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Housing Research Summary for 2015

National Research Council Canada
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Canada

A report prepared for the Canadian Home Builders' Association

May 2016

A French version of this report is **available upon request**.

Une version française de ce rapport est **disponible sur demande**.

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Message from the General Manager of NRC Construction

Richard Tremblay, GM

I am truly honoured to present the 2015 edition of the Housing Report. It describes important technical and research projects, undertaken by NRC in collaboration with clients and stakeholders, towards an improved and more innovative Canadian residential construction industry.

NRC is celebrating its centennial in 2016, and while preparing for our celebrations, we are reflecting on some of our past achievements as the leading engine of innovation in Canada. We are reminded just how important our contributions have been. This is also an exciting time to look ahead, as we invest in industry-driven research and development (R&D) and technical projects that will deliver tangible economic and societal results.

This report provides you with an overview of our current projects – some which have just begun, and others which are reaching completion – as well as some of our most exciting new initiatives and projects.

Our experts have placed considerable emphasis on improving indoor air quality for healthier Canadian homes. With industry, we developed test protocols to help companies evaluate the performance of new technologies and solutions, including indoor passive panels, in-duct air cleaners and portable air cleaners. Building on our notable work in reducing radon levels in homes – including several projects in our unique full-scale testing facilities – we are now working to further improve radon awareness and management. We are pursuing research focused on lowering chemical emissions from building materials and increasing their resistance to mould.

While NRC's R&D activities have helped advance the Canadian construction industry, they have also provided important support to communities. We are proud to be working on an Arctic program through which we are developing technology opportunities with our partners to help northern communities in rising to the challenges of creating sustainable, low-impact development and tangibly improving their quality of life.

To support safe operations for Canadian firefighters, we teamed up with Ottawa Fire Services to develop fire dynamic training tools that merge the science of fire dynamics and current firefighting strategies and tactics. Further, we are reviewing building and fire codes while collaborating with the City of Ottawa and its municipalities, fire departments, developers and insurance companies to evaluate firefighting water needs with the goal of rightsizing water mains.

We also worked with Public Works and Government Services Canada to address the limitations and shortcomings of existing approaches to bridge inspection and management. This collaboration optimized bridge inspection procedures by implementing state-of-the-art bridge management methods aided by structural health-monitoring technologies.

NRC maintains its focus on de-risking innovative technologies and bringing them to market. In 2015, we issued 21 new evaluation numbers through the Canadian Construction Materials Centre, creating market confidence in new Canadian construction products. NRC has also assumed ownership of the Canadian National Master Construction Specification. We will be using our expertise in construction technology to expand its scope, quality and use to encompass a wider range of products and specification projects.

> “We invest in industry-driven research and development (R&D) and technical projects that will deliver tangible economic and societal results.”

We closed 2015 with exciting news. Collaborating with National Resources Canada, we published the National Energy Code for Buildings (NECB). In addition, we launched the new Codes Canada 2015, formerly known as the National Model Construction Codes. These codes – including the National Building, Fire and Plumbing Codes as well as the NECB – respond to the changing needs of Canadians and introduce innovative technologies, materials and research. Some of these changes are updated design requirements to improve accessibility of stairs and washrooms; new requirements for flow rates in showers to reduce water usage in buildings; and additional protection measures, such as higher standards for automatic sprinkler systems to allow for the construction of six-storey wood buildings.

This past year has also seen NRC publish and distribute the Alberta and Quebec Construction Codes, supported by technical seminars delivered by our Codes Canada experts. As well, thanks to our close partnerships with provincial governments, our experts are poised to offer seminars on the national codes to encourage harmonized building and safety regulations across Canada.

I wish to thank you, our partners and collaborators, for fostering innovation with us as we look forward to many more years of groundbreaking research and cutting-edge technologies that will benefit all Canadians.

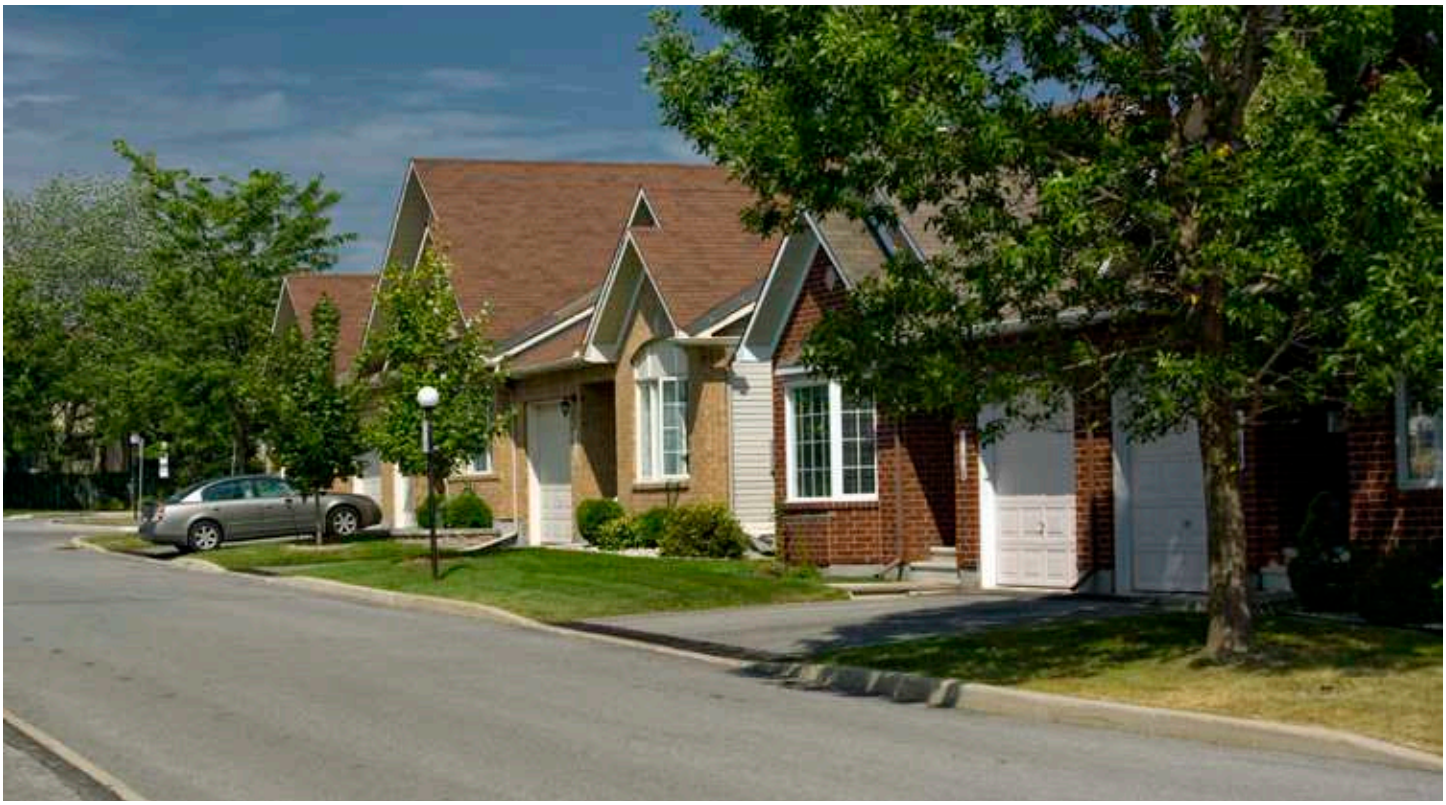
Richard Tremblay,
General Manager

Research

2016 marks the 100th anniversary of the National Research Council of Canada (NRC). Early research at NRC focused on military and agricultural security as well as developing Canada's natural resources. The post-war baby boom and government social and economic policies gave rise to unprecedented prosperity in Canada. NRC returned to civilian research and focused on construction, manufacturing and health technologies that improved the livelihood of all, including returning veterans.

Housing-related research has been carried out at NRC since 1947. This research lead to the development of the national building codes and to many major advances in building practices.

The purpose of this housing report is to inform builders of ongoing research, to provide status reports on completed projects, and to report on code development activities, especially the reviews that take place in the consideration of proposed code changes.



Pollutants in Homes

In conjunction with business partners, NRC Construction is currently conducting several projects aimed at enhancing the comfort and health of occupants by addressing the issues of indoor pollutants.

Reducing radon levels in homes

Since 2011, NRC and Health Canada have been working to develop safe and cost-effective solutions to minimize the health risks from radon gas exposure in Canadian homes and to provide guidance for radon prevention and mitigation. The results will be used to support proposed changes to the National Building Code (NBC) and to provide input for updating guidance documents to be adopted as standards, such as the Canadian General Standards Board's national standards for radon mitigation in residential buildings.

In response to requests from Canadian builders and homeowners, NRC completed several projects in its full-scale facilities to answer the following key questions:

- Can full-size passive radon stacks control radon in the habitable space, maintain negative pressure in sub-slab areas, and create sufficient chimney effect in the stacks?
- Can full-size passive radon stacks with roof turbine vents create sufficient stack effect to allow them to be used as radon mitigation systems? This aspect is especially important for the industry since the passive radon stack has been proposed to the NBC Standing Committee on Housing and Small Buildings as a code change request.
- What is the minimum insulation level required for radon stacks in unheated attic spaces to avoid freezing problems and reduction in stack effect?
- Can downdraft radon control fans be used for active soil depressurization in Canadian winters?
- Can bitumenized felt be used as membrane to prevent radon ingress?
- To what degree can improved membranes and concrete products reduce radon ingress, hence indoor concentrations?

The results will serve as the technical basis for CGSB national standards for radon mitigation and control in residential buildings and for the standing committee of NBC to address building code change requests.

NRC is planning to launch a special interest group to advance the knowledge on radon management, improve radon awareness, and produce innovative technologies and products for radon control.

Information

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Micro-chamber used for screening VOC emissions from solid building materials

Towards lowering chemical emissions from building materials and consumer products

Building materials and consumer products are major sources of formaldehyde and volatile organic compound (VOCs) emissions in buildings. These emissions can have negative effects on the comfort, health and productivity of occupants.

While great strides have been made in the effort to improve air quality in buildings, NRC Construction's research in this field continues to be important, helping the construction industry to evaluate, characterize and mitigate chemical emissions.

In 2015, NRC supported a CSA technical committee developing the first health-based emissions standard for Canada. Members of this committee include representatives from: Health Canada, CHBA, FPInnovations, Composite Panel Association (CPA), Engineered Wood Association (APA), Canadian Wood Council (CWC), Canadian Lung Association and numerous wood product manufacturers. The final outcome, CSA O160 Standard, "Formaldehyde Emissions Standard for Composite Wood Panels," has undergone public review in January 2016 and is scheduled for release in May 2016. This voluntary standard will serve as the basis for Canadian manufacturers to get their low-emissions products certified.

NRC supported the standard development process by providing critical material emissions data from 21 composite wood products tested in its laboratories over the last three years. In another vital contribution, NRC developed a model to establish formaldehyde emission standard levels, which are to be used for the certification of three composite wood products: particleboard, hardwood plywood and medium-density fibreboard. The model can also be adapted to other building materials and consumer products as well as to VOCs, other than formaldehyde, for the development of VOC emissions standards that are technically achievable by manufacturers while stringent enough to protect occupants.

NRC also developed a fast-screening method for VOC emissions from consumer products such as paint, paint remover, and sealant. This small-scale method analyzes VOCs collected from a small volume of the consumer product in a 20 mL vial. The VOCs in question are taken from the air above the sample (head space), and automatically analyzed by a GC/MS system. The results obtained from 19 typical liquid-based products showed that the method can provide nearly equivalent information to that obtained by the conventional emission test method, using the 2,000 times larger 50 L chambers. The results are comparable both in terms of the found VOC spectrum and relative concentrations, that is giving the same "finger print".

This new "rapid" screening method can help reduce cost and time when choosing building materials when applied for identifying VOC emissions at early stages of the product development, or even at early stages of selection and design for safer indoor environments.

Emissions test data for about 80 building and consumer products have now been added to IA-QUEST (Indoor Air QUality Emission Simulation Tool). The database reports new emission data for more than 100 target VOCs from materials such as flooring, interior panels, structural components, insulation and ceiling tiles as well as paints, stains, caulks and adhesives.

In addition to expanding the database, researchers added more functions to the IA-QUEST software. It now includes features for assessing the transport of contaminants between zones or rooms in a building (e.g., from attached garages into living spaces), for evaluating the impact of air cleaning devices, and for conducting product-to-product comparisons based on updated health guidelines and standards for indoor air. This updated version of IA-QUEST, to be released in spring 2016, will make it possible to design for a desired level of indoor air quality through source control of emissions, in combination with ventilation and air cleaning strategies.

Information

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A close-up of mould found on walls

Resistance of building materials to mould

The Ventilation and Indoor Air Quality (V&IAQ) group continues to work with other NRC researchers, Canadian industry partners and the Canadian Construction Materials Centre (CCMC) to develop improved test methods for evaluating the resistance of building materials to mould.

A recent outcome of this work was the completion of a new CCMC Technical Guide *(CCMC Technical Guide for Surface Applied Treatments to Enhance the Mould and Decay Resistance of Wood Products. MasterFormat: 06 05 73.35)* for testing of lumber and wood panels.

NRC welcomes additional industry participation in the development of these test methods, which are intended to assess mould protection performance under temperature and humidity conditions representative of indoor and building envelope conditions.

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Evaluation of Indoor Air Quality Solutions and Technologies (IAQS&T)

In support of efforts to enhance indoor air quality (IAQ) in an energy-efficient manner, NRC is developing test protocols to help companies evaluate the performance of technologies and solutions they devise for the purpose of improving IAQ. Based on the need and technical advice, researchers have developed capacity and methods to assess three key technologies: indoor passive panels, in-duct air cleaners and portable air cleaners (details in the **2014 NRC Housing Report**).

A protocol has been developed to assess the performance of indoor passive panels in regards to three criteria:

1) the ability to remove formaldehyde and toluene from indoor air;

2) the release amount (percentage) of captured pollutants; and

3) the release amount of chemical byproducts such as ozone.

Two commercial samples have been used to validate the usefulness of the protocol.

Through the use of this protocol and the newly established testing capabilities for passive panels, NRC can now offer testing Indoor Passive Panel Technologies (IPPT) in newly created and commissioned chambers for manufacturers desiring to validate their product performance against consensus-based criteria, thus ensuring fast market access. Recently, this protocol and the IPPT chamber were used in a fee-for-service contract with CertainTeed St-Gobain, an IPPT company contracting NRC for testing the performance of their product.

Among the criteria for evaluating the performance of in-duct air cleaners is whether they generate harmful emissions like ozone. In response to the Canadian Standards Association's (CSA) need for testing residential duct-mounted electronic air cleaner products in Canada, CSA has asked NRC to establish the corresponding test capacities, which must comply with stringent quality assurance requirements and ISO 17025. Under the guidance of a multi-stakeholder technical advisory committee, a consensus-based method was developed to evaluate ozone emissions from in-duct electronic air cleaners and ultra-violet germicidal irradiation devices; this was successfully tested for practicability at NRC.

NRC is now in a position to provide services for laboratory testing of air cleaners. This unique ability will allow NRC to respond to clients' requests not only to test their air purification products but also to help them remove some of the risks associated with developing these products and to gain market access.

This project addressing air quality technologies and solutions is a part of the Government of Canada's Clean Air Regulatory Agenda. The multi-year study is conducted under the guidance of a technical advisory committee composed of representatives from Canadian industry associations, federal and provincial agencies, non-government organizations, municipal governments, and standards development organizations.

Information

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Comparing exhaust-only ventilation and energy recovery ventilation

NRC researchers continue to employ the twin test houses at the Canadian Centre for Housing Technology to study and compare various types of ventilation systems and approaches. A project under the Clean Air Regulatory Agenda (CARA) was undertaken in fall 2015 to compare the whole-building indoor air quality achieved with continuous exhaust-only ventilation versus that obtained with balanced energy recovery ventilation (ERV).

Two side-by-side comparison tests were conducted as follows:

1) the exhaust-only system was operated in one house and ERV in the second house, without mixing (furnace fan was turned off);

2) the exhaust-only system was operated in one house and the ERV in the other, with mixing (furnace fan was on cycle).

Prior to conducting the two tests, researchers benchmarked the two houses by measuring the air quality in both in the absence of ventilation. The goal of the tests was to demonstrate and quantify the potential IAQ-related benefits of the two systems. The testing and data analysis have been completed and the report is expected to be available in the spring of 2016.

Information

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Building Envelope

Effect of enhanced insulation on the hygrothermal performance of walls in houses

Completion of project Phases 1 & 2

NRC Construction, in partnership with Canada Mortgage and Housing Corporation, Natural Resources Canada and industry partners, has completed work on a two-year project established in 2013 to investigate the risk of condensation in wall assemblies containing high levels of thermal resistance (R-value).

Given the increasing desire to provide housing that meets or exceeds Energy Star requirements, and in view of builders' concerns regarding possible moisture entrapment in "super-insulted" homes, the intent of this work was to measure the thermal and hygrothermal performance of highly insulated wall assemblies when exposed to Canadian climate extremes and compare it to the performance of a code-compliant reference wall. Six different assemblies were monitored over the two-year period. Taking results obtained from the experiments, researchers benchmarked their computer model which they then used in simulations to investigate the risk of condensation and mould growth in the respective wall assemblies for a select set of locations in Canada, as follows:

- **Vancouver, BC** – mild, wet climate; Heating Degree Days (HDD)18 = from 2600 to 3100; Moisture Index (MI) = 1.44
- **St John's, NL** – cold, wet climate; HDD18 = 4800; MI = 1.41
- **Ottawa, ON** – cold, dry; HDD18 = 4440 – 4500; MI = 0.84
- **Edmonton, AB** – cold, dry, HDD18 = 5120, MI = 0.48
- **Yellowknife, NT** – cold, dry, HDD18 = 8170, MI = 0.58

Full details of results derived from the project are to be published in June 2016. The information developed in this project will assist building practitioners in the design and selection of insulation components for highly insulated wall assemblies as might be used across Canada.

New project – Phase 3

In January 2016, NRC Construction initiated a new project to continue its study of highly insulated walls, this time with the Canadian Wood Council as project sponsor. Three highly insulated wall assemblies are being monitored for several months.

The common elements of the three wall assemblies consist of vinyl siding installed on 19 mm vertical wood strapping and an interior finish consisting of 12.5 mm painted gypsum board. The distinguishing features of the three walls (W1, W2, W3) are as follows:

W1: The most conventional assembly, includes 38 mm x 140 mm (2 x 6 inch) wood-frame wall (R24 glass fibre batt insulation) with 25 mm XPS rigid insulation panel placed on 11 mm OSB wood sheathing, with a 6-mil polyethylene vapour barrier.

W2: Similar to W1, the difference being that the polyethylene vapour barrier is replaced with an interior grade 11 mm OSB wood sheathing panel.

W3: Employs a 2 x 10 inch wood-frame wall containing wood fibre insulation, to the interior of which is installed 11 mm OSB wood sheathing (joints taped) and thereafter, a 2 x 4 inch wood stud wall, also filled with wood fibre insulation. The exterior sheathing panel (25 mm) is a wood fibre-based "diffusion" board product.

W1, W2 and W3 before the finish drywall

W1 represents a link to work undertaken in Phase 1; it has a nominal thermal resistance of R24 (glass fibre batt) plus R5 (XPS). W2 has a nominal resistance of R43 and is representative of walls for "Passivhaus" design. Lastly, W3 permits demonstrating the effectiveness of OSB wood sheathing as a vapour barrier. As part of this wall assembly, considerable use has been made of wood-based insulation products, such as the diffusion board and wood fibre insulation.

Results from this project are to be made available in December 2016.

Information

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Research

Mid-rise wood buildings

Research results are now available on the use of wood-based structural products in mid-rise (up to six storeys) buildings. This project was completed in collaboration with the Canadian Wood Council and FPInnovations, and partnering with Natural Resources Canada and the governments of Ontario, Quebec and British Columbia.

Three summary reports consolidate the research results related to fire safety, acoustics and building envelope performance.

Fire safety summary: Fire research conducted for the project on mid-rise wood construction **http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?action=rtdoc&an=21274556&article=14&fd=pdf**

Acoustics summary: Sound insulation in mid-rise wood building **http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?action=rtdoc&an=21274554&article=0&fd=pdf**

Building envelope summary: Hygrothermal assessment of systems for mid-rise wood buildings **http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?action=rtdoc&an=21274555&article=0&fd=pdf**

Information

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Evaluation of proprietary drainage components and sheathing membranes

This recently completed project assessed the ability of walls with drainage components and sheathing membranes (drainage system) to provide sufficient drainage and drying when subjected to Canadian climates having significant moisture loads (moisture index (MI) > 1.0 and heating degree days ≥ 3400; or, MI > 0.9, heating degree days < 3400) as might be found in the coastal areas of B.C. or Atlantic Canada.

In these regions, the 2010 National Building Code of Canada (NBC; § 9.27 Cladding) requires a capillary break behind all Part 9 claddings. **Currently, acceptable solutions to the NBC requirement for a capillary break include:**

(a) A drained and vented air space not less than 10 mm deep behind the cladding

(b) An open drainage material behind the cladding, not less than 10 mm thick and with a cross-sectional area that is not less than 80% open

(c) A cladding loosely fastened, with an open cross section (such as vinyl, aluminum siding)

(d) A masonry cavity wall or masonry veneer constructed according to § 9.20 (25 mm vented air space)

In this project, the performance of proposed alternative solutions for the capillary break were compared through laboratory evaluation and modeling activities using NRC's hygIRC-C model. The proposed drainage system would be deemed an alternative solution for use with current code compliant Part 9 claddings provided it exhibited better or equal moisture performance as compared to an NBC-compliant reference wall assembly.

Results for the reference wall assembly and other selected alternative solutions will be made available in June 2016.

Information

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Fire-related research

Improved wall systems for fire performance of houses

NRC is continuing the second phase of its research on the fire performance of single-family houses constructed with innovative materials, products and systems. The work is part of a long-term study to assist code authorities and builders to understand how these innovative technologies behave in a fire and how they affect the safety of occupants. **There is a need to establish a benchmark for the expected fire performance (which is typically represented by conventional construction). This will help to provide guidance on the level of performance below which a home becomes an unsafe assembly; hence new products would be required to perform above this threshold.**

During this new phase, researchers are planning to study conventional and innovative load-bearing foundation and above-grade wall systems that support the floor systems in single-family houses. The fire performance of these wall systems must not be less than that of the supported floor systems.

In residential construction, various types of new wall assemblies, some of which contain combustible insulation materials with unknown fire performance, are being introduced. Two examples are insulated concrete forms (ICF) and structural insulated panels (SIP). The fire performance of these assemblies and that of existing preserved wood foundations (PWF) and conventional above-grade wall systems and their impacts on occupant safety, are yet to be determined.

Modified fire-testing facility

The research will consist mainly of full-scale fire tests involving a wide variety of constructions in a two-storey house test facility.

The results, along with those from the previous work on floor systems, will be used to establish parameters for determining acceptable levels of fire performance for houses and to reduce the risk of using innovative technologies.

Information

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A better quality of life:

Enhancing housing and development in the North

NRC's Arctic Program is a broad initiative seeking to develop technologies to help northern communities achieve sustainable, low-impact development, while improving the quality of life for their people. The research addresses four inter-related issues of major economic and social importance: resource development, northern transportation, marine safety, and community infrastructure.

With regard to community infrastructure, the projects have the following goals:

- supporting more reliable water systems and wastewater treatment systems
- mitigating the effects of permafrost degradation on building foundations
- improving the energy efficiency of housing
- developing tools for cleaning contaminated sites

Researchers will monitor the winter performance of a demonstration house in Nunavut

LED lighting study in Iqaluit

NRC is examining the impacts of replacing existing light sources with energy efficient light emitting diode (LED) luminaries, which may substantially decrease energy use. This technology will be assessed in an office building in Iqaluit so that the energy efficiency benefits are fully realized in extreme northern climates, particularly given potential power quality issues associated with diesel generation.

An important objective of this research project is to ensure that this technology delivers benefits for the occupants, including health. This is in addition to the potential savings in energy use, and therefore energy cost. NRC is realizing this research with the help of Qulliq Energy Corporation, who are donating their office building for the study, and Cree Canada, who will be providing the lighting design and equipment.

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Monitoring the Qikiqtaaluk demonstration house in Iqaluit

In the second project addressing energy efficiency, researchers will monitor the winter performance of a demonstration house built by Qikiqtaaluk Corporation in partnership with a Canadian manufacturer of panelized house components (NACSI of Nova Scotia). Qikiqtaaluk requested the study as part of its effort to "try out" building technologies that could provide low-cost alternatives to existing housing, with a view to addressing the housing shortage and related affordability issues in Nunavut.

NRC researchers will assess the energy use of the demonstration house through the winter in Iqaluit. As well, they will assess the thermal characteristics of test sections of the panelized wall using an NRC environmental chamber in Ottawa. The field monitoring will run for a year, beginning the winter of 2016.

The results will be used by Qikiqtaaluk to evaluate the potential of the technology for providing an energy-efficient, low-cost housing solution for the Canadian Arctic in general, and for Nunavut in particular.

Information

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Canadian Centre for Housing Technology Activities 2015

The Canadian Centre for Housing Technology (CCHT) is a partnership between the NRC, Natural Resources Canada (NRCan), and Canada Mortgage and Housing Corporation (CMHC). The CCHT features twin research houses to evaluate the whole-house performance of innovative technologies and control strategies in side-by-side assessment. A third building, the InfoCentre, includes a display area and an office space. It also contains the FlexHousing™ demonstration unit – a town-house designed to enable studies of how space can be adapted to an occupant's changing needs and providing additional facility space for studies on building-integrated photovoltaics and energy management systems, for example.

Since 1999, researchers have assessed over 65 housing-related technologies at the CCHT. Many of the projects, especially in the twin houses, are undertaken as part of research projects with stakeholders while others are independent, one-off studies for particular clients.

Projects undertaken during 2015

Smart power system with advanced energy storage

This project, which began in 2011, was undertaken to explore how energy power systems – including power generation, storage, and energy management – can be integrated to minimize energy consumption and peak power requirements. The study is being carried out in the FlexHousing™ demonstration unit at CCHT.

The energy management system was first used to simulate lighting and appliance usage scenarios typical of an occupancy, in order to develop base-case electrical load profiles. The system was then programmed to explore how those electrical loads could be shifted off-peak and reduced to optimize electrical power requirements.

Recently, working closely with NRCan CANMET laboratories, NRC researchers modified the energy management system by integrating a lithium-ion battery with a grid-tied power inverter and solar energy system. This will enable them to actively test and evaluate various energy management strategies for residential and building applications. Project partners include NRC, NRCan, Defence Research and Development Canada, and Electrovaya Inc.

Evaluation of peak-load shift strategies in electrically heated homes through smart thermostats

During winter 2014-15, NRC researchers evaluated the potential for shifting peak load in electrically heated homes using intelligent load management strategies at the CCHT twin houses. The side-by-side comparison of the load-shifting scenarios validated the potential for a 5 kW peak shift through preheating homes on cold winter days, with minimal overall energy penalty. *(See the Smart Home Technology section for more details.)*

Air balancing and zoning study

An air balancing and zoning study led by NRCan has been underway since 2014. The initial work involved an assessment of airflow rates in each duct of the forced air distribution system in the twin houses. This was followed by the installation and balancing of a zone damper and installation of an airflow measuring station in each duct in the Test House. This enabled experiments to be conducted on more effective zone distribution strategies for forced air systems.

As part of this work, the heating and cooling season performance of a variable-speed, variable capacity, cold-climate air source heat pump is being compared against the conventional furnace system and air conditioner system operating at the CCHT, with various zone distribution strategies. Comfort, response, and energy consumption impacts are being investigated. Also being examined is the potential for the systems and zoning strategies to reduce and/or shift peak loads. The final phases of the project include modelling and laboratory testing. Reporting on the study findings will be completed in 2017.

Evaluating radon mitigation strategies

CCHT facilities are being used to develop technical documentation for Health Canada on the performance of radon remediation strategies. Four full-size passive radon stacks with alternative configurations were installed in the twin houses.

NRC researchers are investigating the following issues associated with the passive stacks:

- Can full-size passive radon stacks with roof turbine vents create sufficient stack effect to allow them to be used as radon mitigation systems?
- What is the minimum insulation level required for radon stacks in unheated attic spaces to avoid freezing problems and a reduction in stack effect?

Winter testing is expected to be completed in April 2016. Funding for this project is provided by Health Canada. (For more details, see **Reducing radon levels in homes**, page 5.)

Balanced (ERV) ventilation effectiveness and IAQ impacts

There is a lack of research to support the allowance of credits for residential mechanical ventilation systems with improved air distribution and increased IAQ performance, such as balanced ventilation systems compared to exhaust-only ventilation systems.

Building codes and standards do not address delivery of outdoor air to each space or forced air circulation/distribution of ventilation air. Instead, an assumption is made that for all ventilation system situations, the entire house is a single, well-mixed zone and the focus is only on relative annual average exposure of contaminants. With this assumption as the basis for ventilation design, the ventilation rate must be high enough to accommodate the worst performing system, which is exhaust-only ventilation.

In order to demonstrate and quantify the indoor air quality-related benefits of balanced ventilation systems, NRC researchers compared a balanced ventilation system, provided by an energy recovery ventilator (or ERV), to an exhaust-only approach in a side-by-side configuration using the twin houses.

The data will provide further support for the concept of a ventilation rate credit for better performing ventilation systems. Funding for this project is provided by Health Canada. (For more details, see **Comparing exhaust-only ventilation and energy recovery ventilation**, page 8.)

For more information on CCHT, consult the Web site at: **www.ccht-cctr.gc.ca**.

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Smart Home Technologies

A smart home is a home that employs digital technologies to provide an enhanced level of convenience, comfort, energy efficiency and security. The use of these technologies (mobile devices, internet connectivity and sensors) continues to rise as they become more commonplace, easy to use and affordable.

A smart home encompasses control of more than just energy use, though. It also includes such things as lighting, heating and cooling, and appliances. NRC is working with utility companies and technology providers to develop and evaluate energy management solutions to reduce peak electricity demand and to increase energy efficiency.

NRC takes a holistic approach in this work, starting with a functional evaluation, followed by an assessment of performance in the controlled conditions of the CCHT test houses. The next step is a pilot project in actual homes, which often also includes subjective response to the technology and the environmental conditions in the home.

Evaluation of peak load shift strategies in electrically heated homes through smart thermostats

In provinces and regions where electricity is the predominant source of heating, the electrical grid experiences peak consumption during cold winter mornings and evenings. For example, the majority of dwellings in Quebec, New Brunswick, Newfoundland and Labrador rely on electricity for heating. For an average household in New Brunswick, 61% of electricity use is for space heating, and electric baseboards are by far the most common form of heat delivery.

Power utilities are keenly interested in peak load shift technologies and strategies that will not only help them avoid strains on the system but also reduce the need for adding new generation capacity. NRC is working with Siemens Canada and NB Power to develop and evaluate thermal storage strategies in electrically heated homes to reduce peak demand on very cold winter mornings.

The strategies involve altering temperature setpoints of smart thermostats on electric baseboard heaters to pre-heat homes at times when the electrical grid still has the capacity to spare, thereby enabling reduced heating demand during subsequent hours of higher demand elsewhere.

NRC successfully demonstrated a proof-of-concept with a test over several days during the winter of 2014. In the winter of 2015, Researchers then conducted a longer test involving more complex load-shifting scenarios at the CCHT twin houses.

The tests confirmed that pre-heating has the potential to achieve a 5 kW peak shift with minimal overall energy penalty.

NRC is now working with its partners to evaluate these strategies in 50 homes in New Brunswick. They will validate the potential load shift, identify the types of house with greater potential for this technology, and evaluate occupants' satisfaction with the load shift strategy.

Remote energy audit

While the previous project is aimed at reducing the peak electric load in electrically heated houses, smart home technologies can potentially improve overall energy efficiency in any home by intelligently operating the heating and cooling systems to minimize the equipment run time. Modern home energy management systems have the ability to collect equipment operation data and information from supplementary sensors installed in the home, providing insights on occupancy, appliance use, and interior environmental conditions, for example.

NRC is working with Rogers Communications to develop solutions to characterize home energy usage from the historical data, develop control strategies to save energy, and identify opportunities for energy savings through the application of data analytic techniques.

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Now available:

Codes Canada 2015

The national model codes governing construction in Canada – the National Building Code (NBC), the National Fire Code (NFC), the National Plumbing Code (NPC) and the National Energy Code for Buildings (NECB) – are now collectively called **Codes Canada**.

For over 75 years, the provinces, territories and the federal government have worked together in supporting an open collaborative process for developing these codes with the aim of harmonizing building and safety regulations across Canada.

The Canadian Commission on Building and Fire Codes (CCBFC) provides direction and oversight on the development of the codes. NRC hosts the code system, manages its funding and supports committee work with the latest technical information and expertise. The most recent result of this long-standing partnership is the publication of the 2015 editions of Codes Canada.

For more information, go to **CodesCanada.ca**

Codes Canada

The knowledge underlying code requirements is derived from new and validated technologies, materials, construction practices and research results, as well as evolving social policies and the changing needs of Canadian society.

The voluntary contributions of construction industry experts, as well as the public that are a vital part of the process, ensure that this knowledge is carefully reviewed. In the end, the process provides uniform, trusted regulations that allow construction professionals to innovate with confidence while ensuring public safety, reducing risks and keeping compliance cost low.

Almost 600 technical changes not only make certain provisions in the new codes clearer and easier to apply, they also introduce new concepts and expand the codes to new areas. Examples of the latter are the introduction of water-use efficiency in the NPC and allowances for six-storey combustible construction in the NBC and NFC.

Changes in the NBC include updates to accessibility and associated design requirements in Part 3, updates to seismic design requirements in Part 4 and the introduction of a new metric for sound transmission in Part 5. There are also significant changes to Part 9, housing and small buildings, with over half impacting stairs, ramps, handrails and guards.

The Canadian Commission on Building and Fire Codes, together with NRC, launched the 2015 editions of Codes Canada in December 2015 with the publication of the NECB. The other three Codes (NBC, NFC and NPC) were published in January 2016. The NECB is also developed in collaboration with Natural Resources Canada (NRCan).

Visit **CodesCanada.ca** for more information and to order your copy of **Codes Canada 2015**.

Information

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Canadian National Master Construction Specification (NMS)

NRC has assumed responsibility for maintaining the Canadian National Master Construction Specification (NMS). NMS is the most comprehensive master specification in Canada, serving as an easy-to-use framework for writing construction project specifications. It is a bilingual reference document containing approximately 750 master specifications, covering not only building construction but also infrastructure and services such as electrical. The content reflects the expertise of many of Canada's foremost authorities on specifications, contract documents, and construction technology.

NMS is used by specification writers, architects, engineers, interior designers and other construction specialists. It helps them to produce clear, complete and accurate specifications for inclusion into construction project manuals and contract documents that are easy for contractors to understand. Updates to existing sections are being administered through Codes Canada, engaging key industry stakeholders, with plans to expand into new technology areas.

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Work begun on 2020 codes

The process of code development is an open and continuous one in which committees constantly deliberate on the merits of future changes to the codes. With the 2020 editions already in their sight, committees are busy reviewing numerous code change requests submitted by stakeholders.

The first public review of changes proposed for the 2020 editions is scheduled for fall 2016. Anyone wishing to request a code change may do so by submitting an **online form** via NRC's website.

New members were recently appointed to the CCBFC for a five-year term ending August 31, 2020. Membership strikes a balance between regulators, industry and general interest groups while ensuring that the various regions of the country are evenly represented.

The CCBFC will convene its first meeting of the 2015-2020 code cycle by the summer of 2016.

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Codes Canada seminars in the works

In coordination with the provinces and territories, NRC will be offering seminars in various cities across the country to explain technical changes to the 2015 editions of Codes Canada.

These seminars offer a unique opportunity for participants to learn from experts and become familiar with many of the new code features and technical updates. Sessions will cover the *National Building Code, National Fire Code, National Plumbing Code and the National Energy Code for Buildings*.

Codes Canada

These sessions will appeal to builders, codes officials, manufacturers, fire protection services, designers, architects, engineers and anyone with a general interest in construction and codes.

Watch the **Codes Canada website** for details on dates and venues.

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Codes Canada 2015 Highlights

Reference standards in Part 9

Many significant changes included in NBC 2015 relate to referenced standards. For example, a large number of new roofing, dampproofing and waterproofing standards replace outdated versions. A set of three new standards governing materials, installation and design of exterior insulation finishing systems (EIFS) is referenced for the first time in Part 9. Other new referenced standards relate to concrete materials and the determination of the load resistance of glass in buildings.

Information

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Concrete strength

The 2014 edition of the CSA A23.1 standard "Concrete materials and methods of concrete construction" calls for higher strength and lower water-cement ratios for concrete used in foundations, footings and interior floor slabs of houses and small buildings.

In considering a proposed update to the 2014 edition of CSA A23.1, the Standing Committee on Housing and Small Buildings conducted a survey to assess failures of foundation walls and concrete floors on ground. The responses were not convincing, as many areas were already using higher strength concrete, and failures were occurring at any strength owing to poor handling and installation practices. The standing committee also determined that while increasing the concrete strength would reduce permeability, there are already requirements in Part 9 for waterproofing and dampproofing. The committee decided that the need to increase the requirements, which would result in higher construction costs, was not clearly established. Therefore, a qualifier to the reference of the CSA A23.1 standard was put in which would keep the requirements in the NBC 2015 as status quo.

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Fire ratings for glass fibre batts

Fire resistance ratings for a number of generic assemblies covered by Parts 5 and 9 of the NBC are referenced in Tables A-9.10.3.1.A. and B. For instance, the listing for exterior wall assembly EW1 in Table A-9.10.3.1.A. currently excludes the use of glass fibre insulation. EW1 is the only fire-rated exterior wall assembly listed in the Table. However, assemblies using glass fibre insulation exist and some have achieved ratings of 45 min and 1 h.

Additionally, the term sheathing used in Part 9 includes insulating sheathing but the term sheathing as used in Table A-9.10.3.1.A. for the existing assembly EW1 was not intended to include foam plastic sheathing.

After investigating the issue, a joint task group of the Standing Committees on Housing and Small Buildings, Environmental Separation, and Fire Protection, introduced a new exterior wall assembly, EW2, with construction specifications using glass fibre insulation to create an even playing field for different products in the marketplace with acceptable performance. Based on the review of UL and ULC listings for assemblies using glass fibre insulation, and based on a selection of limiting construction specifications, the EW2 wall assemblies are deemed to obtain 45 min and 1 h fire resistance ratings. Additionally, the current exterior wall assembly EW1 in Table A-9.10.3.1.A. was revised to use terminology consistent with the remainder of Part 9, Appendix D and the proposed EW2.

A new Table Note (11) was introduced clarifying which sheathing types are deemed acceptable for use in assemblies with combustible cladding. Two new construction options (EW1d, EW2d) were also added using masonry veneer cladding to address common exterior wall assembly construction. A new Table Note (12) clarifies that this construction is permitted to have foam plastic sheathing behind the masonry when supported by structural sheathing towards its inside.

Two new Table Notes (2) and (13) were introduced to help code users define the applications for both exterior wall assemblies EW1 and EW2.

These Table Notes further specify acceptable types of glass fibre insulation and clarify that the spacing of studs, as indicated in the construction specifications, can be considered as a maximum when considering only the fire resistance ratings. This will address situations where tall walls – extending over two stories and constructed with studs spaced 300 mm o.c. – are required to have a 45 min. fire resistance rating in order to comply with spatial separation requirements.

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Fire and sound resistance tables

Because Appendix information is not legally enforceable, acceptable solutions should not be placed in the Appendix. References to fire and sound resistance of building assemblies currently found in Appendix Tables A-9.10.3.1.A. and B were applied to a construction assembly but were not deemed to be an acceptable solution as they were located in the Appendix. These Tables were moved into the body of the 2015 edition of the NBC and labelled as Tables 9.10.3.1.-A. and -B. References to both Tables were also introduced into Parts 5 and 9 respectively to reflect their new location and to confirm the application of the fire resistance rating and sound transmission class of various assemblies as acceptable (enforceable) solutions. No technical changes were made to the assemblies' specifications in the Table.

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Low permeance materials

Water vapour permeance of a material is the ability of the material to allow or prevent water vapour from going through the material. A material with lower permeance restricts the amount of water vapour able to diffuse through it, which would reduce the amount of potential condensation within the building wall assembly. Placing a material with a low water vapour permeance in the wrong location or without designing the building envelope accordingly, may cause damage and deterioration from condensation on this material.

In Subsection 9.25.5. of NBC 2010, a material's water vapour permeance may trigger the requirement to insulate assemblies on the exterior. However, this requirement, which is based on materials having a water vapour permeance of less than 60 ng/Pa•s•m^2, creates an uneven playing field because some exterior insulating sheathing products fall just below the threshold of 60 ng/Pa•s•m^2, while for others the requirements do not apply.

The Standing Committee on Housing and Small Buildings introduced a change in NBC 2015 that relaxes the Part 9 requirement for the application of materials with a permeance value of no less than 30 ng/Pa•s•m^2 that also have a minimum thermal resistance of 0.71 m2K/W (R4) and are installed in locations with less than 6000 heating degree days (HDD). This change recognizes the performance of exterior insulating sheathing products.

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Seismic information for building design in Canada

A major update of the seismic hazard model has been implemented in NBC 2015. Some of the significant findings are as follows:

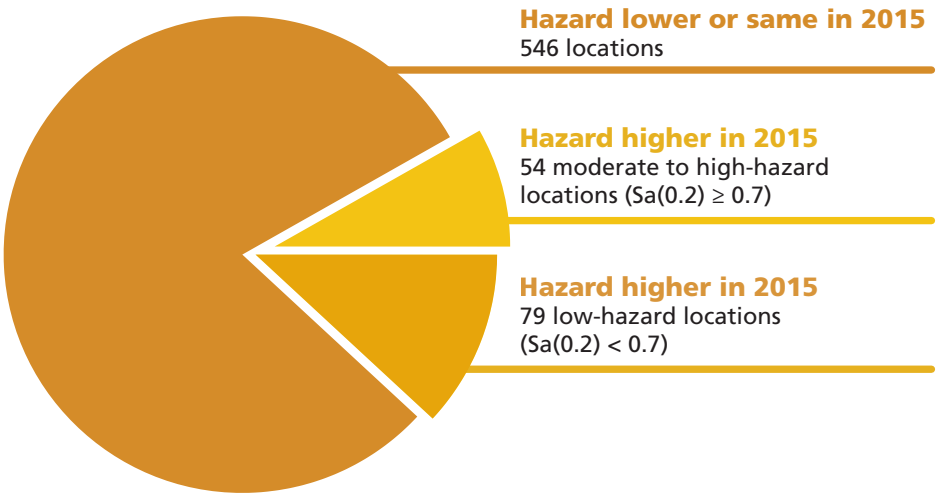
- The Cascadia fault off the west coast of Canada is closer to land than previously thought. This fault could produce a magnitude 9 earthquake, some 20 times more powerful than the magnitude 8.2 that had been forecast.
- Subduction of the Explorer plate beneath Vancouver Island, not previously considered, is capable of producing a magnitude 8.5 earthquake.

As shown in Figure 1, out of the 679 locations in Canada for which seismic data is provided in the NBC, the estimated seismic hazard for low-rise buildings (including housing and small buildings) has been reduced for 546 locations – including all major eastern cities – and has been increased for 133 locations.

In the areas where the seismic risk has increased, 54 of these 133 locations are in areas with a significant seismic hazard. This increase in seismic hazard has pushed some of the 54 locations (particularly in British Columbia) outside the scope of NBC 2010 prescriptive solutions in Part 9. This means that a professional engineer would be required to design houses and small buildings in these locations, creating extra costs. To address this issue, new prescriptive solutions were developed for those locations. As a result, all locations in Canada now have prescriptive solutions available for Part 9 buildings regardless of the seismic hazard of the area.

Figure 1: Comparison of Seismic Hazard between NBC 2015 and NBC 2010

(Comparison valid for Class C soil (most prevalent in Canada) and low-rise buildings) 1 to 3 storey, with design based on Sa(0.2)*



These new prescriptive solutions build on the NBC 2010 requirements; however, some minor adjustments to compliance and enforcement practices will be required.

The cost impact for Part 9 wood-framed buildings, aggregated nationwide, is estimated to be an increase of less than 0.1% of the total cost of new Part 9 wood-framed buildings. The cost increase for an average wood-framed building at the 54 locations of significant seismic hazard is estimated to be approximately 0.2% of the total cost of the building.

Information

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Step dimensions

The step dimensions of stairs inside houses have changed. The run dimension of a step has increased from the current minimum of 210 mm to a new minimum of 255 mm. A cost-benefit analysis showed that 255 mm was the most cost-effective option for typical construction. This change has the potential to reduce the incidence of falls by up to 64% because it permits better foot placement and hence greater stability for occupants. It also aligns NBC 2015 requirements with international codes.

Information

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Snow loads: climatic data

Climatic data in the NBC are continuously reviewed and updated in collaboration with Environment Canada. In 2014, the snow load values listed in Appendix C-2 of the NBC 2010 were updated using the same methodology as in previous Codes. The updates resulted in no change for 84% of the locations, and an 11% increase and 4% decrease for the remaining locations. Most of the increases affect locations in the Yukon, Northwest Territories, and Nunavut.

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Current / Ongoing Work

Report on the performance of the model code development system – Phase 1 complete

A report on the model codes development system has been prepared by a joint Canadian Commission of Building and Fire Codes (CCBFC) and Provincial/Territorial Policy Advisory Committee on Codes (PTPACC) Task Group.

While noting significant progress on improving the system since the last review some ten years ago, the report recommends that government partners re-confirm their shared goals, potentially adjusting the course and re-energizing the system in critical areas.

The report suggests that more collaborative agreements between the Federal/Provincial/Territorial (F/P/T) government partners should capture the shared national interest in Canadian building and fire codes. It also identifies the need to secure political commitment from all F/P/T governments for a sustainable funding strategy for the code development system.

It is anticipated that the report will be made available to stakeholders for their comments in May 2016. The CCBFC will be asked to approve the report and recommendations at its June 2016 meeting.

The membership of the Joint Task Group is being updated for Phase II: the review of the code development process. This work is scheduled to begin shortly.

Information

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Basements

Basements have changed over the last few decades. Today, they are typically fully finished, conditioned spaces that are used daily by occupants. Code requirements for residential basements and crawl spaces, however, have not kept pace in some instances, and one of the CCBFC's current priorities is to review and update these requirements.

The CCBFC's Standing Committee on Housing and Small Buildings has established a task group to investigate basement issues identified by previous task groups. The task group will also act on several code change requests including window well construction, exterior and interior dampproofing, use of low-permeance materials to insulate the top portion of basement walls, foundation wall height and thickness requirements, concrete strength and reinforcement requirements, special solutions for walk-out basements, and use of dimpled boards.

Among the many industry and practice documents available on this topic, the task group will refer to, and base its review of the issues on, the *Performance Guidelines for Basements* published by the National Research Council in 2006.

The task group's work started in winter 2016 and is expected to be completed within 18 months.

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Codes Canada

Fire department response time for houses

In NBC 2010, a 10-minute fire department response time was introduced into Part 9 as a trigger for more stringent spatial separation requirements for detached houses. Since then, some jurisdictions have reported difficulties with the measurement of response times and its application in practice due to inconsistent interpretations.

The main issues revolved around:

- differences in firefighting capabilities among municipalities.
- differences in the method used by municipalities to calculate response time ranging from complicated computerized modelling to simple methods using timers and clocks.
- fluctuations in fire department response times due to weather, road conditions, construction, traffic, and time of day.

An additional, unintended consequence was that the use of the fire department response time as a basis for NBC requirements became a new performance measure for the fire department itself rather than just a trigger to determine construction specifications.

A proposed change was submitted for public review in fall 2014.

The Executive Committee of the CCBFC was informed of concerns raised by the jurisdictions during the Provincial/Territorial post-public review.

After considering various possible options, the proposed change was sent to an ad-hoc technical advisory group to address the concerns raised by the jurisdictions for resolution after the publication of the 2015 code.

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Insulated concrete form construction

Requirements for insulating concrete form (ICF) construction were first introduced in NBC 2005. During the subsequent code development cycle (2005-2010), the Standing Committee on Housing and Small Buildings processed a number of individual changes regarding minor issues related to ICF construction.

In 2012, the standard CAN/ULC-S717.1, "Flat Wall Insulating Concrete Form (ICF) Units" became available. Subsequently, the Standing Committees on Housing and Small Buildings, and Environmental Separation received Code Change Requests to add the standard in Parts 9 and 5 of the NBC.

A joint task group of the Standing Committees on Housing and Small Buildings, and Environmental Separation, was established in January 2014. The task group will review the standard CAN/ULC-S717.1 and the current ICF requirements in Part 9 and will develop a comprehensive approach that considers all aspects of ICF wall construction as well as its interdependency with other construction details. Issues include foundation wall height, dampproofing and waterproofing, restrictions for openings in ICF walls, fire and structural performance implications, and air barrier system continuity. NBC Part 5 requirements governing the use of ICF will also be reviewed.

A final report recommending changes is expected to be ready by the spring of 2017.

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Grab bars in bathtubs and showers in dwelling units

Fall-related injuries are a serious issue for Canadians of all age groups. In homes, falls and injuries in bathrooms are of particular concern.

The Standing Committee on Housing and Small Buildings established a task group to recommend and justify a solution regarding the installation of grab bars in bathtubs and showers in dwelling units.

During the 2010-2015 code cycle, progress was made but lack of comprehensive quantitative data regarding injuries in and around bathtubs and showers has made reaching a conclusive recommendation difficult. New data from the final report of the Toronto Rehabilitation Institute investigating the effectiveness of using grab bars during transfers in and out of bathtubs will allow the task group to progress in its work.

It is anticipated that the work of the task group should be completed in time for the standing committee meetings planned for February 2018.

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Snow loads: Simplified calculation

On another front, application of the simplified snow load calculation for Part 9 buildings has expanded over time, resulting in increasing concern over the growing discrepancy between Part 4 and Part 9 snow loading requirements. The Standing Committees on Housing and Small Buildings, and Structural Design, established a joint task group to review snow load calculations for Part 9 buildings. They also examined the suitability of applying the Part 9 simplified calculation method to roofs with complex shapes.

The joint task group conducted a survey in January 2014 to collect data on snow-related failures. Analysis of the responses received to date suggests that the most significant factors in Part 9 roof failures are improper workmanship and inadequate bracing. Similarly, the joint task group did not receive any reports of failures in properly constructed buildings designed to NBC Part 4, or the National Farm Building Code 1995.

The task group will continue to review survey results as they are submitted.

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Website information

NRC Construction has an **extensive website** with a wealth of information on our programs and collaborative opportunities, technical and advisory services, and on our research facilities.

Construction Innovation

The NRC Construction newsletter, **Construction Innovation**, is available free of charge on the NRC website. It provides information of new initiatives, recent research results, product evaluations and code developments to Canada's construction practitioners.

Construction Technology Updates

Construction Technology Updates are a series of short publications that provide practical information for builders.

Build on expertise

The National Model Construction Codes are now collectively referred to as "Codes Canada." Codes Canada 2015 are developed by experts, for experts, in order to ensure that Canada's national codes remain responsive to new technologies, materials, construction practices, research, social policy, and the changing needs of Canadian society.

They are driven by a collaborative process that relies on the voluntary contributions of construction industry experts as well as the public to ensure that the best available knowledge drives meaningful change. This change allows construction professionals the confidence to innovate safely, reduce risks and keep compliance cost low by establishing uniform, trusted regulations that keep pace with industry change.

Go to **CodesCanada.ca** for more information on the model codes and the Code development system.

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2015 editions of the National Building, Fire, Plumbing, and Energy Codes are now available!

Codes Canada 2015 provide trusted regulations that keep pace with industry change. In fact almost 600 technical changes ensure that Codes Canada are clearer and easier to apply, while presenting new concepts and expanding the codes to new areas.

Over 360 technical changes in the **National Building Code of Canada 2015 (NBC 2015)** permit construction of six-storey wood buildings with additional protection measures. They also update accessibility and associated design requirements, seismic design requirements, climatic data and related design methods and introduce Apparent Sound Transmission Class (ASTC) to assess airborne sound requirements between dwelling units. Changes to stairs, ramps, handrails and guards include a change that increases the run dimension of a step inside the house.

Seventy-seven technical changes to the **National Fire Code of Canada 2015 (NFC 2015)** relate to the introduction of mid-rise wood buildings and introduce the classification system used by Workplace Hazardous Materials Information System (WHMIS) to define dangerous goods.

Twenty-eight technical changes are incorporated in the **National Plumbing Code of Canada 2015 (NPC 2015)** to increase design and material choices and introduce new water-use efficiency requirements that aim to reduce water usage in all buildings, regardless of water source.

Over 90 changes are applied to the **National Energy Code for Buildings 2015 (NECB 2015)** including requirements for new pressure-sensing controls for service water, efficiency regulation of heat rejection equipment, and updates to lighting power density values.

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