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Article

Studying the Effect of Using High Performance Concrete on the Lateral Displacement and Over All Stability of Tall Building

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Abstract: In the pursuit of sustainability, the construction of tall buildings is essential, and new types of concrete can contribute to miniaturizing architectural sections. This research studied a 20-story framed building under two conditions: using ordinary concrete and using high-performance concrete. We found that the building's footprint decreased by approximately 21% in the high-performance concrete case, and the lateral displacement of the top of the building decreased by 31%. Furthermore, we observed that high-performance concrete played a significant role in increasing the building's rigidity, thus enabling the use of smaller structural and architectural elements on larger floors.

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1. Introduction

With increasing population, vertical expansion became necessary instead of horizontal expansion, especially in light of sustainable development and the need to preserve resources for future generations, reduce construction costs, and ensure the provision of services. [1] From this perspective, and with the increasing height of buildings, numerous forces and difficulties arose for this type of building, particularly lateral loads resulting from wind gusts or natural and man-made earthquakes. [2] These forces pose a significant challenge, especially regarding lateral displacement, in addition to second-degree effects that generate forces and stresses that can compromise the overall stability of the structure. [3] To address such challenges, many designers resorted to increasing the dimensions of building elements, thereby increasing the building's self-weight. This, in turn, affects the seismic forces resulting from this weight, in addition to reducing the architectural space. [4] To address this problem, high-performance concrete emerged as an innovative solution that could meet the requirements of these high-rise towers. [5] This concrete possesses several advantages, most notably its high modulus of elasticity, high resistance to creep and shrinkage, [6] and the building's ability to resist lateral deformations and reduce displacement. Hence, the need arose to study the effect of using high-performance concrete on lateral deflection. The overall stability of high-rise buildings[7].

2. Research objective

To study and evaluate the success of high-performance concrete in reducing lateral displacement of tall buildings and improving overall stability under earthquake impact.

3. Literature review

Many recent scientific studies have focused on high-performance concrete, particularly its mechanical properties. These studies have found that the primary advantage of using high-performance concrete lies not only in its increased compressive strength but also in its higher modulus of elasticity [8]. This modulus is a crucial factor in controlling deformations, especially those related to lateral loads [9]. One study demonstrated that using high-performance concrete in columns and shear walls, especially in basements, can reduce creep and maintain building stability.

Analysis of high-rise tower models has shown that replacing conventional concrete with high-performance concrete reduces lateral displacement by 15-25%. Other studies have also found that high-performance concrete has a positive effect on buckling resistance and second-order stress resistance [10]. Khan [11] found that the high strength and modulus of high-performance concrete lead to a lower stability coefficient and reduce safety risks.

Tang[12] found that this type of concrete allows for a reduction in the cross-sectional area of columns and shear walls, especially in basements, and thus can reduce the architectural problem.

Table 1. References.

Researcher	The studied models and concrete resistance	Type of structural analysis	Number of floors studied	Key findings of the study
Jiao et al. [10]	Core Walls	(Nonlinear Time-History)	Towers of varying heights	Increasing the modulus of elasticity of high-performance concrete increased the flexural stiffness of the building, reducing the lateral displacement between floors ($Inter-story Drift$) by 15% to 25%.
Guo et al[13]	Concrete frames and shear walls combined using fiber-reinforced HPC.	Pushover Dynamic	40-60 story	The use of HPC resulted in a 20% reduction in the cross-sections of the lower columns without negatively affecting lateral stiffness, with a significant improvement in seismic energy absorption and displacement control.
Smith & Tang[12]	Outrigger System	Response Spectrum	50 story	The use of HPC in the tie beam columns (Outriggers) increased the system's efficiency in restricting tower movement, reducing the maximum lateral displacement at the top of the building (Top\ Drift) by 18%.

4. Research Methodology

In our research, we will study the case of a regular frame building rising to a height of 20 stories with a regular plan. We will study two cases: one using ordinary concrete and the other using high-performance concrete, and compare them. The ordinary concrete will be type C30, while the high-performance concrete will be type C80; consequently, the EI value will differ accordingly. For modeling, we will use the American code ACI318 [14], and for applying lateral loads, we will use the American code UBC97. We will apply the response spectrum, using a building with SB soil, and in the third seismic zone according to the American code, with the P-delta indices activated [15].

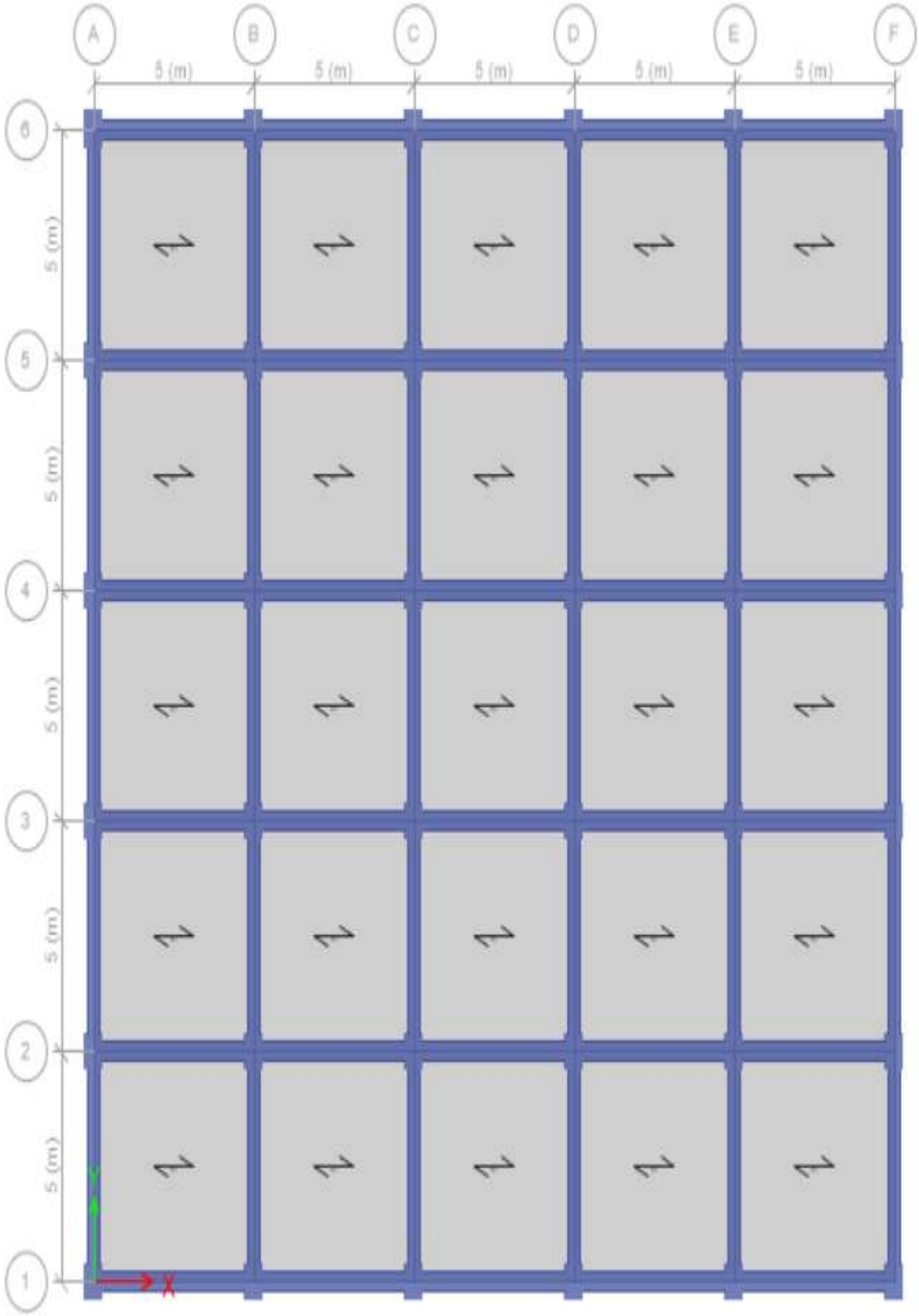


Figure 1. horizontal projection.

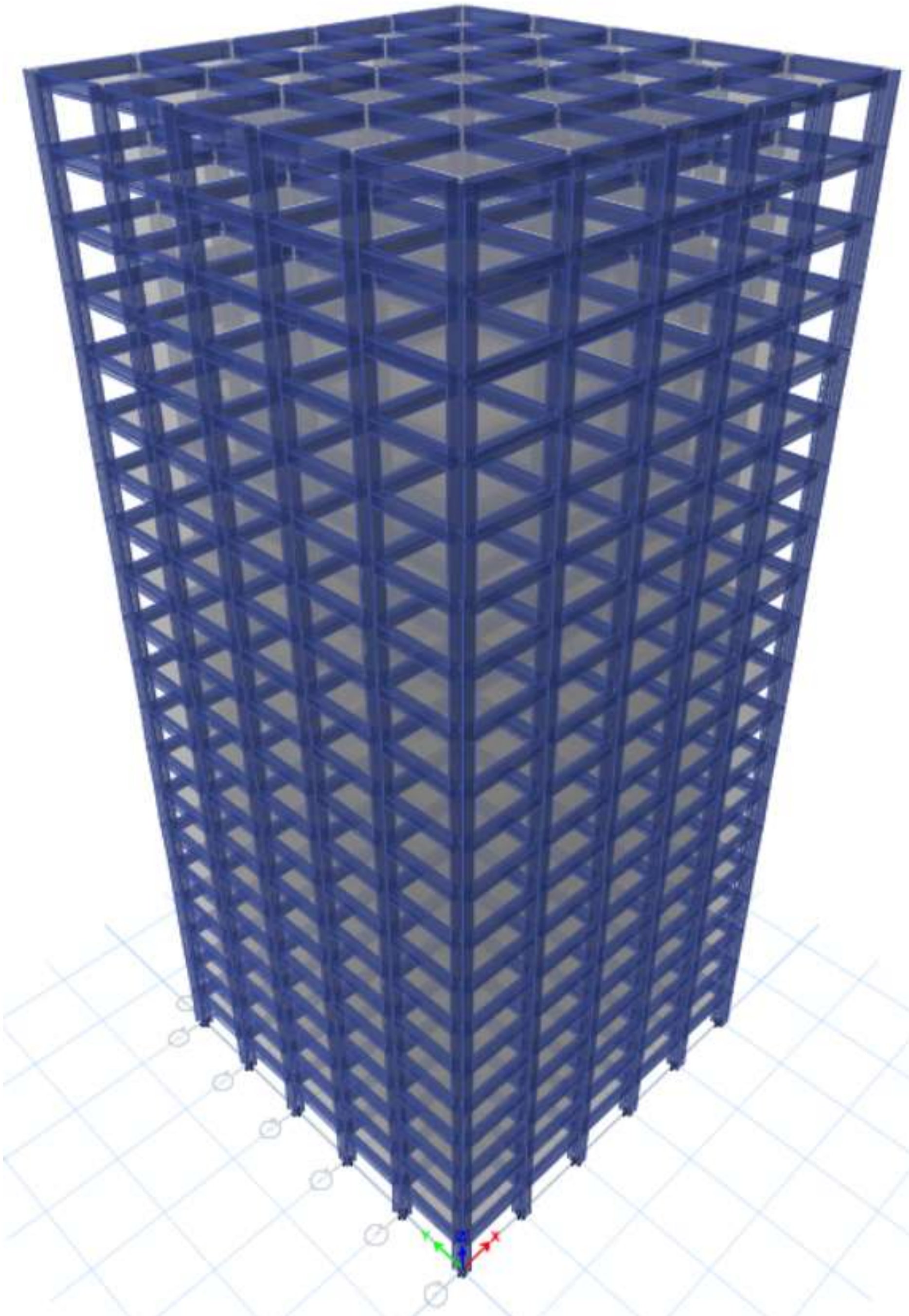
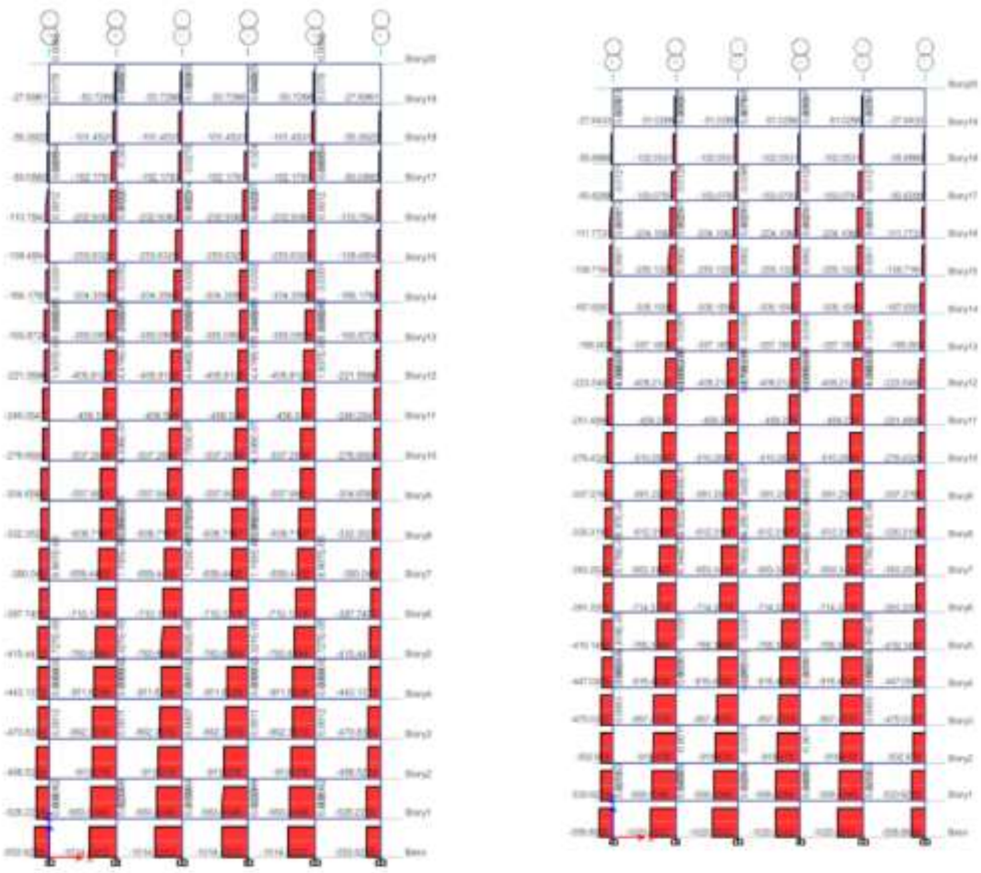


Figure 2. Model.

5. Results and Discussion

After constructing the model, it was subjected to loads, both dead and live, followed by seismic loads calculated using the response spectrum. A comparison of the main forces and factors between the two models reveals the following: Firstly, the generated internal forces, such as the axial forces in the columns resulting from the self-weight load, are as follows:

Internal Force:



C30 C80

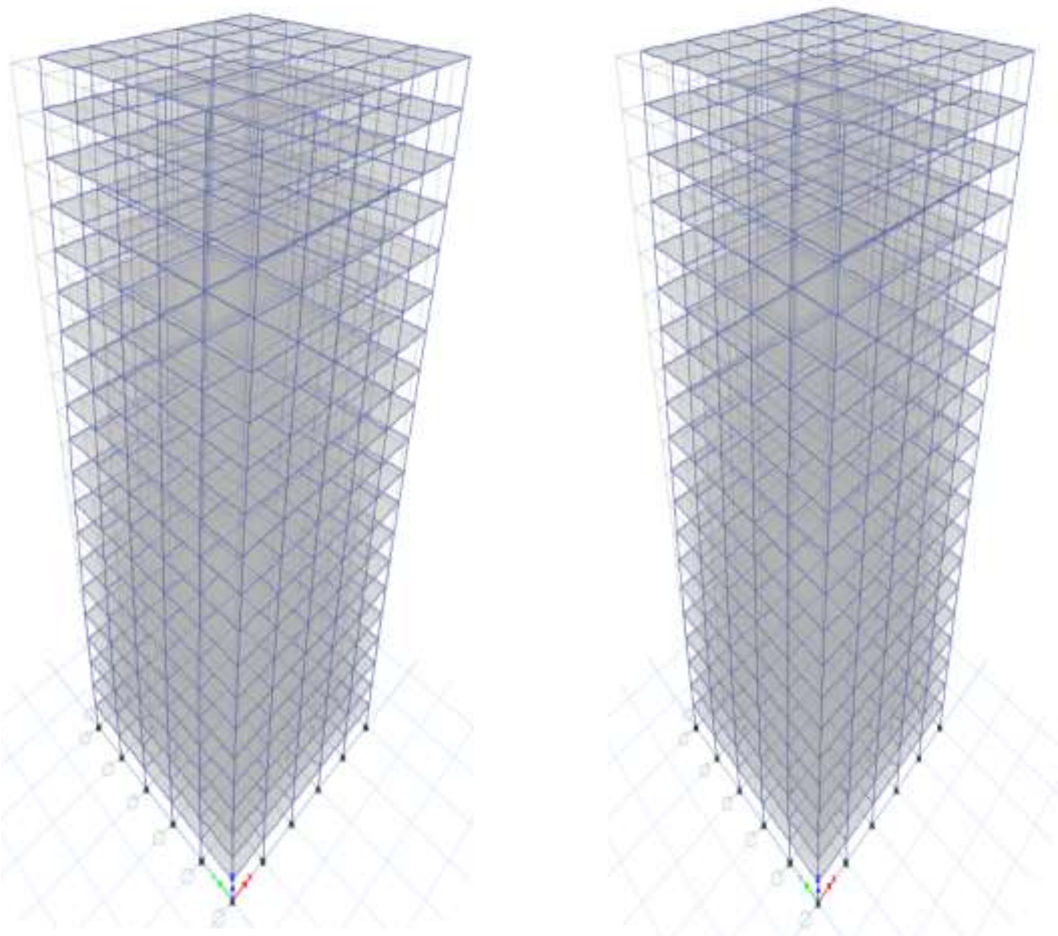
Figure 3. Internal Force.

From the previous figure, we observe that the difference in axial forces resulting from self-weight on the columns was small between the two types of concrete used, meaning that the load is almost the same for both, since we did not modify the sections by changing the type of concrete material.

Period

Comparing the building's lifespan, we observe that for standard concrete, the lifespan was approximately 8.09 seconds, compared to 6.4 seconds for high-performance concrete. This is attributed to the superior strength exhibited by this type of concrete.

Displacement



C30 C80

FIG(4) Displacement

The displacement at the top of the building due to normal seismic loading was greatest at 90 cm at the top of the last floor in the case of high-performance concrete, and the displacement at the top of the building in the case of ordinary concrete was 1.3 meters.

6. Conclusions

Based on the previous results obtained from analyzing a 20-story building with a frame made of ordinary reinforced concrete and the same building with the same sections made of high-performance reinforced concrete, we concluded the following:

The use of high-performance reinforced concrete played a significant role in lateral stiffness due to its high modulus of elasticity, thus allowing for a reduction in the architectural cross-sections of the columns.

The structural load was reduced by approximately 21% in the case of high-performance concrete compared to ordinary reinforced concrete.

The lateral displacement of the top of the building was reduced by 31% in the case of high-performance concrete.

The internal forces were almost the same despite the use of high-performance concrete, but it was possible to reduce the architectural cross-sections, and consequently the self-weight, which led to a reduction in seismic loads and other variables. From the above, we observe that high-performance concrete played a significant role in increasing the building's stiffness, thus enabling the use of smaller structural and architectural elements on large floors.

REFERENCES

[1] M. M. Ali and K. Moon, "Structural developments in tall buildings: Current trends and future prospects," *Architectural Science Review*, vol. 50, no. 3, pp. 205–223, 2007.

[2] T. Ji, "A safety concept for tall buildings under lateral loads," *The Structural Design of Tall and Special Buildings*, vol. 22, no. 12, pp. 911–922, 2013.

[3] A. K. Chopra, *Dynamics of Structures: Theory and Applications to Earthquake Engineering*, 5th ed. Upper Saddle River, NJ: Prentice Hall, 2017.

[4] B. S. Taranath, *Structural Analysis and Design of Tall Buildings: Steel and Composite Construction*. CRC Press, 2016.

[5] P. C. Aïtcin, *High-Performance Concrete*. London: E & FN Spon, 1998.

[6] H. G. Russell, "High-performance concrete—From material to structure," *ACI Structural Journal*, vol. 96, no. 6, pp. 957–964, 1999.

[7] F. Altun, O. Kisi, and K. Aydin, "Predicting the modulus of elasticity of high-performance concrete using soft computing techniques," *Construction and Building Materials*, vol. 22, no. 5, pp. 838–846, 2008.

[8] P. C. Aïtcin, "The durability of high-performance concrete: a review," Cement and Concrete Composites, vol. 25, no. 4-5, pp. 409–420, 2003.

[9] H. G. Russell, "High-performance concrete applications in My Thuan Bridge," ACI Structural Journal, vol. 102, no. 2, pp. 245–252, 2005.

[10] L. Jiao, M. An, and H. M. Shin, "Seismic behavior and drift control of tall buildings using high-strength concrete core walls," Journal of Structural Engineering, vol. 138, no. 6, pp. 780–792, 2012.

[11] R. Khan, "P-Delta effects in high-rise concrete buildings utilizing high-performance materials," Engineering Structures, vol. 41, pp. 290–301, 2012.

[12] J. Smith and Y. Tang, "Structural and economic optimization of tall buildings with high-performance concrete," The Structural Design of Tall and Special Buildings, vol. 25, no. 14, pp. 711–728, 2016.

[13] Y. Guo, L. Zhang, and X. Liu, "Seismic performance and drift evaluation of tall frame-shear wall structures with fiber-reinforced high-performance concrete," *Structures*, vol. 34, pp. 1102–1115, 2021

[14] Building Code Requirements for Structural Concrete (ACI 318-19), *Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary*. Farmington Hills, MI, USA: American Concrete Institute, 2019.

[15] Uniform Building Code (UBC 1997), *Uniform Building Code, Vol. 2: Structural Engineering Design Provisions*. Whittier, CA, USA: International Conference of Building Officials (ICBO), 1997.