STUDENT MANUAL

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PRINCIPLES OF BUILDING CONSTRUCTION: COMBUSTIBLE

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For The Fire Service Community

FEDERAL EMERGENCY MANAGEMENT AGENCY
UNITED STATES FIRE ADMINISTRATION
NATIONAL FIRE ACADEMY

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FOREWORD

The Federal Emergency Management Agency (FEMA) was established in 1979. FEMA's mission is to focus Federal effort on preparedness for, mitigation of, response to, and recovery from emergencies encompassing the full range of natural and manmade disasters.

FEMA's National Emergency Training Center (NETC) in Emmitsburg, Maryland, includes the United States Fire Administration (USFA), its National Fire Academy (NFA), and the Emergency Management Institute (EMI).

To achieve the USFA's legislated mandate (under Public Law 93-498, October 29, 1974), "to advance the professional development of fire service personnel and of other persons engaged in fire prevention and control activities," the U.S. Fire Administration has developed an effective program linkage with established fire training systems which exist at the State and local levels. It is the responsibility of the USFA to support and strengthen these delivery systems. The field courses of the USFA's National Fire Academy have been sponsored by the respective State fire training systems in every State.

This training course addresses the need for fire service Incident Commanders (IC's) to understand fully building construction, methods of construction, materials used in building construction, and fire-resistance requirements in order to conduct fire scene operations safely and make sound strategic decisions. The intent of this course is to prepare IC's, Company Officers (CO's), Safety Officers, and others to read a building correctly and use this knowledge in their decisionmaking process.

The USFA's National Fire Academy is proud to join with State and local fire agencies in providing educational opportunities to the members of the Nation's fire services.

TABLE OF CONTENTS

PAGE

COURSE GOAL

The overall goal of this course is to provide knowledge about the classification system of buildings, the importance of fire resistance for structural support elements, and the risks associated with performing fire-suppression activities inside and around buildings involved in fire. One additional major goal of this course is to enhance the skills of emergency response personnel so that they can read a building correctly and apply the information to the action plan for the incident.

At the conclusion of this course, students will be able to:

- Identify a building and correctly apply the classification system for the building in accordance with NFPA 220, *Standard on Types of Building Construction.*
- Identify the important structural features of a building and use this information in the formation of the Incident Action Plan (IAP), including the strategic goals, tactical objectives, and incident priorities.
- Identify critical sizeup issues such as smoke, heat, and fire travel inside a structure, and predict the path or method of travel based upon the building construction features.
- Identify critical safety issues that affect firefighter safety for each classification of construction and identify appropriate measures to enhance the safety of emergency responders.

TARGET AUDIENCE

This course material is intended to enhance the knowledge of building construction, improve fireground decisionmaking skills, and develop the ability of incident management personnel to make correct and safe decisions:

- Incident Commanders (IC's);
- Company Officers (CO's);
- code enforcement officials;
- Incident Safety Officers;
- individuals assigned as group, branch, or task leaders; and
- firefighters meeting the professional requirements for firefighters III.

COURSE SCHEDULE

Module 1: Introduction

Module 2: Principles of Building Construction

Module 3: Type V Wood-Frame Buildings

Module 4: Type III or Ordinary Construction

Module 5: Type IV or Heavy-Timber Construction

Module 6: Culminating Activity

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COURSE OVERVIEW

Module 1
This module is an introduction to building construction principles and classification of construction methods. It emphasizes the importance of the IC's, CO's, and Safety Officers being able to "read" a building's construction correctly. This module is used as an introduction both in this course and in the *Principles of Building Construction: Noncombustible* course.

Module 2
This module provides an overview of the common principles of construction that apply to all classifications of buildings, and includes subjects such as supporting loads, various methods of transferring loads to the ground, and structural elements that need to be evaluated critically during a fire to determine structural integrity. This module also is used in the *Principles of Building Construction: Noncombustible* course.

Module 3
This module gives general information about wood as a construction material and the five common methods of constructing buildings with wood, and provides an opportunity to apply the principles discussed. The material starts from the foundation and ends at the roof. This is intended to be an introduction to the principles of the construction for NFPA type V wood-frame buildings.

Module 4
This module provides general information about NFPA Type III or ordinary-construction buildings. The material covers the construction materials, construction principles, and problems often encountered as a result of renovations.

Module 5
This module provides general information about NFPA Type IV or heavy-timber buildings. The material covers the construction materials, construction principles, and problems often encountered as a result of renovations.

Module 6
This module provides an opportunity to apply the knowledge, skills, and abilities developed from this course by using scenarios representing common construction classifications found in the emergency responder's jurisdiction.

PROFESSIONAL COMPETENCY STANDARDS TOTALLY OR PARTIALLY COVERED IN THIS COURSE MATERIAL

NFPA 1001, *Standard for Fire Fighter Professional Qualifications* (1997 edition)

Chapter 3 Fire Fighter I

* 3-3.9 (a) "Dangerous building conditions created by fire."

* 3-3.11 (a) "Basic indicators of potential collapse or roof failure: the effects of construction type and elapsed time under fire conditions on structural integrity."

Chapter 4 Fire Fighter II

* 4-3.2 (a) "Dangerous building conditions created by fire and fire suppression activities; indicators of building collapse; the effects of fire and fire suppression activities on wood, masonry (brick, block, stone), cast iron, steel, reinforced concrete, gypsum wall board, glass, and plaster on lath."

*4-5.1(a) "The ability to identify the components of fire suppression and detection systems; sketch the site, buildings, and special features; detect hazards and special considerations to include in the preincident sketch."

NFPA 1021, *Standard for Fire Officer Professional Qualifications* (1997 edition)

Chapter 2 Fire Officer I

***** 2-6.1 "Develop a preincident plan, given an assigned facility and preplanning policies, procedures, and forms, so that all required elements are identified and the appropriate forms are completed and processed in accordance with policies and procedures."

* 2-6.1(a) "Elements of a preincident plan, basic building construction, basic fire protection systems and features, basic water supply, basic fuel loading, and fire growth and development."

Chapter 4 Fire Officer III

* 4-5.1 "Evaluate and identify construction, alarm, detection, and suppression features that contribute to or prevent the spread of fire, heat, and smoke development throughout the building or from one building to another, given an occupancy, to evaluate the development of a preincident plan for any of the following occupancies."

(a) Public assembly
(b) Educational
(c) Institutional
(d) Residential
(e) Business
(f) Industrial
(g) Manufacturing
(h) Storage
(i) Mercantile
(j) Special properties

* 4-5.1 "Fire behavior, program evaluation, building construction, inspection, incident reports, detection, alarm and suppression systems, and applicable codes, ordinances, and standards."

NFPA 1031, *Standard for Professional Qualifications for Fire Inspector* (1998 edition)

Chapter 3 Fire Inspector I

* 3-3.1 "Occupancy classification types, applicable codes and standards, regulations, operational features, and fire hazards presented by various occupancies."

* 3-3.4 "Classify the type of construction for an addition or remodeling project, given field observations or a description of the project and the materials being used, so that the construction type is classified and recorded in accordance with the applicable codes and standards and the policies of the agency being represented."

* 3-3.14 "Types of construction classification, rated construction components, typical building construction methods and materials."

Chapter 4 Fire Inspector II

* 4-3.2 "Identify the occupancy classification of a mixed-use building, given a description of the uses, so that each area is properly classified in accordance with applicable codes and standards."

MODULE 1: INTRODUCTION

OBJECTIVES

At the conclusion of this module, the students will be able to:

1. *Identify and list the critical sizeup factors related to the method of building construction, and the materials used.*

2. *Identify and describe the five types of building construction and list at least three critical factors for fire suppression.*

3. *Given a photograph of a building, identify the method of building construction and describe its construction features.*

INCIDENT COMMANDER MUST BE CAPABLE OF READING BUILDING CONSTRUCTION

It is critical that Incident Commanders (IC's), Company Officers (CO's), Safety Officers, and all other fireground officers have the knowledge, skills, and abilities to evaluate a structure quickly and accurately to identify its class and method of construction. This process often is called "reading a building." The initial decisions made about the building will affect the development of strategic goals and tactical objectives, as well as the overall action plan, and the safety of the emergency responders.

Sizeup

Sizeup considerations are critical to an officer's decisionmaking process. Most fire departments' operational policies require the first-arriving officer to provide an arrival report. Included in the arrival report is a description of the structure involved, the possible extension to exposures, critical life-safety issues, and initial strategic goals.

The Incident Action Plan (IAP) is developed in a sequential manner, with life safety being the highest priority. Both the firefighters' safety and the occupants' safety must be considered. The second step is to consider incident stabilization, while the third consideration is property conservation. All three aspects of the action plan require a thorough understanding of building construction, fire behavior factors within the building, and what aspects of the structure can be considered as strengths and assets to the scene operations. Also consider features that should be of special concern; for example, firefighters working on the roof of a wood-frame building with lightweight wood-truss rafters and fire extension into the rafter area may be at high risk. The truss rafters in this case would be a special concern. Firefighters advancing a hoseline through a fire-resistive building where all structural elements are constructed with a 4-hour fire rating would have limited risk from structural collapse. The fire resistance of the structural elements would be an asset or special strength for the structure.

Building Construction Information

Building construction information is an important consideration that the IC must evaluate in the decisionmaking process. Identifying buildings and understanding the classification system of buildings, along with common terminology used for building construction components, will assist the IC in making good, safe, and timely decisions. In addition, reading a building and the fire's behavior will help explain why certain conditions may be developing. As an example, understanding that many old "ordinary construction" buildings have been renovated over the years with the possibility of multiple ceilings and additional utility shafts will help explain fire behavior factors. Fire conditions with a light smoke condition on the first floor and reports of heavy smoke conditions on the lowest levels of the second floor may indicate fire travel in false ceiling void spaces.

THE INCIDENT COMMANDER MUST ACT QUICKLY

The IC has a limited opportunity to gather information about a building when it is on fire and decisions must be made in moments. The IC is faced with companies arriving and seeking tactical assignments. Heavy smoke conditions may obscure visibility from the Command Post (CP); a Quick Access Prefire Plan (QAP) may not exist for the structure.

Other professions typically have time and support staff to make critical decisions. A physician attending to an ill patient has time to ask questions, conduct research, and make decisions on how best to treat the patient. For difficult building construction problems, a team of fire and building design professionals can be consulted to help solve the problem.

As an IC, you also will have a critical need for information for the next structure fire you respond to. Fire may be extending to the upper floors of the structure, and you will need to answer the questions of how and why it is extending. Unfortunately, you do not have X-ray vision to see through the burning structure to answer the questions. Obviously the construction features are critical to fire, heat, and smoke travel within a building and often affect the spread to adjoining structures. Other critical decisions affecting the safety of firefighters are dependent on your knowledge of construction, such as roof and floor assemblies, lightweight construction materials, and fire-flow requirements.

A QAP provides critical construction information at a glance. This information is critical to the IC, to CO's being given tactical assignments, to the incident Safety Officer, and to others who may have assignments that could be affected by the construction or renovations of the structure. The classification of the structure and appropriate method of construction will provide general information typical for that method or classification.

As an example, to state on the QAP that the building is "wood frame" is good information, but it is only part of the information needed. Fire travel is significantly different in a wood-frame platform-construction building than it is for a wood-frame balloon-construction building. In a balloon building one could anticipate a very quick fire spread up the exterior walls, while in a platform-construction building fire spread up the exterior walls is a very slow process. The proper description must include a particular method of construction when it is constructed from wood.

The QAP will identify the methods and materials used to construct the floors and roof, which is critical knowledge. A fire officer assigned to vertical ventilation would benefit from the knowledge of how the roof was constructed and the materials used before he or she leaves the apparatus. A chainsaw does not work well on a slate roof, and an axe will take a long time to chop through a 2-inch plank roof. Other information such as voids, stairwells, or elevators marked on a QAP will eliminate surprises and will help to identify critical areas to check for fire extension. In addition, knowing if the structure is equipped with detection or suppression equipment also will assist the IC and other officers during the early stages of the fire.

Quick Access Prefire Plan

Building Address: *14 Berry Patch Lane*

Building Description:
110' x 30'; two-story, wood-frame, platform construction, with a basement; firewall between front and rear of structure.

Roof Construction:
Truss rafters covered with cedar shakes, plywood sheathing.

Floor Construction:
2" x 8" floor joists, particle board sheathing.

Occupancy Type:
Single-family dwelling

Initial Resources Required:
1 heavy rescue, 2 engines,
2 tanker/tenders

Hazards to Personnel:
No special hazards

Location of Water Supply:
Icehouse Pond--3,000 feet north

Available Flow:
Dry hydrant--accessible all year

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*675*	*1,350*	*2,025*	*2,700*

**Fire flow based on 110' x 30' two-story--1 exposure--¾ of water is for extinguishment at any involvement*

Fire Behavior Prediction:
Slow horizontal and vertical fire spread.

Predicted Strategies:
Rescue, ventilation, exposures, confinement, extinguishment. Residential sprinkler system in occupied areas of structure should confine or extinguish fire.

Problems Anticipated:
Very large structure will require additional resources to develop water supply if more than 10% involved.

☐ Standpipe:	☒ Sprinklers:	☐ Fire Detection:
No	*Storage tank in basement*	*No*

TYPES OF BUILDING CONSTRUCTION

Building Classification System

Building construction classifications are based upon combustibility and fire resistance. The terminology used to define the buildings has changed over the years, while the features of the construction methods have remained consistent. While building design professionals may identify a building as a Type I, the fire service may refer to it as a fire-resistive building. Both descriptive terms correctly identify the building. The National Fire Protection Association (NFPA) has developed Standard 220, *Standard on Types of Building Construction*, which uses Type I, II, III, IV, or V to identify a particular type of building. The fire service typically has used other terms to identify a building, such as wood frame for a building that uses wood as its structural element, or ordinary for a building constructed with noncombustible exterior walls (usually masonry materials) and having a wood-frame interior. This often is referred to as "Main Street, USA," the type of construction that could be found on the main street in any small town.

Fire-resistance ratings for construction materials are established as a result of recognized and accepted testing methods. Standards such as those developed by the American Society for Testing and Materials (ASTM) commonly are used in building codes to test such items as firewalls, fire doors, and other fire-rated construction components. Agencies such as Underwriters Laboratories (UL), Factory Mutual (FM), and other testing laboratories typically test construction materials and components in the form in which they will be used. As an example, a fire door would be tested with a fire-rated doorframe as a total component. To use a fire-rated door with a lightweight wood frame around it would defeat the purpose, which is to stop a fire from spreading to the other side.

Some construction materials, such as wood, can be protected and gain fire resistance by a variety of methods, including protection within a fire-resistant assembly or by a treatment with a fire-retardant solution. The standards defining various classifications of buildings use the terms "limited combustible" and "noncombustible" to identify certain characteristics about the material. Limited combustible identifies structural materials that have about one-half (not to exceed 3,500 Btu/lb) the heat potential of wood (Douglas fir 8,400 Btu/lb); materials that are essentially noncombustible but have a combustible coat or cover that does not have a flame-spread rating above red oak (a flame-spread rating of 100); or where the entire structural member does not have a flame-spread rating in excess of 25, which is not changed by cutting through the material.

This method typically involves treating the exterior of the wood with a fire-retardent chemical, which will reduce the flame-spread rating below 50. If the lumber is sawed, it then has exposed portions without the fire-retardent treatment, thus negating the limited-combustible intent. Many building codes require structures such as multiple-residence dwelling units that may have exposed wooden joists to be painted with a fire-retardent paint. Some communities have required this fire-retardent paint in areas of buildings that are noncombustible, but painted. The New York City Housing Authority requires the emergency stairwells in highrise apartment buildings to be painted with fire-retardent paint instead of latex or enamel paints to eliminate the vertical spread of fire on the painted surface.

Noncombustible materials are those that will not ignite, burn, support combustion, or release flammable vapors when heated. While these materials cannot be ignited or will not support combustion, they may react to heat in a manner that could affect structural stability. As an example, unprotected steel is a noncombustible material, but expands significantly when heated, which either could push a wall out or, if it is confined, twist and turn with the possibility of structural members falling. In addition, at about 1,000ºF (538ºC) steel loses about 50 percent of its load-carrying capability.

Type I--Fire-Resistive Buildings

Fire-resistive buildings may be used for many different occupancies, such as office buildings, shopping centers, or residential units. The critical structural element is the requirement that all walls, floors, roofs, and supporting members be made of noncombustible materials. In addition, any noncombustible material, such as steel, that is subject to stress from high temperatures must be protected from heat that may cause failure. Structural elements such as bearing walls, columns, beams, girders, trusses, and floors must be constructed in accordance with standards developed as a result of standardized fire-resistance testing. Fire-resistance ratings range from as little as 2 hours for interior bearing walls to 4 hours for beams, girders, and trusses. The advantage of this type of structure for fire suppression operations is that there should be very minimal exposure to structural collapse. There have been several instances in this building classification where fires have burned well past the designed time for fire resistance and, while they have suffered structural deterioration, the structures have not collapsed.

Type II--Noncombustible Buildings

Noncombustible buildings may be used for many different occupancies, such as office buildings, warehouses, and automobile repair shops. The critical structural element is the requirement that structural members such as walls, floors, roofs, and supporting structural members be made from noncombustible or limited-combustible materials. Structural elements may have from 0 to 2-hour fire-resistance rating. The concern for fire suppression operations is that the unprotected steel structural elements, under fire conditions, could expand or relax, thus causing structural failure.

Type III--Ordinary-Construction Buildings

An ordinary-construction building can be used for offices, retail sales, or be a mixed occupancy such as a retail sales store on the first floor and a dwelling unit on the second floor. This construction method often is referred to as "Main Street, USA," since it is representative of building types on a main street in small-town America. The critical structural element is the requirement that the exterior walls be constructed of noncombustible materials, which is most commonly masonry or stone. Interior walls and supporting structural elements typically are made from wood, which may be required to have a fire-resistance rating of up to 1 hour. Fire resistance may be rated from 0 to as much as 1 hour for bearing walls, support columns, beams, girders, floors, and roofs. The advantage of this method of construction is that the exterior walls are noncombustible. The concerns for this classification are the combustible structural elements and void areas created during renovations, e.g., dropped ceilings.

Type IV--Heavy Timber (Mill)

A heavy-timber building most generally is used for manufacturing, storage, or other similar purposes that require a structure to support very heavy floor loads. Today many of these buildings have been converted for other occupancies, such as retail stores and dwelling units. This method of construction also may be called "mill construction," reflecting the intended use for the earliest of these types of buildings. The critical structural elements are that the exterior walls are constructed from noncombustible materials, typically masonry or stone, and the interior support materials are made from large wooden timbers. Supporting columns for floors are required to be a minimum of 8 inches wide and 8 inches in depth. Other support members are a minimum of 4 inches by 6 inches. Floors typically are constructed of heavy planks 3 inches thick, with a finished floor installed above the planks. The strengths for this classification of building are the noncombustible exterior walls and the large wooden interior support systems. Concerns for this building type are the void areas created by renovations, which are not allowed in this type of construction, and openings in the floors for items such as conveyor belts, freight elevators, and power transfer systems, that can allow for rapid fire and smoke spread between floors.

Type V--Wood Frame

A wood-frame building may be used for many different purposes, such as single-family dwellings, multiple-family dwellings, restaurants, or retail stores. There are five distinct methods of wood-frame construction, including log, post-and-beam, balloon, platform, and plank-and-beam. Typically, the structural elements are made from wood. Some other materials may be used as well, such as steel for a center carrier beam to support the floor joists for the first floor. Fire resistance generally is limited, but can be required to be up to 1 hour for certain applications.

Multiple Classifications or Interconnected Construction Types

Fire protection considerations generally are based on the highest level of fire resistance or combustibility under fire conditions. As an example, if a wood-frame building is constructed next to a noncombustible structure, with unprotected openings from the wood-frame building into the adjoining noncombustible building, the fire service, for fire suppression purposes, would consider the entire structure as a wood-frame building. Should the openings from the wood-frame building into the noncombustible building be protected with a fire-resistance-rated closure, the wood-frame building could be treated as an exposure to the noncombustible building. This same method would apply to other similar applications of different construction classification types. In addition, if there is no rated fire separation between the different classifications, the fire-flow requirements must be made for the largest area for both buildings, and should not be treated simply as an exposure.

SUMMARY

A critical element of sizeup must be the ability of the IC to read a building properly to identify several important factors. These include the method or classification of building construction, the resistance to fire and heat for critical structural members, possible renovations within the building that may have created void areas, and explaining the movement of heat, smoke, and fire within the building. It is critical that the IC, Safety Officer, CO, and crew leaders understand their work environment and the strengths of the structure, as well as areas that raise concerns about its structural stability, fire resistance, and ability of fire, heat, and smoke to travel through the building.

Buildings typically are constructed in five distinct classifications.

1. Type I--Fire-resistive buildings;
2. Type II--Noncombustible buildings;
3. Type III--Ordinary buildings;
4. Type IV--Heavy-timber buildings; and
5. Type V--Wood-frame buildings.

Construction materials and methods, as well as their relationship to fire suppression, for Types I and II are covered in this course. Types III, IV, and V are covered in depth in the National Fire Academy (NFA) training course *Principles of Building Construction: Noncombustible.*

Activity 1.1

Identification of Construction Classifications

Purpose

To reinforce your ability to read a building's construction, and to identify the classification of construction, since this may affect the IC's decisionmaking process.

Directions

The instructor will display a slide representative of a certain classification of building construction or a particular method of construction for the wood-frame classification. In the space provided, write the classification and method of construction, if appropriate, for a wood-frame building. After you view the slides, the instructor will review them and ask you to identify the construction classification for a particular slide.

Slide #1 ____________________

Slide #2 ____________________

Slide #3 ____________________

Slide #4 ____________________

Slide #5 ____________________

Slide #6 ____________________

Slide #7 ____________________

Slide #8 ____________________

Slide #9 ____________________

Slide #10 ____________________

Slide #11 ____________________

MODULE 2: PRINCIPLES OF BUILDING CONSTRUCTION

OBJECTIVES

At the conclusion of this module, the students will be able to:

1. *Identify nine different loads or forces within a building that affect its stability under fire conditions.*

2. *Describe at least one safety consideration for impact loads.*

3. *Identify three forces on building materials that may affect structural stability.*

4. *When given a graphic display of various loads within a building, identify the type of load being applied.*

PRINCIPLES OF BUILDING CONSTRUCTION

Every ounce of weight that goes into the construction of a building or is added after it has been constructed must be transferred to the foundation of the building, and eventually to solid ground. Many different types of loads affect the building at all times, and the loads applied to the structural elements will vary from day to day or even from hour to hour. It is critical that Incident Commanders (IC's), Company Officers (CO's), and firefighters fully understand how loads are carried, how they are transferred from one material to another, and that an unanticipated load can cause critical safety concerns.

Types of Designed Loads

As architects and building design professionals start the process of designing and engineering a building construction plan, they must consider several decisions. These decisions will affect the size of construction materials, the load-carrying capacity of the materials, and the amount of fire resistance needed to meet appropriate building and fire codes.

One consideration is the occupancy of the structure. A building designed to serve as office space will have significant structural differences from a building housing a warehouse for paper storage. The owner must provide the load-carrying information carefully and accurately to the design professional, so that the proper structural elements are included in the plans. This is often a critical problem when a structure changes owners, if loads are not evaluated properly by the new owner. A building designed for a 200-pound-per-square-foot load now facing a 1,000-pound-per-square-foot load may not be able to support the new load.

Another consideration is the environmental condition of the area. A building in Hawaii does not have a significant snow load concern, while a building constructed in Vermont will not be subjected to salt water spray. Items such as wind load or shear, snow or rain load, hurricane winds, earthquake zones, and other considerations are critical to the structure and must be considered in its design.

Concentrated and Distributed Loads

A concentrated load places a great deal of weight in one place and on a limited number of structural members. A heavy file cabinet, large pile of copy machine paper, refrigerator or freezer, air conditioning unit on a roof, or other heavy objects place a concentrated load in a small area, which in turn is transferred to other supporting members in a limited manner. If this load has been anticipated and the building is designed for the transfer to other supporting structural members, it would not be of concern to firefighters. If it was not designed and constructed with appropriate structural elements, the floors may sag and even fail under the weight because of inappropriate design and selection of construction materials. As an example, if a hot tub has been installed on the second floor of a lightweight-construction dwelling without the knowledge of the design and construction team, the additional load, which is a concentrated load, may cause the floor to sag or fail. A 200-gallon hot tub will weigh nearly a ton, and may apply its weight in only 36 square feet of space. This load, as well as the weight of other items in the area, may span only four or five floor joists. If those joists rest over a set of windows or doors, the lintel above the windows or doors may be overtaxed under normal conditions, let alone under fire conditions where the materials are being attacked by the fire.

A distributed load is one that is applied over a large area with the load being transferred to the structural support system. As an example, the weight of the hot tub described in the previous paragraph would be distributed over a larger area or greater number of structural supports. If the design professional were aware of a hot tub on the second floor, the floor joists may be doubled, the lintels may be doubled, or more of the load may be transferred to an interior wall.

Dead and Live Loads

The dead weight of a building consists of those components of a structure that are attached permanently, or are built into the structure during its design phase. Each time a building is renovated or a new feature is added, the design load must be evaluated again to ensure that the structural elements will support the load. As an example, an older building without air conditioning being retrofitted with central air may have a large, heavy compressor unit placed on the roof. A building design professional must evaluate all the structural elements from the roof to the ground to determine if the additional load can be supported. In many cases, a larger platform to hold the compressor unit must be constructed on the roof first to distribute the load over a greater area than just that of the frame of the machinery.

All structural elements including the walls, floors, ceilings, and roof are examples of dead load. In addition, permanent fixtures such as bathtubs, furnaces, light fixtures, and other finishing items for the structure would be defined as part of the dead load.

The live load of a building is what the occupants bring in and take out. This aspect of structural loading should be of special interest to firefighters, especially under fire conditions. In many cases, the occupancy has changed from the original owner, and live loads have been placed for convenience rather than for structural safety. A room that was designed originally for an office now may be stacked to the ceiling with heavy cartons of copy paper. In addition, the copy machine that weighs 1,000 pounds or more also may be placed in the same room. This scenario should raise the interest of firefighters and cause them to investigate how the load is being supported. This may be a critical element under fire conditions, as fire and gravity work together toward structural failure.

Static, Impact, and Suspended Loads

Static loads are those that are in place and continuously place the same weight on the supporting structural members. An impact load is one that applies its load in an instantaneous manner. A feather lying on a shelf is a dead load. When the feather falls from the shelf and hits the floor, it is an impact load. While the feather has little weight and falls slowly, the results would be different if it were a 2-ton safe falling 20 feet. The impact load of the safe may far exceed the load-carrying ability of the floor it hits. The failure of this section of floor may cause other structural items to fail. Structural failure, especially with older buildings, is a common occurrence in many communities. New York City typically has several total or partial structural collapses each year. In many instances, it was an impact load that caused the sequence of events leading to the structural failure.

Suspended loads, if not engineered properly, also can create special risks to firefighters. As an example, a mezzanine is a partially suspended floor supported by structural elements. The mezzanine may be supported on one or more sides by an exterior wall, while the remainder of the weight is suspended from cables, rods, or structural steel supports to a structural element above the mezzanine. This entire load must be transferred to the structural support system, along with all the other weight the system was designed to support. In many cases, mezzanines were added after the original structure was constructed. Some suspended loads may be part of the original design of a building. These may include suspended stairways, walkways, or equipment areas. One hotel walkway collapsed under the weight of many people standing and dancing on it.

Axial, Eccentric, and Torsional Loading

The preferred method of supporting any load is with the axial method. The axial method of loading places the load directly through the center of the mass of the supporting element. This method places the load evenly over the supporting element, with no load or force offset to push, twist, or try to turn the supporting structural member. Most buildings are constructed using this principle of loads being supported directly and straight to their support below. This method of support is typically the strongest method of transferring weight to the floor below or to the foundation.

An eccentric load is one that is placed on one side of a supporting member with one side of the support carrying the load and the rest of the support carrying no load. This is similar to placing a joist hanger on a structural member, such as a carrier beam, and then placing the floor joist in the hanger. The load is applied totally to one side of the carrier beam, placing an eccentric load on the carrier beam. If the floor joist simply were placed on the top of the carrier beam, it would have been an axial load and would place less stress on the carrier beam as it supports the floor joist.

A torsional load is one that is trying to twist, turn, pull, or place a load on the structural element that would cause it to turn and possibly fail. As an example, if an eye bolt were installed in a support column, and a cable were attached to help stabilize the wall that is pushing outward, it would place a torsional load on the support column. If the column had a significant load placed on it, the column might not move, but if the load of the cable exceeded the strength of the column, it would cause it to twist and turn.

Compression, Tension, and Shear

All structural elements are always under one or more type of force. The most common force is compression, or a pushing force. It is imperative that the correct structural material be used to resist the appropriate force that will be applied. Wood construction typically uses dimension lumber 2 inches by 4 inches wide or 2 inches by 6 inches wide and 8 feet long. In some instances, the lumber will reach 12, 14, or even 16 feet long. Wood works best under compression when used in the proper method. A 2- by 4-inch structural member is stronger the shorter it is. A 1-foot structural member has a much greater load-carrying capability than does an 8-foot structural member. Wood as a construction material works best when loaded in an axial manner and placed in compression.

Structural steel or cable work well as construction materials when the force to be applied is tension or a pulling force. A steel cable or structural steel member can support heavy pulling loads. Steel rods or cables commonly are used to hold load-bearing walls in place, and work well under tension to hold the walls. Steel cable or rods would support hardly any weight under tension (pushing).

The force of shear is a critical aspect of structural stability, since the entire structure is subject to thousands of critical elements under shear pressure. As nails are used to hold structural elements in place, they are all under shear pressure. Shear force is trying to bend, twist, or pull the structural materials apart or break them. In some instances, specially hardened materials are used because of the forces trying to shear or break the materials. The bolts used on a ladder truck to hold the turntable to the truck require a very special hardened steel bolt because of the shear forces applied when the aerial device is fully loaded and extended. All the weight and force are placed on a series of bolts and, without the special steel, they would shear quickly, causing the ladder to fail. The same principles are applied to a nail holding two boards together or bolts holding steel beams in a highrise building.

Steel and Concrete as a Combination

The tensile strength of concrete can be increased with the addition of structural steel wire or rods. While concrete works extremely well in compression, it does not work well in tension or react well to shear forces. When steel is added it greatly increases the capability of concrete.

Concrete that will be used in compression, but will be subjected to some other forces or concentrated loads, will be strengthened with the addition of steel mesh, wire, or reinforcing rods placed near the center of the concrete slab. Concrete floors, concrete roads, concrete bridges, or concrete foundations all will contain steel to add tensile strength to the concrete.

Concrete that is poured at a factory and transported to a construction site often is prestressed with steel reinforcing rods built into the concrete structural element. Concrete floor slabs are prestressed to carry the anticipated loads and apply them to a supporting member at each end. The structural element is built with an arch that, when a load is applied, is intended to flatten out. This prestressing typically uses concrete, steel reinforcing rods, and a designed arch to prestress the structural member for a specific location and function.

Poststressed concrete is stressed after the concrete is poured in place. As the forms are built, high tensile strength steel cables are placed in the forms in a strategic manner so that they may be tightened as the concrete cures, adding tensile strength to the concrete. The steel cables are pulled very tight, to specific pressures, and then locked in place. This provides a new dimension of load-carrying ability to the concrete. The concrete can carry the compression load easily, and the steel cable will carry the tensile load trying to break the concrete apart. In some instances, if additional loads are to be applied at a later date, the rods can be tightened to provide even greater load-carrying capabilities.

Concrete without steel to provide tensile strength would not be a very effective construction material. The steel wire, mesh, rods, or cables provide it with tensile strength to carry and support heavy loads. Of special interest or concern to firefighters is the impact on this steel if the concrete is heated or if the steel is exposed to heat. As steel is heated, it expands and would therefore allow the concrete to bend, crack, or fail.

Variables in the Stability of Beams

A beam is the horizontal member of the structural support system designed to carry, support, and transfer loads. The deeper or thicker the beam, the greater the load-carrying capability; the shorter the span of a beam, the greater the load-carrying ability. The greater the number of supports for the beam, the larger capacity it will carry.

A simple beam is one continuous structural member supported on each end. It will support greater weight near the ends or support areas of the beam than it would in the center. This would be an example of a floor joist supported at each end.

A continuous beam is one long structural element supported in numerous locations. This could be a center carrier beam in the basement of a dwelling that runs down the center of the structure and will support one end of each floor joist. This carrier beam could be one continuous steel "I" beam, or could be made from several pieces of lumber nailed together and arranged in a staggered manner so there is no one seam all the way through the structural member.

A cantilever beam is one that is supported on one end, but has one end that is unsupported and relies upon the strength of the material to support the loads applied to the unsupported end. Cantilever beams are used for such construction as unsupported balconies. There are different methods of supporting the fixed end, such as extending it inside the floor section and allowing it to extend past the supporting member, such as a wall. Other, more sophisticated methods use cables or rods to suspend part of the beam from a structural member such as a bearing wall. This cable or rod also would place additional stress on the wall, similar to a torsional or eccentric load. Of special concern to firefighters is how the cantilever is supported, what effect the support is having on other structural members, and what will happen if the structural supports deteriorate from a fire.

Behavior of Materials Under Fire Conditions

The stability of a structure or items within a structure at the time of a fire when the structural elements may be compromised is a critical aspect of reading a building and predicting safety concerns. Items such as loads on and within a structure must be evaluated for stability, proper structural design to carry the loads, and the effect on the structural integrity of the structure if the load changes, shifts, or falls.

Structural materials must be evaluated for their resistance to fire and heat, the rapid changes in temperature that may occur, and what may happen when items start falling and impact loads occur.

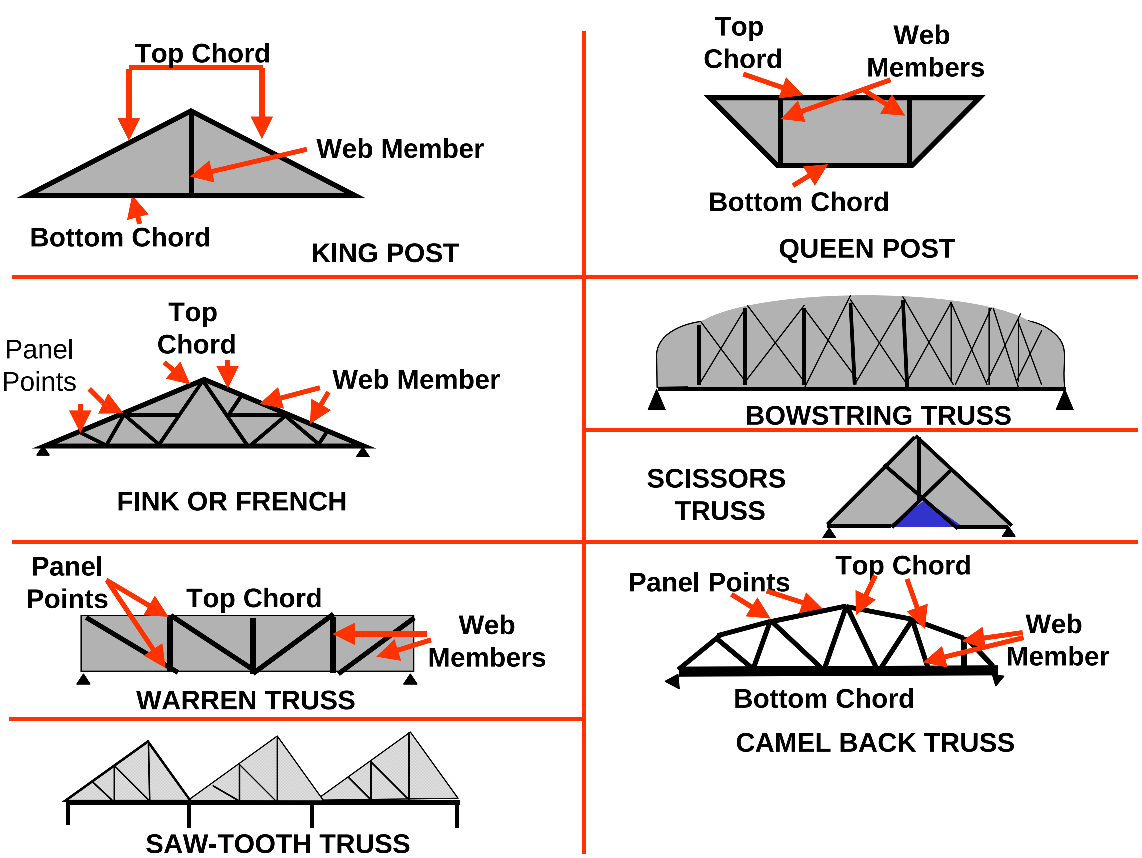
Connections should be evaluated for failure potential and the impact of connection failure on the entire structure. A single steel connector plate failure on a wooden truss rafter or joist could cause catastrophic failure of the entire support system.

Wall structures should be evaluated. It is critical to evaluate whether a wall is a load-bearing wall or a curtain wall (non-load bearing). The loss of a load-bearing wall generally will result in at least a partial structural failure, while loss of a curtain wall may not. In some instances, structural frames are built to support the structural load, and the wall material is simply to keep the weather out. These walls are called floating walls and rely on connections to the support system for strength. Should a backdraft or an explosion occur inside the structure, it could tip the wall outward.

The Use of Triangulation and Arches as a Support System

The arch is one of the oldest known methods of spanning openings and supporting the loads above. Many materials have been used to construct arches, including stone, wood, and brick. When constructed with all components in place, the arch is dependent on each component to hold the other in place. The loss of one component from the arch will cause the rest to fall. This concept today has evolved into steel arches and laminated wooden arches that provide large open spans for churches, arenas, or other such areas.

The use of the triangle provides a very strong element. This concept provides the basic element of the truss rafter or joist. The truss structural element typically is made from wood or structural steel. One new concept is to use lightweight sheet steel wall studs to form lightweight steel truss rafters. One common joist is called the "bar joist," since the web members forming the triangle are made from steel rods similar to the reinforcing rods used in concrete. The top and bottom chords of this joist are made from angle iron. The wooden joists commonly use small-dimension lumber such as a 2- by 4-inch or 2-inch by 6-inch piece of lumber, and connect the elements together with metal gusset plates. The metal plates have been processed through a stamping machine which cuts teeth about ½-inch long from one side of the plate. These teeth are pressed into the wood and hold the elements together. Another process used small pieces of wood, such as plywood, at each splice, which is glued and nailed or stapled. Trusses with the triangulation principles are very strong, but can become a very significant concern for failure under fire conditions. One well-known author of texts on building construction often made the statement, "Beware Of The Truss."



Fire Travel and Extension

The experienced IC, fire officer, and firefighter always are evaluating fire conditions, and particularly fire extension and travel. In many instances, fire uses void areas, such as dropped ceiling spaces, to travel through the building. Any metal-grid ceiling filled in with ceiling tiles is a prime suspect for a void area. Many firefighters report that fire was traveling in the void space directly over their heads and they were unaware of it. One experienced fire officer often suggested to his personnel that, in large open areas, such as supermarkets, offices, or schools that have metal-grid ceilings, they open the ceiling space frequently and early to check for fire travel.

Fire in attic spaces is attacking the structural elements of the structure, and firefighters may be working above it to perform functions such as ventilation. Floors that appear to be extra thick should be examined to determine if the floor support system is bar joist or parallel chord trusses which create huge void areas for fire travel.

Areas around utility services always should be suspected as areas where fire can extend. In many instances, a hole is made in a wall to extend a wire, pipe, or other utility, and the hole is larger than the pipe or wire. The contractor may not come back and seal the area around the pipe or wire, which is now an area for fire travel and extension. In many older buildings totally new plumbing and electrical systems have been installed. This often is accomplished by building a new shaft in the corner of a room or a closet, extending the utilities through the new shaft, and then working the pipes and wires through areas such as voids in the ceiling area.

The movement of smoke, heat, or fire within a structure often is affected by voids, shafts, air currents, and other factors. You must be able to read a building's construction and predict the possible avenues or paths of extension that the fire and heat are taking so that you may become proactive and cut them off. There is absolutely no substitute for knowledge of these potential concerns about a structure before an incident occurs. This can be gained by performing inspections either during the construction of new construction or in existing buildings. Conducting these inspections in existing buildings will be more challenging. Construction information that may not be obvious may be available through your local fire prevention section or building department. The information collected can be drafted into the Quick Access Prefire Plans (QAP's).

Activity 2.1

Identification of Live, Dead, and Impact Loads

Purpose

To provide an opportunity for you to determine which items are dead weight and which are considered live weight in a building.

Directions

1. Refer to your Student Manual (SM).

2. List the 9 items identified in the graphic of the print shop by letter as either a dead load or a live load.

	Live or Dead	***Description of Item***
a.	______________________	*Temporary bracing for new roofing--steel "I" beam (will be removed once new roof is installed.*
b.	______________________	*Supporting bearing wall studs for floor above.*
c.	______________________	*Portable safe on wheels.*
d.	______________________	*Boxes of paper in storage.*
e.	______________________	*Low ceiling light fixture attached to the ceiling.*
f.	______________________	*6-inch column supporting floor above.*
g.	______________________	*Gas furnace bolted to basement floor.*
h.	______________________	*Air conditioning unit permanently attached to the roof structure.*
i.	______________________	*Large copying machine that was designed as part of the original structural floor plan and is permanently attached to the structure*

3. Answer the two questions regarding the safe falling through the floor.

   a. What type of load would it be when the safe hits the boxes of paper on the second floor?

      ____

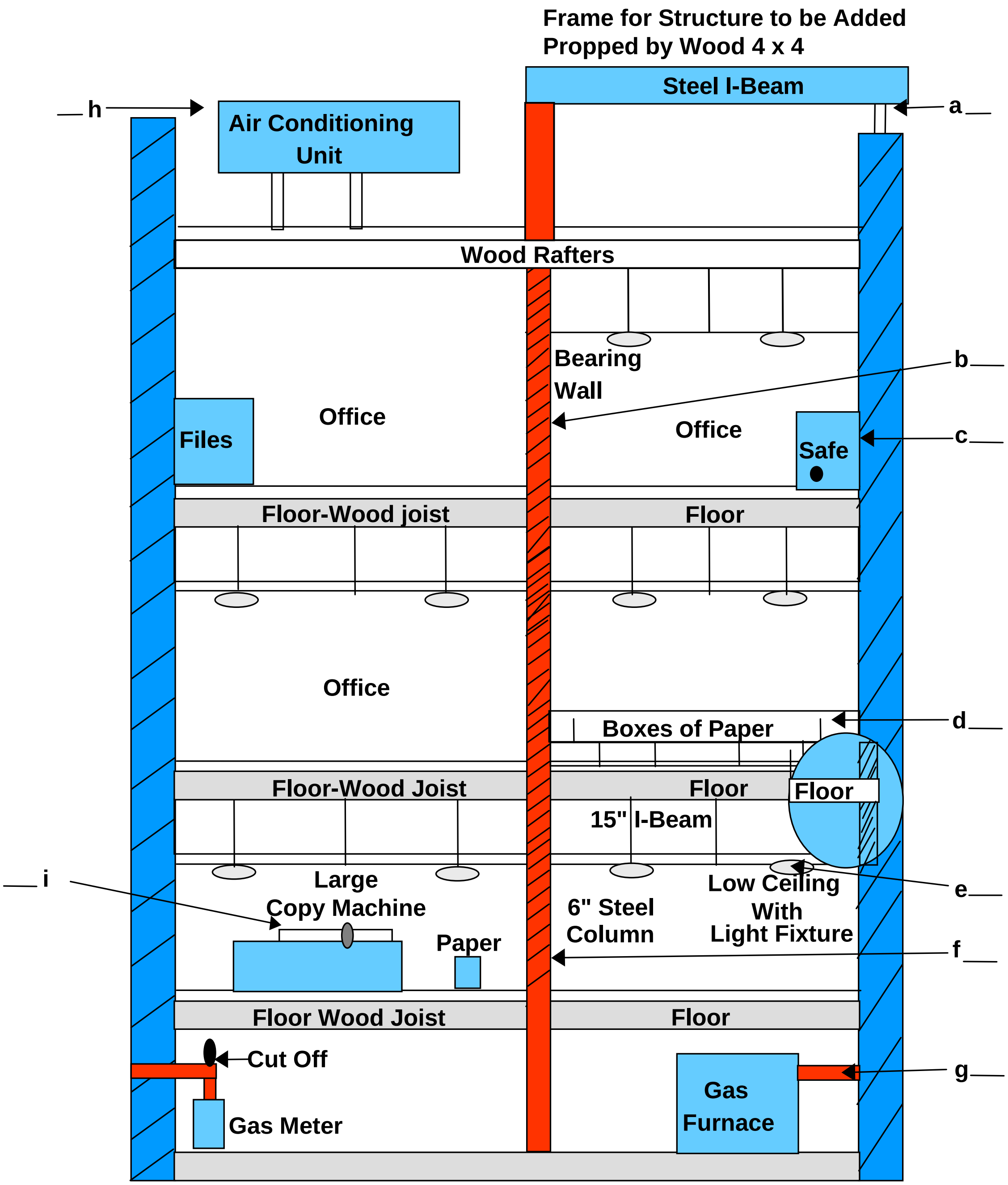
   b. What could happen to the remainder of the structure if the safe fell through the floor, and why could it happen?

      ____
      ____
      ____

4. You will be allowed 20 minutes to complete the activity.

Activity 2.1 (cont'd)

Building Plan



MODULE 3: TYPE V WOOD-FRAME BUILDINGS

OBJECTIVES

At the conclusion of this module, the students will be able to:

1. *Identify and describe five methods of wood-frame construction.*

2. *Identify the strengths and concerns for wood and wood-frame construction.*

3. *Identify and describe three structural or construction features of each type of construction that are critical under fire conditions.*

4. *Identify and justify critical construction features for fire, heat, and smoke travel when given a scenario for each of the five methods of construction.*

CHARACTERISTICS OF TYPE V WOOD-FRAME BUILDINGS

Wood has been the most popular construction material since the United States was first settled. The availability of timber was certainly a factor, as well as the ability to work with the material with a limited range of tools.

The National Fire Protection Association (NFPA) defines Type V (wood-frame) construction as the type in which exterior walls, bearing walls, columns, beams, girders, trusses, arches, floors, and roofs are entirely of wood or other approved combustible material smaller than the material required for Type IV (heavy-timber) construction. In addition, structural members shall have fire-resistance ratings not less than those specified in Table 3-1. Table 3-1 identifies two subclassifications; one requires a one-hour fire-resistance rating for all structural materials except exterior nonbearing walls. The other does not require any fire-resistance rating for structural materials. The subclassification that does not require any fire resistance carries a provision that local authorities having jurisdiction (AHJ) may require that exterior bearing walls and exterior nonbearing walls both be fire resistant. Some communities have established fire limits where buildings with combustible walls may not be constructed; if a building is to have a minimal separation from an adjacent building, it must have a fire-resistive exterior wall. This is done to prevent fire spread and reduce the potential for conflagration.

Table 3-1
Fire-Resistance Rating (in hours) for Type I through Type V Construction

	Type I		Type II			Type III		Type IV	Type V	
	443	332	222	111	000	211	200	2HH	111	000
Exterior Bearing Walls -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting one floor only……………..	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting a roof only…………………	4	3	1	1	0[1]	2	2	2	1	0[1]
Interior Bearing Walls -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	2	1	0
Supporting one floor only……………..	3	3	2	1	0	1	0	1	1	0
Supporting a roof only…………………	3	3	1	1	0	1	0	1	1	0
Columns -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only……………..	3	2	2	1	0	1	0	H[2]	1	0
Supporting a roof only…………………	3	2	1	1	0	1	0	H[2]	1	0
Beams, Girders, Trusses & Arches -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only……………..	3	2	2	1	0	1	0	H[2]	1	0
Supporting a roof only…………………	3	2	1	1	0	1	0	H[2]	1	0
Floor Construction	3	2	2	1	0	1	0	H[2]	1	0
Roof Construction	2	1 1/2	1	1	0	1	0	H[2]	1	0
Exterior Nonbearing Walls	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]

(Shaded) Those members that shall be permitted to be of approved combustible material.

1 See A-3-1 (Table).
2 "H" indicates heavy timber members; see text for requirements.

Wood can be made fire resistive in several ways. It can be treated with a fire-resistive chemical, or it can be encased in a fire-resistive material, such as gypsum board, that is installed in a prescribed manner.

Construction technology has evolved from using logs cut from the forest and placed on top of each other, to the ability to laminate wood, glue wood into heavy timbers, bend wood into circles, and treat it with preservatives.

Wood-frame construction has evolved from the simple log cabin into five general methods of construction. The five recognized methods of wood-frame construction are the following:

1. Log.

2. Post-and-beam.

3. Balloon.

4. Platform.

5. Plank-and-beam.

The strength and load-carrying capacity of wood is affected by several factors. Wood structural members used in a horizontal position, such as for floor joists and roof rafters, have three different types of stress placed on them. The top is under compression, with the wood fiber being compressed toward the center of the structural member. The bottom is under tension and, because of the forces caused by the compression on the top, is being stretched apart. The middle of the structure is in a neutral plane, and is the dividing line between compression and tension. If a structural member must be weakened, such as to drill a hole for an electrical wire, it should be done as close to the neutral plane as possible.

The greater the mass of the structural material, the greater the load-carrying capability. A 2- by 12-inch floor joist will have a greater load-carrying capability than a 2- by 4-inch structural member.

The shorter the span between supports the greater the load-carrying capability. A 2- by 8-inch floor joist with a span of 4 feet between supports will have a greater load-carrying capability than one that spans 8 feet between supports. Structural members placed in a vertical position are primarily under compression and have a greater load-carrying capacity than materials of the same dimension placed in a horizontal position supported only on the ends.

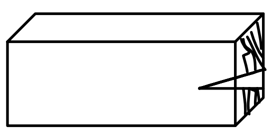
By its nature wood is a combustible material, with its burning time affected by its surface-to-mass ratio. A cross section of a 2- by 4-inch wall stud equals 8 square inches of mass and 12 inches of surface area. A cross section of a 4- by 4-inch post equals 16 square inches of mass and 16 inches of surface area. The 4- by 4-inch post has a great deal more mass without a significant increase in the surface area. If the 2- by 4-inch wall stud were made into toothpicks, it would have thousands more times the surface area, and be consumed by fire in seconds rather than minutes. The other factor that benefits greater mass is the process of combustion itself, where the solid (wood) must be converted to a gas before it burns. After the initial fire chars the outside of the wood, the ability of the wood to off combustible gases is reduced, and the process of combustion is slowed.

Chemical fire treatment is one method of developing fire resistance of wood. Since the treatment may penetrate only the surface, the benefit of the protection may be diminished if the wood is cut. In addition, a problem occurs when plywood is treated with chemicals, as the glue allows the layers to delaminate. The U.S. Fire Administration (USFA) has issued an alert bulletin to inform the fire service of this danger. This type of plywood was allowed to be used in many jurisdictions where a fire-resistant material was required adjacent to firewalls. Several instances were reported when persons working on a roof fell through the plywood roof decking, which had delaminated.

Preservatives also are used to keep the wood from rotting or to prevent insect infestation. Some preservatives are oil or petroleum based and may add to the combustibility of the wood. Others contain chemicals such as ammonium arsenate or chromated copper arsenate, which pose some risk if inhaled during the combustion process, thus necessitating the need to wear self-contained breathing apparatus (SCBA).

Other conditions that affect the strength of wood structural materials include termites, which weaken the wood by tunneling inside; decay, such as fungus, that may destroy the wood fiber; or dry rot (fungus that destroys wet wood, and is dry when the damage is discovered, thus called "dry rot") which reduces the load-carrying capability of the wood. These are critical in structural elements such as floor joists, which, when exposed to fire, may burn faster and weaken more quickly than would otherwise be the case.

Defects in wood also can affect the load-carrying capability, especially if the defect is in the tension or compression mode of a structural member. Common defects include

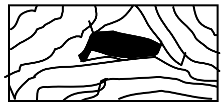


A. SHAKE

Shake: Lengthwise separation between growth rings of wood, which reduces shear resistance.

Slope: Line of the wood fiber in relationship to the direction of the horizontal line at the center of the structural member. This also is known as cross grain, which is prone to warping.

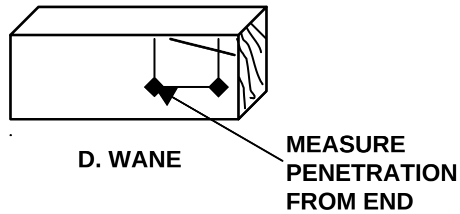
B. SLOPE



C. KNOT

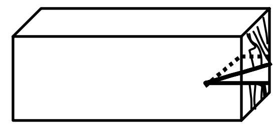
Knots: Changes in tree growth from horizontal to vertical growth, such as for a limb, which cause a fault or weak area, especially if they fall in the compression or tension area of the structural member.

Wane: Bark included in the structural member, which is only minimally attached to the wood and has little strength.



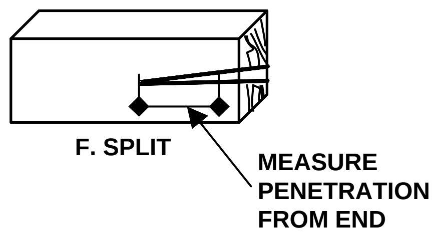
D. WANE

Checks: Separations in wood across growth rings, which reduces shear resistance.



E. CHECK

Splits: Lengthwise separations between the grains of wood, which reduces tension resistance.



F. SPLIT

Other items that affect strength or flammability are plastic construction materials or coverings used to provide a desired look, such as hand-hewn wood beams. Commonly this is found in restaurants, where roof structural members are covered at the ceiling level with imitation wood beams. The material is used for decorative purposes, not for structural purposes. Safety considerations include the "drip effect" caused by the burning plastic at the ceiling level as firefighters operate below.

Connection methods used for wood-frame structural members are a critical aspect of stability. One common construction method is to use construction adhesive. This adhesive often is used for attaching finish materials to structural elements, and is itself a flammable material.

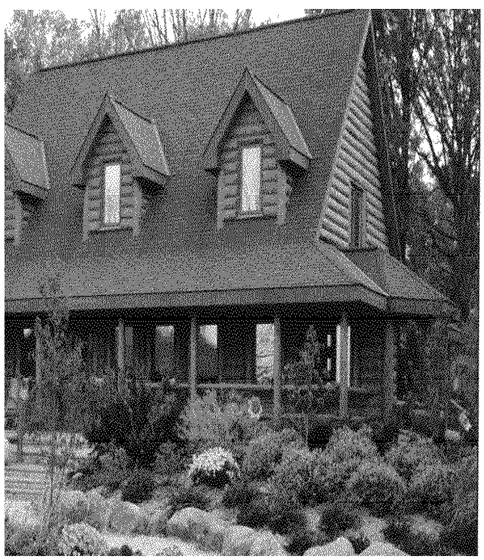
One of the first methods of connecting two structural members was the insertion method, using a mortise on one element and a tenon on the other. This was very common in post-and-beam buildings such as barns and older homes. Another common method still in use today is the tongue-and-groove method, where one member has been cut with a groove on one side and another structural member is cut with a tongue on one side so that the two can be joined in a manner that forms a locking joint. This is commonly used in plank-and-beam roof boards.

Fasteners are the most common devices used, and include nails, metal gusset plates for truss construction, metal plates and bolts, and metal brackets nailed to a structural member to hold another structural member. These devices are called joist hangers.

Another technique is the self-locking method used in early log construction, where logs would be notched and fitted into the next log in a self-locking manner. Log construction today uses this process, but also relies on bolts and nails to lock the walls and wall sections together.

PRINCIPLES OF WOOD-FRAME CONSTRUCTION

Log Construction



Log construction is the most basic of wood-frame construction methods. As the early settlers cleared the land of timber, the smaller logs were used to construct buildings by placing them one on top of another. They were fastened with a self-locking technique where the ends would be notched to interface with a notch from a second log at a 90-degree angle. With the limited availability of tools, mainly using an axe, the settlers could fashion a building from the logs quickly and easily.

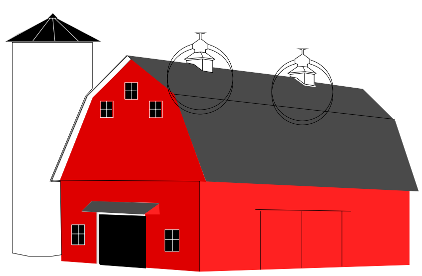
Most modern log homes use logs that have been sawn or machined to produce flat surfaces and a uniform-size log. The logs used in most modern log homes have been kiln dried to prevent cracking and splitting. The logs are prepared with a tongue-and-groove arrangement, so that they lock when they are stacked to form walls. In between the tongue-and-groove splice, a neoprene or silicone weather seal is installed. The logs also are secured with a long nail or bolt that fastens the top log to the one below. This method of securing the logs is continued for the entire height of the wall. As logs in the wall are placed end-to-end for long wall sections, they also are prepared with a tongue-and-groove lock on the ends to provide additional strength to the wall and joint, as well as an additional weather seal.

The base (bottom) log typically is placed on a foundation or on a first-floor deck constructed with typical floor joist and sheathing material such as plywood. In some instances, such as a summer residence, the logs may be placed on pillars instead of a foundation. Another method is to place the first log directly onto a concrete slab prepared to be both the foundation and floor of the building.

Interior walls of a log building are constructed of wall studs and covered with gypsum sheet rock, wood paneling, or boards. In some buildings, a smaller version of construction logs is used for interior partitions. When logs are used for interior walls they are prepared and installed in the same manner as for the exterior walls. Many log buildings used as dwellings have bedroom lofts.

Log homes have a readily available fuel source in the structural elements (wood logs). Due to the mass of the logs, if they should ignite they will quickly char on the outside, which slows the combustion process. Typically the logs are finished with some sealant or protective coating, such as varnish or shellac, which adds to the combustibility of the walls. It is common for log homes to have open floor plans, which provide limited or no fire separation between functional areas (kitchen, dining room, living room, or great room) and, along with the cathedral ceiling, allow a significant heat buildup causing an early flashover. The positive aspect is that the log walls will remain strong for a considerable amount of time under fire conditions. Fire experience has shown that the log walls are still structurally intact and strong after the roof has failed.

Post-and-Beam Construction



Post-and-beam construction followed the log construction methods and became popular as power saws became available. The construction methods used structural members that were typically a minimum of 4 by 4 inches. Structural elements consisted of posts for the vertical members and beams for the horizontal members that spanned between the posts. When erected, the building's skeleton of posts and beams could stand alone until a sheathing material was applied. In buildings such as barns, the dimension of the posts and beams would be much larger than 4 by 4 inches, while dwellings made from this method were the typical 4 by 4 inches or smaller structural elements. Many of the connections on these buildings used a locking technique with a mortise-and-tenon connection secured with a wooden peg through the connection to keep it from separating.

Typically fieldstone would be laid up to create a foundation on which to set the walls and floor of the structure. Floors often were dirt, wood boards, or, later, covered with concrete. This method of construction did not last long for the construction of dwellings, but is still used today for barns. A modified version of this construction method, called pole barns, is used extensively today. Large poles are placed in holes several feet apart. Large-dimension lumber, such as 2 by 6 inches or 2 by 8 inches is used to span between the poles, and the sheathing material is attached to the walls. A ribbon board is attached to the top of the poles and, typically, a wooden truss rafter system is installed. Purlins are placed across the truss rafters, and sheathing material is applied with a regular asphalt roof or corrugated metal plates attached.

The frame of the posts and beams of the building was covered on the outside with boards, and the inside was left open and uncovered, especially in barns. In dwellings, the inside of the posts typically are covered with boards. In some designs today it has become popular to have exposed beams and posts. Many new buildings are made to look like post-and-beam structures inside with the posts and beams left exposed.

Outside wall covering for post-and-beam construction was typically board and batten. The boards were installed vertically on the beams, and the joints between the boards would be covered with a small board called a batten, which was used to seal the open joints between the boards and keep the weather out.

Roof construction was typically a skeleton of posts and beams covered with purlins (boards that run from structural member to structural member). The roofing material then would be attached to the purlins. The roof could have been slate, wooden shake shingles, or sheets of steel. Another method was to use planks over the structural frame instead of purlins. Preincident information about structural members and roof-covering techniques would be vital to determine appropriate strategic goals and tactical objectives.

Special considerations for post-and-beam buildings include work done during renovations to the structure. In many instances, steel structural members have been used to strengthen the structure, or as temporary support while renovations are completed. One area of special concern is the connection of the beams and posts, where the area used to create the mortise and tenon has less mass than the remaining portions of the structural material. If the interior has been finished, the cavity between the interior and exterior wall coverings may create large void areas that will allow fire extension.

Balloon-Frame Construction

Balloon-frame construction was first used about 1833, and became a very popular method of wood-frame construction until about 1950. The advent of sawmills around 1833 opened the way for long and evenly shaped pieces of lumber which were needed for balloon-frame buildings.

With long continuous wall studs that could span from the foundation of a structure to the roof, a new era of building construction began. Most communities have wood-frame structures built prior to 1950, and most of those were constructed with the balloon-frame method. The first nails used to nail the lumber together were made in a blacksmith shop, and were called "cut nails." As machine-made nails became available, the process became even faster and ever more popular. Even when long timbers became scarce, some contractors simply nailed smaller pieces of wood together to make long wall studs.

Foundations are extremely important to a building's stability. Early foundations were made from fieldstones carefully placed on top of each other to create a solid base on which to construct a building. In areas where temperatures go below freezing, it is important to place the footing for the foundation below the frostline, so it will not be affected by the freezing and thawing which cause ground movement. Cinder blocks, concrete blocks, and poured concrete walls replaced the fieldstones for foundations.

A sill plate (piece of dimension lumber such as a 2- by 8-inch board) is placed on top of the foundation, which is where the wall starts. The wall studs are placed on top of the sill plate, and the walls are started. A board called a ribbon board is placed on the studs at the level where the first floor is to be placed. The ribbon board was typically a 1- by 6-inch board which would be nailed horizontally onto the vertical wall studs. The purpose of a ribbon board was to provide an additional base for the floor joist that rests on top of it.

The floor joists were typically 2 by 8 or 2 by 10 inches, and were placed on top of the ribbon board and nailed to the wall studs. A carrier beam at the center of the building would support the opposite end of the floor joist. The center carrier beam, along with the post that supported it, also was wood. The floor joist would be covered with boards, usually laid diagonally across the floor joists.

Second and third floors would be installed in a manner similar to the first floor, using a recessed ribbon board. One major difference was that the ribbon board would be recessed into the wall stud so that it would not protrude out of the wall into the ceiling area of the room. The second-floor joist would be laid upon the ribbon board adjacent to a wall stud and nailed to the wall stud. The floor joist in the center of the building would be supported on top of the interior walls and partitions. This load would be transferred to the floor below and ultimately to the center carrier beam that supports the first floor.

At the top of the wall studs another board, called an overlay (usually 2 by 6 inches), would be attached. This would provide the structure to support a ceiling on the top floor. This also would become the floor joist for the attic, should the attic be finished off. In many instances, only a few boards would be placed on these overlays to create a walkway through the center of the attic to install wiring, open attic windows for ventilation, and to provide some storage area. Many buildings which originally were constructed with no intent of using the attic as a living area have been renovated into occupied areas. This usually requires covering the floor, which may not have been engineered originally or constructed for the additional load. Attics that are occupied as living space always should be evaluated carefully for structural stability to ensure the new loads applied to the structure have been engineered and transferred to the ground properly.

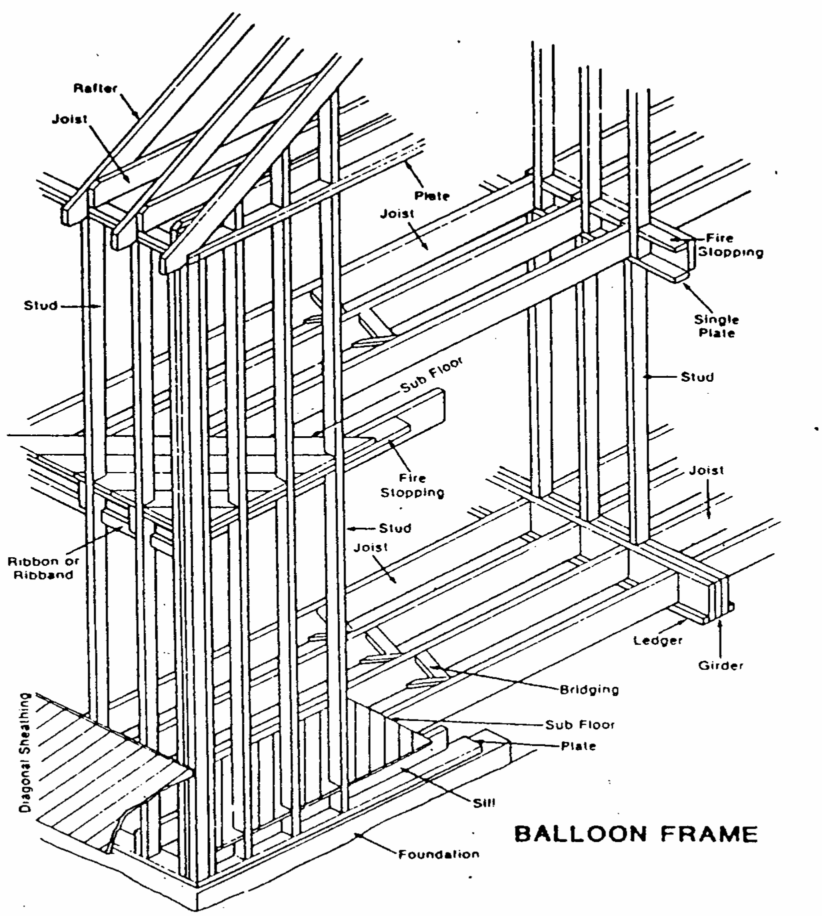
In order to keep the building from twisting and turning (called racking), the corners typically were braced. This bracing would be a 1-inch board recessed into the wall stud so that it would be flat on the interior wall.

In an effort to keep heat in the structure, some enterprising contractors would fill stud channels with brick or stone. The intent was to absorb heat during the day from the sun and act as a heat sink so it would continue to radiate heat well after the sun went down. This additional load built into a second-or third-story wall can pose some unexpected concerns for structural failure because of the weight. The benefit of the heat sink is that it acts as a firestop in the stud channel.

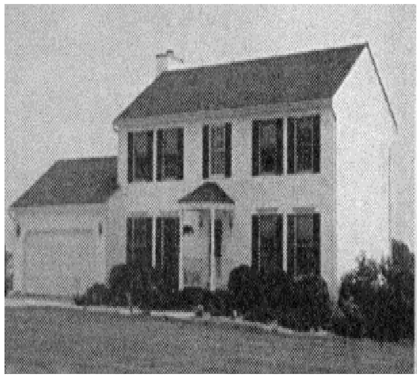
The roof was made from dimension lumber such as 2- by 6-inch roof rafters. They are supported on the exterior wall and at the top, where they interconnect with a rafter coming from the opposite side of the building. In between the two rafters is a board called a ridgeboard. The purpose of the ridgeboard is to help distribute the weight and keep the rafters from pushing sideways until the roof boards are in place. Roof coverings included slate (stone), wooden shake shingles (often made from cedar), metal sheets, or asphalt material such as shingles or rolled roofing.

Stud channels were well suited for tall double-hung windows. It was common to stack the windows in a stud channel with the second-floor windows directly above those of the first floor. This is often a good indicator that a building may be balloon construction. One positive aspect of the stacking of windows is they provided some firestopping in the open stud channels.

Open stud channels are typically the most significant concern for fire travel. With open stud channels interconnected to open floor-joist channels, the spread of fire, heat, or smoke is a significant concern. Generally a fire in a balloon-construction building will travel the exterior walls most easily. In recent years, many older buildings have been renovated, and the stud channels filled with insulation material which also serves as a firestop. Firefighters often have reported that when they went to the attic of a balloon-frame building to check fire extension they could see the light from a firefighter's flashlight in the basement shining up the stud channel. Smoke showing from the exterior walls for the entire length of the wall is a very good indication that the building is balloon construction, and a fire may be in the basement.



Platform-Frame Construction



Platform construction is the most common method of wood-frame construction being used today. The method of building a platform (one floor at a time) started in the late 1940's and became most popular in the early 1950's. As the availability of virgin timber dwindled, long wall studs used to construct balloon-frame buildings became difficult to obtain. Some vendors made long structural members from short pieces spliced end to end, but the practice never gained popularity. In platform construction, one builds a floor deck, puts the walls on the floor, and puts another floor down on top of the wall studs, thus the term "platform." Design professionals have taken advantage of this concept and the flexibility it provides for walls, windows, dormers, and other unique design opportunities.

Like other structures, the foundation is a critical element for the stability of the structure. Foundations are typically poured-in-place concrete or block walls. In some instances, wooden walls have been used for foundations. The wooden foundation walls are constructed from pressure-treated lumber, which provides resistance to rotting and insects. Some building codes prohibit the amount of wooden wall that can be exposed above grade, as it poses the same fire potential as a three-story wood-frame building, which may not be permitted by certain codes. When a foundation wall is breached to allow for a garage door, entry door, bulkhead door, or window, the foundation must be provided with a lintel, which will transfer the load to the walls adjacent to the opening and back onto the foundation.

The first-floor platform is installed directly on the foundation. The floor joists are laid onto a sill, which is bolted to the foundation wall. The inside portion of the floor joist is supported on a carrier beam. This beam may be several pieces of dimension lumber laminated or nailed to form one continuous beam, or it could be a steel "I" beam. This carrier beam is supported approximately every 8 to 10 feet with a post resting on the basement floor or other support. A layer of plywood or particle board is placed over the floor joist (called a subfloor). The platform now is ready for a wall (one story) to be installed. The process is repeated for the second floor, third floor, and may go as high as six stories. In some instances, wood-frame platform buildings have been eight stories or more.

Floor joists can be made in several different ways. The most common joist is dimension lumber, 2 by 6 inches or larger, placed with one end on the foundation and the other on the center carrier beam. Another method is the bar joist truss, which can be made from 2- by 4-inch lumber or larger. Some bar joist trusses have a top and bottom chord that use dimension lumber, while the center web is made from stamped sheet metal plates attached with gang nail plates that are pressed into the wood. Steel bar joists are also an option, though seldom used in wood-frame buildings, since it is difficult to nail the floor elements directly to the steel joist.

A third-floor joist used is the wooden "I" beam, which is made from a top and bottom chord of dimension lumber. Typically a 2- by 4-inch board is run across a saw with a special saw blade which cuts a groove into the lumber from 3/4 to 1 inch deep. A section of plywood or particleboard is glued and sandwiched between the top and bottom chord. The plywood in between the dimension lumber can be 3/8 to 5/8 inch or thicker, depending on the span, the load it will carry, and how much of the neutral plane will be removed for items such as furnace air ducts or an air-conditioning system. These units come under the same stresses as a piece of dimension lumber, with the top chord being under compression, the bottom under tension, and the center being the neutral plane. Any services to be run through the wooden "I" beams should be placed as close to the center as possible. One concern for these units is the lack of mass of material under fire conditions and the potential for early failure.

Floor joists also can be installed in joist hangers which are attached to the foundation or wall area where they will be placed. Joist hangers are intended to carry the structural member without adding another 6 inches (height of the joist) or more to the height of the building. Since room height typically is 8 feet, this technique usually is reserved for the ground floor of the building.

Wall studs are made from dimension lumber such as 2- by 4-inch or 2- by 6-inch boards. In order to meet more stringent energy conservation requirements imposed in many States today, the exterior walls of structures will use wall studs of 2- by 6-inch lumber. Wall studs are sandwiched between a sill at the bottom and a plate on the top. If additional floor loads are to be carried on a wall, many contractors will put a double plate on the top to help carry the load. An advantage of this construction technique for fire suppression is that it is extremely difficult for a fire to burn through the exterior walls. To do so it must burn through the platform, burn through the sill, extend up the stud channel, burn through the plate or double plate, and then start all over again with the next floor. Fire does not travel easily up exterior walls of platform-frame buildings.

Second floors are constructed in the same manner as the first. A deck or platform is put in place with the floor joist and then a subfloor is attached. The structure now is ready for another set of walls and another story. The top floor provides the base for the roof rafters and the overlays (instead of floor joists) for the ceiling of the top floor. If truss rafters are used, the bottom chord of the truss is used for the ceiling of the top floor.

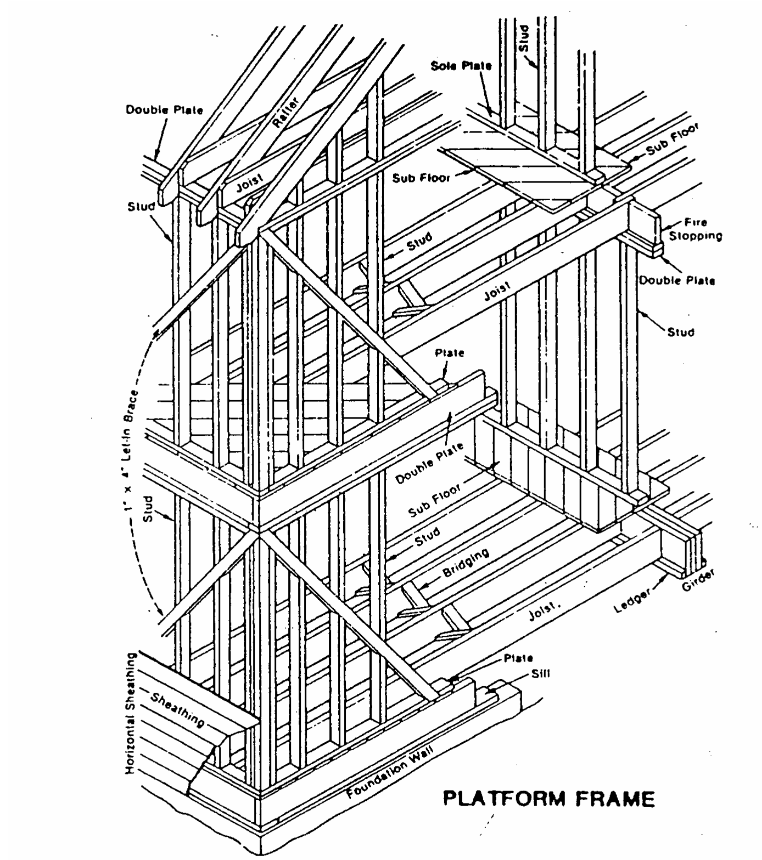
Roofs can be constructed with a simple rafter system, as described in balloon-constructed buildings, or can use trusses. Trusses are made at a factory that has a special facility for building truss rafters. The pieces for the truss are cut, laid on a pattern, metal gusset plates are laid over each connection, and a hydraulic press is used to push the teeth of the gusset plates into the wood in one smooth action. Many lumber supply stores sell metal gusset plates, but without a press, they often are installed with a hammer, which causes many of the teeth to bend and not push into the wood. Flat roofs also can use wooden "I" beams as roof rafters. These are common on commercial buildings, such as strip malls, as the roof rafter system on flat roofs. Dormers can be added as decoration or as a functional area of an occupied upper floor.

Dwellings that use attic areas as living space would have a standard rafter system, since truss rafters occupy the area between the roof and the ceiling below. One common method of platform construction is called Cape Cod This enables a portion of the top floor to be used as living space. The roof rafters start at the top of the first-floor wall and go to the center ridgeboard on a steep pitch. The center area of the floor space is used, and is separated from the outside wall by a "knee wall." The knee wall is installed when the roof line and floor are approximately 24 to 48 inches apart. Often dormer windows are installed for additional light and ventilation; the dormer window sits directly on top of the knee wall. The area behind the knee wall is a void area, and susceptible to fire travel and extension from a fire below or one that comes out of a first-floor window and gets into the soffet overhang of the roof. Doors can be installed in the knee wall, and this area sometimes is used for storage or by children as a play area. In buildings with knee walls, consider conducting a primary search for children behind the knee walls.

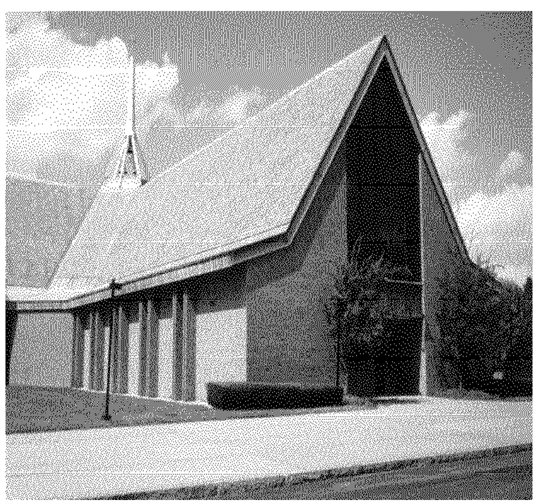
There are special considerations for platform-frame buildings constructed as garden apartments or townhouses. Garden apartments typically have kitchens and bathrooms that are back-to-back with the adjoining apartments, for convenience of plumbing and vent lines. Many fire departments have responded to a kitchen fire in one apartment and have found rapid extension into another kitchen on the same floor or on a floor above.

Garden apartments with clothes dryers will have three vent pipes running from the apartment to the attic and over to the soffit: one vent for the dryer, one for the bathroom fan, and a third for a kitchen fan. A lint fire in the dryer can quickly result in a fire in the attic. A standard tactical objective should be to check the upper floors and attic for fire extension. Often shortcuts during the construction of a building can lead to problems later. Instances have been reported where gypsum board on kitchen walls behind kitchen cabinets was nonexistent or did not cover the wall studs totally, which allowed a fire in one kitchen to extend quickly to another kitchen.

Townhouse construction, while similar to garden apartments, poses some unique challenges. One item that is often different in townhouse construction is done for noise separation between units. The most common method is to design a separation wall that uses 2- by 6-inch sill and plate in the wall assembly and 2- by 4-inch wall studs arranged (staggered) so that each unit will have its own wall studs. This places about 2 inches between the wall studs from one unit to the next. This void area often is filled with insulation. This wall also may be covered with an extra thickness of gypsum board to meet required fire-resistance requirements in the local building code. A second method is to place separate platforms on a common foundation with an air separation between the townhouses. A separate platform with floor joists, center carrier beam, and sheathing material is used for each townhouse. An air space of 2 to 3 inches is left between platforms as a noise-deadening area. Wall assemblies are prepared on top of the platform, similar to a single-family dwelling. Each townhouse has its own side walls, as well as the front and back walls. Some building codes require that the exterior of the side that faces the wall of the neighboring unit be covered with a fire-resistive material (typically gypsum board) to prevent the possibility of rapid fire spread between the townhouses. This air space presents the same challenges as balloon-frame buildings, allowing fire, smoke, and heat to extend rapidly from the basement to the attic if no firestopping is in place.



Plank-and-Beam Construction



The plank-and-beam method of construction uses beams of significant size to provide a framework which then is covered with thick planks that span the framework. While this method of construction is similar to post-and-beam construction, where a rigid frame of posts and beams essentially can stand alone due to the interconnections of the beams and posts, plank and beam uses the plank to tie the structural supports together. Also, the post-and-beam method uses solid lumber elements; the plank-and-beam method uses laminated boards to create large timbers, and uses the plank to tie the structural members (beams) together. This type of construction is used for structures such as churches, large open recreation buildings, or other buildings which require a high ceiling and no supports in the center of the structure to support the weight of the roof.

The structural beams are thick pieces of lumber that taper as they rise toward the peak of the roof; they are made from boards glued together to form the structural member. The ends of the boards are end-spliced and glued. Tests have shown that the finger splice at the ends of the boards, combined with the glue, make the splice as strong or stronger than other parts of the beam. Once laminated, they are sawn into smooth and tapered structural members. The next step in the preparation of the structural beam is to bend or arch it, which is done slowly on large shaping devices. The laminated beams typically are large at the bottom and taper to a much smaller section at the peak of the roof. The purpose is to increase load-carrying capabilities as the load increases from the top downward.

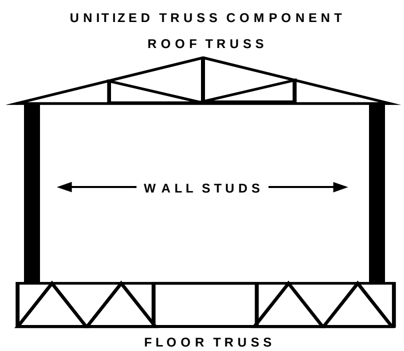
The large beams rest on a concrete foundation at ground level and are secured in a steel saddle, which is secured into the foundation. However, the beams can rest on walls above the foundation, which require some type of special bracing (such as a buttress) to the wall because of the forces trying to push the wall outward. Typically the beams for this structure are between 10 and 20 feet apart. While they will be supporting only the weight of the structure and roof, each beam has a very significant load applied to it, especially in areas that have heavy snow.

In some instances, buildings are renovated with this method or similar methods of construction, to provide cathedral ceilings. Sometimes the entire structural package is placed on top of existing first-floor walls. The Incident Commander (IC) should determine, in the initial review of the structure, the impact of a fire weakening the first floor, as well as how the load from the upper floors is being transferred to the ground through the first floor.

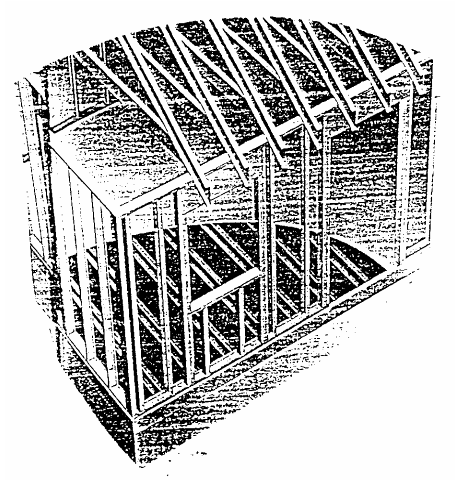
The thick varnished planks are applied directly to the beams to provide a ceiling on the inside and a roof board on the outside. The planks provide rigidity to the structure. The planks are typically 2 to 3 inches thick, and are prepared in a tongue-and-groove manner to provide an interlocking roof system. The roof covering can be applied directly to the planks or, if energy conservation is a concern, a layer of insulation can be applied and another layer of sheathing used over the plank to cover the insulation before the final roofing material is applied. The varnished interior of the plank, along with the beams, can provide an ideal surface for rapid fire spread should it become involved in fire.

Considerations under fire conditions include several items that the IC should be aware of. The thick beams and planks provide a substantial fire load, along with the varnished finish which can generate significant flame spread across the surface. Another feature that will allow the fire to spread rapidly is the typical large, open areas of the structure common to this method of construction. The thick plank on the roof will have a considerable burn-through time, and self-venting is not a viable option. Similar to the concerns for a truss roof rafter system, the loss of one beam could cause building failure, since the span between structural supports (beams) now could be 30 to 40 feet. On the positive side, due to the mass of the structural beams, there is only a limited chance of failure in the early stages of the fire. In some instances where fire suppression has been successful in the early stages of the fire, the structural beams have been refinished and reused during the reconstruction of the building.

NEW TECHNOLOGY



The next generation of truss construction may very well use a process called "unitized trusses" to construct buildings. The unitized truss concept incorporates the truss roof rafter, the wall stud, and the truss floor joist built and installed as one integral unit. This method would work best for trusses built and installed at the construction site, due to the size of the completed unitized truss member. Transportation on highways may pose limitations for factory-built units, due to their size. This method of constructing one element containing the structural members for the floor, walls, and roof could expedite the installation phase of construction. A concern for this process is the danger of failure from one component (such as the floor truss section) and the impact on the rest of the structural member. As with all truss systems, another concern is the load-carrying ability of neighboring trusses when one or more truss in the structural system is lost. In addition, the floor truss section, if covered on the bottom chord of the truss, could create a large void area between the ceiling of the basement and the floor above. The wall studs being an integral part of the unitized truss also creates a balloon construction effect for the exterior wall, since there is no sill or plate in the wall arrangement to stop the spread of heat, smoke, or fire. Early structural collapse or failure can be expected after full fire involvement.



Another change in structural materials is the use of steel studs, which have become popular for many construction projects. Lightweight galvanized (to prevent rusting) sheet steel is formed easily into structural elements such as 2- by 4-inch or 2- by 6-inch wall studs. These noncombustible studs are stamped to provide openings for services such as electrical wiring and waterlines to pass through. One special risk is that the wall stud is an excellent conductor of electricity, and could become energized should an electrical malfunction occur at a wall stud. The steel wall stud is extremely dependent on its covering material to provide strength and stability. Connections to the metal studs typically are made with sheet metal screws, pop rivets, or threaded nails.

Metal wall studs also are configured into lightweight metal truss rafters. The term lightweight trusses can take on a whole new meaning. While the unit is strong once it is constructed and held in place by other elements of the structure, it is an excellent heat sink and could relax very quickly under fire conditions.

Manmade materials, such as plastic structural elements, will become common in the future. Plastic can be molded, formed, made strong, and is a natural extension for the construction industry. One plastics manufacturer has produced a totally plastic single-story dwelling. The dwelling looks like all the rest on the street, with its vinyl siding. Plastic panels for floors, interior and exterior walls, and the roof were made in the factory, taken to the construction site, and installed, with the panels being fused together.

SUMMARY

A thorough sizeup to determine a building's construction classification as well as to identify fire behavior, smoke travel, and heat buildup is extremely important for the IC to be able to make good strategic and tactical decisions. All other officers given tactical assignments, the Safety Officer, and firefighters as well should take the time needed to complete a sizeup to identify concerns about the structure as well as the strengths.

Buildings are classified into five major categories as identified by NFPA 220, *Standard on Types of Building Construction.* While the method of construction is the same for the fire service as it is for the NFPA, the terminology used by the fire service to identify buildings may be different from NFPA 220. The fire service also further defines Type V (wood-frame) buildings by five major construction methods:

1. Type I--Fire resistive.
2. Type II--Noncombustible.
3. Type III--Ordinary.
4. Type IV--Heavy timber or Mill.
5. Type V--Wood frame.

    a. Log.
    b. Post-and-beam.
    c. Balloon.
    d. Platform.
    e. Plank-and-beam.

Fire, heat, and smoke travel inside wood-frame and wood-construction buildings can be affected significantly by the method of construction. Balloon-frame buildings typically experience quick and easy fire spread up the outside wall stud channels as well as across the floor joists which are interconnected to the studs. Platform-frame construction seldom sees extensive fire travel up the outside walls, due to the materials blocking the fire's path. Fire travel most often is observed in the inside walls.

Activity 3.1

Log Construction

Purpose

To apply knowledge of the construction features of log buildings under fire conditions.

Directions

1. Your group will be assigned one of the three scenarios.

2. Your group should read its scenario, review the slide of its building, select a spokesperson to represent your group, and answer the questions below.

   a. List specific safety concerns as they pertain to the classification of the building.

   b. Has flashover occurred yet? If not, is there a danger of it happening?

   c. What method of wood-frame construction was used in this building?

   d. List three positive features for this method of construction.

   e. List at least one special concern for this method of construction.

   f. How will fire, heat, and smoke travel through this structure?

   g. Would you expect fire suppression to be a significant challenge? Why?

3. After 15 minutes, the groups should be prepared to report their findings.

Scenario 1: 14 Pine Bush Road

A fire has been reported in a day care center. The normal occupancy is 50 children and 15 adults. The caller states that smoke is coming from a storeroom in the basement. The caller also reports that the building is being evacuated. It is 1210 hours on a Tuesday afternoon. The local television station was at the center filming a news segment and now has switched to the live news program.

Quick Access Prefire Plan

Building Address: *14 Pine Bush Road*

Building Description:
Two-story building constructed as a day care center 40' by 60' with a full basement that has several classrooms, storage rooms, and small cafeteria. Year built: 1995.

Roof Construction:
2" by 10" rafters 24" on-center covered with plywood and asphalt shingles.

Floor Construction:
2" by 10" joists 16" on-center covered with 1" of plywood and carpet.

Occupancy Type:
Day care center
Normal census = 50 children & 15 adults

Initial Resources Required:
4 engines, 2 ladders, 2 ambulances

Hazards to Personnel:
Cleaning supplies stored in basement maintenance area.

Location of Water Supply:
12 & 40 Pine Bush Road

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*400*	*800*	*1,200*	*1,600*

**Estimated fire flow based on 40' by 60' two stories and no exposures.*

Fire Behavior Prediction:
First floor has cathedral ceilings for high buildup and early flashover. Vent early.

Predicted Strategies:
RESCUE and ACCOUNTABILITY are critical, followed by exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
On special occasions many parents and guests are present for special events. Normal census may go as high as 150 at these events. Look for the number of cars in parking lot as a clue--normally about 12.

☐ **Standpipe:**

☒ **Sprinklers:**
Basement only except maintenance room.

☒ **Fire Detection:**
Heat and smoke detection with auto dialer to 911 dispatch.

Scenario 2: 2 Hilltop Drive

A fire has been reported in a single-family residence. The elderly caller reports that her husband was working on the oil furnace in the basement when an explosion occurred. She further states that there is smoke coming from the basement door and her husband does not answer.

Quick Access Prefire Plan

Building Address: *2 Hilltop Drive*

Building Description:
Two-story single-family dwelling 24' by 30' with a full and furnished basement. Year built: 1978.

Roof Construction:
2" by 8" rafters 24" on-center with plywood and asphalt shingles.

Floor Construction:
2" by 8" floor joists 24"on-center placed in metal joist hangers (both floors).

Occupancy Type:
Single-family dwelling with no exposures

Initial Resources Required:
3 engines, 1 ladder, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
Hilltop and Pine--Note: Threads NYC Corp thread--use adapter

Available Flow:
2,000 gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*200*	*400*	*600*	*800*

**Estimated fire flow based on 24' by 30' three stories of occupied area.*

Fire Behavior Prediction:
Open spiral stairs from basement level to first floor and open spiral staircase from first to second floor. Will cause difficulty in advancing hoselines between floors.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, salvage.

Problems Anticipated:
No special problems.

☐ **Standpipe:**	☐ **Sprinklers:**	☐ **Fire Detection:**

Scenario 3: 47 Lake View Road

A fire has been reported in a single-family summer home. The caller reports that from across the lake smoke is seen coming from the building. The time is 0540 on a Saturday.

Quick Access Prefire Plan

Building Address: *47 Lake View Road*

Building Description:
Two-story single-family dwelling 28' by 35' with no basement. Year built: 1996.

Roof Construction:
2" wooden planks over large timber rafters 36" on-center.

Floor Construction:
Concrete slab first floor, 2" by 8" joist for second floor with 1/2" plywood.

Occupancy Type:
Single-family summer residence

Initial Resources Required:
2 engines, 1 tanker/tender, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
Lake at residence--accessible only during summer months.

Available Flow:
Unlimited

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*150*	*325*	*475*	*650*

**Estimated fire flow based on 28' by 35', two stories and no exposures.*

Fire Behavior Prediction:
No special considerations.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Water supply in cold weather will be difficult to obtain from lake.

❑ **Standpipe:**

❑ **Sprinklers:**

❑ **Fire Detection:**

Activity 3.2

Post-and-Beam Construction

Purpose

To apply knowledge of the construction features of post-and-beam buildings under fire conditions.

Directions

1. Your group will be assigned one of the three scenarios.

2. Your group should read its scenario, review the slide of its building, select a spokesperson to represent your group, and answer the questions below.

    a. List specific safety concerns as they pertain to the classification of the building.

    b. Has flashover occurred yet? If not, is there a danger of it happening?

    c. What method of wood-frame construction was used in this building?

    d. List three positive features for this method of construction.

    e. List at least one special concern for this method of construction.

    f. How will fire, heat, and smoke travel through this structure?

    g. Would you expect fire suppression to be a significant challenge? Why?

3. After 15 minutes, the groups should be prepared to report their findings.

Scenario 1: 177 Rolling Hills Road

A fire has been reported in an automobile garage. The caller states that he/she had some problems with his/her car on the way home from work, and the brakes were hot when it was put in the garage 15 minutes ago. He/She also states there is an antique car stored in the garage, as well as several motorcycles. The time is 1815 hours on a Thursday.

Quick Access Prefire Plan

Building Address: *177 Rolling Hills Road*

Building Description:
Two-story 30' by 30' barn converted to a two-car garage with additional storage. Storage on the second floor includes several old containers of pesticides for the orchards that used to be part of the property. Year built: 1927.

Roof Construction:
Heavy beams 36" on-center with purlins, sheet metal covering.

Floor Construction:
First floor is dirt and second is heavy beams 24" on-center covered with 2" planks.

Occupancy Type:
Garage and storage

Initial Resources Required:
2 engines, 2 tanker/tenders

Hazards to Personnel:
Several (estimated at 25 cardboard drums) containers of pesticides stored on second floor.

Location of Water Supply:
Village of Happiness 2 miles to the west on route 3.

Available Flow:
5,000 gallons total at scene in tanks.

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*150*	*300*	*450*	*600*

**Estimated fire flow based on 30' by 30', two stories and no exposures.*

Fire Behavior Prediction:
Rapid involvement if fire starts, vehicles stored inside, early flashover.

Predicted Strategies:
If second floor is involved, treat the building fire as a hazardous materials event.

Problems Anticipated:
Water supply, hazardous materials stored, vehicles stored inside.

☐ **Standpipe:**	☐ **Sprinklers:**	☐ **Fire Detection:**

Scenario 2: 199 Blue Sky Mountain Road

A fire has been reported in a dairy barn. The facility houses about 100 head of cattle, and can hold up to 100 tons of cattle feed (hay). The caller reports smoke in the upper portion of the barn. He/She reports that he/she has been putting the crops in there for the past several weeks. It is 1530 hours on a Sunday.

Quick Access Prefire Plan

Building Address: *199 Blue Sky Mountain Road*

Building Description:
Two-story dairy barn 40' by 100' and no exposures. Year built: 1955.

Roof Construction:
Large beams covered with purlins and 3/4" boards with asphalt shingles.

Floor Construction:
First floor concrete on the ground--second is 3" by 12" joists covered with 2" planks.

Occupancy Type:
Dairy barn

Initial Resources Required:
3 engines, 1 heavy rescue, 1 ambulance

Hazards to Personnel:
Upper portion of the building can contain a lot of weight from storage of crops.

Location of Water Supply:
175 & 220 Blue Sky Mountain Road

Available Flow:
750 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*675*	*1,350*	*2,000*	*2,700*

**Estimated fire flow based on 100' by 40' two stories and no exposures.*

Fire Behavior Prediction:
Rapid fire involvement and early flashover in crop storage area.

Predicted Strategies:
Rescue of people (remove cattle if it can be done safely), exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Fast-moving fire--heavy caliber streams early.

❑ **Standpipe:**

❑ **Sprinklers:**

❑ **Fire Detection:**

Scenario 3: 22 South Canyon Road

A fire has been reported in a storage barn used to store fertilizer, tractors, and other agricultural-related equipment. The barn has been a site of vandalism with two small fires in the previous month. The time is 1930 on a Friday.

Quick Access Prefire Plan

Building Address: *22 South Canyon Road*

Building Description:
Two-story storage barn 40' by 50' and no exposures. Year built: 1927.

Roof Construction:
Heavy beams 36" on-center covered with 1" boards and asphalt shingles.

Floor Construction:
Dirt floor

Occupancy Type:
Storage barn

Initial Resources Required:
2 engines, 1 ladder, 1 heavy rescue

Hazards to Personnel:
Storage of fertilizer and other chemicals.

Location of Water Supply:
12 & 38 S. Canyon

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	*25%*	50%	75%	100%
Estimated Fire Flow in gpm	*350*	*700*	*1,050*	*1,400*

**Estimated fire flow based on 40' by 50' two stories and no exposures.*

Fire Behavior Prediction:
A small fire will quickly involve the entire structure. There are no fire separations, and flashover should occur early.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
A small fire will quickly become a large fire.

❑ **Standpipe:**

❑ **Sprinklers:**

❑ **Fire Detection:**

Activity 3.3

Balloon-Frame Construction

Purpose

To apply knowledge of the construction features of balloon-frame buildings under fire conditions.

Directions

1. Your group will be assigned one of the three scenarios.

2. Your group should read its scenario, review the slide of its building, select a spokesperson to represent your group, and answer the questions below.

    a. List specific safety concerns as they pertain to the classification of the building.

    b. Has flashover occurred yet? If not, is there a danger of it happening?

    c. What method of wood-frame construction was used in this building?

    d. List three positive features for this method of construction.

    e. List at least one special concern for this method of construction.

    f. How will fire, heat, and smoke travel through this structure?

    g. Would you expect fire suppression to be a significant challenge? Why?

3. After 15 minutes, the groups should be prepared to report their findings.

Scenario 1: 37 Park Lane

A fire alarm has been received from a neighbor who reports that there is smoke coming from the roof area of the building. She also reports that an elderly lady lives there alone and has a significant hearing problem. It is 1030 hours on a Tuesday.

Quick Access Prefire Plan

Building Address: *37 Park Lane*

Building Description:
Two-story single-family dwelling 24' by 35' with a full basement used for storage and utilities. Year built: 1932.

Roof Construction:
2" by 6" rafters 16" on-center with boards and asphalt shingles.

Floor Construction:
2" by 10" floor joists 12" on-center covered with 3/4" boards and asphalt-based tile.

Occupancy Type:
Single-family dwelling

Initial Resources Required:
2 engines, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
20 & 42 Park Lane

Available Flow:
500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*200*	*400*	*600*	*800*

**Estimated fire flow based on 24' by 35' two stories with one exposure.*

Fire Behavior Prediction:
No special problems anticipated.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, salvage.

Problems Anticipated:
No special problems.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Scenario 2: 333 Glen Road

A fire has been reported at a two-family dwelling. The caller stated that he/she has smelled smoke for several hours, which he/she thought was coming from the basement. Now he/she can see smoke coming from the eaves. The caller states he/she has an elderly bedridden occupant on the second floor. It is 1530 hours on a Friday.

Quick Access Prefire Plan

Building Address: *333 Glenn Road*

Building Description:
Two-story 50' by 35' dwelling with a one-story in-law apartment 30' by 30' attached to the original two-story structure. Both buildings have full basements. Years built: 1927 and 1947.

Roof Construction:
2" by 10" rafters 16" on-center with 3/4" boards and asphalt shingles.

Floor Construction:
2" by 8" joist 12" on-center with 3/4" boards and carpet.

Occupancy Type:
Two-family dwelling

Initial Resources Required:
3 engines, 2 tankers/tenders, 1 ambulance

Hazards to Personnel:
Two buildings are interconnected with a common wall between them.

Location of Water Supply:
Village of Freemont 3 miles north on highway 3

Available Flow:
6,000 gallons total at scene

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*375*	*750*	*1,125*	*1,500*

**Estimated fire flow based on 50' by 35' 2 stories and 30' by 30' one story and no exposures.*

Fire Behavior Prediction:
Fire travel from one structure into the other due to the common wall and the two buildings being interconnected.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Fire movement throughout the structure due to the construction methods.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Scenario 3: 121 Dunn Lane

A fire has been reported in a two-family dwelling. The caller reports a fire in the attic. He/She further states that there had been trouble with the electrical system for the entire second floor for the past 2 days. It is 0530 on a Wednesday.

Quick Access Prefire Plan

Building Address: *121 Dunn Lane*

Building Description:
2-story, two-family dwelling 30' by 50' with a full basement and one exposure. Year built: 1932.

Roof Construction:
2" by 8" rafters 16" on-center covered with 3/4" boards and asphalt shingles.

Floor Construction:
2" by 10" joist 16" on-center covered with 1" of plywood and carpet.

Occupancy Type:
Two-family dwelling

Initial Resources Required:
2 engines, 1 ladder, 1 ambulance

Hazards to Personnel:
Previous calls to this residence have seen four to six large dogs on the second floor.

Location of Water Supply:
112 and 144 Dunn Lane

Available Flow:
750 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*350*	*625*	*975*	*1,250*

**Estimated fire flow based on 30' by 50' two-story and one exposure.*

Fire Behavior Prediction:
Building has had some renovation including some new plumbing services and all new flooring (replaced 3/4" boards with 1" of plywood) that may allow additional fire, heat, and smoke travel.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Fire, heat, and smoke travel through walls and voids.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Activity 3.4

Platform-Frame Construction

Purpose

To apply knowledge of the construction features of platform-frame buildings under fire conditions.

Directions

1. Your group will be assigned one of the three scenarios.

2. Your group should read its scenario, review the slide of its building, select a spokesperson to represent your group, and answer the questions below.

   a. List specific safety concerns as they pertain to the classification of the building.

   b. Has flashover occurred yet? If not, is there a danger of it happening?

   c. What method of wood-frame construction was used in this building?

   d. List three positive features for this method of construction.

   e. List at least one special concern for this method of construction.

   f. How will fire, heat, and smoke travel through this structure?

   g. Would you expect fire suppression to be a significant challenge? Why?

3. After 15 minutes, the groups should be prepared to report their findings.

Scenario 1: 27 Colonie Street

A fire has been reported in a single-family dwelling by a caller who identified herself as a babysitter. She states that the smoke detector in the garage is going off, and when she opened the door there was a lot of smoke. She reports that everyone is out and she is calling from the neighbor's house.

Quick Access Prefire Plan

Building Address: *27 Colonie Street*

Building Description:
Two-story single-family dwelling 35' by 30' with an attached two-car garage and no exposures. Year built: 1985.

Roof Construction:
Wood truss rafters 24" on-center covered with 5/8" plywood and asphalt shingles.

Floor Construction:
2" by 8" joists 16" on-center covered with 5/8" plywood and carpet.

Occupancy Type:
Single-family dwelling

Initial Resources Required:
2 engines, 2 tankers/tenders, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
Everett Pond dry hydrant is accessible all year--third engine is sent to the hydrant upon arrival report of a working fire.

Available Flow:
500,000 gallons

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*225*	*450*	*675*	*900*

**Estimated fire flow based on 35' by 30'.*

Fire Behavior Prediction:
1-hour fire rating from garage to dwelling including protected openings.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
No special problems.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Scenario 2: 19 Everett Road

A fire has been reported in a single-family dwelling. The caller states that he/she was working on a motorcycle in the garage when the cleaning material caught fire. One person has slight burns but has escaped the basement. The time is 1500 on a Saturday.

Quick Access Prefire Plan

Building Address: *19 Everett Road*

Building Description:
Two-story single-family dwelling 40' by 28' with a full basement including a basement garage. Year built: Original structure 1952 and garage/family room addition 1969.

Roof Construction:
2" by 6" rafters 16" on-center covered with 1/2" plywood and asphalt shingles.

Floor Construction:
2' by 8" joists 16" on-center covered with 5/8" plywood and carpet.

Occupancy Type:
Single-family dwelling

Initial Resources Required:
3 engines, 1 heavy rescue, 1 ambulance

Hazards to Personnel:
Basement is used occasionally to repair cars and motorcycles, including flammable liquid storage.

Location of Water Supply:
2 & 29 Everett Road.

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*200*	*400*	*600*	*800*

**Estimated fire flow based on 40' by 28', two stories and no exposures.*

Fire Behavior Prediction:
No fire-rated separation between garage and dwelling areas, which will allow fire travel between all areas.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Flammable liquid storage in basement.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Scenario 3: 39 Southgate Lane

A fire has been reported in an apartment building housing six units. The caller states that the occupants were using the gas-fired grill on the second-floor balcony when a fire occurred at the valve on the propane tank. He/She further stated that he/she could not turn the valve off and the hose burned through with the propane now burning freely. It is 1430 on a Sunday.

Quick Access Prefire Plan

Building Address: *39 Southgate Lane*

Building Description:
Three-story apartment building 130' by 30' with a center corridor access/egress from a front and rear entry into the common stairwell. The building houses six apartments. One masonry 2-hour firewall with protected openings from floor slab to underside of roof. Note: firewall is the left wall inside front entrance--apartment wall for odd-numbered units. Year built: 1997.

Roof Construction:
Wooden truss rafters covered with 5/8" plywood. Plywood treated with fire-resistant chemicals has been installed 48" from both sides of the firewall.

Floor Construction:
Wooden "I" beams (1/2" plywood and 2" by 4" constructed) covered with 3/4" particle board.

Occupancy Type:
Six-family dwelling

Initial Resources Required:
3 engines, 1 ladder, 1 ambulance

Hazards to Personnel:
Lightweight structural members in roof and floors could result in early structural failure.

Location of Water Supply:
3, 39 & 50 Southgate

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*475*	*950*	*1,425*	*1,900*

**Estimated fire flow based on 50' by 30', three stories with one exposure.*

Fire Behavior Prediction:
Void areas created between floor joists will allow extensive fire travel, truss rafters may limit vertical ventilation opportunities.

Predicted Strategies:
Rescue, exposures, confinement, extinguish, overhaul, ventilation, and salvage.

Problems Anticipated:
Anticipated: Need to check for extension between apartments and floors. Need to check for extension through firewall.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Manual pull stations in hall-local

Activity 3.5

Plank-and-Beam Construction

Purpose

To apply knowledge of the construction features of plank-and-beam buildings under fire conditions.

Directions

1. Your group will be assigned one of the three scenarios.

2. Your group should read its scenario, review the slide of its building, select a spokesperson to represent your group, and answer the questions below.

   a. List specific safety concerns as they pertain to the classification of the building.

   b. Has flashover occurred yet? If not, is there a danger of it happening?

   c. What method of wood-frame construction was used in this building?

   d. List three positive features for this method of construction.

   e. List at least one special concern for this method of construction.

   f. How will fire, heat, and smoke travel through this structure?

   g. Would you expect fire suppression to be a significant challenge? Why?

3. After 15 minutes, the groups should be prepared to report their findings.

Scenario 1: 1147 Cherry Tree Street

A fire has been reported in a church office. The caller stated that he/she could smell smoke that could be burning electrical wires. It is 0930 on a Thursday.

Quick Access Prefire Plan

Building Address: *1147 Cherry Tree Street*

Building Description:
One-story church 50' by 50' with an office, choir room, and a small reception area and no basement. Year built: 1987.

Roof Construction:
2" planks, layer of insulation, 1/2" plywood covered with asphalt shingles. The roof is supported on beams that taper from 48" at ground level to 8" at the roof peak. The beams are 8" wide and made from laminated wood.

Floor Construction:
Concrete slab covered with carpet.

Occupancy Type:
Church

Initial Resources Required:
3 engines, 1 ladder, 2 tankers/tenders, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
Village of Freedom hydrant 2 miles to the west on Palmer Avenue. Note: Notify fire dispatch before using.

Available Flow:
5,000 gallons in tanks

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*425*	*850*	*1,275*	*1,700*

**Estimated fire flow based on 50' by 50' equivalent to 2-story and no exposures.*

Fire Behavior Prediction:
Large open space with large amount of combustible materials--fast fire and early flashover.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Water supply limited to tank water and tanker/tender shuttle.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Heat detection connected to local alarm

Scenario 2: 29 Pineapple Grove Road

An explosion and fire has been reported at a church. The caller stated that there was some type of explosion in the basement, and there also is a fire in the basement. It is 1045 hours on Sunday, and church services were in progress at the time of the explosion.

Quick Access Prefire Plan

Building Address: *29 Pineapple Grove Road*

Building Description:
One-story church 50' by 60' with church offices and classrooms located in the basement. Year built: 1982.

Roof Construction:
2" planks over beams that are 54" at ground level and taper to 12" at the peak of the roof. The beams are 12" thick.

Floor Construction:
Steel bar joist covered with 4" by 4' purlins covered with 1" plywood. The basement ceiling is suspended from the steel bar joist.

Occupancy Type:
Church, offices, and classrooms

Initial Resources Required:
3 engines, 2 ladders, 2 ambulances

Hazards to Personnel:
Clear span (50') steel floor joists create a void area between the floor above and ceiling below.

Location of Water Supply:
2, 27, and 40 Pineapple Grove Road

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*500*	*1,000*	*1,500*	*2,000*

**Estimated fire flow based on 50' by 60', two stories and no exposures.*

Fire Behavior Prediction:
Large open areas for fire, heat, and smoke extension will make interior attack difficult to manage.

Predicted Strategies
Rescue (accountability for occupants--including basement), exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Ability to make successful interior attack due to fire load and open areas.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Smoke detection and manual pull stations connected to autodialer to 911 dispatch

Scenario 3: 56 Apple Orchard Road

A fire has been reported in a church. A police officer responded to a call from neighbors reporting a burglar alarm ringing at the church and initiated the fire call. The time is 0600 hours on a Thursday.

Quick Access Prefire Plan

Building Address: *56 Apple Orchard Road*

Building Description:
One-story church 40' by 50' with an office, choir room, and a small reception area in the basement. Year built: 1984.

Roof Construction:
2" planks, layer of insulation, ½" plywood covered with asphalt shingles. The roof is supported on beams that taper from 48" at ground level to 8" at the roof peak. The beams are 8" wide and made from laminated wood.

Floor Construction:
2" by 12" floor joist 12" on-center covered with 1" plywood and carpet.

Occupancy Type:
Church

Initial Resources Required:
3 engines, 1 ladder, 1 tanker/tender, 1 ambulance

Hazards to Personnel:
Basement is cut up into offices and other small spaces.

Location of Water Supply:
22, 29, and 87 Apple Orchard Lane.

Available Flow:
3,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*350*	*675*	*1,025*	*1,350*

**Estimated fire flow based on 40' by 50' equivalent to two story and no exposures.*

Fire Behavior Prediction:
Large, open sanctuary with large amount of combustible materials--fast fire and early flashover. Basement is cut up into small offices and spaces.

Predicted Strategies
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Primary search and rescue from basement area.

☐ **Standpipe:**

[X] **Sprinklers:**
Basement only.

[X] **Fire Detection:**
Heat detection connected to local alarm only.

MODULE 4: TYPE III OR ORDINARY CONSTRUCTION

OBJECTIVES

At the conclusion of this module, the students will be able to:

1. *Identify and describe the characteristics of ordinary (NFPA Type III) construction.*
2. *Identify the strengths and concerns for ordinary construction.*
3. *Identify and justify critical construction features for fire, heat, and smoke travel when given a scenario for an ordinary construction.*

CHARACTERISTICS OF ORDINARY CONSTRUCTION

The National Fire Protection Association (NFPA) Standard 220, *Standard on Types of Building Construction*, defines Type III construction in the following manner: "Type III construction shall be that type in which the exterior walls and structural members that are portions of the exterior wall are of approved noncombustible or limited-combustible materials and interior structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs are entirely or partially of wood of smaller dimensions than required for Type IV construction or of approved noncombustible, limited-combustible, or other approved combustible materials. In addition, structural members shall have fire resistive ratings not less than those specified in Table 3-1."

Table 3-1
Fire Resistance Rating (in hours) for Type I through Type V Construction

	Type I		Type II			Type III		Type IV	Type V	
	443	332	222	111	000	211	200	2HH	111	000
Exterior Bearing Walls -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting one floor only……………..	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting a roof only…………………	4	3	1	1	0[1]	2	2	2	1	0[1]
Interior Bearing Walls -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	2	1	0
Supporting one floor only……………..	3	3	2	1	0	1	0	1	1	0
Supporting a roof only…………………	3	3	1	1	0	1	0	1	1	0
Columns -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only……………..	3	2	2	1	0	1	0	H[2]	1	0
Supporting a roof only…………………	3	2	1	1	0	1	0	H[2]	1	0
Beams, Girders, Trusses & Arches -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only……………..	3	2	2	1	0	1	0	H[2]	1	0
Supporting a roof only…………………	3	2	1	1	0	1	0	H[2]	1	0
Floor Construction	3	2	2	1	0	1	0	H[2]	1	0
Roof Construction	2	1 1/2	1	1	0	1	0	H[2]	1	0
Exterior Nonbearing Walls	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]

(Shaded) Those members that shall be permitted to be of approved combustible material.

1 See A-3-1 (Table).
2 "H" indicates heavy timber members; see text for requirements.

Notes regarding Table 3-1:

1. Only exterior bearing walls must be constructed of noncombustible materials, while interior bearing walls, columns, beams, girders, trusses, arches, floors, and roofs may be constructed with combustible material, that has been provided with an appropriate level and approved method of fire resistance.

   As an example, wood could be covered in an appropriate manner with gypsum board of an appropriate depth to create a 1-hour fire-resistive structural element.

2. The requirements for fire resistance of exterior nonbearing walls located in close proximity to property lines, other buildings, or exposures, the provision of spandrel wall sections, and the limitation of protection of wall openings are not related to type of construction. They might be specified in other standards and codes, where appropriate, and might be required in addition to the requirements of this standard for the type of construction.

   As an example, a community may establish an area as having "Fire Limits" which typically either requires a significant separation of buildings from each other or requires the exterior walls to be made from noncombustible materials. Many of these Fire Limits were established in communities to prevent conflagrations that often occurred when wood-frame buildings were placed close to each other.

3. The identification of a 211 or 200 Type III building is a subclassification for this method of construction. It often is used by municipalities to identify a specific type of construction with its appropriate fire resistance.

   As an example, a municipality may allow only a Type III--211 building to be constructed on a particular building lot or for a specific occupancy where a higher level of fire resistance is desired.

Main Street USA

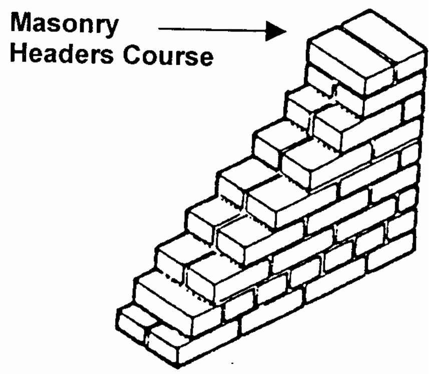
Other common terms applied to Type III or ordinary construction are "Main Street USA," and a "Taxpayer." The term "Taxpayer" evolved from "Main Street USA," where a building owner would operate a retail store on the first floor and live in an apartment on the second floor. It was said that the property taxes for the building were paid for by the store's income, and the shop owner lived above the store tax free.

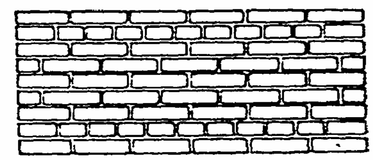
Buildings of ordinary construction generally are built no taller than six to eight stories due to the thickness of the supporting walls required to support the floor loads above the ground. The tallest building of ordinary construction is located in Chicago, Illinois, and is 15 stories high. Most ordinary-construction buildings on "Main Street" are only two or three stories high.

Exterior Wall Construction

Exterior walls of ordinary construction generally are constructed of brick. A true brick wall is two or more courses of brick thick. If a solid brick wall is being built, it is customary to lay five to six layers of brick lengthwise (stretcher rows) in the wall and then lay one at a 90-degree angle (header row) to the courses of brick below. This serves to tie the wall together as a solid unit. The bricks laid lengthwise are called "stretchers" and the rows laid at a 90-degree angle, where only the end of the brick is seen, are called "headers." Some walls have been constructed with the headers laid in a pattern in every course or every other course. This usually will be represented by a header, one or two stretchers, and another header with the pattern repeated. One continuous vertical section of masonry wall one brick in thickness is called a "wythe." A true brick wall has two or more wythe, while a fascia or decorative wall will have only one wythe of brick. In reading a building, the fact that there are both headers and stretchers could be one indication that it is a solid brick wall.

Solid Walls



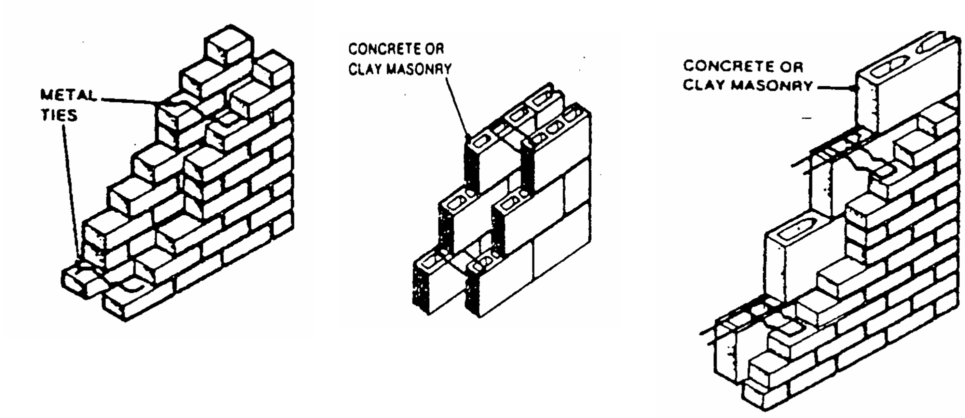


**6th Course Headers
Common Bond
(Typical)**

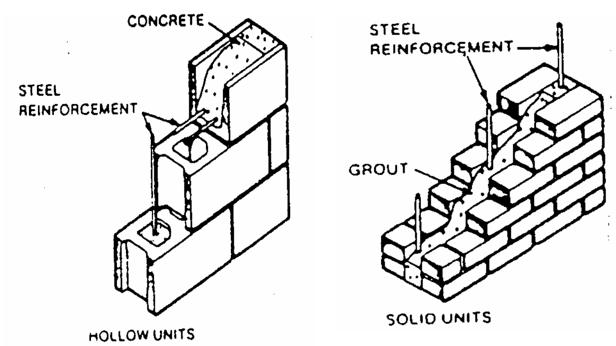
Another material commonly used for exterior wall construction is concrete block. The block is the load-bearing wall and carries the loads above. Often the wall is faced with a brick veneer finish to resemble a brick building. During the installation of the block wall, metal wall ties (small strips of metal) are laid every two or three rows of blocks in the mortar between the blocks. When the veneer brick wall is constructed the wall ties are installed in the mortar to tie the brick wall to the block wall. The brick wall is one brick wide and the same height as the block wall.

This same technique is used for other types of buildings, such as wood frame, where a brick veneer may be used as the exterior finish. In this case, the metal wall ties are nailed onto the wooden studs. Without some type of support, the brick wall would float and possibly tip over. If the brick veneer wall is being installed at the same time as the block wall, a lightweight steel reinforcing truss can be applied every two or three courses between both the block wall and the brick wall in place of the wall ties.

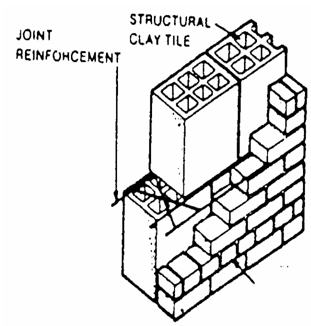
Some older buildings used a clay terra cotta block in place of today's modern concrete block as the load-bearing wall. Terra cotta is a material similar to brick, which is fired in a kiln to harden the material. A tile used to line a chimney is similar to that used for wall construction, except that the construction tile has numerous divisions inside the tile for strength. The terra cotta block wall was brittle and subject to being broken when struck with heavy objects. The exterior wall was faced with one layer of brick similar to the technique used for block walls. One danger of veneered walls placed adjacent to block walls is that it is possible, through various building connections, that gases from a fire, such as carbon monoxide, could accumulate in the small cavity between the two walls.



Cavity Walls

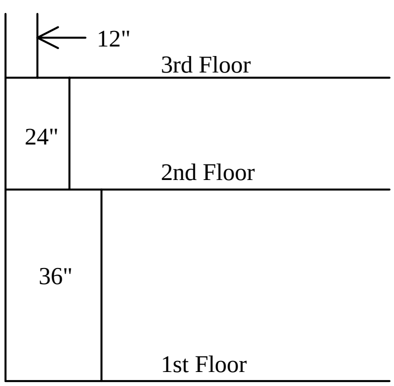


Reinforced Walls



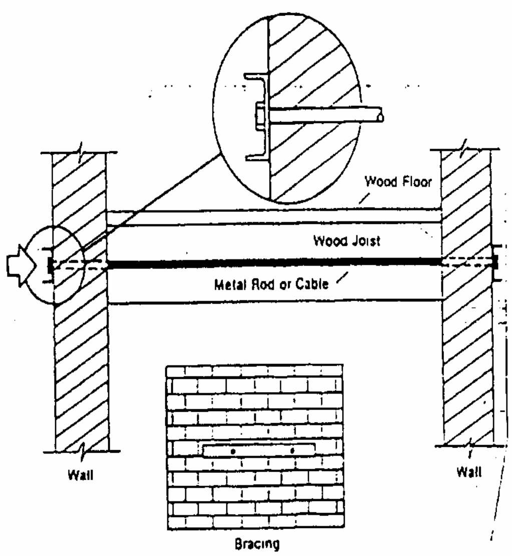
Solid Wall

Wall thickness of a Type III building typically will range from 6 to 30 inches thick, depending upon the load it must carry. Remember that every ounce of weight from the roof load through the first floor of the building must be carried and transmitted to the foundation of the building.

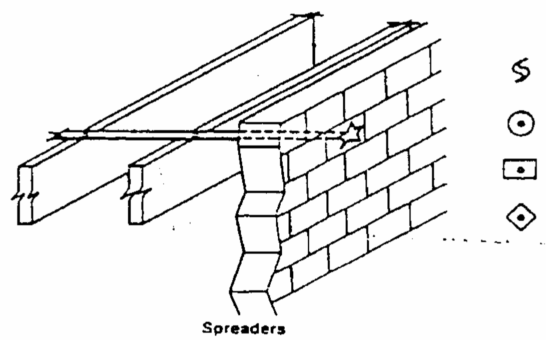


Bearing walls carry the load of the structure, which is transferred to the wall from the floor joists and roof rafters. Failure of a load-bearing wall can result in catastrophic structural collapse. It is critical that all emergency scene personnel be able to identify the load-bearing walls and understand the dangers associated with wall failure. Bearing walls are typically the longest walls of the structure. This may be the front (street side) or, most often, the sides of the building. The longest walls typically are used to support the load, since this requires the shortest span for the floor joists and roof rafters inside the building.

Walls may have a heavy load that may push in a lateral manner instead of directly downward on the wall, and tend to tip the wall outward. This often happens when loads are applied directly against the walls, or when large open areas lack adequate materials to tie the two walls together, such as when cathedral ceilings are built improperly. To counteract the push against the walls a masonry pier can be built into the block wall, a buttress (brace larger at the bottom than at the top) can be installed, or tie cables and rods can be installed, which is the most common method. The concern for the steel tie rods and cables is that they are subject to relaxation or elongation when heated, thus allowing the walls to move. The rods and cables are connected with turnbuckles that can be adjusted to compensate for the load applied above.

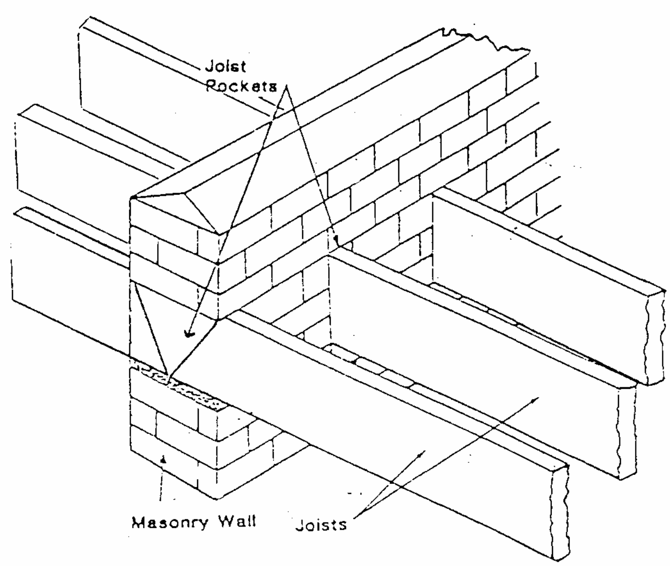


Load-Bearing Walls



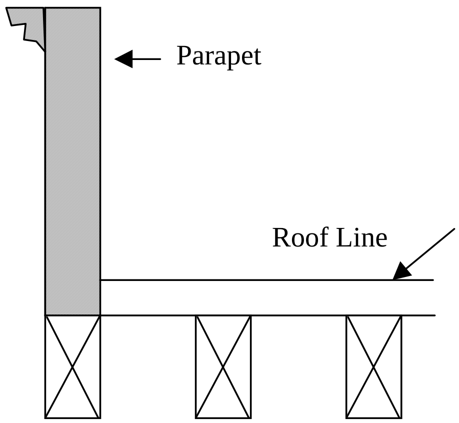
Curtain Walls

Common walls between two buildings often were used in ordinary construction. This was particularly true when the same developer was constructing multiple buildings adjacent to each other. The single wall not only separated the two buildings, but also provided the support for a load-bearing wall for both buildings. A catastrophic event, such as an explosion, on one side of the wall could have catastrophic results for the neighboring building if the common wall was damaged. As the buildings were constructed, a joist pocket would be built into the wall and the floor joists or roof rafters from both buildings would share the opening in the wall. This "good-neighbor policy" also raises concerns under fire conditions, with the potential for fire to extend from one building into the next through the common wall joist pocket. A typical tactical objective is to enter the exposure building and open ceilings to inspect for common joist pockets and to evaluate fire, smoke, or heat travel. Another concern if a significant fire should occur in one building and the structural supporting members holding the floors and roof should be lost is that the load applied to the common wall is totally from one side. This could raise concerns for the possibility of collapse. Often, when a building has been removed from one side of a common wall, special bracing is provided for the wall. To keep floor joists from pushing the wall down should they fall from the joist pocket, the floor joists were cut on an angle which is called a "fire cut." The fire cut provided the maximum surface for the joist to rest on the bottom, but was cut to provide minimum clearance for the top of the joist pocket.



Fire Cut Joists

All loads above the foundation must be transmitted to the foundation. This is especially critical when openings in the load-bearing walls must be spanned for windows, doors, or other structural features. The entire load above the opening must be carried and transferred to the wall at some other point which usually is directly adjacent to the opening. The load can be carried and transferred back to the wall with a lintel or an arch. A lintel is typically a steel angle iron placed at the top of the opening and resting on the walls adjacent to the opening. An arch is made from stone or masonry materials, and each component is dependent on the element next to it for its strength. If one piece of the arch is removed, the entire arch will fail. Wood also can be used to construct either a lintel or an arch.



One common method of finishing the top of a load-bearing wall is to apply a large masonry cornice. While the wall may be a total of 12 inches thick, the cornice or top of the wall may be twice that size. Any such load applied to the exterior wall that is not applied in a straight vertical line with the wall to the foundation will cause stress on the wall. This stress is trying to push, pull, or twist the wall. This load is carried and transmitted back to the load-bearing wall with a technique called corbelling; at a location in the wall several rows below the top of the roof, each row of brick is laid a little further out from the plane of the wall than the previous row. The next row is installed another inch or two further out than the previous row. This technique is used until the desired width of the wall at the roof line has been achieved. The concern for firefighters is that this technique places a heavy load on top of the wall from all the extra brick used during the corbelling technique. Under fire conditions, or if a ladder or aerial device were placed against the wall, it could apply enough load for the wall to fail in this area. It would seldom cause catastrophic wall failure and structural collapse, but if a firefighter were near the wall when the parapet failed, the falling brick could be a significant safety consideration.

Other loads applied to exterior walls also may place stress on the wall. As an example, a marquee attached to the front wall of a movie theater typically is secured to the exterior of the wall, placing an eccentric load on the wall. In addition, the front wall may not be a load-bearing wall and may have a limited tie into the building. Gravity is constantly trying to pull this wall over. Under normal conditions, the wall may carry the load just fine. Under fire conditions, it may not be able to support the load. It is critical that this load be taken into consideration when placing firefighters and equipment in the vicinity of the eccentric load.

Non-load-bearing walls are not designed to carry the weight of the structure. Their main purpose is to enclose the ends of the building. These walls often are called "curtain walls," as representative of their function. Curtain walls or non-load-bearing walls of an ordinary-construction building are typically the short walls of the building. In most cases, these will be the front and rear walls. Many front walls, especially on the ground-floor level, are mainly glass, which has little load-carrying capability. In many instances during building renovations, the front wall of a building has been partially or totally removed and the building remains standing with a minimum of bracing.

The non-load-bearing walls typically carry an end of the carrier beams for the floor joists and roof rafters. Since the curtain walls do not have a heavy load applied to them they often are held in place with metal rods. The rods pierce the exterior wall with some type of washer. The washer, which may be a round or square piece of steel plate or, in some cases, a decorative washer in the form of a star, is used to expand the surface area of the tie rod against the wall. The tie rod typically will go into the structure through two or three floor joists and be secured into the floor joist that runs parallel to the front curtain wall. The tie rod is threaded, and will have a nut and washer adjusted against the other floor joists it passes through. This technique allows the load being transferred to the floor joists to be distributed over two or three joists. When reading a building, if tie rods are observed, there are several considerations that must be made. Tie rods through a front curtain (non-load-bearing) wall may have less significance than tie rods or cables through a side (load-bearing) wall. Failure of the rods or cables through a bearing wall may cause catastrophic structural failure during a fire, while failure of the rods in a curtain wall simply may allow the wall to separate from the building and collapse without total structural failure.

Many buildings have had cosmetic applications to cover deficiencies. This may be a brick wall with mortar missing or deteriorated brick. On block walls it may be used to cover sections that have settled or shifted, causing a portion of the wall to separate from the rest of the wall. Once the integrity of the mortar has been broken and the block shifted, this wall will no longer act as one unit and may be subject to shifting or partial collapse. The most common method to provide a cosmetic cover is with a stucco or plaster mix applied over the exterior wall. This technique is called "parging."

Interior Wall Construction

Interior walls for Type III buildings are most often wood. The wood may be 2 by 4 or 2 by 6 inches. A lot of renovation or new construction uses sheet metal studs formed in the shape of a "C" with two 2-inch sides and the section between 4 inches; this resembles a "C" with square corners. These studs are predrilled for wiring to pass through. The metal studs most commonly are connected with metal screws, screw nails, or pop rivets. In older construction the studs were covered with wood lath and a coat of plaster. Wood lath is an ideal fuel source; it has a rough surface with a lot of surface area due to the small splinters of wood attached to the lath. This lath, in comparison to a planed and smooth surface of a wall stud, has a great deal more available fuel surface area per square inch of wood than the dimension lumber. Therefore, a fire in a wall stud channel with wood lath would have an excellent dry, abundant, and perfectly arranged fuel source.

In recent years, the wall covering applied to the studs has been gypsum board, more commonly called "drywall board." Typically, the building support systems, such as plumbing, heating, and electrical systems, traverse the interior walls and may create open voids for fire extension and travel. Often when these buildings are renovated, new utilities are installed in a corner of a room and a new wall is used to box around the utility services. Interior walls often provide critical support to carry the load of the floors above and the roof. While the exterior loads are carried on the load-bearing walls, the remainder of the load must be carried by the interior walls.

Often, an older building is modernized or an occupancy is changed and newer, heavier loads are placed inside the structure with new coolers, freezers, or air conditioning units placed on the roof. The closer these loads are placed to the outside load-bearing walls the better. Another common problem occurs when a retail store on the first floor is expanded into an adjoining unit. An ordinary building typically would have two separate stores on the ground level separated by an interior wall which is supporting the load of the floors above. When a retail store is expanded into the other side, the temptation is to remove the wall between the two units so customers and employees can move easily from one side to the other. It is critical that the load be carried over. Support columns on the floor below will need to be braced to carry the additional concentrated load.

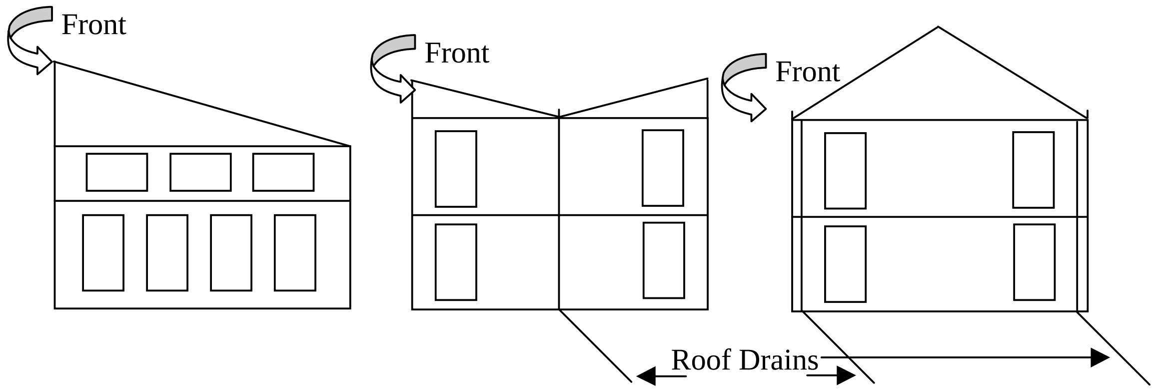
Floors

Floors of Type III or ordinary construction are typically one of the strengths of this type of construction. When the Type III buildings were constructed, floor joists usually were 3 by 10 inches in dimension or larger for the first floor, and placed 12 inches on-center. This provided a great deal of strength to carry loads placed on the floors, especially for the retail stores. Floor joists for the floor(s) above may use smaller dimension lumber such as 2 by 8 inches. Another important aspect was the fact that the floor joists placed in wall sockets on the load-bearing wall were cut on an angle so that, should a fire occur and the interior of the building be burned away, it could fall into the interior of the building without causing the wall to collapse. This was called a "fire cut," where the end of the joist or rafter is cut so that the top is shorter than the bottom. Should it fall from the socket of the interior it would do so without causing the joist or rafter to act as a lever and push the top of the wall outward, as it would had it been cut at a 90-degree angle.

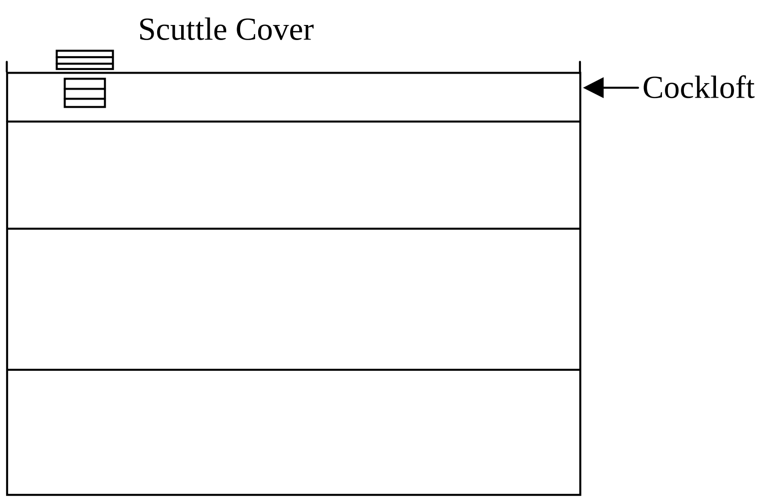
Ceilings usually are attached to the floor joists above. Commonly, a wood strip called a "furring strip" would be attached to the bottom of the joist and ceiling materials attached. This material may be lath and plaster, sheet metal plates, ceiling tile, or gypsum board. The original ceilings were high to compensate for the lack of air conditioning. Over the years, many of these ceilings have been lowered, with a metal-grid-and-ceiling-tile method being the most common. This creates void areas for fire travel. It is always a good strategic consideration to check for fire extension, with the tactical objective being to open the ceiling to inspect for fire travel. Some support for the floors above included cast iron columns. In addition to the cast iron columns it is critical to look at the method of connection to the carrier beam system to ensure it is properly supported and secured. About the turn of the century, a few buildings were faced with a cast iron front. These fronts may have limited load-carrying capability for the curtain wall, but more often were used for their decorative purposes.

Roofs

Roofs are installed on ordinary construction using a variety of methods. The most basic roof is sloped from the front wall to the rear wall with an adequate slope to provide drainage. Another method is a nearly flat roof with just enough slope to drain the water to centralized roof drains with a piping system which brings the water from the roof to the basement and sewer system. A third type is a peaked roof with roof drains at the lowest ends of the roof pitches. Roof rafters are placed on a support system that carries the exterior roof load to the load-bearing walls, similar to the floor joists below. In newer buildings the roof structure may be constructed from truss rafters or from rafters constructed with a wooden "I" beam arrangement. Roof boards or plywood are placed over the rafters and a roofing material is applied. Roof materials may include an asphalt-based paper and hot tar, rubber or vinyl sheets cemented to the roof, or corrugated steel sheets. In some instances an asphalt roof may be covered with a layer of stone to protect the asphalt material from the daily expansion and contraction from the heating and cooling process. In addition, many vinyl or rubber roofs may be protected with lightweight concrete blocks intended to be used for persons walking on the roof to service equipment located there.



Each roof structure will provide a void area that is a critical concern for fire extension. This area often is referred to as a "cockloft." This cockloft usually is accessible from within the building via a scuttle hole and ladder, commonly placed into the ceiling of the top floor or on a rear porch to provide access. Inside the cockloft there is typically a ladder that leads to a scuttle opening onto the roof. This is an easy access to the roof for maintenance purposes. This scuttle opening also can provide a quick ventilation opening into the cockloft area if ladder access can be gained to the roof from the exterior. Remember that there may be several inches to several feet from the top of the building wall to the roof below. It is critical that building preplans indicate the roof construction and features so that, should roof operations become necessary, critical decisions can be made at the ground level. These would include the construction of the roof, the roof covering, and the tools or equipment needed to open the roof.



Building Renovations

Building renovations are a special concern to firefighters, as they can create some special safety or operations problems. One typical problem is combustible additions being made to the exterior walls, which are of a noncombustible material. A fire in the exterior or wooden addition may extend easily into the ordinary-construction building through unprotected openings. Another typical renovation is the addition of a mansard "eyebrow" onto the exterior wall. This is a typical renovation for buildings used for retail purposes. The mansard may cover over openings into the structure, such as windows. In addition the mansard eyebrow typically is attached to the exterior wall and places an eccentric load on the wall. Mansards are deficient in firestops and commonly are wide open from end to end. Another common concern is the installation of a new roof over the old roof, complete with new rafters. Often, in order to reduce costs of a new roofing system (which would include the removal of the old roof), a new structure is placed over the existing roof creating a void for fire extension. This problem can be encountered during a ventilation effort after the first roof is opened only to find a second roof. It is important to inspect the buildings in your area before a fire occurs and to prepare a Quick Access Prefire Plan (QAP) showing the features or special concerns of the structure.

FIRE TRAVEL CONSIDERATIONS AND FIRE BEHAVIOR PREDICTIONS

Horizontal fire spread on the same floor of Type III buildings is often the result of building renovations that have created void areas. Examples of these void areas include dropped ceilings, walls breached to extend building services such as plumbing, heating, or electrical wires from one area to another, building renovations covered with combustible materials, such as a mansard eyebrow installed on an exterior wall over windows, or joist pockets in common walls where one building's structural member is placed alongside the neighbor's joist or rafter.

Often, vertical fire spread from floor to floor is caused by vertical voids created during renovations, or by updating the building's utility services. Utility shafts often pass from floor to floor, and have openings that allow fire to spread floor to floor. Other openings that penetrate the floors and provide an opportunity for vertical fire spread include elevator shafts, dumbwaiter shafts, and trash chutes. It is typical that Type III buildings have open stairways without fire doors or separations. A fire that enters or starts in the common hall, quickly spreads to the upper floors. Many older buildings were finished with wood paneling or partially finished with wainscotting (wood about halfway up the wall from the stair treads).

The potential for collapse always must be considered. The load-bearing walls should be evaluated carefully for areas of deterioration, areas that appear to be carrying extremely heavy loads, or signs that the walls may push outward, such as an area with metal washers and bolts on the load-bearing walls. Also check for load-transfer methods used over doors, windows, or areas where the walls have been breached and not properly reinforced with a lintel. In many instances walls are breached to install items such as air conditioning units by removing a few blocks or bricks from a wall to install the metal case for the air conditioning unit. This metal case does not replace a lintel, and the load above may not be transferred properly.

Any wall being held in place by a cable or steel rods always should be of special interest, since heat can affect the steel and cause it to relax or stretch. As the metal cable or rod stretches, the walls may move outward. When two buildings share a common wall, there is always a concern that fire could move from one building to the other. It is important to check for extension at all levels (floors) and in multiple locations at each level. If an adjoining building that used to share the common wall is gone, the wall may be eccentrically loaded and additional water placed inside by firefighting hose streams, falling structural elements, or other shifts in the building that may cause wall failure.

Non-load-bearing walls (usually the front and rear) are especially vulnerable to failure. Items that may cause failure are especially heavy loads on the wall (such as signs or marquees), mansard roof additions attached to the outside of the wall, wall tie (steel rod) failure, or interior structural collapse.

Older manuals used to have formulas to predict how far the walls would fall if they collapsed. Experience has shown that the distance they will fall is unpredictable. Firefighters have been killed working too close to the curtain walls when they collapsed and fell. As a minimum, a safe distance must include the height of the wall plus a safety margin depending upon conditions at the scene.

SUMMARY

Type III buildings typically will have two load-bearing walls (long walls) and two curtain walls (short walls). The load of the building is placed on the load-bearing walls, which must be transferred to the ground.

Buildings of ordinary construction often are renovated, with new void spaces created. These include horizontal voids created by dropped ceilings and vertical voids through new utility chases.

The cockloft area is particularly vulnerable to rapid fire extension due to the heavy fire load in a confined and open space.

It is extremely important for fire officers, Incident Commanders (IC's), and Safety Officers to read a building's construction carefully before developing their strategic goals or implementing their tactical objectives.

Activity 4.1

Ordinary (Type III) Constuction

Purpose

To apply knowledge of the construction features of an ordinary (Type III) building under fire conditions.

Directions

1. Your group will be assigned one of the three scenarios.

2. Read the scenario, review the slides of the building, and answer the questions below as they relate to your scenario.

   a. List specific safety concerns as they pertain to the classification of the building.

   b. Has flashover occurred yet? If not, is there a danger of it happening?

   c. What method of construction was used for this building?

   d. List three positive features of this method of construction.

   e. List one special concern for this method of construction.

   f. How will fire, heat, and smoke travel through this structure?

   g. Would you expect fire suppression to be a significant challenge? Why?

3. Select a spokesperson to record your answers and report the group's findings when your group is asked to report. You have 20 minutes for this activity.

Scenario 1: 41 Birch Lane

A fire has been reported in a single-family residence. The caller reported a smoke condition in the second floor. The caller stated that it has been raining heavily and the roof is leaking at several locations through the second-floor ceiling, including through the light fixtures. The caller also states that normally, during a heavy rain, he/she can hear water running through the drain pipes, but today he/she cannot, which leads him/her to believe the roof drains are plugged. It is 1330 on a Tuesday.

Quick Access Prefire Plan

Building Address: *41 Birch Lane*

Building Description:
2-story, single-family dwelling 40' by 30' with a full basement and no exposures. Year built: 1922.

Roof Construction:
Rafters are 2" by 10" placed 16" on-center with 3/4" boards covered with 1/2" plywood and covered with asphalt paper and tar. The roof slopes to the center where two roof drains carry water to a storm drain in the basement.

Floor Construction:
2" by 10" joist 16" on center covered with 3/4" boards and hardwood flooring.

Occupancy Type:
Single-family dwelling

Initial Resources Required:
3 engines, 1 ladder, 1 ambulance

Hazards to Personnel:
If roof drains plug it will add up to 12" of water on the roof.

Location of Water Supply:
39 and 58 Birch Lane

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*200*	*400*	*600*	*800*

*Estimated fire flow based on 30' by 40', two story and no exposures.

Fire Behavior Prediction:
Building has had several alterations, including dropped ceilings and a new plumbing chase from the basement to the second-floor bathroom.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Void areas with fire, smoke, and heat travel.

☐ **Standpipe:**	☐ **Sprinklers:**	☐ **Fire Detection:**

Scenario 2: 22 Elm Street

A fire has been reported in an office building housing real estate, insurance, and brokerage offices on the first floor and an architect's office on part of the second floor. The other half of the second floor is vacant and for rent. The fire is reported in the insurance office on the first floor. The police officer on patrol reported the fire. It is 0630 on a Tuesday.

Quick Access Prefire Plan

Building Address: *22 Elm Street*

Building Description:

2-story building 30' by 70' with no basement and no exposures. The building originally was constructed to house offices for a large knitting mill across the street. The mill offices have been closed and the building was subdivided into 5 offices (3 down and 2 up). Exterior walls are brick. Only a partial basement for boiler. Year built: 1931.

Roof Construction:

2" by 8" rafters 12" on-center covered with 1" boards and asphalt shingles.

Floor Construction:

2" by 10" joists 12" on-center covered with 3/4" boards and hardwood floors.

Occupancy Type:

Five offices

Initial Resources Required:

3 engines, 1 ladder, 1 heavy rescue

Hazards to Personnel:

No special hazards.

Location of Water Supply:

2, 22, and 42 Elm Street

Available Flow:

1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*350*	*700*	*1,050*	*1,400*

**Estimated fire flow based on 30' by 70', two stories with no exposures.*

Fire Behavior Prediction:

Dropped ceilings on both floors have created void area for fire extension. Sprinklers were lowered below new suspended ceiling with no sprinkler protection in void floor joist area.

Predicted Strategies:

Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:

Building is cut up, making access difficult, void areas between ceiling and floor or ceiling above, and sprinkler system is old.

☐ **Standpipe:**

[X] **Sprinklers:**
Wet system--connection on Side C

[X] **Fire Detection:**
Water flow alarm from sprinklers is connected to a master alarm box #221

Scenario 3: 37 Oak Street

A fire has been reported at a single-family dwelling. The building is used as a bed and breakfast with four guest rooms on the second floor. The owners occupy the first floor. It is 0630 on a Saturday in early October and the guest rooms are all rented.

Quick Access Prefire Plan

Building Address: *37 Oak Street*

Building Description:
2-story dwelling unit 30' by 40' with a full basement and no exposures. The second floor has four guest rooms which are rented as a bed and breakfast. Year built: 1920.

Roof Construction:
2" by 8" rafters 16" on-center with 3/4" boards covered with 1/2" plywood and asphalt shingles.

Floor Construction:
2" by 10" joists 12" on-center covered with 3/4" boards and hardwood floors throughout.

Occupancy Type:
Dwelling with four rental guest rooms on second floor

Initial Resources Required:
2 engines, 2 tankers/tenders, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
City of Cohoes--5th Avenue at Super Shop. Note: notify city fire dispatch before opening hydrant.

Available Flow:
5,000 in tank

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*200*	*400*	*600*	*800*

**Estimated fire flow based on 30' by 40', times two stories and no exposures.*

Fire Behavior Prediction:
Open stairwell from first floor to second is finished with combustible wooden wall covering which will quickly cause fire spread up the stairs.

Predicted Strategies:
Rescue (account for guests), exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Water supply if fire involves more than two or three rooms.

☐ **Standpipe:**

☐ **Sprinklers:**

[X] **Fire Detection:**
Smoke and heat detection--local alarm only

MODULE 5: TYPE IV OR HEAVY-TIMBER CONSTRUCTION

OBJECTIVES

At the conclusion of this module, the students will be able to:

1. *Identify and describe the characteristics of heavy-timber (NFPA Type IV) construction.*
2. *Identify the strengths and concerns for heavy-timber construction.*
3. *Identify and justify critical construction features for fire, heat, and smoke travel in a heavy-timber building when given a scenario.*

CHARACTERISTICS OF HEAVY-TIMBER CONSTRUCTION

National Fire Protection Association (NFPA) Standard 220, *Standard on Types of Building Construction*, defines Type IV construction in the following manner: "Type IV construction shall be that type in which the exterior walls, interior walls, and structural members that are portions of such walls are of approved noncombustible or limited-combustible materials. Other interior structural members, including columns, beams, girders, trusses, arches, floors, and roofs shall be of solid or laminated wood without concealed spaces and shall comply with the provisions of 3-4.2 through 3-4.6. In addition, structural members shall have fire resistive ratings not less than those specified in Table 3-1."

Table 3-1
Fire Resistance Rating (in hours) for Type I through Type V Construction

	Type I		Type II			Type III		Type IV	Type V	
	443	332	222	111	000	211	200	2HH	111	000
Exterior Bearing Walls -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting one floor only……………..	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting a roof only…………………	4	3	1	1	0[1]	2	2	2	1	0[1]
Interior Bearing Walls -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	2	1	0
Supporting one floor only……………..	3	3	2	1	0	1	0	1	1	0
Supporting a roof only…………………	3	3	1	1	0	1	0	1	1	0
Columns -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only……………..	3	2	2	1	0	1	0	H[2]	1	0
Supporting a roof only…………………	3	2	1	1	0	1	0	H[2]	1	0
Beams, Girders, Trusses & Arches -										
Supporting more than one floor, columns, or other bearing walls……..	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only……………..	3	2	2	1	0	1	0	H[2]	1	0
Supporting a roof only…………………	3	2	1	1	0	1	0	H[2]	1	0
Floor Construction	3	2	2	1	0	1	0	H[2]	1	0
Roof Construction	2	1 1/2	1	1	0	1	0	H[2]	1	0
Exterior Nonbearing Walls	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]

[shaded box] Those members that shall be permitted to be of approved combustible material.

1 See A-3-1 (Table).
2 "H" indicates heavy timber members; see text for requirements.

NFPA 220 Type IV Constructed Buildings

3-4.2 Wood columns supporting floor loads must be 8" by 8" minimum. Wood columns supporting roof loads must be 6" by 8" minimum.

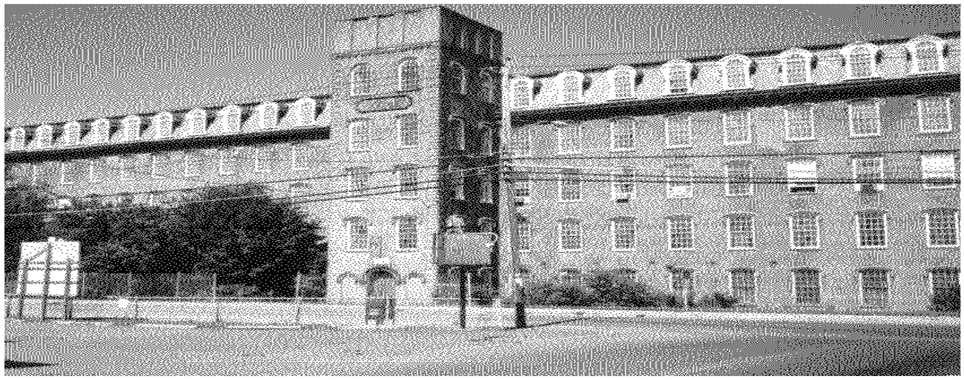
3-4.3 Wood beams and girders supporting floor loads must be 6" by 10" minimum. Wood beams, girders, and other roof framing supporting roof loads only must be 4" by 6" minimum.

3-4.4 Framed or glued laminated arches that spring from grade or the floor line and timber trusses that support floor loads must be 8" by 8" minimum. Framed or glued laminated arches for roof construction that do not spring from grade of the floor line and do not support floor loads must be 6" by 8" minimum for the lower half the member height and must be 6" by 6" minimum for the upper half. Framed or glued arches for roof construction that spring from the top of the walls or wall abutments and timber trusses that do not support floor loads must be 4" by 6" minimum. Splice plates shall be not less than 3 inches in thickness.

An exception to this provision allows that spliced members be permitted to be composed of two or more pieces not less than 3 inch thickness where blocked solidly throughout their intervening spaces or where such spaces are tightly closed by a continuous wood cover plate not less than 2" in thickness, secured to the underside of the members.

3-4.5 Floors must be of splined or tongued and grooved plank not less than 3" thick that is covered with a 1" minimum thick tongued and grooved flooring laid crosswise or diagonally to the plank or with 1/2" plywood or laminated plank 4" in thickness minimum covered with 1 inch tongued and grooved flooring laid crosswise or diagonally or with 1/2" plywood.

3-4.6 Roof decks must be of splined or tongued and grooved plank and must be a minimum of 2" in thickness, or 3" thick laminated plank, or 1 1/8" thick interior plywood (exterior glue), or of approved noncombustible or limited-combustible materials of equivalent fire durability.



Heavy-timber buildings also have been called "mill construction," since this was the typical original occupancy for this type of construction. The thick, noncombustible exterior and interior walls were made from multiple courses of brick, which provided a strong base to carry heavy loads from machinery and manufactured goods. The floor and roof supports were constructed from large, solid or, in later years, laminated timbers covered with thick planks. This building type was very popular as the Industrial Revolution developed, and often these heavy-timber buildings were constructed next to sources of water power. Today many of the heavy-timber or mill buildings have been converted to other purposes, such as retail sales stores, multiple-family dwelling units, or office spaces. These buildings seldom have a full basement, but may have a partial basement large enough for a heating plant, such as a boiler. Most of these buildings were protected by sprinkler systems. One advantage of this method of construction was that very little of the structure was enclosed to create voids.

Exterior wall construction had to be noncombustible, commonly brick, block, or stone. Walls at the lower levels were typically thicker than those at the top level. This stepped wall system allowed for greater load-carrying capacity at the lower levels, and the loads were accumulated from the upper floors and transmitted to the building's foundation. Typically, the walls were 24 to 36 inches thick at ground level. Wall sockets would be placed in both the interior and exterior walls to accommodate the floor support timbers. Common walls between buildings and floor supports seldom were used in heavy-timber construction. Generally each building had a separation to reduce the potential of fire spreading from one building to another. Unlike ordinary construction, which typically had two bearing walls and two curtain walls, the heavy-timber building would have four bearing walls, and no curtain walls. Lintels or arches to transfer loads over openings were made from materials of substantial strength. Occasionally, additional bracing or support cables were added to the exterior walls to provide additional strength to keep the walls from pushing outward.

Interior bearing walls are commonly masonry continuously supported to the ground, with brick or stone being the most popular materials. Interior walls were extended through each floor, with pockets in the wall to accept joists or beams from the floor support system. The interior walls also would be built in a stepped fashion to accommodate the heavy loads applied on them that must be transmitted to the foundation.

Floors were made from heavy planks, with a finish floor laid diagonally across the planks, which provided additional strength. Typically a layer of asphalt-based paper would be placed between the plank and finish floor to prevent water or other moisture from seeping to the floors below, which could damage machinery or goods. Floors often were equipped with openings in the exterior wall that provided an avenue for water to escape that floor of the building. These devices resemble a mail door assembly installed in a dwelling's door to allow the mail carrier to open a slot and slide mail inside the opening. This device was called a "scupper." This is a critical element that should be looked for by the Incident Commander (IC) while reading a building, since water from an operating sprinkler system or water applied from a hoseline should find its way to a scupper. If not, the water may be adding weight to the floor and building. Floors were pierced for many reasons, which provides for fire, smoke, or heat extension to upper floors. Open stairwells, open freight elevator shafts, conveyor systems, or power transfer shafts often pierced floors without any fire separation or fire resistance.

Roof construction was very similar to Type III or ordinary construction. One difference may be the addition of large ventilation systems that pass through the cockloft area and exit onto the roof. In some manufacturing operations, these ventilation systems would become saturated with lint or dust, and fires could occur.

Building renovations can create some special safety and operational concerns for firefighters. As an example, a change in occupancy from a manufacturing facility to retail stores would result in ceilings being dropped; often the sprinkler system was renovated to protect the occupied area, but the void between the dropped ceilings and the original wood ceilings (underside of floorboard for floor above) was left unprotected. Other concealed spaces are constructed to meet the new demands for building services such as plumbing, heating, ventilation, air conditioning, or electrical needs. Renovations typically hide a great deal of the exposed wood surfaces that are vulnerable to fire extension and travel. This type of construction is not allowed to have any concealed spaces located under roof or floor areas as noted in the Model Building Codes.

FIRE TRAVEL CONSIDERATIONS AND FIRE BEHAVIOR PREDICTIONS

Horizontal fire spread on the same floor can pose some unique challenges. Floors may be oil-soaked, the fire loading may be significant, and typically the floors provide large open areas for fire travel. Sizeup considerations include the need for large-caliber, straight-stream hoselines to provide reach and penetration into the fire area.

Vertical fire spread from floor to floor will happen most often through normal openings in the floors for stairwells and other services. Building renovations during the change of occupancy also may cause some vertical void areas as shafts are created for building services such as plumbing, heating, and electrical wires.

This type of building is very strongly built with noncombustible walls and heavy-timber supports for the floors and roof, which also are constructed from substantial materials. The massive timbers will burn for a considerable time before collapse occurs. The thick floors will keep the fire from extending to the floor above for a considerable amount of time. Many Type IV or heavy-timber buildings are protected with sprinkler systems (dry systems are common in areas that are unheated and susceptible to freezing). In addition, antifreeze wet sprinkler systems are commonly used on loading dock areas, which require a limited number of sprinkler heads, but still can be susceptible to freezing. Renovation of these types of structures usually require the existing installed sprinkler system to be upgraded.

SUMMARY

Heavy-timber or NFPA Type IV buildings will have four bearing exterior walls made from noncombustible materials. Exterior walls typically are thicker at the lower levels, which are meant to carry the accumulated loads from the floors above. Walls (both exterior and interior) will have sockets built into them to accept floor joists or beams from the floor support system. Interior load-bearing walls will be of noncombustible materials similar to the exterior walls and play a critical role both in fire separation and in supporting the heavy loads found in this type of building. Floors may have unprotected openings for stairwells, freight elevators, or conveyor devices, which will allow fire extension to the floors above. The positive aspect of these buildings is that they are built for strength, with heavy-timber supports for the floor and roof structure, providing a strong and stable building in the early stages of a fire.

Activity 5.1

Principles of Heavy-Timber Construction

Purpose

To apply knowledge of the construction features of a heavy-timber (Type IV) building under fire conditions.

Directions

1. The instructor will divide the class into groups and assign each group one of the scenarios.

2. Review the scenario, review the slide of your assigned building, and work as a group to answer the questions below.

    a. List specific safety concerns as they pertain to the classification of the building.

    b. Has flashover occurred yet? If not, is there a danger of it happening?

    c. What method of construction was used for this building?

    d. List three positive features for this method of construction.

    e. List one special concern for this method of construction.

    f. How will fire, heat, and smoke travel through this structure?

    g. Would you expect fire suppression to be a significant challenge? Why?

3. You have 20 minutes to discuss the scenario and answer the questions on the worksheet. Select a spokesperson to record your answers and report your findings to the rest of the class.

Scenario 1: 18 Mill Street

A fire has been reported in a self-storage facility. The caller reported that there is a bell ringing on the outside of the building under a sign that states "Call the Fire Department," there is water running out of a pipe on the side of the building, and there is smoke on the top floor. The time is 1030 hours on a Saturday.

Quick Access Prefire Plan

Building Address: *18 Mill Street*

Building Description:
Five-story 220' by 60' with no exposures. The building once was used as a textile mill and now only some of the floors are occupied: 1st and 2nd paper manufacturer uses for paper storage, 3rd and 4th a self-storage rental firm, and the 5th is vacant. Overall the building has been well maintained and managed. Two old open-shaft freight elevators have been replaced with new units in an enclosed shaft. The building has a 3-hour firewall with protected openings at the middle creating two sections 100' by 60'. Storage rooms (1,000) are not individually sprinklered while floor area above and around them is sprinklered. Year Built: 1912.

Roof Construction:
2" by 12" rafters covered with 2" planks and an asphalt and tar roof.

Floor Construction:
3" by 14" joists 12" on-center covered with 3" plank and 1" tongue-and-groove boards along with scuppers.

Occupancy Type:
Storage building.

Initial Resources Required:
4 engines, 2 ladders, 1 heavy rescue

Hazards to Personnel:
Paper storage on 1st and 2nd floors constitutes a large fire load and is water absorbent; self-storage floors have unknown materials stored by owners.

Location of Water Supply:
2, 20, & 40 Mill Street

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*3,000*	*6,000*	*9,000*	*12,000*

**Estimated fire flow based on 100' by 60' by five stories and one exposure.*

Fire Behavior Prediction:
Building has been well maintained with fire-rated stairwells between floors and all openings protected. Should contain fire to one floor. Most viable avenue of extension is via exterior walls' windows.

Predicted Strategies:
Rescue (accountability for self-storage visitors-security maintains a log of entry and exit), exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Accessibility to and through paper storage area with 10' high storage and self-storage lockers (1,000 storage rooms of various sizes). Floors are sprinklered but storage rooms are not sprinklered.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class III System.	*Wet system-OS&Y valve in bsmt. FD connection Side 1.*	*Water flow alarm and smoke detection tied into master box 4421.*

Scenario 2: 36 Mill Street

A fire has been reported in a six-story building which is currently under renovation. The building was originally a shirt factory and now is being converted to government office space. The caller states that a welder was cutting some pipes in the north wing and a fire started on the fourth floor. Renovation work on the first three floors is nearly completed, and all systems are operational. It is 0930 on a Thursday.

Quick Access Prefire Plan

Building Address: *36 Mill Street*

Building Description:
Six-story building, 250' by 75' with one 3-hour firewall in the center which has protected openings. There are no exposures. The sprinkler system on the fourth floor north wing has been shut off for renovation; all other systems are operable. Year Built: 1921.

Roof Construction:
2" by 10" rafters 12" on-center with 2" planks 1/2" plywood, insulation, and a new vinyl roof covering.

Floor Construction:
3" by 12" joists 12" on-center covered with 3" planks, 1/2" plywood, and carpet.

Occupancy Type:
Mill being converted to government office space.

Initial Resources Required:
3 engines, 2 ladders, 1 heavy rescue

Hazards to Personnel:
Building under renovation, oxygen/acetylene tanks, construction debris.

Location of Water Supply:
2, 20, & 40 Mill Street

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*1,375*	*2,750*	*4,125*	*5,500*

**Estimated fire flow based on one floor section 125' by 75' with three exposures. Each floor is segregated and separated, which will provide some fire separation--exterior fire extension is a critical element for fire extension.*

Fire Behavior Prediction:
Fire containment at the firewall and to one floor is likely if fire does not extend via exterior windows. Sprinkler system in areas where operable should confine or extinguish a fire.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Accessibility through stairwells as occupants (estimated to be 1,000 workers) are exiting--may be quicker to ladder and enter through a window.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class I system in stairwells at each floor.	*Wet system-OS&Y valve in basement--FD connection Side 1.*	*Smoke, heat, and water flow tied into master box 311. Enunciator panel inside front door at security station.*

Scenario 3: 48 Mill Street

A fire has been reported in a used furniture store which occupies part of the first floor of a five-story building. The building used to house a furniture factory, but now is vacant except for the first-floor occupant. The caller reports that he/she was varnishing furniture in a rear work room when the fire started on a workbench. It is 1430 hours on a Saturday.

Quick Access Prefire Plan

Building Address: *48 Mill Street*

Building Description:
5-story "L" shaped factory 80' by 100' and a four-story section 30' by 50' with no exposures. The water supply to the sprinkler system has been closed for over a year. No fire separations between two sections of "L" shaped building, and open shafts between floors. Year Built: 1910.

Roof Construction:
2" by 12" rafters 12" on-center with 2" planks, asphalt paper, and tar.

Floor Construction:
2" by 12" joists 12" on-center covered with 3" tongue-and-groove floor planks.

Occupancy Type:
Furniture store--part of first floor, remainder vacant.

Initial Resources Required:
3 engines, 2 ladders, 1 heavy rescue

Hazards to Personnel:
Most of building is vacant, vandalized, large amount of combustible materials (rags, cardboard, and pallets), and open elevator shaft (elevator removed).

Location of Water Supply:
2, 20, & 40 Mill Street

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*3,750*	*7,500*	*11,250*	*15,000*

**Estimated fire flow based on 100' by 80' five stories and 30' by 50' four stories. Note: No fire separations between two portions of "L" shaped building.*

Fire Behavior Prediction:
Fast fire spread and flashover due to totally open floor areas and open shafts between floors.

Predicted Strategies:
Rescue and then evaluate conditions to determine if offensive operations can be initiated safely. The building contains a heavy fire load, has been vandalized, and fire suppression system is turned off. Note: Place two charged lines into fire department connection and evaluate effectiveness of sprinkler system.

Problems Anticipated:
Large open areas, heavy fire load, and open shaft openings in floor will allow rapid fire spread and flashover.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
No water supply	*Water supply off*	*Out of service*

MODULE 6: CULMINATING ACTIVITY

OBJECTIVE

At the conclusion of this module, the students, when given a scenario, will be able to identify and describe the characteristics of a particular building classification, its construction features, and critical considerations for the Incident Commander (IC).

Activity 6.1

Culminating Activity

Purpose

To apply the knowledge, skills, and information gained from this course to review a scenario and make decisions critical to emergency scene operations.

Directions

1. Your instructor will divide the class into groups, and assign each group one of the 12 scenarios.

2. Review your assigned scenario, the Quick Access Prefire Plan (QAP), and the slides of your building, and work as a group to answer the questions below. Select a spokesperson to represent the group.

   a. What classification of construction is the building in your scenario? If it is a wood-frame structure, what method of construction does it appear to be?

   b. List specific safety concerns as they pertain to the classification of the building.

   c. Has flashover occurred yet? If not, is there a danger of it happening?

   d. List three positive features of this method of construction.

   e. List three special concerns you have for this building.

   f. How will fire, heat, and smoke travel through the structure?

   g. What strategies would you employ for this fire?

   h. What tactical operations would you implement for this fire that are consistent with your strategies?

   i. Would you expect fire suppression to be a significant challenge? Why or why not?

3. You have 45 minutes to discuss your scenario and answer the questions on the worksheet.

Scenario 1: Senior Citizen Apartment Center

A fire has been reported at the Victory Mills Senior Citizen Apartment Center. The alarm was received by a box alarm followed by a caller who states that he/she is on the second floor in apartment 211 and smoke is coming from the first floor. The time is 1030 on a Tuesday.

Quick Access Prefire Plan

Building Address: *12 Mill Street--Victory Mills Senior Citizen Center*

Building Description:
4-story 1,000' by 80' apartment building with 128 units--three firewalls create four areas with 32 units each. (Basement occupied as one story.) Year built: 1927.

Roof Construction:
2" by 10" rafters. Heavy timber with 2" plank covered with asphalt paper, insulation, and a new vinyl roof. Each of the four units has a stairwell to the roof.

Floor Construction:
3" by 12" joists with 3" plank covered with 1" boards.

Occupancy Type:
128 one-bedroom dwelling units divided into four separate sections separated by a 4-hour firewall with protected openings.

Initial Resources Required:
2 engines, 1 tower ladder, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
2, 10, & 18 Mill Street

Available Flow:
2,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*2,075*	*4,150*	*6,225*	*8,300*

**Estimated fire flow based on one floor area 250' x 80' with one exposure.*

Fire Behavior Prediction:
Eight apartments on each floor level between firewalls. One interior wall goes to the ceiling of the structure and separates four apartments from the remaining four. Fire extension above dropped ceiling will spread rapidly into four units. Note: Apartment ceilings are metal grid hung from wire and fire-resistant tile.

Predicted Strategies:
Evacuate occupants to opposite sides of firewalls, check for extension above ceiling. Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Rescue and accountability of occupants.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**

Scenario 2: 180 Main Street

A fire has been reported in a neighborhood retail drugstore by a third-floor occupant who reports that she is unable to escape with her three children, as both the front and rear stairs are blocked with smoke and fire. She will await your arrival. It is 0615 and, upon arrival, you do not see or hear any occupants on the third floor.

Quick Access Prefire Plan

Building Address: *180 Main Street*

Building Description:
3-story with brick exterior walls and wooden interior walls housing a drugstore on the first floor and two apartments on each of the second and third floors (total four apts.) size 50' by 120' with exposure Side "B" 8 feet. Year built: 1914.

Roof Construction:
1" boards over 2" by 10" rafters covered with paper and tar--center drains.

Floor Construction:
3/4" boards over 2" by 8" floor joist 12" on-center.

Occupancy Type:
Drugstore and 4 apartments

Initial Resources Required:
2 engines, 1 ladder, 1 ambulance

Hazards to Personnel:
Drugs and chemicals in first-floor occupancy.

Location of Water Supply:
180 Main St.

Available Flow:
1,500 gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*1,875*	*3,750*	*5,625*	*7,500*

**Estimated fire flow based on 120 x 50 times three stories and 1 exposure.*

Fire Behavior Prediction:
Open stairwells from first floor to third--rapid fire travel. Utility shaft terminates in cockloft providing fire spread from basement to attic. Fire extension from 2nd to 3rd floor via bay windows on front (unsupported to the ground). Ceilings on all floors have been lowered with void area above.

Predicted Strategies:
Rescue occupants; use caution with smoke and runoff water from drugstore.

Problems Anticipated:
Water pressure in the area is usually low (50 psi) on Main Street.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Scenario 3: 47 Briarwood Road

A fire has been reported in a church. It is 1600 on a Tuesday. A custodian reported the fire and stated that there was a meeting taking place in the church, but he/she believes that everyone has left. He/She also states that he/she was polishing the wood ceiling planks with linseed oil at the time the fire started.

Quick Access Prefire Plan

Building Address: *47 Briarwood Road*

Building Description:
1-story church 100' by 40'--no basement. Church has small office, altar rooms, and choir room at the rear of the sanctuary. Church school, main offices, etc., are in separate building (exposure Side "C"). Support beams range from 48" thick at floor to 12" at roof peak. Year built: 1987.

Roof Construction:
Two-inch planks over laminated beams covered with shingles.

Floor Construction:
Concrete slab covered with carpet--no basement.

Occupancy Type:
Church

Initial Resources Required:
3 engines, 1 ladder, 1 heavy rescue, 1 ambulance

Hazards to Personnel:
Large open area with heavy fire load--flashover.

Location of Water Supply:
51 Briarwood Rd.

Available Flow:
2,000 gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*830*	*1,660*	*2,490*	*3,320*

**Estimated fire flow based on 100' by 40' times 2 stories (used 2 stories due to height of cathedral ceiling and wood plank ceiling material) with one exposure.*

Fire Behavior Prediction:
Rapid fire spread due to combustible wall/ceiling finish and high ceilings--flashover will occur early. Exit doors on all four sides.

Predicted Strategies:
Rescue and large lines with straight stream nozzles. Use aerial ladder to vent roof early.

Problems Anticipated:
Accessibility of hoselines from the exterior to interior through small windows.

☐ **Standpipe:**	☐ **Sprinklers:**	☐ **Fire Detection:**

Scenario 4: 122 Green Meadows Drive

A fire has been reported in an old barn that now is used to store golf course maintenance equipment. The caller reported that a mechanic was working on a tractor when an explosion occurred. The caller reports that the mechanic has not been seen since. It is 1100 on a Wednesday.

Quick Access Prefire Plan

Building Address: *122 Green Meadows Drive*

Building Description:
2-story 50' by 60' dairy and hay barn currently used for the storage of equipment. Year built: 1932.

Roof Construction:
3/4" boards over purlins placed 36" on-center over heavy beams covered with wood shingles (cedar shake shingles).

Floor Construction:
2" planks over heavy-timber beams. (no basement)

Occupancy Type:
Storage barn

Initial Resources Required:
2 engines, 1 tanker/tender

Hazards to Personnel:
Storage of tractors, mowers, and other equipment. Storage of pesticides and herbicides for the maintenance of the golf course.

Location of Water Supply:
Dry hydrant at pond located at clubhouse (accessible all year) 3,000 feet from storage barn.

Available Flow:
2 million gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*500*	*1,000*	*1,500*	*2,000*

**Estimated fire flow based on 50' by 60' by 2 stories (equivalent to two story) and no exposures.*

Fire Behavior Prediction:
Rapid fire extension due to open area, flammable liquids, combustible materials, and general storage.

Predicted Strategies:
Small fire--extinguish and control water runoff; large fire--defensive strategy and avoid contact with smoke due to chemicals inside. Control any runoff water.

Problems Anticipated:
Rapid fire extension, hazardous materials in storage, large amount of combustibles.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Scenario 5: Dalamar Court Village

A fire has been reported from apartment 21 of Dalamar Court Village. The caller stated that his/her neighbor was cooking with grease on the stove when a fire occurred. The neighbor was burned when he/she tried to put the fire out. It is 0930 on a Monday.

Quick Access Prefire Plan

Building Address: *Dalamar Court Village (18 buildings with 8 units each).*

Building Description:
2-story 120' by 50' garden apartments. Eight apartments with one 3-hour firewall between four units, four units on each side of firewall. Year built: 1996.

Roof Construction:
Plywood over wood truss rafters 24" on-center.

Floor Construction:
Plywood over wooden "I" beams 16" on-center.

Occupancy Type:
Each building has eight apartments.

Initial Resources Required:

Hazards to Personnel:
Lightweight structural members.

Location of Water Supply:
Hydrant at each end of each building.

Available Flow:
1,000 each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*625*	*1,250*	*1,875*	*2,500*

**Estimated fire flow based on 60' by 50' by two stories and one exposure adjacent to the firewall.*

Fire Behavior Prediction:
Fire, heat, and smoke travel between adjacent kitchens and baths. Fire, heat, and smoke extension to attic via vents from apartments. Fire travel through floor joist channels between joists.

Predicted Strategies:
Rescue, exposures, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Lightweight floor joists and roof rafters--early failure potential under fire conditions.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Local alarm for bldg. only.

Scenario 6: Maria Parkway

A fire has been reported in a single-family dwelling. The caller reported smoke in the basement and smoke in the attic. The caller states that a plumber is working in the basement and told the owner to call the fire department. It is 1330 on a Saturday.

Quick Access Prefire Plan

Building Address: *21 Maria Parkway*

Building Description:

2-story 60' by 40' dwelling with offices in the basement. The walk-out basement is finished off for a doctor's office with examination rooms, offices, etc. (One entrance/exit at basement level and another up stairs to first floor.) Basement is partially sprinklered. Year built: 1907.

Roof Construction:

3/4" roof boards over 2" by 10" rafters 12" on-center. Roof slopes front to rear with 48" parapet on front wall.

Floor Construction:

Two layers of 1/2" boards over 2" by 10" floor joists 12" on-center.

Occupancy Type:

Single-family dwelling and medical officers.

Initial Resources Required:

3 engines, 1 ladder, 1 ambulance

Hazards to Personnel:

Medical offices in basement--medical supplies, oxygen cylinders, etc.

Location of Water Supply:

14 & 48 Maria Pkwy.

Available Flow:

1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*600*	*1,200*	*1,800*	*2,400*

**Estimated fire flow based on 60' by 40', three stories and no exposures.*

Fire Behavior Prediction:

Vertical pipe chase from basement to attic for utilities and ventilation of the basement--rapid fire extension via pipe chase. Medical offices in basement sprinklered with wet system--other rooms in basement, such as boiler room and storerooms, not protected.

Predicted Strategies:

Rescue (remember medical offices in basement), exposures, confinement, extinguishment, overhaul, ventilation, and salvage. Note: vent attic early if extension is probable to that area.

Problems Anticipated:

Building remodeled several times with many void areas.

❑ **Standpipe:**	❑ **Sprinklers:**	❑ **Fire Detection:**

Scenario 7: High Lake Road

A fire has been reported in a retirement community at High Ledge Lake. The call was received from a security company monitoring the fire-alarm system at the residence, reporting an active fire alarm at 22 High Lake Road. No one is answering the telephone at that residence. The time is 0730 on a Sunday.

Quick Access Prefire Plan

Building Address: *22 High Lake Road*

Building Description:
2-story, 80' by 40' with a full occupied walk-out basement. Year built: 1997.

Roof Construction:
Plank and beam with air space, purlins, plywood sheathing, and asphalt shingles (roof over a roof).

Floor Construction:
2" by 10" joists with 5/8" plywood sheathing.

Occupancy Type:
Single-family dwelling.

Initial Resources Required:
3 engines, 1 tanker/tender, 1 rescue

Hazards to Personnel:
Occupant stores up to 5 pounds of black powder in basement; front porch steps lead directly into the lake; occupant stores pesticides and herbicides for gardens.

Location of Water Supply:
Lake access 250' to West at #36 High Lake Road

Available Flow:
Unlimited

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*800*	*1,600*	*2,400*	*3,200*

**Estimated fire flow based on three stories of occupied space and no exposures.*

Fire Behavior Prediction:
Large open floor space in living and dining room--cathedral ceilings two stories high, second-floor bedrooms open on balcony overlooking living room, will generate fast heat buildup and limit rescue from bedrooms from interior of structure.

Predicted Strategies:
Rescue, exposure protection, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Limited access on lake side of building.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Rich Security*

Scenario 8: Wendy's Path

A fire has been reported at a single-family dwelling. The caller stated that he/she was driving by and saw smoke coming from the garage. A major electrical storm just passed through the area with several lightning strikes in the area. The time is 0545 on a Sunday.

Quick Access Prefire Plan

Building Address: *14 Wendy's Path*

Building Description:
2-story, single-family dwelling 30' by 40' with attached two-car garage 30' by 28'. Note: Room over garage will be made into children's playroom. Year built: 1998. Basement under dwelling area only.

Roof Construction:
1/2" particle board over wooden truss rafters 24" on-center.

Floor Construction:
First floor--3/4" particle board and carpet over wood bar joists 24" on-center and second floor 2" by 8" joists supported on interior walls with metal joist hangers.

Occupancy Type:
Single-family dwelling.

Initial Resources Required:
2 engines, 1 heavy rescue, 1 ambulanc

Hazards to Personnel:
Lightweight roof and floor system.

Location of Water Supply:
Corner Wendy's Path and Briarwood Road (400')

Available Flow:
200 gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*350*	*700*	*1,050*	*1,400*

**Estimated fire flow based on 30' by 40' by two stories and 28' by 30' two stories with no exposures.*

Fire Behavior Prediction:
All combustible structural elements covered with 1/2" gypsum board to limit fire spread, open stairwell from first floor to second floor.

Predicted Strategies:
Rescue, exposure, confinement, extinguishment, overhaul, ventilation, salvage.

Problems Anticipated:
No special problems--one-hour fire separation between garage and dwelling.

- [ ] **Standpipe:**
- [ ] **Sprinklers:**
- [ ] **Fire Detection:**

Scenario 9: 1 Southgate Road

A fire has been reported in a single-family dwelling. The caller stated that his/her son was playing on the second floor when he/she smelled smoke coming from the garage. He/She also reports that he/she cannot find his/her son, and he may be hiding behind the wall. It is 1000 on a Thursday.

Quick Access Prefire Plan

Building Address: *1 Southgate Road*

Building Description:
2-story, single-family dwelling 35' by 30' with an attached one-car garage 24' by 14' with storage room above which is accessible from the second floor. One-hour fire separation between garage and dwelling. Note: extensions on both front and rear walls are walk-in closets. Year built: 1955.

Roof Construction:
3/4" boards over 2" by 10" rafters 16" on-center covered with asphalt shingles.

Floor Construction:
First floor on concrete slab, second has 2" by 10" floor joist covered with 5/8" plywood, and carpet.

Occupancy Type:
Single-family dwelling

Initial Resources Required:
2 engines, 2 tankers/tenders, 1 ambulance

Hazards to Personnel:
Kneewall across front side on second floor creates void area--has one door into storage space directly under dormer windows.

Location of Water Supply:
Hydrant at 4555 Main Street in Town of Menands (3 miles)

Available Flow:
6,000 gallons total in tanks on apparatus.

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*225*	*450*	*675*	*900*

**Estimated fire flow based on 35' by 30' by two stories and 24' by 14' two stories with no exposures.*

Fire Behavior Prediction:
Fire from first floor into soffit will allow fire into void space behind kneewall.

Predicted Strategies:
Rescue, exposure, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Water supply.

❑ **Standpipe:**

❑ **Sprinklers:**

❑ **Fire Detection:**

Scenario 10: 1224 Broadway

A fire has been reported by an occupant of the second floor who reports smoke coming from around the light switches and electrical outlets on the outside wall. The caller states that he/she can hear music coming from the first-floor apartment but is not sure anyone is home. It is 1930 on a Thursday.

Quick Access Prefire Plan

Building Address: *1224 Broadway*

Building Description:
Two-family, 2-story building 30' by 60'. The building has been renovated with new electrical and plumbing installed. During the renovations the ceilings on both floors were lowered 12". Year built: 1927.

Roof Construction:
2" by 10" rafters with 3/4" boards covered with slate shingles.

Floor Construction:
2" by 10" floor joists with 3/4" tongue-and-groove floor boards.

Occupancy Type:
Two-family dwelling (one unit up and one unit down).

Initial Resources Required:
2 engines, 2 tankers/tenders, 1 ambulance

Hazards to Personnel:
Basement has large accumulation of old furniture, appliances, and boxes of clothes

Location of Water Supply:
1218 Broadway

Available Flow:
400 gpm.

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*400*	*800*	*1,200*	*1,600*

**Estimated fire flow based on 30' by 60', two stories and one exposure.*

Fire Behavior Prediction:
Rapid fire spread up outside walls, interior utility shaft, and void areas created by dropped ceilings.

Predicted Strategies:
Rescue, exposure, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Heavy fire load in basement--difficult to get to and can cause entrapment for entry teams. Note: may wish to use tag lines (ropes) on entry personnel into basement.

☐ **Standpipe:**

☐ **Sprinklers:**

☐ **Fire Detection:**

Scenario 11: 27 Park Street

A fire has been reported by an occupant of a single-family dwelling who reports a fire on the second floor. The caller also stated that he/she has a collection of guns and ammunition on the property with some of them loaded. It is 0930 on a Saturday.

Quick Access Prefire Plan

Building Address: *27 Park Street*

Building Description:
2-story 30' by 30' single-family dwelling that originally shared a common wall with 29 Park Street (torn down 5 years ago). Basement used for light storage and utilities. Year built: 1939.

Roof Construction:
2" by 12" rafters covered with 1/2" plywood, insulation, and vinyl covering.

Floor Construction:
2" by 10" covered with 3/4" tongue-and-groove boards.

Occupancy Type:
Single-family dwelling.

Initial Resources Required:
2 engines, 1 ladder, 1 heavy rescue

Hazards to Personnel:
Loaded guns and ammunition.

Location of Water Supply:
25 and 37 Park St.

Available Flow:
500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*150*	*300*	*450*	*600*

**Estimated fire flow based on 30' by 30', two stories and no exposures.*

Fire Behavior Prediction:
Fire on wooden rear porch can spread fire quickly from floor to floor.

Predicted Strategies:
Rescue, exposure, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Former common wall has no special bracing and any compromise of structural members inside structure may cause wall failure.

☐ **Standpipe:**

☐ **Sprinklers:**

☐ **Fire Detection:**

Scenario 12: 37 Museum Drive

A fire has been reported at a museum which was a former one-room school building. The building was moved to this site and restored to its original condition. The museum is open, and the caller states that there is smoke coming from underneath (crawlspace) the building. It is 1530 on a Sunday.

Quick Access Prefire Plan

Building Address: *37 Museum Drive*

Building Description:
1-story 35' by 25' wooden rural schoolhouse being used as a museum to display life in a country school. The building houses one large classroom, two small rooms, and a storage room. Year built: 1901.

Roof Construction:
2" by 8" rafters 12" on-center with purlins and a slate roof.

Floor Construction:
2" by 12" joists 12" on-center with two layers of 3/4" boards.

Occupancy Type:
Museum building.

Initial Resources Required:
3 engines, 1 tanker/tender, 1 ambulance

Hazards to Personnel:
No special hazards.

Location of Water Supply:
Snake River drafting site 2 miles on RT 378 (Dry hydrant open year around--Philadelphia threads (use adapter).

Available Flow:
Unlimited supply

	Estimated Fire Flow*			
Level of Involvement	*25%*	50%	75%	100%
Estimated Fire Flow in gpm	*75*	*150*	*225*	*300*

*Estimated fire flow based on 35' by 25', one story with no exposures.

Fire Behavior Prediction:
Open area with adequate combustible materials for a fast fire with rapid heat buildup--watch for early flashover.

Predicted Strategies:
Rescue, exposure, confinement, extinguishment, overhaul, ventilation, and salvage.

Problems Anticipated:
Water supply 2 miles--call early for additional water supply.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Heat detection to local alarm only.*