Effects of Concrete filled Steel tubular sections on seismic response of multistoried building

Priyanka samadhan Jadhav and Sarjerao Patil

Department of Civil Engineering, Sipna College Of Engineering And Technology, Amravati, Maharashtra, India

Email: smh.pelfberry@gmail.com

How to Cite this Article:

Jadhav, P. S. & Patil, S. (2026). Effects of Concrete filled Steel tubular sections on seismic response of multistoried building. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(6). https://doi.org/10.55041/ijcope.v2i5.490

https://doi.org/ 10.55041/ijcope.v2i5.490

Introduction

The increasing growth of urban infrastructure and rising awareness regarding earthquake safety have created a strong demand for durable, economical, and earthquake-resistant multistorey buildings. Reinforced cement concrete (RCC) framed structures have traditionally been the most widely adopted construction system because of their simplicity, availability of materials, and cost-effectiveness. However, conventional RCC structures may experience limitations in terms of ductility, seismic energy dissipation, and post-earthquake structural recovery, especially in regions subjected to strong seismic activity. To overcome these challenges, composite structural systems such as Concrete-Filled Steel Tubular (CFST) members have emerged as an efficient alternative for seismic-resistant construction.

CFST members consist of hollow steel tubes filled with concrete, combining the advantageous properties of both materials into a single structural element. The steel tube provides tensile strength, confinement, and enhanced ductility, while the concrete core contributes compressive strength, stiffness, and improved fire resistance. Due to this composite interaction, CFST members demonstrate superior structural efficiency and seismic performance compared to conventional RCC members. When incorporated into multistorey buildings as columns or lateral load-resisting components, CFST systems can significantly influence important dynamic characteristics such as natural time period, stiffness distribution, modal behavior, and overall seismic response. Consequently, parameters including lateral displacement, storey drift, base shear, storey shear, time period, and storey stiffness are directly affected by the adoption of CFST members.

The present study aims to compare the seismic behavior of conventional RCC framed buildings with equivalent structures utilizing CFST sections in major load-bearing components. The investigation seeks to evaluate variations in global and local seismic performance parameters and to identify the structural mechanisms responsible for improvements in seismic resistance. The study also intends to provide practical recommendations for the design and retrofitting of buildings located in earthquake-prone regions.

A reliable comparative analysis requires that all models be developed using consistent assumptions regarding geometry, loading conditions, mass distribution, and seismic input. Therefore, the floor plan, loading pattern, and overall building configuration are maintained identical for both RCC and CFST structural systems, while only the material and sectional properties are varied. The primary response parameters selected for comparison include lateral displacement, inter-storey drift, base shear, storey shear, natural time period, and storey stiffness. These parameters are critical indicators of structural safety and seismic performance. Lateral displacement and storey drift are directly related to serviceability and non-structural damage, while excessive drift may lead to structural instability and collapse. Base shear and storey shear represent the magnitude and distribution of seismic forces within the structure and indicate the demand imposed on foundations and vertical load-resisting elements.

The natural time period of a structure governs its interaction with earthquake ground motion and significantly influences seismic acceleration response. Structures with shorter time periods generally attract higher seismic forces in certain spectral ranges but may experience reduced displacement demands. Storey stiffness distribution is another important factor affecting mode shapes, deformation patterns, and concentration of seismic demand. CFST members generally provide higher stiffness and improved ductility compared to conventional RCC sections. The confinement effect of the steel tube delays concrete cracking and spalling, while the composite action between steel and concrete improves post-yield behavior and energy dissipation capacity. As a result, buildings incorporating CFST members often exhibit reduced lateral displacement and lower storey drift, although they may attract comparatively higher base shear due to increased stiffness.

From the perspective of modern seismic design philosophy and performance-based engineering, evaluation of CFST systems should not be limited to linear elastic analysis alone. Comprehensive seismic assessment requires nonlinear static and dynamic analyses, including pushover analysis and time-history analysis, to evaluate energy dissipation characteristics, plastic hinge formation, and post-elastic behavior. The actual seismic performance of CFST structures also depends on factors such as connection detailing, structural redundancy, fabrication quality, and construction practices. Additionally, economic considerations, fabrication facilities, and local construction expertise influence the practical implementation of CFST systems in the building industry.

Through a systematic comparative investigation of RCC and CFST structural systems, the present research aims to provide a clear understanding of the seismic advantages and limitations associated with CFST applications in multistorey buildings. The study focuses on evaluating displacement behavior, drift response, base shear, storey shear, natural time period, and storey stiffness to support the development of safer and more efficient earthquake-resistant structural systems.

The development of composite structural systems combining steel and concrete has received considerable attention in structural engineering research over the past few decades. Among various composite systems, CFST members have emerged as one of the most promising solutions for seismic-resistant structures. Earlier experimental and analytical studies established that the steel tube confinement significantly improves the compressive strength and ductility of the concrete core, while the concrete infill delays local buckling of the steel tube. This composite interaction enables CFST sections to sustain larger inelastic deformations and plastic rotations without sudden failure.

Several researchers have demonstrated that CFST columns possess superior axial load capacity, bending resistance, and energy dissipation characteristics compared to conventional RCC columns. Experimental investigations on cyclically loaded composite frames have shown stable hysteretic behavior and enhanced seismic performance for structures incorporating CFST columns. Properly detailed beam-to-column connections in CFST frames also facilitate controlled yielding in beams, thereby preventing undesirable column failure mechanisms and improving overall structural ductility.

2. Modeling

Table 3.1: Analysis data for example building

Plane dimensions	12x12 m
Total height of building	91 m
Height of each storey	3m
Height of parapet	1m
Depth of foundation	1.5m
Size of RC beams	300x450mm
size of RC columns	500x500mm
Size of steel beams	ISMB 500
size of steel columns	ISMB 600
Size of concrete filled steel beams	300x300x12mm
size of concrete filled steel columns	300x450x12mm
Thickness of slab	125 mm
Thickness of external walls	230 mm
Thickness of internal walls	115mm
Thickness of shear wall	230mm
Seismic zone	IV
Soil condition	Hard
Response reduction factor	5
Importance factor	1
Floor finishes	1.5 kN/m^2
Live load at all floors	3 kN/m^2
Grade of Concrete	M25
Grade of Steel	Fe500
Density of Concrete	25 kN/m^3
Density of brick masonry	20 kN/m^3

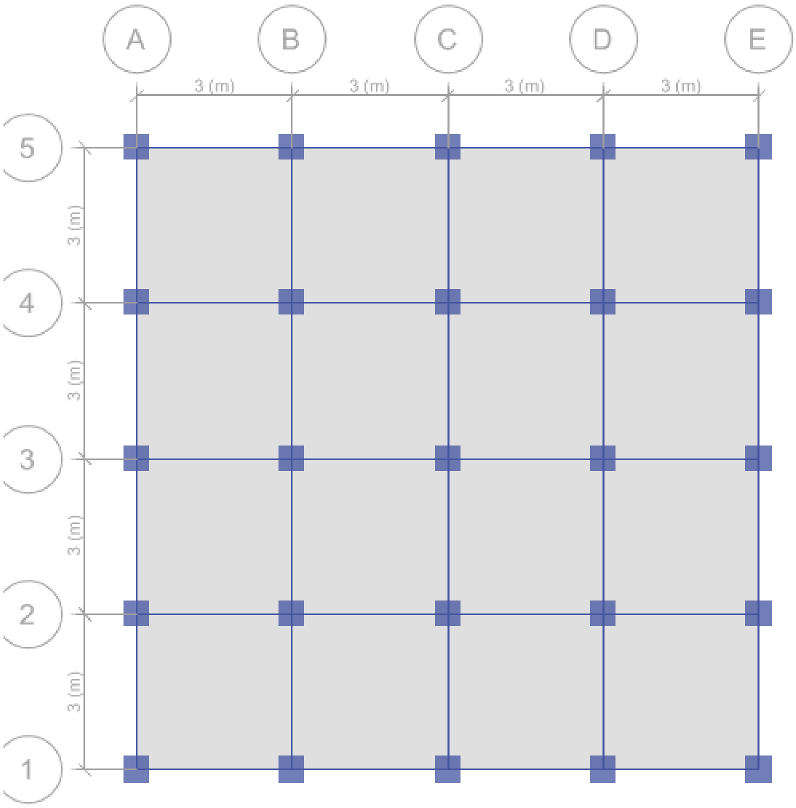

Figure 1 : Plan of building

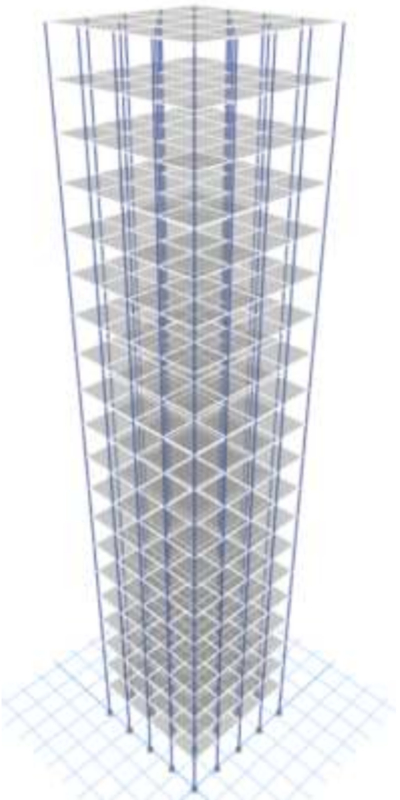

Figure2: 3D Model of building generated in ETABS

ISSN: **3108-1754 (Online)**
Volume 02 Issue 06 June-2026 | Impact Factor: 3.5

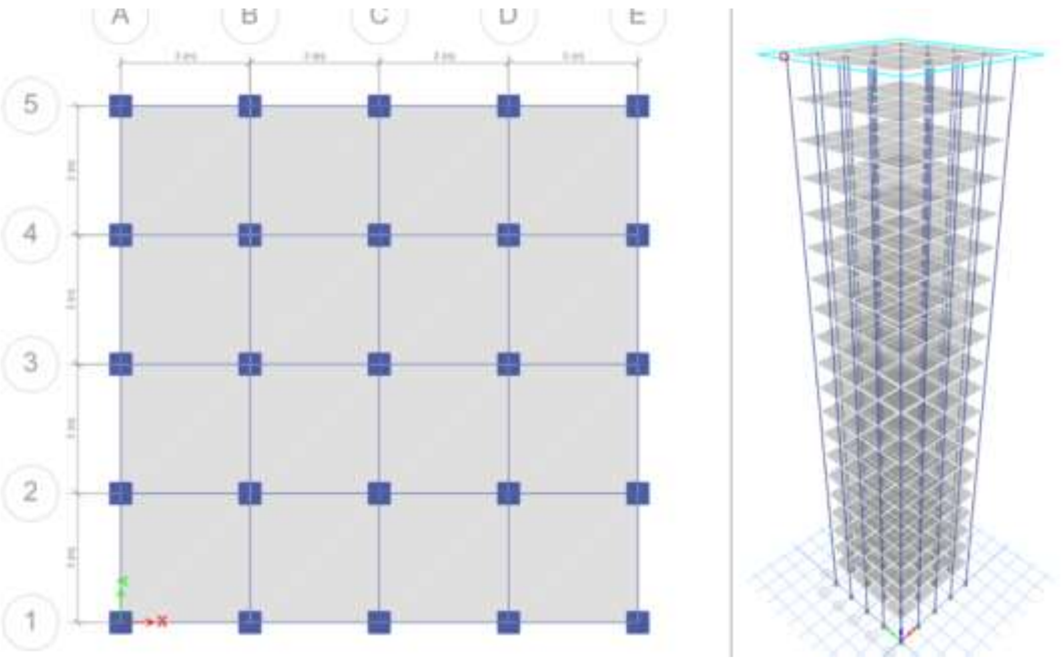

Figure 3: Model I: 20 storey RCC Building

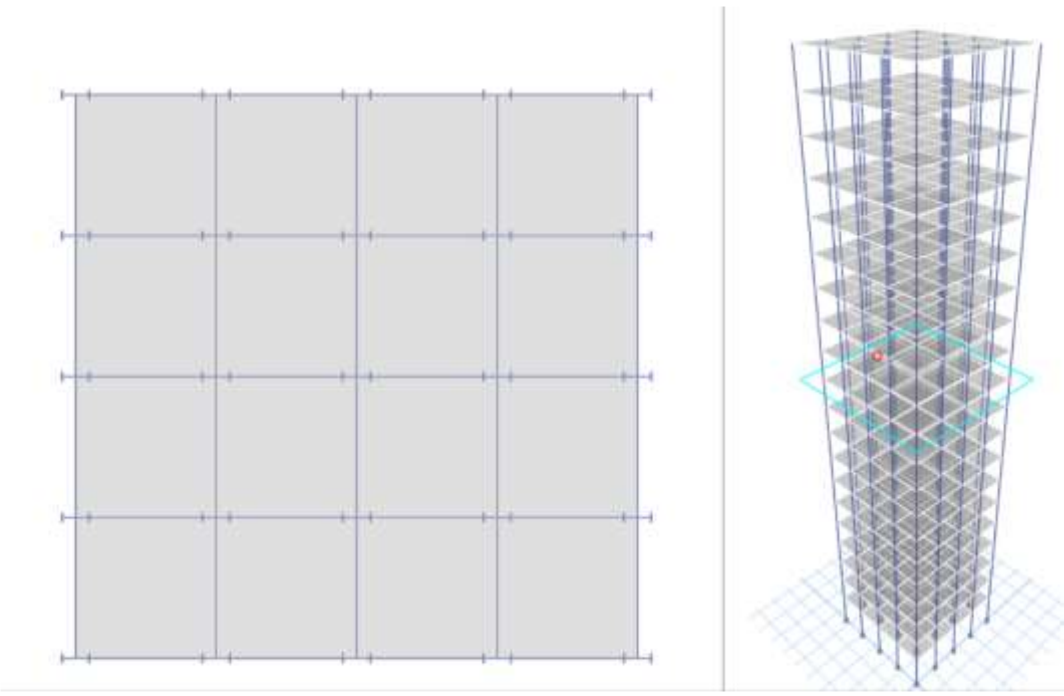

Figure 4: Model II: 20 storey Steel Building

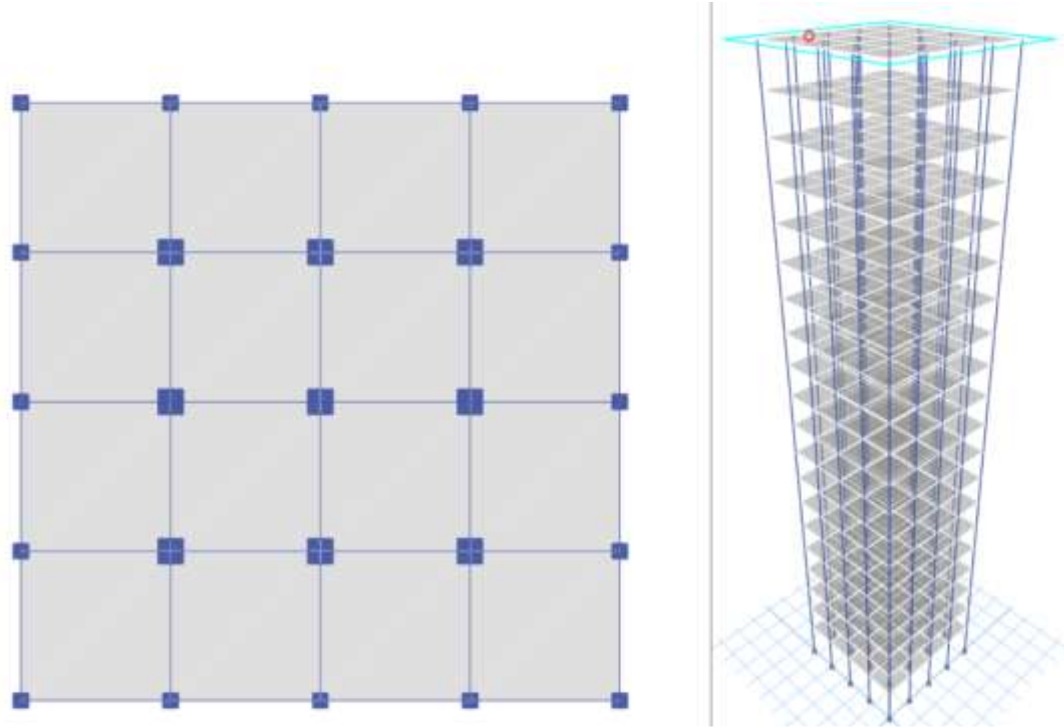

Figure 5: Model III: 20 storey Building with concrete filled columns at external face

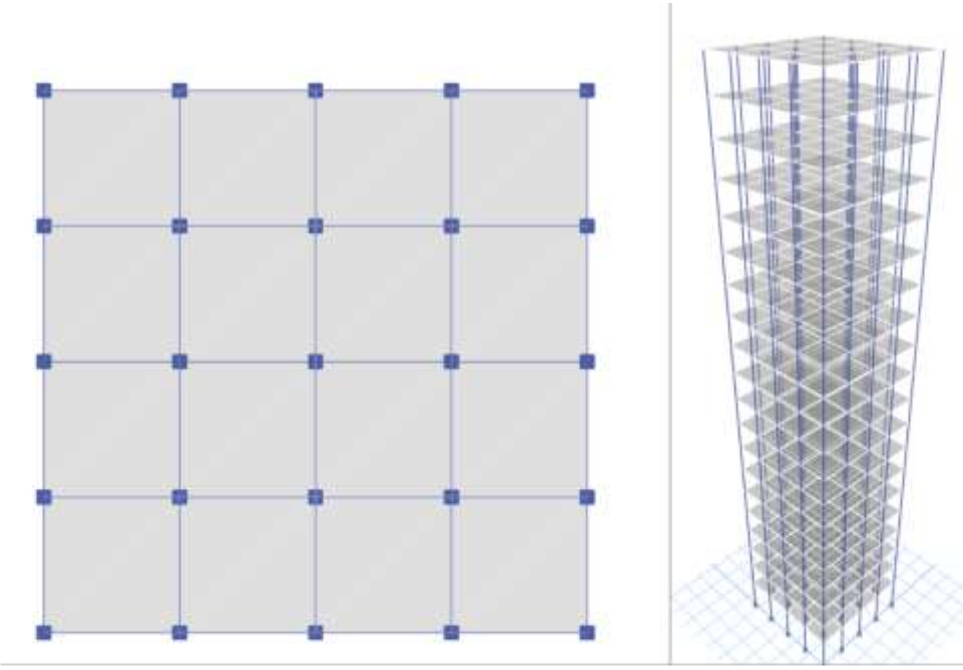

Figure 6: Model IV: 20 storey Building with concrete filled columns at all locations

Table 1 Lateral Displacement

Storey	Mod I	Mod II	Mod III	Mod IV
Story20	27.3	26.4	30.7	32.1
Story19	26.6	25.4	30.0	31.4
Story18	25.8	24.3	29.1	30.5
Story17	24.8	23.2	28.1	29.5
Story16	23.7	21.9	26.9	28.2
Story15	22.5	20.5	25.6	26.9
Story14	21.2	19.1	24.1	25.4
Story13	19.8	17.7	22.5	23.8
Story12	18.3	16.2	20.9	22.1
Story11	16.8	14.7	19.2	20.3
Story10	15.2	13.2	17.4	18.5
Story9	13.6	11.6	15.7	16.7
Story8	12.0	10.1	13.9	14.8
Story7	10.4	8.6	12.0	12.9
Story6	8.9	7.2	10.2	11.1
Story5	7.3	5.8	8.5	9.2
Story4	5.7	4.5	6.7	7.4
Story3	4.3	3.2	5.0	5.6
Story2	2.8	2.1	3.3	3.8
Story1	1.4	1.0	1.7	2.1

Table 2 Storey Drift

Storey	Mod I	Mod II	Mod III	Mod IV
Story20	0.7	1.0	0.7	0.7
Story19	0.8	1.1	0.9	0.9
Story18	1.0	1.2	1.1	1.1
Story17	1.1	1.3	1.2	1.2
Story16	1.2	1.3	1.3	1.4

Story15	1.3	1.4	1.5	1.5
Story14	1.4	1.5	1.6	1.6
Story13	1.5	1.5	1.6	1.7
Story12	1.5	1.5	1.7	1.8
Story11	1.6	1.5	1.8	1.8
Story10	1.6	1.5	1.8	1.8
Story9	1.6	1.5	1.8	1.9
Story8	1.6	1.5	1.8	1.9
Story7	1.6	1.4	1.8	1.9
Story6	1.6	1.4	1.8	1.9
Story5	1.5	1.3	1.8	1.8
Story4	1.5	1.2	1.7	1.8
Story3	1.4	1.2	1.7	1.7
Story2	1.4	1.1	1.6	1.7
Story1	1.4	1.0	1.7	2.1

Table 3 Time Period

Mode	Mod I	Mod II	Mod III	Mod IV
1	2.531	5.472	2.882	3.049
2	2.531	2.558	2.882	3.049
3	2.080	2.273	2.507	2.588
4	0.814	1.821	0.933	0.994
5	0.814	1.058	0.933	0.994
6	0.688	0.822	0.831	0.858
7	0.450	0.751	0.519	0.558
8	0.450	0.692	0.519	0.558
9	0.406	0.582	0.492	0.509
10	0.312	0.477	0.362	0.391
11	0.312	0.456	0.362	0.391
12	0.285	0.405	0.347	0.359

Table 4 Storey Shear

Storey	Mod I	Mod II	Mod III	Mod IV
Story20	35.8734	28.0191	27.8466	25.5749
Story19	93.4232	76.6960	73.5569	67.2777
Story18	145.1735	120.4675	114.6608	104.7780
Story17	191.4323	159.5942	151.4029	138.2989
Story16	232.5075	194.3366	184.0279	168.0636
Story15	268.7071	224.9549	212.7802	194.2952
Story14	300.3390	251.7099	237.9046	217.2169
Story13	327.7111	274.8617	259.6455	237.0518
Story12	351.1313	294.6711	278.2475	254.0230
Story11	370.9076	311.3983	293.9553	268.3537
Story10	387.3480	325.3039	307.0135	280.2670
Story9	400.7603	336.6484	317.6665	289.9861
Story8	411.4525	345.6921	326.1591	297.7341
Story7	419.7326	352.6955	332.7357	303.7341
Story6	425.9084	357.9192	337.6410	308.2094
Story5	430.2879	361.6235	341.1195	311.3829
Story4	433.1791	364.0689	343.4159	313.4780
Story3	434.8899	365.5159	344.7747	314.7177
Story2	435.7281	366.2249	345.4405	315.3251
Story1	436.0101	366.4582	345.6628	315.5267

Table 5 Storey Stiffness

Storey	Mod I	Mod II	Mod III	Mod IV
Story20	52443.205	28630.151	39025.718	36736.794
Story19	113589.125	71380.884	83656.539	76770.946
Story18	149957.035	102573.846	109187.984	98873.018
Story17	173955.638	126224.016	125644.335	112955.722
Story16	191081.214	144858.215	137215.364	122755.846

Story15	204054.442	160069.127	145882.754	130036.645
Story14	214383.411	172924.900	152723.521	135743.583
Story13	222994.397	184188.028	158385.799	140440.787
Story12	230500.336	194435.403	163291.415	144491.471
Story11	237335.893	204131.784	167734.702	148146.584
Story10	243831.209	213679.252	171935.606	151591.855
Story9	250255.898	223454.521	176070.628	154974.930
Story8	256847.503	233841.468	180292.309	158422.209
Story7	263832.098	245264.745	184742.638	162050.336
Story6	271440.577	258231.138	189563.174	165973.994
Story5	279931.382	273391.565	194904.183	170314.264
Story4	289609.017	291657.449	200926.534	175167.432
Story3	301096.649	314597.078	207831.651	180539.130
Story2	315650.315	345894.219	215478.099	183907.223
Story1	305728.274	356781.649	198859.788	148754.395

Conclusion

Based on the analytical comparison of the four 20-storey structural models, it is observed that the structural system significantly influences the seismic response and overall stability of the building. Model I, representing the conventional RCC building, exhibited comparatively higher storey shear and stiffness values, indicating greater lateral load resistance but moderate displacement behavior. Model II, the steel building model, showed the maximum time period and comparatively lower stiffness, resulting in reduced base shear but increased flexibility under seismic loading. Model III, incorporating concrete-filled steel tubular columns at the external faces, demonstrated improved seismic performance through reduced displacement and enhanced stiffness compared to the conventional steel structure. Model IV, consisting of concrete-filled steel tubular columns at all locations, exhibited the highest lateral displacement control, better drift performance, and improved structural stability due to enhanced composite action and stiffness distribution throughout the structure. The overall study indicates that the use of concrete-filled steel tubular columns considerably improves seismic performance, reduces deformation demand, and enhances the structural efficiency of multistorey buildings subjected to earthquake loading.

References

1. Chen, H., Wang, L., Chen, H., & Cui, W. (2021). *Experimental study on the seismic behavior of prefabricated L-shaped concrete-filled steel tube with rectangular multi-cell columns under different lateral loading conditions. Journal of Constructional Steel Research*, 181, 106590. Elsevier.
2. Chen, J., Chen, Z., Ning, F., & Wang, X. (2025). *Buckling behavior of axially loaded I-section steel-reinforced self-compacting concrete-filled steel tubular columns. Journal of Building Engineering*, Elsevier.

3. Chen, Z., Zhou, J., Li, Z., Wang, X., & Zhou, X. (2020). Seismic behavior of concrete-filled circular steel tubular column–reinforced concrete beam frames with recycled aggregate concrete. *Applied Sciences, 10*(12), 4253. https://doi.org/10.3390/app10124253
4. Darwish, A. Q., & Bhandari, M. (2022). *Seismic response reduction of high-rise steel–concrete composite buildings equipped with base isolation system. Materials Today: Proceedings*, Elsevier.
5. Ding, F., Zhang, S., Pan, Z., Lei, J., Wang, L., & Duan, L. (2025). Seismic performance of square concrete-filled steel tubular column–composite beam single-side bolted joints: An experimental and numerical study. *Engineering Structures, 323*, 118901. https://doi.org/10.1016/j.engstruct.2025.118901
6. Elwardany, H., Seleemah, A., & Jankowski, R. (2017). *Seismic pounding behavior of multi-story buildings in series considering the effect of infill panels. Engineering Structures*, 144, 139–150. Elsevier.
7. Fathieh, A., & Mercan, O. (2016). *Seismic evaluation of modular steel buildings. Engineering Structures*, Elsevier.
8. Feng, R., Shen, L., & Yun, Q. (2020). *Seismic performance of multi-story modular box buildings. Journal of Constructional Steel Research*, Elsevier.
9. Gao, S. (2025). *Life cycle sustainability assessment of concrete-filled steel tubular frames in earthquake regions. Engineering Structures*, Elsevier.
10. Guettala, S., Khelaifia, A., Chebili, R., & Guettala, S. (2024). *Effect of infill walls on seismic performance of multi-story buildings with shear walls. Asian Journal of Civil Engineering*, Springer.
11. Huang, F., Fu, C., Zhuang, Y., & Xiong, Z. (2017). *Experiment on seismic performance of concrete-filled steel tubular arch-rib under multi-shaking-tables. Thin-Walled Structures*, 115, 204–215. Elsevier.
12. Huang, Y. (2015). *Seismic behavior of concrete filled steel tubular built-up columns.* Doctoral dissertation, University of Naples Federico II.
13. Khan, K., & Yan, J. B. (2021). *Modular steel building with new-type bolted joints. Advanced Steel Construction.*
14. Kumari, B. (2018). *Concrete filled steel tubular (CFST) columns in composite structures. IOSR Journal of Electrical and Electronics Engineering.*
15. Mahurkar, T., & Dabhekar, K. (2024). *Design and analysis of a multi-storey steel building (G+8) by response spectrum analysis. AIP Conference Proceedings*, 3045(1), 020045. AIP Publishing.