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BSR E1.21–202x

Entertainment Technology—
Temporary Structures Used for Technical Production of Outdoor Entertainment Events

Rig/2023-2003r1a

Approved by the ANSI Board of Standards Review on _______________

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Interest category codes:

CP = custom-market producer	DE = designer
DR = dealer rental company	G = general interest
MP = mass-market producer	U = user

Table of Contents

FOREWORD

Prior to the inception of this standard, there were essentially no rules, regulations, guidelines, or recommended practices for the design, installation or dismantling, operation or use, and inspection of temporary special event structures. This standard presents a coordinated set of rules that may serve as a guide to government, municipal authorities and other regulatory bodies responsible for public safety in the context of special events. This standard was developed with the presumption that its provisions will be carried out by qualified persons and organizations, each with experience, competency, and qualifications commensurate with the type of action described, so that safety is enhanced during all phases of the structure's usable lifespan. This document contains many different types of statements to ensure safety. Some statements are suggested or advisory, while others constitute mandatory requirements. Compliance with both types may be required by workers and by their employers.

Safety codes and standards are intended to enhance public safety. Revisions are made as a result of committee consideration of factors such as technology advances, new data, and changing environmental and industry needs. Revisions do not imply that previous editions were inadequate.

This version of the standard reflects updates to the ICC building and fire code requirements for temporary special event structures, and intends to remain harmonized with them as a valuable reference. Compliance with this Standard does not of itself confer immunity from legal obligations.

This document uses annex notes to provide additional reference information about certain specific section requirements, concepts, or intent. Subject matter with a corresponding annex note reference is identified by the asterisk (*) symbol, and the associated reference text is found in Appendix A, Commentary, identified with the referring text section number – e.g. an annex note to section 3.2 will be identified in Appendix A, Commentary as A.3.2. The annex notes are informational only, and do not add or subtract from the mandatory requirements of this standard.

1* Scope and intent

The temporary structures within the scope of this document shall be limited to those dedicated to the technical production of outdoor entertainment events. General public access temporary structures, such as food vendor tents, portable toilets, and other portable temporary structures for directly serving the audience or attendees at outdoor entertainment events, are not included in the scope of this standard. Custom temporary structures supporting performance platforms are included in the scope of this document. This document does not include manufactured modular floor staging systems used as platforms for performance, where such structures are independent of other temporary structures.

This document establishes a minimum level of design and performance parameters for the design, manufacturing, use and maintenance of temporary ground-supported structures used in the production of outdoor entertainment events. The purpose of this guidance is to ensure the structural reliability and safety of these structures and does not address fire safety and safe egress issues.

The intent of this standard is to establish a reasonable standard for care by providing the minimum acceptable requirements at which temporary structures shall be designed and used.

2 Definitions

2.1 allowable load. The maximum load that can be safely supported by a component or temporary structure.

2.2 base plate. The component or part of the temporary structure that spreads load to the supporting substrate.

2.3 buckling. Lateral displacement of a compression member from the original centerline under axial load, usually sudden.

2.4 competent person. A person who is capable of identifying existing and predictable hazards in the workplace and who is authorized to take prompt corrective measures to eliminate them.

2.5 dead load. The self-weight of the temporary structure.

2.6 effective wind surface area. The surface area exposed to wind.

2.7 live load. The variable gravity load or weight supported by the temporary structure.

2.8 lock-off. Means of supporting the allowable load of a temporary structure in a fixed position, independent of the lifting device(s).

2.9 manufacturer. Person or company who fabricates components for the temporary outdoor structure.

2.10 MPH. Miles per hour.

2.11 payload. The equipment load or weight supported by the temporary structure.

2.12 qualified person. A person who, by possession of a recognized degree or certificate of professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve problems relating to the subject matter and work.

2.13 shall. Denotes a mandatory requirement.

2.14 superimposed load. Loads associated with wind, rain, snow, ice, seismic etc.

2.15 temporary. A period of time that is less than 180 days in duration.

2.16 tower. One or more components assembled vertically to support load.

3 Design and engineering

The intent of this section of the standard is to provide the minimum basis on which temporary structures shall be designed. This section cites the various standards that shall be used in conjunction with this standard as applicable.

3.1 Reference standards.

The following reference standards shall be used as applicable to the intended materials and relevant conditions of use:

- 2024 International Building Code (IBC)
- SEI/ASCE 7-22, *Minimum Design Loads for Building and Other Structures*
- ANSI E1.2, *Entertainment Technology – Design, Manufacture and Use of Aluminum Trusses and Towers*
- ANSI ES1.7 – 2021, *Event Safety – Weather Preparedness*
- ANSI ES1.19 – 2020, *Event Safety – Structural Safety Requirements*
- ASCE 19-16 *Structural Applications of Steel Cables for Buildings*
- *ADM2020 Aluminum Design Manual - Specifications for Aluminum Structures*
- AISC 360-16 *Specifications for Structural Steel Buildings*
- AISC 303-16 *Code of Standard Practice for Steel Buildings and Bridges*
- American Institute of Steel Construction, *Manual of Steel Construction 13th Edition*
- ACI 318-19(22) *Building Code Requirements for Structural Concrete*
- AWS D1.1/D1.1M:2015 *Structural Welding Code – Steel*
- AWS D1.2/D1.2M:2014 *Structural Welding Code – Aluminum*
- AWS B2.1/B2.1M:2014-AMD1 *Specification for Welding Procedure and Performance Qualification*

3.2* Design requirements

3.2.1 Design shall be performed in accordance with established engineering practice.

3.2.2 Temporary structures shall be designed to support specified loads in accordance with the referenced standards and with the Authority Having Jurisdiction (AHJ) requirements.

3.2.3 All relevant standards shall be used in the design of the temporary structures and shall be dependent on the intended conditions of use.

3.2.4 All conditions of use and use guidelines considered in the design shall be explicitly outlined in the engineering documentation.

3.2.5* The strength of individual components or assemblies shall be established using either Load and Resistance Factor Design (LRFD), Allowable Stress Design (ASD), or by physical testing methods performed in accordance with a recognized national standard. The method used shall be stated in engineering documentation.

~~**3.2.6** When using allowable stress design load combinations of SEI/ASCE 7, reduced wind loads as determined by this standard shall not be multiplied by a load combination factor of less than 1.0.~~

3.3 Analysis

3.3.1 The analysis of temporary structures for the intended load conditions shall be performed by calculation, modeling, physical testing or combination of these methods.

3.3.2 The analysis shall consider the worst combination, application, and configuration of loads and effects within the use guidelines. Load combinations shall be determined by referencing SEI/ASCE 7 or the applicable building code, except as modified by ~~3.2.6 above~~3.5.2.5 below.

3.3.3 The analysis shall assure the overall structural stability and bracing requirements for all applications within the use guidelines.

3.3.4 The analysis shall account for the effects of eccentricities in element and component connections.

3.3.5 The deflections of the individual structural elements and the overall deflection of the temporary structure due to the design loads shall be determined within the structural calculations. The qualified person responsible for the structural design of the structure shall determine allowable deflection limits.

3.3.6 The structural layout and allowable deflections of the structural elements shall ensure that unwanted pooling or accumulation of rain water does not occur.

3.4 Engineering documentation

3.4.1 Engineering drawings of the structural elements and general arrangement drawings of the temporary structure shall be developed and maintained.

3.4.2* Engineering drawings shall include dimensions, components, subassemblies, material types, fastener types and specifications, weld sizes and types, and welding consumables.

3.4.3 Engineering calculations, design notes and/or test results shall be developed and maintained that demonstrate compliance with this standard for the intended load conditions and all applications within the use guidelines.

3.4.4 The engineering documentation shall include definitive statements about the operating limits of the temporary structure including environmental conditions and physical forces, and shall include the following:

3.4.4.1 allowable payload, per element or subassembly as applicable;

3.4.4.2 unfactored service-level design wind speed; wind reduction factors used, and design wind speed.

3.4.4.3 assumed effective wind area inclusive of the temporary structure and equipment suspended from, or attached to, the temporary structure;

3.4.4.4 allowable live load;

3.4.4.5 allowable snow/ice load or accumulation, if applicable;

3.4.4.6 allowable minimum and maximum temperature, if applicable;

3.4.4.7 seismic design loads, if applicable;

3.4.4.8 allowable wind speed during erection of the temporary structure, if different than the design wind speed;

3.4.4.9 If the design calls for mitigating actions or changes to the temporary structure configuration when specified environmental thresholds are reached - e.g. lowered to the ground, or removal of superimposed loads such as wind speed or snow accumulation (as defined in section 3.5.4), the user information shall contain definitive statements about these operating limits for each defined environmental condition.

3.4.4.9.1 Environmental thresholds that require specific mitigating actions.

3.4.4.9.2 Required actions when specified environmental thresholds are reached.

3.4.4.10 Notes and calculations addressing effects of wind pressures on coverings and overhanging elements when effective wind area under roof/canopy/overhanging elements is changed.

3.4.4.11 Notes and calculations addressing effects of wind pressures on coverings and overhanging elements if side walls or backdrops are changed.

3.4.4.12 Notes and calculations addressing any specific limitations regarding the addition of coverings, canopies, overhanging elements, side walls, backdrops, or any other feature that can significantly change wind pressures, total weight, or attract snow and ice.

3.4.5 A summary sheet shall be prepared showing all the design loadings, support reactions, and operating parameters of the temporary structure and shall be provided with the structural calculations that form part of the engineering documentation.

3.4.6 Where guy wires or other bracing systems are used, the proposed guy/bracing arrangements, guy/bracing forces and hold down requirements shall be reported in the design calculations provided with each temporary structure.

3.5 Loading

3.5.1* Seismic loading. Seismic loads calculated in accordance with IBC Section 1613 and Section ~~3103.5.1.4~~3103.6.1.4 shall be permitted. Public occupancy structures assigned to Seismic Design Categories A and B need not be designed for seismic resistance. Seismic loads acting on temporary structures assigned to Seismic Design Categories C through F shall be permitted to be taken as 75% of loads determined in IBC Section 1613, as stated in IBC Section ~~3103.5.1.4~~3103.6.1.4.

3.5.2* Wind loading

3.5.2.1 The wind load on all effective wind surface areas shall be included in the analysis. Reduction of design wind speed pressure on the overall structure containing elements that will be removed as part of the weather hazard mitigation plan shall be permitted. The reduced design wind speed when such elements are present shall not be less than 40 MPH per allowable stress design load combinations (52 mph ultimate wind loads per LRFD design load combinations).

3.5.2.2 The overall stability and resistance to wind uplift and overturning forces shall be provided by means such as guy wires anchored to ground anchors (or ballast), diagonal braces, ballast applied to the tower sections, and dead load.

3.5.2.3 The design wind speed for temporary structures as defined by this document shall be determined by applying the duration coefficients noted in 3.5.2.3.1, and multiplying those coefficients by the basic wind speed specified in ASCE 7, except as modified by 3.5.2.4 and 3.5.2.5.

3.5.2.3.1 Where the structure will be installed for a period of time not more than 180 days, the design wind pressure defined in ASCE7 can be reduced by multiplying the velocity pressure by 0.65, in accordance with the IBC section 3103.6.1.2 exceptions.~~a wind load reduction factor of 0.65 shall be permitted to be applied to the velocity pressure defined in ASCE 7 per IBC Section 3103.5.1.2. This provision shall apply in lieu of the load reduction factors in Table 3103.5.2.~~

3.5.2.4* Where temporary structures will be erected in hurricane-prone or other similar sustained wind event areas, and precautionary measures such as dismantling or securing in the event of a hurricane warning can be taken within 48 hours, a basic wind speed as defined in IBC ~~3103.5.1.2~~3103.6.1.2, shall be permitted. Wind pressures determined by the IBC wind speed shall be based upon a 3-second gust per ASCE 7.

3.5.2.5* Where wind-effect mitigation actions are required, the amount of time needed to take the mitigation action shall be compared against the expected weather notification lead time. A qualified person shall validate the triggering thresholds and fastest anticipated weather approach rate against the time required for action. In such case, the temporary structure shall be permitted to be designed using a reduced wind speed of not less than 40 mph, 3 second gust, based on these actions being performed within the validated time period. Design wind pressure shall be determined using the SEI/ASCE 7 load combinations, with an ASD Load Combination Factor of not less than 1.0, or LRFD Load Combination Factor of not less than 1.6. Once said elements are removed or modified, the remaining temporary structure shall meet the requirements of 3.5.2.3.

3.5.3* Load considerations

3.5.3.1 A load case shall be analyzed for when the temporary structure is being assembled but with no payload applied.

3.5.3.2 If the allowable wind speed during installation as determined by a qualified person is less than the maximum design wind speed for the completed temporary structure, then this shall be expressly stated in the engineering documentation.

3.5.3.3 All load combinations shall be considered per SEI/ASCE 7 except as noted in section 3.5.3.4, and stability calculations shall be done with and without the payload.

3.5.3.4 For all load combinations and all stability calculations, a minimum design factor of 1.5 shall be applied against overturning and sliding. (1.5 x overturning moment < 1.0 x restoring moment).

3.5.3.5 Consideration shall be made for site specific wind load increases due to tunneling effects.

3.5.3.6 The effects of dynamic loading shall be considered. A minimum impact factor of 1.25 shall be applied to loads when accounting for the effects of active hoisting operations.

3.5.4* Superimposed loads (rain, snow, ice, etc.)

3.5.4.1 All roof, overhead and elevated structures shall be designed for a minimum superimposed live load of 5 psf (24.4kg/m²) uniformly distributed across the whole area, and not less than a total load of 300 lbs (136.4 kg).

3.5.4.2 Measures shall be taken to prevent unwanted pooling or accumulation of water on roof coverings, between the structural members.

3.5.4.3.1 If the temporary structure is used in an area and at a time of year where snow is possible, then the engineering documentation shall include snow loading per ASCE 7 with allowable ground snow reduction factors per IBC Table ~~3103.5.1~~3103.6.1.1. For temporary structures that employ an operation management plan per Section 7 of this document, ground snow loads, p_g, as defined by ASCE 7, can be reduced by multiplying the ground snow load by 0.65, ~~(per IBC Section 3103.5.1.1)~~in accordance with the IBC section 3103.6.1.1 exception.

3.5.4.3.2 Ice loads shall be permitted to be determined with the largest maximum nominal thickness of 0.5 inches for all Risk categories, per IBC Section ~~3103.1.5~~3103.6.1.5.

3.5.4.3.3 Where the temporary structure is not subject to snow or ice loads or not constructed during times snow or ice is to be expected, snow and ice loads need not be considered. The total duration of time the temporary structure is to be erected shall be considered when determining the likelihood of a snow or ice event.

3.5.4.4 Where access onto the structure is required, the maximum applied loading from personal safety devices shall be analyzed in conjunction with the anticipated worst-case superimposed loads. The personal safety device loads shall be determined based on the requirements of ANSI E1.39 (current version). Where ANSI E1.39 is deemed not applicable, loads shall be based on OSHA 29 CFR 1926.

3.6 Lifting devices

3.6.1 Lifting devices shall be specified in accordance with the guidelines and recommendations of the manufacturer.

3.6.2 Where the lifting devices are designed for erection of temporary structures only, lock-off devices shall be specified as part of the temporary structure.

3.7 Temporary structure installation and erection

3.7.1* Structural adequacy during erection and installation, including limitations imposed by weather, shall be evaluated

3.7.2* The effective length of compression elements, such as towers, in various stages of erection shall be considered.

3.7.3 An allowance shall be made for sway when determining the structural strength of an unbraced tower.

3.7.4* The engineering design shall establish maximum tolerances for limits of out-of-plumb and horizontal, both during setup and use, including deflections from loading and from horizontally moving loads.

3.7.5 Horizontal loads during erection and installation shall not exceed the allowable load limits of the components exposed to such loads.

3.8* Ground Conditions and Foundations

3.8.1 Minimum required soil bearing pressures shall be provided in engineering documentation. Design calculations shall show how loads are transferred to founding strata.

3.8.2 The required capacity and maximum extension of any column base leveling device shall be stated in the engineering documentation.

3.8.3 Interactions between adjacent foundations, supports, or anchors shall be evaluated.

3.8.4 Temporary structures shall use the presumptive soil bearing pressures as defined by IBC Section ~~3103.5.2~~3103.6.2 and Table 1806.2 of the IBC. These presumptive values shall be used unless higher bearing pressures are proven through testing and evaluation by a registered design professional.

3.9* Stability

3.9.1 General A registered design professional shall design the lateral force resisting system(s) used on the temporary structure.

3.9.2* Guy-wire and cross-bracing assemblies. The requirements of this section shall apply to guy wires and cross-bracing assemblies.

3.9.2.1 Guy wire and cross-bracing assemblies shall be used to transfer the structure's lateral forces to the ground.

3.9.2.2 All guy wire and cross-bracing components and assemblies shall have a working load limit defined in the calculations, the equivalent strength of which shall be equal to or greater than the design loads.

3.9.2.3 Where used, wire rope assemblies shall be designed and constructed in accordance with ASCE 19, using purpose-made connectors at each end. Other materials are permitted to be used subject to compliance with applicable standards for those materials and loading requirements of the system.

3.9.2.4* A means of adjusting tension in guy wire and cross-bracing assemblies shall be provided as part of the assembly.

3.9.2.5 Guy wire assemblies shall be anchored to resist design loads.

3.9.3 Embedded anchors. Embedded earth anchors shall be selected, installed, and tested in accordance with the manufacturer's guidelines and recommendations, shall take into consideration the length of time that the temporary structure will be in place, shall consider the soil conditions at each anchorage location where the temporary structure is to be erected.

3.9.4* Ballast.

3.9.4.1 The amount and location of ballast shall be determined by a qualified person and shall be site-specific. The weight of ballast required shall resist slippage and uplift with a minimum design factor of 1.5 times the horizontal and vertical vector reactions created by the applied tension load.

3.9.4.2 The design for stability of the structure shall include the effects of seismic activity on the ballast's reliance on friction for resisting movement and stability.

3.9.4.3 The design for stability of the structure shall include the effects of environmental conditions, such as rain, humidity, snow/ice, and temperature, on the ballast's reliance on friction for resisting movement and stability.

3.9.4.4* The ballast system shall maintain the designed force resisting capacity without becoming unstable, slipping, or overturning.

4 Manufacturing

4.1 Intent
The intent of this section is to ensure that all manufacturers maintain a minimum level of quality throughout the manufacturing process and that each and every component is traceable back to the manufacturer.

4.2 Material
Materials used in the manufacturing of structural components shall comply with applicable material standards in accordance with section 3.2.3 of this document.

4.3 Fabrication

4.3.1 Fabrication techniques for structural elements shall be approved by a qualified person.

4.3.2 Individual fabricators employed in the manufacturing process shall meet applicable standards of qualification as approved by a qualified person.

4.3.3 Welding of structural elements shall be performed using qualified welding procedures in accordance with the requirements of AWS B2.1. Welders and welding operators shall be qualified in accordance with the requirements of AWS B2.1. Where approved by a qualified person, the use of alternative standards and qualifications shall be permitted and documented.

4.4 Inspection

4.4.1 Individual components of the temporary structure shall be inspected by a competent person during and after fabrication to ensure the component has been built in accordance with design drawings.

4.4.2 Fastening assemblies, connections and other such critical component interactions shall be tested after fabrication, for compliance with stated requirements.

4.5 Identification

4.5.1 The manufacturer shall use components and materials that have certified material properties and that are traceable to their source.

4.5.2 The manufacturer shall keep on file records of all component and material certifications including manufacturer, model, serial no. if one is assigned, date of receipt, and all certifications.

4.6 Documentation
Manufacturer-provided documentation for temporary structures shall include the following:

4.6.1 Complete design calculations and drawings of the overall temporary structure bearing the seal and signature of a registered design professional.

4.6.2 Written instructions for the proper use and maintenance of the system and individual components. These instructions, including drawings where applicable shall include the following:

4.6.2.1 Recommended preventative maintenance.

4.6.2.2 Handling and storage guidelines.

4.6.2.3 Erection and dismantling procedures.

4.6.2.4 Inspection requirements including specific component rejection criteria.

4.6.2.5 Emergency contact information.

4.6.3 Additional documentation as determined by the manufacturer.

4.7 Training

The manufacturer shall provide instructions, for training purposes, on the proper use of the temporary structure. Manufacturer's instructions shall include the following information:

4.7.1 Intended use of temporary structure.

4.7.2 Initial on-site training and assembly and disassembly of the complete temporary structure.

4.7.3 Operational guidelines.

4.7.4 Temporary structure limitations.

4.7.5 Additional tasks or recommendations as determined by the manufacturer.

5 Use and care

5.1 User responsibility

The structure's user shall conform with the requirements of this standard.

5.1.1 AHJ compliance required. The structure's user shall be responsible for compliance with the requirements of the authority having jurisdiction (AHJ).

5.1.2 Operations management plan required. The structure's user shall prepare an operations management plan (OMP) conforming to section 7, with collaborative input from the user's engineer, the system manufacturer, and any other person deemed essential to the OMP development process.

5.1.2.1 The OMP shall include weather hazard mitigation in accordance with ANSI ES1.7.

5.1.2.2 Risk mitigation actions in the OMP shall be printed and attached to the structure, at a location readily visible and accessible by event personnel.

5.1.2.3 The OMP shall be available for reference on-site.

5.2 Designated person.

A qualified person shall be designated to have overall responsibility on site for the temporary structure.

5.2.1 The designated person shall have knowledge of the engineering documentation for the temporary structure's components and configurations in use. Deviations from the engineering documentation shall be permitted only with written approval by a registered design professional.

5.2.2 The designated person shall develop a risk assessment plan for each use, and shall provide instruction for the safe erection, use and dismantling of the temporary structure.

5.2.3 The designated person shall prepare layout drawings consistent with the engineering documentation.

5.2.4 The designated person shall have authority to implement the actions required by the OMP to ensure the safety of people in relation to the temporary structure.

5.2.5 The designated person shall inform all persons and entities having responsibilities pertinent to the OMP.

5.2.6 The designated person shall coordinate and account for all loads to be placed on the temporary structure, including gravity loads and effective wind area.

5.2.7 The designated person shall check the site of the temporary structure for underground services before load bearing elements are positioned, including bases, ground anchors and ballast points.

5.3 Pre-use

5.3.1* Foundations shall comply with the requirements of section 3.8.

5.3.2 The temporary structure shall be braced to provide stability during erection to prevent buckling, overloading or failure of components.

5.3.3 All anchors, ballast and guy wires shall be clearly marked and protected from traffic and equipment on site.

5.3.4 Components shall have manufacturer's load ratings that meet or exceed the required working loads.

5.4 During Use

5.4.1 The user shall adhere to the guidelines set forth in the operations management plan, including monitoring of environmental factors (i.e. wind, rain, snow). Environmental monitoring shall be recorded at regular intervals, and shall be continuously monitored during times when hazardous environmental events are predicted or anticipated.

5.4.2 Safety equipment shall be provided in accordance with OSHA and AHJ requirements.

5.4.3* The designated person shall be responsible to ensure that the entire temporary structure is electrically grounded prior to energizing any electrical component attached to the temporary structure.

5.4.4* The temporary structure shall be checked by the designated person at regular intervals during use, after unattended periods, and after a significant loading or environmental event.

5.4.5 The designated person shall coordinate to prevent the general public from tampering with components that may infringe potential traffic areas.

5.4.6 A copy of the engineering document package shall be maintained on site and be available for inspection.

5.5 Post Use

Following each use of the temporary structure, the designated person shall conduct a complete inspection of each component in accordance with section 6 of this document.

The temporary structure shall be braced to provide stability during erection dismantling to prevent buckling, overloading or failure of components.

6* User inspection

6.1 Intent

The intent of this section is to establish minimum required inspection routines and guidelines for the user. Advice shall be sought by the user for specific inspection routines from the manufacturer or from a qualified person for all systems, materials, and components.

6.2 Inspection Requirements

6.2.1 A detailed, hands-on inspection of all temporary structure components shall be performed by a qualified person, when purchased or acquired, and at least once per year. Inspection records shall be kept.

6.2.1.1 The inspection records shall be dated and signed by the person conducting the inspection.

6.2.1.2 The inspection records shall be kept on file until components are permanently removed from service.

6.2.2 Visual inspections of all temporary structure components shall be performed by a competent person, and shall be conducted prior to each use.

6.2.3 Visual inspection by a qualified person shall be performed immediately after an incident that might in any way have caused damage to any part of the temporary structure or individual components of the temporary structure.

6.3 Repair and removal from service

6.3.1 If any component fails the inspection criteria, or is suspected of being damaged, the component shall be removed from service and marked accordingly.

6.3.2 A qualified person shall perform and document an assessment of any component removed from service and not destroyed.

6.3.2.1 Returning an assessed component back into service shall be permitted, if the assessment results show that the component does not lessen the strength and durability of the structure.

6.3.2.2 Repairing a component shall be permitted if the repaired component does not lessen the strength and durability of the structure.

6.3.2.3 Any component damaged beyond repair shall be permanently removed from use or service.

7* Operations management plan

7.1 The OMP shall govern the operations of the temporary assembly throughout its use period, including load-in and load-out of all supported and nearby elements.

7.2 The OMP shall include all manufacturers' operational guidelines.

7.3 The OMP shall define the actions to be taken for different parts of the structures during and in anticipation of specified weather conditions. A qualified person shall verify that such actions can be achieved as documented.

7.4 The OMP shall include environmental monitoring procedures.

7.4.1 Active on-site wind speed monitoring shall be maintained for the entire period the structure is assembled. Weather stations with anemometers shall be used on site to monitor wind. They shall be placed at an elevation within 5 ft. of the highest elevation production element and clear of any components of the structure that might shield it from the wind. Wind speed monitoring shall be recorded on site at regular intervals, and continuously when any significant environmental event triggering threshold is reached. Triggering thresholds shall be defined in the OMP.

7.4.2* The weather and wind forecast for the structure's location shall be continuously monitored by the user's designated person. A regular liaison shall be maintained with a qualified meteorologist, a local airport or other qualified weather information center to ascertain if any significant weather events are expected in the immediate vicinity of the temporary structures. National Weather Service advisories shall be considered as a last resort source for information, and shall not be permitted for use as a triggering threshold for OMP weather-related mitigating actions.

7.4.3* When predictive assessment of weather data indicates thunderstorms, lightning, high winds, tornado, flood, tsunami, or other severe conditions, critical mitigating actions shall immediately be taken to make the structure's area safe for all personnel, guests, and performers consistent with the established OMP.

7.4.4 When the mitigation actions required by the OMP include accommodating the effects of ice or snow, the OMP shall include requirements for monitoring the ice and snow accumulation.

Appendix A, Commentary

This commentary is not part of the Standard and contains no mandatory requirements. It offers some explanatory information about the clauses in the standard. The relevant clauses have the same clause number, but without the "A" prefix. The clause numbering here is not continuous because no comments are offered on some of the clauses in the Standard.

Since no mandatory requirements are stated in this commentary, if there is any disagreement between the text of this appendix and the requirements stated in the body of the standard, the requirements in the body of the standard shall prevail.

A.1 Scope

This section of the standard defines the scope of the standard and defines the types of temporary structures that are covered by the standard. There are a variety of materials and technologies utilized in temporary structures that are intended to be included in the scope of this document. These could include scaffold based structure, aluminum or steel towers and trusses and lumber construction. Additionally, there is an array of lifting or erection methods and systems incorporating hydraulic, winch or chain hoist technology. All of these may be included in this standard. It is not the intent to exclude any existing or future technology.

While the scope of this document does not include fire safety issues, it is important to consider that certain conditions may arise that require fire safety consideration. These could include temporary structure location, safe egress, combustibility of materials, and the nature of equipment in use.

A.3 Design and Engineering

A.3.2 It is understood that many temporary outdoor structures may incorporate aluminum truss and towers as components in the systems.

When such components are to be used on more than one occasion, ANSI E1.2 requires that the allowable loads for the components of aluminum structure, as calculated in accordance with the “Specifications and Guidelines for Aluminum Structures” published by the Aluminum Association, be multiplied by a load-reduction factor of 0.85 to account for minor damage that may occur during the transportation and use of the equipment.

If a temporary structure is made of steel, then the engineer may choose to adopt the same design philosophy and use the same load-reduction factor.

If the designer anticipates that the structural element or temporary structure will be loaded and unloaded a very large number of times (in excess of 20,000 loading cycles), then the engineer should consider performing a thorough fatigue analysis of the stress ranges created by cyclic loading in accordance with accepted engineering practice.

A.3.2.5 Physical testing used to determine the strength of a component or assembly must be performed in accordance with a recognized national standard. Examples include, but are not limited to the following:

- The Aluminum Association “Specifications & Guidelines for Aluminum Structures” – Appendix 1 Testing
- ASTM E72 “Standard Test Methods of Conducting Strength Tests of Panels for Building Construction”
- ASTM E73 “Standard Practice for Static Load Testing of Truss Assemblies”
- ASTM E196 “Standard Practice for Gravity Load Testing of Floors and Low Slope Flat Roofs”
- ASTM E455 “Standard Method for Static Load Testing of Framed Floor or Roof Diaphragm Constructions for Buildings”
- ASTM E564 ”Standard Practice for Static Load Test for Shear Resistance of Framed Walls for Buildings”

A.3.4.2 While fire safety issues are excluded from the scope of this document, it is prudent to perform a risk assessment when selecting structural or non-structural materials that may be affected by excessive heat.

A.3.5.1 Seismic Loading

This standard allows a reduction in seismic design load, consistent with the duration of the intended use. It is important to note that exposure-based risk should not be increased if a short duration of use is considered.

If the assembly is used for a touring production, then the seismic loads of the possible locales should be considered. The structural features (such as amount of ballast, guying/bracing scheme, etc.) can be modified from site to site depending on the local seismic conditions, if such variations are included in the operations management plan and user information.

A.3.5.2 Wind Loading

Because of the lightweight nature of many temporary structures used for technical production, particularly stage roofs and scaffold towers, proper consideration of wind loading is critical to their safe use.

It is also important to consider that additional loads suspended from these temporary structures can have significant impacts on their structural performance. It is critical that a minimum threshold of these loads is considered and incorporated in the design calculations of these temporary structures and imperative that the engineer investigate these potential forces during the design process.

In the absence of specific information on the tributary wind area of structural elements of any trussed assembly (roof structure, towers, etc.), then the area should be assumed to be 0.50 x apparent elevation of truss and tower section. If such elements are clad, then the tributary wind area shall be the projected surface area of the cladding.

The wind load on all exposed truss and tower sections, roof skin, backdrops, banners, advertisements, suspended or supported equipment, and supported scenery shall be determined in the structural calculations that form part of the engineering documentation for a particular event if these are more restrictive than the parameters assumed by the manufacturer.

Unless expressly stated in the design, the overall stability and resistance to wind uplift, overturning and sliding forces are provided by a series of wire guys anchored to ground anchors (or ballast), ballast applied to the temporary structure, self-weight of the temporary structure, and a percentage of the payload (operational loads) likely to be present when the design wind loads occur.

Design wind loads take into consideration the duration of exposure – the amount of time the structure is installed – relative to the likelihood that the structure will be exposed to any given wind speed. Using the same design criteria as used for permanent structures – structures intended to last for 50 years or more – results in unreasonably high design wind loads that make the component size and installation time frame for temporary structures costly and impractical. The allowable wind loads on a temporary special event structure may be reduced by the design professional, based on both duration of exposure and the ability to lower the load effects using an operation management plan. As with all engineering analysis, the professional engineer should provide justification in their analysis for any wind load reduction. Since temporary structures are defined by the building codes as being installed for a period of time less than 180 days, the applicable load factor can be 0.65 multiplied by the velocity pressure per the IBC.

Where the temporary structure are to be erected in areas prone to hurricanes, (such as Florida, where the basic wind speed is well above 115 mph) it is impractical to design temporary structures using hurricane-force wind speeds. Since hurricanes are predictable wind events, it is reasonable to design the temporary structure to a lower basic design wind speed. These temporary structures can, therefore, be designed for basic wind speeds ~~of~~per IBC Section ~~3103.5.1.2~~3103.6.1.2, which ~~can then~~permits them to be reduced by multiplying it by a factor of 0.65 as indicated above.

If elements that are attached to the temporary structure can be removed within a clearly-defined period of time designated for wind mitigation actions, and the operations management plan requires their removal at specific wind speed thresholds, then their respective wind surface areas need not be considered in the full wind pressure calculations. This exclusion only pertains to elements that will be removed for wind mitigation actions. If elements can be removed within the defined time period, but, for example, remain in place overnight, or during times when personnel is not present to perform the wind mitigation actions, then they must be included in the total effective wind area used for wind pressure calculations.

Furthermore, because unexpected wind events occur frequently in the US, the design wind speed should not be reduced for those elements that cannot be removed within the designated time period. The difficulty and risk associated with the removal of any elements from the temporary structure during a wind event should be carefully considered. These considerations should be noted in the operations management plan.

Therefore, two distinct wind load design cases should be considered in the engineering documentation. Case 1 applies the forces due to a 3-second gust design wind speed of not less than 40 mph (service level), to the temporary structure with all attached components. Case 2 applies the forces due to the modified design wind loads discussed above to the temporary structure, with all attached components except for those that will be removed for wind mitigation actions.

If the assembly is used for a touring production, then the wind loads of the possible locales should be considered, for use as a worst-case. The temporary structure features (such as amount of ballast, guying/bracing scheme, etc.) can be modified from site to site depending on the local wind conditions, if such variations are included in the operations management plan and user information.

A.3.5.2.5 Section 3.5.2.5 considers a maximum allowable wind speed for worker safety, but in doing so it also defines a specific wind speed load case for engineering analysis.

A 40 MPH (service level) wind speed is an established threshold at which it is considered unsafe for workers to engage in wind surface area reduction (weather hazard mitigation) activities. Therefore, wind mitigation actions must be accomplished at wind speeds lower than this threshold, and at or below wind speeds determined in the Operations Management Plan.

It is critically important to consider the reliability of weather data and accuracy of weather forecasting, when establishing criteria for mitigation actions, particularly when assessing whether there is sufficient time to complete any mitigation action. The predicted time for an anticipated weather event must be longer than the actual time needed to perform the mitigation actions.

A.3.5.3 Load considerations

All roof and similar overhead and elevated temporary structures should be designed for a minimum superimposed live load of 5 psf uniformly distributed across the whole roof area. This load is not to be considered in conjunction with the design payload. It has been chosen as a baseline to ensure that the temporary structure is robust. This effectively means that temporary roofs and similar overhead and elevated structures would have a minimum design payload. For example, for a typical 60' x 40' roof, the minimum design payload is 12,000 pounds uniformly distributed over the plan area of the roof.

Connections between vertical support elements (towers or columns) and horizontal elements (trusses or beams) are not always fixed, pinned or bolted connections. Those connections could in fact be contact points designed to slide or roll. Such contact points usually produce localized stress areas in structural members, which may limit overall capacity.

A.3.5.4 Superimposed loads such as rain, snow, ice, etc

Temporary roof and similar overhead and elevated structures are not generally designed to withstand loads associated with ice and snow. However, if it is known that the temporary structure is to be used in an area and at a time of year where snow is possible, then the engineering documentation should include this load case. If snow loading is considered as a load case, then provision for clearing snow from a roof covering and similar elevated structures could be made in the Operation Management Plan and a reduced value for snow loading may be considered.

A3.7.1 When towers and elevated framing of a temporary structure such as a stage roof are erected, the structural adequacy of the towers should be checked for the following design cases:

- The towers are being raised from horizontal to vertical.
- The towers are vertical and the roof grid is at low level and is supported by the lifting devices.
- As above with the roof grid being raised from a low level to a high level.
- As above, with the grid supported by lock-off devices.
- As above, with the guy wires attached.

A3.7.2 The coefficients set out in Table A1 are those commonly used to determine the effective length or height of a tower. Clarification of the terminology in Table A1 follows:

If a point is allowed to translate in any direction and allowed to rotate about any axis then it is considered *free*.

If a point is restrained against translation in any direction but is free to rotate about any axis it is considered *pinned*.

If a point is restrained against translation in any direction and restrained against rotation about any axis it is considered *fixed*.

If a point is allowed to translate but is restrained against rotation about any axis it is considered to be a *slide bearing*.

Table A1: Factors for determining the effective lengths of towers

Effectively pinned at both ends.	K = 1.0
Effectively fixed at one end and a slide bearing at the other end.	K = 1.20
Effectively pinned at one end and a slide bearing at the other end.	K = 2.0
Effectively fixed at one end and free at the other (e.g. a flag pole.)	K = 2.1

Reference: American Institute of Steel Construction. (1995). *Manual of Steel Construction Allowable Stress Design* (9th ed.).

A3.7.4 In a temporary structure designed with vertical towers, a sway force can be generated by a lack of verticality. (e.g. a tower shall not be out of plumb by more than 75mm (3 inches) at a tower height of 15 meters (50 feet)).

A.3.8 Ground Conditions and Foundations

Designers, users and Local Authorities should be aware that the performance of soils under short-term loading could be significantly different from that when the soil is loaded for a longer term. Long-term settlement and associated differential settlement are often less significant for temporary structures than for permanent structures. Temporary structures are generally quite flexible and can safely accommodate a larger degree of differential settlement than permanent structures.

It is also important to assess the current conditions and potential changes to the ground and foundations during the use time. Conditions such as insufficient drainage, recent heavy rains, recent freezing/thawing events, recent soil disturbances caused by excavation or heavy vehicle traffic, and other factors can have a significant impact on the soil conditions and allowable loads. Additionally, the actual ground contact points for the installation should be evaluated for possible impact from drainage (i.e. undercutting of the footings, sloughing of material on sloped sites, etc.)

The traditional values of allowable bearing pressures may not be appropriate where a temporary structure is supported on small soleplates for a short period of time and the loads are relatively small. The allowable bearing pressures for temporary structures may, therefore, be quite different from those associated with permanent buildings.

Where the loads on the ground are relatively small, a common method of support for temporary roof structures and other temporary structures is to place timber spreaders on the ground and to use proprietary scaffolding screw jacks with steel soleplates. These screw jacks take up any differences in ground level.

Table A2: Presumptive load-bearing values

Bearing material	Allowable vertical bearing pressure		Lateral Sliding Resistance	
	lbs/ft²	**kN/m²**	Coefficient of friction[a]	Cohesion (psf)[b]
Crystalline bedrock	12,000	656	0.70	-

Bearing material	Allowable vertical bearing pressure		Lateral Sliding Resistance	
	lbs/ft²	**kN/m²**	Coefficient of friction[a]	Cohesion (psf)[b]
Sedimentary and foliated rock	4,000	190	0.35	-
Gravel and sandy gravel	3,000	140	0.35	-
Sand, silty sand, clayey sand, silty gravel and clayey gravel	2,000	95	0.25	-
Clay, sandy clay, silty clay, clayey silt, silt and sandy silts	1,500	70	-	130

Reference: *International Building Code, IBC-~~2018~~2024, Table 1806.2*.
a. Coefficient to be multiplied by the dead load
b. Cohesion value to be multiplied by the contact area, as limited by IBC Section 1806.3.2

The IBC presumptive bearing values are intended for building foundations and similar structures. Proper judgment should be used when applying these values to small footings without embedment into the soil, and other conditions that deviate from building-style footings.

Base plates may be placed directly onto grassed surfaces underlain by ground of an adequate bearing capacity. Any assessment of the allowable bearing capacity of ground below base plates should be conservative.

Section ~~3103.5.2~~3103.6.2 of the IBC limits the presumptive load-bearing value for temporary structures supported on a pavement, slab on grade, or other collapsible or controlled low strength substrate soils, to a maximum allowable value of 1,000 psf.

In the absence of reliable local or professional engineering knowledge, an allowable bearing pressure not exceeding 1000 lbs/ft^2 (50 kN/m^2) should be assumed, except as noted below. However, due diligence to pursue accurate information is recommended. Mud, organic silt, organic clays, peat or unprepared fill should not be assumed to have a presumptive load-bearing capacity unless data to substantiate the use of such values is provided by a qualified person or the building official deems the load-carrying capacity of mud, organic silt, or unprepared fill is adequate for the support of lightweight, temporary structures.

The use of timber, plywood sheets or metal plates is generally satisfactory to distribute the loads from the base plate to the founding strata. Concentrated base plate loads should be assumed to distribute through a spreader at 1 to 1 through the thickness, unless proven otherwise by calculation.

A.3.9 Stability
Stability of temporary structures is an important issue that must be carefully considered. Stability includes resistance to sliding, overturning, and uplift. Stability relies on structure self-weight and a reliable load path, in conjunction with base anchorage to the supporting substrate. Base anchorage can be accomplished in a number of ways including ballast, earth anchors, and building-type foundations.

A3.9.2 Guying and Cross-bracing Assemblies
It is recommended that all guying and cross-bracing assemblies and hardware shall be exposed to allow for visual inspection and access for testing and adjustment.

A3.9.2.4 Guying and Cross-bracing Assemblies
It is recommended that the design should allow for the stretching and slipping of rigging and the deflection of structural elements. These changes can cause loads and reactions within the structure to shift.

A3.9.4 Ballast
The amount of ballast should be determined by a qualified person and is site specific. The type of ballast should be determined by a qualified person and could be site specific. The amount and type of ballast required is dependent upon a number of factors. These include, but are not limited to:

- the force to be resisted,
- the nature of the bearing surface,

- the nature of the supporting substrate,
- the type of ballast used,
- the angle of the guy or cross-bracing assembly to the ground,
- the coefficient of friction between the ballast and the ground,
- the factor of safety to be adopted.

Table A3: Minimum values of static coefficients of friction, μ, between common materials.

Material 1	Material 2	μ
Aluminum	Aluminum	0.3
Aluminum	Steel	0.2
Asphalt	Rubber	0.25
Concrete	Soil	0.2
Concrete	Rubber	0.45
Grassy field	Rubber	0.2
Metal	Wood	0.2
Rubber	Asphalt	0.25
Rubber	Concrete	0.45
Rubber	Grassy field	0.2
Steel	Aluminum	0.2
Steel	Steel	0.16
Wood	Metal	0.2
Wood	Wood	0.2

For the values in Table A3, it is assumed that the materials are wet.

The user should consider undertaking tests on site to determine the coefficient of friction.

Notwithstanding the above, the user should determine if the use of ballast to provide stability is permitted or limited in the area where the temporary structure is to be used. For example, it is understood that the use of friction to provide seismic stability is not permitted in California.

A3.9.4.4 Resistance to sliding can be achieved by using supplemental fixing methods, provided that the methods can be calculated by a qualified person, or field-tested after installation.

A.5.3 In conditions where differential settlement is a possibility, consideration should be given in accordance with 3.7.4 to prevent instability of the temporary structure.

A.5.4.3 The following grounding guidelines are suggestions only. It is the responsibility of the user to ensure that all grounding procedures meet the provisions of the National Electrical Code (NEC) or other relevant prevailing codes.

- An adequate number of earth rods should be positioned in the ground and be connected to earth clamps on the temporary roof structure itself by suitable wiring.
- The surface of the aluminum should be cleaned bare metal with steel wool to remove the oxidization before the earth clamps are fitted.
- The user should note that various sections or components of a temporary structure may not have a proper electrical grounding connection between adjacent components. Therefore, consideration must be given to grounding all parts of the temporary structure. For example, sections of a self climbing truss assembly may be isolated by non-conductive elements such as nylon wheels, roundslings or wood.

A5.4.4 Components within a temporary structure to be checked at regular intervals should include anything that may loosen or change during the use. These could be:

- Fasteners
- Tension assemblies
- Compression assemblies
- Rigging
- Ballast
- Footings
- Ground anchors

Environmental events, including excessive wind, rain or snow, may change the moisture content of the ground or the tension in various anchorage components.

A.6 User Inspection

If specific inspection criteria exist for any temporary structure component, the prevailing applicable standards or authority having jurisdiction requirements should be followed. For example, any aluminum truss and tower components should be inspected in accordance with ANSI E1.2, Entertainment Technology – Design, Manufacture and Use of Aluminum Trusses and Tower.

A.7 Operations management plan example

An example of an operations management plan to be prepared by the user could follow these guidelines:

Design wind criteria:

- *Wind speeds are measured at XX feet above ground level;*
- *Scrim or back drop to be removed at XX mph;*
- *Scrims on sound wings to be removed at XX mph;*
- *Sound cabinets to be lowered to stage level at XX mph;*
- *Roof to be lowered to stage level at XX mph.*

Other documentation

This document shall be read in conjunction with the following documents:

- *Operating Manual provided by Manufacturer*
- *ANSI E1.21, Entertainment Technology – Temporary Ground Supported Outdoor Structures*
- *ANSI ES1.7, Event Safety – Weather Preparedness*
- *Signed and sealed Engineering Report(s)*

Site Operations:

- *The user shall designate a qualified, responsible person(s) to be present on site for the whole of the period of the installation. This person shall have authority to implement the actions required by the OMP,*
- *The persons responsible for various aspects of operations, including erection, use and dismantling, shall be defined in writing prior to start of construction.*
- *Individuals responsible for various tasks, including those not under direct supervision of the user, must be identified prior to event. This must include, but is not limited to:*
    - *Wind/weather monitor;*
    - *Stage Manager;*
    - *Security Personnel;*
    - *Artists Representative;*
    - *Promoter Representative;*
    - *Stage vendor crew lead;*
- *Additionally, if a specific chain of command to any of the key responsible positions is in place, then all individuals in the chain must be aware of their immediate supervisor;*
- *The contact information for emergency services and for key responsibility positions including names, phone numbers and work locations must be provided prior to event.*
- *It must be clear to all relevant parties what actions are to be taken and at which thresholds as identified by the design wind criteria. This communication and training must take place prior to the event.*

Monitoring

- *The wind speed shall be monitored and records shall be kept on site. This shall be done by the designated wind/weather monitor.*

- *The wind speed measurements shall be taken at the height of the temporary roof structure above ground, at a location where a true wind speed will be measured.*
- *A regular liaison, with a weather information service will be maintained to ascertain if any significant weather events are expected in the immediate vicinity of the temporary roof structure.*

Actions
The following actions will be undertaken by the user's designated personnel on site when the 3 second wind speed gusts approach the following speeds against a background of rising wind speeds or if such wind is forecast with a degree of certainty.

Element (e.g. backdrop, sound scrim, coverings, equipment)
Level 1: XX% of design wind load at XX mph
Personnel to be on alert

Level 2: XX% of design wind load at XX mph
Personnel to be put on standby to remove the element

Level 3: XX% of design wind load at XX mph
Personnel to remove the element

If a tropical storm or hurricane is forecast to have wind exceeding the allowable pressures used for the temporary structures as defined by a registered design professional, dismantle the structure, or portions of the structure that are not designed to resist such wind forces, and secure all components. The removals shall be performed well in advance of the strong winds arriving at the site at a maximum wind speed as defined in the OMP.

In areas prone to tornado activity, The user should use weather monitoring and alert methods that will provide advance notification and advisories, so that the user does not rely solely on on-site visual observations.

The decision to suspend an event can be made by the user's designated person, production manager, promoter, or authority having jurisdiction if the public safety is jeopardized for any reason. The method of initiating the event suspension will be agreed upon and in writing prior to the event to allow for immediate action if required.

The decision to cancel an event can be made by the user's designated person, production manager, promoter, or authority having jurisdiction based on inclement weather. The method of initiating the event cancellation will be agreed upon and in writing prior to the event to allow for immediate action if required.

A.7.4.2 The National Weather Service provides statements, summaries and assessments of existing weather data. Warnings are issued when conditions defining the warning are occurring, or have already happened – the warnings are issued in real-time, and reliance exclusively on this type of alert to begin critical mitigation actions means that mitigation actions occur reactively to the alert, rather than preemptively.

A.7.4.3 There are a variety of actions that can be taken to address hazards due to high wind conditions. Engineering the temporary structure to withstand the design wind loads as-is is the preferred solution, if feasible. However, practical realities may make it impractical to engineer all elements of a temporary structure for the design wind loads.

The next alternative is to rapidly remove certain elements to reduce wind loading area, as long as such removals are planned in advance and can be accomplished reliably and safely. The physical act of rapidly removing elements when high wind is approaching comes with some risk, which must be considered versus the practicalities of making the structure more robust to preclude the need for such removals.

The alternative of last resort is to abandon the site and evacuate people a safe distance away from the temporary structure. There are significant risks associated with the process of evacuating people, which is greater if the general public is being evacuated, and the risk increases with the quantity of people. The venue type and size, anticipated audience population, and many other factors influence the feasibility of performing a safe evacuation in the allotted time. If an evacuation is part of the OMP, a formal risk assessment must be conducted by qualified persons considering various perspectives of the production. For a tour, the local conditions at each site must be considered in each risk assessment in order to determine if the evacuation is suitably safe. The act of efficiently implementing an evacuation when high wind is approaching comes with a good deal of risk, especially if audience members might not wish to move or might misunderstand what is happening, which must be considered versus the practicalities of making the structure more robust to preclude the need for the evacuation.

For further information, consult the following references:

- *The Event Safety Guide*
- ANSI ES1.19, *Safety Requirements for Special Event Structures*