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Structural Performance Optimization of 3-Legged Self-Supporting Telecommunication Towers: A Comparative Study of Pipe, Angle, and Hybrid Sections with X, K-Up, and K-Down Bracing Configurations

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Abstract: With the explosive growth of wireless communication networks, structurally sound and energy efficient towers are in great demand. In this paper, the structural analysis of three-legged self-supporting telecom towers with three different section types (Angle, Pipe and Hybrid) and three different bracing schemes (X-Bracing, K-Up Bracing and K-Down Bracing) is compared. We used TNX Tower, a program based on the FEA approach, to model and evaluate towers with heights of 100 ft, 150 ft, & 200 ft. Conforming to the requirements of IS 875 Part 3:2015, IS 1893 Part-I:2016, & TIA-222-H, the investigation included Non-linear P-Delta effects to precisely assess the structural behavior under wind & seismic loading scenarios. Results for Base Shear, Maximum Horizontal Deflection, and Bending Moment were the main foci of the research. In terms of stiffness and deflection, pipe sections topped the list, whereas angle sections had the opposite effect, resulting in lower bending moments or base shear values. K-Down bracing was found to be more structurally efficient than X-bracing, in most cases, by reducing deflection, bending moment or base shear. The results indicated that the type of sections & type of bracing used would have an impact on the overall stability and performance of a telecommunication tower.

Keywords: Self-Supporting Tower, Telecommunication Tower, Pipe Section, Angle Section, Hybrid Section, X-Bracing, K-Bracing, P-Delta Analysis, Finite Element Analysis, TNX Tower, Deflection, Base Shear, Bending Moment.

INTRODUCTION

There is an absolute need for sturdy and dependable telecommunications towers due to the explosion of wireless communication technology. Wind, gravity, & the weight of ancillary equipment are the primary sources of static and dynamic stresses experienced by these structures, which may reach considerable heights. Because it is both efficient and stable, the self-supporting lattice tower is still a fundamental design. The tower's overall performance is dictated by two main structural elements: the bracing system's arrangement and the cross-section for the members (legs and bracing). Selecting the best mix is a challenging technical undertaking that has an effect on the tower's cost, safety, and service life. It's a really reasonable request. For your structural analysis, it is essential that you comprehend the tower's geometry and the purpose of the bracing patterns.

Telecom towers that are self-supporting don't need guy wires since their stability is provided by a wide, rigid lattice structure. Typically, there are two primary geometries to consider when making a design decision: towers with three legs (triangular bases) and those with four legs (square or rectangular bases). The three-legged tower's triangle base makes it naturally stiff, which means it can be built with less material than a four-legged tower of the same height and load. This makes it more cost-effective and requires a smaller footprint for the foundation. In addition, the triangular cross-section is more aerodynamically efficient since it reduces the projected area to the wind, which is particularly useful for pipe sections. When it comes to constructions that are substantially higher or have large, numerous antenna loads, the four-legged tower is the way to go due to its greater stability and load capability. Its square base makes it easier to build with conventional angle sections and provides great torsional resistance, but it usually needs more steel and a bigger base area.

The tower's legs are braced so that shear stresses from wind and seismic loads are distributed down them. The distribution of forces between the compression and tension members is determined by the pattern that is selected. When it comes to transmitting and resisting lateral shear stresses, especially those caused by wind and seismic loads, the tower panels' bracing system is crucial. Two diagonal elements cross inside a panel to create an X in the X-bracing arrangement, also called cross bracing. This method is very efficient since it increases the buckling capability for the main tower legs by drastically decreasing their unsupported length.

The design of these diagonals is often based on the assumption that the compression member would buckle under lateral stress, with one diagonal mainly acting in tension and the other in compression. As an alternative, the K-bracing system forms a "K" shape when two diagonal members join at one node along the primary vertical leg. Either K-down, with the meeting point beneath the horizontal member, or K-up, with the meeting point over the horizontal member, is an orientation that this system may be orientated in. K-bracing is often used to shorten the bracing members, which helps save material. When comparing this pattern to the force distribution achieved by X-bracing, it is important to note that this pattern directly introduces vertical shear forces or secondary bending moments into the main tower legs at the central node. This must be carefully considered in the structural analysis.

OBJECTIVES

- To assess and contrast, under wind & seismic loading circumstances, the structural performance of three-legged self-supporting telecom towers with Angle, Pipe, & Hybrid sections.
- To use non-linear P-Delta analysis to examine how X-Bracing, K-Up Bracing, & K-Down Bracing configurations affect Maximum Deflection, Bending Moment, & Base Shear.

RESEARCH METHODOLOGY

This section goes into depth about the model's details and analytic techniques. The purpose of this research is to determine Bending Moment (BM), Maximum Lateral Deflection, and Base Shear for each of the three model types. All 27 models are analyzed using the Non-linear P-Delta analysis approach.

Non-Linear-Delta Analysis Method

When evaluating the structural integrity of tall, narrow buildings such as the 150 ft telecommunication towers within your project, it is essential to take into account the P-Delta effect, which is also called second-order analysis. The non-linear interaction between the structure's lateral displacement (Delta) and axial loads (P, usually gravity or the vertical component of wind/ice loads) is taken into consideration by this effect. The following are some of the reasons why your particular structural study requires meticulous incorporation of the P-Delta effect within the methodology: Because of its inherent slimness and optimization, lattice towers are often several times taller than they are wide. The P-Delta effect is more pronounced for higher and lighter buildings.

Underestimating the real displacement or internal forces, which do not take this secondary moment into account, might result from using a conventional linear static analysis that does not take the tower's structural properties into account. Your analysis would not be complete without P-Delta testing, as this will guarantee a trustworthy comparison of all 18 models. The ANSI/TIA-222 standard, which you must adhere to, is essential for producing optimized and dependable designs; it calls for the exact computation of all major structural effects. To carry out these complex analyses, specialized software is required, such as TNX Tower. When it comes to modeling tubular sections, you should be aware that structures like Pipe and Hybrid sections are lighter and more optimized by nature, making them more vulnerable to P-Delta effects compared to heavy angular sections.

Numerical Method Finite Element Analysis(FEA)

For this purpose, tnxTower software is used. Finite element analysis (FEA) models have the ability to integrate material non-linearities, geometric flaws, and detailed loading conditions. FEA simulations are powerful tools for this purpose. The program tnxTower was used for this. The non-linearities of the material, geometric flaws, and specific loading circumstances may all be included in FEA models.

Input Data of Self-supporting tower

All other characteristics are held constant for each of the three tower heights that are examined: 100 feet (30.48 meters), 150 feet (45.72 meters), and 200 feet (60.96 meters).

Table 1: Topography Details

Type	Values
Region	Pune, India
Wind Speed	39 m/sec (88 mph)
Terrain Category	3
Important Factor	1
Risk Coefficient	1
Topography	1

Relevant Codes	IS 875 Part 3 :2015, IS-1893 Part-I 2016, TIA-222-H

Table 2: Typical Section properties for Self-support Tower

Height of tower	100’	150’	200’
Height of slant portion	80’	120’	160’
Height of straight portion	20’	30’	40’
Base width	12’	16’	20’
Top width	4’	4’	4’

Table 3: Tower Leg Properties for Angle and Pipe Section (100’, 150’, 200’)

Height	Angle Section	Pipe Section
80'-100'	L3x3x1/4	Sabre 2.875 x .203
60'-80'	L3x3x1/4	Sabre 2.875 x .375
40'-60'	L3 1/2x3 1/2x5/16	Sabre 3.5 x .3
20'-40'	L5x5x3/8	Sabre 4.5 x .237
0'-20'	L5x5x3/8	Sabre 4.5 x .337
140'-150'	L3x3x1/4	Sabre 2.875 x .203
120'-140'	L3x3x1/4	Sabre 2.875 x .203
100'-120'	L3 1/2x3 1/2x5/16	Sabre 3.5 x .3
80'-100'	L5x5x3/8	Sabre 4.5 x .337

60'-80'	L5x5x3/8	Sabre 4.5 x .337
40'-60'	L5x5x3/8	Sabre 4.5 x .337
20'-40'	L5x5x3/8	Sabre 4.5 x .337
0'-20'	L5x5x3/8	Sabre 4.5 x .337
190'-200'	L3x3x1/4	Sabre 2.875 x .203
170'-180'	L3x3x1/4	Sabre 2.875 x .203
140'-160'	L3 1/2x3 1/2x5/16	Sabre 3.5 x .3
120'-140'	L3 1/2x3 1/2x5/16	Sabre 3.5 x .3
100'-120'	L3 1/2x3 1/2x5/16	Sabre 3.5 x .3
80'-100'	L5x5x3/8	Sabre 4.5 x .337
60'-80'	L5x5x3/8	Sabre 4.5 x .337
40'-60'	L5x5x3/8	Sabre 4.5 x .337
20'-40'	L5x5x3/8	Sabre 4.5 x .337
0'-20'	L5x5x3/8	Sabre 4.5 x .337

Tower Elevation ft	**Horizontal Bracing Member Size**		**Diagonal Bracing Member Size**	
	Angle Section	**Pipe Section**	**Angle Section**	**Pipe Section**
100'-80'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
80'-60'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD

60'-40'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
40'-20'	L2x2x3/16	ROHN 2 STD	L2x2x3/16	ROHN 2 STD
20'-0'	L2x2x3/16	ROHN 2 STD	L2x2x3/16	ROHN 2 STD

Table 4: Tower Bracing Properties for Angle and Pipe Section

Tower Elevation ft	**Horizontal Bracing Member Size**		**Diagonal Bracing Member Size**	
	Angle Section	**Pipe Section**	**Angle Section**	**Pipe Section**
140'-150'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
120'-140'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
100'-120'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
80'-100'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
60'-80'	L2x2x3/16	ROHN 2 STD	L3x3x1/4	ROHN 2 STD
40'-60'	L 2 x 2 x 3/16	ROHN 2 STD	L3x3x1/4	ROHN 3 STD
20'-40'	L2x2x3/16	ROHN 2 STD	L3x3x1/4	ROHN 3 STD
0'-20'	L2 1/2x2 1/2x1/4	ROHN 2.5 STD	L3x3x1/4	ROHN 3 STD

Tower Elevation ft	**Horizontal Bracing Member Size**		**Diagonal Bracing Member Size**	
	Angle Section	**Pipe Section**	**Angle Section**	**Pipe Section**
180'-200'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
160'-180'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
140'-160'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
120'-140'	L1 1/2x1 1/2x1/8	ROHN 1.5 STD	L2x2x3/16	ROHN 2 STD
100'-120'	L2x2x3/16	ROHN 2 STD	L2x2x3/16	ROHN 2 STD
80'-100'	L2x2x3/16	ROHN 2 STD	L3x3x1/4	ROHN 3 STD
60'-80'	L2x2x3/16	ROHN 2 STD	L3x3x1/4	ROHN 3 STD
40'-60'	L2 1/2x2 1/2x1/4	ROHN 2.5 STD	L3x3x1/4	ROHN 3 STD
20'-40'	L2 1/2x2 1/2x1/4	ROHN 2.5 STD	L3x3x1/4	ROHN 3 STD
0'-20'	L2 1/2x2 1/2x1/4	ROHN 2.5 STD	L3x3x1/4	ROHN 3 STD

Tower Elevation (ft)	Angle Section (Horizontal & Diagonal Bracing)	Pipe Section (Horizontal & Diagonal Bracing)
100' SST	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L2×2×1/8	ROHN 1.5 STD
150' SST	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L2×2×1/8	ROHN 2 STD
200' SST	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L1×1×1/8	ROHN 1.5 STD
	L2×2×1/8	ROHN 2 STD
	L2×2×1/8	ROHN 2 STD
	L2×2×1/8	ROHN 2 STD

RESULT

Software used for the dissertation is detailed in this chapter. The study examines three types of models: bending moment, maximum lateral deflection, and base shear. The software used for modeling and analysis is TNX Tower, which is widely used in the telecom industry. TNX Tower relies on the finite element method and accurately simulates structural behavior under wind and seismic loading. For each of the three model kinds, the research delves into the following: bending moment, maximum lateral deflection, and base shear. The research and modeling are carried out utilizing the widely used TNX Tower software in the telecom sector. An precise simulation for structural behavior under wind and seismic stress is provided by TNX Tower, which is based on the finite element approach.

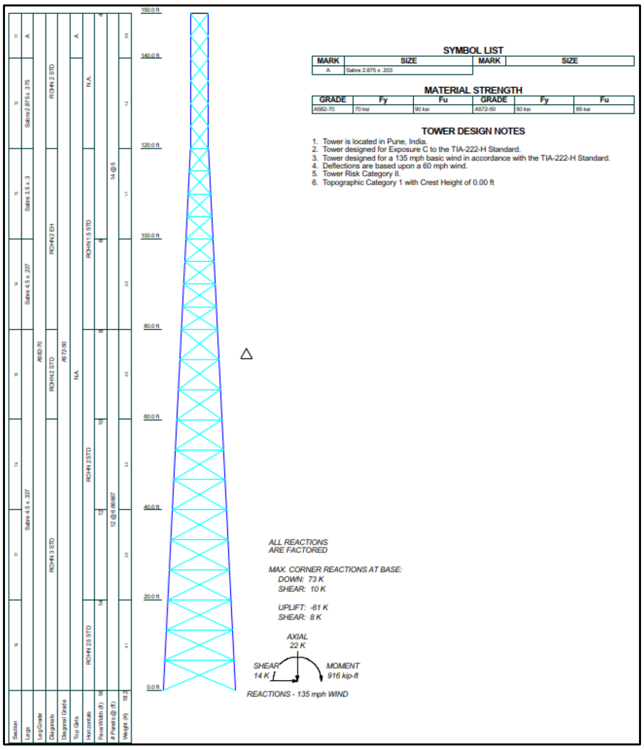
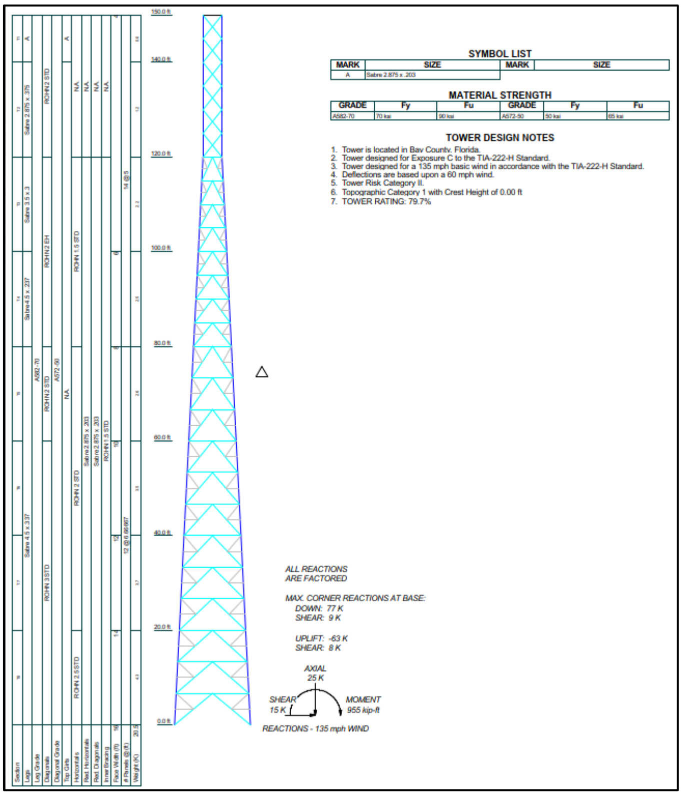


Figure 1: 150' Self Support Tower With X-bracing



SYMBOL LIST

MARK	SIZE	MARK	SIZE
A	Sabre 2.875 x .203		

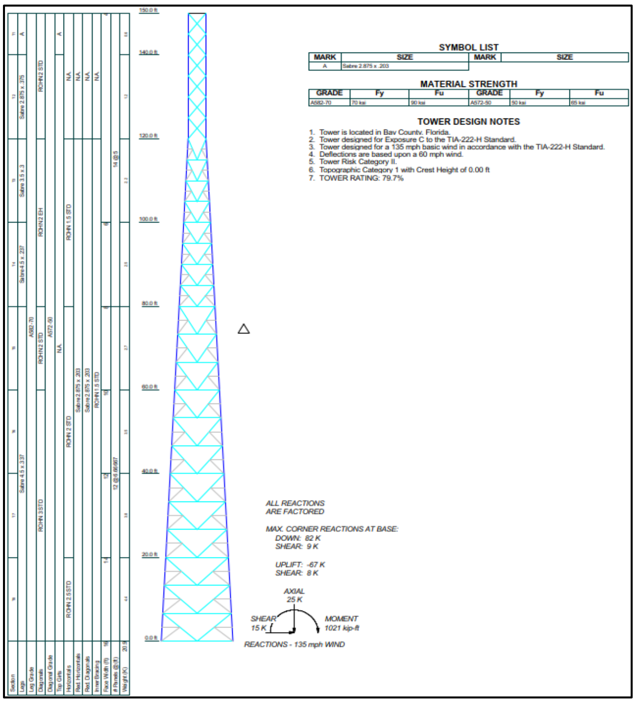
MATERIAL STRENGTH

GRADE	Fy	Fu	GRADE	Fy	Fu
A582-70	70 ksi	90 ksi	A572-50	50 ksi	65 ksi

TOWER DESIGN NOTES

1. Tower is located in Bay County, Florida.
2. Tower designed for Exposure C to the TIA-222-H Standard.
3. Tower designed for a 135 mph basic wind in accordance with the TIA-222-H Standard.
4. Deflections are based upon a 60 mph wind.
5. Tower Risk Category II.
6. Topographic Category 1 with Crest Height of 0.00 ft
7. TOWER RATING: 79.7%

Figure 2: 150' Self Support Tower With K-Down bracing



SYMBOL LIST

MARK	SIZE	MARK	SIZE
A	Sabre 2.875 x .203		

MATERIAL STRENGTH

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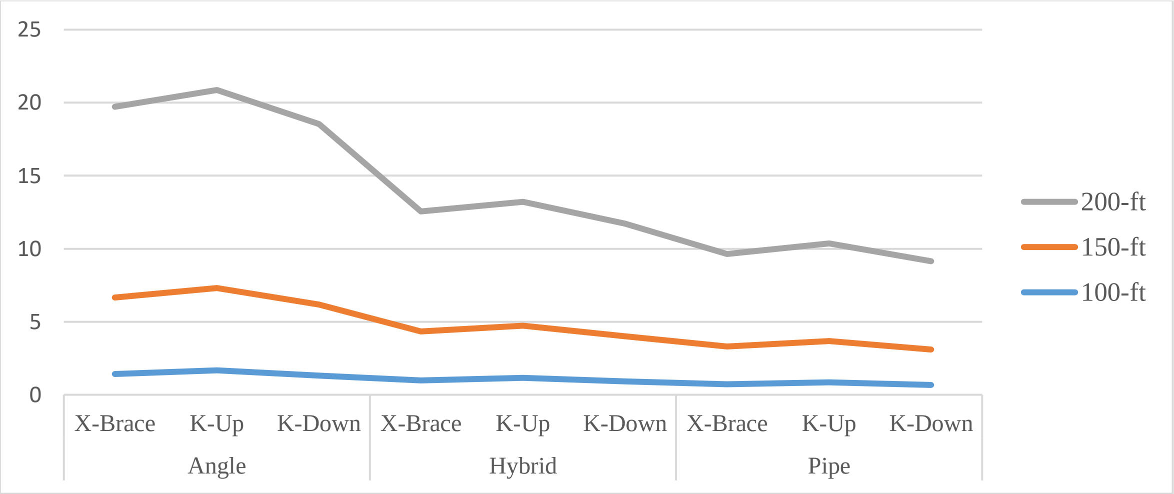
Figure 3: 150' Self Support Tower With K-UP bracing

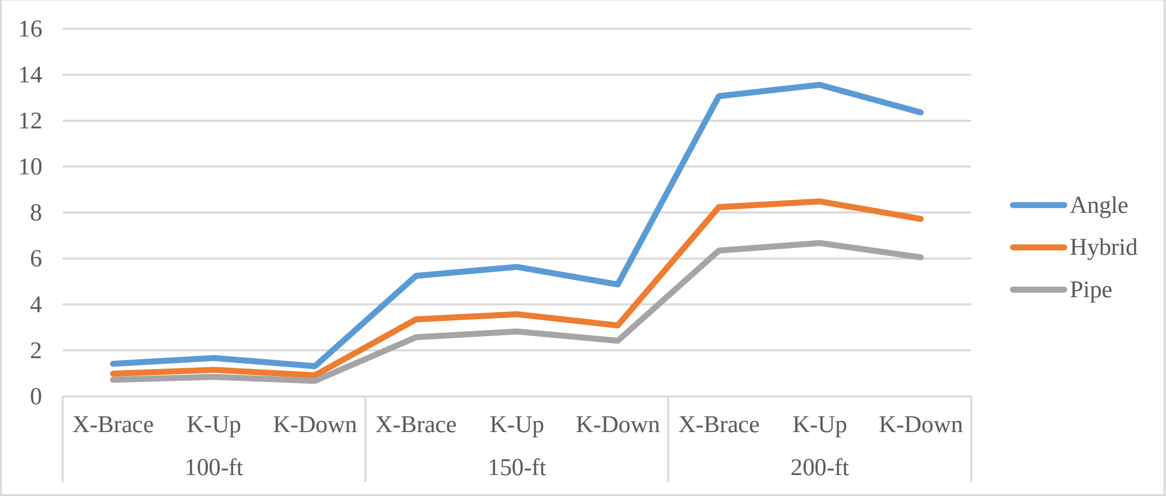
Maximum Displacement Analysis

A key indicator of serviceability is deflection. Antenna misalignment & structural fatigue might result from high deflection.

Table 5: Maximum Horizontal Deflection For 3-Legged Tower

Section	Type of Bracing	Wind+Seismic Induced Displacement (in)		
		100-ft	150-ft	200-ft
Angle	X-Brace	1.422	5.239	13.062
	K-Up	1.672	5.635	13.563
	K-Down	1.313	4.864	12.357
Hybrid	X-Brace	0.985	3.346	8.234
	K-Up	1.157	3.576	8.486
	K-Down	0.915	3.087	7.718
Pipe	X-Brace	0.728	2.568	6.342
	K-Up	0.85	2.829	6.673
	K-Down	0.672	2.426	6.046





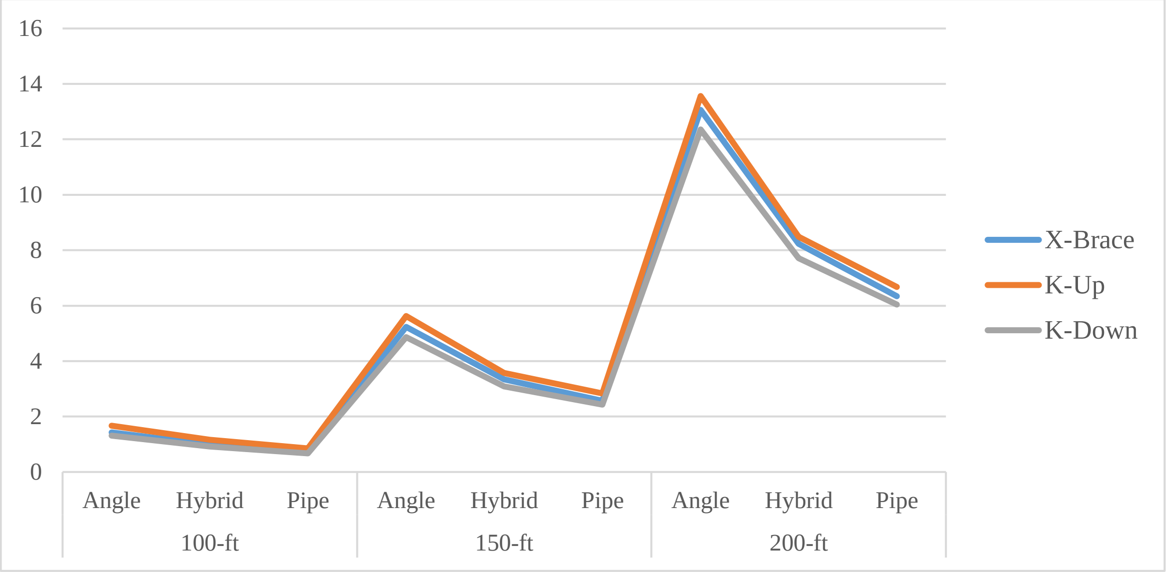


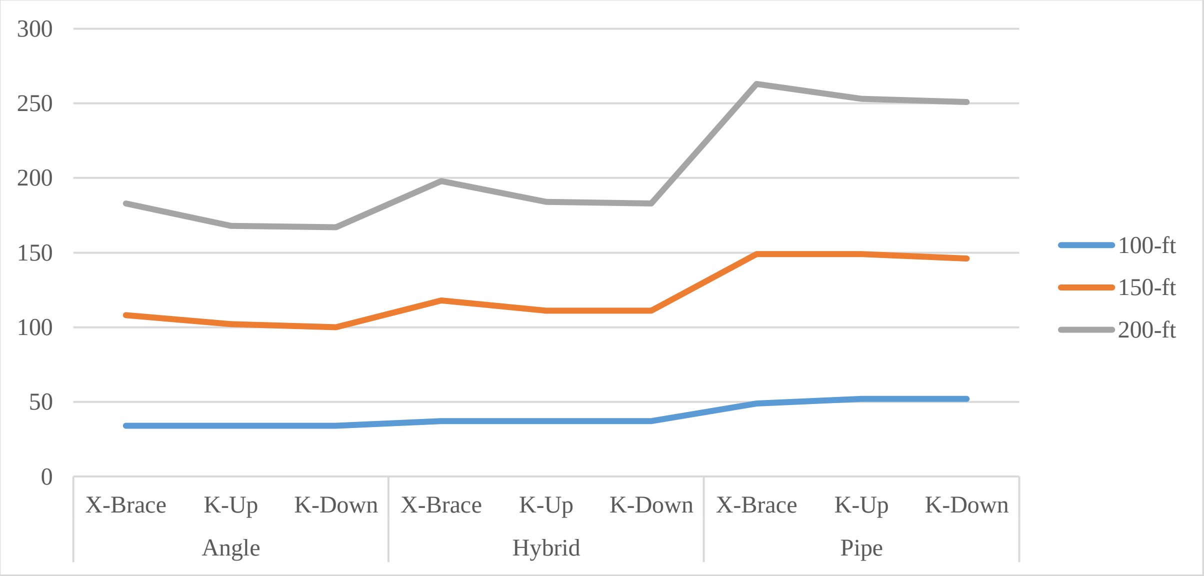
Figure 4: Maximum Horizontal Deflection For 3-Legged Tower

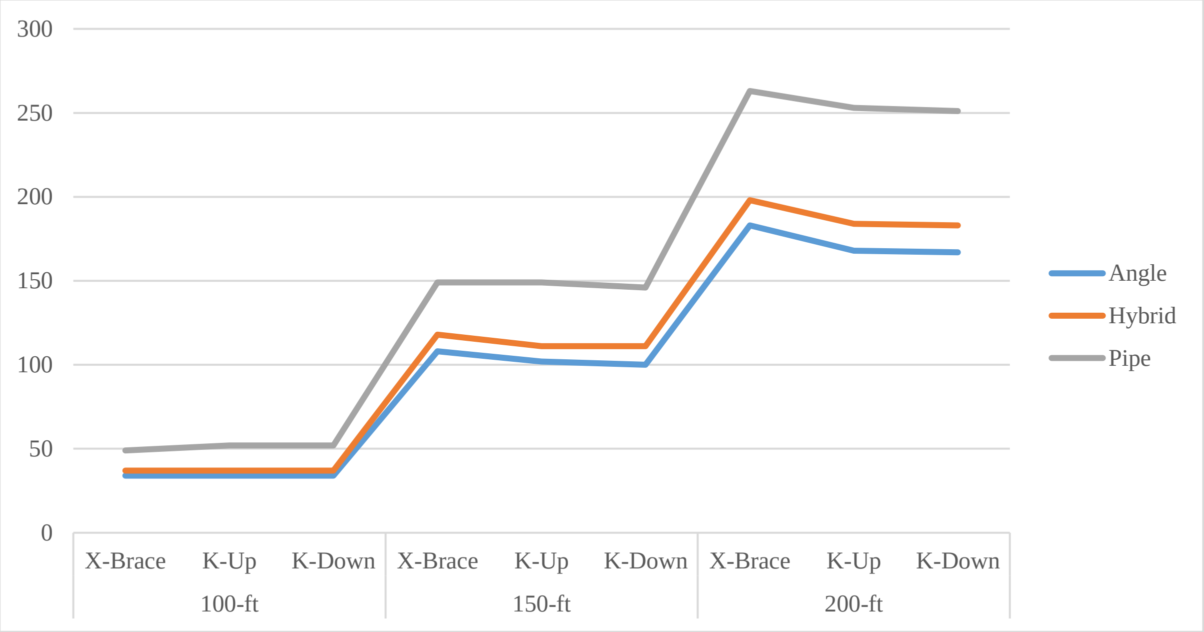
Bending Moment Analysis

An important metric for the sizing of structural members and the stability of the foundation in the event of an overturning is the Bending Moment (BM) near the foundation, which measures the internal stresses. Kilo-Newton Meters are the units of measurement.

Table 6: Maximum Bending Moment For 3-Legged Tower

Section	Type of Bracing	Wind + Seismic Induced BM (KN.M)		
		100-ft	150-ft	200-ft
Angle	X-Brace	34	108	183
	K-Up	34	102	168
	K-Down	34	100	167
Hybrid	X-Brace	37	118	198
	K-Up	37	111	184
	K-Down	37	111	183
Pipe	X-Brace	49	149	263
	K-Up	52	149	253
	K-Down	52	146	251





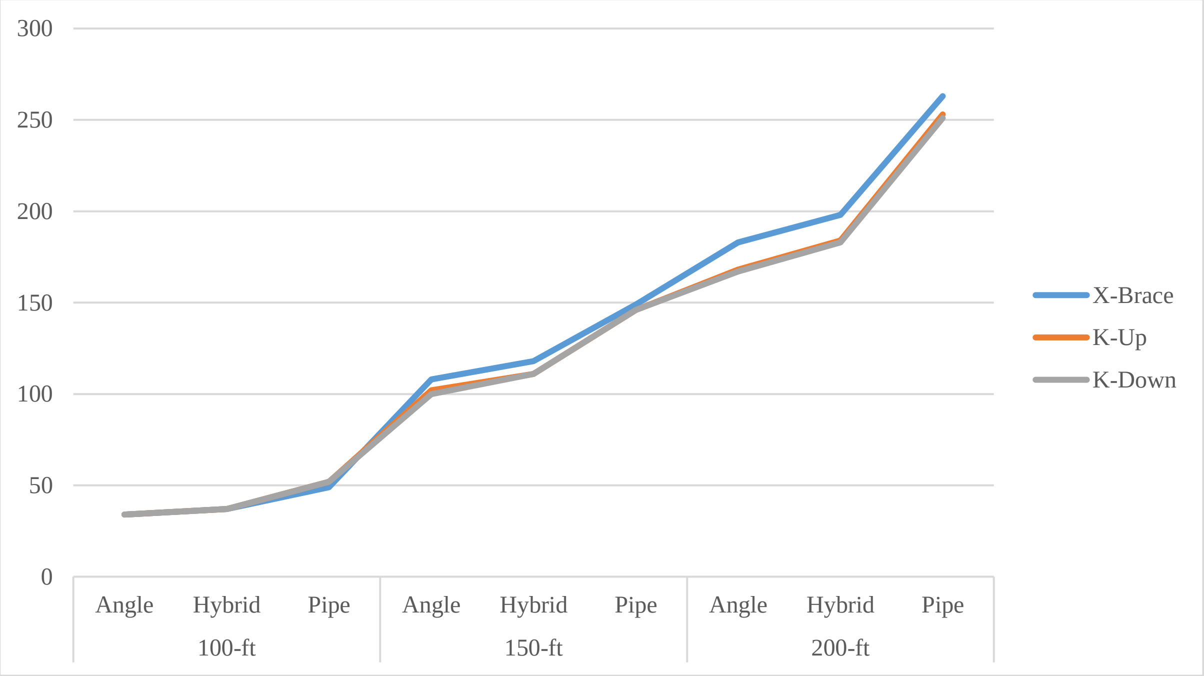


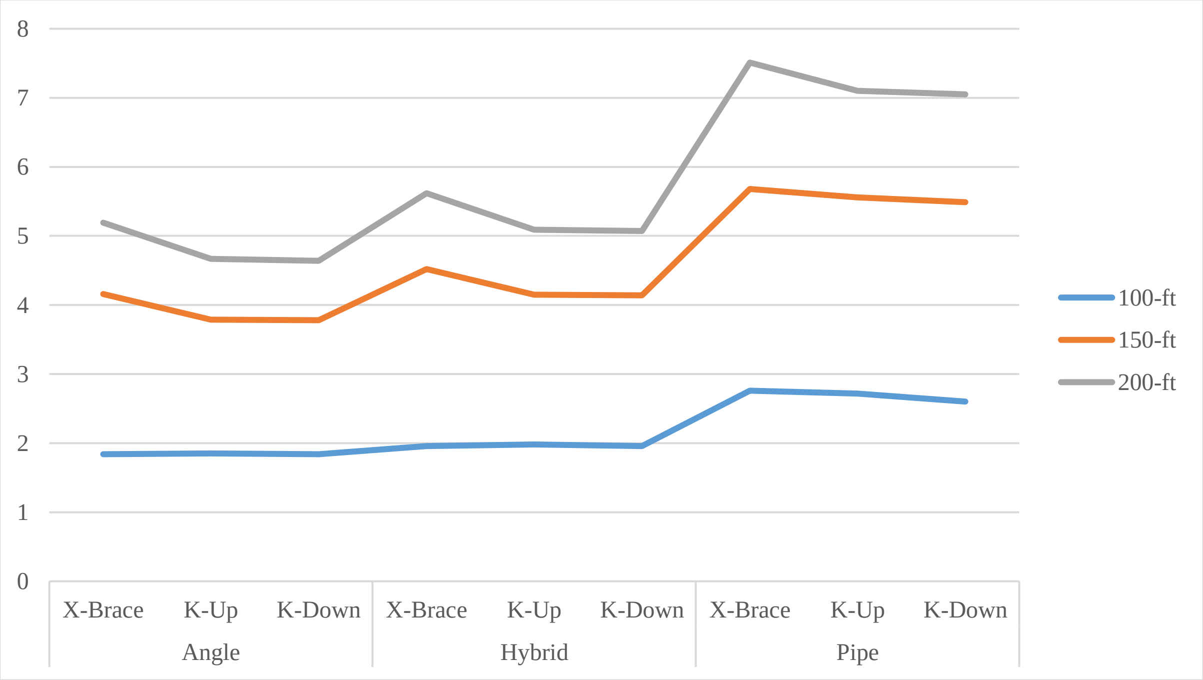
Figure 5: Maximum Bending Moment For 3-Legged Tower

Base Shear Analysis

Base shear, as shown in table 7, is a crucial metric for foundation design as it measures the greatest lateral force that would occur at the base of a tower structure as a consequence of ground motion generated by an earthquake. An essential metric for foundation design, base shear is shown in table 7 and represents the total lateral force acting on the foundation.

Table 7: Base Shear For 3-Legged Tower

Section	Type of Bracing	Wind + Seismic Induced base Shear (KN)		
		100-ft	150-ft	200-ft
Angle	X-Brace	1.84	4.16	5.19
	K-Up	1.85	3.79	4.67
	K-Down	1.84	3.78	4.64
Hybrid	X-Brace	1.96	4.52	5.62
	K-Up	1.98	4.15	5.09
	K-Down	1.96	4.14	5.07
Pipe	X-Brace	2.76	5.68	7.51
	K-Up	2.72	5.56	7.1
	K-Down	2.6	5.49	7.05



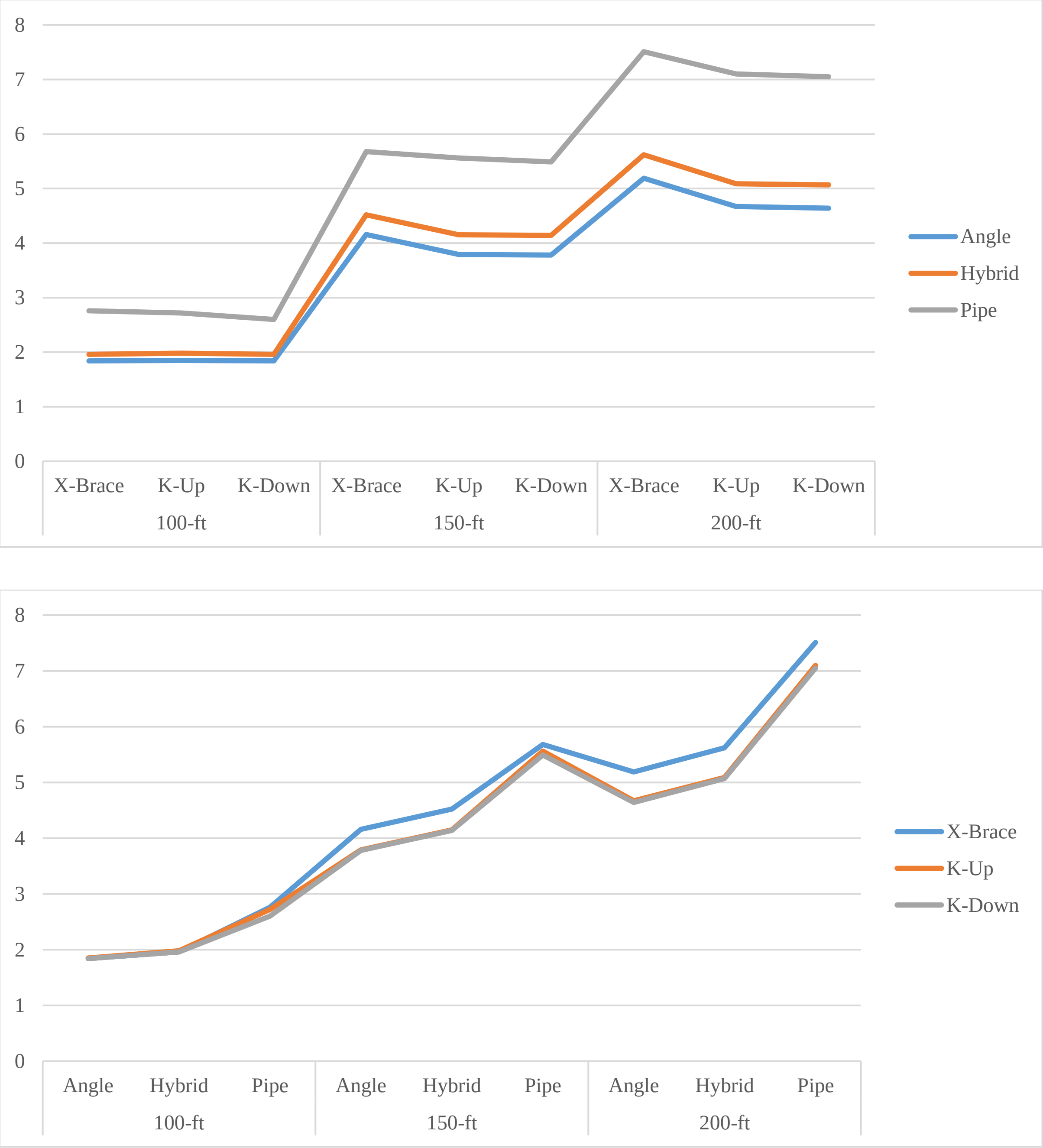


Figure 6: Base Shear For 3-Legged Tower

Comparative analysis

The structural performance for self-supporting towers of 100 ft, 150 ft, & 200 ft tall were compared using various bracing schemes and section kinds. Important response metrics including deflection, bending moment, or base shear were used for the comparison, which was conducted under the same loading circumstances. In order to determine the optimal bracing arrangement and section type for enhanced structural performance and stability, the percentage variation were computed.

Table 8: % Change in Deflection Bracing Comparison (within same section, X-Brace = baseline)

Section	**Bracing (vs X-Brace baseline)**	**% Change in Deflection vs X-Brace**		
		100-ft	**150-ft**	**200-ft**
Angle	X-Brace (Baseline)			
	K-Up	+17.58%	+7.56%	+3.84%
	K-Down	−7.67%	−7.16%	−5.40%
Hybrid	X-Brace (Baseline)			
	K-Up	+17.46%	+6.87%	+3.06%
	K-Down	−7.11%	−7.74%	−6.27%
Pipe	X-Brace (Baseline)			
	K-Up	+16.76%	+10.16%	+5.22%
	K-Down	−7.69%	−5.53%	−4.67%

Table 8 analyzes the deflection of several bracing methods inside the same section type using the X-brace arrangement as the baseline. All tower heights & section types showed larger deflection values for the K-Up bracing system than the X-brace system. The highest increase occurred in 100-ft buildings and subsequently decreased with height, suggesting that K-Up bracing had less impact in larger structures. However, K-Down bracing decreased deflection in all situations compared to X-bracing. A 5%–8% decrease indicates that K-Down bracing improves stiffness & lateral stability. Pipe sections had the largest deflection reduction, indicating structural efficiency.

Table 9: % Change in Deflection Section Comparison (same bracing, Angle = baseline)

Bracing	**Section (vs Angle baseline)**	**% Change in Deflection vs Angle**		
		100-ft	**150-ft**	**200-ft**
X-Brace	Angle (Baseline)			
	Hybrid	−30.73%	−36.13%	−36.96%
	Pipe	−48.80%	−50.98%	−51.45%
K-Up	Angle (Baseline)			
	Hybrid	−18.64%	−31.74%	−35.03%
	Pipe	−40.23%	−46.00%	−48.91%
K-Down	Angle (Baseline)			
	Hybrid	−35.65%	−41.08%	−40.91%
	Pipe	−52.74%	−53.69%	−53.71%

Table 9 compares angle, hybrid, & pipe deflection for the identical bracing system using the angle section for the baseline. Hybrid & pipe sections decreased tower deflection more than angle sections. Pipe sections had the highest deflection decrease, reaching over 50% in numerous instances, indicating their superior stiffness and lateral displacement resistance. Despite its lesser reduction than pipe sections, hybrid sections improved over angle sections. Pipe sections manage tower deflection better across all bracing configurations & heights.

Table 10: % Change in BM Bracing Comparison (within same section, X-Brace = baseline)

Section	Bracing (vs X-Brace baseline)	% Change in BM vs X-Brace		
		100-ft	150-ft	200-ft
Angle	X-Brace (Baseline)			
	K-Up	0.00%	−5.56%	−8.20%
	K-Down	0.00%	−7.41%	−8.74%
Hybrid	X-Brace (Baseline)			
	K-Up	0.00%	−5.93%	−7.07%
	K-Down	0.00%	−5.93%	−7.58%
Pipe	X-Brace (Baseline)			
	K-Up	+6.12%	0.00%	−3.80%
	K-Down	+6.12%	−2.01%	−4.56%

With X-bracing as the reference, Table 10 compares bending moment variations to different bracing methods inside the same section type. In 100-ft towers, modifying bracing arrangement had little influence on bending moment, while higher towers saw greater decreases. Compared to X-bracing, K-Up and K-Down bracing decreased bending moments in 150- and 200-foot towers. The load distribution efficiency of K-Down bracing was usually somewhat higher than K-Up bracing. In pipe sections, bending moment increased somewhat at 100 feet but decreased in larger towers. This shows that alternate bracing solutions become more efficient as tower height increases.

Table 11: % Change in BM Section Comparison (same bracing, Angle = baseline)

Bracing	**Section (vs Angle baseline)**	**% Change in BM vs Angle**		
		100-ft	**150-ft**	**200-ft**
X-Brace	Angle (Baseline)			
	Hybrid	+8.82%	+9.26%	+8.20%
	Pipe	+44.12%	+37.96%	+43.72%
K-Up	Angle (Baseline)			
	Hybrid	+8.82%	+8.82%	+9.52%
	Pipe	+52.94%	+46.08%	+50.60%
K-Down	Angle (Baseline)			
	Hybrid	+8.82%	+11.00%	+9.58%
	Pipe	+52.94%	+46.00%	+50.30%

The bending moment for each section type is presented in Table 11 for the baseline with the same bracing system and angle sections. In a few cases, the bending moment was increased by 40% with pipe sections, and by 8–11% with hybrid parts. More stiff pipe sections result in greater internal forces for lateral stress, resulting in higher bending moment. The bending moments are smallest in angle sections, hybrid sections and pipe sections.

Table 12: % Change in Base Shear Bracing Comparison (within same section, X-Brace = baseline)

Section	**Bracing (vs X-Brace baseline)**	**% Change in Base Shear vs X-Brace**		
		100-ft	**150-ft**	**200-ft**
Angle	X-Brace (Baseline)			

	K-Up	+0.54%	−8.89%	−10.02%
	K-Down	0.00%	−9.13%	−10.60%
Hybrid	X-Brace (Baseline)			
	K-Up	+1.02%	−8.19%	−9.43%
	K-Down	0.00%	−8.41%	−9.79%
Pipe	X-Brace (Baseline)			
	K-Up	−1.45%	−2.11%	−5.46%
	K-Down	−5.80%	−3.35%	−6.13%

Using X-bracing as a baseline, Table 12 shows how base shear varies for various bracing schemes inside the same section type. From the results, it was noticed that the base shear of 150-ft & 200-ft towers were generally reduced due to K-Up & K-Down bracing in all section types. The most noticeable drop was in the steepest towers at around 10% in angle or hybrid sections. While some reductions in base shear were rather small, some pipe section reductions were also detected. The effect of bracing arrangement is quite limited in shorter towers but it was observed that for some 100-ft tower examples, base shear was slightly higher for K-Up bracing. K-Down bracing was the most effective in reducing base shear, all things considered.

Table 13: % Change in Base Shear Section Comparison (same bracing, Angle = baseline)

Bracing	**Section (vs Angle baseline)**	**% Change in Base Shear vs Angle**		
		100-ft	**150-ft**	**200-ft**
X-Brace	Angle (Baseline)			
	Hybrid	+6.52%	+8.65%	+8.29%
	Pipe	+50.00%	+36.54%	+44.70%

K-Up	Angle (Baseline)			
	Hybrid	+7.03%	+9.50%	+8.99%
	Pipe	+47.03%	+46.70%	+52.03%
K-Down	Angle (Baseline)			
	Hybrid	+6.52%	+9.52%	+9.27%
	Pipe	+41.30%	+45.24%	+51.94%

Table 13 gives a comparison of base shear values of different section types against each other with the same bracing arrangement and angle sections as a baseline. Angle sections have the least base shear, Hybrid & pipe sections have more. Pipe parts grew most – up to more than 50% – and hybrid parts grew 6-10%. During analysis, stiffness of the sections of pipe creates greater lateral forces, resulting in greater base shear. The structural stiffness of pipe sections was better and their deflections were lower, which lead to a better stability despite higher base shear.

CONCLUSION

This study focuses on the structural performance of 3-legged self-supporting telecommunication towers with different section types and different bracing layouts by using the Non-linear P-Delta analysis in the TNX Tower computer program. The study consisted of three different heights of the tower, 100, 150 and 200 feet, and wind and seismic loads. The results indicate that the height of the tower has a significant influence on the dynamic behaviors of tower, such as base shear, bending moment, and deflection. All response parameters increased sharply with increasing height, due to the increased slenderness and large lateral load effects. Pipe sections outperformed all other section types in regard to displacement control and lateral stiffness. The pipe section towers had the minimum deflection regardless the tower height or construction of the bracing. Bigger Bending Moments & Base Shear Pressures were obtained for pipe sections as compared to Angle & Hybrid sections due to their higher stiffness. Although they were subject to greater lateral deflections, angle sections had the least bending moments & base shear values. The bracing systems comparison showed that in most cases K-Down bracing was superior to X-Bracing & K-Up bracing. K-Down tower bracing reduced the amount of the deflection, bending moment, and base shear while enhancing the tower's stability & load distribution properties. K-Up bracing, on the other hand, tended to increase the deflection values, especially for shorter towers. The research found that the kind of member sections and bracing design had a significant impact on the structural performance of telecom towers. As far as rigidity and structural stability, the pipe and K-Down bracing combination was the best overall configuration. The results of this research can be used by structural engineers to determine safe and economical tower designs for telecommunications towers.

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