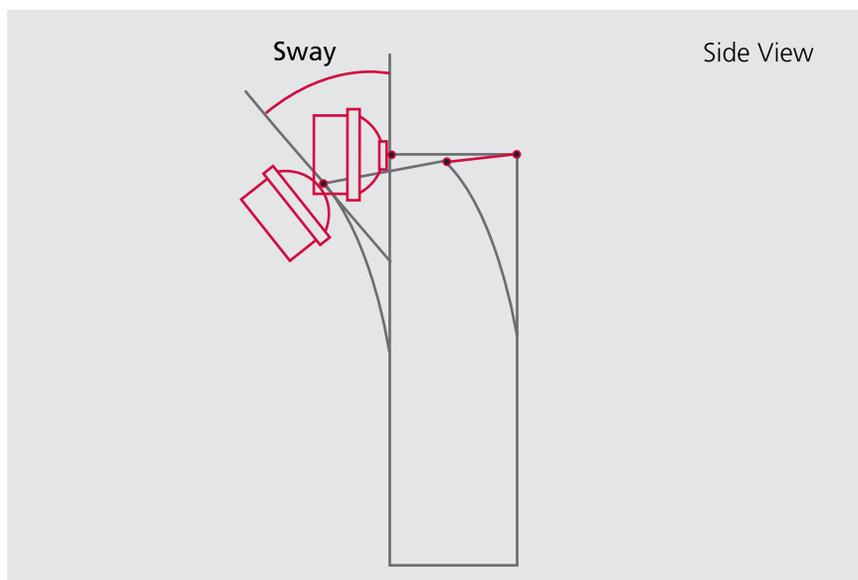
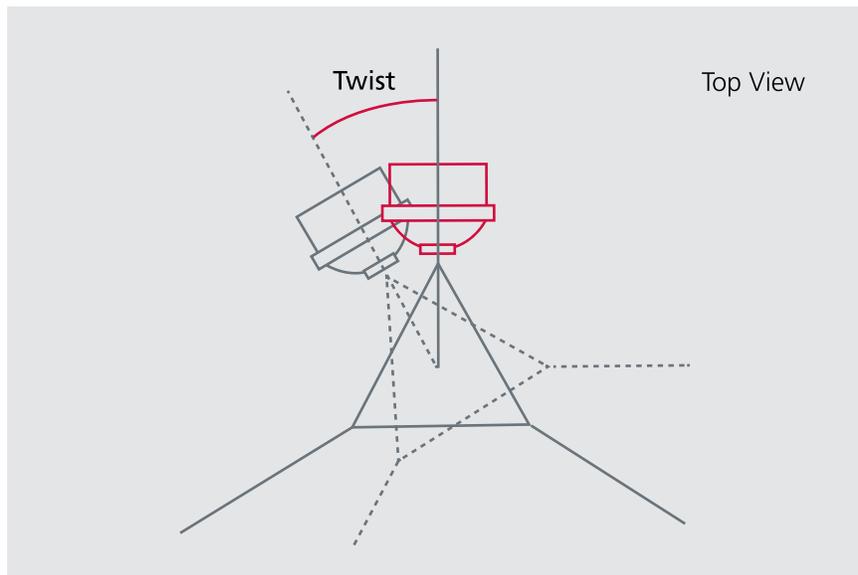


1. What is twist and sway and what are the values representing?

Twist is the number of degrees that a tower rotates within a plane parallel to the ground. This is illustrated in the diagram below, which shows twist as the angle in which a tower rotates around its center. Similarly, sway is the number of degrees that a tower rotates within a plane perpendicular to the ground. This is illustrated in the diagram below and shows a line tangent to the curvature of the tower at the node where the dish is attached to the tower.



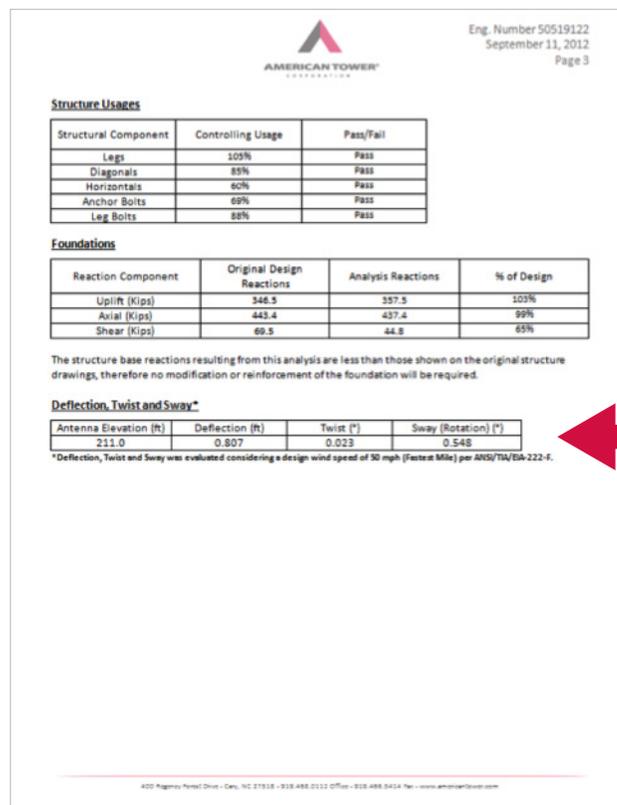
2. Where can the twist and sway data be found within an American Tower Structural Analysis Report?

On reports dated after August 1, 2012 the twist and sway data can be found within a chart (shown below) on the third page of the report in the section labeled “Deflection, Twist and Sway.” On some towers that have many loads within the loading tables, this information is pushed to the fourth page. However, the information is still in the section labeled “Deflection, Twist and Sway.”

Deflection, Twist and Sway*

Antenna Elevation (ft)	Deflection (ft)	Twist (°)	Sway (Rotation) (°)
211.0	0.807	0.023	0.548

*Deflection, Twist and Sway was evaluated considering a design wind speed of 50 mph (Fastest Mile) per ANSI/TIA/EIA-222-F.



Reports dated prior to August 1, 2012 would either have this information shown on the second page of the report within the section labeled “Results” or in some cases, this information was not shown within the report. In cases, please see the answer to the third question on how to find the twist and sway results from the calculations of an American Tower Structural Analysis Report.



3. Where can the twist and sway data for self-support and guyed towers be found within the calculations of an American Tower Structural Analysis Report?

The twist and sway data can be located at the end of the software output within the calculations. If there are no foundation calculations, this will be the last section within the deliverable. Otherwise, these calculations will be directly preceding the foundation calculations at the end of the analysis. The output will be titled "Deflections and Rotations." In TIA-222-G analyses, the first load cases within the section, which are labeled "Serviceability - ..." are the important cases. In TIA-222-F analyses, these will be labeled "50.00 mph Wind...". There are four columns; elevation of equipment (in feet), followed by deflection (in feet), twist (in degrees) and sway (in degrees).

Site Number: 52864
 Location: MCI Crownsville MD, MD
 Code: ANS/TIA-222 Rev G
 Struct Class: II
 Exposure: B
 Topo: 1

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Deflections and Rotations

Load Case	Elevation (ft)	Deflection (ft)	Twist (deg)	Sway (deg)
Serviceability - 60.00 Wind 60 deg	81.77	0.0874	0.0024	0.2595
	158.23	0.1091	0.0051	0.0068
	174.69	0.1180	0.0049	0.0343
	194.69	0.1195	0.0050	0.0192
	198.23	0.1184	0.0052	0.0247
	210.00	0.1121	0.0070	0.0658
	218.23	0.1054	0.0081	0.0526
	230.00	0.0955	0.0073	0.0262
	234.92	0.0929	0.0072	0.0716
	250.00	0.0802	0.0071	0.0485
Serviceability - 60.00 Wind 90 deg	81.77	0.1034	-0.0195	0.2671
	158.23	0.1123	0.0056	0.0233
	174.69	0.1173	0.0070	0.0486
	194.69	0.1151	0.0086	0.0303
	198.23	0.1134	0.0091	0.0384
	210.00	0.1051	0.0114	0.0760
	218.23	0.0969	0.0130	0.0647
	230.00	0.0849	0.0136	0.0212
	234.92	0.0816	0.0136	0.0911
	250.00	0.0666	0.0136	0.0633
Serviceability - 60.00 Wind Normal	81.77	0.1193	0.0022	0.2687
	158.23	0.1169	0.0030	0.0303
	174.69	0.1180	0.0018	0.0029
	194.69	0.1126	0.0005	0.0381
	198.23	0.1104	0.0003	0.0305
	210.00	0.1001	0.0011	0.0883
	218.23	0.0906	0.0016	0.0713
	230.00	0.0772	0.0005	0.0117
	234.92	0.0728	0.0005	0.0585
	250.00	0.0558	0.0005	0.0619
40.00 mph 60 deg with 0.50 in Radial Ice	81.77	0.0946	0.0029	0.3616
	158.23	0.0927	0.0037	0.0299
	174.69	0.0904	0.0034	0.0458
	194.69	0.0806	0.0033	0.0469
	198.23	0.0778	0.0033	0.0496
	210.00	0.0673	0.0043	0.0789
	218.23	0.0578	0.0050	0.0702
	230.00	0.0438	0.0049	0.0370
	234.92	0.0389	0.0049	0.0807
	250.00	0.0214	0.0048	0.0683
40.00 mph 90 deg with 0.50 in Radial Ice	81.77	0.1051	0.0014	0.3633
	158.23	0.0915	0.0073	0.0510
	174.69	0.0853	0.0084	0.0633
	194.69	0.0713	0.0096	0.0624
	198.23	0.0679	0.0099	0.0654
	210.00	0.0549	0.0112	0.0967
	218.23	0.0450	0.0124	0.0876
	230.00	0.0329	0.0133	0.0598

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4. Where can the twist and sway data for monopoles be found within the calculations of an American Tower Structural Analysis Report?

In general, monopole structures will not have significant twist. For this reason, the analysis only gives deflection and rotation values. The rotation value is the same as the sway. These two values are typically found two pages before the end of the software output. They will be in the section labeled "Load Case: 1.0D + 1.0W 60.00 mph Serviceability" and sub-labeled "Calculated Forces." On this page, the far left column lists the elevation. The second and third columns from the right provide deflection (in inches) and rotations (in degrees). All other columns can be ignored.

Load Case: 1.0D + 1.0W 60.00 mph Serviceability 25 Iterations
 Gust Response Factor: 1.10 Wind Importance Factor: 1.00
 Dead Load Factor: 1.00
 Wind Load Factor: 1.00

Calculated Forces

Seg Elev (ft)	Pu FY (-) (kips)	Vu FX (-) (kips)	Tu MY (ft-kips)	Mu MZ (ft-kips)	Mx MX (ft-kips)	Resultant Moment (ft-kips)	phi r'n (kips)	phi vn (kips)	phi in (ft-kips)	phi mn (ft-kips)	Total Deflect (in)	Rotation (deg)	Ratio
0.00	-32.53	-6.09	0.00	-660.48	0.00	660.48	4,296.75	2,148.37	9,837.03	4,925.83	0.00	0.00	0.142
5.00	-31.39	-5.99	0.00	-630.01	0.00	630.01	4,256.45	2,128.23	9,586.13	4,800.19	0.02	-0.04	0.139
10.00	-30.27	-5.88	0.00	-600.07	0.00	600.07	4,215.20	2,107.60	9,336.11	4,675.00	0.08	-0.07	0.136
15.00	-29.17	-5.78	0.00	-570.65	0.00	570.65	4,172.99	2,086.49	9,087.08	4,550.29	0.17	-0.11	0.132
20.00	-28.09	-5.67	0.00	-541.76	0.00	541.76	4,129.81	2,064.91	8,839.14	4,426.14	0.30	-0.14	0.129
25.00	-27.03	-5.55	0.00	-513.43	0.00	513.43	4,085.68	2,042.84	8,592.39	4,302.58	0.47	-0.18	0.126
30.00	-25.98	-5.43	0.00	-485.68	0.00	485.68	4,040.59	2,020.29	8,346.96	4,179.88	0.67	-0.21	0.123
35.00	-24.96	-5.31	0.00	-458.53	0.00	458.53	3,994.54	1,997.27	8,102.94	4,057.49	0.91	-0.25	0.119
40.00	-23.95	-5.18	0.00	-432.00	0.00	432.00	3,947.53	1,973.76	7,860.44	3,936.06	1.19	-0.28	0.116
45.00	-22.96	-5.05	0.00	-406.10	0.00	406.10	3,899.55	1,949.78	7,619.57	3,815.45	1.51	-0.32	0.112
50.00	-21.02	-4.91	0.00	-380.84	0.00	380.84	3,850.52	1,925.31	7,380.44	3,695.71	1.86	-0.35	0.109
55.00	-20.63	-4.88	0.00	-375.93	0.00	375.93	3,801.72	1,900.86	7,151.67	3,571.43	1.93	-0.36	0.105
55.00	-19.86	-4.78	0.00	-356.39	0.00	356.39	3,842.37	1,921.19	7,340.75	3,675.83	2.24	-0.39	0.102
60.00	-18.91	-4.64	0.00	-332.50	0.00	332.50	3,792.32	1,896.16	7,103.78	3,557.17	2.67	-0.42	0.098
65.00	-17.98	-4.51	0.00	-309.29	0.00	309.29	3,741.31	1,870.65	6,868.78	3,439.49	3.12	-0.45	0.095
70.00	-17.07	-4.37	0.00	-286.76	0.00	286.76	3,689.24	1,844.67	6,635.85	3,322.86	3.61	-0.48	0.091
75.00	-16.17	-4.23	0.00	-264.92	0.00	264.92	3,636.41	1,818.20	6,405.11	3,207.32	4.13	-0.51	0.087
80.00	-15.30	-4.09	0.00	-243.76	0.00	243.76	3,582.51	1,791.26	6,176.66	3,092.92	4.69	-0.54	0.083
85.00	-14.44	-3.96	0.00	-223.29	0.00	223.29	3,527.66	1,763.83	5,950.61	2,979.73	5.28	-0.57	0.079
90.00	-13.60	-3.82	0.00	-203.50	0.00	203.50	3,471.85	1,735.93	5,727.07	2,867.79	5.89	-0.60	0.075
90.75	-13.47	-3.80	0.00	-200.63	0.00	200.63	3,463.40	1,731.70	5,693.76	2,851.11	5.99	-0.61	0.074
95.00	-12.26	-3.68	0.00	-184.48	0.00	184.48	3,415.08	1,707.54	5,506.14	2,757.16	6.54	-0.63	0.071
96.00	-11.97	-3.65	0.00	-180.80	0.00	180.80	3,349.57	1,714.79	5,343.52	2,724.62	6.67	-0.64	0.099
100.00	-11.48	-3.54	0.00	-166.20	0.00	166.20	3,232.70	1,661.85	5,131.92	2,628.73	7.22	-0.66	0.094
105.00	-10.88	-3.41	0.00	-148.48	0.00	148.48	2,290.51	1,445.25	3,593.23	2,198.28	7.92	-0.69	0.087
110.00	-10.29	-3.28	0.00	-131.43	0.00	131.43	2,256.55	1,428.17	3,455.54	2,130.34	8.57	-0.72	0.081
115.00	-9.72	-3.15	0.00	-115.04	0.00	115.04	2,221.23	1,410.61	3,318.97	1,661.95	9.44	-0.75	0.074
120.00	-9.16	-3.02	0.00	-99.29	0.00	99.29	2,185.15	1,092.57	3,183.61	1,594.17	10.25	-0.78	0.066
125.00	-8.61	-2.89	0.00	-84.20	0.00	84.20	2,148.11	1,074.06	3,049.58	1,527.06	11.08	-0.81	0.059
130.00	-8.08	-2.77	0.00	-69.74	0.00	69.74	2,110.11	1,055.06	2,916.99	1,460.66	11.94	-0.83	0.052
135.00	-7.56	-2.64	0.00	-55.91	0.00	55.91	2,071.15	1,035.58	2,785.94	1,395.04	12.82	-0.85	0.044
137.50	-7.30	-2.58	0.00	-49.31	0.00	49.31	2,051.31	1,025.66	2,721.03	1,362.54	13.27	-0.86	0.040
140.00	-6.83	-2.51	0.00	-42.87	0.00	42.87	2,031.24	1,015.62	2,656.54	1,330.24	13.73	-0.87	0.036
141.75	-6.51	-2.47	0.00	-38.47	0.00	38.47	1,746.42	873.21	2,301.91	1,152.67	14.05	-0.88	0.037
145.00	-6.22	-2.39	0.00	-30.45	0.00	30.45	1,725.48	862.74	2,232.51	1,117.91	14.65	-0.89	0.031
150.00	-5.78	-2.27	0.00	-18.50	0.00	18.50	1,692.48	846.24	2,126.72	1,064.94	15.58	-0.90	0.021
151.00	-2.69	-0.80	0.00	-16.23	0.00	16.23	1,685.76	842.88	2,105.71	1,054.42	15.77	-0.90	0.017
155.00	-2.37	-0.71	0.00	-13.03	0.00	13.03	1,658.51	829.25	2,022.22	1,012.61	16.52	-0.90	0.014
160.00	-1.98	-0.59	0.00	-9.49	0.00	9.49	1,623.58	811.79	1,919.12	960.99	17.47	-0.91	0.011
165.00	-1.60	-0.48	0.00	-6.53	0.00	6.53	1,587.69	793.85	1,817.52	910.11	18.43	-0.91	0.008
170.00	-1.23	-0.37	0.00	-4.14	0.00	4.14	1,550.85	775.42	1,717.54	860.05	19.39	-0.92	0.006
175.00	-0.87	-0.26	0.00	-2.29	0.00	2.29	1,513.04	756.52	1,619.28	810.84	20.35	-0.92	0.003
180.00	-0.53	-0.16	0.00	-0.97	0.00	0.97	1,474.27	737.14	1,522.84	762.55	21.32	-0.92	0.002
185.00	-0.19	-0.06	0.00	-0.18	0.00	0.18	1,431.51	715.95	1,425.71	713.91	22.28	-0.92	0.000
188.00	0.00	-0.06	0.00	0.00	0.00	0.00	1,400.07	700.04	1,362.70	682.36	22.86	-0.92	0.000



5. Is there twist and sway data on PE letters?

Professional Engineer (PE) letters do not have twist and sway data within the document and do not have calculations that allow for twist and sway data to be extracted. For this reason, PE letters will no longer be completed for Financial Services projects unless specifically asked for by the customer. Otherwise, all services will be completed as full analyses so that twist and sway data can be calculated and reported.

6. Why are twist and sway values taken from the service case and not from the full-wind case?

Using the most recent wind maps from the 2012 International Building Code, wind speeds for the full-wind cases are developed based upon a 700-year mean recurrence interval. These wind maps correspond with the wind speeds used within our analyses after TIA-222 related safety factors are considered. This level of risk is considered too stringent by TIA-222 for service concerns, and lower wind speeds are allowed. Service-case wind speeds are generally developed assuming a 10-year mean recurrence interval. Based upon this information, the maximum twist and sway values reported in the service cases should only be reached approximately once every 10 years. The minimum service wind speed used in TIA-222-F is a sustained wind speed equal to 50 mph (fastest mile). TIA-222-G uses a gusting minimum service wind speed of 60 mph (three-second gust).

7. Will twist and sway limits be maintained during other tenant installations?

Twist and sway values will be checked for all Financial Services tenants on any analyses that are completed. If these values are found to be outside of their limits, the tower will need to be modified to reduce twist and sway for any existing dishes that are out of tolerance before installation of new equipment will be allowed to occur.

8. Is there a way to verify that twist and sway limits are being upheld during other tenant installations?

Current twist and sway values can be verified by ordering a twist and sway analysis from American Tower. This analysis will provide a report similar to a typical structural analysis and will use the most up-to-date loading at the time of the order. This offers additional confidence to any carrier that is concerned about twist and sway levels being maintained. This service will be similarly priced to a typical structural analysis based upon all calculations and twist and sway tables being included in the deliverable.



9. What types of towers are best for installation with regard to minimizing twist and sway?

Self-support towers and guyed towers with large face widths generally behave best with regard to twist and sway values. Such towers are stiffer and more resistant to twisting and swaying. Conversely, self-support and guyed towers that have small face widths and monopoles should be avoided if possible. Most guyed towers that have face widths equal to or less than two and a half feet will behave poorly when large dishes having diameters equal to or greater than eight feet are installed. Similarly, a rule of thumb for installation on self-support towers is to avoid installing more than 30 feet away from where a tower loses its taper and has straight sections. This mostly happens once the face width becomes small. This can also limit the length that a self-support tower can be extended, since such large runs of small face-width straight sections will perform poorly in twist and sway. Other good towers for installation of dish equipment are AT&T Tag towers and guyed H-Frame towers. Both of these tower types were designed for large dish installations and have improved resistance to twisting and swaying.

10. Where is the best location to install on a tower?

On guyed towers, the best location to install a dish with regard to twist and sway values is just above a guy location. Guy attachment points generally help to straighten a tower and will typically behave well with regard to twist and sway in their locality. This effect works both above and below the guy attachment, although installations below guy attachment points will need to avoid physical interference with the guy wires. Self-support and monopole towers will generally be stiffer and more resistant to twist and sway the lower the installation is on the tower. Since this is generally counter to height needs, the following rules can be followed. Generally, monopoles are not good for installation of large dishes. If a monopole is to be used, smaller dishes should be chosen, even if this could require an additional node on the proposed path. On self-support towers, installing on tapered sections or within the first 30 feet of a straight section will offer the best chance of having acceptable twist and sway results. Installing higher up on straight sections can still often work but will cause increasing chances of unacceptable twist and sway as the elevation increases. This is one of the driving factors on height extension limits for microwave equipment.

11. Can self-leveling mounts be used to mitigate towers that have high twist and sway results?

Certain marine applications have used self-adjusting mounts to recalibrate microwave communications systems in real time. Some of these mounts can hold up to 500 pounds making them ideal for any six-foot or smaller dish installations. Such mounts would be able to keep a dish steady even during a wind event. Currently, American Tower is performing additional research to see if there are cost-effective solutions from these mount providers. [BATS Wireless](#) has provided promising feedback with regard to this type of installation and can be contacted with regard to more specific customer installations.



12. What are the options if a tower fails to meet twist and sway limits?

If an analysis gives results that are unacceptable per twist and sway limits, there are a few options that can be completed. Often, the limits given for larger dishes are more stringent than that for smaller dishes. Larger dishes also add more loading to towers which will cause larger twist and sway in the structure. Due to this, changing equipment to smaller dishes can often change the limits and calculated values enough to turn an unacceptable result into a passing result. If this type of change is possible, it is often the best course of action since there will be no need for reinforcement. If reducing dish sizes is not an option, modification of the tower can be done. Due to the nature of twist and sway and tower stiffness, modification may not always be feasible. In most cases, towers should be able to be brought into twist and sway compliance through modification design and installation. If none of these options work, use of a self-leveling mount may be an option. In cases where the tower is out of specification in terms of twist and sway, the mount will be able to keep the dish in alignment with the next node in the microwave path.

13. Can TIA-222-G recommended twist and sway allowances be relaxed in some cases without losing reliability?

In some cases, TIA-222-G recommended twist and sway values can be relaxed. Prior versions of TIA-222 have allowed up to 12 dB degradation, which can still be acceptable without causing a significant loss in reliability for dishes that are typically six feet in diameter or smaller. Larger dishes will often require tighter adherence to TIA-222 recommendations. These dishes have the potential to see a small increase in allowed twist and sway. Shorter distances between the nodes along paths may also increase twist and sway tolerances without jeopardizing the reliability of the network. Dishes that use millimeter wave technology should not deviate beyond TIA-222 recommended values regardless of distance between nodes or other factors.

If you have additional questions,
please contact:

877-409-6966

leasing@americantower.com

