A New Tool to Design Above-Grade Walls for the National Building Code of Canada

Keith Calder
Jensen Hughes
Unit 135, 13900 Maycrest Way, Richmond, BC V6V 3E2
Phone: 604-295-4000 • E-mail: kcalder@jensenhughes.com

Keith Robinson, RSW
Dialog
Suite 100, 10237 – 104 St., Edmonton, AL T5J 1L3
Phone: 780-917-4690 • E-mail: krobinson@dialogdesign.ca

Brian Lieburn and Les Yard
Dow Building Solutions
Abstract

A new tool has been developed to help designers meet fire provisions in the National Building Code of Canada (NBC) when using foam plastic insulation to meet improved energy code requirements. This paper provides information for three different perspectives: 1) Provider—a manufacturer needing to educate designers about code requirements when using foam plastic insulation, 2) Fire scientist and NBC expert—a tool to allow simple building characteristics to be entered to deliver accurate code guidance, and 3) Building designer and specifier—explains the value of the tool for the design community.

Speakers

Keith Calder — Jensen Hughes, Richmond, BC

KEITH CALDER is a fire engineer and building code consultant with experience in the development of risk-informed solutions to demonstrate building code compliance. He has nearly 20 years of experience in building/fire code consulting, fire modeling, and fire investigation. Calder is a member of NFPA 80A, an alternate member of NFPA 5000/703, and a member of the Canadian Commission on Building and Fire Codes’ Standing Committee on Use and Egress.

Keith Robinson, RSW — Dialog, Edmonton, AL

KEITH ROBINSON has worked as a specifications writer since 1981 and is currently an associate at DIALOG in Edmonton, Alberta. Robinson specializes in building envelope components and heads development of DIALOG’s master specifications. In addition to working on projects across Canada and in Egypt, Japan, and Costa Rica, Robinson instructs courses for the University of Alberta and participates with several standards review committees for ASTM and NFPA.

Nonpresenting Coauthors

Brian Lieburn and Les Hall — Dow Building Solutions
A NEW TOOL TO DESIGN ABOVE-GRADE WALLS FOR THE NATIONAL BUILDING CODE OF CANADA

EXECUTIVE SUMMARY
A new tool has been developed to help designers meet fire provisions in the National Building Code of Canada (NBC) when using foam plastic insulation to meet improved energy code requirements. With over 200 exceptions for combustible and noncombustible construction, the requirements for the use of foam plastics in the NBC can easily be confusing.

This paper provides three perspectives involved with the development and implementation of this new tool:
1. The provider, a foam plastic insulation manufacturer, educating designers about code requirements when using foam plastic insulation.
2. A fire scientist and NBC expert, developing a tool to allow simple building characteristics to be entered and delivering accurate code guidance.
3. A building designer and specifier, explaining the value of the tool for the design community.

The tool has been available for use since April of 2017. Integrating the tool into building information modeling (BIM) will be the next step in the evolution of the tool.

INSULATION MANUFACTURER PERSPECTIVE

The entire building industry has been working hard to set aggressive targets with respect to energy codes, while at the same time ensuring that building codes maintain or improve the safety aspects of how we build. As a manufacturer of foam plastics, Dow Building Solutions has often been perceived as being somewhat stuck between the two important imperatives of energy and fire code compliance. Many industry stakeholders have been subtly encouraging the company to help bridge the gap. They have seen that Dow has helped to support the code and innovation agenda in the U.S. and have wanted us to weigh in in a similar fashion in Canada. The rub is that the Canadian building code is challenging. Although the model NBC is updated on a five-year cycle through an ongoing process, and there have been significant efforts and improvements over the past few cycles, the code itself remains complex. Regional differences in terms of how much of the NBC is adopted and modified by each province offer additional challenges to the designer, code consultants, code officials, and manufacturers alike. Adding complexity to this are differing professional opinions, interpretations of the code, local municipal silos, and varying degrees of involvement by authorities having jurisdiction (AHJ).

This challenge is no more evident than in the case of the above-grade wall (Figure 1). There is a commonly held industry belief that you cannot use foam plastics in above-grade walls of buildings required to be of noncombustible construction, with few exceptions. This creates additional confusion. Years of effort to better understand the code and the barriers and limitations actually revealed to us something different and unexpected. The use of foam plastics is actually code-acceptable in many NBC Part 3 combustible and noncombustible construction types with appropriate conditions based on building height, number of stories, streets facing, wall assembly

Figure 1 – John Paul II Building, Vancouver, BC. This project permitted foam plastic insulating sheathing on above-grade walls, but was required to be built of noncombustible construction.
components, cladding type, etc. The best quote we have heard is something to the effect of, “Canadian code is straightforward in this area. There is combustible and non-combustible construction with over 200 exceptions.” Needless to say, the complexity of the code, the legalese used to write it, and the difficulty in understanding the code’s intent do not help provide quick and ready answers.

We recognized that code officials, designers, and contractors needed a method to navigate all of these layers of complexity so they could understand and state with confidence what the code said. Dow partnered with Jensen Hughes, a global code consulting firm, to develop a code tool based on the 2015 NBC that provides clarity on what the code says and clearly provides the answer as to when and under what conditions foam plastics can be used in above-grade walls. The results are revealing, and initial response has indicated that this is a deep unmet need in the industry.

The tool has been demonstrated with selected national architects, engineers, and code development individuals to validate a Canadian response to its legitimacy and value. Based on industry feedback, it was clear that there was a demand; but for the tool to be used today, we needed more confidence what the code said. Dow partnered with Jensen Hughes, a global code consulting firm, to develop a code tool based on the 2015 NBC that provides clarity on what the code says and clearly provides the answer as to when and under what conditions foam plastics can be used in above-grade walls. The results are revealing, and initial response has indicated that this is a deep unmet need in the industry.

The NBC defines a material as noncombustible based on a standard test: CAN/ULC-S114, Fire Test for Determination of Non-combustibility in Building Materials; and any material that does not meet this test, or is not clearly noncombustible, is considered to be combustible. The test is of such severity that it may be assumed that any building material containing even a small proportion of combustibles will itself be classified as combustible.

Buildings permitted to be of combustible construction allow the use of combustible materials in exterior wall construction (with some additional limitations based on material properties), with the exception of buildings located in proximity of the site boundary (spatial separation requirements) and recently permitted combustible mid-rise buildings.

Buildings required to be of noncombustible construction permit limited use of combustible materials in exterior walls where it can be demonstrated by testing or limited use that the combustible materials and components will not significantly contribute to the growth and spread of fire. Testing can include small bench-scale combustibility tests up to full-scale three-level exterior wall tests (CAN/ULC-S134, Standard Test Method of Fire Test of Exterior Wall Assemblies). In most cases, the end result is the provision of protective noncombustible barriers to limit the participation of combustible materials when exposed to fire.

The code tool was developed to simplify the complexity of the NBC requirements relative to combustible components in exterior walls based on three key steps:

1. Determination of the governing major occupancy
2. Determination of the construction requirements for the building
3. Determination of the construction requirements for the exterior walls of the building

**Step 1: Determination of the Governing Major Occupancy**

The governing major occupancy is determined based on an assessment of all of the major occupancies intended for the building to determine the most restrictive major occupancy. The building construction requirements are then based on the governing major occupancy.

**Building Occupancy:** The building (governing major)

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**Figure 2 – 2015 NBC. Building area defined graphically in the code.**

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**NBCC EXPERT AND FIRE ENGINEER PERSPECTIVE**

As outlined earlier in this paper, the building code requirements in Canada relative to the use of foamed plastic insulation in exterior above-grade walls are complex. Maneuvering the complexity of these requirements can be daunting and confusing, often requiring a degree of judgement. In an increasingly litigious environment, the confusion results in design judgements that tend to err on the conservative, limiting design options that may otherwise be considered allowable. The purpose of developing the code tool was to reduce the degree of confusion and simplify the steps to determining compliance for the use of foamed plastic insulation in above-grade exterior walls.

The NBC limits building construction types primarily as a function of building size with respect to the ability of a responding fire service to control a fire. The larger and taller a building, the greater the hazard of a fire to be beyond the ability of the responding fire service to control it. The NBC addresses this hazard through the limitation of the use of combustible components. In this respect, the NBC defines two types of material categories relative to construction types: noncombustible and combustible.

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**Third story**

**Second story**

**First story**

**Building area = area of third story**

Grade
occupancy is determined as a function of the principal use of the building, and considers the potential fire and life safety risk associated with the use. Major occupancy classifications include: assembly (A); care, treatment, and detention (B); residential (C); office (D); mercantile (E); and industrial (F). Subclassifications are included in some cases.

**Step 2: Determination of the Construction Requirements for the Building**

The key factors required by the NBC in establishing building construction requirements and whether a building is required to be constructed of noncombustible construction, or is permitted to be of combustible construction, are identified as follows:

**Building Area:** The NBC defines the building area as “the greatest horizontal area of a building above grade within the outside surface of exterior walls or within the outside surface of exterior walls and the centre line of firewalls.” This is essentially the building footprint (see Figure 2). The greater the building area, the more likely the building is required to be constructed of noncombustible construction.

**Building Height:** The NBC defines building height based on grade and determination of first story. Grade is considered to be the lowest of the average levels of ground adjacent to the exterior walls, and the first story is established based on the story with a height greater than 2 m (6.5 ft.) above grade (see Figure 3). This can become quite complicated where a building is on a sloping lot. The building height is the number of stories, including the first story. The greater the building height, the more likely the building is required to be constructed of noncombustible construction. Most buildings greater than six stories in building height are required to be of noncombustible construction.

**Sprinkler:** The NBC considers a building to be sprinklered if it is equipped with a sprinkler system throughout the building—the key being “throughout.” A building with a partial sprinkler system is not considered to be sprinklered. The NBC recognizes the benefit of sprinklers in reducing the risk of fire growth and spread by allowing a greater use of combustible construction.

**Streets Facing:** The NBC considers a building to face one or more streets as a function of the proximity of a certain percentage of an exterior wall to a street. Similar to sprinklers, the NBC recognizes the benefit of proximity to streets in facilitating fire department response by allowing greater use of combustible construction.

**Step 3: Determination of the Construction Requirements for the Exterior Walls of the Building**

The combustibility of exterior wall construction is governed by the required type of construction of the building as outlined above, but also may be limited by the spatial separation requirements. The spatial separation requirements apply, regardless of the type of construction of the building. The spatial separation requirements consider the area of each exterior fire compartment face, ratio of height to width of the face where the building is not sprinklered, and proximity to the lot line. The exterior walls of buildings located in proximity to the lot line have limitations on amount and configuration of combustible material to limit the probability of fire spread from one building to another. The flame spread rating of a foamed plastic insulation is critical to whether it is permitted to be included in exterior above-grade wall construction. This relates to the insulation’s propensity to spread fire if ignited. In addition to the spatial separation requirements, the building height, occupancy, and whether a building is sprinklered, all determine whether foamed plastic insulation is permitted within the exterior walls of a building required to be constructed of noncombustible construction.

Once all of the key building and exterior wall characteristics have been entered, the code tool provides output on a wall basis detailing the protective features required (if any) to permit the use of foamed plastic insulation in the construction of the exterior wall. The protective features may include interior/exterior protective barriers or identify specific testing that can be conducted as an alternative. As noted earlier in this paper, the purpose of requiring protective barriers is to limit the participation of the foamed plastic insulation if exposed to fire, and the purpose of specific testing is to demonstrate that the foamed plastic insulation included in an exterior wall assembly will not significantly contribute to the growth and spread of fire.

The code tool has been developed with basic inputs representing the three steps outlined above and provides specific requirements for each step. Several figures
showing the three steps are included herein with sample input and output values (see Figures 5 and 6).

In addition to allowing a dynamic assessment of a building design where the input can be changed and assessed to establish the impact on the NBC requirements, the code tool also allows a user to save cases and select a postscript-based summary output for each case. The ultimate goal of the tool is to:

• Provide an interactive, dynamic, and comprehensive means to inform a manufacturer, builder, designer, or authority whether foam plastic insulation is permitted by the NBC to be included in exterior above-grade wall construction of a specific building/wall.

• Determine the protective feature or testing (if any) required to limit the risk of fire associated with the insulation.

BUILDING DESIGNER AND SPECIFIER PERSPECTIVE

We (within our companies, and generally throughout the design community) have been disallowing combustible wall components without fully comprehending the requirements of the building code, with code analyses frequently defaulting to ULC S134, where they may not actually be required (see Figure 7).

This is problematic for the designer, since it reduces availability of wall components as a whole—not just the wall insulation—and makes assessing requests for substitutions during the bid and construction periods more complex than it needs to be.

• Buildings are not about products—they are about allowing for the maximum number of materials that can be used by describing their performance attributes appropriate to the assembly and building usage.

• Disallowing products based on an inaccurate interpretation of the building code is unfair and potentially damaging to fair market pricing under current construction procurement practices.

• Limiting selection to named products that exclude potential substitutions that can match project performance requirements creates a shopping list and potential design liability for the registered professional of record.

So, the question is: Why are design professionals defaulting to a more restrictive assembly type than what is necessary to meet project performance requirements?

Simply put, the limitations on distance and material selection in the building codes are difficult to understand. They are not written in a way that allows for intuitive comprehension. They are written by experts who fully understand the aspects of what they are writing about, but don’t allow for guidance for people who are not conversant in the language used to describe the decision-making inherent in references contained in the building codes.

The irony is that the design professional of record is responsible to the building code officials for interpretation of the building code and signing off at the completion of the project, indicating that the structure is constructed substantially in conformance with the building code.

Ease of application of design theory for making insulation components and other related exterior assemblies universally non-
combustible makes providing the final affidavit to the project easier to prepare and reduces the liability exposure of the registered professional. But just because something is easy does not make it correct.

The Canadian Code Assessment Engine provides the equivalent of a roadmap for the registered professional, allowing a visible matrix based on hard data inputs to confirm acceptable fire performance for limiting distance and material selection. While it doesn't tell the registered professional what to do, it provides output that enables the designer to make appropriate choices based on occupancy type, number of stories, and the height of the building using assembly choices based on combustible, combustible/noncombustible, or noncombustible selections, with or without sprinklers.

This is an extremely effective tool for registered professionals. It allows them to maintain design control and influence, limit areas of the building to noncombustible construction when required, and provides for a wider selection of acceptable performance-based material solutions for other parts of the building where limiting distance permits a wider range of combustible building components.

The tool is also extremely effective at red-flagging non-compliant construction choices. Take, for instance, the types of fires that have occurred in London and Dubai over the last few months. If the reference building code defined the combustibility requirements similarly as Canadian and American building codes currently do, the tool would have tagged the insulation and cladding choices as non-compliant, given the constructed (noncombustible, unsprinklered, and greater than 18 m in height) configuration of the buildings in question.

Building code interpretations are being performed more regularly by younger, less-experienced members of the project team. The baby boomers who grew up with building code language are retiring, and the newer generation does not have the experiential exposure to interpretation that the previous generations grew up with. Communications are fundamentally different, and most reading comprehension on the Flesch-Kincaid reading ease schedule resides between 60 and 80 (plain English, easy to read, with a conversational level of complexity). The building code is written with a reading ease level of between 30 and 50 (difficult to read, usually requiring a university-level understanding of English).

The Canadian Code Assessment Engine realigns the user experience and allows individuals having a higher Flesch-Kincaid rank to better interpret the Building Code and complete the required code analyses from a more informed platform.

**FUTURE WORK**

**BIM Integration:** Specifications and drawings affected by combustible/noncombustible material selections will include links inserted into master guide specifications, allowing for greater design technology integration between the model and the output documents prepared for projects. Integration of the Canadian Code Assessment Engine into the model will permit better efficiencies when submitting digital documentation to building code officials, with results being tied directly to modelled assemblies and elements, and reducing the time required for the building code official to confirm compliance with building code requirements.

**CONCLUSIONS**

The code assessment tool benefits building designers by allowing quick reviews of various assemblies for conformance to the fire provisions in the NBC. This allows designers to deliver more choices to the customer. The tool provides better certainty for foam plastic insulation suppliers knowing where and how their products can be used. The tool assists plan examiners and building officials by providing the building project information and the appropriate code references to verify code conformance.

**REFERENCES**

2010, 2015 National Building Code of Canada
2014 Alberta Building Code
2012 British Columbia Building Code
2012 Ontario Building Code
2013 Quebec Buildings Chapter Safety Code
2014 Vancouver Building By-law