# Temporary Structures Need Wind-Load Standards

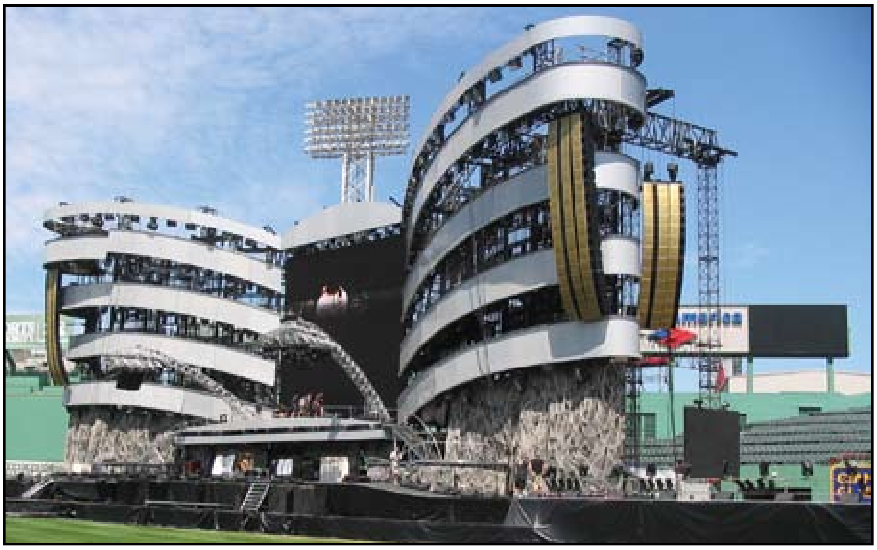
*By William B. Gorlin, P.E., S.E., SECB*



Structural engineers are experienced at designing and building a structure to conform with applicable codes. But what happens when that regulatory guidance is lacking? When building a temporary structure such as a concert stage, where does the engineer look for direction on the wind-resisting strength of that structure? From the local building codes? The preference of the event owner or equipment owner? The engineer's own professional judgment? All of the above?

Because of the absence of industry-wide standards, the answer is less clear-cut than you might think. The engineering community has long wrestled with the question, "How strong is strong enough?" in resisting wind loads for temporary structures such as concert stages, tents, temporary display structures, temporary screens, temporary roofs and shade structures, and lighting and speaker towers.

Equally important is the question of how to erect a temporary structure that balances costs with safety benefits. Some building codes require temporary structures to comply with the wind-load guidelines applied to permanent buildings, and others leave the issue to the discretion of the building official. Accordingly, engineers are designing temporary structures that are strong enough to survive a once-a-century hurricane when in fact they will be used for only a short period – sometimes just a day or two – and would never be used to shelter people during a strong storm. The most these structures are likely to face is a thunderstorm, but the building codes call for designing for hurricanes, which drives up costs unnecessarily without increasing safety.



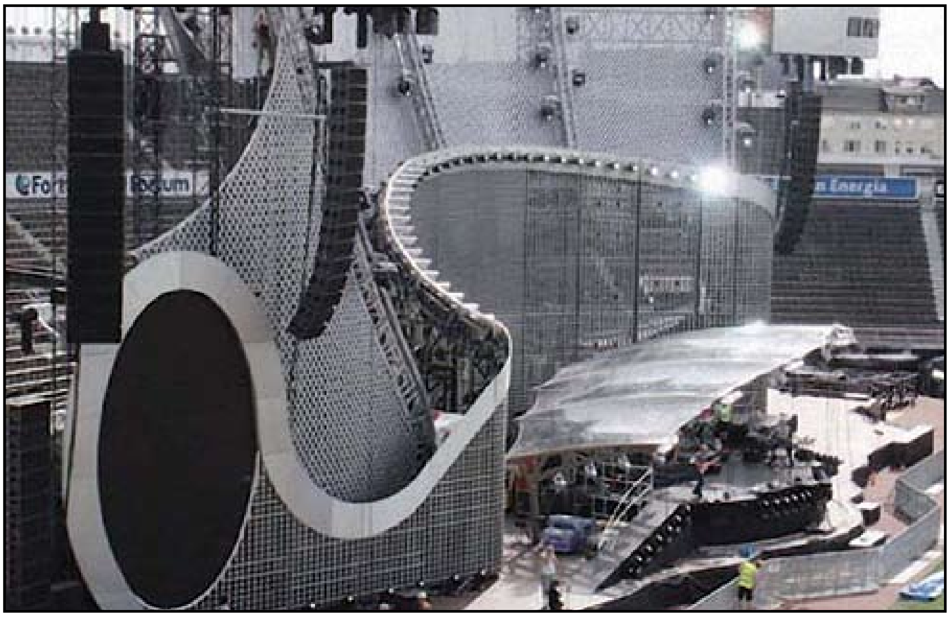
*Rolling Stones Bigger Bang tour, Fenway Park, Boston, August 2005. McLaren provided engineering services for the concert stage. Courtesy of Mark Fisher.*

The regulatory landscape for temporary structures is not completely barren; guidelines do exist in specific areas. For example, for temporary concert stage roofs there is a standard promulgated by the Entertainment Services and Technology Association (ESTA): American National Standard E-1.21-2006, Entertainment Technology, *Temporary Ground-Supported Overhead Structures Used to Cover the Stage Areas and Support Equipment in the Production of Outdoor Entertainment Events*. This is an excellent standard that considers the practical situations associated with such events.

## Issuing a Call for Broad-Based Standards

Its effectiveness notwithstanding, the ESTA E-1.21 standard addresses only an important but narrow range of temporary structures. The fact remains that there are no absolute standards governing the wind-resisting strength of a wide range of temporary structures. Engineers charged with designing a temporary display assembly, for example, have to rely on their own judgment and that of the municipal or state jurisdiction in which the structure is built. Without appropriate standards, safety may be compromised or costs needlessly increased.

That is why we strongly advocate the issuance of authoritative guidelines on wind loads for all types of temporary structures. To determine appropriate wind pressures, structural engineers start by consulting building codes. These codes define the design loads that structures are subject to in a gamut of environmental conditions, whether it be wind, rain, snow, varying temperatures or earthquake. For wind loads, nearly all states and municipalities have adopted into their codes ASCE 7, a standard developed by the American Society of Civil Engineers that defines minimum design loads on buildings.



*Constructing the concert stage for the Genesis 2008 tour.*

*Above: Bank of America Gift Box, a temporary 350 square foot pavilion on Fifth Ave. in New York City, built as a "gift" to the people of New York for the 2007 holiday season. McLaren engineered the temporary building structure, temporary foundation and rooftop ribbon assembly. Courtesy of McLaren Engineering Group.*

## Adapting the Standard for Permanent Structures under Construction

Most building codes, however, don't specify requirements for temporary structures, whose lifespan ranges from one day to two years. Accordingly, engineers may consult another standard, called ASCE 37, which addresses design loads on permanent structures under construction – short term, similar to temporary structures.

ASCE 37 includes provisions for modifying wind loads to reduce them for short-term exposure during construction, which is relevant here because temporary structures such as stages and tents typically are erected for six weeks or less. Following this standard, the wind load applied to a structure under construction is 56 percent of that applied to a permanent structure, because of its reduced exposure to wind. Engineers have equated this probability with that of a temporary structure erected for a similar time.

## Factoring In the Human Element

While the ASCE standards provide a blueprint on wind loads from a strictly engineering standpoint, they fail to incorporate the human element. For example, if a homeowner climbs an extension ladder – a temporary structure – to clean the gutters on his roof, he will not wait until a "56 percent of code wind" figure is reached before dismounting the ladder. A strong enough breeze will coax him down or discourage him from going up in the first place.

In everyday life, people use forecasting and good judgment to deploy temporary structures – village placards, farmers' market tents, shade structures, umbrellas – in wind speeds much lower than codes stipulate. In virtually all of these scenarios, the structures are dismantled in time.

Engineers attempt to apply this common-sense approach to more significant engineered structures, such as temporary stages, band shells, lighting and speaker towers, and display walls. We must use our judgment to determine a wind-speed threshold above which action is required to eliminate risk, and must gauge the appropriate level of manpower, equipment and time to dismantle the assembly safely and timely.

Such practical approaches that consider the limited duration of exposure and human factors have been incorporated by ESTA E-1.21, the entertainment industry standard cited earlier. This standard should form the framework for the development of a broader-reaching standard to address wind and other environmental loads on temporary structures.

## Seeking Professional Organizations to Spearhead Standards Effort

Organizations such as ASCE or ESTA should take the lead in establishing more-encompassing standards for temporary structures that consider factors such as designing for a range of wind threshold levels, maximum time for dismantling structures, and monitoring and operational procedures. An anemometer (wind gauge), for instance, should be required on site and monitored continuously, and weather forecasts should be reviewed routinely.

The following example illustrates the need for broad-based standards from an authoritative industry group. Let's say a tower is erected to raise a large video screen for an outdoor entertainment event. If windy conditions are impending, at what wind speed is it prudent to take the video screen down and lay it flat on the stage so it doesn't collect wind and become, in essence, a sail? The equipment owner may advocate a minimum threshold – say, 40 miles per hour – and in the absence of widely established guidelines, engineers would rely on that guidance, coupled with their own professional judgment in arriving at appropriate thresholds.

*Fabricating the red ribbon bow, which was 12 feet high, 50 feet long, weighed 3 tons and made of 10-guage steel. Courtesy of McLaren Engineering Group.*

But other questions arise: What is the safest method of dismantling the screen? What personnel are needed? What if the wind is shy of the 40 mph threshold – can the structure still be taken down safely? When weather forecasts have predicted the wind condition, is there enough time from the forecast notice to take it down? These questions underscore the need for more definitive, broad-based standards addressing various potential wind thresholds, dismantlement times and other areas.

Setting realistic standards also means accounting for the surrounding environment. For example, if the structure is near an open body of water or field, and a strong wind is probable, the standard's maximum threshold should be raised to reflect those conditions. If forecasts call for a hurricane and accompanying winds of 70 mph or greater, standards should allow for adequate advance warning – at least a day and a half to two days.

## Cost versus Safety: Striking the Right Balance

The lack of standards hurts a project's bottom line, too. We have designed dozens of concert stages, ranging from large touring and live-event sets for the Rolling Stones, Bon Jovi and Madonna to smaller ones for the Rev. Billy Graham and the New York Philharmonic. In all cases, we used ESTA E-1.21 combined with good judgment to determine appropriate wind thresholds and established proper operational guidelines.

If a hurricane were approaching, however, you would not erect the temporary structure, nor would you have it protecting people during the storm. In fact, strong winds would likely keep people away from the event altogether, and may well prompt event owners to cancel or postpone the event. In any case, the worst these structures are likely to face is a tropical storm, but in the absence of other guidelines the building codes apparently require engineers to design for hurricanes, which needlessly escalates costs without enhancing safety.

The cost-versus-safety argument will only intensify as live outdoor events and major traveling productions – such as Cirque du Soleil and concert tours – grow more popular. Promising signs have emerged in recent years, including the introduction of ESTA E-1.21 as well as an ESTA initiative called the Entertainment Technician Certification Program (ETCP), which strengthens certification standards for theater and arena riggers and entertainment electricians. Only about 350 technicians nationwide have attained this certification. This is an encouraging start for raising the qualifications bar, but the program needs to expand to include more types of temporary assemblies. The more professionals earn this certification, the greater the level of safety and risk mitigation.

## Differentiating Wind Thresholds for Time and Financial Constraints

Without clear-cut standards, some progressive organizations have filled the vacuum by establishing their own prerequisites for wind conditions. For instance, one rigging equipment rental company allows event producers to choose required ballast (counterweight) for wind thresholds of 40, 50 or 60 mph for a video screen – depending on the producer's appetite for paying for extra ballast to accommodate a higher wind threshold. The lower the wind threshold, the higher the probability of the wind occurring.

Those instances are the exception, though. Event owners often are at the mercy of local building officials who may be unfamiliar with temporary wind loads and lacking the engineering savvy to distinguish among various wind-load scenarios. Owners should have defined parameters for the levels of financial exposure they will face in dismantling operations compared with the cost of upgrading to a higher wind threshold.

For each possible wind threshold (such as 40 to 70 mph in increments of 10 mph), the standard should include the maximum time required to dismantle the system, so that the structure can be taken down safely before the threshold wind is forecast or likely to arrive. The dismantling approach must be realistic to achieve and properly documented. Furthermore, the threshold could be in steps, such as lowering a video wall and speakers at 40 mph and dismantling the entire truss structure at 60 mph.

Decisions on wind loads for temporary structures must not be a haphazard, case-by-case exercise. Authoritative, comprehensive standards must be established to account for different wind thresholds and timetables for dismantlement, to ensure optimum safety, and to allow for cost-effective staging and operation.▪

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