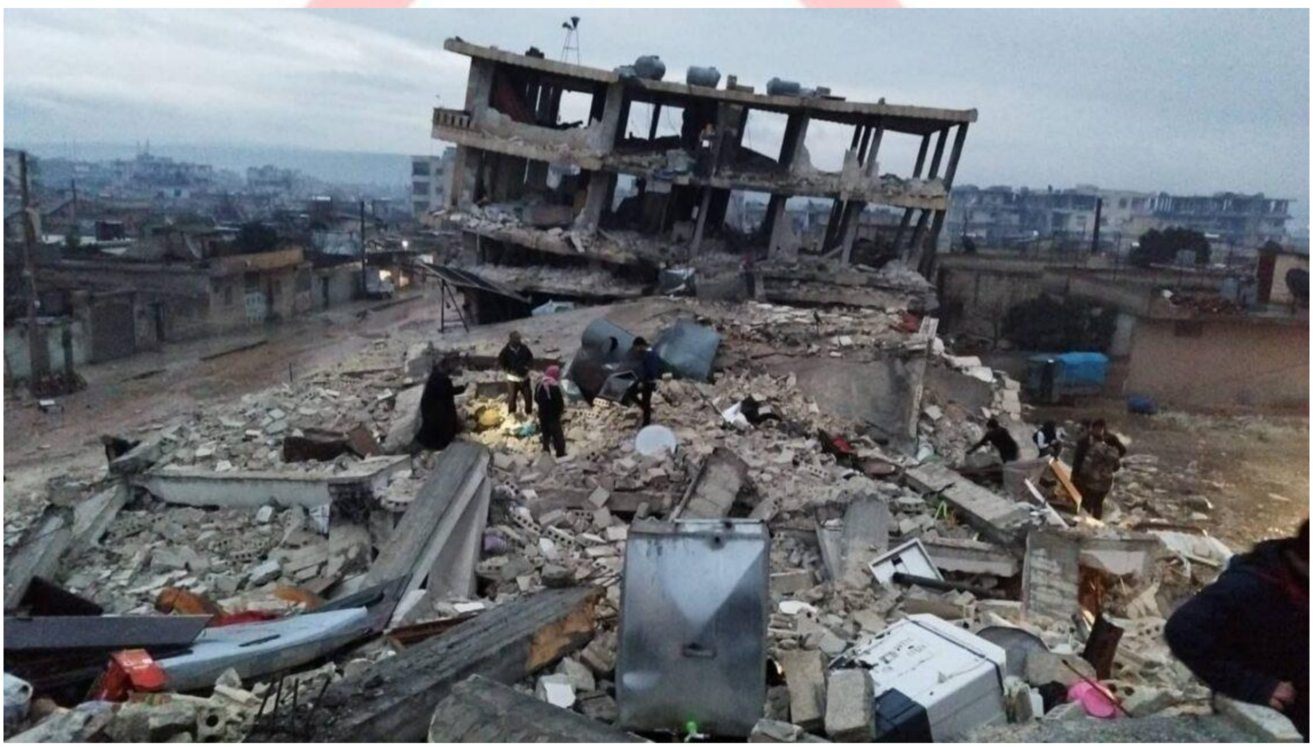

Fig 1 earthquake happened in Turkey

Background

The seismic load on a structure is produced by the deformation of the structure during vibration, as opposed to the gravity load and the wind load (with the exception of thin structures). Therefore, the seismic load is a component of the structure's dynamics and is controlled by Second Law of Newton. Newton's Third Law governs both gravity and the effective wind load.

The inertia force acting on the structure is known as the seismic load, and it varies continuously over time, measured in time units, t, starting at the beginning of the vibration. We are interested in finding the maximum seismic force and its distribution on the structure during the vibration for design reasons.

Since the seismic force is a dynamical phenomena, it is dependent on the stiffness and mass distribution across the structure. Furthermore, the way that plasticity distributes throughout the structure affects the seismic force as well, as buildings are usually made to respond to vibrations in an inelastic manner. Any method that aims to quantify the seismic force must take these two parameters into account since they are crucial in establishing the maximum size and dispersion of the seismic force.

The dynamics factor has to account for the fact that the ground vibration is amplified by the seismic force as a result of the structure's resonance effect, and that the maximum amplification varies with the structure's free vibration period. Recall that for an elastic structure, the free vibration period (T) equals $\sqrt{(M/K)}$. Therefore, if the structure is seen as a single, uniform mass, the dynamics factor and, consequently, the maximum seismic force, rely on the mass (M) and elastic stiffness (K) of the structure.

We can express the seismic force in terms of the structure's acceleration since it is an inertial force. The acceleration response spectrum is the graph that shows the maximum acceleration as a function of the free vibration or natural period.

The acceleration response spectrum, which is seen above, is a typical graph of the averaged and smoothed maximum acceleration caused by an earthquake of elastic structures built on rock. Observe that the rock acceleration has a maximum magnification of around 2.5.

Observe also that following the plateau, the magnification rapidly diminishes (i.e. for more flexible or taller structures), and that structures with a limited period (i.e., high stiffness or shorter structures) experience larger magnification of the ground acceleration.

structures were significantly affected by the soil resonance effect. It has lately been recognized, nevertheless, that the soil resonance effect may also happen in the short period range, particularly on soft sites. Therefore, it is crucial to take these facts into account by defining the spectrum in terms of the acceleration at a brief period of time and the acceleration at A longer period frame. Spectra are often discussed at 0.2 and 1.0 second periods.

Given the spectral accelerations at any second, any spectrum can be visually built. The durations, both shorter and longer. They go by the names SS and S1, respectively.

We now take into consideration the other significant component, which is the impact of the diffusion of plasticity or inelasticity across the structure. A ductile structure gives at one point, then another, then another, and so on, until the force is too much for the structure to support. This process occurs as the seismic force grows. A uniform or regular ductile frame structure has historically served as the fundamental reference for determining the formulas for the seismic force and for analyzing the impact of the plastic spread—that is, the series of hinge formation—on the force's magnitude.

The IBC 2009 refers its users to the ASCE 7-05 "Minimum Design Loads for Buildings and Other Structures" which specifies the design base shear by the formula:

V = CS W (1)

Cs = SDS/(R/I) (2)

Cs = SD1/(T(R/I)) (3)

Cs = SD1TL/(T2 (R/I)) (3b)

The parameters utilized to calculate the design seismic force are the design spectral accelerations. It should be noted that the desired behavior of the structure is such that non-structural materials do not collapse on occupants and that structural elements may be repairable at this level of seismic force, which is equivalent to that associated with a mild earthquake. The term "life safety (LS) limit state" refers to this. An earthquake with a higher magnitude is correlated with the collapse prevention (CP) limit state than the LS limit state.

The construction is designed to remain intact during a powerful earthquake, even though non-structural parts would probably have collapsed and the structural parts are probably irreparable. The seismic force level corresponding to this severe earthquake, known as the maximum considered earthquake (MCE) below, is assumed by the code to be about 1.5 times that of the LS limit state. The US codes have always included this 1.5 collapse gap, and they still do.

To Determine the design seismic forces we need to follow this steps

1. Determine the Occupancy Category (I to IV) using the table.

2. Locate the I factor value using the table.

3. Determine the values for SS, S1, and TL based on the maps.

4. Determine which class the site belongs to (A to F).

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5. To obtain the Fa and Fv values, use the table.

6. Determine the SDS and SD1 using formulae.

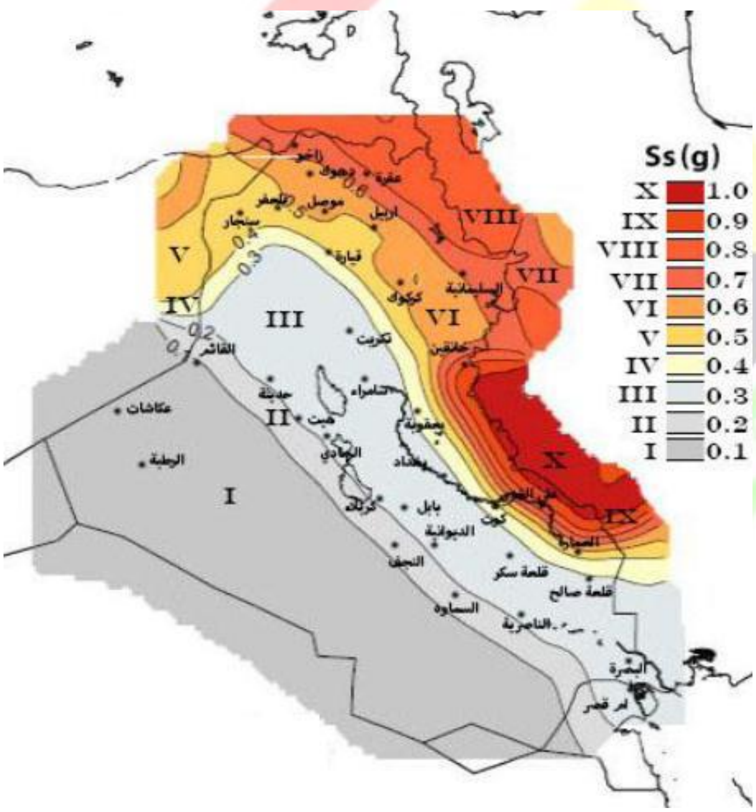
7. Use equation to find Ta (or T and Ta).

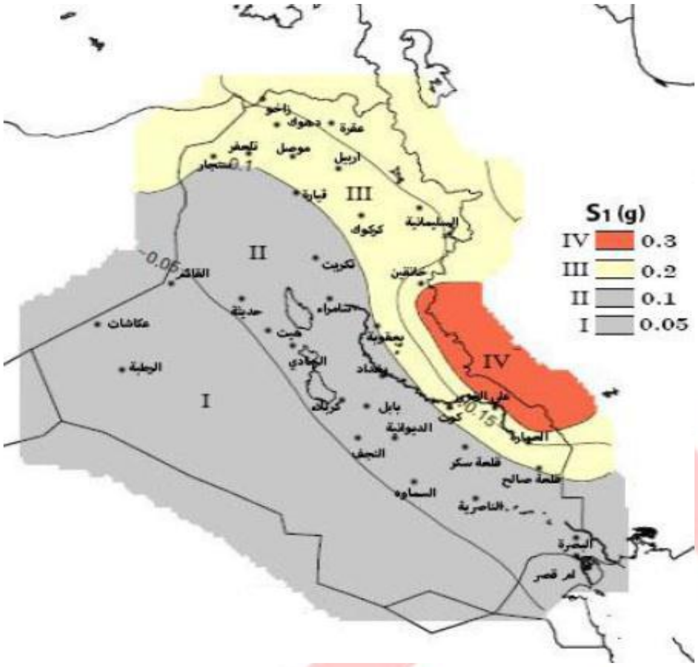
8. Find the SDC (A to F) using the tables.

9. Determine the R (as well as Cd and Ω0) component by using the chart or the pertinent structural tests.

10. Calculate the construction's weight, W

11. Use equs to confirm the limits on V after replacing Cs and V, respectively, in the equations.





The site class (A to F) and sit coefficients (Fa, Fv) must be determine

$$S_{MS} = F_a S_s$$

$$S_{M1} = F_v S_1$$

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I_e}\right)}$$

$$T_a = C_t h_n^x$$

$$C_s = \frac{S_{D1}}{T\left(\frac{R}{I_e}\right)}$$

$$V = C_s W \qquad C_s = 0.5 S_1 / (R/I_e)$$

$$F_x = C_{vx} V$$

$$C_{vx} = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k}$$

$$V_x = \sum_{i=1}^{x} F_i$$

TABLE 1613.2.3(1)
VALUES OF SITE COEFFICIENT F_a [a]

SITE CLASS	MAPPED RISK TARGETED MAXIMUM CONSIDERED EARTHQUAKE (MCE_R) SPECTRAL RESPONSE ACCELERATION PARAMETER AT SHORT PERIOD					
	$S_s \leq 0.25$	$S_s = 0.50$	$S_s = 0.75$	$S_s = 1.00$	$S_s = 1.25$	$S_s \geq 1.5$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	Note b	Note b	Note b
F	Note b	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at short period, S_s.
b. Values shall be determined in accordance with Section 11.4.8 of ASCE 7.

Seismic Force-Resisting System	Response Modification Coefficient, R^a
B. BUILDING FRAME SYSTEMS	
1. Steel eccentrically braced frames	8
2. Steel special concentrically braced frames	6
3. Steel ordinary concentrically braced frames	3¼
4. Special reinforced concrete shear walls [g,h]	6
5. Ordinary reinforced concrete shear walls[g]	5
6. Detailed plain concrete shear walls[g]	2
7. Ordinary plain concrete shear walls[g]	1½
8. Intermediate precast shear walls[g]	5
9. Ordinary precast shear walls[g]	4
10. Steel and concrete composite eccentrically braced frames	8
11. Steel and concrete composite special concentrically braced frames	5
12. Steel and concrete composite ordinary braced frames	3
13. Steel and concrete composite plate shear walls	6½
14. Steel and concrete composite special shear walls	6
15. Steel and concrete composite ordinary shear walls	5
16. Special reinforced masonry shear walls	5½
17. Intermediate reinforced masonry shear walls	4
18. Ordinary reinforced masonry shear walls	2
19. Detailed plain masonry shear walls	2
20. Ordinary plain masonry shear walls	1½
21. Prestressed masonry shear walls	1½
22. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance	7
23. Light-frame (cold-formed steel) walls sheathed with wood structural panels rated for shear resistance or steel sheets	7
24. Light-frame walls with shear panels of all other materials	2½
25. Steel buckling-restrained braced frames	8
26. Steel special plate shear walls	7

Example calculation for V, Fx, and Vx, that we toked above we apply for the building in Ranya city

Find the design seismic forces for a six-story reinforced concrete office building in Ranya city that resists ductile moments. The building is built on dense soil at a site where Ss = 1.24g and S1 = 0.3g. Each level weights 4500 kN, except for the roof, which weighs 4200 kN.

Base Shear:

V = CS W

Occupancy category = II

I = 1.0 TL is irrelevant as the structure’s height is much less than required for this portion of the acceleration response spectrum to be activated.

Site class = D

Fa = 1.0

Fv = 2

SMS = Fa Ss = 1.0 (1.24g) = 1.24g

SM1 = Fv S1 = 2 (0.3g) = 0.6g

SDS= 2/3 SMS= 2/3(1.24g)= 0.82g

SD1= 2/3 SM1= 2/3 (0.6g) = 0.4 g

$$T_a = C_t h_n^x \qquad (12.8\text{-}7)$$

Ta = 0.016 x (6 x 3.0 x 3.28)$^{0.9}$ = 0.63 sec

0.8 SD1/SDS = 0.8 x 0.4/0.82 = 0.39 < 0.63 sec. Hence use the second table only for determining the SDC.

0.2g ≤ SD1 hence for OC II, Seismic Design Category = D

R = 8 (special moment frame)

Cs = SD1I /(RT) = 0.4 x 1 /(8 x 0.62828) = 0.07958

SDSI/R = 0.82 x 1/8 = 0.1025 > Cs

Hence Cs = 0.07958 > 0.01 :OK

W = 5x4500 + 4200 = 26700 kN

V = 0.07958 x 26700 = 21247.86 kN

Vertical Distribution (Fx) , Vx and Mx:

Fx = Cvx V

Cvx = wx hx k / (Σi n wi hi k)

T > 0.5 therefore by interpolating between k = 2 @ 2.5s, and 1.0 at 0.5s, k = 1.065 @ 0.63s

$$\text{Vx} = \sum_{i=x}^{n} Fi$$

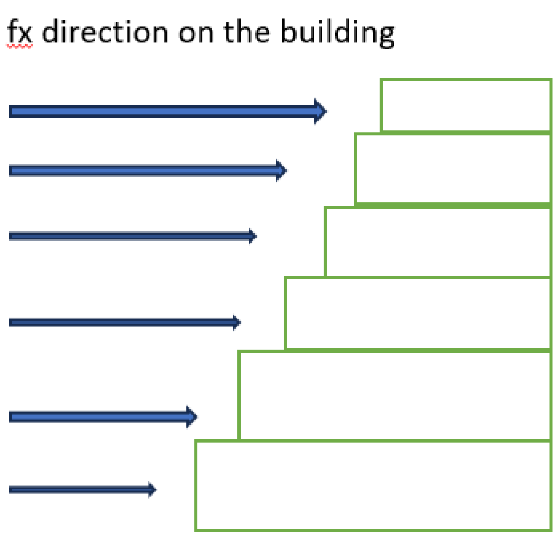
$$Mx = \sum_{i=x+1}^{n} Fi(hi - hx)$$

The computations for Vx and Mx, which are easily completed with a spreadsheet, are displayed in the following table.

Level, i	wi kn	hi m	(h,i)^k	w,i (h,i)^k	FX kn	cvx
6	4200	18	21.72	91224	5936.936513	0.279413
5	4500	15	17.84	80280	5224.691565	0.245893
4	4500	12	14.1	63450	4129.380665	0.194343
3	4500	9	10.38	46710	3039.927043	0.14307
2	4500	6	6.74	30330	1973.902531	0.092899
1	4500	3	3.22	14490	943.0216838	0.044382
0				326484	21247.86	

Discussion

After we applied the seismic cod IBC for the building above its showed that the FX that resist earthquake is much bigger than the original design for the building unfortunately the seismic in our country is concerned case that we have to deal with it. however there is more than one way to make stronger building by make bracing and ,Shear Walls, Strong Connections…..



Conclusion

When seismic stimulation was used to bend beams and columns, the resulting bending moments were significantly greater than those resulting from static loads. While the difference was marginal at other levels, the compressive stresses produced by all occurrences of loads in ground floor columns were higher than tensile stresses in these columns. In the examined beams, the tensile and compressive stresses were roughly equal. The imposed seismic load was too much for the frame to withstand. A building in Ranya was designed to be built, and we did an evaluation of the design with the use of system code IBC, which is one of the world’s standards for testing buildings defense against seismic, or, in other words, earthquakes. After analyzing the probability of an earthquake in this area, which is Ranya, we came to the conclusion that this building doesn’t stand against the probability of an earthquake in this area, and it would collapse. After analyzing the case study, we recommended it to the owner of the building, which is a six-story building in Ranya, to be redesigned in a way that it could stand an earthquake.

(Gatscher, 2012) (Alshaheen, 2022) (Anon., n.d.) (Elgamal, 2010) (El-Kholy, n.d.) (Anon., 2020) (S. K. Ghosh, n.d.) (Dhanvijay's, 2023) ((Dr.-Ing.), n.d.) (Little, 2020) (BA Shah, 2021)

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References

(Dr.-Ing.), A. Z., n.d. ETHIOPIAN/EUROPEAN AND AMERICAN CODES. In: *building cod for seismic designe* . s.l.:s.n.

Alshaheen, A. S., 2022. *Seismic Assessment of Asymmetrical Existing RC Building in South of Iraq by Nonlinear Time History Analysis.* [Online].

Anon., 2020. IBC Table 1604.5 Risk Category. In: s.l.:s.n.

Anon., n.d. *nternational Code Council, Inc. International Building Code (IBC 2003), 2003.*. [Online].

Dhanvijay's, V., 2023. Comparative Study of Different Codes in Seismic Assessmen. *reserchgate*

Elgamal, A., 2010. *International Building Code 2006 – Section 1613 Earthquake Loads.* [Online].

El-Kholy, A. M., n.d. El-Kholy, A.M., Sayed, H. and Shaheen, A.A., 2018. Comparison of Egyptian Code 2012 with Eurocode 8-2013, IBC 2015 and UBC 1997 for seismic analysis of residential shear-walls RC buildings in Egypt. Ain Shams Engineering Journal, 9(4), pp.3425-3436..

Gatscher, J. A., 2012. *Elements of 2012 IBC / ASCE 7-10 Nonstructural Seismic Provisions: Bridging the Implementation Gap.* s.l., s.n.

Jabbar, S., 2018. Seismic Analysis of Reinforced Concrete Buildings in South of Iraq based on Different Codes. *reserchgate.*

Little, M., 2020. Understanding the Requirements for. *kholer.*

Mehta, K., 2012. Seismic Loads Based on IBC 2012/ASCE 7-10.

S. K. Ghosh, P., n.d. *Seismic Design Provisions in*, s.l.: s.n.