Advanced Engineering Days

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Examination of buildings with different number of floors using non-linear time history analysis according to TBEC-2018 and EC 8 seismic codes

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Cite this study: Yılmaz, M., & Can, H. (2023). Examination of buildings with different number of floors using non-linear time history analysis according to TBEC-2018 and EC 8 seismic codes. Advanced Engineering Days, 8, 49-51

Keywords
SAP 2000
TBEC-2018
Eurocode 8
Nonlinear time history analysis
Seismic performance

Abstract

As a result of the earthquakes that have occurred on the earth from the past to the present, the issue of earthquake performance of structures has come to the fore in structural and earthquake engineering. In Turkey, with the Turkish Seismic Code (TSC-2007) conditions were defined for the first time in the regulation for the evaluation and reinforcement of existing structures. Within the scope of this research, the carrier system; Consisting of a unhollow reinforced concrete shear wall frame system with high ductility, located in the 1st degree seismic zone, having the same floor formwork plan; The seismic performance evaluation of 10, 15 and 20 storey existing reinforced concrete buildings was made by using nonlinear time history analysis according to Turkish Building Earthquake Code 2018 (TBEC-2018) and Eurocode 8 (EC 8) earthquake codes. Within the scope of the study, SAP200 (v25) computer software was used for modeling of the structures and performance analysis. In scope of the data obtained, it has been determined that TBEC-2018 is on the safer side compared to Eurocode 8.

Introduction

Earthquakes are among the natural disasters that occur on earth and cause loss of life and property. Our country is in the Alpine-Himalayan seismic zone, which is one of the important and active seismic zones in terms of earthquake risk, starting from the Azores Islands and extending to Southeast Asia [1].

As a result of the earthquakes that have occurred since the existence of the universe until today, the subject of seismic performance of structures has gained significant importance in the fields of structural engineering and earthquake engineering [2]. With the opportunities offered by today's construction technology, earthquake-resistant high-rise constructions have become widespread in our lives. The collapse of many buildings and the loss of lives because of the recent severe earthquakes which are Izmir, Elazığ, Van, Kahramanmaraş and Hatay show that sufficient precautions have not been taken regarding the safety of existing constructions [3]. To minimize the damage caused by earthquakes on structures and the loss of life, buildings must be designed to be earthquake resistant.

Material and Method

In this study there are 3 constructions which are 10, 15 and 20 stories with have 7 spacings for X direction and 5 spacings for Y direction. These constructions have been considered as existing buildings in the 1st degree seismic zone in Bayraklı district of Izmir province, at 38.4633126 north latitude and 27.18229563 east longitude. The carrier system of constructions is a unhollow reinforced concrete shear wall frame system with high ductility (Figure 1). These constructions have the same floor plans, and each floor is 3m height. The purpose of use of the buildings is residential. Using the PEER database, ground motion records were selected according to TBEC-2018 [4] part 2, part 5, EN 1998-1:2004 [5] (Eurocode 8 part 1) part 3 and part 4.

Ground motion records were selected by choosing the fault type, magnitude, Joyner-Boore-distance (Rjb) and shear wave speed (Vs30) parameters appropriately. round motion records selected according to both seismic codes were scaled on the PEER [6] database. The obtained scaling coefficients were tested with the SeismoMatch [7] program. SAP2000 [8], a computer software, was preferred for analysis and calculations. Effective section stiffnesses were assigned for the modeled structures according to both seismic codes, and plastic hinges were defined. Then, the following steps were followed:

For nonlinear time history analysis, the response spectrum is defined according to both seismic codes.

According to TBEC-2018, AFAD [9] interactive web application was used for response spectrum.

Response spectrum data defined according to Eurocode were taken from the EN 1998-1 (2004)[5] regulation.

11 ground motion records were selected for TBEC-2018 and 4 ground motion records were selected for Eurocode 8.

Ground motion records were identified with the time history function, then they were matched with the response spectrum.

After the matching process was completed, nonlinear time history (direct integration) function was defined as a load case and analyzes were performed.

Tablo 10. Yapı hakkında genel bilgiler

Kat Adedi	10	15	20
Kullanım Amacı	Konut	Konut	Konut
Deprem Bölgesi	1	1	1
Zemin Sınıfı	ZD	ZD	ZD
Kat Yüksekliği (m)	3	3	3
Toplam Bina Yüksekliği (m)	30	45	60
Beton Sınıfı	C35	C35	C35
Donatı Çeliği	S420	S420	S420
Kolon Kesiti (cmxcm)	65x60	85x75	95x90
Kiriş Kesiti (cmxcm)	25x50	25x50	30x55
Döşeme Kalınlığı (cm)	15	15	15
P. Duvar Kalınlığı (cm)	25	25	30

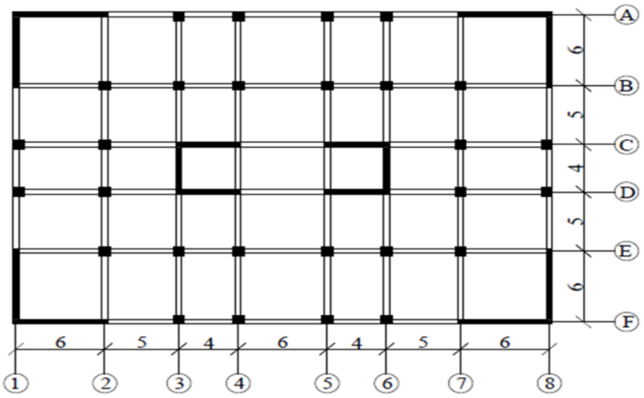

Figure 1. General information about constructions and floor plans.

Results

Data regarding the top floor displacements, and damage levels of structural elements for the most unfavorable of the analysis performed as an example are included in Tables 1, 2, 3 and 4.

Table 1. Damage performances for beams (20-storey)

Beams	TBEC-2018	EC 8	% (TBEC-2018)	% (EC 8)
SH (DL)	884	775	65	56.98
KH (SD)	473	574	34.78	42.21
GÖ (NC)	3	11	0.22	0.81

Table 2. Damage performances for columns (20-storey)

Columns	TBEC-2018	EC 8	% (TBEC-2018)	% (EC 8)
KK	275	244	49.11	43.57
SH (DL)	260	279	46.43	49.82
KH (SD)	25	37	4.46	6.61

Table 3. Damage performances for shear walls (20-storey)

Columns	TBEC-2018	EC 8	% (TBEC-2018)	% (EC 8)
KK	114	113	95	94.17
SH (DL)	4	5	3.33	4.17
KH (SD)	2	2	1.67	1.67

Table 4. Max top floor displacement for all time history analysis

	Ux (cm)	Uy (cm)
10 kat		
TBEC-2018	10.58	10.54
EC 8	16.28	16.53
15 kat		
TBEC-2018	18.46	19.25
EC 8	28.73	29.41
20 kat		
TBEC-2018	29.63	28.59
EC 8	42.37	42.26

Discussion

Although there are studies on determining the seismic performance of existing reinforced concrete buildings according to TBEC-2018 or EC 8, the studies carried out with both regulations are very few. While most of the identified studies are related to the TSC-2007 and Eurocode 8, very few studies are related to TBEC-2018 and Eurocode 8. Due to the lack of sufficient studies and the lack of common and clear findings among the studies conducted, in this study, the nonlinear time history analysis to be carried out according to Eurocode 8 was investigated more comprehensively. The nonlinear time history analysis in Eurocode 8 chapter 3 and chapter 4 was supplied the conditions, analyzes have been made.

Conclusion

As a result of the modal analysis, the building vibration periods obtained according to TBEC-2018 are greater than the values obtained according to Eurocode 8. The reason for this is due to effective section stiffness. As a result of the most unfavorable time history analysis; The maximum displacement values of buildings obtained according to TBEC-2018 were lower than EC 8. According to the data obtained from the analyses, the seismic performance of the structures was determined as controlled damage (significant damage) according to both seismic codes. When we look at the overall numerical data, especially the data of the most unfavorable analysis, it seems that TBEC-2018 is on the safer side compared to Eurocode 8.

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