Fire Inspector I & II

CHAPTER TWO
BUILDING CONSTRUCTION

Part 1

Slide 1	Welcome to Chapter 2 - Building Construction. This chapter is divided into 3 Parts. In Part 1 we will discuss:
	• Building construction
	• Building design
	• Materials used in construction including
	  ○ Masonry
	  ○ Concrete
	  ○ Steel
	  ○ Glass
	  ○ Gypsum board
	  ○ Wood
	  ○ Plastics

Slide 2	Knowing the varieties of building construction and types of material used are vital to the fire inspector. Building construction affects how a fire grows and spreads. Your main concerns as a fire inspector is fire prevention and fire behaviour if a fire occurs. You should understand: • The design of the building • The type of materials used • The type of construction 50% of modern building and fire codes are based on fire protection. The year the building was built will reveal information about the building and fire code it was built to comply with.
Slide 3	The size and use of the building is one of the main factors designers use in deciding what materials to use in the construction of the building. These include common building materials like masonry, concrete, steel, glass, along with gypsum board, wood and plastic.
Slide 4	Masonry includes stone, concrete blocks and brick. The components are usually bonded together into a solid mass with cement. Masonry materials are fire resistive and are a poor conductor of heat. For these reasons, masonry is often used to construct a fire wall, to prevent the spread of fire from one side of the wall to the other. This photo shows a test fire that was deliberately set on the right-hand side of a duplex. The duplex had been used for a number of practice fires prior to being burned to the ground which accounts for the smoke staining on the left side of the building. There was a concrete block wall separating the two halves at the chimney but it did not parapet the roof as would be required in a true

	fire wall. As you can see from the photo, the fire burned for a long time on the right-hand side of the duplex and only spread to the other half via the fire on the roof. **Even though the wall did not parapet the roof it slowed the spread of fire significantly as seen in this photo. The right had side has totally collapsed while the fire is still in the growth phase on the left side of the building.**
Slide 5	Not all Masonry walls are fire walls as they may be used over a wood-framed building or façade. If exposed to fire conditions for a prolonged time, the wall may collapse. In this case a warehouse caught fire and due to the extreme fuel load, fire suppression activities were defensive. The masonry wall, outlined in red, collapsed during the fire. Fire investigators concluded that thermal expansion of the steel roof trusses due to the heat of the fire pushed the wall over. As a general rule, steel beams are good conductors of heat and will elongate at a rate of about 25mm or 1" per 300cm or 10' of length at a temperature of around 540c or 1000 degrees f. In this case, the width was about 40 feet so the steel beam could have pushed the top of the wall out about 4". Concrete block walls are also susceptible to collapse from strong wind during construction.
Slide 6	Concrete is a naturally fire-resistive building material. It does not burn or conduct heat well, so it is often used to insulate other building materials from fire. Concrete is often used for foundations, columns, floors, roofs, and exterior pavement. Steel reinforcing rods are often embedded in the concrete to strengthen it when it is under tension. Concrete can be damaged by fire when moisture inside the concrete converts to steam. As the steam expands, it can cause sections of the concrete surface to break off in a process called spalling. Severe spalling can expose the steel reinforcing rods.
Slide 7	Concrete can be poured in place but also be pre-cast and erected at the site. Panels erected on site are often referred to as tilt-up construction. With tilt-up a lot of the strength of the walls comes from the roof assembly. If the roof is damaged by fire, the walls may start to collapse, as shown in this photo. If for any reason you need to enter a building made with tilt up components that has been damaged by fire, the building should be assessed and shored up as required prior to entry. As with any fire operation, safety comes first.

Slide 8	Steel is a commonly used building material. It is very strong in both tension and compression. Steel can also be produced in a wide variety of shapes and sizes from heavy beams to thin sheets. By itself, steel is not considered fire resistive and conducts heat well so it tends to expand and lose strength as the temperature of a fire increases. For this reason, steel is often protected by masonry, concrete, or layers of gypsum board. Other metals such as aluminum and zinc can also be used in construction but these are usually for decorative or light weight applications such as window frames, eve troughs, downspouts and decorative roofs.
Slide 9	Glass is found in almost all buildings. It can be used in windows, doors, skylights and sometimes walls. Ordinary glass breaks easily but can be manufactured to resist breakage and to withstand impact or high temperature. Many different types of glass are available. They are:
Slide 10	**Ordinary glass:** which will usually break when exposed to heat. It can leave large shards which may have sharp edges. **Tempered glass:** which is much stronger than ordinary glass. It is made by thermal or chemical treatments to increase its strength compared with normal glass. Tempering puts the outer surfaces into compression and the interior into tension. Such stresses cause the glass, when broken, to crumble into small granular chunks instead of splintering into jagged shards like plate glass does. The granular chunks are less likely to cause injury. Tempered glass is used in a variety of applications, including passenger vehicle windows, shower doors, architectural glass doors, mobile phone screen protectors, and as a component of bulletproof glass. **Laminated glass:** is manufactured by placing a thin sheet of plastic between two sheets of glass. This results in a much stronger product that when exposed to fire, it is likely to crack, but remain in place.
Slide 11	Video.
Slide 12	**Glass blocks:** are thick pieces of glass similar to bricks or tiles that are designed to build walls so light can be pass through. Glass blocks have limited strength but can usually withstand a fire. Some glass blocks are approved for use with fire-rated masonry walls.

Slide 13	**Wired glass:** is made by moulding tempered glass with a reinforcing wire mesh. When exposed to heat, the wire is supposed to hold the glass together and prevent it from breaking. This product is often used in fire doors and windows designed to prevent fire spread but has been scrutinized for breaking and causing serious injuries. In the March 2017 edition of Construction Canada's newsletter, the following information appeared in part: After extensive review, the Canadian General Standards Board withdrew their CAN/CGSB-12.11, standard for Wired Safety Glass, which assess wired glass as a safety glass. Traditional polished wired glass can no longer be used in doors and other safety-rated locations, according to the updated CAN/CGSB 12.1-2017, Safety Glazing. This means, to qualify as safety glazing used in doors, sidelights, and other locations where impact safety is required, all glazing products must meet a Class B rating or the more stringent Class A rating. Traditional polished wired glass does not even meet the lower Class B rating.
Slide 14	This change in the safety glazing standard is due to overwhelming public safety concern over several injury reports and multi-million-dollar lawsuits stemming from accidental impact with wired glass, which in years gone by was the most commonly used fire-rated glazing product in commercial buildings, especially in schools. According to an expert quoted in an article that appeared in Global News, the Ontario School Boards' Insurance Exchange reported more than $5.8 million in costs for 114 wired-glass injury claims from 2001 to 2015.
Slide 15	Video.

Slide 16	Gypsum is a natural mineral composed of calcium sulfate and water molecules to make plaster of Paris. Gypsum itself is a good insulator and non-combustible. Gypsum is approximately 21 percent by weight chemically combined water which greatly contributes to its effectiveness as a fire resistive barrier. When gypsum drywall is exposed to fire, the water is slowly released as steam, effectively retarding heat transmission. Gypsum board (also called drywall, Sheetrock, or plaster board), is commonly used to cover interior walls and ceilings. Gypsum board has limited combustibility because the paper covering will burn slowly when exposed to a fire. It does not conduct or release heat that would contribute to fire spread. Gypsum board is not structurally strong and it must be properly mounted on wood or steel studs. Gypsum board will only protect the wood from fire for a limited time.
Slide 17	Both regular and Type X gypsum board are covered under the ASTM C 1396, gypsum board standard specification as referenced by the building code. ASTM International, formerly known as American Society for Testing and Materials, is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. Regular drywall, which is defined as a limited combustible, has naturally occurring fire resistance due to the presence of gypsum in the core but is not fire rated. Type X drywall has special core additives that allow it to be used in fire rated designs and usually comes in 5/8” thickness. Type X drywall products will have a UL/ULC Marking printed on the back of each board identifying it as a fire-resistance rated board. There are also moisture resistant and waterproof drywall products on the market.
Slide 18	Wood is the most commonly used building material found in most buildings. It is readily available in Canada, locally produced and is easy to use. It can be shaped into many different forms from heavy structure supports to thin strips of exterior siding. A wide variety of wood products are used in building applications. Some are: Dimensional Lumber which is wood squared and cut into uniform lengths from heavy timber to lightweight boards. Laminated wood consists of individual wood pieces glued together. Lamination is used to produce beams that are longer and stronger than solid lumbers and to manufacture curved beams. This is also referred to as engineered wood.

Slide 19	Wood panels are made by gluing thin pieces of wood together. Plywood is the most common type of wood panel used in construction. Oriented Strand Board or OSB as it is commonly referred to and particle board panels are also in wide use but are weaker than plywood or solid wood panels. This photo shows OSB panels used to sheet the outside of the building. Wood trusses are assemblies of wood or wood and metal combinations used to support floors and ceilings. The design of a truss enables a limited amount of material to support a heavy load. In this photo light dimension lumber used to form the roof truss system that is strong enough to withstand a substantial snow load. This photo shows a silent floor truss system. Wooden beams are load-bearing members assembled from individual wood components. The shape of a wooden I-beam (**pronounced Eye beam**), or box-beam, enables it to support the same load that a solid wood beam of similar size could support.
Slide 20	"Fire-retardant treated wood" as defined by the National Building Code, as "wood or a wood product that has had its surface-burning characteristics, such as flame spread rate, rate of fuel contribution, and density of smoke developed, reduced by impregnation with fire-retardant chemicals.' Fire retardant treated wood must be pressure impregnated with fire-retardant chemicals in accordance with the CAN/CSA-O80 Series of Standards, Wood Preservation, and when fire-tested for its surface flammability, must have a flame spread rating not more than 25. The downside of fire-retardant wood is that the treatment process can also reduce the strength of the wood. The building code defines flame spread rating the following: "*Flame-spread rating means an index or classification indicating the extent of spread-of-flame on the surface of a material or an assembly of materials as determined in a standard fire test"* Flame spread is primarily the surface burning characteristic of materials, and a flame-spread rating is a way to compare how rapid flame spreads on the surface of one material compared to another. Flame-spread rating requirements are applied in the National Building Code of Canada (NBC) primarily to regulate interior finishes. References: NBC 2020 Section 1.4 Definitions NBC 2020 3.1.4.5. Fire-Retardant-Treated Wood Canadian Wood Council Fire Retardant Treated Wood

Slide 21	Fire-retardant chemical treatments applied to FRTW, retard the spread of flame and limit smoke production from wood in fire situations. FRTW products are harder to ignite than untreated wood products and preservative treated wood products. Pressure treating with a fire-retardant chemical allows for expanded use of both dimensional lumber and plywood in the National Building Code. It allows the designer greater flexibility in dealing with some of the fire safety aspects of the code where wood is the preferred construction material, or where a potential fire hazard exists. References: NBC Section 1.4 Definitions NBC 3.1.4.5. Fire-Retardant-Treated Wood Canadian Wood Council Fire Retardant Treated Wood
Slide 22	A new type of technology recently incorporated into the National Building Code is encapsulated mass timber construction. Encapsulated mass timber construction is defined by the 2020 National Building Code of Canada as: “that type of construction in which a degree of fire safety is attained by the use of encapsulated mass timber elements with an encapsulation rating and minimum dimensions for structural members and other building assemblies.” Mass timber refers to large wood products, which are typically panelized and engineered. In encapsulated mass-timber construction (EMTC) buildings, the primary load-bearing structure is made of either solid or engineered wood; protected, or “encapsulated”, in a noncombustible or similarly protective material, such as gypsum wallboard. References NBC 2020 Article 3.2.2.48. EMTC Group C, up to 12 Story’s, Sprinklered NBC 2020 Article 3.2.2.57. EMTC Group C, up to 12 Story’s, Sprinklered NBC 2020 DIV A Section 1.4. Definitions Encapsulated Mass Timber Construction up to 12 Story’s

Slide 23	Mass timber products can be formed by mechanically fastening and/or bonding with adhesive, smaller wood components such as dimension lumber or wood veneers to form large, prefabricated beams, walls, floors and roofs. Mass timber products have sufficient volume and cross-sectional dimensions to offer significant benefits in terms of fire, acoustics, and structural performance, in addition to providing construction efficiency. In this building, the walls and floors are panels made up of cross laminated 2X6" dimensional lumber boards, five layers thick. The wall panels are 9.14 m or 30 feet long that are tilted up and supported by the roof assembly. The panels interlock as can be seen in this photo. Doorways, windows and other required openings are precut at the factory.
Slide 24	Panel thicknesses usually range between 100 to 300 mm (4 to 12 in), but panels as thick as 500 mm (20 in) can be produced. Panel sizes range from 1.2 to 3m (4 to 10 ft) in width and 5 to 19.5 m (16 to 64 ft) in length. The maximum panel size is limited by the size of the manufacturer's press and transportation regulations.
Slide 25	This is a photograph of the nearly finished building. At a glance, it may be hard to determine the type of construction. Mass timber is a broader and more material-specific phrase, whereas heavy timber has the traditional and very historical meaning related to a construction type. The use of EMTC has many benefits. Mass timber weighs less than concrete and is faster to construct. It is also sustainable, producing less carbon emissions when compared to steel and concrete. Mass timber is fire-resistant, due to its mass and charring characteristics. Its fire resistance is enhanced by encapsulating it in fire-resistive and/or noncombustible material. References: NFC 2020 Subsection 56.4.

Slide 26	In December of 2019, the Province of BC facilitated an early adoption of the 2020 National Building Code EMTC building regulations to permit buildings up to 12 storeys for qualifying municipalities, through an opt-in regulation. Through the opt-in option, and by an alternative solution basis, the Province of BC already has a number of EMTC tall buildings, including: the 18-storey Tallwood House at Brock Commons (the tallest mass timber building in the world until 2019), the 19-storey Terrace House at 1250 West Hastings (7 storeys mass timber on 12 storeys concrete), and the 10-storey mass timber office tower at 2150 Keith Drive, also in Vancouver, BC. One would assume that mass timber construction will present some challenges to firefighting operations. References: NFC 2020 Subsection 5.6.4.
Slide 27	Plastics are synthetic materials that are found in a wide variety of products. They are found throughout a building interior and exterior including: window frames, plastic panels, insulations, fittings, piping, and vinyl siding to list just a few. The combustibility of plastics varies greatly but many plastics produce quantities of heavy, dense, dark smoke and release high concentrations of toxic gasses as they burn. Thermoplastic materials melt and drip when exposed to moderate to high heat while thermoset materials are fused by heat and will not melt as the plastic burns but their strength will decrease dramatically. This photo shows a combustibility test performed on ABS pipe at a fire scene. The fire investigators wanted to see if the pipe would sustain combustion which it clearly did. This was a field test that supported their hypothesis about fire spread.

Slide 28	That's the end of part one of Building Construction. In this part we discussed: • The types of building construction • The year of construction will identify the building and fire code requirements it was built to comply with. • That 50% of building and fire codes are based on fire protection • The size and use of the building is a main factors in what construction materials are used. • Not all Masonry walls are fire walls • With tilt-up concrete a lot of the strength of the walls comes from the roof • steel is often protected by masonry, concrete, or layers of gypsum board. • Glass can be manufactured to withstand heat and breaking • Traditional wired glass can no longer be used in doors
Slide 29	• Type X drywall can be used in fire rated designs • Type X drywall has a UL/ULC Marking printed on the back of each board • Fire-retardant treated wood is available but the downside is loss of strength • flame-spread rating is how rapid flame spreads the surface of a material • Mass timber construction offers benefits in terms of fire, acoustics, and structural performance • And we concluded this Part discussing a variety of plastic products that are found throughout a building. We identified that thermoplastic materials melt and drip, thermoset materials are fused by heat and will not melt but their strength will decrease dramatically.
Slide 30	Please move to part two.