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STABILITY DURING ROOF SYSTEM INSTALLATION & DISMANTLE:

How do I ensure it goes up and down safely?

In previous ESG Report articles, we described how lateral forces apply to temporary roof truss structures, and described some of the bracing methods used to compensate for such forces. Those methods are premised on the structure being in place, but we should not overlook the installation and dismantling process that also occurs. In this article we'll discuss the potential stability issues that exist during those processes. These issues apply equally to a variety of applications, such applications as roof systems, goal posts, and sound system delay towers.

The concern for lateral stability is just as important during Installation and Dismantling (I & D) as it is while the structure is in use, primarily because the methods for achieving stability aren't as obvious. In fact, during I & D, some of the system elements that are normally braced aren't even in place yet.

Let's use a four column roof system, with a column at each corner, as an example. During I & D the column locations are determined, and the column bases are placed accordingly. With most systems, the column base is a separate assembly, with some type of hinging mechanism attached. The columns are built on the ground horizontally, attached to the hinge, and then pivoted up into a vertical position. Once vertical, the hinges are locked to prevent pivoting.

At this point in the process, we have a column – maybe more than one column – that is not yet attached to any horizontal roof truss element. It's free-standing, essentially unbraced, and therefore unstable. Any lateral force could potentially overturn the column, representing a danger to the installing technicians. Now what? You shouldn't be this far into the installation process without a plan.

For our purpose, unrestrained columns present a simple issue of overturning, and we want to prevent this from happening. From an engineering perspective, we want the resisting moment greater than the overturning moment.

In Figure 1, we demonstrate how a 30 mph wind load translates to overturning moment (note that

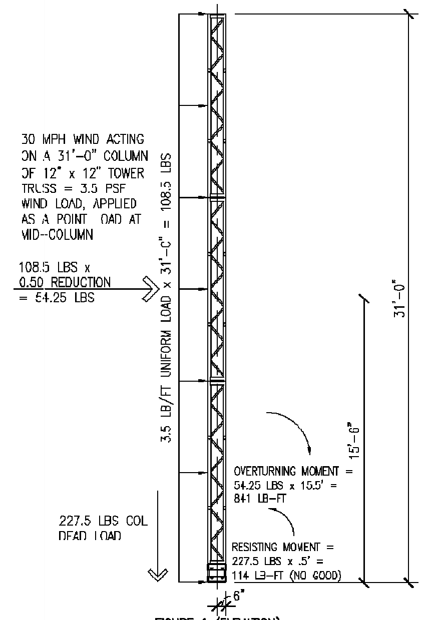

FIGURE 1 (ELEVATION)

FIGURE 1 (PLAN VIEW)

our example only demonstrates the overturning moment, with no sliding forces). Normally, the wind load is applied to the entire surface area of any effected element, but - because the sides of the column are not a solid, uniform surface – we can use a wind surface area reduction factor, due to the ratio of open area to solid truss component. In our case, assume 50% for this reduction factor. In our example, this translates to a 3.5 lb/sq ft uniformly distributed load, which we can then apply as a point load, at the mid-point of the column. You can see how this apparently small load translates into an overturning moment of 841 ft-lb. While that doesn't seem like much, the resisting moment is only 114 ft-lb.

Imagine a column of 12"x12" box truss – its foot print is 1 sq ft, so balancing this on the ground is about as easy as balancing a pencil on your fingertip. The math shown in Figure 1 proves why this isn't stable; the overturning moment is much greater than the resisting moment, primarily because the base doesn't provide a significant moment arm.

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Let's step aside for a moment to describe a basic principle for achieving stability: make the base of the column heavy enough to resist the moment in the column itself. We can easily accomplish this by adding ballast, but that might be impractical for a column having a small footprint. Another way to improve stability is to effect an increase in the resisting moment by making the column base footprint larger, but making the base plate larger to accommodate more ballast might also be impractical. So, let's take this a step further and effect a larger column base, by connecting smaller components together. [see figure 2].

Attaching a set of four 5'-0" long outriggers to the column base increases the foot print size to about 8-6" sq ft, and we have significantly improved stability by both a) increasing the column dead load, and b) increasing the resisting moment arm from 6", to about 4'-3". You can see how this solution works by making the resisting moment larger than the overturning moment. However, this footprint size might be inordinately large in comparison to a small-mass column. For the amount of time needed to install a roof system, it might also be practical to temporarily attach large outriggers to the column bases, and then remove the outriggers once the system is installed with the required lateral bracing and guy wires (see our September 2005 ESG Report for a comprehensive discussion on this topic).

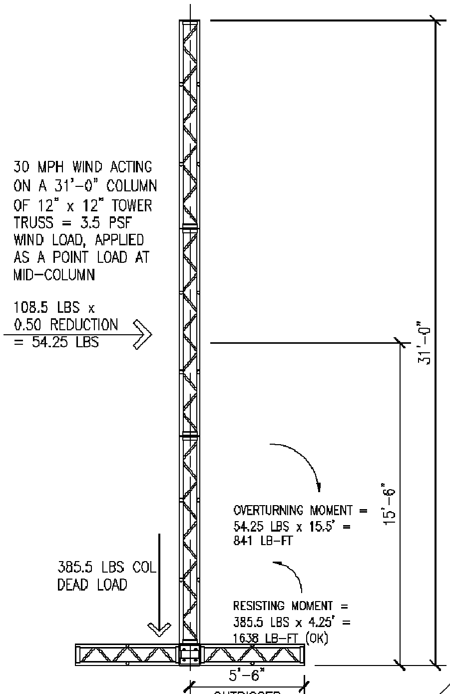

FIGURE 2 (ELEVATION)

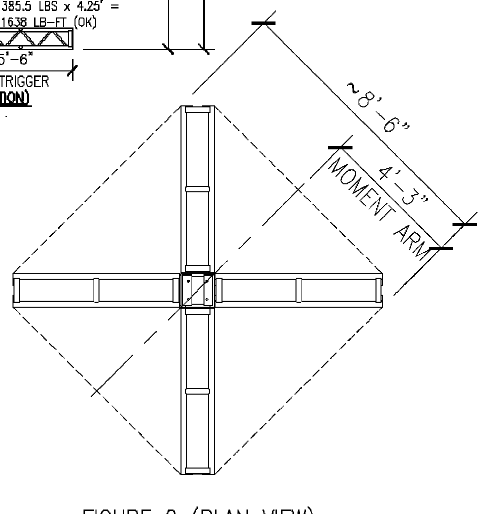

FIGURE 2 (PLAN VIEW)

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We should point out that truss manufacturers offer several ways to attach base plates, and outriggers. Notice in the figure 2 plan view that our 4'-3" moment arm represents a worst-case assumption of a common attachment method. Even though the columns may be oriented as shown in the figure 2 elevation, the tower is essentially free-standing, and will therefore tip in the direction providing the least resistance to an applied tipping force. This brings us to another solution: Instead of using free-standing columns, let's tie all of the columns together, using a base truss assembly [see figure 3 below].

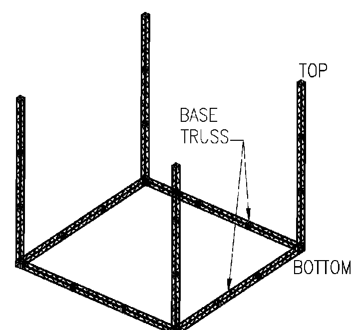

FIGURE 3 (ISOMETRIC VIEW)

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In this method, we achieve a large base mass, which also contributes to the overall stability of the fully-installed system by giving us a way to couple ballast to the system. In most cases, the roof system is over a stage, so the stage can be built over the base truss system such that the base truss remains as an integral and stabilizing part of the installed system, but without being an obstruction in the process.

When your system is properly designed and built to withstand lateral loads, you might need this extra measure of stability anyway, so why not take advantage?

To conclude, we'll stress again that roof truss systems must be braced for lateral stability, whether the structure is temporary or permanent. You should plan ahead in order to achieve this stability at all times during an event, including installation and dismantling. Some situations require solutions that are installed only for the duration of the I & D process, while others allow methods that remain an integral part of the system for the entire use period. You decide what's best for your specific event – but above all: be safe, and plan ahead!