Advanced Engineering Days

aed.mersin.edu.tr

Comparison of a 9-story reinforced concrete structure using the equivalent seismic load method according to the TSC 2007 and TSC 2019

Furkan İnal *1, **Hüsnü Can** 2

1Mersin University, Civil Engineering Department, Türkiye, furkaninal@mersin.edu.tr
2Gazi University, Civil Engineering Department, Türkiye, husnucan@gazi.edu.tr

Cite this study: İnal, F., & Can, H. (2022). Comparison of a 9-story reinforced concrete structure using the equivalent seismic load method according to the TSC 2007 and TSC 2019. 5th Advanced Engineering Days, 107-110

Keywords
Seismic code
Equivalent seismic load method
Concrete structures

Abstract

This study analyzed a 9-story reinforced concrete structure with a floor plan of 35x25 m^2 using the Equivalent Seismic Load Method following the TSC 2007 and TSC 2019. Using effective cross-sectional stiffness, it was calculated that spectral acceleration values came out more from the solved building according to the TSC 2019 compared to analyses carried out according to TSC 2007. However, because the structural behavior coefficient was taken to be smaller in TSC 2019 due to the shear wall placement, the equivalent seismic loads were close to each other in both analyses. In the new seismic code, the reduction of the stiffness of the load-bearing elements has led to an increase in the period values, which has led to a more ductile behavior of the building.

Introduction

An earthquake has a unique feature among natural disasters in that it occurs without prior warning. Although some preliminary signs can be seen before the earthquake occurs, reliable results on predicting the earthquake in advance are not yet available today [1].

Seismic codes constitute the basis of earthquake-resistant building design and reflect the technology and knowledge of that day's building design. Therefore, to design structures, designers and practitioners should understand current seismic codes well. For this purpose, a 9-story concrete structure with a floor plan of 35x25 m, the height of each floor of which is 3 m, was analyzed using the equivalent seismic load method by TSC 2007 [2] and TSC 2019 [3] and the results obtained were compared.

Material and Method

Version 17.0.1 of the ETABS program was used in the analysis of the reinforced concrete structure [4]. The class of reinforced concrete elements is selected as C35, the modulus of elasticity of the material is taken as E_c=33000 MPa, while the reinforcement class is B420C, and the modulus of elasticity is E_s=200000 MPa. Dead and live loads applied to the structure are given in Table 1 and Table 2.

Table 1. Dead loads affecting the structure

Weight of the structure	γ_c = 25 kN/m^3
Flooring load (Normal story)	g = 1,5 kN/m^2
Partition wall	g = 4 kN/m^3
Flooring load (Rooftop)	g = 4 kN/m^3

Effective section stiffness factors, one of the biggest innovations brought by the 2019 Seismic Code, were used in the analyzes made according to the TSC 2019, and the stiffness factors of the load-bearing elements were not changed in the analyzes made according to the TSC 2007.

Table 2. Live loads affecting the structure

Slab live load	q = 3,5 kN/m^2
Rooftop live load	q= 1,00 kN/m^2
Snow load	q = 0,75 kN/m^2

Istanbul/Avcılar was chosen as the place where the structure will be built. According to TSC 2007, the soil class was designated as Z3, while according to TSC 2019, the soil class was selected as ZD.

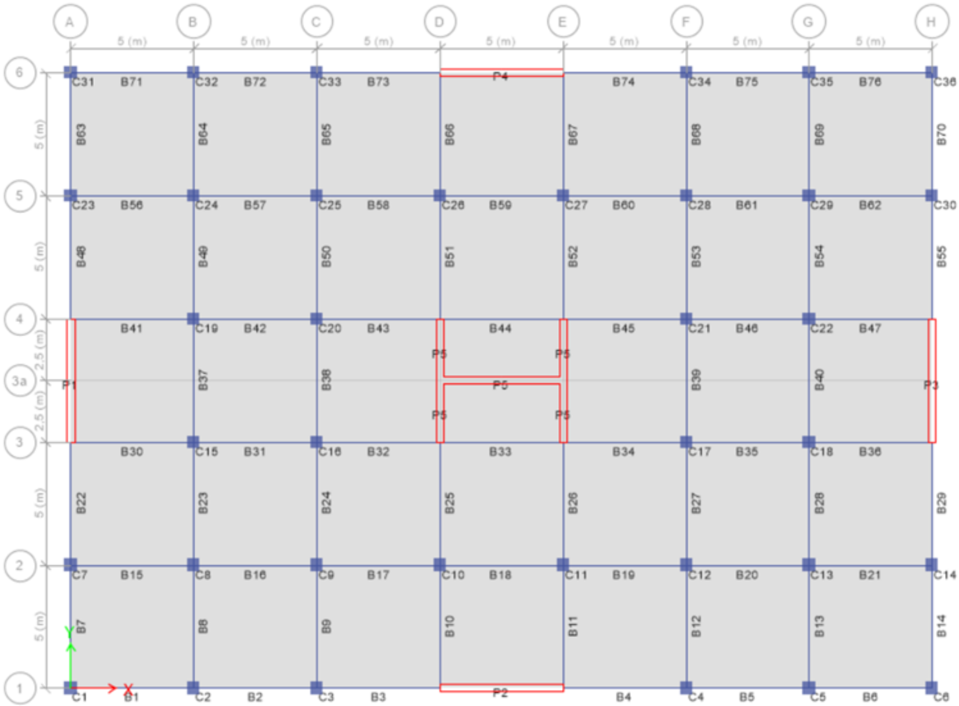


Figure 1. Floor plan of the building

The height of all floors is 3 m. The floor plan of the building is shown in Figure 1, the sectional and perspective views are shown in Figure 2. The building was planned to be used as a residence, the floors were considered as a rigid diaphragm and ±5% additional eccentricities were calculated in two vertical directions perpendicular to each other.

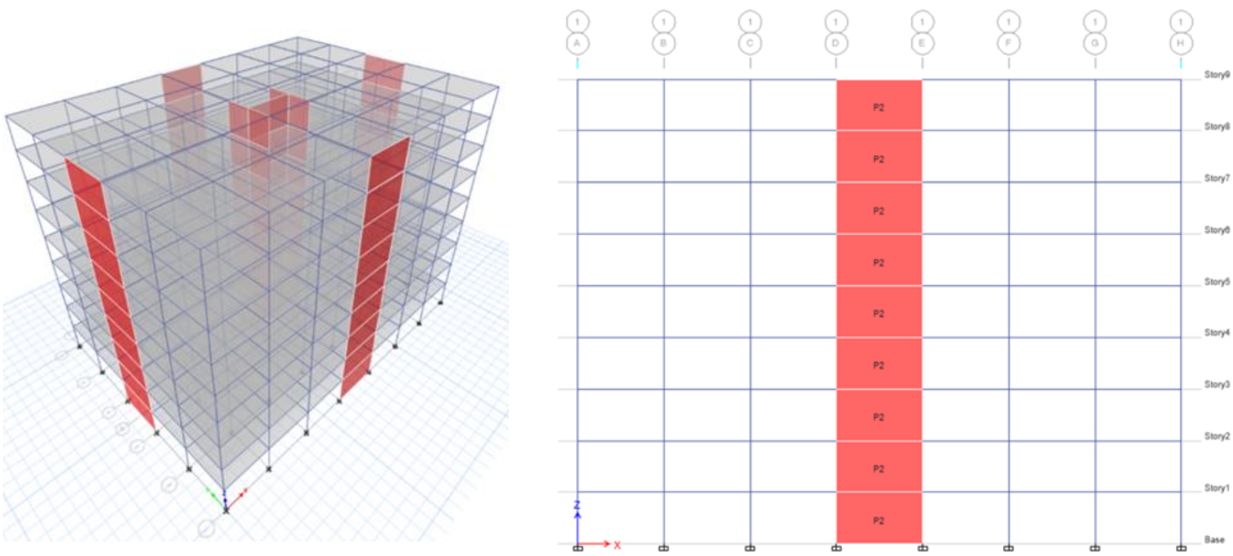


Figure 2. Perspective and 1-1 cross-sectional view of the 9-story building

In Table 3, the overturning moment (ΣM_{DEV}) values of the shear walls of the structure and the overturning moments (ΣM_o) for the whole building due to seismic loads are given.

Table 3. Overturning moments of the shear walls and the whole building

Shear walls	X-X Direction Bending Moment (kNm)	Y-Y Direction Bending Moment (kNm)
P1	369	83913
P2	80920	353
P3	369	83913
P4	80920	353
P5	323459	168591
ΣM_{DEV}	486037	337122
ΣM_o	1048224	935587

In Table 4, it is seen that the overturning moment calculated for the whole building (M_o) is less than 1/3 of the calculated earthquake direction for any of the shear walls.

Table 4. $M_o/3$ control in a 9-story structure

Shear walls	X Direction $\Sigma M_{DEV}/\Sigma M_o$	Y Direction $\Sigma M_{DEV}/\Sigma M_o$
P1	0,04%	8,97%
P2	7,72%	0,04%
P3	0,04%	8,97%
P4	7,72%	0,04%
P5	30,86%	18,02%

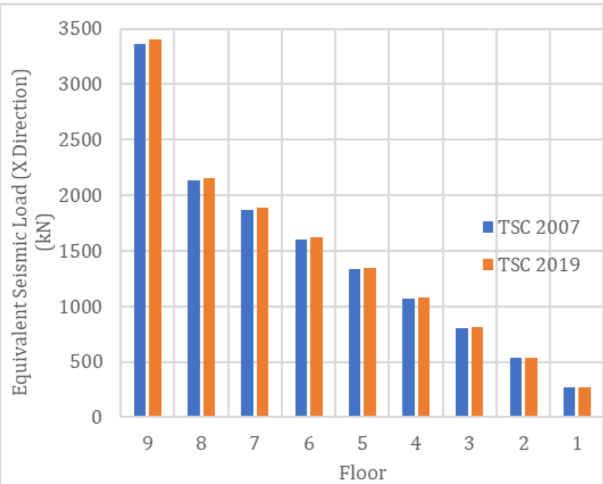
In Table 5, the structural response coefficient (R) will be used as 5.60 since the sum of the base overturning moment of the shear walls (M_{DEV}) at the side axis of the building is less than 1/6 of the total overturning moment for the entire structure (M_o).

Table 5. $M_o/6$ control in a 9-story structure

Shear walls	X Direction $\Sigma M_{DEV}/\Sigma M_o$	Shear walls	Y Direction $\Sigma M_{DEV}/\Sigma M_o$
P2	7,72%	P1	8,97%
P4	7,72%	P3	8,97%

Results and Discussion

The distribution of the shear forces calculated in the X and Y directions to the floors of the building as a result of the analyzes made using the Equivalent Seismic Load Method specified in the 2007 and 2019 seismic codes are given in Figure 3.



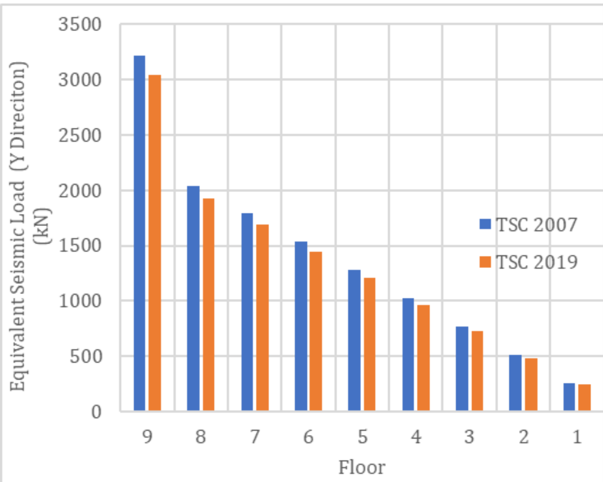


Figure 3. Equivalent seismic forces acting on the structure in the X and Y directions

When Figure 3 is examined, it was found that the seismic loads in the X and Y directions were almost the same. To better understand the role of effective cross-sectional stiffness in calculations, it is necessary to examine the spectral acceleration values corresponding to the given natural vibration periods in Table 6.

Table 6. Elastic spectral acceleration values corresponding to the natural vibration periods of the structure

	TSC 2007 (sec)	Structural Behavior Coefficient (R)	Spectral Acceleration (g)	TSC 2019 (sec)	Structural Behavior Coefficient (R)	Spectral Acceleration (g)
X Direction	0,57	7.00	1	0,833	5.60	≈ 0,808
Y Direction	0,634	7.00	≈ 0,96	0,93	5.60	≈ 0,724

According to the new code, changing the effective sectional stiffness of the load-bearing elements has led to a longer period of the structure, which has led to a greater increase in the unreduced seismic load values of the previous code. However, because of the new code penalizing the structure due to the shear walls placement, the unreduced seismic loads were divided into 7 in the previous regulation, while in the new regulation it was divided into 5.60, which led to the fact that the values of seismic loads calculated according to the TSC 2019 were close to the values of seismic loads calculated according to the TSC 2007.

Conclusion

When the results of the analysis made according to both seismic codes are examined, it has been determined that the structure solved with the TSC 2019 exhibits a more ductile behavior, since the effective section stiffness is taken into account. Compared to the horizontal elastic design spectra of the 2007 and 2019 Seismic Codes, the spectral acceleration values of the TSC 2019 are higher. However, in TSC 2019, it was observed that the equivalent seismic loads were similar to each other since the structural behavior coefficient was taken to be smaller due to the shear walls layout. While the differences between the shear forces calculated for the X direction were insignificant, the shearing forces calculated with TSC 2019 for the Y direction were discovered to be 5.5% less compared to TSC 2007.

References

1. Celep, Z. (2018). Deprem Mühendisliğine Giriş ve Depreme Dayanıklı Yapı Tasarımı. İstanbul: Beta Publications.
2. TSC-2007. (2007). Specifications for buildings to be built in seismic areas. Ministry of Public Works and Settlement.
3. TSC 2019. (2018). Turkish Seismic Code. Disaster and Emergency Management.
4. ETABS 2017. (2017). Extended Three-Dimensional Analysis of Building Systems. Computer and Structures Inc.