# Construction Site Fire Response

## Preventing and Suppressing Fires During Construction of Large Buildings

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## Executive Summary

- Buildings are at their most vulnerable during the construction stage, due to the presence of combustible materials, ignition sources, lack of fire-safety systems or separations, and potential site security issues.
- An estimated 100,000-plus building projects in Canada each year involve wood-based construction, and these numbers may increase with building code changes that permit taller wood buildings. Research shows that wood buildings are as safe as steel or concrete buildings once fire-safety systems are in place, but, like all buildings, are more vulnerable to fires when they lack those systems.
- While fire departments provide both prevention and suppression services to construction sites, the greater focus should be on preventing fires. Familiarity with applicable codes, regulation, construction site practices and hazards can help departments more effectively prevent and suppress fires at construction sites.
- Pre-incident (or pre-fire) plans are a critical tool in construction site fire safety. Developed by the site representative and fire department in partnership, the plans gather critical information that will be required for an effective response if a fire occurs. Emphasis should be placed on keeping the department informed of changes during the course of construction that could affect the department's ability to prevent and suppress fires, such as changes to access or water supply.
- Fire prevention personnel should develop a dialogue with all parties involved in a construction site, including site representatives, suppression personnel and building inspectors.
- Key prevention activities also include staying aware of the status of built-in fire mitigation during construction, ensuring site security, and ongoing inspections and monitoring.
- Suppression planning activities should begin in the pre-construction phase, and should include a determination of the department's capacity to address the types and scope of fires that could occur at the site.
- At sites where no lives are at risk, a defensive approach (e.g. attacking from the exterior) to firefighting is more common, given the high level of hazard at construction sites. It is also recommended to "go big quick" – generate as much water flow as possible, as quickly as possible.
- Suppression planning considerations should consider the differences in peak heat production in construction site fires, along with exposure risks to neighbouring buildings.

# Introduction

Construction sites present fire departments with a different set of challenges from those associated with completed buildings. The construction stage is the most dangerous point in any building's lifespan due to a number of risks, including:

- Proximity of combustible materials to ignition sources (e.g. electrical equipment and hot work such as welding and roofing);
- Lack of completion of any built-in fire-safety systems such as sprinklers;
- Absence of doors, finished walls and other separations that may slow fire spread; and
- Potential site security issues.

Canada has seen numerous examples of large-scale construction site fires over the years, including those in Calgary, Alberta in March 2015, Kingston, Ontario in December 2013 and Richmond, British Columbia in 2011. (See Appendix A for an inventory of major Canadian construction fires involving wood-frame construction.)

Typical hazards at construction sites include:

- Temporary heating equipment;
- Smoking;
- Waste disposal;
- Open burning;
- Spontaneous ignition;
- Cutting and welding;
- Electrical malfunctions;
- Flammable and combustible liquids;
- Flammable gases; and
- Explosives.

The leading causes of fires in buildings under construction or demolition are:

- Incendiary or suspicious events;
- Open flames and embers; and
- Heating equipment.

## *The Changing Landscape*

It is estimated that more than 100,000 building projects in Canada each year involve wood-based construction (e.g. wood-frame, post-and-beam, mill or cross-laminated timber).

With this widespread and growing use of wood – due in part to building code changes permitting taller wood buildings – comes the greater need for fire departments to focus on construction site fire safety.

Research by the University of the Fraser Valley in 2014 demonstrated that wood buildings are as safe as those built with steel and concrete when effective fire-safety systems are in place. However, like all buildings, wood buildings are more vulnerable to fires when they lack those systems – as is the case during construction. The introduction of taller wood buildings increases both the complexity of fire protection at construction sites, and the potential for fire loss.

### *The British Columbia Experience*

Proposed changes to the 2015 National Building Code and National Fire Code would provide the ability to construct wood-frame buildings of up to six storeys (see more on the codes in the Standards, Codes and Regulation section below).

Since 2009, the British Columbia Building Code has permitted buildings of 18 metres from the ground to the uppermost floor of the top storey, subject to further restrictions based on higher seismic loads. This is the equivalent of five or six storeys, with a floor area of 7,200 square metres. Other related code requirements:

- Additional buildings may be constructed on the same site. If the buildings are linked, similar-sized structures may be repeated, providing there is a two-hour firewall (or four-hour firewall for mercantile or medium industrial occupancies).
- Lower floors must either have the studs closer together to support the weight of the floors above, or use larger or doubled-up/tripled up studs at typical spacing.
- Along with the different stud specifications, floor penetrations have to be continuous through all the floors to meet seismic/structural requirements.

The requirements have led to some changes in construction processes. For example, floor and wall construction has mainly changed to panelized assemblies constructed off-site in a manufacturing plant and trucked to the site. The floor panels are typically 12 by 45 feet long and wall panels are typically 12 by 22 feet long.

However, as building codes elsewhere in Canada change to allow taller wood-frame buildings, fire departments should expect that traditional on-site "stick" method of construction may continue for some time until the supply of manufactured wall and floor panels can grow to meet the demand.

Other B.C. considerations:

- Shear walls are required for exterior walls and/or interior corridor walls due to earthquake load conditions. These requirements will not be relevant in all areas of Canada.
- Elevator shafts and stairwells must be enclosed by fire-rated walls (minimum one hour). Laminated 2x6s are typically used to achieve this fire rating.
- Mid-rise buildings are sprinklered to meet the requirements of NFPA 13 *Standard for the Installation of Sprinkler Systems*.
- The exterior wall finish must be non-combustible or of limited combustibles, meeting criteria when tested to CAN/ULC-S134-13 *Standard Method of Fire Test for Exterior Wall Assemblies*.

### *Trends Around the World*

Taller wood buildings are common in some other countries, according to a federal report entitled *The National Building Code of Canada: A Tool for Recovery in the Forest Industry?*, written by David Surprenant of the Industry, Infrastructure and Resources Division. At the time of the 2010 report, Germany, Norway and Sweden did not limit the number of storeys, the United Kingdom allowed up to seven storeys (with exemptions for up to nine), and the United States allowed up to six storeys.

### *Role of the Fire Department*

Fire departments typically provide both prevention and suppression services at local construction sites. While a greater focus should be placed on prevention, departments need to also prepare their suppression approach in case a fire does occur.

The typical activities and factors that affect the local fire department's role are outlined below and addressed in more detail later in this report.

| | TYPICAL ACTIVITIES | CONTRIBUTING FACTORS |
|---|---|---|
| **PREVENTION** | • Liaise with site representatives and building inspector (ongoing)<br>• Review/approve pre-incident plan<br>• Inspections and enforcement<br>• Monitoring of site changes, particularly effect on access and water supply | • Department resources<br>• Understanding of risks<br>• Regulatory knowledge |
| **SUPPRESSION** | • Planning for site-specific fire scenarios / suppression tactics<br>• Typically defensive approach | • Life safety and exposure risks<br>• Department resources<br>• Structure height / site access |

### *Levels of Risk Management*

Construction sites fall into one of three risk management categories, outlined below. The local fire department's role and level of involvement will vary based on each site's risk management category.

**Minimal** – Typically small developments of single-family homes or small townhouse complexes.

- Rarely fenced.
- Limited security (e.g. only when plumbing /wiring roughed in).
- Limited firefighting and control capabilities on site.
- Minimal or no emergency planning, site cleanup or orderly materials storage.

**Moderate** – Ranging from mid-rise condo projects with 100-plus units to projects with multiple buildings on one site.

- Fenced from the start of the project.
- Security provided evenings and weekends.
- Formalized hot work permits and company-trained safety officers.
- Roughed-in fire protection devices that are installed after the floor above is completed.
- Any buildings occupied while construction is still occurring on the site have fully functioning sprinkler and fire detection systems prior to occupancy.

**High** – Typically larger, risk-managed projects such as hospitals, schools and government buildings.

- Provide their own project managers and site fire protection.
- Use hot works permit systems and just-in-time construction materials deliveries.
- Usually provide an onsite project engineer who works with the project manager.

- Security provided from the start of project during silent times and weekends.
- Usually trades are not permitted onsite when project manager and site safety officer are not present to supervise.
- Fire and detection systems are installed as the building is constructed.
- Partial occupancy is usually not permitted until completion.

## Purpose and Scope

Many Canadian fire departments have limited experience in preventing and suppressing fires at large-scale construction sites. The purpose of this report is to reduce the risk and losses from construction site fires by providing fire departments with information based on a review of best practice, legislation, regulation, and standards from across Canada, the United States and Europe.

The information is meant to enhance fire departments' capacity and knowledge related to construction sites, but not replace their approved firefighting methods and procedures for high-risk sites.

Regulations related to construction of buildings and fire safety varies across the country, and the information in this report may not reflect the local, provincial and federal regulation in all areas. Personnel involved in fire prevention and suppression at construction sites should ensure they are familiar with the applicable regulations in their jurisdiction.

While the report is focused on the construction of new buildings, the information may also be relevant to sites where existing buildings are undergoing demolition, alternations, renovations, repairs or maintenance.

## Standards, Codes and Regulation

Construction fire safety in Canada is addressed through a variety of legislation, regulation, standards and guidelines. It is important that fire department personnel are familiar with the applicable codes and regulation in their area.

### *Federal*

National Model Construction Codes are developed and maintained by the Canadian Commission on Building and Fire Codes (CCBFC), an independent committee established by the National Research Council. The model codes include the National Building Code, the National Fire Code, the National Plumbing Code and the National Energy Code. Provinces and territories may adopt the codes as their own, either as-is or with amendments. It is important that fire personnel are familiar with the codes that apply to their jurisdiction.

*National Building Code of Canada (NBCC)*

Part 8 of the NBCC 2010 includes construction site regulations.[1] Provinces and territories that have adopted Part 8 with little or no modification are:

| | |
|---|---|
| British Columbia | Northwest Territories |
| Saskatchewan | Nova Scotia |
| Manitoba | Nunavut |
| Québec | Yukon |
| New Brunswick | Prince Edward Island |
| Newfoundland and Labrador | |

The 2012 Ontario Building Code does not include requirements for fire and life safety at construction sites.

*National Fire Code of Canada (NBCC)*

Section 5.6 of the NFCC covers construction site fire and life safety.[2] Provinces and territories that have adopted the NFCC with little or no modification are:

| | |
|---|---|
| Saskatchewan | Newfoundland and Labrador |
| Manitoba | Northwest Territories |
| Québec | Nova Scotia |
| New Brunswick | Yukon |

British Columbia and Alberta have province-specific construction and demolition safety sections in their provincial fire codes.

The 2012 Ontario Fire Code does not include requirements for fire and life safety at construction sites. However, the 2014 Ontario Fire Code does cover fire and life safety for demolition (Part 8) and during repairs or renovations (Article 2.6.1.10).

Nunavut and Prince Edward Island have not adopted fire regulations that address fire and life safety at construction sites.

## *Provincial*

Provincial Occupational Health and Safety (OHS) regulations primarily focus on the protection of workers and others present at workplaces. Worker safety at construction sites is commonly addressed through general OHS provisions, although some regulations have additional specific provisions for construction sites, such as in Ontario.

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[1] The NBCC was under review at the time of publication of this guide; the 2015 version is expected to permit the construction of wood buildings of up to six storeys, from the current four storeys. No changes are proposed for Part 8 of the NBCC 2015.

[2] The NFCC was under review at the time of publication of this guide; the 2015 version is expected to include additional provisions in Section 5.6 for construction of wood buildings of up to six storeys.

### *Hot Work Permits*

Hot work requirements vary across Canada. While all jurisdictions require employers to have appropriate safety measures and safe work procedures for hot work, Alberta is the only province where the provincial OHS regulations require hot work permits.

A number of jurisdictions, including BC, Manitoba, New Brunswick, Newfoundland and Nova Scotia, use the Canadian Standards Association's W117.2 standard *Safety in Welding, Cutting and Allied Processes* to address hot work safety. The standard can be viewed for free at ohsviewaccess.csa.ca.

Even where hot work permit systems aren't required, they are a recommended requirement of construction site fire plans.

### *National Fire Protection Association (NFPA)*

Relevant NFPA standards include:

- NFPA 241 *Standard for Safeguarding Construction, Alteration, and Demolition Operations*;
- NFPA 1620 *Standard for Pre-Incident Planning*;
- NFPA 51B *Fire Prevention in the Use of Cutting and Welding Processes*; and
- NFPA 10 *Standard for Fire Extinguishers*.

### *International Code Council (ICC)*

The ICC produces two documents that are relevant to construction fire safety: the International Building Code (IBC) and the International Fire Code (IFC). Although the codes focus on the United States, both documents provide good practices that are relevant to construction site fire safety in Canada. Relevant sections:

- Section 3301 of both codes addresses fire safety during construction, remodel and demolition.
- Section 3308.02 of both codes identifies the responsiiblity of the property owner to maintain an approved pre-fire plan in cooperation with the fire chief.
- Section 3310 of the IFC provides information on required access.
- Section 3312 of the IFC defines water supply requirements.

## Construction Site Milestones

Understanding key milestones in the construction process will help fire departments be more effective in their planning and monitoring of a site. Many of the milestones for the construction of mid-rise wood-frame buildings are common to all construction projects. Information in this section is based on extensive insurance company course-of-construction inspection experience and interviews with construction superintendents, construction companies and developers.

The milestones reflect the period after the building design has been approved, permits have been issued and the project is ready to proceed, with no exceptions to requirements for providing automatic sprinkler protection and standpipes, internal fire-rated separations and adequate water supply for firefighting.

### *Site Preparation – Before Construction Begins*

- A standard connection is installed to the site water supply's underground system, yard mains and hydrants before framing begins or any other substantial combustible load is introduced to the site.
- Site fencing and security are in place.
- Designated storage areas are defined for building materials, flammable liquids and combustibles.
- A hot work protocol is established and agreed to by all trades, contractors and subcontractors in writing.
- Site entry points and routes for fire department responders are designated.
- Site maps are produced with the location of storage and firefighting equipment, as well as evacuation routes from all areas of the site.

### *First Phase – Basement*

- Daily written site management and safety officer reports are maintained on all daily activities, material deliveries and storage/placement locations.
- When basement concrete has cured and forms removed, a suitably sized water main is installed in the building water room and connected to either the municipal water supply or approved alternative. The water main is designed to service the entire building to facilitate the eventual installation of automatic sprinkler systems and standpipe and hose systems.
- Milestone: confirming the amount of water and pressure available at the base of the riser, which will dictate the size of fire pump if one is required. If a pump is required, it will be installed along with an adequate power supply. Wood-frame or other combustible construction should not proceed until this is completed.

### *Ground Floor and Above*

- Protocols are established for implementing through-floor service openings (e.g. water, phone and power lines) and the fire stopping required for each service opening. The selected fire-stop system has been tested to CAN/ULC-S115. As each floor assembly is completed, fire stopping is installed.
- Fire hose connection piping is activated prior to the next floor being erected. Active hose stations, with a suitable length of hose and variable fog nozzle, are on each floor prior before the next floor construction proceeds.
- The hot work protocol is strictly followed, and all activities involving hot work are logged in the project manager's or engineer's daily logbook.
- As each floor (including wood-frame balconies) is finished, the floor surface is placed over the wood deck. No torch-down membranes are permitted on balconies without a non-combustible surface installed.
- As each floor is completed, all fire separations are completed, including installation of fire-rated doors.

- Each floor exit is clearly marked with signs and directional lighting. As the project proceeds past the second floor, temporary stairs are installed and all workers informed of their exit and evacuation routes. No employee or contractor is permitted in the building until they have been provided with this information.
- If hot work is required for the roof covering, a separate hot work protocol is established.
- Gypsum board that is required in the completed design is installed as soon as possible in order to reduce the amount of exposed combustible materials.
- A safety protocol is established for heating the building, especially if interior heating devices are used. Exterior heaters are the preferred method of heating the building, using flexible hosing and ducting to direct the heat. A less desirable method is enclosure, which involves installing plastic shrink-wrap around the building to hold in the heat to dry the building during the drywall stage. Shrink-wrap is highly flammable and should not be used if possible. If it is used, shrink-wrap must not enclose the emergency stairways on the exterior of the building.
- Sprinkler systems and fire-detection devices are physically roughed-in prior to interior finishes but are not activated until interior finishes are installed. However, the sprinkler systems should be activated prior to upper floor construction, depending on climate and weather conditions. Ideally, gypsum board is to be installed first, allowing sprinkler installation and system activation, followed by remaining interior finishing before proceeding to the next level. (Several project engineers felt this would be possible when the penetrations in the floor above have been fire stopped and the concrete finish has been applied to the wood deck floor surface. Water migration from rain could be mitigated if those two features were completed as the building was erected.)

## Fire Prevention Planning – Overview

As inventor and former U.S. President Benjamin Franklin once said, “An ounce of prevention is worth a pound of cure.” Fire departments should strive to limit their interaction with construction sites to prevention activities.

A number of factors play a role in preventing fires at construction sites. See Appendix B for a knowledge, skills and abilities checklist for fire prevention personnel.

### *Pre-incident / Pre-fire Plans*

Pre-incident plans (also known as pre-fire plans) gather together critical information needed by the fire department to make life-saving decisions if a fire occurs at a construction site, including fire department access, water supply, location and operational status of firefighting equipment, escape routes, flammable materials storage and other details. Pre-incident plans are addressed in greater detail in the next section.

### *Communications*

Developing a strong rapport with all parties involved in a construction site is a valuable, but sometimes overlooked, tactic.

### *Site representatives*

Pre-construction meetings between the site representative and fire department are important to lay the groundwork of the pre-incident plan and should include a review of NFPA 1620 and NFPA 241. Topics for discussion should include the timing of the construction, anticipated weather conditions, and the shifting of content within the building.

Throughout the construction phase, regular meetings and/or other means of communication should be established to address issues as they arise, such as problems with access to the site, status of water supplies, reporting of emergencies, and the status of built-in fire protection systems such as fire alarms, detectors, and sprinklers at different stages of construction.

Providing on-site fire extinguisher training can also help build the rapport with site representatives and staff, while also improving site safety. Fire personnel can demonstrate the use of different types of extinguishers and perhaps extinguish a fire within a small metal garbage can to show the size of fire that can be put out by an extinguisher.

### *Suppression Personnel*

Pre-construction meetings are a good time for suppression personnel to become informed about the plans for the site – 3 a.m. is not the ideal time to meet the contractor for the first time. This approach has been known to make a significant difference in fire department performance if a fire occurs. As the project proceeds, prevention personnel should also keep suppression personnel informed about changes, milestones and other issues.

### *Building Inspectors*

Communication channels should also be built between the fire department and building inspectors. Local building inspectors may be at the building almost daily, or at least weekly, while fire inspectors may only visit periodically, for example, to check on the installation of alarms or sprinklers. Building inspectors may not be aware of all the potential fire hazards on a construction site. Informing them of risks such as trash build-up and possible ignition sources will provide the fire department with another set of eyes on the ground.

## *Built-in Fire Mitigation*

Standards and best practices recommend installation of fire protection devices (e.g. standpipes, automatic sprinklers and fire alarm systems) as early as possible in the construction process. However, based on weather and other factors, some of the components may not be fully operational until more advanced stages of the project or when the building is certified for occupancy.

Fire departments should be aware of the status of these components throughout the course of the project. Knowing whether the systems are in service or not would be a key factor in the Incident Commander's decision-making process if a fire occurs.

### *Site Security*

Strong site security is essential in preventing construction site fires and can include measures such as fencing, sign-in/sign-out sheets and posted security guards. These measures help to keep out unauthorized individuals (including potential arsonists), track who is present at the site at any particular time (important information if a fire occurs), and monitor sources of potential fires. However, strong site security can also affect site access for emergency vehicles, so should be considered during Pre-Incident Plan development (see Access, below).

A site security plan should be developed based on an assessment of the site's security vulnerabilities. The plan should include:

- Personal observation
- Log books
- Video technology
- Scheduled patrol routes
- Proper notification procedures

### *Inspections and Monitoring*

Fire departments should make an effort to maintain a consistent presence throughout the construction process. This should include in-person inspections and monitoring of the progress, as well as regular communications with the site representative. Conditions at a construction site are constantly in flux, and it is critical that the fire department remain aware of changes that could affect the fire safety of the site as well as their ability to respond effectively.

## Pre-incident Plan Considerations

The standard for pre-incident planning is NFPA 1620, although individual fire departments may have their own version of pre-incident planning, with guidelines based on locally adopted policies and procedures. In all cases, the objective is to develop a common understanding of the facts, probabilities and possibilities of what could occur at a specific site. This task should be a team effort between the site representative and fire department.

A particular emphasis should be placed on keeping the department informed of changes to the site during construction that will affect their ability to prevent and suppress fires. This includes changes to water supply, site access, evacuation routes, hazardous materials storage locations, and firefighting equipment locations and operational status.

Updated copies of the plan should be available at the construction site and provided to the emergency responders who are first called to the scene when an event occurs.

### *Plan Components*

A pre-incident plan typically includes information, site plans and drawings that illustrate:

- Fire department access points to the site;
- Locations of fire extinguishers and initial attack equipment;
- Any special provisions for firefighting activities;
- The disposition of all built-in fire protection systems;
- Emergency escape routes and stairs;
- Available water supplies and positions of hydrants and hose reels that are operative;
- Any other operative fire safety systems that have been provided;
- Locations of assembly points and registers of persons currently on the site; and,
- Details of temporary accommodation and storage areas, including location for storage of hazardous items

### *Operational Planning*

Fire departments should identify the following before construction begins and monitor them throughout the construction phase.

- The number and location of fire hydrants and other water sources;
- The types of materials and equipment present at various stages of construction, and methods of storage;
- Additional resources and/or activities that may be needed in the event of a fire, e.g. moving of vehicles, moving of temporary structures;
- How the local fire department will be contacted when an event occurs;
- Contact number for local emergencies;
- Distance from site by first-due company; and,
- Whether the construction site address is known by the dispatch system.

#### *Subcontractors*

Before work begins, it is important to ensure subcontractors have fire prevention and emergency response plans in place. Proper plans for subcontractors would include:

- Training;
- Head count process;
- Emergency warning system;
- Evacuation and assembly procedure;
- Provision of fire equipment;
- Hot work permit system;
- Use of flash-back arrestors;
- Use, storage and maintenance of compressed gases;
- Inspection and condition of welders; and,
- Use of personal protective equipment.

### *Access*

Access is an important consideration of the plan, including both site access and access to the building exterior for firefighting. Considerations include the following:

- Incident command posts should be located in close proximity with the construction company site office. This provides the contractor and sub-contractor access to the incident command post and provides the incident commander with access to site-specific information.
- To maintain suitable access for fire apparatus, the site should include all-weather driving surfaces that have at least six metres unobstructed width and can withstand the live loads of fire apparatus.
- Dead-end roads that are longer than 45 metres should be provided with a turn-around.
- Driving surfaces should be kept clear of debris and obstacles that could block apparatus.
- Procedures should be in place for on-site personnel to provide perimeter access to the fire department (e.g. by opening gates) for emergency response or inspection purposes.

### *Other Considerations*

In addition to access, other elements to be considered in the plan:

- **Constant maintenance of fire protection equipment**. This includes making sure hydrants are clearly visible and that extinguishers are adequate and inspected. The inspection process is important because employees may discharge an extinguisher, either on purpose or accidentally, leaving the extinguisher empty.
- **Keep materials from being built-up around buildings.** Piles of wood or other ordinary combustibles, including trash piles, should be kept away from buildings unless they are part of an active construction process.
- **Maintain a no-smoking policy in or near buildings.** Set-up designated smoking areas for employees. Make sure these areas are covered, to prevent giving employees an excuse to smoke in the building during inclement weather. Monitor the no-smoking policy by conducting audits.
- **Use a hot work/burn permit system.** An effective policy has the following elements:
    - Pre-inspection of work area;
    - Having a charged fire extinguisher at all times, at the point of the work; and,
    - Monitoring the area for at least 30 minutes after work is conducted. This means a fire-watch remains at the work area for 30 minutes (with a fire extinguisher) after work has been completed. It may also be required to have a fire monitor at the work area while hot work is occurring.

## Suppression Approaches and Tactics

As mentioned earlier, suppression personnel should develop a working relationship with the site representative during the pre-construction planning period, to determine in advance what the department will need to consider if a fire occurs. Topics would include water supply and vehicular access.

The planning process should also determine:

- If the department has the capacity to handle the types and scope of fires that could occur on the site or if it will need to rely on outside resources; and,
- How the site representative should interact with the incident commander to share information as quickly as possible, and what information might be needed.

This advance planning and preparation will be of great assistance to the incident commander in assessing tactics for the initial attack.

See Appendix C for a knowledge, skills and abilities checklist for suppression personnel.

### *Fire Department Capacity*

The National Building Code in Canada, as well as provincial building codes, contains a general discussion on assumptions about firefighting capabilities and water supply that were made in establishing all the fire safety provisions of the code, and how additional life safety measures may be needed if they are not present.

After five- and six-storey wood construction was introduced in British Columbia in 2009, fire department capacity was also discussed in a 2013 bulletin published by the Professional Engineers and Geo Scientists of BC entitled *APEGBC Technical and Practices Bulletin:*

> "4.13 the firefighting provisions of the BCBC (British Columbia Building Code) are based on the assumption that adequate fire department response is provided and that a pumper truck is available as a backup to charge the sprinkler and standpipe systems. Where fire department capabilities are limited, a FPE (fire protection engineer) should consider the availability and capability of local firefighting services for mid-rise wood-frame projects. Where necessary and if fire Department services are limited, a FPE should consider additional fire protection measures. These measures may include but are not limited to: enhancement of the reliability of the sprinkler system, such as backup water supply, fire pump, generator, etc.; and, enhancement of the reliability and/or FRR (fire-resistance rating) of fire separations."

Not every department can provide the same level of response to construction site fires – the number of apparatus, firefighters and expertise will vary from community to community.

It is critical that the pre-incident plan reflects the level of service available by the local fire department, and whether mutual aid is required.

### *Automatic and Mutual Aid*

If the fire occurs that commits all of a department's resources, it is not uncommon to call for assistance from neighbouring departments. Two terms explain this relationship:

- Automatic aid: an agreement between communities where equipment will be sent automatically to an emergency if requested by the incident commander; and,
- Mutual aid: a reciprocal agreement between two departments that agree to help each other, upon request.

Of the two forms of aid, mutual aid typically takes longer to respond to the fire site. This should be considered when assessing the department's capacity – especially in regards to aerial apparatus.

### *Attack Approach*

*Offensive vs. Defensive*

A common public complaint at the scene of large fires is that "all they did was stand on the outside and pour water on it." This may be very accurate, given the high level of hazard at construction sites, and the fact that incident commanders are reluctant to unnecessarily risk the lives of firefighters.

Incident commanders often have to choose between offensive and defensive operations in a matter of moments upon arrival. When no lives are at risk, they typically take a defensive approach (e.g. attacking from the exterior) at construction sites, rather than an offensive approach (entering the building). That doesn't mean fire departments should not do everything possible to safely extinguish the fire. However, an offensive approach should generally be limited to instances where lives are at risk (e.g. someone is trapped in the building).

There is great truth in the fireground phrase that we will "risk a lot to save a lot, but we will not risk a life to save a little." It does no good to kill or injure firefighters when lives are not at risk and a building is already destroyed.

*"Going Big Quick"*

From a tactical perspective, what happens in the first 10 minutes of arrival at a fire scene sets the stage for what happens in the next two hours. Every fire department has a response procedure for structure fires. Responders should be prepared to "go big quick" – that is, generate as much water flow as they can, as quickly as possible. This is no time to be timid. Pulling a booster line may do the job when a fire is the size of a trash barrel and sitting in a parking lot, but it is far from adequate if the fire is in a vertical shaft in a building that has exposed building components.

Most departments have pre-connected 1¾-inch lines they can place in service in minutes. One guideline to consider is that if a 1¾-inch line seems sufficient, consider going in with a 2½-inch attack line. "Going big quick" also includes the notion of getting master streams and suppression operations established as quickly as possible. If aerial apparatus is available, it is important to quickly establish a master stream in the air.

However, lack of pre-connects, master streams or aerial apparatus would severely limit this approach.

### *Water Flow Considerations*

The determination of basic water flow – how much water should be available for fire protection at a site – is a common practice by fire departments. Typically, the calculation assumes a building has been certified for occupancy and has mitigation features in place.

A different water flow calculation is required for buildings that are still under construction and are therefore either fully or partially unprotected. Common observations at construction site fires in which buildings have burned down are: "The building was fully involved before we got there," or, "The heat was so intense that the primary priority was exposure protection."

Because of higher fire loads and lack of fire protection, peak heat production occurs differently in unfinished buildings than in completed buildings, and the risk of exposure fires is greater (see below). This should be a major consideration when calculating water flow and planning the suppression approach.

#### *Heat Production*

In a structure fire, energy can be measured in two terms:

- Total heat release: the total number of BTUs (British thermal units) released when all the fuel is consumed; and
- Peak heat release rate: when the discharge of BTUs is at its highest rate.

When building fires reach the peak heat release stage, they then have an effect on neighbouring structures. Two different fires may have the same total heat release but can have different peak heat release rates, and as a result may affect neighbouring structures differently. For example, a fire load of 25 pounds of lumber that is packed tightly together could result in a slow-burning situation with a low peak heat release rate. However, the same fire load of 25 pounds of lumber that is arranged "campfire-style," with lots of surface area exposed and room for air-flow around it, could create a fast-burning situation with a higher peak heat release rate. In both cases, the total heat released and the heat released per pound of lumber is the same; it is the degree of that heat release over a period of time that is different.

#### *Exposure Fires*

All structure fires transmit heat as a form of energy, like a heat wave – this is called radiation. Simultaneously, heat from a fire will also warm the surrounding air, causing it to rise. The transfer of heat through the movement of hot air is called convection. In particular, radiant heat (also called heat flux) can have a significant impact on exposed buildings, including starting exposure fires.

The amount of radiant heat generated depends on the type of flame and fuel source. The amount of radiant heat that reaches a receiving surface is also affected by the distance and angle(s) between the radiation source and the receiving surface.

The risk to neighbouring structures can be exacerbated by embers and burning materials that rise into the air and are carried by the wind – a higher risk in buildings with unenclosed walls. The reason for this is two-fold:

(1) Embers and burning materials can lodge in angles and crevices on the exterior of nearby buildings, or even find their way inside exterior building components, where they may smolder until enough heat is generated to ignite any combustible material or debris (leaves, etc.) they come in contact with.
(2) Materials will ignite more quickly and at a lower level of radiant heat when an external ignition source, such as embers and burning debris, collides with the heat-receiving surface.

## Conclusion

Construction site fires present unique challenges to fire departments, and the continuing growth in wood-frame construction will expose more communities across the country to the potential risks. However, fire departments can significantly reduce these risks by enhancing their knowledge of construction site processes and hazards, and through targeted and consistent fire prevention and suppression planning.

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The Canadian Wood Council would like to thank all the emergency responders who serve Canadians in Communities across the county and dedicate this report to all those who work tirelessly to reduce the advent and impact of fire.

## References

Significant portions of the information in this report were adapted from the American Wood Council technical design guide entitled *Departments' Role in Prevention and Suppression of Fires During Construction of Large Buildings*.

Other information sources:

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## Biographical Information

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## Definitions

**Aerial apparatus:** Fire apparatus designed with a mounted aerial device, such as a ladder, a snorkel, or any other combination of technology that will allow the company to reach upper floors on a fire and to provide a master stream platform to be operated from above.

**Automatic aid:** A plan developed between two or more fire departments for immediate joint response on first alarms.

**Command post:** The location where the incident commander and associated staff are located during an emergency incident.

**Defensive attack:** A decision to fight a fire from the exterior of a building and to protect exposures because of several factors, including lack of life safety risk, or potential injury or danger to firefighters.

**First due:** The engine company that would normally be dispatched to a specific site; the closest fire station to a working site.

**Incident commander:** Within an Incident Command System structure, **t**he person responsible for all decisions relating to the management of the incident and is in charge of the incident site.

**Incident Command System:** A management system designed to enable effective and efficient on-scene incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure.

**Initial attack:** Firefighting activities that occur between the arrival of the fire department on the scene of a fire and the tactical decision by the incident commander that the resources dispatched on

the original response are insufficient to control and extinguish the fire, or that the fire is extinguished.

**Master stream:** Large-bore nozzles that discharge more than 1,000 gallons per minute. They can be operated from the ground or from aerial apparatus.

**Mutual aid:** Reciprocal assistance by emergency services under a prearranged plan to provide aid upon request.

**Offensive attack:** A decision to fight the fire by engaging in interior operations that can be performed safely, based upon a need to save lives or protect extreme values. The variable factors in offensive attack include the use of the two in/two out rule and following effective standard operating procedures for firefighter safety.

**Water flow:** Also referred to as fire flow, this is the flow rate of a water supply available for firefighting.

## Appendix A – Incident Inventory and Trends

The following is a list of just some of the major wood-frame construction project fires in Canada along with the source and estimated loss value.

- March 2001: 160-bed nursing home, Hamilton, ON – propane heaters - $7M
- April 2001: 245-unit Liberty Walk townhome project, Toronto, ON – roofer's torch - $10M
- September 2001: school renovation, Wainwright, AB – roofer's torch - $11M
- October 2001: hotel/convention centre, Sun Peaks, BC – propane heater - $15M
- May 2002: 208-unit condo/townhouse project, Erlton (Calgary), AB – roofer's torch – $66M
- November 2002: 125-bed nursing home, Calgary, AB – propane torch - $30-40M
- April 2003: Alliston Park condo complex, Calgary, AB – arson – over $10M
- July 2004: 135-unit retirement home, Winnipeg, MB – arson - $4M
- January 2005: 134-unit condo complex, Toronto, ON – cause unknown - $6M
- August 2005: 32 townhomes on both sides of street, Calgary, AB – cause unknown - over $3M
- September 2006: 30-unit waterfront condo, Nanaimo, BC – arson – over $5M
- July 2007: 149-unit MacEwan Gardens condo project, Edmonton, AB – arson - $20-25M
- November 2007: 12-unit condo project, Nepean, ON – cause unknown - $2M
- October 2008: four-storey condo complex, Surrey, BC – cause suspicious – over $3M
- February 2011: trucks and materials in subdivision project, Hopedale, NL – arson - $1M
- May 2011: 188-unit, six-storey condo project, Richmond, BC – cause suspicious - $38-60M
- March 2013: Health Sciences Centre expansion, Winnipeg, MB – arson - $1M
- September 2013: condominium complex, Rutherford (Edmonton), AB – arson - $20M
- December 2013: five-storey student residence, Kingston, ON – smoking - $30M
- March 2014: condominium complex, Edmonton, AB – cause unknown - $6M
- April 2014: Comfort Inn hotel, Regina, SK – propane heater - $1M
- April 2014: Seniors' residence, Pouch Cove, NF – unknown cause – $1M
- May 2014: four homes in residential subdivision, Richmond Hill, ON – welding – over $2M

## Appendix B – Checklist for Prevention Personnel

Prevention personnel should have the knowledge, skills and ability to:

- ☐ Properly supervise fire safety activities during construction and demolition.
- ☐ Evaluate applicable fire and building codes.
- ☐ Assure compliance with occupational health and safety regulations.
- ☐ Utilize the provisions of NFPA 241.
- ☐ Evaluate and properly utilize standpipes, automatic sprinkler systems, fire alarm systems and portable fire extinguishers.
- ☐ Conduct a fire inspection program in an onsite scenario.
- ☐ Oversee security and guard services.
- ☐ Develop and implement a pre-fire plan in accordance with NFPA 1620.
- ☐ Conduct the training of subordinate personnel in the use of all fire protection equipment.
- ☐ Evaluate the operational status of fire protection equipment approved for the specific site.
- ☐ Supervise hot work operations, including follow-up on permit processes.
- ☐ Evaluate, access and remedy any impairments to any required fire protection systems.
- ☐ Understand how to protect essential equipment that may be exposed to potential damage.
- ☐ Work with the site representative to develop an effective pre-incident plan.
- ☐ Evaluate any issue associated with access or water supply that would limit the local department's ability to combat fires on-site.

## Appendix C – Checklist for Suppression Personnel

Prevention personnel should have the knowledge, skills and ability to:

- ☐ Evaluate applicable fire and building codes.
- ☐ Assure compliance with occupational health and safety regulations.
- ☐ Utilize the provisions of NFPA 1620.
- ☐ Evaluate and properly utilize standpipes, automatic sprinkler systems, fire alarm systems and portable fire extinguishers.
- ☐ Conduct a fire attack based on an on-site scenario.
- ☐ Conduct the training of subordinate personnel in the use of all fire protection equipment.
- ☐ Evaluate the operational status of fire protection equipment approved for the specific site.
- ☐ Evaluate, access and remedy any impairments to any required fire protection systems.
- ☐ Understand how to protect essential equipment that may be exposed to potential damage.
- ☐ Integrate information from the site representative into the incident command system. This task includes the use of pre-fire information.
- ☐ Evaluate any issue associated with access or water supply that would limit the local department's ability to combat fires on-site.