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

Copyright 2017 ESTA.
All rights reserved.

Rig/2010-2025r7

Approved as an American National Standard by the ANSI Board of Standards Review on 19 December 2013.

This standard was originally published when the Entertainment Services and Technology Association was operating under the name of PLASA North America. ESTA has reverted to its original name, and this document has been rebranded with the current corporate name and logo. No changes have been made to the contents of the standard.
NOTICE and DISCLAIMER

ESTA does not approve, inspect, or certify any installations, procedures, equipment or materials for compliance with codes, recommended practices or standards. Compliance with an ESTA standard or an American National Standard developed by ESTA is the sole and exclusive responsibility of the manufacturer or provider and is entirely within their control and discretion. Any markings, identification or other claims of compliance do not constitute certification or approval of any type or nature whatsoever by ESTA.

ESTA neither guarantees nor warrants the accuracy or completeness of any information published herein and disclaims liability for any personal injury, property or other damage or injury of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document. In issuing and distributing this document.

In issuing this document, ESTA does not either (a) undertake to render professional or other services for or on behalf of any person or entity, or (b) undertake any duty to any person or entity with respect to this document or its contents. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstance.

Note: Draft or proposed standards or recommended practices are subject to change. Conformance to a draft or proposed standard or recommended practice is no assurance that the product or service complies to the final approved standard or practice or any other version thereof.

Published by:
Entertainment Services and Technology Association
630 Ninth Avenue, Suite 609
New York, NY 10036
USA
Phone: 1-212-244-1505
Fax: 1-212-244-1502
standards@esta.org
The ESTA Technical Standards Program

The ESTA Technical Standards Program was created to serve the ESTA 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. ESTA works closely with the technical standards efforts of other organizations within our industry, including USITT and VPLT, as well as representing the interests of ESTA 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, Event Safety, Floors, Fog and Smoke, Followspot Position, Photometrics, Rigging, and Stage Lifts.

ESTA encourages active participation in the Technical Standards Program. There are several ways to become involved. If you would like to become a member of an existing working group, as have over four hundred people, you must complete an application which is available from the ESTA office. Your application is subject to approval by the working group and you will be required to actively participate in the work of the group. This includes responding to letter ballots and attending meetings. Membership in ESTA is not a requirement. You can also become involved by requesting that the TSC develop a standard or a recommended practice in an area of concern to you.

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

Technical Standards Manager
Karl G. Ruling
Entertainment Services and Technology Association
630 Ninth Avenue, Suite 609
New York, NY 10036
USA
1-212-244-1505
karl.ruling@esta.org

Assistant Technical Standards Manager
Erin Grabe
Entertainment Services and Technology Association
630 Ninth Avenue, Suite 609
New York, NY 10036
USA
1-212-244-1505
erin.grabe@esta.org

Technical Standards Council Chairpersons
Mike Garl
Mike Garl Consulting LLC
1-865-389-4371
mike@mikegarlconsulting.com

Mike Wood
Mike Wood Consulting LLC
1-512-288-4916
mike@mikewoodconsulting.com

Rigging Working Group Chairpersons
Bill Sapsis
Sapsis Rigging, Inc.
1-215-228-0888 x206
bill@sapsis-rigging.com

Christine Kaiser
Syracuse Scenery & Stage Lighting Co., Inc.
1-315-453-8096
ckaiser@syracusescenery.com
Acknowledgments
The Rigging Working Group members when this document was approved by the working group on 18 September 2013 are shown below.

Voting members:
- Mike Adamovich; M.G. McLaren, P.C.; G
- Jesse Adams; Rose Brand; DR
- Mark Ager; Tait Towers Manufacturing LLC; CP
- Tray Allen; James Thomas Engineering, Inc.; MP
- Matthew Antonucci; Contract Services Administration Trust Fund; U
- Dana Bartholomew; Tait Towers Manufacturing LLC; CP
- William Beautyman; Limelight Productions, Inc.; DR
- Nils Becker; Electronic Theatre Controls, Inc.; MP
- Patrick Leigh Bettigton; Tait Towers Manufacturing LLC; CP
- Keith Bohn; Milos Group; MP
- David Bond; Arcofab; U
- William Bradburn; Aerial Arts, Inc.; U
- Vincent J. Cannavale; Motion Laboratories; CP
- David Carmack; Columbus McKinnon Corp.; MP
- Joseph Champelli; ZFX Flying Inc.; CP
- Stu Cox; ZFX Flying Inc; CP
- Dan Culhane; SECOA; CP
- Jonathan Deull; JSD Projects LLC; U
- Brad Dittmer; Stage Labor of the Ozarks; U
- Douglas M. Eldredge; LMG Inc.; DR
- Adrian Forbes-Black; Total Structures Inc.; MP
- Howard Forryan; Harting KGAA; G
- Mike Garl; Milos Group; MP
- Ed Garstkiwicz; Harting KGAA; G
- Ethan William Gilson; Advanced Lighting and Production Services; U
- William B. Gorlin; M.G. McLaren, P.C.; G
- Jerry Gorrell; Theatre Safety Programs; G
- Earle T. Greene; Walt Disney Company; U
- Joshua Grossman; Schuler Shook; DE
- Joel A. Guerra; Texas Scenic Company; DR
- Rod Haney; I.A.T.S.E. Local 891; U
- Tim Hansen; Oasis Stage Werks; DR
- Pete Happe; Walt Disney Company; U
- Herb Hart; Columbus McKinnon Corp.; MP
- Peter Herrmann; Motion Laboratories; CP
- David Herrmann; Motion Laboratories; CP
- Donald Hoffend III; Avista Designs, LLC; G
- Donald A. Hoffend Jr.; Avista Designs, LLC; G
- Christine L. Kaiser; Syracuse Scenery & Stage Lighting Co., Inc.; DR
- Rodney F. Kaiser; Wenger Corp.; CP
- Theresa Kelley; Total Structures Inc.; MP
- S. Lars Klein; Arup; DE
- Edwin S. Kramer; I.A.T.S.E. Local 1; U
- Kyle Kusmer; Steven Schaefer Associates; G
- Roger Lattin; I.A.T.S.E. Local 728; U
- Michael Lichter; Electronic Theatre Controls, Inc.; MP
- Dan Lisowski; University of Wisconsin - Madison; U

© 2017 ESTA
Voting members cont'd:

Joseph McGough; Foy Inventerprises, Inc.; CP
Orestes Mihaly; Production Resource Group; DR
John (Jack) Miller; I Weiss; CP
Jeff T. Miller; Walt Disney Company; U
Rick Montgomery; R&M Materials Handling; MP
Reid Neslage; H & H Specialties Inc.; MP
Mark Newlin; Xtreme Structures and Fabrication; MP
James Niesel; Arup; DE
Richard J. Nix; Steven Schaefer Associates; G
Jyle Nogee; Theatre Design Services, LLC; DE
Shawn Nolan; Production Resource Group; DR
Tracy Nunnally; Hall Associates Flying Effects; CP
Kimberly Corbett Oates; Schuler Shook; DE
Carlos Ortega; PSAV Presentation Services; U
Edward A. (Ted) Paget; Daktronics Inc.; CP
Miriam Paschetto; Geiger Engineers; G
Rocky Paulson; Freeman Companies; DR
Troy Post; R&M Materials Handling; MP
Woody Pyeatt; A V Pro, Inc.; DR
Gregory Quinkert; Motion Laboratories; CP
John Ringelman; Freeman Companies; DR
Rick Rosas; Texas Scenic Company; DR
Eric Rouse; Pennsylvania State University; U
Shawn Sack; Columbus McKinnon Corp.; MP
Bill Sapsis; Sapsis Rigging, Inc.; U
Peter A. Scheu; Scheu Consulting Services, Inc.; G
Todd Spencer; PSAV Presentation Services; U
Stephen G. Surratt; Texas Scenic Company; DR
Peter V. Svitavsky; Wenger Corp.; CP
Will Todd; Milos Group; MP
Elmer Veith; Total Structures, Inc.; MP
Steve Walker; Steve A. Walker & Associates; G
Charlie Weiner; LMG Inc.; DR
Michael Wells; Xtreme Structures and Fabrication; MP
Marty Wesstrom; Mountain Productions Inc.; DR
Jeff Wilkowski; Thern, Inc.; MP
R. Duane Wilson; Amer. Society of Theatre Consultants; DE
Robert Young; Arup; DE
Art Zobal; Columbus McKinnon Corp.; MP

Observer (non-voting) members:

Frank Allison; G
Brent Armstrong; Brent Armstrong; U
William Ian Auld; Auld Entertainment; U
Warren A. Bacon; Warren A. Bacon; U
Rinus Bakker; Rhino Rigs B.V.; G
Robert Barbagallo; Solotech Inc.; DR
Roger Barrett; Star Events Group Ltd.; DR
F. Robert Bauer; F.R. Bauer & Associates, LLC; G
Maria Bement; MGM Grand; U
Roy Bickel; Roy Bickel; G
Lee J. Bloch; Bloch Design Group, Inc.; G
Steve (BOZ) Bodzioch; LMG Inc.; G
Observer (non-voting) members cont’d:

Ron Bonner; PLASA EU; G
Louis Bradfield; Louis Bradfield; U
Buddy Braile; Bestek Lighting & Staging; U
Barry Brazell; U
André Broucke; G
David M. Campbell; Geiger Engineers; G
Michael J. Carnaby; Mikan Theatricals; DR
Daniel J. Clark; Clark-Reder Engineering, Inc.; G
Benjamin Cohen; Reed Rigging, Inc.; DR
Ian Coles; Total Structures, Inc.; MP
Gregory C. Collis; I.A.T.S.E. Local 16; G
Bruce Darden; Rigging Innovators, Inc.; CP
Randall W. A. Davidson; Risk International & Associates, Inc.; U
Robert Dean; ZFX Flying Inc.; DR
François Deffarges; Nexo; MP
Cristina Delboni; Feeling Structures; MP
Jim Digby; Linkin Park Touring/The Collective; U
Noga Elion-Bahar; Elion Engineering Industrial Weighing Systems; MP
James B. Evans; Mountain Productions Inc.; DR
Tim Franklin; Theta-Consulting; G
Luca Galante; Alfa System Sas; CP
Jay O. Glerum; Jay O. Glerum & Associates, Inc.; U
Rand Goddard; W.E. Palmer Co.; CP
Reuben Goldberg; Technic Services; U
Thomas M. Granucci; San Diego State University; U
Pat Grenfell; Mainstage Theatrical Supply; DR
Sean Harding; High Output, Inc.; G
Greg Hareld; Kleeege Industries; U
Dean Hart; Freeman Companies; U
Marc Hendriks; Prolyte; MP
Ted Hickey; OAP Audio Products; MP
Chris Higgs; Total Solutions Group; G
Daniel Lynn Houser; Real Rigging Solutions, LLC; U
Wes Jenkins; Down Stage Right Industries; CP
Joseph Jeremy; Niscon Inc.; CP
Peter Johns; Total Structures, Inc.; MP
Ted Jones; Chicago Spotlight, Inc.; U
Kent H. Jorgensen; IATSE Local 80; G
Gary Justesen; Oasis Stage Werks; DR
John Kaes; U
JoAnna Kamorin-Lloyd; Vincent Lighting Systems; U
Nevin Kleege; Kleeege Industries; U
Jerald Kraft; JTH Lighting Alliance; CP
Ken Lager; Pook, Diemont & Ohl, Inc.; DR
Jon Lagerquist; South Coast Repertory; U
Eugene Leitermann; Theatre Projects Consultants, Inc.; G
Jon Lenard; Applied Electronics; MP
Mylan Lester; Creation Logics Ltd.; U
Baer Long; Act 1 Rigging Inc.; G
Dennis J. Lopez; Automatic Devices Co.; MP
Jeff Lucas; Cirque Du Soleil, Inc.; G
Darren Lucier; North Guard Fall Protection Inc.; U
Sam Lunetta; Michael Andrews; DR
Observer (non-voting) members cont’d:
Gary Mardling; Kish Rigging; DR
Chuck McClelland; Jeamar Winches Inc.; MP
Richard C. Mecke; Texas Scenic Company; DR
Hank Miller; W.E. Palmer Co.; CP
Shaun Millington; SEW-Eurodrive, Inc.; MP
Timothy Mills; Geiger Engineers; G
Scott Mohr; R&R Cases and Cabinets; G
John "Andrew" Munro; animaenagerie; U
Bob Murphy; Occams Razor Technical Services; G
Rikki Newman; U
Michael Patterson; Pook Diemont & Ohl, Inc.; CP
Ben Peoples; Pittsburgh Hoist & Sandbag Company; CP
G. Anthony Phillips; I.A.T.S.E. Local 16; U
Philip J. Pisczak; The National Telephone Supply Company; G
Michael Powers; Central Lighting & Equipment, Inc.; DR
Kurt Pragman; Pragman Associates, LLC; G
Michael Reed; Reed Rigging, Inc.; DR
Mark Riddlesperger; LA ProPoint, Inc.; CP
Timo Risku; Akumek; DE
Michael L. Savage, Sr.; Middle Dept. Inspection Agency, Inc.; G
Peter "Punch" Christian Schmidtke; Hollywood Lighting, Inc.; DR
Steven C. Shaw; Performance Rigging Systems, Inc.; MP
Knut Skjonberg; Skjonberg Controls, Inc.; CP
Monica Skjonberg; Skjonberg Controls, Inc.; CP
William Scott Sloan; U
John C. Snook; Thermotex Industries Inc.; CP
Rob Stevenson; SEW-Eurodrive, Inc.; MP
Andy Sutton; AFX UK Ltd.; U
Joachim Stoecker; CAMCO GmbH; MP
John Van Arsdale; University of Wisconsin - Madison; U
John Van Lennep; Theatrix Inc.; DR
Stephen Vanciel; U
Jiantong Wu; Beijing Special Engineering Design & Research Institute; G

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
NOTICE and DISCLAIMER........................................................................................................................... i
Contact Information....................................................................................................................................... iii
Acknowledgments ........................................................................................................................................ iv
Table of Contents ....................................................................................................................................... viii
1* SCOPE ................................................................................................................................................... 1
2* DEFINITIONS .......................................................................................................................................... 1
3 DESIGN AND ENGINEERING .................................................................................................................... 2
  3.1 Intent................................................................................................................................................... 2
  3.2* Design .............................................................................................................................................. 2
  3.3 Analysis ............................................................................................................................................. 3
  3.4 Engineering documentation ................................................................................................................ 3
  3.5 Loading ............................................................................................................................................ 4
    3.5.1* Seismic Loading ....................................................................................................................... 4
    3.5.2* Wind loading .......................................................................................................................... 4
    3.5.3* Load considerations ................................................................................................................. 5
    3.5.4* Superimposed loads such as rain, snow, ice, etc. .................................................................. 5
  3.6 Lifting devices ................................................................................................................................... 6
  3.7 Temporary structure installation and erection ..................................................................................... 6
  3.8* Ground Conditions and Foundations .............................................................................................. 6
  3.9* Stability ......................................................................................................................................... 7
    3.9.1 General ...................................................................................................................................... 7
    3.9.2* Guying and Cross-bracing Assemblies .................................................................................. 7
    3.9.3 Ground Anchors ....................................................................................................................... 7
    3.9.4 Ballast ...................................................................................................................................... 7
4 MANUFACTURING ................................................................................................................................. 7
  4.1 Intent ................................................................................................................................................... 7
  4.2 Material .............................................................................................................................................. 8
  4.3 Fabrication ......................................................................................................................................... 8
  4.4 Inspection ......................................................................................................................................... 8
  4.5 Identification ..................................................................................................................................... 8
  4.6 Documentation ................................................................................................................................... 8
  4.7 Training ............................................................................................................................................ 9
5 USE AND CARE ...................................................................................................................................... 9
  5.1 Intent ................................................................................................................................................... 9
  5.2 Responsibility .................................................................................................................................... 9
  5.3* Pre-Use ......................................................................................................................................... 9
  5.4* During Use ..................................................................................................................................... 10
  5.5 Post Use .......................................................................................................................................... 11
6* USER INSPECTION .............................................................................................................................. 11
  6.1 Intent ................................................................................................................................................... 11
  6.2 Inspection Requirements ................................................................................................................... 11
  6.3 Repair and removal from service .................................................................................................... 11
Appendix A, Commentary ........................................................................................................................... 13
  A.1 Scope .............................................................................................................................................. 13
  A.2 Definitions ..................................................................................................................................... 13
  A.3 Design and Engineering ................................................................................................................... 13
  A.6 User Inspection ............................................................................................................................... 21
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 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 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.