



Professional Engineers
Ontario

Design Evaluation & Field Review of Demountable Event & Related Structures

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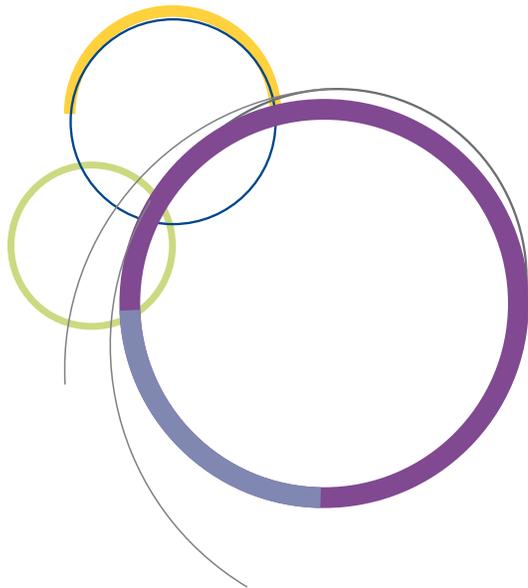
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DESIGN EVALUATION AND FIELD REVIEW OF DEMOUNTABLE EVENT AND RELATED STRUCTURES

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Notice: The Professional Standards Committee has a policy of reviewing guidelines every five years to determine if they are still viable and adequate. However, practice bulletins may be issued from time to time to clarify statements made herein or to add information useful to those professional engineers engaged in this area of practice. Users of this guideline who have questions, comments or suggestions for future amendments and revisions are invited to submit these to PEO using the "Guideline Amendment and Revision" form available at: <https://www.peo.on.ca/index.php/about-peo/committees-and-task-forces/professional-standards-committee-and-subcommittees>

ABSTRACT

The purpose of this guideline is to define best practices for engineers who do structural designs, design evaluations or general review for demountable event and related structures. Design evaluations may require the engineer to verify that the design of a manufactured structure is adequate based on the manufacturer's stated design criteria, that the stated design criteria complies with those needed by the Ontario Building Code, or to validate that the design criteria for a structure meets the site-specific design requirements for the event location.

General review is to confirm that the structures are erected in accordance with the drawings, manufacturer's instructions and the design intent.

This guideline is to be used in conjunction with other applicable guidelines such as *Structural Engineering Design Services for Buildings, Assuming Responsibility and Supervising Engineering Work, Professional Engineers Providing General Review of Construction as Required by the Ontario Building Code*, and *Structural Condition Assessments of Existing Buildings and Designated Structures*.

Note to reader:

This guideline references proposed amendments to the Ontario Building Code related to demountable event structures. These amendments were developed based on the 2015 *Report of the Expert Advisory Panel on Outdoor Temporary Stages* related to demountable event structures, which was established by the Ministry of Municipal Affairs and Housing (MMAH). As of the writing of this guideline, these proposed amendments have not been approved by the government and have not been filed into regulation. The 2012 building code requirements are still those that apply to demountable event structures. PEO guidelines, however, are intended to reflect best practices for the profession.

The proposed amendments to the building code were also endorsed in the coroner's jury report from the Office of the Chief Coroner, Ministry of the Solicitor General, into the death of Scott Johnson due to the partial collapse of a suspended structure. This report can be found at: <https://www.mcscs.jus.gov.on.ca/english/DeathInvestigations/Inquests/Verdictsandrecommendations/OCCInquestJohnson2019.html>.

While it is the responsibility of the design engineer to determine what constitutes as safe and code compliant structure, they are advised to carefully consider the proposed amendments to determine what is appropriate for their situation. These amendments can be found at: https://www.peo.on.ca/sites/default/files/2020-04/OBC_changes_Binder1.pdf.

The text in red refers to the proposed amendments to the building code that have not been implemented as of the publishing of this practice guideline.

1.

PURPOSE OF PEO GUIDELINES

Professional Engineers Ontario (PEO) produces guidelines to educate licensees and the public on best practices.

For more information on PEO's guideline and development process, including PEO's standard form for proposing revisions to guidelines, please see the "Guideline Development and Maintenance Processes" document available at: www.peo.on.ca/about-peo/committees-and-task-forces/professional-standards-committee-and-subcommittees.

For a complete list of PEO's guidelines, visit www.peo.on.ca/knowledge-centre/practice-advice-resources-and-guidelines.

2.

PREFACE

In November 2015, PEO Council approved the formation of a subcommittee of engineers experienced in design evaluations of demountable event structures. They were tasked to investigate the professional and ethical aspects of conducting design evaluations of demountable event structures. The subcommittee was instructed to develop best practices for engineers undertaking this work and prepare a guideline describing these best practices. As per the Council approved terms of reference, the subcommittee reviewed investigation and engineering reports of several recent collapses at events and took these reports into account in preparing this guideline.

The subcommittee met for the first time on May 26, 2016. Following consultations with engineers, co-regulators and other stakeholders, the subcommittee submitted a completed draft of this document to the Professional Standards Committee (PSC) for its approval on September 10, 2019. Then the PSC presented a final draft which was approved by Council at its meeting on November 19, 2019.

Notes:

1. References in this guideline to “engineers” apply equally to professional engineers, temporary licence holders, provisional licence holders and limited licence holders.
2. References in this guideline to “practitioners” refer to engineers and to firms, which hold a certificate of authorization to offer and provide engineering services to the public as defined in the *Professional Engineers Act*, henceforth referred to as the Act.
3. For the purposes of this guideline, the term “public interest” refers to the safeguarding of life, health, property, economic interests, the public welfare and the environment, for the benefit of the general public.
4. This guideline uses the term “building” as defined in the *Building Code Act, 1992 Ontario*. “Building” is also used in this guideline to mean “designated structures” as identified in the Ontario Building Code.
5. In general, for construction under federal jurisdiction, the National Building Code of Canada is the applicable code.

3.

PURPOSE AND SCOPE OF THIS GUIDELINE

This guideline applies to the design evaluation of demountable event structures, **as defined in the building code**, as well as similar structures exempted from the building code, such as television and movie sets, and structures exempt due to size or height. This guideline also covers design and design evaluation of related structures integral to the event, including stage platforms, columns and towers that support lighting, video and sound equipment.

This guideline sets best practices for these activities that are consistent with the professional and ethical obligations of engineers contained in the Act. It is not intended to be used as a textbook of instruction by persons who lack the professional qualifications, related technical knowledge and practical experience.

The building code also includes requirements for demountable event structures that are outside the scope of this guideline. The engineer should nonetheless be aware of these requirements. They include issues such as permitting, egress, guards, clearances and firefighting provisions, to name a few. The engineer should document the limit of their responsibility with the client and advise the client that there may be requirements beyond the engineer’s scope of service.

Several technical documents have been published by recognized national and international authorities on design verification and

design validation methods that should be referenced to properly evaluate the design of demountable event structures. These are being revised, expanded and enhanced on a regular basis to keep pace with engineering research and technological advances. Some of these technical guides and references are cited in Appendix 1.

As per the *Code of Ethics*, it is the duty of practitioners to act at all times with “knowledge of developments in the area of professional engineering relevant to any services that are undertaken, and competence in the performance of any professional engineering services that are undertaken.” Consequently, engineers engaged in design, design evaluations or field review of demountable event structures must be knowledgeable of codes, legislation, standards and technical publications in this area of engineering practice.

4.

INTRODUCTION

Demountable event structures that require a building permit to be issued before being erected and used will also require permit application documents sealed by an engineer who is licensed to practice in Ontario. To seal design documents for demountable event structural systems that have not previously been evaluated by a practitioner requires an engineer to conduct their own design evaluation to assess the structural system’s conformance with building code requirements and also its suitability for the design criteria of the specific location for which a building permit is requested. The assessment should also consider the requirements found in Construction Projects Regulation (O.Reg. 213/91) under the *Occupational Health and Safety Act* as they apply.

Design evaluations of a manufactured demountable event structural system can be separated into two functions:

1. A verification that the manufactured system is structurally adequate for the stated design criteria; and
2. A validation that the stated design criteria meets or exceed the building code specified site-specific design requirements.

Verification of the design requires sufficient analysis of the demountable event structure to confirm that the structure, including any ancillary structure, sub-system or component, is structurally adequate for the manufacturer’s stated design criteria or other applicable criteria determined by the engineer. Validation is the comparison of the verified design criteria for the structure against the site-specific design requirements as specified by the building code or as determined by the engineer when building code minimums are deemed inadequate. More than one engineer may be retained to provide specific portions of the evaluation.

This guideline also addresses demountable event structures that are designed by practitioners for specific or multiple event

locations using a combination of manufactured components and common structural elements. When custom structural assemblies of materials and components are designed by an engineer, design verification is a de facto part of the design process. Custom designs used in more than one location, however, still require validation for each event site not considered in the original design.

The criteria used for evaluations and design should comply with the requirements of the building code as well as appropriate climatic loading requirements and geotechnical conditions for the event location. Climatic design criteria to be considered will vary based on whether an event is located inside a larger facility or is outside and unprotected. Seasonal loads, such as snow, may also not be relevant for the timeframe that the event structure is in place. The use and occupancy criteria, however, should be unaffected by location.

When a building permit is required to erect a demountable event structure, field review of the erection and sign-off letter will also be required before the structure can be occupied. This guideline discusses best practices for engineers who conduct the field review. As is the case for field review of permanent structures under construction, the field review engineer need not be the same person as the design engineer.

5.

PROFESSIONAL COMPETENCE

Note that according to section 72(2)(h), O. Reg. 941/90 under the Act, it is professional misconduct for practitioners to undertake work that they are not competent to perform by virtue of their training and experience. Furthermore, failure to make responsible provisions for complying with applicable statutes, regulations, standards, codes, bylaws and rules in connection with work being undertaken by or under the responsibility of the practitioner is professional misconduct according to 72(2)(d), O. Reg. 941/90.

6.

PROFESSIONAL REQUIREMENTS

Practitioners who do structural designs, design evaluations or field review for demountable event structures and related structures are required to hold a certificate of authorization and have professional liability insurance coverage applicable to the areas of practice of the practitioner as required by the Act.

7.

DESIGN EVALUATIONS

7.1 Scope of Work

The scope of work for which the engineer may be retained can include:

- The evaluation of the design of a purpose-built, manufactured demountable event structure, which transforms its configuration between one suitable for transportation and a configuration suitable for its intended use with little assembly required, to verify that it meets the manufacturer's stated design criteria, or other design criteria as determined by the engineer;
- The selection of purpose-built, commercially manufactured components used to construct various structures by on-site assembly of the components into more complex forms for a specific use;
- The design or evaluation of a custom design prepared by design professionals using generic components and material assembled to create structures for a specific purpose at an event;
- The determination of site-specific design requirements for the event structures and an evaluation of whether the design criteria for the proposed structures are suitable for the event location; or
- The field review and inspection of the installation and general review for occupancy.

7.2 Design Verification

Demountable event structures are often designed and manufactured outside of Ontario. Consequently, practitioners in Ontario are retained to ensure that the design of these structures complies with applicable statutes, regulations, standards, codes, bylaws, rules, and industry best practices. Design verification by an engineer refers to a review of the engineering design documents, including installation, dismantling, maintenance, and operation plans for these structures to ensure conformance with local or appropriate design requirements.

The design criteria used in the verification of a manufactured structure or in the design of a custom structure must be prominently noted on the verification documentation so that it is readily available to the engineer tasked with conducting a site validation.

When evaluating manufactured components, the design criteria of the manufacturer may be used to verify that the design of the component or structure is adequate. For components certified by a recognized agency and suitable for the application, the engineer can rely on the certification, provided the components are in serviceable condition. For manufactured components in common use with industry-accepted capacities, such as scaffold frames, the engineer can specify the appropriate component and the minimum load capacity required.

When evaluating custom design structures, the design criteria should be appropriate for the intended use. Custom designed structures are, by definition, suitable for the event sites considered and do not require a design validation.

For all systems not designed by an engineer licensed in Ontario, design verification is needed. The engineer doing it should consider the PEO guideline, Assuming Responsibility and Supervising Engineering Work. The role of the verification engineer is to provide their opinion based on adequate documentation that the design either does or does not comply with the appropriate codes and design criteria, and whether there is sufficient information available for site validation and general review. The engineer's seal should be qualified with the statement that "Site Validation (by Others) is Required," since demountable event structures can be moved to different sites.

7.3 Design Validation

Demountable event structures are often used in several different locations. Consequently, practitioners are engaged to evaluate that the design of the structure meets the design criteria requirements at a specific site. This evaluation is to verify the structure is adequate for the loading and climatic conditions of the new location. Safety factors found in O. Reg. 213/91 must be considered as well.

Design validation by an engineer means examining the engineering design documents, including the site specific installation drawings and operation plans for these structures, for adequacy with respect to the requirements of the proposed location. Engineers doing design validations can choose to rely on the sealed design or verification documents of other engineers licensed in Ontario; however, they should take reasonable steps to confirm that the design or verification is valid by advising the prior engineer of the proposed design reuse and location.

7.4 Design Criteria

Loads used for the design or review of specific structures should be in accordance with the building code and applicable Ministry of Labour regulations. Dead loads are to be actual weights of the materials. Superimposed loads should be actual weights when known or an allowance when variation is possible. Superimposed loads may include dynamic forces, either during assembly or during the performance, that need to be considered.

Use and occupancy loads for structures that are intended to be occupied or that are located in areas accessible to the public should be based on the building code. Structures where access to the public is restricted could be designed based on the maximum anticipated loads; however, should these loads be less than that specified by the building code, those maximum loads are to be posted on the structure affected.

Climatic loads should be based on building code values, however, reductions in those loads may be possible due to seasonal expectations, duration of the event and actual exposure to the elements.

Strategies that require an action by the event crew to limit wind load on a structure, such as lowering the roof or cutting tarpaulin ties, are not recommended since they are in conflict with clause 25(1)(e) of the *Occupational Health and Safety Act*. It is recommended that "any loads" in this clause be interpreted as meaning those loads specified by the building code or other relevant regulations.

Even when a design meets building code wind load requirements, the engineer should develop an action plan in consultation with their client for unanticipated wind events. This action plan is to be incorporated into the operations management plan (OMP) document. This document is usually the responsibility of the event organizer, however, practitioners preparing a design for a demountable event structure are responsible for providing the appropriate design and operational content for the OMP to the event organizer. Practitioners evaluating a design by others need to also evaluate the associated OMP design and operation content to determine that the required information is present and correct.

When a practitioner is verifying a design by others that includes manual intervention load mitigation strategies, they should confirm that the design meets building code requirements in its altered state after those strategies are carried out. The practitioner should assess and discuss with the client whether adjustments can be made to either reduce or eliminate the need for manual intervention, or reduce the acceptable design load criteria by limiting the duration of the risk.

Due to the limited timeframe over which demountable event structures are erected, the risk that a significant earthquake event will occur is very remote. Also, the inherent flexibility of modular structures lessens the probability of damage from an earthquake event. For these reasons, it would be unusual for earthquake considerations to govern the design and considering earthquake forces is normally unnecessary.

Drawings and Documents

Guidance on the content of design and erection drawings is available in the PEO guideline, *Structural Engineering Design Services in Buildings*. Drawings should be clear and consistent, including their measurement system, they should explain key elements in plain language, including a legend for any acronyms, and they should include an index of all drawings and documents that constitute the complete set of design and erection drawings.

The engineer should confirm with their client that only sealed drawings and documents are final versions and that only sealed drawings and documents are to be used for fabrication, erection or operation of the demountable event structure.

The set of drawings and documents should be adequately detailed for peer review of the design work, including the design criteria determination, and for third-party review of the assembly and structure in the completed state. Suspended load locations, limits

and allowable variations should be clearly shown on loading diagrams for each load bearing element or assembly.

8.

GENERAL REVIEW

The building code requires that the construction of a demountable event structure that is regulated by section 3.18 of Division B be reviewed by an engineer. A demountable event structure that requires a building permit requires general review of the installation to confirm that the structure is assembled or erected in accordance with design drawings, manufacturer's instructions and the design intent. Guidance can be taken from the guideline, *General Review of Construction as Required by the Building Code*. Additional inspection detail is required and the engineer should make their assessment as to the level of detail needed to confirm the installation is acceptable.

Variations from typical general review considerations for demountable event structures include issues such as foundations bearing on grade and stability provided by tie-down anchors and ballast. Bearing capacities, pull-out resistance and adequate ballast for the design should be confirmed. Condition of components is also a consideration since all parts have probably been used numerous times before. Confirm that all components are in accordance with the drawings and that they have been inspected by qualified people with the authority to reject defective parts and conduct a general review for suspect elements. Loading on the structure can vary from that used for the design verification, either due to gravity loads from lighting or A/V equipment changes, or due to wind loads from screens, signage or banners that were not originally included.

To enable a competent engineer to conduct the general review, the verification documentation must be sufficiently detailed in its diagrams and instructions for both the purposes of erection and assembly as well as for the review of the structure and applied loads. Variations and deficiencies in the structure's configuration are to be identified and corrected. Variations in the loading of the structure that exceed identified load allowances are to be removed until approved and documented by the verification engineer. The general review is not completed until all variations and deficiencies are corrected or documented and reviewed. Large or complex demountable structures may need more than one general review inspection during erection. All structures where corrective action is required will require follow-up review unless the adjustments are made and reviewed during the general review visit.

General review needs to be completed before the structures are approved for occupancy by anyone other than the erection crew. After the structure is approved for occupancy, if adjustments to

the structure are required other than routine maintenance, the engineer should be notified so they can decide if any follow-up inspection is warranted.

9.

DEFINITIONS

Many words and phrases that have been appropriated into the lexicon of engineering are capable of being misunderstood by clients, insurers, lawyers, real estate agents, building officials and the public. It is therefore incumbent on engineers who write design evaluation reports for demountable event structures to choose their words wisely and to define their meaning carefully.

The definitions of the key words and phrases used in this guideline are those assigned to them in the following statutes, regulations, codes, standards and commentaries in the priority in which they are listed.

1. The Act and the regulations made under it.
2. The *Building Code Act* and the Building Code, Ontario Regulation 332/12 under the *Building Code Act*.
3. The *Occupational Health and Safety Act*, R.S.O. 1990, c. O.1.
4. The National Building Code of Canada.
5. The technical standards referenced in the building code applicable to the design, construction, renovation, occupancy and use of buildings referenced therein.
6. Those listed below to which specific meanings have been assigned in this guideline.
7. The meanings that are commonly assigned to them by dictionaries within the context in which they are used by engineers, technicians, builders and the skilled trades that implement structural engineering work.

Specific definitions for key words and phrases likely to appear in design evaluation reports, which this guideline recommends for the sake of consistency, are as follows:

Demountable event structure—A structure intended to be used for a limited duration that is dedicated to the production of events, including custom temporary structures, for either indoor or outdoor use. **As defined in the building code:**

- Demountable event structure means a stage platform, together with walls and roofs related to the platform and any appurtenant (associated) structures capable of supporting banners, stage sets, props or sound, lighting or associated equipment, that are*
- (a) *intended to be erected, assembled or installed for a limited, specified time,*
 - (b) *for one-time use or are capable of being dismantled at their location and moved to be reconstituted elsewhere,*

- (c) *intended primarily for occupancy by performers and workers and are intended for only limited public occupancy, and*
- (d) *intended to be used for public or private performances or events, other than those used in connection with movie or television productions.*

Structural integrity—Is defined in the Structural Commentary L of the 2010 edition of the NBC—Part 4 of Division B to mean the ability of a structure to absorb local failure without widespread collapse.

Structurally adequate—Buildings are deemed to be structurally adequate provided they satisfy the evaluation criteria prescribed by Commentary L of the User’s Guide—NBC of the Structural Commentaries (Part 4 Division B).

Structurally sufficient—Buildings and other designated structures that are designed and built to the minimum structural requirements of the current building code, in compliance with a valid building permit and, where applicable, with the design and general review requirements of the building code are deemed to be structurally sufficient.

Structurally sound—A building or other structure which exhibits no evidence of defects, damage, deterioration or distress that might impair its structural function or its present occupancy and use. Sound is not the same as adequate. Sound simply means undamaged.

Structurally Unsafe—As per article 15.9 (2) of the *Ontario Building Code Act*:

A building is unsafe if the building is,

- a) *structurally inadequate or faulty for the purpose for which it is used; or*
- b) *in a condition that could be hazardous to the health or safety of persons in the normal use of the building, persons outside the building or persons whose access to the building has not been reasonably prevented.*

APPENDIX 1.

References for Engineers Conducting Design Evaluations

Note that this list is provided for information only and should not be considered a comprehensive list. These references are informally grouped and presented in no particular order. This list in no way limits the responsibility of an engineer or the scope of this guideline. Further, the hyperlinks provided were valid only at the time of publication and may change after time.

CODES	
National Building Code of Canada (structural commentaries)	http://www.nrc-cnrc.gc.ca/eng/publications/codes_centre/2010_user_guide_nbc_part4.html
Building Code	https://www.ontario.ca/laws/regulation/060350
IStructE Code of Conduct & Guidance Notes	http://www.istructe.org/webtest/files/dd/dd7926b2-0487-4f20-a66c-c892fa670e11.pdf
ANSI E1.21-2006 "Entertainment Technology Temporary Ground Supported Overhead Structures Used to Cover the Stage Areas and Support Equipment in the Production of Outdoor Entertainment Events"	Not applicable
GUIDELINES	
IStructE Temporary Demountable Structures Guidance on Procurement, Design and Use (April 2007)	http://shop.istructe.org/temporary-demountable-structures.html
Ministry of Labour -Temporary Performance/ Event Structures Safety Guideline for the Live Performance Industry in Ontario	https://www.labour.gov.on.ca/english/hs/pubs/liveperformance/gl_live_structures.php



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