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Comparison of an 18-story reinforced concrete structure using the response spectrum analysis according to the TSC 2007 and TSC 2019

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Abstract

This study utilized TSC 2007 and TSC 2019 seismic codes to investigate the earthquake forces of an 18-story reinforced concrete building with a 35x25m^2 floor plan using the response spectrum method. Because of the effective cross-sectional stiffness, spectral accelerations are greater in TSC 2007 than in TSC 2019. Even though the structural behavior coefficient was taken to be smaller in TSC 2019 due to the shear wall placement, the shear forces of the previous code are greater. 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

Numerous cities have been founded and thrived in earthquake-prone locations throughout history. The risk of loss of life and property from earthquakes is increasing as cities grow and structure heights rise. As a result, structures in earthquake zones must be earthquake-resistant.

To develop structures, designers and practitioners must comprehend the most recent seismic codes, which serve as the cornerstone of earthquake-resistant structures. In this investigation, the response spectrum analysis approach described in TSC 2007 [1] and TSC 2019 [2] was utilized to investigate an 18-story concrete building, and the results were compared.

Material and Method

Version 17.0.1 of the ETABS program was used in the analysis of the reinforced concrete structure [3]. The class of reinforced concrete elements is selected as C40, the modulus of elasticity of the material is taken as E_c=34000 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

Concrete load	γ_c = 25 kN/m^3
Slab load (Normal story)	g = 1,5 kN/m^2
Partition wall	g = 4 kN/m^3
Slab 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 analyses made according to the TSC 2019, and the stiffness factors of the load-bearing elements were not changed in the analyses 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

İstanbul/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.

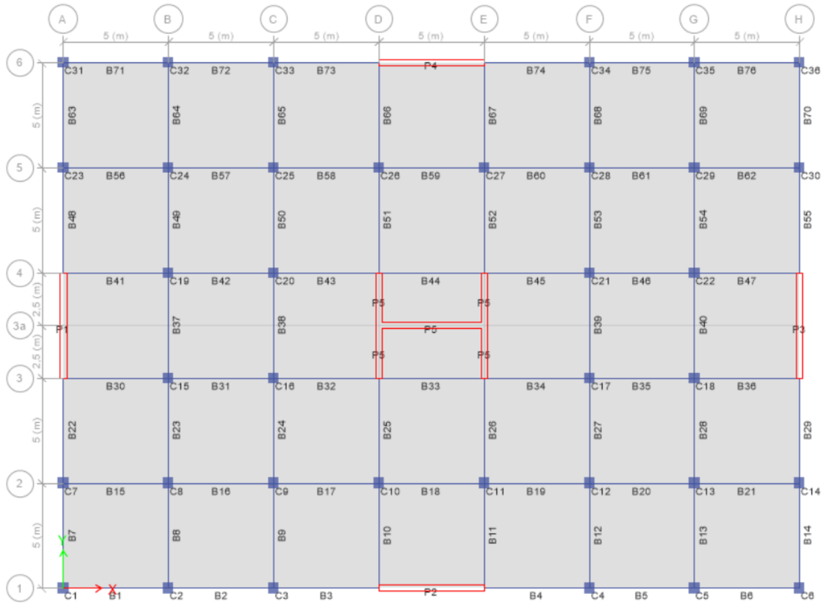


Figure 1. Floor plan of the building

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.

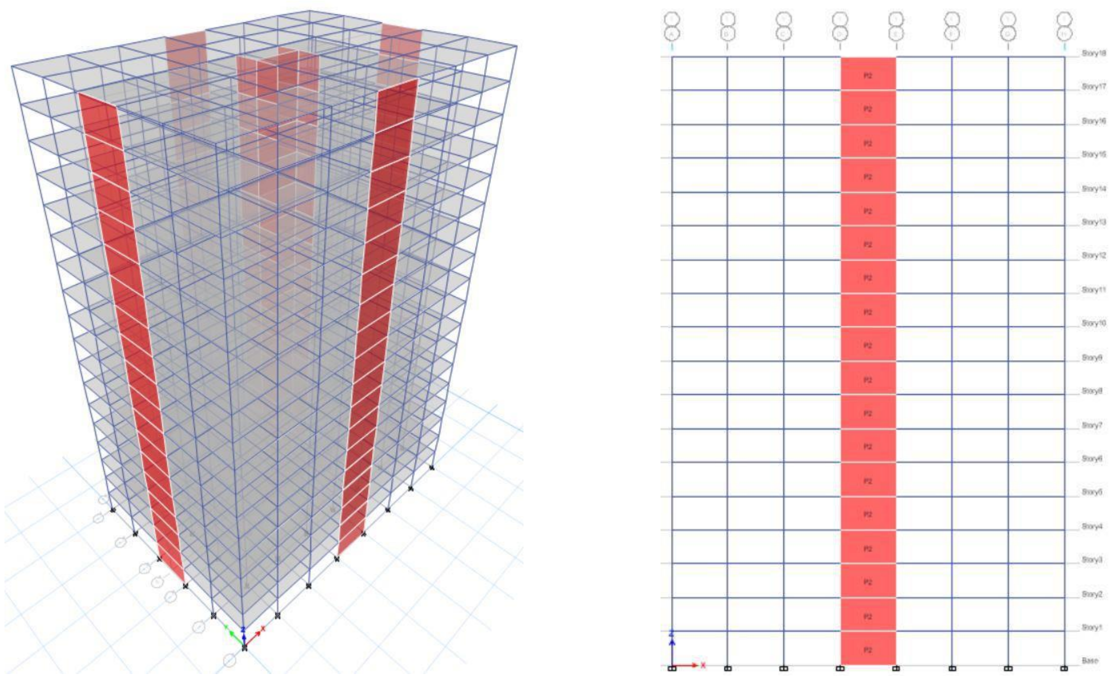


Figure 2. Perspective and 1-1 cross-sectional view of the 18-story building

Table 3 gives the overturning moment (ΣM_{DEV}) values of the shear walls of the structure and the overturning moments (ΣMo) for the building due to seismic loads.

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

Shear walls	X-X Direction Bending Moment (kNm)	Y-Y Direction Bending Moment (kNm)
P1	365	86242
P2	82106	358
P3	365	86242
P4	82106	358
P5	342890	173224
ΣM_{DEV}	507833.01	346425.99
ΣM_o	1876274	1731952

Table 4 shows 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 the 18-story structure

Shear walls	X Direction $\Sigma M_{DEV}/\Sigma M_o$	Y Direction $\Sigma M_{DEV}/\Sigma M_o$
P1	0.02%	4.98%
P2	4.38%	0.02%
P3	0.02%	4.98%
P4	4.38%	0.02%
P5	18.28%	10.00%

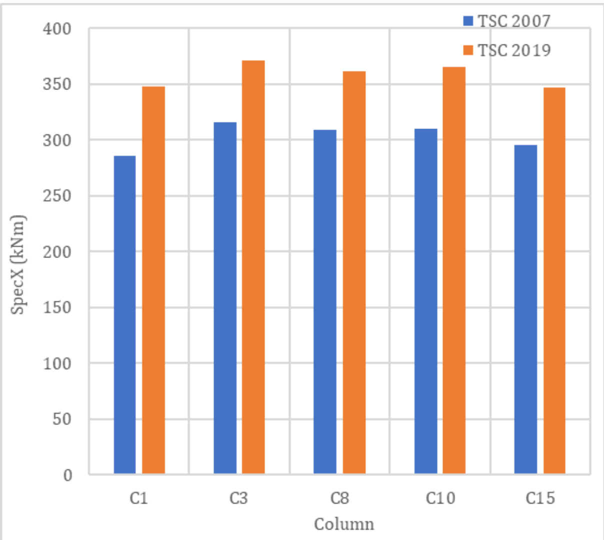
In Table 5, the sum of the base overturning moment of the shear walls (M_{DEV}) at the side axis of the building is less than 1/6 of the total overturning moment for the entire structure (M_o) consequently structural response coefficient (R) will be used as 5.60.

Table 5. $M_o/6$ control in the 18-story structure

Shear walls	X Direction $\Sigma M_{DEV}/\Sigma M_o$	Shear walls	Y Direction $\Sigma M_{DEV}/\Sigma M_o$
P2	4.38%	P1	4.98%
P4	4.38%	P3	4.98%

Results and Discussion

Figure 3 shows the distribution of the moments derived in the X and Y directions of the chosen columns on the first floor as a result of analyses performed using the Response Spectrum Method as stipulated in the 2007 and 2019 seismic codes. TSC 2019 moment values were higher in both directions than the preceding code.



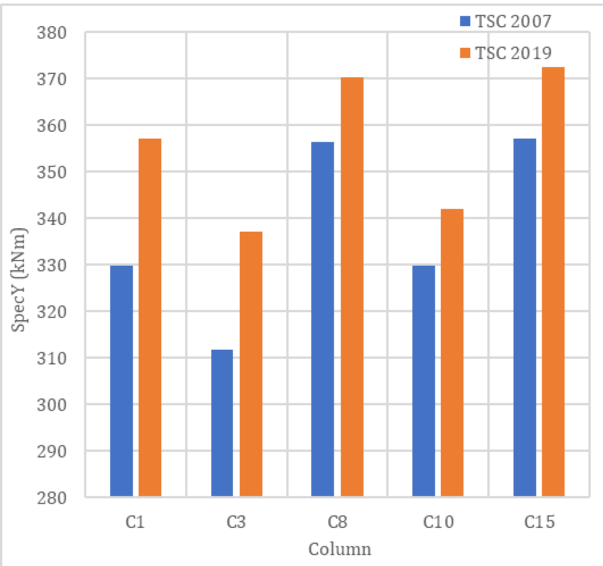


Figure 3. Moment values according to response spectrum analysis in the X and Y directions

In Table 6, changing the effective sectional stiffness of the load-bearing elements has led to a longer period of the structure, which has led to lesser shear forces in the current code. Although the new code penalizes the structure due to the location of the shear walls, the seismic forces of the previous code are still higher than those of the 2019 TSC.

Table 6. Shear forces according to response spectrum analysis

	TSC 2007				TSC 2019			
	T (sec)	Structural Behavior Coefficient (R)	Spectral Acceleration (g)	V_{tx} (kN)	T (sec)	Structural Behavior Coefficient (R)	Spectral Acceleration (g)	V_{ty} (kN)
X Direction	1.22	7.00	≈0.567	12197.26	1.843	5.60	≈0.365	11337.06
Y Direction	1.335	7.00	≈0.527	12741.63	2.006	5.60	≈0.345	10380.49

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 both seismic codes, the spectral accelerations of the TSC 2007 are higher. This leads to a higher computation of the shear forces determined by the response spectrum analysis in the 2007 code. However, when the selected columns on the first floor are examined, it is observed that the moment values in the new code are 18% higher in the X direction and 6% higher in the Y direction than in the prior regulation.

References

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