ANSI E1.21-2013
Entertainment Technology — Temporary Structures Used for Technical Production of Outdoor Entertainment Events

Rig/2010-2025r7

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worldwide standards for the entertainment industries

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The PLASA Technical Standards Program

The PLASA Technical Standards Program was created to serve the PLASA membership and the entertainment industry in technical standards related matters. The goal of the Program is to take a leading role regarding technology within the entertainment industry by creating recommended practices and standards, monitoring standards issues around the world on behalf of our members, and improving communications and safety within the industry. PLASA works closely with the technical standards efforts of other organizations within our industry, including USITT and VPLT, as well as representing the interests of PLASA members to ANSI, UL, and the NFPA. The Technical Standards Program is accredited by the American National Standards Institute.

The Technical Standards Council (TSC) was established to oversee and coordinate the Technical Standards Program. Made up of individuals experienced in standards-making work from throughout our industry, the Council approves all projects undertaken and assigns them to the appropriate working group. The Technical Standards Council employs a Technical Standards Manager to coordinate the work of the Council and its working groups as well as maintain a “Standards Watch” on behalf of members. Working groups include: Control Protocols, Electrical Power, Floors, Fog and Smoke, Followspot Position, Photometrics, Rigging, and Stage Lifts.

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The Rigging Working Group, which authored this Standard, consists of a cross section of entertainment industry professionals representing a diversity of interests. PLASA is committed to developing consensus-based standards and recommended practices in an open setting.

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Interest category codes:

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

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FOREWORD

(This foreword contains no mandatory requirements.)

It has been assumed in the drafting of this standard that the execution of its design provisions are entrusted to appropriately qualified and experienced people, and that the fabrication and use is carried out by qualified and suitably experienced people and organizations.

This standard presents a coordinated set of rules that may serve as a guide to government and other regulatory bodies and municipal authorities responsible for the guarding and inspection of the equipment falling within its scope. The suggestions leading to accident prevention are given both as mandatory and advisory provisions; compliance with both types may be required by employers of their employees.

Safety codes and standards are intended to enhance public safety. Revisions result from 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.

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

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 structure such as food vendor tents, portable toilets, and other portable temporary structure for directly serving the audience or attendees at outdoor entertainment events are not included in the scope of this standard. Custom temporary structure supporting performance platforms are included in the scope of this document. This document does not include pre-engineered, manufactured, modular staging systems used as a performance platform independent of other temporary structure.

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.

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 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 ponding: Accumulation of water that does not drain off a surface.

2.13 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.

2.14 repetitive use: Components of temporary structure assembled and dismantled on multiple occasions.

2.15 shall: Indicates that the rule is mandatory and must be followed.

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

2.17 temporary: A period of time that is less than 6 consecutive weeks in duration.

2.18 tower: One or more components assembled vertically to support load

2.19 user: The entity ultimately responsible for the structure at a given point in the structures temporary life-cycle. Note that this entity could be different during different phases ranging from assembly, erection, use, and dismantling. This entity must be clearly identified in accordance with section 5 of this document for each given phase of operation.

3 DESIGN AND ENGINEERING

3.1 Intent

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

3.2*Design

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

3.2.2 Temporary structure shall be designed to support specified loads in accordance with the referenced standards and AHJ requirements.

3.2.3 All relevant standards shall be used in the design of the temporary structure and shall be dependent on the intended conditions of use. These would include, but are not limited to, the following standards and documents:

3.2.3.1 SEI/ASCE 7-10, “Minimum Design Loads for Building and Other Structures”

3.2.3.2 ASCE 37-02, “Design Loads on Structures During Construction,” section 6 only

3.2.3.3 ANSI E1.2, Entertainment Technology – Design, Manufacture and Use of Aluminum Trusses and Towers

3.2.3.4 ASCE 19-10 “Structural Applications of Steel Cables for Buildings”

3.2.3.5 ASM1-10 “Aluminum Design Manual - Specifications for Aluminum Structures”

3.2.3.6 AISC 360-05 "Specifications for Structural Steel Buildings”

3.2.3.7 AISC 303-10 "Code of Standard Practice for Steel Buildings and Bridges”

3.2.3.8 American Institute of Steel Construction, “Manual of Steel Construction 13th Edition”

3.2.3.9 ACI 318-08 Building Code Requirements for Structural Concrete

3.2.3.10 AWS D1.1-04 Structural Welding Code – Steel

3.2.3.11 AWS D1.2-03 Structural Welding Code – Aluminum

3.2.3.12 AWS B2.1-2009 Specification for Welding Procedure and Performance Qualification

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

3.2.5* The strength of individual components or assemblies can be established using either Load and Resistance Factor Design or Allowable Stress Design methods, or by physical testing in accordance with a recognized national standard and referenced in engineering documentation.

3.2.6 When using load combinations of SEI/ASCE 7, wind loads shall not be multiplied by a factor less than 1.0.

3.3 Analysis

3.3.1 The analysis of temporary structure 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.

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.

3.3.6 The allowable deflections of the structural elements shall be such to ensure that ponding 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 design wind speed

3.4.4.3 assumed effective wind area inclusive of 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 allowable wind speed during erection of the temporary structure, if different than the design wind speed

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

3.4.4.8.1 Environmental thresholds that require specific mitigating actions.

3.4.4.8.2 Required actions when specified environmental thresholds are reached.

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

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

3.4.4.11 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 guys 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

3.5.1.1 Loading associated with seismic activity for the intended locale(s) shall be evaluated per SEI/ASCE 7-10.

3.5.1.2 A reduction in seismic design load may be permitted consistent with the duration of the intended use per ASCE 37-02.

3.5.2* Wind loading

3.5.2.1 The wind load on all effective wind surface areas including but not limited to the temporary structure and any additive elements to the temporary structure, including but not limited to video walls, scenery, coverings, lighting and audio equipment, shall be included in the analysis.

3.5.2.2 The overall stability and resistance to wind uplift and overturning forces shall be provided by means such as wire guys 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 structure as defined by this document shall be 0.75 times the basic wind speed defined in SEI/ASCE 7-10, except as modified by 3.5.2.4 and 3.5.2.5.

3.5.2.4* Where a temporary structure 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 of 115 mph, 3 second gust per ASCE 7-10, shall be permitted.

3.5.2.5* Where elements attached to a temporary structure can be removed or modified to mitigate wind effects in less than 5 minutes, the temporary structure with these elements in place shall be permitted to be designed using a reduced wind speed of not less than 40 mph, 3 second gust. Wind pressure shall be determined using an ASD Load Factor of not less than 1.0, or LRFD Load Factor of not less than 1.6. Once said elements are removed or modified, the remaining temporary structure shall meet 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 structural calculations that form part of the engineering documentation.

3.5.3.3 All load combinations shall be considered per SEI/ASCE 7-10 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 Wind shielding from adjacent permanent structure may be considered if proven by sound engineering principles.

3.5.3.6 Consideration shall be made for site specific wind load increases due to funneling effects.

3.5.3.7 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 such as rain, snow, ice, etc.

3.5.4.1 All roof, overhead and elevated structure shall be designed for a minimum superimposed live load of 5 psf (24.4kg/m^2) uniformly distributed across the whole area. This live load shall not be less than a total of 300 lbs. This load need not be considered in combination with payload.

3.5.4.2 Measures shall be taken to prevent ponding of roof coverings between the structural members.

3.5.4.3 Snow and ice load need not be considered if the temporary structure is to be used in a locale where snow and ice is not possible during the intended use. However, if it is known that the temporary structure is to be used in an area and at a time of year where snow and ice is possible, then the engineering documentation shall include this load case. Where snow or ice can be removed to mitigate loads, the temporary structure may be designed to a reduced snow or ice load of not less than 10 psf.

3.5.4.4 Where persons will need access to the structure, the maximum applied loading of personnel safety devices as per OSHA 29 CFR 1926 shall be analyzed in conjunction with worst case superimposed loads.

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 structure 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 of the temporary structure 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 un-guyed tower.

3.7.4* The engineering design shall set parameters for the safe limits of out of plumb and horizontal both during setup and use. This will include deflection from loading and horizontally moving loads.

3.7.5 Horizontal loads during erection and installation shall be considered in accordance with ASCE 37-02.

3.8* Ground Conditions and Foundations

3.8.1 Minimum required 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 screw jacks shall be stated in the engineering documentation.

3.8.3 Supports shall be positioned far enough apart so that there is no interaction between adjacent foundations, unless the interaction between foundations is considered.

3.9* Stability

3.9.1 General

Safe use of these temporary structures is dependent upon close coordination of structural design, installation and use. A qualified person shall design the temporary structure with means for lateral stability.

3.9.2* Guying and Cross-bracing Assemblies

Where guying and cross-bracing assemblies are used the following clauses shall apply.

3.9.2.1 Guying and cross-bracing assemblies shall be used where necessary to transfer the lateral forces that are imposed on the temporary structure to the ground.

3.9.2.2 All guying and cross-bracing components and assemblies shall have a safe working load defined in the calculations 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 19-10, 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 guying and cross-bracing assemblies that can become slack shall be specified as part of the assembly.

3.9.2.5 Guying assemblies shall be anchored to resist design loads.

3.9.3 Ground Anchors

If ground anchors are used, then they shall be specified in accordance with the manufacturer's guidelines and recommendations, taking into consideration the length of time that the temporary structure will be in place and the soil conditions at the 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.

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 design shall include the stability of the ballast.

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 Critical component interaction shall be tested after fabrication.

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 instruction for training purposes on the proper use of the temporary structure including the following:

4.7.1 Intended use of temporary structure.

4.7.2 **I**nitial 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 Intent

The intent of this section of the standard is to provide the user with the minimum basis on which temporary structures shall be properly implemented and maintained.

5.2 Responsibility

Prior to use, responsibility for the structure shall be clearly defined and agreed upon between all relevant entities for all phases of use. This shall include but not be limited to equipment owner, property owner, promoter, installer, artist or operator. Specifically, the “user” shall be designated for each of the use phases.

5.3* Pre-Use

5.3.1 The user shall designate a qualified person or persons to have overall responsibility on site for the temporary structure.

5.3.2 The user’s 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 with written approval by a registered design professional.

5.3.3 The user’s 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.

5.3.4 The user’s designated person shall prepare layout drawings consistent with the engineering documentation.

5.3.5* An operations management plan (OMP) shall be prepared by the user and his engineer.

5.3.5.1 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.

5.3.5.2 The user’s 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.

5.3.5.3 The OMP shall include all manufacturers' operational guidelines.

5.3.5.4 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.

5.3.5.5 The OMP shall include environmental monitoring procedures.

5.3.5.5.1 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 during any significant environmental event.

5.3.5.5.2 The weather and wind forecast for the stage 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 weather information center to ascertain if any significant weather events are expected in the immediate vicinity of the temporary structures.

5.3.5.5.3 When a severe thunderstorm, tornado or other warning indicating severe conditions for the site is issued by the local National Weather Service office, critical actions will immediately be taken to make the stage area safe for all personnel, guests, and performers consistent with the established OMP.

5.3.6 The user shall be responsible for compliance with the requirements of the authority having jurisdiction.

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

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

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

5.3.10 It is the responsibility of the user's designated person to check the site of the temporary structure for underground services before load bearing elements are positioned, including bases, ground anchors and ballast points.

5.3.11 All anchors, ballast and guys shall be clearly marked and protected from traffic and equipment on site.

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

5.3.13 The user shall inform all persons and entities having responsibilities pertinent to the OMP.

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 at the time of a significant environmental event.

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

5.4.3* The user's 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 user's designated person at regular intervals during use, after unattended periods, and after a significant loading or environmental event.

5.4.5 The user shall coordinate to prevent the general public from tampering with components that may infringe into 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 user's designated person shall conduct a complete inspection of each component in accordance with section 6 of this document.

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.

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 structure 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.2 Definitions

This section provides definitions of the terminology and nomenclature used within this standard.

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 repetitive use 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.

A3.2.5 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”

A3.4.2 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 the risk should not be increased if a short duration of use is considered.

Refer to Section 6.5 of ASCE 37 for applicable provisions for seismic loads on temporary structure which references provisions of ASCE 7-95. These provisions in ASCE 37 include guidance for reducing seismic forces, as well as thresholds for neglecting seismic forces for structures erected for not more than 6 months, depending on location.

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.

ASCE 37*, Design Loads for Structures Under Construction* indicates that the design wind speed can be reduced to 75% of the basic wind speed defined in ASCE 7*, Minimum Design Loads for Buildings and Other Structures*. This modified design wind speed is deemed appropriate for temporary structures that

are in place for less than six weeks. Wind load is proportional to the square of the wind speed and therefore the temporary structure design wind load is approximately 56% of the basic wind load.

Where 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 in accordance with the above. Hurricanes are predictable wind events. Therefore, it is permitted to design temporary structure to a lower basic design wind speed. These temporary structures can, therefore, be designed for basic wind speeds of 115 mph, which can then be reduced by multiplying it by a factor of 0.75 as indicated above.

If elements that are attached to the temporary structure can be removed within 5 minutes, and the operations management plan requires their removal at specific wind speed thresholds, then they need not be considered in the full wind pressure calculation. This exclusion only pertains to elements that will be removed prior to personnel leaving the site during off hours, if elements can be removed within 5 minutes but remain in place overnight, then they must be considered as part of the effective wind area in the engineering documentation.

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 in less than 5 minutes. The user shall consider the difficulty and associated risk with the removal of any elements from the temporary roof structure during a wind event. This consideration should be noted in the operations management plan.

There are, therefore, two distinct wind load design cases that should be considered in the engineering documentation. One where the temporary structure and all attached components are considered with a design gust wind speed of not less than 40 mph and one where the temporary structure and all components that cannot be removed in 5 minutes are considered with a design gust wind speed as discussed above.

If the assembly is used for a touring production, then the wind loads of the possible locales shall be considered. 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.3.5.2.4 ASCE 7-10 includes a major revision to the wind loading chapter so referenced wind speeds do not correlate with prior versions of ASCE 7. As a result 90 MPH wind gusts referenced in E1.21-2006 correlates with 115 mph wind gusts referenced herein.

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. ASCE 7-2010 increased basic design wind speeds for all locations, while reducing the Velocity Pressure formula load factors, compared with prior ASCE 7 editions. Resulting design wind pressures do not significantly differ from ASCE 7-05 to ASCE 7-10, but performing calculations using the same numerical wind speed would yield notably different pressure results. However, the intent of section 3.5.2.5 is not to permit a reduction in the allowable wind loads on the structure in this particular load case. Section 3.5.2.5 establishes that this specific load case must use a minimum wind pressure result not less than prior versions of the standard required. To accomplish this a higher load factor must be used when using ASCE 7-10 for design.

A 40 MPH wind speed is also an established threshold at which it is considered unsafe for workers to engage in wind surface area reduction activities. Therefore, such hazard response activities must be accomplished at wind speeds lower than this threshold, and at wind speeds determined in the Operations Management Plan.

A.3.5.3 Load considerations

All roof and similar overhead and elevated temporary structure 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 roof structure is robust. This effectively means that temporary roofs and similar overhead and elevated structure would have a minimum design payload. For example, for a typical 60' x 40' roof, the minimum design payload is 12,000 pounds (5450 kg) 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 could be made in the Operation Management Plan and a reduced value for snow loading may be considered.

A.3.7 Temporary structure Erection

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 structure and other temporary structure 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: Representative values of allowable bearing pressures for foundations

Bearing material	Allowable bearing pressure	
	lbs/ft^2	**kN/m^2**
Crystalline bedrock	12,000	656
Sedimentary and foliated rock	4,000	190
Gravel and sandy gravel	3,000	140
Sand, silty gravel, clayey gravel	2,000	95
Clays and silts	1,500	70

Reference: *International Building Code, IBC-2006, Table 1804.2*.

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.

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 needs to be carefully considered. 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.

A3.9.2 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.

A.5.3.5 Pre-Use

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*
- *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 67.5 mph (3-second gust) or 55.6 mph (1 minute average), dismantle the structure, or portions of the structure, that is 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.

If a tornado is sighted, the site should be fully evacuated immediately, and people should take appropriate refuge.

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.5.3.7 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 the 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