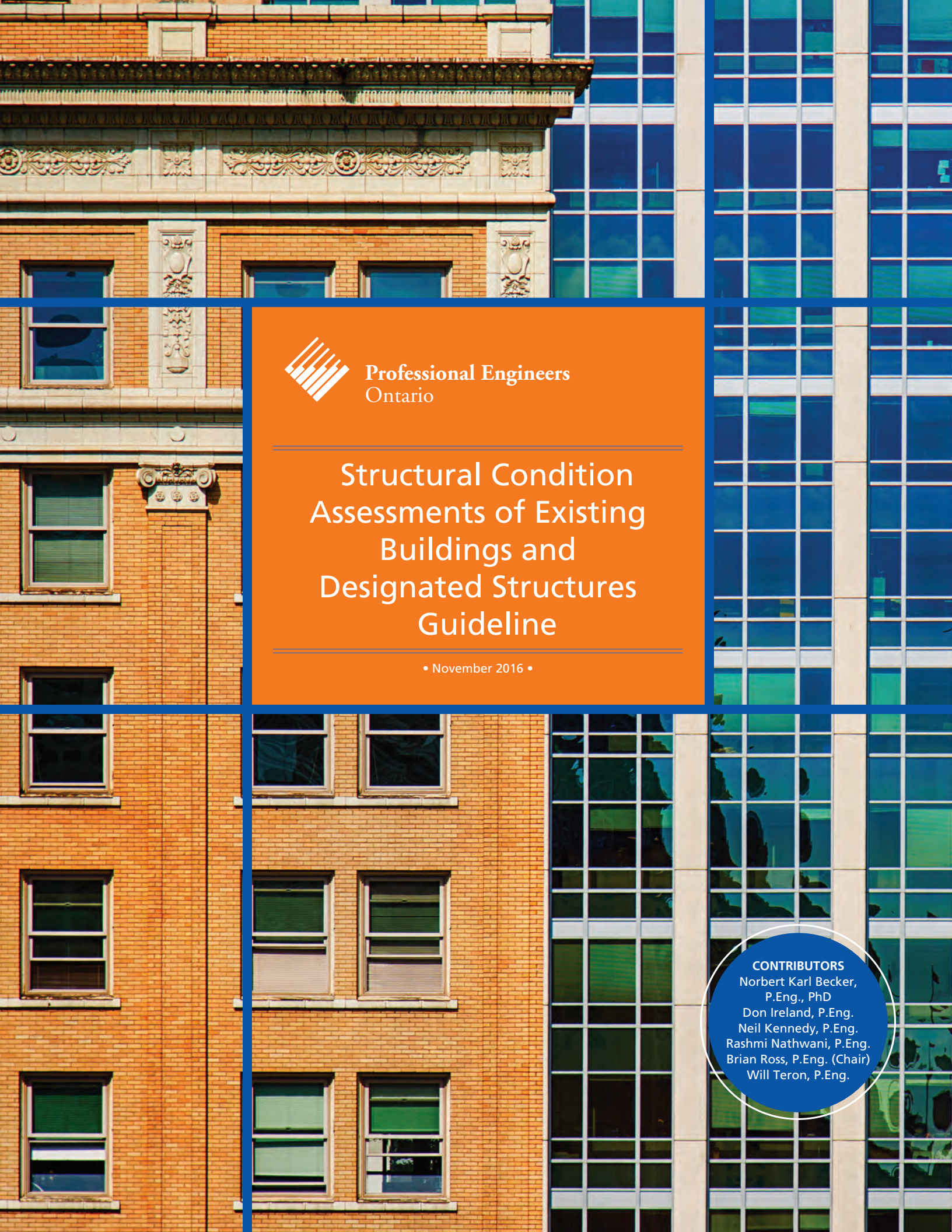

Professional Engineers
Ontario

Structural Condition Assessments of Existing Buildings and Designated Structures Guideline

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Notice: The Professional Standards Committee has a policy of reviewing guidelines every five years to determine if the guideline is 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 engineers engaged in this area of practice. Users of this guideline who have questions, comments or sug-gestions for future amendments and revisions are invited to submit these to PEO using the standard form included in the following Guideline Development and Maintenance Processes documents

ABSTRACT

The purpose of this guideline is to define the professional and technical requirements imposed on practitioners who perform structural condition assessments of existing buildings as defined in the *Building Code Act*, 1992, including designated structures as defined in the Building Code. Structural condition assessments of existing buildings are to be methodical, scientific investigations with clearly defined objectives, carried out with sufficient rigour to provide reliable findings.

The structural condition assessment objectives are to be based on the particular circumstances that cause the assessment to be required. These objectives, the assessment program and the findings are to be clearly stated.

1.

PURPOSE OF PEO GUIDELINES

Professional Engineers Ontario (PEO) produces guidelines to educate licence holders and the public about best practices.

For more information on PEO's guideline development and maintenance process, includ-ing PEO's standard form for proposing revisions to guidelines, please refer to the **Guideline Development and Maintenance Processes** document.

To view a complete list of PEO guidelines, please visit the Practice Advice Resources and Guidelines section of the PEO website.

2.

PREFACE

In late 2013, the Professional Standards Committee formed a subcommittee of engineers experienced in performing structural condition assessments. They were tasked to investigate the legal, ethical and technical aspects of conducting structural condition assessments. The subcommittee was instructed to develop best practices for professional engineers undertaking this work and to prepare a guideline describing these best practices. As per the Council approved terms of reference, the subcommittee reviewed the recommendations contained in the *Report of the Elliot Lake Commission of Inquiry* released on October 15, 2014, and took these recommendations into account when preparing this guideline.

The subcommittee met for the first time on November 27, 2013, and submitted a completed draft of this document to the Professional Standards Committee for approval on October 18, 2016.

At various stages of the development process, drafts of this guideline were distributed to a network of reviewers. These reviewers were a valuable source of additional comments and questions. Following consultations with engineers and other stakeholders, the final version was approved by Council at its meeting on November 18, 2016.

Note:

1. References in this guideline to the word "engineers" apply equally to professional engineers, temporary licence holders, provisional licence holders and limited licence holders.
2. References in this guideline to the word "practitioners" refer to engineers and to firms that 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 purpose 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 Building Code).

3.

PURPOSE AND SCOPE OF THIS GUIDELINE

The purpose of this guideline is to define the professional and technical best practices expected of practitioners who perform structural condition assessments of existing buildings in Ontario.

This guideline applies to buildings and designated structures, as defined in the Building Code. Furthermore, this guideline does not cover other types of building assessments, such as code compliance reports, building envelope assessments, performance audits, reserve fund studies and fire safety audits. Finally, although on-site sewage systems are considered "buildings" under the Building Code, these systems are not covered by this guideline. This guideline is not intended to be used as a textbook of instruction by persons who lack the professional qualifications, related technical knowledge and practical experience.

Numerous technical documents have been published by recognized national and international authorities that focus on the systematic and scientific methods that can be used to accurately assess the residual strength, durability and reliability of structural materials, assemblies and systems in existing buildings. These are being revised, expanded and enhanced on a regular basis to keep pace with scientific research and technological advances. A representative sample of these technical guides and references are cited in this guideline. 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 structural condition assessments must be knowledgeable of codes, legislation, standards and technical publications in this area of engineering practice.

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Although this practice guideline was prepared primarily for the structural condition assessment of buildings or parts thereof required to be designed by an engineer, it can also be used for the structural condition assessment of other buildings and structures.

4.

INTRODUCTION

Structural condition assessments as described in this guideline are within the practice of professional engineering, and fall into two categories:

1. preliminary assessments, and
2. detailed assessments.

These assessments types are described in sections 8.2 and 8.3.

Reasons for structural condition assessments of buildings include:

1. an assessment may be mandated or ordered by an authority, or it may be required for financing, a change in ownership, or to accommodate an expansion or modification or change of occupancy or use. Often in these cases, no reason for concern is known at the outset. Where no indications of structural concern are found, a preliminary assessment may be sufficient.
2. an assessment where damage, distress or deterioration is suspected or known to exist. Causes may include leakage, an aggressive environment, fire, impact, earthquake, severe weather, vulnerable building materials or building systems with a known history of deterioration.

5.

PROFESSIONAL COMPETENCE

Engineers undertaking an assessment must have knowledge and experience in:

1. the use, properties, life expectancy, durability and environmental reactivity of construction materials, elements and members utilized in the past and present;
2. past and present methods of constructing buildings including developments in this area;
3. failure mechanisms of structures and structural elements; and
4. structural engineering as it applies to the building being assessed.

Note that according to section 72(2)(h), O. Reg. 941/90 under the Act, it is considered 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 provision for complying with applicable statutes, regulations, standards, codes, by-laws 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.

Note that according to section 72(2)(h), O. Reg. 941/90 under the Act, it is considered professional misconduct for practitioners to undertake work that they are not competent to perform by virtue of their training and experience.

6.

PROFESSIONAL RESPONSIBILITY AND LIABILITY

Engineers who perform structural condition assessments of existing buildings are engaging in a specialized area of professional practice that can have significant ramifications. Practitioners are encouraged to seek the advice of legal counsel and insurance professionals to assist them in understanding any risks and the extent to which their professional liability insurance provides coverage before they undertake any such work.

6.1 Disclosures

Practitioners should disclose the following information in their proposals, terms of reference, engineering agreement and/or reports:

1. the specific purpose and defined scope of the structural condition assessment, as well as any limitations or exclusions imposed on the work by the practitioner or the client.
2. any outstanding or past orders/requirements issued by any government body or regulatory authority that are disclosed by the owner or client.
3. the specific statutes, regulations, codes and technical standards applied to the assessment.
4. the location of the property and the specific buildings (or the specific parts thereof) that are the subject of the assessment, along with their estimated age, prior use(s) and current uses, and other permitted use(s).
5. a summary of the engineer(s) relevant work experience.
6. any perceived conflict of interest, including but not limited to:

- the relationship of the practitioner(s) to the client for whom the structural condition assessment is being prepared;
- any ownership or financial interests the practitioner may have, either with the property being assessed or the outcome of the structural condition assessment; and
- any relationship of the practitioner(s) to any building engineers, designers, contractors, and/or owners involved with the building at any point in time.

In situations where there is an imminent risk to the public, the engineer is to contact the appropriate authority so that public safety is protected.

6.2 Duty to Report

For more detailed information on the duty to report, please refer to the *Professional Engineering Practice* guideline. Below are recommendations specific to structural condition assessments.

Practitioners who undertake a structural condition assessment of an existing building have a professional duty to ensure that their work is performed reasonably in accordance with applicable professional standards. They are required by the Code of Ethics under the Act, General R.R.O.1990 Reg. 941 Paragraph 77.2.i to regard their duty to public welfare as paramount. Furthermore, article 72(2)(c), O. Reg. 941, provides that failure to report a situation that a practitioner believes may endanger the safety or welfare of the public would constitute professional misconduct on the part of the practitioner. Engineers who discover a structural defect in a building or related structure during the course of an assessment that, in their professional opinion, poses a health or safety risk to the occupants, users or the public, should implement the following actions:

- in situations where there is an imminent risk to the public, the engineer is to contact the appropriate authority so that public safety is protected.
- if the risk is not imminent, the engineer is to report the risks to their client promptly and confirm it in writing; with a request that the client copy the report to the property owner, occupants or other appropriate parties immediately or within a given timeframe appropriate for the circumstances.
- if the client takes no appropriate action within the given timeframe, the engineer is required by the Act to notify the appropriate municipal and/or provincial authorities including the chief building official/Ministry of Labour (MOL).

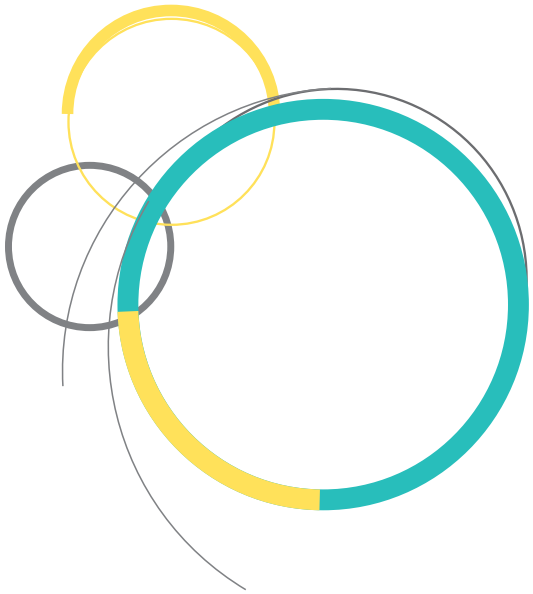
6.3 Duty of Care

Practitioners are advised that, in addition to their clients, building owners, government agencies, building officials and the public may rely upon the results of their condition assessment. If their assessment fails to discover and report a serious defect that ought reasonably to have been discovered, and such defect subsequently causes or contributes to a structural failure or building collapse, they may be held accountable for the damages.

Practitioners should never provide services without a signed agreement that clearly describes the scope of services to be provided, clearly limits the obligations of the practitioner, and clearly assigns the risks that the practitioner will assume. Practitioners should only assume risks that are within their ability to control and never those where the performance of a third party, such as a contractor, might have an effect on the outcome.

Engineers should exercise their best efforts to comply fully with the requirements of an order or requirement by an authority. If the engineer is unable to comply with a specific order, the engineer should clearly disclose any deviations from the order or requirement in the assessment report(s) and provide a justification for any such deviations.

The engineer is required to perform the assessment and prepare the assessment report without bias to any party. If the report is prepared in contemplation of litigation, it should comply with the PEO guidelines such as *The Professional Engineer as an Expert Witness* and *Professional Engineers Providing Forensic Engineering Investigations,* as well as the requirements placed on experts by the R.R.O. 1990, Reg. 194: Rules of Civil Procedure.



The engineer should discuss the report with the client to explain the results and recommendations.

An insufficient fee does not justify services that do not meet the intent of these guidelines. As stated in the *Professional Engineering Practice* guideline: "Practitioners should not accept assignments where the terms of reference and/or the project budget do not allow them to provide a service commensurate with their professional obligations to the client and the public."

Practitioners should never provide services without a signed agreement that clearly describes the scope of services to be provided, clearly limits the obligations of the practitioner, and clearly assigns the risks that the practitioner will assume. Practitioners should only assume risks that are within their ability to control and never those where the performance of a third party, such as a contractor, might have an effect on the outcome.

7.

PROFESSIONAL REQUIREMENTS

Professional requirements imposed on those who perform structural condition assessments of existing buildings for the public include:

1. Certificate of Authorization and professional liability insurance coverage applicable to the areas of practice of the practitioner as required by the Act if the assessment is provided as a service to the public.
2. compliance with legislation, codes, standards and orders from an authority applicable to the assessment site or the performance of work or activities on the site.
3. the engineer shall prepare instructions for the owner and the contractor on the safe removal and/or disassembly of items from the building or the load testing on the building, if required, to adequately complete the assessment. The engineer shall take into consideration how the work could detrimentally alter the loads or stresses in any part of the building; contravene the Building Code; impair the health and 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"; compromise fire or other life safety protection systems; disturb asbestos or other hazardous materials; or obstruct normal operations of the building.

8.

PERFORMING STRUCTURAL CONDITION ASSESSMENTS

8.1 Scope of Work

The primary objective is to assess the condition of the structure. Secondary objectives will vary depending on circumstances such as whether damage is known to have occurred, or if a change of use for the building is being investigated. For these secondary objectives, the assessment should look beyond the condition of the structure and determine the structural adequacy for actual or proposed loads, or the extent of damage and appropriate repairs. The scope of work should be clearly defined to ensure that the assessment objectives are met.

The assessment methodology will vary depending on the building configuration and physical constraints. The assessment techniques may range from a visual review through non-invasive techniques, to destructive sampling and testing. In some instances, occupancy of the building or the portion being assessed may be restricted. For the services requested, the engineer and the client must understand and agree to the scope of work, which should include:

- reason for the assessment;
- assessment objectives;
- methodology to be followed;
- anticipated difficulties in conducting the assessment and achieving the objectives;
- limitations of the findings; and
- deliverables.

8.2 Preliminary Assessment

The preliminary assessment results in a written report of a condition survey of the building that is qualitative rather than quantitative in nature. While such a qualitative assessment is based on a visual review, it requires a systematic approach to ensure that all critical areas are addressed and appropriate recommendations are provided. The principles of Structural Commentary L from National Building Code (NBC) Structural Commentaries (Part 4 of Division B) should guide the engineer.

The engineer conducting a structural condition assessment must undertake an onsite review. Photographs and other visual support provided by others are helpful but do not replace site reviews.

a) Study of documents and other evidence

Prior to visiting the building for inspection, the engineer conducting the preliminary assessment should review all relevant or necessary documents and drawings that are available. This would include, but is not limited to, the original design and construction documents and drawings. Furthermore, engineers should be aware of any structural condition registry, should one be established. This review will assist the engineer to:

1. understand the building's layout and its primary structural systems;
2. identify the originally specified design loads in order to assess the existing loading and proposed usage relative to established criteria;
3. identify if there have been any additions or alterations; and
4. identify critical areas for inspection.

The engineer should request from the client:

- original construction documents;
- orders issued by an authority;
- previous assessment reports;
- reports of chronic issues; and
- other reports that may be available.

Records of ongoing maintenance and repairs should be reviewed. When possible, maintenance staff and property managers should be interviewed to identify known areas of distress, corrosion, cracking or water leakage. Any building or leakage issues that have been reported to a health and safety committee or safety representative should be requested.

If the subject building is an 'older' building, a review of local, provincial and national heritage registries should be undertaken to verify if any heritage easements or designations are in place.

The engineer should make an effort to find any reports and information that is available which would identify any particular concern to the inspection teams, such as designated substances or hazardous materials as defined in the *Occupational Health and Safety Act*.

b) Site assessment

The engineer conducting a structural condition assessment must undertake an onsite review. Photographs and other visual support provided by others are helpful but do not replace site reviews.

For the preliminary assessment, the engineer is expected to carry out a visual inspection to:

1. verify the adequacy of the primary structural systems to the extent possible using non-destructive methods.
2. survey the condition of the building to identify:
   a. structural construction defects;
   b. signs of structural damage, distress or deformation; or
   c. signs of significant deterioration.
3. assess the use of the building to identify apparent deviations from intended use, misuse or abuse.
4. look for additions or alterations that may cause an adverse effect on the structure.
5. identify any building envelope conditions that may adversely affect the structural system.

The assessment should document characteristics including: member and frame geometry; material type; visually evident deterioration, deformation, damage; surface conditions; and critical connection details. Frequently, these characteristics will be recorded in qualitative terms from 'excellent,' through 'good' to 'fair' or 'poor.' It is important that these terms be defined in the report. Please refer to the Definitions section for more information on these terms.

There could be some difficulties in conducting a visual inspection because some of the main structural elements in a building may be covered up by finishes. It is therefore important that the engineer exercise professional judgment in determining which covered areas should be exposed for inspection. Reference to structural layout plans to determine the presence of critical structural elements would be crucial under such circumstances.

If the assessment is being conducted because the building was affected by a potential structurally compromising event, such as a fire, vehicle impact or flooding, the engineer may be directed to limit the scope of the assessment to those struc-

There could be some difficulties in conducting a visual inspection because some of the main structural elements in a building may be covered up by finishes. It is therefore important that the engineer exercise professional judgment in determining which covered areas should be exposed for inspection. Reference to structural layout plans to determine the presence of critical structural elements would be crucial under such circumstances.

tural elements that were affected by the event. This limited assessment should cover the elements directly affected, adjacent members and connections, and any other components within the affected element's critical load path.

c) Preliminary numerical analysis

The preliminary assessment is not intended to be a comprehensive analysis of the building, however engineering computation may be required to verify the adequacy of critical elements. These calculations usually use approximate methods and should be focused on the suspect areas or elements of the building to determine if the conditions identified are cause for concern. These calculations can identify a need for immediate action, further investigation or provide satisfaction that a particular element is structurally adequate.

d) Reporting

A preliminary assessment should conclude with a sealed written report issued to the client in a timely manner. The report should include:

- purpose of the assessment;
- scope of service provided including any limitations or restrictions imposed on the engineer conducting the assessment;
- general description of the building and its structure;
- summary of areas reviewed, personnel involved, methodology and observations; and
- analysis, conclusions and recommendations including the need for any immediate measures or additional assessment [see below].

e) Decisions on immediate actions

When the preliminary assessment indicates a potentially dangerous condition (a situation that endangers the safety or welfare of the public), the engineer is obligated to expedientlly report (verbally and in writing) the condition and potential risks/dangersto someone who has authority or responsibility to deal with the situation (refer to section 6.2 Duty to Report). This report will frequently include the need for immediate actions to mitigate the risk. It may be necessary to provide such written notice in a short letter in advance of the complete report.

Possible recommendations for immediate actions may include:

- installation of temporary shoring or bracing to prevent collapse;
- restriction of access to the building or part thereof; or
- installation of a protective enclosure to minimize infiltration of the elements.

f) Recommendation for detailed assessment

A preliminary assessment report may recommend that a detailed assessment be undertaken. The engineer must clearly state the reasons and timeframe, and indicate the consequences of failing to do so.

8.3 Detailed Assessment

The main task of the detailed assessment is to determine if the building or part being investigated is structurally adequate. The analysis should be done in general accordance with the National Building Code (NBC) Structural Commentary L.

The main task of the detailed assessment is to determine if the building or part being investigated is structurally adequate. The analysis should be done in general accordance with the National Building Code (NBC) Structural Commentary L.

A detailed assessment may require invasive investigation and extensive engineering work, which could require significant investment by the owner. Consequently, the scope of the detailed assessment should be balanced against the probable risks to the public. The investigation program should be consistent with, and add to, the preliminary assessment. The assessment may be limited to a specific area of the building, or may focus on a specific structural aspect located throughout some or all of the building.

a) Detailed documentation search and review

Structural design information and building maintenance records should be requested from appropriate sources. This information may be of significant value and may assist in understanding the structure's history, and limiting the extent of site surveys or destructive investigations.

Depending on the age of the building, the municipal building department may have records of the original designer, builder or owner. The engineer may need to contact those parties in an effort to assemble the historic records. Additional costs may be incurred for these searches.

After the document search is complete, information obtained should be site verified and any gaps supplemented by site measurements and observations using non-destructive and/or destructive methods. The goal is to compile a structural record of the as-built condition on which the structural analysis can be based.

b) Building examination

The building examination is a primary component of a structural condition assessment. It is important that the examination is carried out in a systematic and scientific manner. The purpose is to identify significant structural concerns, including: defects, damage, distress and deterioration.

c) Forms and checklists

Forms and checklists, such as those found in the references listed in Appendix 1, may be helpful in developing a work plan for conducting structural condition assessments. These forms and checklists may need to be customized to suit the nature and conditions of the assessment and inspection; however, forms and checklists can never replace the judgment of an experienced engineer.

d) Materials testing

A detailed investigation into the engineering properties of the materials used in the building structure may be required. The scope of this work will depend, in part, on the type of materials used for the building, as well as the issue being investigated. Engineers with expertise in specific materials may need to be retained, such as a timber specialist for identification of species and grading. Where member capacities need to be determined and the physical properties of the materials are not known, taking samples for testing is often required. Care should be exercised when removing samples to ensure thestructural integrity is not compromised. Any damage caused to the structure or fire-rated assemblies needs to be restored.

Any observed material deterioration or defect needs to be quantified and its potential impact on the building analyzed. Based on these observations, the engineer will provide an opinion on the potential impact of the defect or deterioration. For example, a structural steel element with a reduced section due to corrosion should be measured for remaining sound material and the impact of its reduced section properties and capacities determined.

e) Structural analysis

When an area of concern is identified, a structural analysis may be required to quantify the level of structural adequacy of a member, portion of the building, or building as a whole.

Design criteria such as design live and climatic loads used for an analysis of the building should be based on commentary L of the Structural Commentaries in the NBC. Design dead loads for the building should be based on volumes of materials noted and standard density values available from reference publications.

f) Report

Engineers must present their findings in a report addressed to the client. The level of detail of the report depends on the original reason for the assessment and will match the degree of complexity of the inspection and analysis. The report's contents should be in accordance with Appendix 2–Report Sample Format.

The reports should be written in a clear and easily understood style to accommodate a non-technical audience. All opinions expressed in the report must be supported by relevant analysis or discussion. For example, if the opinion on a particular problem is that it is of no structural significance, the report should provide sufficient explanation to support that opinion. The report should cite the statutes, regulations, codes, technical standards and guidelines relevant to the assessment.

Structural condition assessment reports contain statements of professional opinion and therefore must be sealed. For further information on the use of seal, refer to the guideline *Use of the Professional Engineer's Seal*.

Any observed material deterioration or defect needs to be quantified and its potential impact on the building analyzed. Based on these observations, the engineer will provide an opinion on the potential impact of the defect or deterioration. For example, a structural steel element with a reduced section due to corrosion should be measured for remaining sound material and the impact of its reduced section properties and capacities determined.

8.4 Emergency Assessments

Engineers may be retained by a government agency (e.g. emergency services) to conduct structural condition assessments after an emergency where an unsafe condition is likely and there is limited time to make a proper assessment. This guideline does not cover such emergency assessments.

Emergency assessments may have specific protocols depending on the circumstances and the jurisdiction having authority. For more information on emergency assessments refer to the Applied Technology Council (ATC), Federal Emergency Management Agency (FEMA) and other documents listed in Appendix 1.

8.5 Heritage and Older Buildings

The structural assessment of older buildings, including designated heritage buildings, presents unique challenges for engineers that may not be found in relatively modern buildings. These challenges include:

- buildings that predate the publication of provincial Building Codes or design standards;
- materials, assemblies, and construction methods no longer referenced in commonly available texts, manual and standards; and

- buildings that have been listed or designated as having heritage value and are therefore protected by legislation.

Construction materials and methods have evolved over the past two centuries. The engineer must be aware of the evolution of materials and systems so that the appropriate assessment and analysis is completed. Proper identification of material properties is essential to avoid inaccurate analysis.

Over the past few decades there have been numerous heritage buildings that have been negatively impacted by inappropriate assessments. Engineers conducting structural assessments must have experience and expertise in heritage building materials and methods so that appropriate and effective assessments are provided.

For condition assessments on older buildings, a verification of heritage designation is required. Registries of designated buildings and districts are maintained by local municipalities as well as provincial and federal authorities. The *Ontario Heritage Act* regulates alteration or demolition of the identified heritage attributes. It is noted that the heritage status reflects not only the appearance, but the integrity of all components as a unique product of the specific building technology and materials of the time. Engineers shall make provisions for complying with the *Ontario Heritage Act* when recommending any repairs and or interventions.

8.6 Housing and Small Buildings

This practice guideline was developed primarily for the structural condition assessment of buildings which, by virtue of their size, classification, occupancy and use, must be designed by an engineer. For other buildings, this guideline can be modified as appropriate to suit the scope of the assessment.

8.7 Building Facades

Non-structural facades, such as veneers and curtain walls, are not considered part of the structure and, therefore, not covered by this guideline. Nonetheless, the facade assessments are important since facades form part of the building envelope and their failure can result in a risk to the public and the underlying structure. For more information on facade assessments, refer to the ASTM facade standards listed in Appendix 1.

8.8 Parking Structures

Parking structures and other structures exposed to vehicular traffic present a particular concern due to their exposure to the elements, de-icing salts and dynamic loads of vehicles. For more information on conducting structural condition assessments on parking structures, refer to the guidelines, standards, articles and reports listed in Appendix 1.

DEFINITIONS

Many engineering terms, words and phrases have the potential of being misunderstood by clients, insurers, lawyers, real estate agents, building officials and the public. It is therefore incumbent on engineers who prepare structural condition reports 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 (NCC) 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 structural condition assessment reports, which this guideline recommends for the sake of consistency, are provided below.

Primary structural system

A combination of primary structural elements that support a building's self weight and applicable live loads based on occupancy, use of the space and environmental loads, such as wind, snow and seismic forces.

Structural integrity

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 exhibiting 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."

Phrases that should not appear in structural condition assessment reports due to the risk of conveying an inaccurate impression, include:

Structurally safe

This term is problematic due to wide mis-interpretation to mean free from any risk of injury, failure or damage. However, should the engineer choose to use this term, it should be based on the following definition:

An engineer who has determined that an existing building, other structure (or specified part thereof) is **structurally adequate** in accordance with this practice guideline may express the professional opinion that this building, structure (or specified part thereof) is **structurally safe** for its present occupancy and use provided that,

a) it is maintained in its current condition;
b) it is not subjected to extreme weather conditions beyond those prescribed by the Ontario Building Code; and
c) its primary structural systems are in the professional opinion of this qualified structural engineer unlikely to collapse suddenly and without warning if subjected to the limiting weather conditions and load combinations imposed on their structural design by Part 4 of the OBC.

In general conformity

General review letters issued by professional engineers pursuant to the applicable requirements of the Building Code are not intended to be, and therefore cannot be relied upon as, **proof** that a building is either **structurally sufficient** or **structurally adequate**. The scope of the services required of professional engineers who provide **general review** services for new buildings pursuant to the provisions of the Building Code and the requirements of the Act and regulations is limited to periodic visits during construction and routine and random quality control inspections and tests. For more information, refer to the PEO guideline *Professional Engineers Providing General Review of Construction as Required by the Ontario Building Code*.

Often engineers are asked to make qualitative assessments. While reports should include definitions of qualitative terms specific to the assessment, the following terms from Ontario's Structure Inspection Manual (OSIM) published by the Ministry of Transportation and dated October 2000 (revised November 2003 and April 2008) could be used:

(i) excellent
- this refers to an element (or part of an element) that is in "new" (as constructed) condition
- no visible deterioration type defects are present and remedial action is not required.
- minor construction defects do not count as visible deterioration type defects.

(ii) good
- this refers to an element (or part of an element) where the first sign of "Light" (minor) defects are visible. This usually occurs after the structure has been in service for a number of years. These types of defects would not normally trigger any remedial action since the overall performance of the element is not affected.

(iii) fair
- this refers to an element (or part of an element) where medium defects are visible. These types of defects may trigger a "preventative maintenance" type of remedial action where it is economical to do so.

(iv) poor
- this refers to an element (or part of an element) where severe and very severe defects are visible. In concrete, any type of spalling or delamination would be considered "poor" since these defects usually indicate more serious underlying problems in the material. These types of defects would normally trigger rehabilitation or replacement if the extent and location affect the overall performance of that element.

APPENDIX 1–REFERENCES OF INTEREST

REFERENCES OF INTEREST FOR ENGINEERS CONDUCTING STRUCTURAL CONDITION ASSESSMENTS

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:

REFERENCE	WEBSITE
BOOKS	
85 Years of Open-Web Steel Joist Construction	http://steeljoist.org/publications-1/85-years-of-open-web-steel-joist-construction-download
Structural Analysis of Historic Buildings by J. Stanley Rabun	http://www.torontopubliclibrary.ca/detail.jsp?Entt=RDM1145682&R=1145682
Structural Condition Assessment by Robert T. Ratay, PE	http://ca.wiley.com/WileyCDA/WileyTitle/productCd-0471647195.html
Structural Renovation of Buildings by Alexander Newman, P.Eng.	http://www.mhprofessional.com/product.php?isbn=0070471622
Why Buildings Fall Down by Matthys Levy	http://www.torontopubliclibrary.ca/detail.jsp?Entt=RD-M247364&R=247364
Conserving Buildings: A Manual of Techniques and Materials, Revised Edition by Martin E. Weaver	http://ca.wiley.com/WileyCDA/WileyTitle/productCd-0471509442.html
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
GUIDELINES	
11-99 Guideline for Structural Condition Assessments of Existing Buildings (ASCE)	http://www.asce.org/Product.aspx?ID=2147487569&ProductID=180889246
Evaluation, Maintenance and Upgrading of Wood Structures (ASCE)	http://cedb.asce.org/CEDBsearch/record.jsp?dockey=0034977
IStructE Code of Conduct & Guidance Notes	http://www.istructe.org/webtest/files/dd/dd7926b2-0487-4f20-a66c-c892fa670e11.pdf
Standards & Guidelines for Conservation of Provincial Heritage Properties (MTC)	http://www.mtc.gov.on.ca/en/publications/Standards_Conservation.pdf
Periodic Structural Inspections—Guidelines for Structural Engineers (Singapore)	http://www.bca.gov.sg/periodicstructuralinspection/others/psi_pe.pdf
Guideline for the Assessment of Existing Structures (SAMCO)	http://www.samco.org/network/download_area/ass_guide.pdf
CSA S478-95 (R2007)—Guideline on Durability in Buildings	http://shop.csa.ca/en/canada/structures/s478-95-r2007/invt/27002521995
IStructE (2010) Appraisal of existing structures. 3rd ed. London: IStructE	http://shop.istructe.org/appraisal-of-existing-structures-third-edition.html
IStructE (2008) Guide to surveys and inspections of buildings and associated structures London: IStructE	http://shop.istructe.org/surveys-and-inspections-of-buildings.html
IStructE (2013) Manual for the systematic risk assessment of high-risk structures against disproportionate collapse London: IStructE.	http://shop.istructe.org/manual-for-the-systematic-risk-assessment-of-high-risk-structures-against-disproportionate-collapse.html
IStructE (2010) Practical guide to structural robustness and disproportionate collapse in buildings London: IStructE.	http://shop.istructe.org/practical-guide-to-structural-robustness-and-disproportionate-collapse-in-buildings-2010.html
Ontario's Structure Inspection Manual (OSIM)	http://www.ogra.org/files/OSIM%20April%202008.pdf
Guidelines for Seismic Evaluation of Existing Buildings (NRC)	http://nparc.cisti-icist.nrc-cnrc.gc.ca/eng/view/object/?id=7cc614b7-a58f-4c98-a5f7-f62bb189d08d

Parking Structures	
NPA Parking Garage Maintenance Manual	https://weareparking.org/store/ViewProduct.aspx?id=1546302
ICE—Recommendations for the Inspection, Maintenance and Management of Car Park Structures	http://www.icevirtuallibrary.com/content/book/101134
BPA—Liability for Car Park Maintenance	http://www.britishparking.co.uk/write/Documents/Library/parking%20news/PPN30-%20Liability%20for%20car%20park%20maintenance%20-%20November%202011.pdf
BPA—Parking Life Care Plans	http://www.britishparking.co.uk/write/Documents/safer%20parking/Park%20Mark%20LifeCarePlansLeaflet%202011%20-%20page%20for%20web%20-%20small%20version.pdf
BPA—Asset Management and Maintenance for Parking Structures	http://www.britishparking.co.uk/write/Documents/Library/ppns/PPN%20017%20Octob%2005%20Asset%20Management%20and%20Maintenance%20of%20Parking%20Structure.pdf
PTI DC80.3-12: Guide for Evaluation & Repair of Unbonded Post-Tensioned Concrete Structures	http://www.post-tensioning.org/store/PTI_DC80.3-12:_Guide_for_Eval_Repair_of_Unbonded_Post-Tensioned_Concrete_Structures
Emergency Assessments	
Applied Technology Council Publications	https://store.atcouncil.org/
FEMA 306 Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings: Basic Procedures Manual	http://www.fema.gov/media-library-data/20130726-1506-20490-1995/fema-306.pdf
STANDARDS	
562-13 Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings (ACI 562-13) and Commentary	https://www.concrete.org/store/productdetail.aspx?ItemID=56213
A23.1-09/A23.2-09 (R2014) Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete	http://shop.csa.ca/en/canada/concrete/a231-09a232-09-r2014/invt/27012102009
Building Facades	
ASTM E2270–14 Standard Practice for Periodic Inspection of Building Facades for Unsafe Conditions	http://www.astm.org/Standards/E2270.htm
ASTM E2841–11 Standard Guide for Conducting Inspections of Building Facades for Unsafe Conditions	http://www.astm.org/Standards/E2841.htm
ASTM C1496-11 Standard Guide for Assessment and Maintenance of Exterior Dimension Stone Masonry Walls and Facades	http://www.astm.org/Standards/C1496.htm
ASTM E1825-06(2012) Standard Guide for Evaluation of Exterior Building Wall Materials, Products, and Systems	http://www.astm.org/Standards/E1825.htm
Parking Structures	
CSA Standard S448.1-10—Repair of Reinforced Concrete in Buildings and Parking Structures	http://shop.csa.ca/en/canada/structures/s4481-10/invt/27000572010
CAN/CSA-S413-94 (R2007) Parking Structures R2007) Parking Structures	http://shop.csa.ca/en/canada/structures/s413-07-r2012/invt/27005102007

REPORTS	
Deterioration of Parking Structures: Extent, Causes, and Repair Considerations Prepared by Suter Keller Inc. for the Research Division of Canada Mortgage and Housing Corporation, 31 March 1986	http://publications.gc.ca/collections/collection_2011/schl-cmhc/nh18-1/NH18-1-60-1986-eng.pdf
Nature, extent, and impact of residential parking structure deterioration Prepared by TROW Lmt. For the Technical Research Division Policy Development & Research Sector of Canada Mortgage and Housing Corporation, November 1981	http://publications.gc.ca/collections/collection_2011/schl-cmhc/nh18-1/NH18-1-58-1981-eng.pdf
Parking Structures	
ASCE—Condition Assessment of Parking Structures	http://ascelibrary.org/doi/abs/10.1061/40889(201)105
CMHC Deterioration of Parking Structures: Extent, Causes and Repair Considerations	http://www.cmhc-schl.gc.ca/odpub/pdf/62617.pdf?lang=en
CMHC Parking Structure Deterioration: A Survey and Analysis of its Extent and Influencing Factors	http://www.cmhc-schl.gc.ca/odpub/pdf/62623.pdf?lang=en
Case Studies	
Failures Wiki Building, Architectural and Civil Engineering Failures and Forensic Practices	http://failures.wikispaces.com
Failure Case Studies: Civil Engineering and Engineering Mechanics	http://matdl.org/failurecases/index.html
Report of the Elliot Lake Commission of Inquiry (Three Volumes) 15 October 2014	http://www.attorneygeneral.jus.gov.on.ca/inquiries/elliotlake/report/index.html

APPENDIX 2–REPORT SAMPLE FORMAT

REPORT SAMPLE FORMAT

Engineers who perform structural condition assessments of existing buildings should communicate their findings and conclusions to their client in a written report prepared under the signature and seal of the engineer(s) who directed and supervised the assessment. The report should be written in a manner that is unbiased, accurate and understandable by a non-engineer, while containing sufficient technical data and documentation for an independent peer-review.

A sample format, which provides a framework for a structural condition assessment report, is provided below. The level of detail in the report should reflect the complexity of the assessment.

1. INTRODUCTION

A concise, introductory section that documents:

- **who** retained the practitioners (e.g. building owner, tenant, prospective purchaser, building official, an insurance adjuster, etc.);
- **when** the practitioner was retained and when was the work done;
- **what** type of assessment was conducted (preliminary or detailed);
- **where** is the building located; and
- **why** the assessment is being performed.

2. BACKGROUND INFORMATION

A summary of the information upon which the practitioner relied to prepare the report, such as:

- a general description of the building (or part thereof) being assessed by the practitioner including its estimated age, floor area, number of stories, current or proposed occupancies, known changes in use, building additions, alterations and repairs. Further, a general description of its structural systems should also be included;
- a list of any prior assessments;
- the identity of the original architect, engineer, builder and owner, if relevant;
- disclosures as required by Section 6.1 of this guideline;
- any limitations imposed on the scope of the structural condition assessment by the client or practitioner; and
- identification of all sub-consultants who participated in the assessment and their defined scope of work.

3. PURPOSE

Include a complete statement of the purpose and objectives of the structural condition assessment and the part(s) of a building or other structure to which it applies.

4. METHODOLOGY

Fully describe the methodology employed by the practitioner to assess the structural condition of the building (or part thereof) to enable a knowledgeable reader to determine the level of effort applied to the assessment and the level of confidence which can reasonably be inferred from the results, conclusions and recommendations.

The report should include a chronological description of the tasks completed at the building site during the course of the assessment; the dates when these tasks were performed; and the team members, equipment and methods employed to accomplish these tasks. Additionally, list the technical standards and guidelines (e.g. PEO, CSA, ASTM, etc.) applicable to the methodology used for the structural condition assessment. Any deviations from these standards and guidelines should be disclosed and justified.

5. DOCUMENT REVIEW

Provide a complete listing of all relevant documents (e.g. drawings, specifications, maintenance records, previous structural assessment reports) reviewed by the engineer. Include a discussion of the available documents and those that were not (but would have been of assistance.) Describe any observations that provided the engineer with insight or concern before conducting the site investigation.

6. BUILDING EXAMINATION

This section should include the relevant observations used in the structural assessment. If the scope of the assessment is limited to a localized part of the structure, this section of the report can be brief. For a detailed assessment this section of the report may need to be expanded and subdivided. The content commonly reported is listed below:

- the results of all observations and diagnostic inspections to assess the condition of the exposed structural elements and to identify areas of localized damage, deterioration and distress should be documented, including references to photographs.
- the rationale for the removal or non-removal of finishes for more detailed inspections or for testing.

7. ANALYSIS

The results of any calculations performed to assess structural adequacy should be produced, and the standards and/or guidelines used for the evaluation should be referenced. Any detailed calculations (if required to support the conclusions) could be included in the appendices of the report.

8. DISCUSSION

This section of the report should explainthe assessment results in a manner easily understood by the client, building owner, building officials, regulators and non-engineers. If inadequacies are identified, the report discussion should include:

- the nature, extent and significance of structural inadequacies discovered during the course of the structural condition assessment.
- the probable cause of structural inadequacies (if known.)
- an explanation of the possible safety concerns, and associated risks, posed by any deficiencies discovered by the structural assessment; and the consequences of not addressing the deficiencies within a given timeframe.

9. CONCLUSIONS AND RECOMMENDATIONS

The engineer's conclusions should be based on the observations and analysis of the structural condition assessment. Conceptual solutions which could mitigate the structural inadequacies and recommendations for further analysis, investigations, repairs or other remedial measures should be included.

10. APPENDICES

When required, background documents, photographs, calculations, data and evaluation results upon which the engineer(s) relied for the assessment, can be included in the appendices.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