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Research towards a Performance-Based Building Code –Preliminary Analysis NBC Part 3: Fire and Life Safety Provisions

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List of Acronyms

Acronym	Definition
ABCB	Australian Building Codes Board
CCBFC	Canadian Commission on Building and Fire Codes
CCMC	Canadian Construction Materials Centre
IFEG	International Fire Engineering Guidelines
IRCC	Inter-jurisdiction Regulatory Collaboration Committee
NBC	National Building Code [of Canada]
NCC	National Construction Code [of Australia]

List of Abbreviations

Abbreviation	Definition
Div.	Division [of the National Building Code]

Executive Summary

Motivated by successes and continued evolution of international developments in performance-based design and performance-based codes, the question is posed whether there may be opportunities for Canada to capitalize on the international experiences and lessons learned.

In response, an overall project, *Research towards a Performance-Based Building Code*, was initiated with the intent to investigate and collate international approaches, experiences, and benefits observed so far so they can be considered in a Canadian context.

The overall scope of this research project intends to cover fire and life safety provisions in Part 3 and earthquake provisions in Part 4 of Division B of the 2015[1] edition of the National Building Code (NBC). This project will ultimately require the coordination of efforts between the research and the code development communities to identify knowledge gaps and future research needs in the areas of fire and life safety and earthquake design. It is proposed that results from this project inform the code development system and, perhaps, the discussion whether to introduce a new performance-based compliance path in the NBC, which would follow its due process, as determined by the Canadian Commission on Building and Fire Codes[1] (CCBFC).

As a foundational step to support this overall effort, an understanding of the current portion of performance requirements in the NBC would be beneficial. Where performance requirements refer to provisions that have a clearly defined level of performance, this requires measurable performance targets, clearly defined evaluation methods and a thorough understanding of how the intended level of performance was developed. A high-level survey of the current provisions that are prescriptive, performance, or a combination would provide a starting point to identify where there are groups of code provisions with no clear level of performance identified, topics that may need additional review and potential research to develop performance targets with the associated measurement methods.

The preliminary analysis of the fire and life safety provisions of Part 3 of the NBC 2015 is summarized in the report. This effort was designed to provide a fundamental step towards understanding the proportion of current requirements with prescriptive or performance-based targets, whether the values for these targets are qualitative, quantitative, or a combination, and the associated measurement methods. This preliminary analysis is undertaken to support a better understanding of the opportunities and obstacles of a performance-based approach for the NBC in the Canadian context.

In the short-term, improvement in setting the level of performance for each provision may improve our approach to alternative solutions—within the current code compliance options—and inform potential for impact and benefits of developing a new compliance option via a performance-based code framework. Such an improvement towards a more performance-based code may support the harmonization of building code requirements across Canada by providing performance targets for the safety level of buildings, so that individual prescriptive requirements may be discussed within the broader context of the intended performance of a building or part thereof. In addition, a clearly described performance framework and approach with quantified performance targets may also help to create a level playing field for various construction materials, products and technologies, and expedite national and international trade.

[1] While the report publication date is 2023, work summarized in this report was conducted prior to the publication of the 2020 edition of the NBC and before the start of the transition of the Code Development System to the Harmonized Code Development System, starting on November 22, 2022. Therefore, the information in the report is consistent with the documents and system that were current at the time the work was conducted.

The analysis resulted in a summary of individual fire and life safety provisions of Part 3 of the NBC 2015 categorized by:

- Design parameters (that describe the intended use, activities and function of the spaces of a building or facility are defined by the project owner and design team [Appendix A]); and
- Provision metrics (that describe all the elements that can be measured quantitatively or defined qualitatively) (Appendix B) are;
    - Qualitative, quantitative or a combination of these; and
    - Prescriptive, performance-based or a combination of these.

To facilitate future consideration of the performance targets and associated measurement methods for groups of provisions, the metrics involved in each provision were listed. To provide a first-level consideration of the code topics or areas that may be of interest to review in terms of the current relative proportion of prescriptive or performance-based requirements with qualitative or quantitative metrics. This may assist future identification of potential areas for detailed review when identifying well defined levels of performance.

The preliminary analysis performed is intended to provide a foundation for future consideration and in-depth analysis. The analysis, therefore, does not represent the final results of a full understanding of the level of quantification and performance-related requirements of current fire and life safety provisions of Part 3 of the NBC 2015. The results may provide insights to assist with the selection of topics that will be considered and addressed as quantified performance targets and measurement methods are developed, and eventually safety levels for buildings or parts thereof.

Approximately 1,677 provisions were extracted from Part 3 of Division B of the NBC 2015 (refer to Section 3 for more details). Of these approximately: 76 percent are prescriptive requirements; 16 percent are a combination of prescriptive and performance requirements; and 8 percent are performance requirements.

Overall, the results of the preliminary analysis are consistent with the general description found in Explanatory Note A-1.2.1.1.1(1)(b) of Division A of the NBC 2015 that, in many cases, the acceptable solutions in Division B provide performance targets that are not defined very precisely, and less precisely than would be needed in support of a performance-based code. In a more performance code, the level of performance would be described by "… *quantitative performance targets and prescribed methods of performance measurement for all aspects of building performance*…" [Explanatory Note A-1.2.1.1.1(1)(b)].

The results of the preliminary analysis provide insights into the approximate proportions of provisions with prescriptive or performance-based targets and whether the values for these targets are qualitative, quantitative or a combination, with associated measurement methods for each provision analyzed. This permits insights into individual provisions as well as groups of provisions, whether by Article, Subsection, topic or concept, which is a fundamental step towards being able to identify areas that need better defined levels of performance. This would also inform future discussions that would identify needs and obstacles in the Canadian context for consideration of the development of a performance-based framework for codes.

Recommendations are included for potential next steps following this preliminary analysis to support the potential development of performance baselines for the current fire and life safety provisions of Part 3 of the NBC 2015. These include suggestions for examples for relatively smaller topics that may assist to develop approaches for more complex concepts.

Depending on future work planning, the results from the preliminary analysis could be used to group related provisions to provide an initial insight into each selected area or topic. Identifying what groups of provisions to focus on will be heavily influenced by the objectives identified by stakeholders engaged during the next steps of the overall project. Based on the areas or topics that are identified as priorities in the Canadian context, it is further recommended that lessons learned from international jurisdictions are consulted in terms of development of performance-based code frameworks and continued improvement of their acceptable solutions.

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Purpose of Report

This report was originally prepared as part of the first in a series of reports intended for the "*Research towards a Performance-Based Building Code"* pilot project. The other reports that have been released as a public version in 2022 and were based on the first stage of the project include:

- Bénichou, N., Review of Performance-Based Fire Safety Regulations in Selected Countries: Australia, Report No. A1-018529.2, Cat.No. NR24-110/2-2022E-PDF, National Research Council Canada, 2022; and
- Su, J., Review of Performance-Based Fire Safety Regulations in Selected Countries: New Zealand, Report No. A1-018529.1, Cat.No. NR24-110/1-2022E-PDF, National Research Council Canada, 2022.

Another report that was subsequently developed for the pilot project that has also been released publicly (before the public version of this report was finalized) is:

- Bwalya, A., Su, J., Bénichou, N., Singh, J., Martin, H., Wise, T. Rabeau, A., and Leonard, G., Report on the Workshop on Research towards a Performance-Based Building Code, Virtual Workshop on 9 March 2022, Report No. Report No: A1-020201-01, National Research Council Canada, 2022.

This report summarizes the approach and initial insights of the preliminary analysis of the level of quantification and identified performance targets, and associated measurement methods for current requirements of the National Building Code (NBC), using the fire and life safety provisions of Part 3 of Division B of the NBC 2015 as a demonstration of concept.

While the report publication date is 2023, the work summarized in this report was conducted prior to the publication of the 2020 edition of the NBC and before the start of the transition of the Code Development System to the Harmonized Code Development System, on November 22, 2022. Therefore, the information in the report is consistent with the Code version and system that was current at the time the work was conducted, and care is taken to identify this by using references for clarity throughout.

1 Introduction

There is a current effort underway to better understand the opportunities and obstacles of a performance-based approach for the National Building Code (NBC) in the Canadian context. Stemming from successes and continued evolution of international developments in performance-based design and performance-based codes, there may be opportunities for Canada to capitalize on the international experiences and lessons learned. This may be utilized to improve our approach to alternative solutions—within the current code compliance options—and consider potential impact and benefits of developing a new compliance option via a performance-based code framework.

In response, an overall project was initiated with the intent to investigate and collate international approaches experiences and benefits observed so far so they can be considered in a Canadian context.

The overall scope of this research project intends to cover fire and life safety provisions of the Part 3 and earthquake provisions in Part 4 of Division B of the NBC 2015[2]. This project will ultimately require the coordination of efforts between the research and the code development community. It is proposed that results from the research will inform the code development system, which would follow its due process, as determined by the Canadian Commission on Building and Fire Codes[2] (CCBFC).

As a foundational step to support this overall effort, an understanding of the current portion of performance-based requirements in the National Model Codes would be beneficial. Where performance-based requirements refer to provisions that have a clearly defined level of performance, this requires both a measurable performance target, defined evaluation method and a thorough understanding of how the intended level of performance was developed. A high-level survey of the current provisions that are prescriptive, performance-based, or a combination would provide a starting point to identify where there are groups of code provisions with no clear level of performance identified, topics that may need additional review and potential research to develop performance targets, and associated measurement methods.

To address this, a preliminary analysis of the fire and life safety provisions of Part 3 of the NBC 2015 was undertaken. A summary of preliminary analysis is provided in this report.

1.1 Background

As background for a preliminary analysis of the provisions of the NBC 2015, a brief summary of the history of the intent and implementation of the development of the National Model Codes provides useful context in understanding the current state of the provisions. The following provides this overview.

The NBC became an objective-based code in 2005. It provides two compliance options, namely: to meet the acceptable solutions or to develop an alternative solution. Alternative solutions provide a compliance option to address a design that deviates from applicable requirements [NBC 2005, Division A, Sentence 1.2.1.1.(1)]. Typically, an alternative solution focuses on addressing one or a small number of provisions at a time.

An alternative solution must meet at least the minimum level of performance required by the acceptable solutions for the performance area described by the objectives and functional statements. The description of performance areas is entirely qualitative; therefore, the applicable acceptable solution may provide the context

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for the intended level of performance. However, these provisions may be prescriptive or performance-based targets, with values for these targets that are qualitative, quantitative, or a combination. In addition, the way to measure these values may or may not be defined. The associated intent statements may provide clarification of what a provision is intended to include or preclude; therefore, may assist the code user to establish a performance target for an acceptable solution. [NBC 2015, Division A, Clause 1.2.1.1.(1)(b) and Explanatory Note A-1.2.1.1.(1)(b)] However, without a clearly quantified intended performance target and associated measurement method, it would be difficult to use a performance-based approach to evaluate a proposed design, which explains why other approaches are used, such as comparative or benchmark approaches [IFEG 2005; Bergeron 2008].

Furthermore, alternative solutions are considered code compliant only after approval by the authority having jurisdiction is achieved for the proposed solution for the project [NBC 2015, Division C, Explanatory Note A-2.3.1.; Frye et al. 1998]. These solutions are developed, evaluated and reviewed to consider acceptance on a project-by-project basis. Acceptance is not intended to provide a standard for future compliance because of the focused and individual nature of this compliance approach. The onus to demonstrate compliance of an alternative solution lies with the builder, designer or building owner proposing the deviation from the acceptable solutions. [NBC 2015, Structure of objective-based codes]

The introduction of an objective-based code was originally envisioned as a step or transition towards a performance-based code, which is based on specifying performance criteria as opposed to prescribing how each component is built to meet the requirements [CCBFC 1995; Bergeron 2004. A performance-based code provides a framework for the evaluation of proposed designs to innovatively address the code in terms of systems, portions of buildings, or buildings, instead of a provision-by-provision approach of the current compliance options [Meacham 2010].

Since the release of the 2005 edition of the NBC, little has changed to the overall structure of the code to make it more accepting of performance-based design. Most code changes since then have focused on updating prescriptive provisions. Some code changes may have been used to consciously introduce or clarify acceptable solutions with better defined performance targets or improved quantification of the target.

1.1.1 Motivation

The process to change the code can be lengthy and require significant effort, making it difficult to enact major structural changes. The NBC code cycle was set as five years. Conversely, new construction research and technologies are frequently announced and there is a desire to implement them quickly in the market. For example, the pace of change that is currently seen in the low carbon construction market—in particular around mass timber and other engineered wood products—is outstepping the pace at which the National Model Codes can adapt [Bergeron 2008].

Prescriptive codes can be a barrier to innovation with designers confined to the explicit description of requirements that may not be directly applicable to the intended design vision or available innovations [Meacham 2010].

While, as mentioned in the introduction, alternative solutions allow for deviation from the prescriptive limitations, there are challenges. Such challenges to the alternative solution development process include the level of quantification of the performance target for the applicable acceptable solution, plus additional time and costs required for developing the engineering brief to reach agreement for the approach and acceptance criteria, then conducting engineering analysis, modelling, testing, and potential third-party peer review depending on the particular approach proposed. Some jurisdictions can be challenged by alternative solutions either from:

- A lack of clearly quantified performance targets and defined evaluation methods for various provisions that need to be identified for acceptance criteria on a project-by-project basis;

- The extent of engineering knowledge or experience required to develop agreement on the approach where acceptance criteria for each proposed solution undertake a technical review of the reported results of the analysis; or
- The complexity and/or volume of alternative solutions may exceed available internal resources.

Modernizing the NBC to become a more performance-based code in the future would move toward addressing the quantification of intended performance targets and may provide more context for the framework for the evaluation approach. This would support streamlining the use of performance-based approaches by providing more explicit performance criteria and development of an evaluation framework; that would in-turn:

- Improve the ease of development and review of alternative solutions in the current objective-based code framework;
- Allow larger portions of a building or structure to be more holistically evaluated; and
- Enable designers to use state of the art knowledge and research in the development and evaluation of their designs and aid a more transparent and efficient development and review process.

Such an improvement towards a more performance-based code may support the harmonization of building code requirements across Canada by providing performance targets for the safety level of buildings, so that individual prescriptive requirements may be discussed within the broader context of the intended performance of a building or part thereof. A clearly described performance framework and approach with quantified performance targets may also help to create a level playing field for various construction materials, products and technologies, and expedite national and international trade.

As for timing, the completion of the 2020 edition of the NBC marked the beginning of a new code cycle. Now is the opportunity to start looking towards what future editions of the NBC could look like and how it can be updated to be most effective and advantageous to Canadians. With a desire to facilitate building construction code harmonization across Canada, this represents an opportunity to renew movement towards a performance-based NBC.

From an international context, several countries such as Australia [NCC 2019] and New Zealand [NZBC 2017; C/VM2 2020], have already introduced performance-based codes with success and have, subsequently, launched evaluations of these systems to benefit from gaps and lesson learned feeding into a continued development of their code frameworks [Wade 2014; MBIE 2020].

Therefore, the available information, experience, and timing are set to capitalize on developing an understating of the potential for impact and benefits of a more performance-based code in the Canadian context.

1.2 Objectives

1.2.1 Overall Project Objectives

The objective of the overall project is to provide an analysis of the current state of the NBC and identify knowledge gaps and future research to be initiated in the areas of fire and life safety, and earthquake design in anticipation of the research potentially required by the CCBFC to consider the introduction of a new performance-based compliance path in the NBC.

1.2.2 Overall Project Approach

The overall project was proposed to be achieved using a staged approach.

During the first stage, foundational work included:

- A jurisdictional scan of international efforts to develop, implement and evolve performance-based codes, selecting case studies to investigate the impact, benefits and lessons learned for each example country [Bénichou 2022; Su 2022]; and
- A preliminary analysis of the earthquake design provisions of Part 4 and fire and life safety provisions of Part 3 of the NBC 2015 to provide a high-level overview of the level of quantified performance incorporated in the acceptable solutions to help inform future estimates of the level of effort and range of topics that would need to be addressed.

This report provides a summary of the portion of the project that focused on the preliminary analysis of the fire and life safety provisions of Part 3 of the NBC 2015. A similar preliminary analysis was also conducted for the earthquake design provisions of Part 4 that is summarized in a separate report.

1.2.3 Objectives for this Report

This report summarizes the approach and results of the preliminary analysis of the fire and life safety provisions of Part 3 of the NBC 2015.

1.2.3.1 Scope

The scope of the preliminary analysis that is summarized in this report was limited to:

- A focus on fire and life safety provisions of the Part 3 of the NBC 2015[3].
- Categorization of individual provisions, where each provision was considered at the Clause level and no higher than the Sentence level.
- Use of the language of the content in the:
    - Code provision text [NBC 2015];
    - Attributions of objectives and functional statements [NBC 2015 Section 3.10.]
    - Intent statements [CCBFC 2018];
    - Guidance provided in Explanatory Notes to Part 3 of the NBC 2015; and
    - NBC 2005 application statements [CCBFC 2008], where they could be appropriately mapped to NBC 2015 Sentences.
- Identifying first-order cross-references during the analysis to ease future stages of the project.
    - While these cross-references will be needed to group provisions when considering the impact on the minimum level of safety for a building design or a part of a building, these did not have a direct impact on the results reported here from the preliminary analysis because of the focus on individual provisions.
- Only the language in the content of the above listed documents was used, therefore there was no further interpretation of requirements in the analysis.

This report provides a summary of the approach developed and an overview of the results of the analysis. Experience gained during the application of this preliminary analysis was also intended to help refine the approach and support the application to other areas of the National Model Codes in future work. The results

[3] The work summarized in this report was conducted prior to the publication of the 2020 edition of the NBC and before the start of the transition of the Code Development System to the Harmonized Code Development System, on November 22, 2022. Therefore, the information in the report is consistent with the documents and system that was current at the time the work was conducted, and care is taken to identify this by using references for clarity throughout.

summarized here are recommended to be used in the context of the limitations of scope and analysis approach.

2 Analysis Approach

With the intent to refine the analysis approach before expanding to other areas of the National Model Codes and to provide a foundation for informing future work, the preliminary analysis approach used:

- Consideration of each provision by Clause or Sentence;
- Identification of code text and supplementary documents associated with each provision:
    - Categorization (Appendix B);
    - List of the metrics and values involved; and
    - First-order interdependence code context of provisions.

Each potion of this approach is described in the follow sections.

2.1.1 General Description of Approach

Clauses of the fire and life safety provisions of Part 3 of the NBC 2015 were reviewed to classify the type of requirement to provide a snapshot of what proportions are quantitative or qualitative, and prescriptive or performance-based.

2.1.1.1 Provision Size

For this analysis, a provision was considered as a portion of the acceptable solutions associated with a level of performance to achieve compliance for one topic. When an acceptable solution for one topic has more than one option that a code user could select to achieve compliance, these were considered separately. The intent of this approach was to inform an initial estimate of the proportion of requirements that are prescriptive or performance, and qualitative or quantitative. In addition, it was also intended to provide initial insight into topics that include an option to address applicable requirements with a clear quantitative performance criteria and evaluation method, and those that would potentially benefit from a clarification of the intended performance criteria and/or evaluation method.

The smallest provision size considered was at the Clause level. Therefore, Sub-clauses were analyzed as one provision at the Clause level.

Where Clauses are written as a series of individual requirements so that each Clause provides a different option to that could be used to achieve compliance for the Sentence, then each Clause of the Sentence was analyzed as one provision. (These Clauses are typically joined by “or”.) Such Clause provisions represented the smallest provision size used in this analysis.

Where Clauses are written as a bank of requirements so that all Clauses in the Sentence need to be addressed to achieve compliance, then the whole Sentence (the bank of Clauses) was analyzed as one provision. (These Clauses are typically joined by “and”.) Therefore, the largest provision size used in this analysis was at the Sentence level.

2.1.1.2 Categorization

To identify the proportion of the current provisions that provide a clearly defined level of performance with a quantified performance target and measurement method, each provision was categorized as qualitative, quantitative, or a combination. When the requirement was quantitative, it was identified whether the provision was prescriptive, performance-based or a combination, and whether a way to measure the metric was described.

Certain building elements, areas, or buildings or part thereof have multiple requirements in the National Model Codes that define the performance of that element using prescriptive, performance-based, or a combination of types of requirements. The overall performance of that building element is a combination of those requirements. To assist with further understanding of how provisions may work together for the combined level of performance for a building or part thereof, each provision was categorized with a selection of design parameters. Where design parameters are the project inputs that describe the intended use, activities and function of the spaces of a building or facility are defined by the project owner and design team (Appendix A). These parameters were selected to assist with future sorting and grouping of provisions so that the performance can be assessed considering all applicable provisions together.

In summary, the preliminary analysis approach categorized each fire and life safety provisions of Part 3 of the NBC 2015 as follows:

- The type of topic or issue addressed by the requirement:
    - What risk is being addressed; and
    - How that risk is being mitigated.
- First-order cross-references for context of the requirement:
    - References to other requirements, such as scope statements, exceptions, base requirements to the exception, other applicable requirements referenced, and referenced standards and other documents; and
    - The code context of each reference (that would aid in mapping interdependent relationships of provisions).
- Selected design parameters to assist with future sorting and grouping of provisions (Appendix A):
    - Major occupancies;
    - Occupancy groups (to identify requirements applicable to occupancy types that are not required to be a major occupancy);
    - Subgroups (to identify requirements applicable to spaces that may apply to multiple occupancy types and are not identified by a Group or Division, e.g. attic space, crawl space, service space, service room, etc.);
    - Construction type;
    - High buildings;
    - Building height (maximum number of storeys or height between grade and a specific location); and
    - Whether the building or a part thereof is required by the provision to be protected by an automatic sprinkler system.
- The level of quantification of the current acceptable solution requirement:
    - Qualitative, quantitative or a combination; and
    - Performance-based, prescriptive or a combination.
- The list of all metrics involved in the provision and each associated value (whether qualitative or quantitative, prescriptive or performance) and the context for a measurement or calculation method, if described.

The population of each of these categories used the literal wording of the code, attributions, intent statements and applicable application statements, where available. No interpretation of the provisions was used in the analysis.

First-order cross-references within each provision were captured to further provide a layer of context. This will be useful in the future, when grouping interdependent provisions together when estimating a combined level of intended performance.

This provides a consistent way to group provisions to facilitate the development of baselines in the next stages of this work.

2.1.1.2.1 Topic or Issue Addressed

The topic or issue of the provision describes what risk is being mitigated. For provisions with attributions, the objectives were used to provide direction.

For provisions without attribution statements, intent statements were considered for guidance on the issue intended to be addressed by the provision. If the intent statement did not provide guidance, where the provision was an exception then the language of the base requirement was used for context.

Examples of topics addressed or mitigated include:

- Interpretation of building or facility design parameters, or requirement descriptions;
- Injury due to fire of a person in or adjacent to the building;
- Delay when moving to a safe place;
- Damage due to fire or structural insufficiency of the building, or adjacent buildings;
- Damage to the building due to fire impacting areas beyond the point of origin;
- Damage to adjacent building due to fire impacting areas beyond the building of origin; or
- Combustible material significantly contributing to the fire growth and spread.

A list of issues addressed or mitigated is included in Appendix B.1.

2.1.1.2.2 Mitigation Strategy

The mitigation strategy employed by each provision was drawn from the code language as to how the identified risk is addressed. In practice, the associated intent statements or even the title of the article may provide additional insight.

Examples of mitigation strategies includes:

- Reducing the ignition propensity of materials
- Limiting the contribution to fire growth and spread:
    - materials with negligible effect
    - over exterior cladding
    - across the roof materials
    - across skylight
    - over combustible glazing
- Limiting major occupancy classifications of building or parts thereof
- Fire separation of major occupancies and other occupancies
- Limiting the:
    - Application, e.g., traveling cables on elevating devices
    - area of a space, e.g., mezzanines
    - use of a space, e.g., platforms
    - use of materials
- Limiting construction type
- Separation of foamed plastic insulation from adjacent spaces by a thermal barrier

A list of mitigation strategies is included in Appendix B.1.

2.1.1.2.3 First-order cross-references context

The first-order cross references for each provision were identified from:

- Provision text
- Application or scope statement for the subsection
- Exception or base requirements
- Referenced standards or other documents
- Cross-references to provisions
- Signposts to similar provisions or issues that may overlap

The code reference for each context was recorded to provide a simple mapping of the first level of interconnection working both “forwards” (e.g., where cross-references to other provisions or referenced documents to address the requirement exist) from the provision and “backwards” (e.g., if base requirements for a particular provision is an exception to or if applications statements from earlier in the same subsection are present) throughout the document.

2.1.1.2.4 Metrics

In terms of the requirements analyzed, metrics describe all the elements that can be measured quantitatively or defined qualitatively (Appendix B). This covers all the items or components that go into describing the situation and the minimum level of performance (whether the description of the performance target is explicit and measurement method is apparent). These may include:

- The consideration of a requirement, such as design parameters (Appendix A) to be inputted;
- Thresholds that trigger requirements to be met; and
- Output of the requirements that needs to be provided to conform.

Inputs for one requirement may be outputs or thresholds for another one. Furthermore, when designing a building to comply with the applicable code requirements, the designer, contractor, or building owner may have additional project objectives outside the code to reduce construction costs, maximizing the usability of certain spaces, and applying innovative materials and construction technologies to support the architectural vision of the space. These may require certain metrics to be *balanced* between different requirements that may be influenced by two or more major themes. Therefore, all metrics involved in each requirement were noted to ease future cross-checking interactions and potential interdependencies of requirements.

Examples of metrics includes:

- Building area
- Grade (location, relative location)
- First storey (location, relative location)
- Limiting distance
- Occupant load
- Major occupancy or occupancies
- Subsidiary occupancies
- Fire load (dependant on intended contents)
- Dangerous goods (whether they are present)
- Combustible materials (whether they are present)
- Storage (whether present, or not permitted in a space)
- Fire separation (whether required or provided)
- Fire-resistance rating
- Fire-protection rating
- Flame spread ratings
- Smoke developed classifications
- Material type

- Material thickness
- Material melting temperature
- Construction type

In some cases, a metric might also be a categorization parameter; however, the value for the metric may provide more context for the provision. For example, the parameter may trigger applicable requirements.

The associated value, whether qualitative or quantitative, was recorded for each metric. If a measurement method was included in the provision, then this method was also recorded to provide a context for the metric value.

A list of example metrics with associated values is included in Appendix B.2.

2.1.2 Analysis Limitations

High-level analysis limitations are summarized in this section to provide an understanding of the usefulness, applicability and interpretation of the results of the preliminary analysis and future planning efforts.

2.1.2.1 Topic of Fire and Life Safety in Isolation

The fire and life safety provisions of Part 3 of the NBC 2015 were selected in the preliminary analysis—summarized in this report—to demonstrate a concept. First-order interaction and interdependence were included in the preliminary analysis for the scope of requirements analyzed. Other interaction and interdependence expected between those requirements and others in the National Model Codes that were not part of the scope will need consideration future detailed analysis.

2.1.2.2 Influence of Major Fire and Life Safety Themes

The major themes used to group requirements for the fire and life safety provisions of Part 3 of the NBC 2015 were influenced by the concepts used to describe buildings and the current fire and life safety strategies commonly used in the Canadian context. These major themes are obvious in the layout of the NBC 2015 Part 3.

For consistency with the current NBC, the major themes are used in this preliminary analysis. However, it is acknowledged that the major themes that were used in the development of the NBC fundamentally influence the provisions and how they are grouped together.

As part of future applications or use of this preliminary analysis, it is recommended to consider the influence that these major themes of fire and life safety strategies have on the layout of the requirements, and compare safety levels for buildings with international codes that employ different approaches to fire and life safety strategies.

For example, the use of noncombustible versus combustible concept for construction type and materials may need careful consideration when compared to various types of assembly with fire-resistance ratings without the concept of combustible and noncombustible materials.

2.1.2.3 Historical Assumptions

Historical assumptions used in the development of a provision are not always documented clearly in the archived proposed changes but may be found in minutes, agenda packages, research, or other documents used by the technical or standing committees at the time when the change was introduced. Based on this preliminarily review of fire and life safety provisions of Part 3 of the NBC and future identification of priority topics, there may be provisions that could benefit from a historical analysis in search of the underlying assumptions behind the code requirement. Until such time as the code analysis is complete, identifying precise

provisions that would benefit the most from a historical analysis could result in misplaced effort. For this reason, investigating the historical assumptions is being recommended as future work.

3 Results

This section summarizes the results from the preliminary analysis. This focuses on the numbers or proportions of types of provisions and what they contain within the limits of the selected categories. Discussion of these results is included in Section 4.

3.1 Raw Information Extracted for Processing

A summary of the provisions extracted includes:

- Initially 2,496 raw fire and life safety provisions were extracted from Part 3 of the NBC;
    - This number was reduced to 1,677 provisions after accounting for Clauses that must all be complied with to address the Sentence requirements (typically joined by “and”) that were analysed together as a single provision;
- Approximately 35 definitions were included as line items, where the definition provided a context to a reference to directly incorporate quantitative and qualitative descriptions for metrics used in the provisions; and
- Three additional provisions were added from Part 1 of the NBC that included design parameters related to project location.

A summary of the results after applying the categorization approach is included in the following sections.

3.2 Proportion of Qualitative and Quantitative Provisions

The proportion of qualitative versus quantitative was identified for the fire and life safety provisions analyzed. The preliminary analysis showed the following results:

- Approximately 1 percent of the total provisions are neither qualitative nor quantitative, as they provide direction such as scope, definitions or other context;

Of the provisions that are quantitative or qualitative requirements (i.e., not including scope, definitions, or signposting without qualitative or quantitative requirements), approximately:

- 47 percent are qualitative requirements, and of these:
    - 87 percent of these provisions are prescriptive;
    - 4 percent are a combination of prescriptive and performance requirements; and
    - 9 percent are performance requirements (e.g., a requirement to comply with referenced standard test method without provision of an acceptance criteria).
- 24 percent are a combination of qualitative and quantitative requirements, and of these:
    - 36 percent of these provisions are prescriptive;
    - 60 percent are a combination of prescriptive and performance requirements; and
    - 3 percent are performance requirements
- 29 percent are quantitative requirements, and of these:
    - 88 percent of these provisions are prescriptive;
    - 2 percent are a combination of prescriptive and performance requirements; and
    - 10 percent are performance requirements.

Another way of considering the total provisions that are quantitative or qualitative requirements (i.e. not including scope, definitions, or signposting without qualitative or quantitative requirements), approximately:

- 76 percent are prescriptive requirements;

- 17 percent are a combination of prescriptive and performance requirements (e.g. requiring a referenced standard test method with additional qualitative requirements); and
- 8 percent are performance requirements.

Presenting these in terms of the total provisions that are quantitative or qualitative requirements (i.e. not including scope, definitions, or signposting without qualitative or quantitative requirements) is included in Table 1.

Table 1. Approximate percentage of that are quantitative or qualitative requirements (i.e. not including scope, definitions, or signposting without qualitative or quantitative requirements)

	Prescriptive	**A Combination**	**Performance**
Qualitative	41%	2%	4%
A Combination	9%	14%	1%
Quantitative	26%	<1%	3%

3.2.1 Topics with a Majority of Qualitative Requirements

Code topics with a majority of qualitative requirements (in Division B, except where noted) from the preliminary analysis results included:

- Definition of Words and Phrases (Division A, Subsection 1.4.1.)
- Fire Safety Plan (Division B, Subsection 1.1.4.)
- General –
    - Scope and Definitions (Subsection 3.1.1.)
    - Classification of Buildings or Parts of Buildings by Major Occupancy (Subsection 3.1.2.)
    - Multiple Occupancy Requirements (Subsection 3.1.3.)
    - General - Tents and Air-Supported Structures (Subsection 3.1.6.)
    - Fire-Resistance Ratings (Subsection 3.1.7.)
    - Penetrations in Fire Separations and Fire-Rated Assemblies (Subsection 3.1.9.)
    - Roof Assemblies (Subsection 3.1.14.)
    - Fabrics (Subsection 3.1.16.)
    - Occupant Load (Subsection 3.1.17.)
- Building Fire Safety –
    - Fire Alarm and Detection Systems (Subsection 3.2.4.)
    - Additional Requirements for High Buildings (Subsection 3.2.6.)
    - Lighting and Emergency Power Systems (Subsection 3.2.7.)
- Integrated Fire Protection and Life Safety Systems (Subsection 3.2.9.)
- Safety within Floor Areas –
    - Assembly Occupancy (Subsection 3.3.2.)
    - Care, Treatment or Detention Occupancies (Subsection 3.3.3.)
    - Industrial Occupancy (Subsection 3.3.5.)
    - Design of Hazardous Areas (Subsection 3.3.6.)
- Exits –
    - General (Subsection 3.4.1.)
    - Exit Signs (Subsection 3.4.5.)
- Vertical Transport –
    - General (Subsection 3.5.1.)
    - Standards (Subsection 3.5.2.)
    - Dimensions and Signs (Subsection 3.5.4.)
- Service Facilities –
    - General (Subsection 3.6.1.)

    - Service Rooms (Subsection 3.6.2.)
- Health Requirements –
    - Height of Rooms (Subsection 3.7.1.)
- Self-service Storage Buildings –
    - Building Fire Safety (Subsection 3.9.2.)

A summary of the results for each subsection for the approximate level of provisions categorized as qualitative, quantitative, or a combination of qualitative and quantitative is included in Appendix C.1.

3.2.2 Topics with a Majority of Quantitative Requirements or a Combination of Qualitive and Quantitative Requirements

Code topics that result with a majority of quantitative requirements, or combination of qualitative and quantitative requirements (in Division B), included:

- Climatic and Seismic Data (Division B, Subsection 1.1.3.)
- General –
    - Noncombustible Construction (Subsection 3.1.5.)
    - Combustible Construction (Subsection 3.1.6.)
    - Fire Separations and Closures (Subsection 3.1.8.)
    - Firewalls (Subsection 3.1.10.)
    - Fire Blocks in Concealed Spaces (Subsection 3.1.11.)
    - Flame-Spread Rating and Smoke Developed Classification (Subsection 3.1.12.)
    - Interior Finish (Subsection 3.1.13.)
- Building Fire Safety –
    - General (Subsection 3.2.1.)
    - Building Size and Construction Relative to Occupancy (Subsection 3.2.2.)
    - Spatial Separation and Exposure Protection (Subsection 3.2.3.)
- Safety within Floor Areas –
    - All Floor Areas (Subsection 3.3.1.)
    - Residential Occupancy (Subsection 3.3.4.)
- Exits –
    - Number and Location of Exits from Floor Areas (Subsection 3.4.2.)
    - Width and Height of Exits (Subsection 3.4.3.)
    - Fire Separation of Exits (Subsection 3.4.4.)
    - Types of Exit Facilities (Subsection 3.4.6.)
    - Fire Escapes (Subsection 3.4.7.)
- Vertical Transport –
    - Fire Separations (Subsection 3.5.3.)
- Service Facilities –
    - Vertical Service Spaces and Service Facilities (Subsection 3.6.3)
    - Horizontal Service Spaces and Service Facilities (Subsection 3.6.4)
    - Air Duct and Plenum Systems (Subsection 3.6.5.)
- Health Requirements –
    - Plumbing Facilities (Subsection 3.7.2.)
    - Medical Gas Piping Systems (Subsection 3.7.3.)

A summary of the results for each subsection for the approximate level of provisions categorized as qualitative, quantitative, or a combination of qualitative and quantitative is included in Appendix C.1.

3.2.3 Topics with a Majority of Prescriptive Requirements

Code topics that result with a majority of only prescriptive requirements (in Division B, except where noted) included:

- Definition of Words and Phrases (Division A, Subsection 1.4.1.)
- Climatic and Seismic Data (Division B, Subsection 1.1.3.)
- Fire Safety Plan (Subsection 1.1.4.)
- General –
    - Scope and Definitions (Subsection 3.1.1.)
    - Classification of Buildings or Parts of Buildings by Major Occupancy (Subsection 3.1.2.)
    - Multiple Occupancy Requirements (Subsection 3.1.3.)
    - Combustible Construction (Subsection 3.1.4.)
    - Tents and Air-Supported Structures (Subsection 3.1.6.)
    - Fire-Resistance Ratings (Subsection 3.1.7.)
    - Fire Separations and Closures (Subsection 3.1.8.)
    - Penetrations in Fire Separations and Fire-Rated Assemblies (Subsection 3.1.9.)
    - Firewalls (Subsection 3.1.10.)
    - Fire Blocks in Concealed Spaces (Subsection 3.1.11.)
    - Interior Finish (Subsection 3.1.13.)
    - Roof Assemblies (Subsection 3.1.14.)
    - Roof Coverings (3.1.15.)
    - Fabrics (Subsection 3.1.16.)
    - Occupant Load (Subsection 3.1.17.)
- Building Fire Safety –
    - General (Subsection 3.2.1.)
    - Building Size and Construction Relative to Occupancy (Subsection 3.2.2.)
    - Spatial Separation and Exposure Protection (Subsection 3.2.3.)
    - Fire Alarm and Detection Systems (Subsection 3.2.4.)
    - Provisions for Firefighting (Subsection 3.2.5.)
    - Additional Requirements for High Buildings (Subsection 3.2.6.)
    - Lighting and Emergency Power Systems (Subsection 3.2.7.)
    - Mezzanines and Openings through Floor Assemblies (Subsection 3.2.8.)
- Safety within Floor Areas –
    - All Floor Areas (Subsection 3.3.1.)
    - Assembly Occupancy (Subsection 3.3.2.)
    - Care, Treatment or Detention Occupancies (Subsection 3.3.3.)
    - Residential Occupancy (Subsection 3.3.4.)
    - Industrial Occupancy (Subsection 3.3.5.)
    - Design of Hazardous Areas (Subsection 3.3.6.)
- Exits –
    - General (Subsection 3.4.1.)
    - Number and Location of Exits from Floor Areas (Subsection 3.4.2.)
    - Width and Height of Exits (Subsection 3.4.3.)
    - Fire Separation of Exits (Subsection 3.4.4.)
    - Exit Signs (Subsection 3.4.5.)
    - Types of Exit Facilities (Subsection 3.4.6.)
    - Fire Escapes (Subsection 3.4.7.)
- Vertical Transport –
    - General (Subsection 3.5.1.)
    - Standards (Subsection 3.5.2.)
    - Dimensions and Signs (Subsection 3.5.4.)

- Service Facilities –
  - General (Subsection 3.6.1.)
  - Service Rooms (Subsection 3.6.2.)
  - Vertical Service Spaces and Service Facilities (Subsection 3.6.3.)
  - Horizontal Service Spaces and Service Facilities (Subsection 3.6.4.)
  - Air Duct and Plenum Systems (Subsection 3.6.5.)
- Health Requirements –
  - Height of Rooms (Subsection 3.7.1.)
  - Plumbing Facilities (Subsection 3.7.2.)
  - Medical Gas Piping Systems (Subsection 3.7.3.)
- Self-service storage Buildings –
  - General (Subsection 3.9.1.)
  - Building Fire Safety (Subsection 3.9.2.)
  - Floor Areas (Subsection 3.9.3.)

A summary of the results for each subsection for the approximate level of provisions categorized as prescriptive, performance, or a combination of prescriptive and performance is included in Appendix C.1.

3.2.4 Topics with a Majority of Requirements that are a Combination of Prescriptive and Performance Requirements

Code topics that result with a majority of requirements that are a combination of prescriptive and performance requirements (in Division B) included:

- General –
  - Noncombustible construction (Subsection 3.1.5.)
  - Flame-Spread Ratings and Smoke Developed Classifications (Subsection 3.1.12.)
- Integrated Fire Protection and Life Safety Systems (Subsection 3.2.9.)
- Vertical Transport –
  - Fire Separations (Subsection 3.5.3.)

A summary of the results for each subsection for the approximate level of provisions categorized as prescriptive, performance, or a combination of prescriptive and performance is included in Appendix C.1.

3.3 Summary

The individual fire and life safety related provisions of Part 3 of the NBC 2015 were categorized by:

- Design parameters (Appendix A); and
- Provision metrics (Appendix B) that were:
  - Qualitative, quantitative, or a combination of these; or
  - Prescriptive, performance-based, or a combination of these.

In summary, approximately 1,677 provisions were extracted from Part 3 of Division B of the NBC 2015. Of the total provisions analyzed, approximately: 76 percent are prescriptive requirements; 16 percent are a combination of prescriptive and performance requirements; and 8 percent are performance requirements.

To facilitate future consideration of the level of performance of groups of provisions, the metrics and associated measurement methods involved in each provision were listed to provide a first-level consideration of the code topics or areas that may be of interest to review in terms of the current relative level of qualitative or quantitative metrics and prescriptive or performance-based requirements. This may assist with future identification of potential areas to be considered for detailed review when identifying quantified performance targets with associated measurement methods.

4 Discussion

Overall, the results of the preliminary analysis are consistent with the general description found in Explanatory Note A-1.2.1.1.1(1)(b) of Division A of the NBC 2015, that, in many cases, the acceptable solutions in Division B provide performance targets that are not defined very precisely, and less precisely than would be needed in support of a performance-based code. In a more performance code, the level of performance would be described by "*… quantitative performance targets and prescribed methods of performance measurement for all aspects of building performance…*" [Explanatory Note A-1.2.1.1.1(1)(b)].

While, as clearly shown in Section 3, the preliminary analysis provides high-level insights into the numbers (and therefore proportions) of provisions that are qualitative, quantitative, or a combination, and prescriptive, performance-based, or a combination on an individual provision basis. This can be a useful first step to identify current provisions that have a more clearly quantified level of performance, or those needing treatment to develop a more quantified performance target and more clearly defined measurement method.

This preliminary analysis permits insights into individual provisions as well as simple groupings of provisions, whether by Article, Subsection, topic, or concept, which is a fundamental step towards being able to identify areas that need better defined levels of performance. This would also inform future discussions that would identify needs and obstacles in the Canadian context for consideration of the development of a performance-based framework for codes.

However, to identify priority groups of these articles, subsections, areas, or topics, other objectives need to be added into the mix. These other objectives will be identified by the various stakeholders engaged as part of future work.

For instance, selecting smaller topics to address first may assist in developing experience for increasing the quantification of current levels of performance and expanding this to consider buildings or parts thereof and, eventually, developing design benchmarks for the current code provisions. Such examples may include:

- Fabrics and textiles [including Articles 3.1.6.5., 3.1.16.1., 3.6.5.2., and 3.6.5.3.];
- Firewall requirements [including Article 3.1.10.2.] (may be approached as a sub-topic of combustible and noncombustible materials and construction provisions);
- Smoke control for high buildings [including Articles 3.2.6.2., and 3.2.6.3.];
- Interior finish provisions [including Subsection 3.1.13.];
- Limiting distance and areas of unprotected openings [including Article 3.2.3.1.]
- Maximum travel distance for each occupancy [including Subsection 3.4.2.];
- Interconnected floor area provisions, including egress from the space [including Subsection 3.2.8., and Sentence 3.4.3.2.(6)]; or
- Plumbing facilities provisions [including Subsection 3.7.2.].

When considering these example topics, such detailed analysis will need to include the impact of the interconnection of the provisions with other requirements that extend beyond the scope of this preliminary analysis and address, or include consideration of, the other limitations of this preliminary analysis and the results.

Alternatively, provisions that are qualitative with performance elements may provide a simple target to improve the clarity by quantification of levels of performance within the current code. Such examples include:

- Door assembly leakage rate requirements to comply with ANSI/UL-1784 without acceptance criteria [Sentence 3.1.8.4.(4)].

The results of the preliminary analysis provide an opportunity to group provisions with an initial insight as to the level of qualitative or quantitative and prescriptive or performance-based provisions. Identifying what groups to focus on will be heavily influenced by the objectives identified by stakeholders engaged during future efforts. In

addition, it is recommended that future steps also incorporate the interconnectedness of code provisions, building upon the individual provision analysis started here.

4.1 Potential Topics with International Lessons Learned

It is raised here that as this work develops, it is recommended that lessons learned from international jurisdictions are consulted based on the areas or topics that are identified as priorities in the Canadian context. The development approach and how topics were addressed may streamline some of the fundamental work needed in developing more quantitative levels of performance that address the Canadian context.

From the perspective of the approach and how topics are address, the jurisdictional surveys of Australia and New Zealand, developed as part of the first stage of this project [Bénichou 2021; Su 2021], focused on a performance-based code structure of performance targets within a performance-based framework. The acceptance criteria and methods to measure the performance of a design were in the context of the performance-based framework: design fire scenarios and the associated metrics and values for acceptance. These relate to the performance of a building or part thereof.

It is noted that there is no direct link between the current NBC acceptable solutions and such performance-based framework scenarios and acceptance criteria. A performance-based framework might be thought of as a top-down perspective: from the holistic consideration of the intended performance of the space that could be evaluated using a suite of fire scenarios to challenge the proposed design of a building or a part thereof; compared to a bottom-up perspective: from individual provisions that are defined separately and need to be combined to build the overall result of a benchmark for a building or part thereof.

As the next steps of this project evolve and acceptable solutions are grouped to investigate potential benchmarks for buildings or parts thereof, there will be opportunities for more comparison and drawing from international lessons learned in developing performance-based frameworks for fire and life safety concepts. However, even at the initial steps as Canada moves towards improved quantification of acceptable solutions, understanding the potential end goal of a performance-based framework may help in developing useful and practical solutions.

From another perspective, during the development of current international performance-based code frameworks, critical individual topics may have been identified where the intended level of performance needed to be better quantified or described. Identification of these efforts were not within the scope of the jurisdictional surveys developed as part of the first stage of this project [Bénichou 2021; Su 2021]. Therefore, more detailed discussions with the developing organizations may be useful to draw out historical information if similar topics had arisen. Furthermore, even with a performance-based framework in place, jurisdictions continue to improve their acceptable solutions. Therefore, it is recommended that communications are continued with international jurisdictions so that historical lessons can be benefited from and opportunities to collaborate or cooperate may be leveraged for ongoing improvement of the quantification of acceptable solutions.

5 Summary

Motivated by successes and continued evolution of international developments in performance-based design and performance-based codes, the question is posed whether there may be opportunities for Canada to capitalize on the international experiences and lessons learned.

In response to this, an overall project was initiated, *Research towards a Performance-Based Building Code*, with the intent to investigate and collate international experiences of approaches and benefits observed so far so they can be considered in a Canadian context.

The overall scope of this research project intends to initiate insight for fire and life safety provisions in Part 3 and earthquake provisions in Part 4 of the NBC 2015. This project will ultimately require the coordination of efforts between the research and the code development communities to identify knowledge gaps and future research needs in the areas of fire and life safety and earthquake design. It is proposed that results from this project inform the code development system that would follow its due process.

As a foundational step to support this overall effort, an understanding of the current portion of performance requirements in the NBC would be beneficial. Where performance requirements refer to provisions that have a clearly defined level of performance, this requires a measurable performance target, defined evaluation method, and thorough understanding of how the intended level of performance was developed. A high-level survey of the proportion of current provisions that are prescriptive, performance or a combination would provide a starting point to identify where there are groups of code provisions with no clear level of performance identified and topics that may need additional review and potential research to develop levels of performance.

The preliminary analysis of the fire and life safety provisions of Part 3 of the NBC 2015 is summarized in this report. This effort was designed to provide a fundamental step towards understanding the proportion of current requirements with prescriptive or performance-based targets, and whether the values for these targets are qualitative, quantitative or a combination. This preliminary analysis was undertaken to support a better understanding of the opportunities and obstacles of a performance-based approach for the NBC in the Canadian context.

In the short-term, improvement in setting the level of performance for each provision may improve the approach to alternative solutions—within the current code compliance options—and inform potential for impact and benefits of developing a new compliance option via a performance-based code framework.

The analysis resulted in a summary of individual fire and life safety related provisions of Part 3 of the NBC 2015 categorized by:

- Design parameters (Appendix A); and
- Provision metrics (Appendix B) that were:
    - Qualitative, quantitative, or a combination of these; and
    - Prescriptive, performance-based, or a combination of these.

To facilitate future consideration of the performance targets and measurement methods for groups of provisions, the metrics and associated values involved in each provision were listed. To provide a first-level consideration of the code topics or areas that may be of interest to review, the current relative proportion of prescriptive or performance-based requirements with qualitative or quantitative metrics was identified. This may assist future identification of potential areas for detailed review when identifying quantified performance targets with defined measurement methods.

The preliminary analysis performed is intended to provide a foundation for future consideration and in-depth analysis. The analysis approach was limited to individual provisions, therefore, does not represent the final results of a full understanding on the level of quantification and performance-related requirements of fire and life safety provisions of Part 3 of the NBC 2015. Future work is recommended to consider the interrelationship of provisions. Hence the preliminary analysis results may provide high-level insights to assist with the selection of topics that can inform next steps to consider and address improvement of the clarity of the intended quantified performance targets with defined measurement or calculation methods and eventually define safety levels for buildings or portions of buildings.

The results of the preliminary analysis provide an opportunity to group provisions with an initial insight as to the level of qualitative or quantitative and prescriptive or performance criteria. Identifying what groups to focus on will be heavily influenced by the objectives identified by stakeholders engaged during future efforts.

5.1 Recommendations

Recommendations for next steps from the preliminary analysis to support the potential development of performance baselines for the current fire and life safety provisions of Part 3 of the NBC 2015 include:

- Draw the benefits from this approach and refine this when expanding the consideration to other areas of the national model codes.
    - The preliminary analysis of individual provisions provides a demonstration of concept for future work for other areas of the national model codes. While the analysis approach used is limited to individual provisions and tailored to consider the way fire safety requirements have generally evolved, the approach and results provide useful insights and a snapshot of the current state of this area of the codes.
- Group related provisions to provide an initial insight into each selected area or topic.
- Enrich the preliminary analysis by gathering historical background for select provisions that would assist in identifying intended levels of performance where the current context could be clarified.
- Using the preliminary analysis results to inform the selection of example topics or areas to consider the current level of performance in detail and identify an approach to develop a more quantitative performance target or more clearly define the measurement method.
    - Relatively smaller topics may be initially selected to trial development approaches that will then inform more complex topics. In all cases, the limitations of the preliminary analysis need to be addressed when the results are used. Where possible, also draw from international experience for the development of quantification of the same or similar topics. Examples of relatively smaller topics may include:
        - Interconnected floor area provisions, including egress from the space;
        - Maximum travel distance for each occupancy;
        - Fabrics and textiles; or
        - Firewall requirements (may be approached as a sub-topic of combustible and noncombustible materials and construction type provisions).
- Because of the substantial extent (approximately 21 percent directly and a larger portion indirectly of those included in this preliminary analysis) that provisions are interconnected with the concept of combustible and noncombustible materials and construction, and the different metrics associated with level of performance for construction type requirements compared with various building component requirements, it is recommended that care be used in the planning to address the clarification of the level of performance of associated provisions.
    - Considering the different metrics and associated measurement and evaluation methods, construction type (performance of assemblies, compartmentalization, etc.) and material (fire spread, smoke development, etc.) perspectives could be performed in parallel:
        - To allow for the different expertise to focus on applicable and potential evaluation methods, and
        - With a collaboration to leverage synergies.
- Address the concept of quantification of performance targets with measurement methods for combustible and noncombustible materials and construction provisions, starting with careful initial planning that would benefit from a:
    - Review of international approaches to move from a combustible and noncombustible approach to materials and construction type is recommended as a next step to better inform discussions and future planning.
    - In-depth mapping the extent of the current code interrelationship of combustible and noncombustible materials and construction type provisions (that were estimated in this preliminary analysis as 21 percent directly and a larger portion indirectly are interrelated).
- Revisit the concept of building classifications (by building height, building area, etc.) to consider the development of a more consolidated and performance-based approach.

- Incorporation of the changes included in the NBC 2020 as part of future work to provide continued applicability of the analysis content and a current understanding of the most recent steps towards improving the level of performance for provisions and associated opportunities.

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Appendix A Design Parameters

A.1 Building or Facility Design Parameters

Design parameters that describe the intended use, activities and function of the spaces of a building or facility are defined by the project owner and design team. These design parameters may represent design limitations or constraints, or some flexibility for change may be possible to allow for changes that impact applicable options for compliance within the context of the NBC Division B Part 3 acceptable solutions.

In the context of the NBC, the design parameters are described in prescriptive qualitative (or a combination of qualitative and quantitative) ways. For the Division B, Part 3 context, these descriptions are primarily located in within:

- The code text of Division B, Part 3; and
- The definitions of NBC defined terms in Division A, Sentence 1.4.1.2.(1)

These descriptions provide consistent language and information transfer from project to project; and are applicable to all options for compliance. Since these design parameters appear as metrics throughout the document as thresholds for certain acceptable solution requirements or influencing applicable requirements directly or indirectly, descriptions of select design parameters have been included in the preliminary analysis summarized in this report.

The design team then uses the descriptions to provide the quantitative values for each of the design parameters based on the initial project description and constraints for the building or facility and the intended level of fire and safety hazard based on the intended use, activities and functionality of the spaces. These design parameter values then dictate the applicable acceptable solution requirements, or options for compliance, for a specific project.

A.1.1 Example list of design parameters

A list of example design parameters that describe the fundamental building design intent and therefore drive the applicable acceptable solution requirements are included in Table 2.

Table 2. List of typical design parameters for a building

Design Parameter
Building area
Building height (in storeys)
Grade (location)
First storey (location)
Limiting distance
Occupant load
Major occupancy and other occupancies
Subsidiary occupancies
Fire load (dependant on intended contents)
Dangerous goods (whether they are present)

Appendix B Categorization Parameters

B.1 List of Issue being Addressed and Mitigation Strategies

A list of example issues being addressed by a provision are included in Table 3.

Table 3. Examples of issues being addressed by a provision

Issue Being Addressed
Building or facility design parameters for identification of level of fire and life safety hazard
Risk of combustible materials significantly contributing to fire growth and spread
Risk of damage due to fire of the building
Risk of damage due to fire or structural insufficiency of the building or adjacent buildings Risk of damage to adjacent buildings
Risk of damage due to fire or structural insufficiency of the building or adjacent buildings
Risk of damage due to fire to the building due to fire start or impact beyond the point of origin
Risk of damage to adjacent buildings due to fire impacting areas beyond the building of origin
Risk of damage to the building due to fire impact beyond the point of origin
Risk of delay when moving to a safe place
Risk of failure or collapse from exposure to fire
Risk of injury due to fire of a person in or adjacent to the building
Risk of injury to persons in or adjacent to the building due to fire impacting areas beyond the point of origin
Risk of injury to persons in or adjacent to the building due to fire start or fire impacting areas beyond the point of origin
Risk of interpretation of application of code
Risk of interpretation of building or facility design parameters
Risk of interpretation of building or facility design parameters and requirement descriptions
Risk of interpretation of code language
Risk of interpretation of design parameters for fire and life safety strategies
Risk of interpretation of fire safety plan contents for a building or facility
Risk of interpretation of required information for proposed work
Risk of interpretation of scope
Risk of interpretation of type of material
Risk related to an unsprinkerled space
Risk related to building height

A list of example mitigation strategies employed by a provision to address issues are included in Table 4.

Table 4. Examples of mitigation strategies

Mitigation Strategies
Ability to readily locate and use the elevator keys in a fire situation
Ability to readily locate and use the key-operated switches for emergency recall of elevators
Access to exit
Account for radiation from hot unexposed wall surfaces by increasing unprotected openings
Accumulation of combustible materials
Aggregate width of exits
Aisle design
Arrangement of and signage for doors
Attachment [securing] and arrangement of fixed seats in places of assembly
Automatic fire extinguishing system
Barrier or railing; or window non-openable and designed to withstand the lateral design loads for balcony guards
Building design parameters descriptions of internal features
Building or facility design parameters descriptions on spatial separation
Buildings are limited in size;
By limiting the flame-spread rating of wall and ceiling finished
Capacity of a means of egress
Capacity of stairs in an access to exit
Casting penetrations in place
Characteristics of a non-metallic totally enclosed raceway
Clarification of defined terms
Clarification of material types permitted in combustible construction
Clarifying protection of electrical conductors
Clarifying scope and application of subsection
Clear height of stairways
Clear height over landings
Clearance to hazardous goods
Clearance to other structures
Closing mechanisms for exit doors that are normally required to be kept closed.
Combustible glazing not permitted in wall or ceiling assemblies and in closures used to construct an exit enclosure
Conform to the NFC
Conformance to referenced standards
Considering the total area of exposed building face
Construction of floor assemblies
Construction type
Containing fire in a basement
Continuity of Handrails
Continuous construction
Control of hazardous substances
Dwelling units have a direct means of evacuation to the exterior
Limiting building area
Limiting building height
Limiting use
Number of walls facing a street
Open area of perimeter walls

B.2 List of Metrics used in Analysis

A list of examples of metrics in provisions are included in Table 5.

Table 5. Examples of metrics

Examples of Metrics	Notes on Metric	Examples of Values
Major occupancy	This is a defined term and is applicable to the building [Note that this is one of the column headings to help sort the requirements at the next steps too]	Group A (or excluding a specific group)
Occupancy	This occupancy occurs in the building and need not be the or one of the major occupancies [Note that this is one of the column headings to help sort the requirements at the next steps too]	Group A
Subsidiary occupancy	"subsidiary" would be directly described [Note that this is one of the column headings to help sort the requirements at the next steps too]	Limits of the size of an occupancy that is permitted to be considered subsidiary
Other spaces not defined above	These are spaces that would be part of what is captured above (in a major occupancy, other occupancy, etc.), but that there are specific requirements for these spaces [note that this is one of the column headings to help sort the requirements at the next steps too]	There may be requirements that apply to such specific spaces as an attic, crawl space, concealed space, service space, service room, basement, mezzanine, dwelling unit, secondary suite, post-disaster building, etc.
Use or activity	Requirements specifically applicable to a use of a space or an intended activity; this is similar to other spaces noted above, but it highlighted here to help the understanding of what might be captured here [Note that this is one of the column headings to help sort the requirements at the next steps too]	Hot works, storage, dispensing,
Occupant load	The number of persons	… for more than 60 persons
Fire load	The mass and energy per unit area that may be permitted in an area or a threshold amount may trigger a requirement	
Building area	A defined term	For a building area not more than xxx m^2

Examples of Metrics	Notes on Metric	Examples of Values
Building height	A defined term [Note that this is one of the column headings to help sort the requirements at the next steps too]	Not more than XXX storeys; or maximum XXX m from floor of first storey to floor of upper most storey
Storey	A defined term	… not permitted above the xxx storey of the building
Location of first storey	A requirement might be dependent on whether the part of the building of interest is located on the first storey, or perhaps adjacent (above or below) the first storey, or related to where the first storey is located (e.g., Principal entrance, etc.)	… located above or below the first storey
Location of grade	Requirements or limitations may be relative to the location of grade	Not more than … below the floor of…
Dangerous good present	Whether dangerous goods are intended to be present in the building at all or limits of amounts may trigger requirements	Not more than xxx l stored material or stored in a certain type of container/tank/arrangement (could have limits on the type of storage, handling or use as well)
Flammable liquid	Whether flammable liquids are intended to be present in the building at all or limits of amounts may trigger requirements	Not more than xxx l stored material or stored in a certain type of container/tank/arrangement (could have limits on the type of storage, handling or use as well)
Combustible liquid	Whether combustible liquids are intended to be present in the building at all or limits of amounts may trigger requirements	Not more than xxx l stored material or stored in a certain type of container/tank/arrangement (could have limits on the type of storage, handling or use as well)
Type of construction	Defined terms of combustible construction and noncombustible construction	(Note this is part of the basic columns to help sort the requirements and preliminary analysis in the next steps)
Combustible/noncombustible material of a component	Noncombustible/combustible are defined terms and have reference to the test method CAN/ULC-S114	The classification of a material as combustible or noncombustible may be a requirement or may trigger a requirement; no combustibles are presented (the content is intended to be limited

Examples of Metrics	Notes on Metric	Examples of Values
		only to the equipment for the service space, etc.)
Type of material	If a material is specified or a list of materials	Sheet metal, gypsum wallboard, solid masonry, etc.
Thickness, melting temperature, etc.	A description of a specified material	Sheet metal with a minimum thickness of …. Mm;
Foamed plastics	This may be present or it may be prohibited	Foamed plastics is not permitted in ….; where foamed plastic in a wall or ceiling assembly is exposed to….
Flash point	Various test standard, applicable one is dependent on the liquid	A flash point below xxx, or a flash point between xxx and xxx
Fire-resistance rating	By standard test method CAN/ULC-S101 or by prescriptive method by Appendix D	Not less than XXX h fire-resistance rating
Fire-protection rating	Be standard test method depending on the type of closure	Not less than xxx h fire-protection rating; or not less than the fire-resistance rating required for the fire separation that the closure is located in
Flame-spread rating	Be standard test method CAN/ULC-S102	A flame-spread rating not more than XX
Smoke developed classification (or index)	Be standard test method CAN/ULC-S102	A smoke developed classification (or index) of not more than XXX
Leakage rate	For smoke/fire dampers tested to the standard method CAN/ULC-S112.1; for door leakage ANSI/UL-1784	Testing of a smoke or combination smoke/fire damper to the standard and achieving conformance with a specified class; or required testing of door leakage to a standard (note no performance target is currently identified for door leakage)

Examples of Metrics	Notes on Metric	Examples of Values
Provision of sprinklers	Requirements may require sprinkler protection to be provided; other requirements may be required if a sprinkler system is provided (required or not required but provided voluntarily); or if the area/space/building is not sprinklered, then…. [note that this is one of the column headings to help sort the requirements at the next steps too]	… sprinklered throughout building; … sprinklered throughout storey; … sprinklered fire compartment; … if the area/space/building is not sprinklered, then….
Ventilation system design	Related to smoke control or areas with grease laden vapours	A minimum of … air changes per hour…
Protected floor space	Described in NFC in relation to interconnected floor space	Protected floor space is required where…
Open-air storey	A defined term that has a requirement for minimum open area of the "walls" that is intended to provide natural cross-ventilation of the space;	For …. the storey must be designed to be an open-air storey; if the storey is designed to be an open-air storey...
Fire protection system	May include fire alarm system, smoke alarms, etc.	… is required;
Street	A defined term, can be related to spatial separation or fire department access	… if the building faces xxx streets
Unprotected area	Is related to spatial separation requirements	Not more than xx percent is permitted…
Openings in exterior wall	Related to spatial separation, exit protection, etc.;	Not more than an area of xx m^2 is permitted…
Cladding type	Is related to spatial separation requirements	Combustible permitted /noncombustible required
Exterior wall requirements	Related to spatial separation, exit protection, etc.; note that exterior walls have slightly different requirements to other fire separations	Minimum fire-resistance rating of … h;
Limiting distance	A defined term and related to spatial separation	… if the limiting distance is less than xx m; where the limiting distance is equal to or greater to xx m, then…;

Appendix C Summaries of Analysis Results

C.1 Summary of Subsection Categorization

A summary of the proportion of the NBC 2015 Part 3 fire and life safety provisions analyzed for this preliminary analysis and the proportions of each as either qualitative or quantitative, and prescriptive or performance are summarized in Table 6.

Table 6. Summary of the categorization of each subsection

				Percentage of the Provisions Analysed So Far							
Subsection	**How Incoporated into the Analysis**	**No. Provisions in Analysis**	**No. Provisions Analysed**	**Qualitative**	**A combination**	**Quantitative**	**N/A**	**Prescriptive**	**A combination**	**Performance**	**N/A**
Division A. Subsection 1.4.1.	Select definitions	35	100%	63%	17%	20%	0%	69%	14%	17%	0%
1.1.3.	Select sentences	2	100%	0%	0%	100%	0%	100%	0%	0%	0%
1.1.4.	Select sentences	1	100%	100%	0%	0%	0%	100%	0%	0%	0%
3.1.1.	All requirements	4	100%	50%	25%	0%	25%	75%	0%	0%	25%
3.1.2.	All requirements	7	100%	71%	29%	0%	0%	100%	0%	0%	0%
3.1.3.	All requirements	10	100%	70%	10%	20%	0%	70%	0%	30%	0%
3.1.4.	All requirements	36	100%	47%	42%	11%	0%	75%	17%	8%	0%
3.1.5.	All requirements	86	100%	23%	70%	7%	0%	37%	56%	7%	0%
3.1.6.	All requirements	14	100%	50%	50%	0%	0%	79%	21%	0%	0%
3.1.7.	All requirements	10	100%	80%	10%	10%	0%	70%	10%	20%	0%
3.1.8.	All requirements	81	100%	51%	0%	49%	0%	72%	0%	27%	0%
3.1.9.	All requirements	25	100%	72%	28%	0%	0%	44%	40%	16%	0%
3.1.10.	All requirements	16	100%	25%	31%	44%	0%	56%	19%	25%	0%
3.1.11.	All requirements	23	100%	30%	65%	4%	0%	70%	26%	4%	0%
3.1.12.	All requirements	5	100%	0%	80%	20%	0%	20%	60%	20%	0%
3.1.13.	All requirements	27	100%	15%	33%	52%	0%	56%	33%	11%	0%
3.1.14.	All requirements	9	100%	78%	0%	22%	0%	78%	0%	22%	0%
3.1.15.	All requirements	8	100%	63%	13%	25%	0%	50%	25%	25%	0%
3.1.16.	All requirements	1	100%	100%	0%	0%	0%	100%	0%	0%	0%
3.1.17.	All requirements	6	100%	50%	17%	33%	0%	83%	17%	0%	0%
3.2.1.	All requirements	20	100%	40%	55%	0%	5%	55%	40%	0%	5%
3.2.2.	All requirements	193	100%	30%	59%	9%	2%	58%	39%	1%	2%
3.2.3.	All requirements	85	100%	24%	39%	38%	0%	62%	32%	6%	0%
3.2.4.	All requirements	127	100%	82%	1%	15%	2%	87%	1%	9%	3%
3.2.5.	All requirements	66	100%	45%	33%	17%	3%	67%	8%	17%	5%
3.2.6.	All requirements	33	100%	58%	18%	24%	0%	61%	18%	21%	0%
3.2.7.	All requirements	38	100%	55%	21%	24%	0%	79%	16%	5%	0%
3.2.8.	All requirements	21	100%	43%	38%	14%	5%	52%	29%	14%	5%
3.2.9.	All requirements	1	100%	0%	100%	0%	0%	0%	100%	0%	0%

Table 6 (continued) Summary of the categorization of each subsection

				Percentage of the Provisions Analysed So Far							
Subsection	**How Incoporated into the Analysis**	**No. Provisions in Analysis**	**No. Provisions Analysed**	**Qualitative**	**A combination**	**Quantitative**	**N/A**	**Prescriptive**	**A combination**	**Performance**	**N/A**
3.3.1.	All requirements	118	100%	47%	0%	53%	0%	91%	3%	7%	0%
3.3.2.	All requirements	72	100%	75%	0%	25%	0%	96%	0%	4%	0%
3.3.3.	All requirements	35	100%	60%	0%	40%	0%	100%	0%	0%	0%
3.3.4.	All requirements	29	100%	48%	0%	52%	0%	100%	0%	0%	0%
3.3.5.	All requirements	29	100%	52%	10%	34%	3%	90%	0%	3%	3%
3.3.6.	All requirements	22	100%	64%	32%	5%	0%	55%	23%	18%	5%
3.4.1.	All requirements	20	100%	90%	0%	10%	0%	100%	0%	0%	0%
3.4.2.	All requirements	23	100%	43%	0%	57%	0%	100%	0%	0%	0%
3.4.3.	All requirements	22	100%	9%	0%	91%	0%	100%	0%	0%	0%
3.4.4.	All requirements	16	100%	44%	6%	50%	0%	75%	6%	19%	0%
3.4.5.	All requirements	11	100%	64%	0%	36%	0%	91%	9%	0%	0%
3.4.6.	All requirements	103	100%	44%	0%	56%	0%	96%	0%	4%	0%
3.4.7.	All requirements	19	100%	26%	0%	74%	0%	100%	0%	0%	0%
3.5.1.	All requirements	2	100%	100%	0%	0%	0%	100%	0%	0%	0%
3.5.2.	All requirements	5	100%	100%	0%	0%	0%	100%	0%	0%	0%
3.5.3.	All requirements	7	100%	0%	100%	0%	0%	0%	100%	0%	0%
3.5.4.	All requirements	3	100%	67%	0%	33%	0%	100%	0%	0%	0%
3.6.1.	All requirements	6	100%	83%	17%	0%	0%	83%	17%	0%	0%
3.6.2.	All requirements	27	100%	52%	48%	0%	0%	89%	7%	4%	0%
3.6.3.	All requirements	22	100%	14%	50%	36%	0%	50%	45%	5%	0%
3.6.4.	All requirements	8	100%	13%	38%	38%	13%	50%	38%	0%	13%
3.6.5.	All requirements	34	100%	35%	6%	59%	0%	79%	15%	6%	0%
3.7.1.	All requirements	2	100%	100%	0%	0%	0%	100%	0%	0%	0%
3.7.2.	All requirements	32	100%	19%	9%	69%	0%	91%	6%	0%	0%
3.7.3.	All requirements	1	100%	0%	0%	100%	0%	100%	0%	0%	0%
3.8.1.	Topic not included	-	-	-	-	-	-	-	-	-	-
3.8.2.	Topic not included	-	-	-	-	-	-	-	-	-	-
3.8.3.	Topic not included	-	-	-	-	-	-	-	-	-	-
3.9.1.	All requirements	5	100%	60%	20%	0%	20%	60%	0%	0%	40%
3.9.2.	All requirements	6	100%	67%	0%	33%	0%	83%	0%	0%	17%
3.9.3.	All requirements	8	100%	50%	25%	25%	0%	100%	0%	0%	0%