Principles of Building Construction: Noncombustible

PBC:NC-Student Manual

2nd Edition, 1st Printing-April 2000

U.S. DEPARTMENT OF HOMELAND SECURITY FEMA

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U.S. DEPARTMENT OF HOMELAND SECURITY

FEDERAL EMERGENCY MANAGEMENT AGENCY

UNITED STATES FIRE ADMINISTRATION

NATIONAL FIRE ACADEMY

FOREWORD

On March 1, 2003, the Federal Emergency Management Agency (FEMA) became part of the U.S. Department of Homeland Security. FEMA's continuing mission within the new department is to lead the effort to prepare the nation for all hazards and effectively manage federal response and recovery efforts following any national incident. FEMA also initiates proactive mitigation activities, trains first responders, and manages the National Flood Insurance Program and the U.S. Fire Administration.

FEMA's U.S. Fire Administration (USFA) serves as the agency fire protection and emergency response community expert. It is located at the National Emergency Training Center in Emmitsburg, Md., and includes the National Fire Academy and the Emergency Management Institute. The mission of the USFA is to save lives and reduce economic losses due to fire and related emergencies through research and training, public education and coordination with other federal agencies and fire protection and emergency service personnel.

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 USFA's National Fire Academy offers a diverse delivery system. Courses are delivered at the Emmitsburg campus and throughout the nation in cooperation with state and local fire training organizations.

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 to use this knowledge in their decisionmaking process.

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COURSE GOAL

The overall goal of this course is to provide knowledge about the classification system of buildings, the importance of the 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 to "read" a building's construction and to 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 requirement for firefighter Level III.

COURSE OVERVIEW

Module 1

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

Module 2

This module provides an overview of the common principles of construction that apply to all classifications of buildings. Subjects include 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: Combustible* course.

Module 3

This module gives general information about NFPA Standard 220 Type II or noncombustible, unprotected steel construction buildings. The course material covers steel as a construction material, lightweight steel construction buildings, "big box" buildings, and rigid frame steel buildings, and the effect of fire and heat on steel structural elements.

Module 4

This module provides general information about NFPA Standard 220 Type I and Type II noncombustible protected buildings. The course material covers the construction materials, steel protected with fire-resistant material, and poured-in-place, prestressed, and post-tensioned concrete construction.

Module 5

This module provides an opportunity to apply the skills learned in this course. Twelve scenarios are provided covering unprotected as well as protected steel construction buildings.

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 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 other 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: Combustible.*

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.

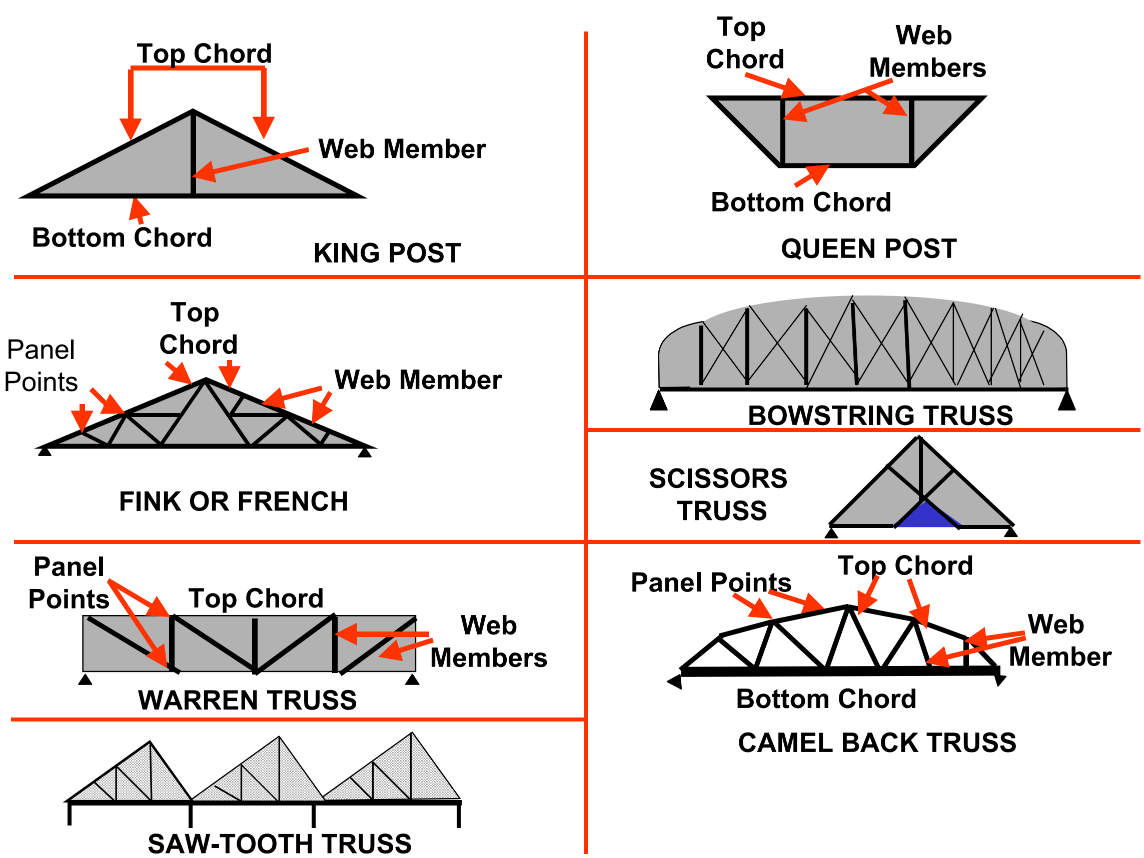
Connections should be evaluated for failure potential and the impact of connection failure on the entire structure. A single steel connector plate failure on a wooden truss rafter or joist could cause catastrophic failure of the entire support system.

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?

      ____

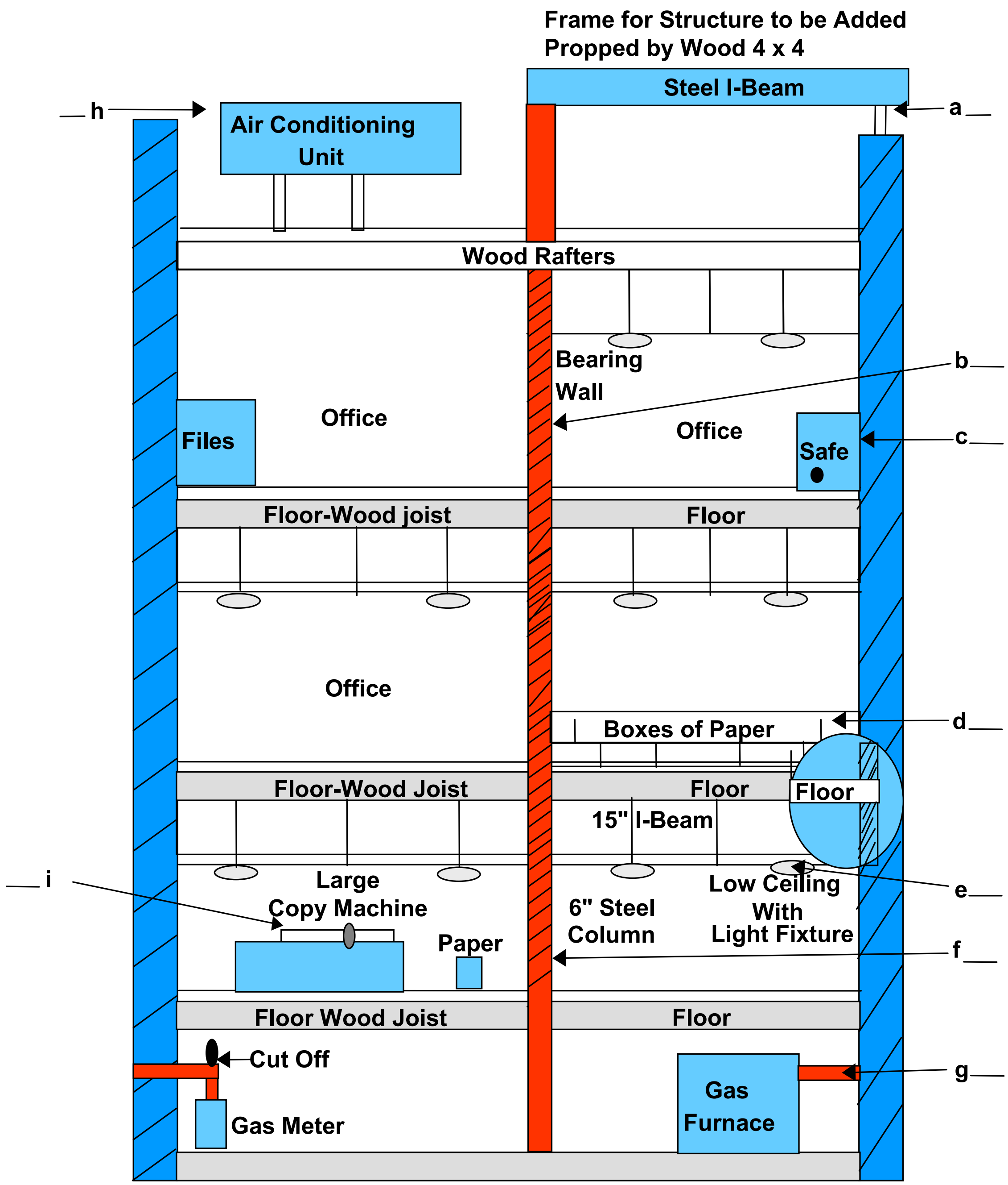
   b. What could happen to the remainder of the structure if the safe fell through the floor, and why could it happen?

      ____
      ____
      ____

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

Activity 2.1 (cont'd)

Building Plan



MODULE 3: UNPROTECTED NONCOMBUSTIBLE BUILDINGS

OBJECTIVES

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

1. *Identify the structural elements of a Type II lightweight steel construction building and identify the safety concerns associated with this method of construction under fire conditions.*

2. *Identify the structural elements of a Type II rigid frame steel construction building and identify the safety concerns associated with this method of construction under fire conditions.*

3. *Identify and justify critical consideration features for fire, heat, and smoke travel when given a scenario for both methods of steel construction buildings.*

CHARACTERISTICS OF TYPE II OR UNPROTECTED NONCOMBUSTIBLE BUILDINGS

Since 1870, steel has been a popular construction material to support parts of buildings or to carry the entire load of the structure. From the first structural elements made from cast iron to today's modern steel-framed highrise, the use of steel as a structural material has become very popular.

The National Fire Protection Association (NFPA) defines Type II (unprotected noncombustible) construction as the type that does not qualify as Type I (protected noncombustible) construction in which structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are of approved noncombustible or limited-combustible materials and shall have fire-resistance ratings not less than those specified in Table 3-1. Table 3-1, as indicated in NFPA 220 *Standard on Types of Building Construction*, identifies three subclassifications. Subclass 000 specifies no fire-resistance ratings for the materials except that local codes may require fire-resistance ratings for exterior walls in close proximity to property lines, other buildings, or exposures. Subclass 111 requires a fire-resistance rating of 1 hour for all structural materials except the exterior nonbearing walls. A third category, found in subclass 222, requires a 2-hour rating for structural materials supporting floors and 1 hour for elements supporting the roof. As found in subclass 111, the exterior nonbearing walls do not require any fire-resistance. The distinction of whether a building will be constructed with subclass 000, 111, or 222 is determined by local fire and building codes, and usually depends on the building height, size, or occupancy. If a fire-resistance rating is required, it can be achieved in several ways to protect the structural steel elements. These will be discussed in Module 4: Protected Noncombustible Buildings. Also, as shown in Table 3-1, local codes may require exterior nonbearing wall structural elements to have a fire-resistance rating or other protection due to their proximity to other buildings or exposures.

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 beof approved combustible material.

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

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Two common tests are used to determine the ability of construction materials to keep a fire from penetrating from the side of the material exposed to the fire test through to the opposite side. These are the American Society for Testing and Materials (ASTM) 119 and Underwriters Laboratories (UL) 263. The construction materials are placed in the same configuration that would be used in the actual construction, and placed in a test chamber. If, after a predetermined exposure time to a predetermined amount of heat, the heat and fire have not extended through the structural element, the first part of the test is completed. Structural materials to be used in a vertical configuration, such as a wall, also will be subjected to a hose stream test to simulate fire department application of extinguishment water from a straight stream nozzle.

STEEL AS A STRUCTURAL MATERIAL

Cast-iron columns providing structural support for exterior wall

Cast Iron

Cast iron was the first form of iron to be used as a structural element in buildings. Identified both for its strength under compression and a noncombustible material, it was first used in supporting columns around 1870. The columns could be manufactured easily at a foundry and transported to the construction site for installation. The forms used could be designed with a bell-shaped top and bottom to provide greater stability and still have heavy loads applied to them. Some early attempts to use cast iron for beams or girders were unsuccessful or had limited success, since cast iron has limited strength under tension or against shear forces. The problem with some of the earlier cast-iron materials was that, in many instances, they were not formed in a uniform manner. While the exterior of the column was uniform, the interior walls could be 1-inch thick on one side and 1/2-inch thick on the opposite side. Later, methods of pouring the forms with molten iron were improved and the quality also improved.

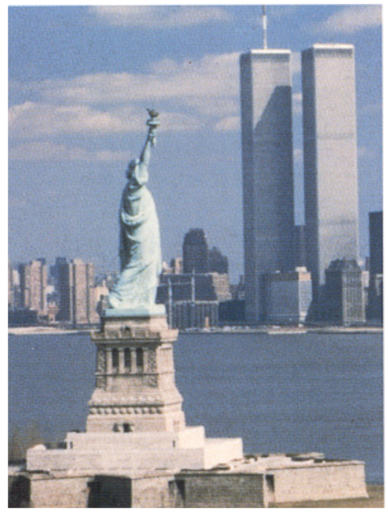
Cast-iron building front providing structural support to exterior wall of building

Cast iron could be formed to create arches and lintels to span window and door openings in walls, which provides greater flexibility to the building designer and the contractor installing the materials. Cast-iron lintels and arches typically replaced stone elements, which were much heavier and required extra strength in the load-bearing walls to carry the weight of the stone. Some attempts were made to create the complete building exterior wall from cast iron at a foundry, transporting the components to the construction site, and installing the pieces with bolts and rivets. Many such buildings still stand today, especially in the business districts of older cities.

Concerns for firefighters involving cast-iron columns, lintels, arches, or exterior building support walls include their susceptibility to sharp blows from heavy objects. Since cast iron does not bend, flex, or twist it can fail at connections or in the support columns. Many contractors, when removing cast-iron items such as bathtubs or heating radiators, break the material with a sharp blow from a sledgehammer. While any iron or steel structural element can fail under fire conditions, most experts report that cast-iron elements most typically fail as a result of improper connections or eccentric loads rather than failure of hot columns being hit with cold water.

Cast-iron supports have been reliable structural elements for more than 100 years. One concern often raised today is the loads applied to the structural elements. Part of this concern comes from a lack of confidence in the uniformity of the casting, corrosion that may have occurred over the years inside the column which is not visible from the outside, and the difficulty of making solid connections from other structural elements to the cast-iron elements. In many instances, the loads simply rest on top of the column with a limited connection or no connection. In other instances straps, hangers, or other steel elements are used to connect structural materials to the columns. Firefighters should evaluate loads applied to columns and the method of how they are attached in order to determine if the load is an axial, eccentric, or torsional load. The ability of the columns to support the loads applied, especially under fire conditions, should be a critical safety consideration for Incident Commanders (IC's), Safety Officer, Company Officers (CO's), and firefighters.

Structural Steel Becomes Popular Construction Material



The Statue of Liberty was constructed in 1886 using 250,000 pounds of steel, covered with 200,000 pounds of sheet copper

Steel as a structural material gained popularity in America at about the turn of the century (1900) when steel mills began to produce what is commonly called "structural steel." The steel mills, particularly in the Northeast, were able to make long beams and columns that could be transported to the construction site and installed with rivets, bolts, or by welding two steel elements together. Some of the advantages of structural steel are that it is strong in both compression and tension, in addition to its ability to twist in a torsional manner without fracturing or failing. This was a big change from cast iron, which was strong only in compression.

Another benefit of using steel as a construction material is the ability to add other materials to strengthen the steel or preserve it. One such additive is copper which limits the corrosion of the steel. This is often seen today on bridge supports that were not painted and appear to be rust colored, but are not exhibiting the normal signs of heavy corrosion. This type of steel also has been used extensively to construct water tanks for fire apparatus. By adding carbon, nickel, and other alloy materials the tensile and shear strength of steel can be increased. Some of the strongest structural steel is used to make cable, and is used in post-tensioned concrete. This steel is referred to as "cold-drawn steel" which means that it is produced cold rather than being heated and softened to be formed into structural elements. Steel also can be made harder and stiffer by heat treating where the steel is heated to a specific temperature and then cooled instantly.

- Structural steel (ordinary carbon): strength of 33,000 to 45,000 pounds per square inch.

- High-strength structural steel (alloys added): strength of 42,000 to 75,000 pounds per square inch (psi). Used for special applications such as supporting a mezzanine.

- Heat-treated high carbon and alloy steel has strength of 70,000 to 120,000 psi. Typically used for pre-tensioned concrete and where special strength steel is required.

- Cold-drawn steel has strength of up to 150,000 psi. Typically used for cold-drawn steel cable or rods used for post-tensioned concrete.

Concerns for firefighter safety are centered around the fact that structural steel expands as it is heated, will lose about half its load-carrying capacity at 1,000°F (538°C), and will totally relax at 1,500°F (816°C). Hardened steels will react even sooner. As an example, at 300°F (149°C) structural steel will actually increase in its load-carrying capacity, while cold-rolled steel used to make cables for post-tensioned concrete will lose about a third of its strength at 600°F (316°C). Cold-drawn steel cables stretched to carry 150,000 pounds per square inch under normal conditions can be reduced to 97,500 pounds of carrying capacity at only 600°F (316°C). Fires in structures using this cold-drawn steel risk structural failure, or at least require special consideration for IC's to observe signs of heating and floor sagging. One such sign could be concrete floors sagging due to the elasticity of the steel. Of particular concern is the potential for structural failure due to the inability of the steel cables to support the loads applied. A structural steel beam heated to a temperature of 1,000°F will expand as much as 1 inch for every 10 feet of length. A steel beam serving as a center carrying beam for steel bar joists 40 feet long heated to 1,000°F could become 40 feet, 4 inches. The additional 4 inches must go somewhere, and may be accommodated by pushing outward against the walls or, as it more commonly happens, twisting and turning to accommodate the additional length. When this occurs it may drop the bar joist or may fall from supporting posts.

Surface-to-mass considerations are critical to the speed at which structural elements may heat to critical temperatures where failure may occur. A piece of flat sheet steel used for roofing or an exterior covering will absorb heat that affects the exposed area much more quickly than it would a 1/2 inch thick 10-inch "H" column used to support a roof. The thicker the steel the longer it will take to cause failure. This is critical when the structure is a light frame building rather than a rigid frame structure that was constructed with large steel structural members. In some fires inside lightweight buildings with a metal roof covered with asphalt-based roofing, the sheet steel was heated through and produced combustible gases from the asphalt roofing above. The gases were unable to escape through the roofing materials and were forced between the seams of the sheet steel roof covering, causing significant fire conditions at the roof level where there should have been no fire.

LIGHTWEIGHT STEEL CONSTRUCTION

Lightweight steel construction buildings can be used for hundreds of different occupancies

Skeleton Framing

Skeleton framing of lightweight steel structural columns, beams, and truss joists has become very popular. The buildings can be manufactured at a steel fabrication plant, transported to the construction site, and erected in a short period of time. The structural frame carries the load of the structure and its contents which allows for lightweight non-load-bearing curtain walls to be used to close the structure. This type of building can be used for a wide variety of occupancies including offices, commercial buildings, warehouses, strip malls, and hundreds of others.

The building starts with concrete pads placed around the footprint of the building. These pads are placed below the frost line on a solid footing, as the steel columns for the structure will be placed on them. In some instances cardboard tube forms are placed in deep holes and then filled with concrete. At the top of the concrete pad or concrete tube, anchor bolts are secured in the concrete before it dries and cures.

Steel columns then are placed on the bolts in the concrete pads and the columns are secured to the concrete base. The steel columns are equipped with flat flanges on the top and on the sides near the top. The flanges are used to secure the columns to the foundation and the beams to the columns. These beams and girders will extend to the next column to the left, to the right, and directly forward. Interior columns will have beams or girders attached to all four sides. These structures, commonly referred to as boxes, can extend continuously for hundreds of feet in all directions. In many new, large commercial stores today, such as building material and supply stores, they are referred to as the "big box" building.

"H"-shaped columns are used for vertical support. To ensure their design to carry an axial load they are constructed in proportional sizes. If the flanges (outside sides) are 10 inches across, the web between the sides will be 10 inches as well. When a load is placed on the column, the entire element is under compression and the equal dimensions help distribute the load equally to all parts of the column.

"I"-shaped structural elements are used for beams and girders to support floor or roof loads. These structural elements are placed under both compression (on the top) and tension (on the bottom) with the section in the middle being in the neutral plane. The general rule of thumb is that the greater the dimension of the web of the "I" beam, the greater the load it is intended to carry. The web of the element will be larger than the top and bottom flanges. When a load is applied, such as from a series of steel bar joists carrying a floor or roof load, the top of the beam is being compressed and the tension is trying to tear the bottom apart. If other structural elements must be run through the beam, such as for utility or ventilation ducts, it is critical that they be placed as close to the center of the web as possible. The top and bottom flange should not be compromised without special bracing or structural support. Spacing between columns is dependent upon how much load is to be supported and the size of the structural materials that will be used to support the load.

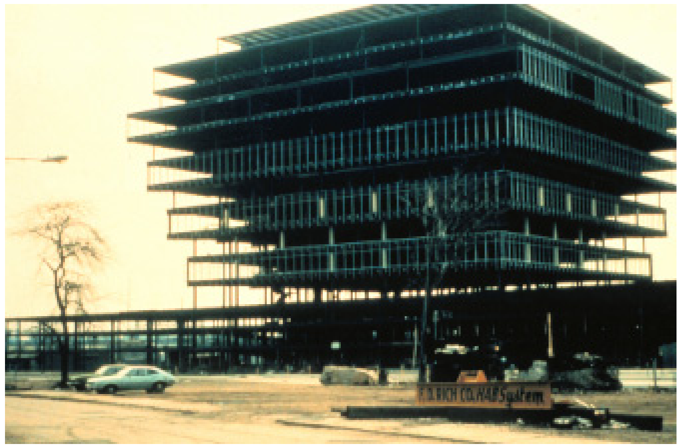
The box concept can be extended not only horizontally but vertically as well. Additional columns can be welded or bolted to the top of the columns attached to the concrete pads, and additional floors added. If the building has multiple floors, the first steel column may be long enough to support the first two or three floors, with flanges attached to support the floor beams at the appropriate height. For short spans or light loads box columns shaped from formed sheets of steel into a box shape also can be used to support the loads, instead of using "H" columns.

Steel bar joists are used to support floor and roof structural elements

Roof loads include a variety of loads that must be supported, ranging from the structural materials, snow or water loads (90 psi snow load requirement in upstate New York), heating and cooling equipment, compressors for refrigeration equipment, and the unexpected loads such as a company of firefighters assigned to a ventilation task during a fire. The most common structural material used to support the roofing materials is the lightweight steel bar joist. The bar joist is named for the steel bars that used to be formed in a "V", sandwiched support floor and roof loads between lightweight angle iron, and welded. The bars are usually 1/2 to 3/4 inch in diameter and the angle iron is typically 2 or 3 inches by 1/4 inch thick. Since the top is under compression it is the longer part of the element, and the bottom being under tension will not be supporting the beams or bearing wall. The "V" or "truss" principle provides the support from within the materials to carry the load and transfer it to the load-bearing elements such as beams and girders.

Roofing material for a pitched roof most typically will be sheets of corrugated steel attached to purlins that stretch across steel bar joists. Roof decking for a flat roof most typically is made from corrugated sheet steel attached to the steel bar joist, covered with a Styrofoam-type insulation covered with either asphalt paper and tar roof covering or a vinyl sheet roofing material. The roof then may be covered with round stone or lightweight patio-type masonry blocks that are used as foot paths over the roof so as not to damage the roofing materials. The Styrofoam insulation can produce a spongy or soft feeling when walking on the roof. This condition should be evaluated by firefighters to determine if the structural elements are weakened, or if the roof material is causing the soft feeling. While it would be preferred to have the roof elements identified on a building preplan, it may be necessary to make an inspection opening of the roof away from the fire area to determine the materials used. The roof elements will affect your ability to open a ventilation hole quickly.

Skeleton Framing for Multiple-Story Buildings



Multiple-story steel framework structure with limited or no special fire-resistance provided for the structural elements is considered an NFPA Type II Unprotected building

Steel skeleton frame buildings can be constructed two, three, or more stories in height. Each component of the structure is designed and installed so as to transfer the load to the ground. The entire building is only as strong as the weakest component of the framework. A frame of steel columns with steel beams attached to the columns creates a box-like support framework to support multiple floors and the roof. The framework starts in a fashion that is similar to the one-story structure with the steel column attached to a concrete pad and flanges which are attached to the columns and used to attach the beams that will extend to the next column. This same concept is used to create a framework for a two-story, three-story, or even taller building. In Module 4: Protected Noncombustible Buildings, this concept will be discussed when it is used to construct highrise buildings.

Floor construction for the upper floors will have a section that will be used for a stairway framed out in the steel framework. Other openings may be framed as well to accommodate utility shafts, elevator shafts, or other building services such as heating or air conditioning ducts. Floors can be constructed of lightweight steel bar joist or with pre-tensioned concrete slabs. Concrete slabs 3 to 6 inches thick using reinforcing rods for tensile strength are common methods of installing floors. They are quickly and easily fabricated at a concrete facility, and poured with hollow tubes, which both reduces the weight and provides for a ready-made utility shaft. The other common method of floor construction is to place steel bar joist on the steel box frame, cover the floor joist with steel corrugated decking that will serve as a form, and pour several inches of concrete equipped with reinforcing rods over the steel decking forms.

Roof construction can use methods similar to those described for a one-story structure, use concrete slabs as described for floor construction above, or may use large steel bowstring truss rafters to span a large space without interior supports and place the entire load on the exterior walls. Steel bowstring truss rafters have been used for many applications where a large clear span was desired. The tops of the steel trusses typically have a 2- by 6-inch beam placed on the top flange of rafters to which "U"-shaped steel purlins attach to span the distance between rafters on which to attach roof materials. The most common roof covering over the truss rafters and purlins is corrugated sheet steel, which is then covered with an insulation board and either a vinyl or asphalt covering. Special loads, such as air conditioning units, require special bracing that spans to structural members to adequately support the load. It must be remembered that this weight is often carried on unprotected steel elements, which could relax under fire conditions and allow the assembly to fail. Another type of roof support using a truss principle is called "space frame truss." This is a three-dimensional truss where the support members of the truss form a "V" with three elements, with web members filled into all three structural elements. This creates a "V"-shaped member with support provided from all three directions. This same concept also is used for heavy trusses that span large areas such as arenas or gymnasiums. In addition to the special trusses themselves, they are also interconnected with each other to provide support in multiple directions within the truss as well as between the trusses themselves. The critical concern is the same as with any truss: if the building should lose any one truss it is subject to losing all the trusses.

Steel elements typically are connected to each other by using bolts. For structural elements supporting heavy loads, special carbon steel bolts are used. Bolts holding two pieces of steel together are under tension when the nut is tightened and the section between the two pieces of steel is under shear pressure. Bolts used for connecting the structural elements are typically 5/8 to 1 inch in diameter. In earlier construction, rivets were used to connect the elements. A rivet would be heated red hot so it was soft, pushed through the hole in the steel, and while one worker applied pressure to the side with the head attached, another worker on the opposite side would use a special hammer to flatten or peen the head of the rivet until it was tightly secured in place. This was a labor- and time-intensive process, and required special heating equipment to heat the rivets. The third method of securing the steel is by welding the connections. This provides a solid or rigid connection that has no flex or give once it is completed. The strength and quality of the weld is dependent upon the ability of the welder to produce the welded joint properly.

SPECIAL APPLICATIONS FOR STEEL CONSTRUCTION

Rigid frame steel buildings use the arch principle to provide a clear span open floor space

Rigid Frame

Rigid frame steel construction is also commonly called long-span steel construction. It provides large open clear spans without interior support columns. These buildings commonly are used for commercial purposes such as gymnasiums, rollerskating rinks, warehouses, and even office buildings. The support for the structure comes from large rigid steel columns and arches which typically are made from steel "I" beams. Unlike wooden laminated arches, steel arches can be made from several components and then connected with bolts or by welding the connections.

The column portion of the rigid frame arch is attached to anchor bolts secured into a concrete pad. The beam extends from the top of the column to the center of the roof span in the form of an arch. Flanges are welded onto the top of the steel column and onto the beam section that forms one-half of the arch. Either special carbon alloy bolts are used to connect the two sections, or they are welded together. When the frame extends from the opposite side of the structure the two halves are connected at the peak with bolts or by welding. The two beams connected to the two columns form an arch which, by its very nature, is extremely strong.

The most common method of attaching a roof to a rigid frame building is to place lightweight steel bar joist from arch to arch. Corrugated steel sheet roofing then is attached to the steel bar joist. The roof elements are the lightest construction materials in the structural system and typically the first to fail under fire conditions. The structural arches made from substantial steel elements will absorb heat for a longer time before the materials start to relax, causing structure failure. One principle of this method of construction is to limit the amount of weight that must be supported by providing enough slope to the roof for water or snow to run or slide off quickly and to use lightweight construction materials to support the roof. Often structural elements or building components, such as heaters, equipment storage racks, mezzanines, or other heavy objects, are hung from the rigid frames or the steel bar joist that support the roof. Any weight placed on the bottom cord of a truss structural member is placing an undesigned load on one particular part of the truss.

Specialized Steel Structures

Steel frame geodesic domes are commonly used for entertainment purposes, special applications, or, in some instances, dwellings

Geodesic domes use a triangulation principle to form a lightweight structural framework that then can be covered with a lightweight covering such as aluminum or composite material. The triangulation of the framing materials works on the same principle of truss rafters that provide strength along their exterior surface to the ground support. Supporting interior loads is critical, since the structure typically is not capable of supporting additional loads, such as floors or floor loads. Typically, floor loads would be supported with columns and beams.

WALLS

Steel columns of a box skeleton frame structure may be incorporated into a masonry wall, which also may provide support to the steel bar joist on the exterior wall

The steel box frame or rigid frame building typically does not rely on interior walls for structural support. Interior walls are typically non-load-bearing, and simply are used to segregate areas of the building. Exterior walls enclose the structure and, in some instances, may provide fire-resistance as the steel columns may be incorporated into masonry walls during the construction of the wall. Another construction technique is to use masonry exterior walls to provide support for the steel bar joist on the exterior of the structure, especially if the building is to be only a single span (one bar joist truss) floor or roof element. A masonry wall on each side of the building supports the roof or floor elements above.

Curtain exterior walls typically are used to enclose the exterior of the structure. The terms "curtain walls" and "panel walls" often are used interchangeably to describe non-load-bearing enclosing walls on framed buildings that gain their support from structural members, such as columns. Curtain walls simply hang like a curtain and actually add weight to the supporting columns and beams. Curtain walls are used for all size buildings ranging from one-story to 100 stories, while panel walls commonly refer to one-story buildings. Curtain walls can be made from sheet steel, steel studs covered with a lightweight covering, glass, or concrete block used to fill in between the steel support columns. The exterior wall also may be finished with a veneer layer of facing brick to give the appearance of a masonry building. In some instances, steel bar joist roof rafters will be placed directly on top of the concrete block wall to support the exterior wall end of the roof system.

BUILDINGS COMBINING MASONRY SUPPPORTS WITH STEEL FRAME

Poured-in-place concrete walls are tilted up once the concrete is cured and, once in place, often provide support for the steel bar joist roof supports

Many noncombustible buildings use a combination of masonry supports and structural steel. The masonry can be concrete block, poured-in-place concrete, or concrete panels prefabricated at another location and brought to the construction site. In some instances the concrete walls actually are poured and cured at the construction site adjacent to the position where they will be placed on a foundation. They are simply tilted up and secured in place after the concrete is cured.

If the distance between exterior walls permit, steel bar joist will be a simple span from one wall to the other without the need for additional support. A simple span building could be as wide as 20 to 25 feet. If the span exceeds the capability of a single span, a column-and-beam system must be installed between the two walls. When inspecting buildings, the single interior support column will be easily observed in the middle of the building. The columns may be covered with a fire-resistant material (see Module 4). In a larger building that requires two columns-and-beam supports the columns will appear at one-third and two-thirds of the distance across the building. This has been described previously as the "box" system, where a box-like framework is formed at the top of the columns from column to column.

The "big box" structure is common today in nearly every community

The "big box" store is common today, and is used for many different occupancies. Chain lumber and hardware stores, office supply stores, and numerous other commercial operations use the big box building. The term "big box" comes from the many box-like structures created by the beams attached to the tops of the columns and when viewed from the top, it appears as many square steel boxes which will support either a floor system or, most commonly, a roof system.

FIREFIGHTER SAFETY CONSIDERATIONS IN STEEL FRAME STRUCTURES

As with any structure, the fire load of the contents inside the structure can pose special risks to firefighters. This is especially true in lightweight, unprotected noncombustible buildings. Some local building codes may require the Type II building to have NFPA 220 subclass 111 or 222 fire-resistance added to structural elements. In most cases, however, if the building owner provides 1- or 2-hour fire-resistive protection for a Type II building, it may not require much additional protection to make the building a Type I structure. Most often Type II buildings will have limited, if any, fire-resistive protection for the structural steel elements.

Structural steel exposed to heat will expand and, above 500°F (260°C) start to lose strength to support loads. At about 1,000°F (538°C) it will typically lose about one half its load-carrying capability and at 1,500°F (816°C) cannot even support its own weight.

The time for the structural materials to reach these temperatures will depend in part on the size or mass of the steel object. A lightweight steel bar joist roof rafter will heat to 1,500°F much faster than a 24-inch "I" beam that is 3/8 inch thick if they are both placed at the same location in a fire.

Firefighters should quickly recognize the characteristics of a Type II lightweight steel-supported structure and the problems anticipated under fire conditions. Firefighting strategic goals and operational procedures should be adjusted accordingly, especially if a fire has been burning with the fire and heat directly affecting the structural elements. While there is no hard-and-fast rule of how long it will take for the steel to relax, it always should be anticipated when there is a potential for heat buildup or direct flame impingement. There is no substitute for preincident planning and determining the structural elements of a building before the fire occurs.

SUMMARY

It is critical that IC's, CO's, Safety Officers, and firefighters identify a building's type in order to identify the critical characteristics of the structure.

Each building type will have characteristics that may be considered strengths, such as the fact that steel is a noncombustible construction material. Each building also will have characteristics that are of concern, such as the fact that when unprotected steel is a structural material it will lose its ability to carry the weight being supported or even its own weight if it reaches a temperature of 1,500°F.

Steel is used in several different applications. The first application of steel was cast iron, which was used for support columns or for entire building exterior walls. Structural steel became a popular structural material at the turn of the century when steel mills started to produce columns and beams that could be used to frame and support a building. Today structural steel is a very common construction material and, with fire-resistance treatment, the steel can be provided with a fire-resistance rating of 3 or more hours. Specially hardened steel can be made to provide as much as 150,000 pounds per square inch strength under tension. This steel is commonly used for post-tensioned concrete.

The term "noncombustible building" provides a descriptive picture of structural elements typically made from steel or concrete. The term "unprotected noncombustible building" provides a descriptive picture of structural elements that are protected from fire and will not be affected by heat for a given period of time. It is important that emergency response personnel understand the affected features of the building involved in fire in order to predict the structural stability and the safety of the firefighters.

Activity 3.1

Cast-Iron Structural Elements

Purpose

To apply the principles of cast-iron construction elements under fire conditions.

Directions

1. You will be divided into small groups.

2. Each group should read its assigned scenario and view the fire scenario slide.

3. You have 15 minutes to answer the questions and select a spokesperson.

4. Report your group's findings and responses to the questions:

   a. Are there any cast-iron structural elements in the structure or occupancy? If yes, what are they?

   ____
   ____
   ____
   ____
   ____

   b. Was there any unusual activity inside the building prior to the fire that is a concern? If yes, what?

   ____
   ____
   ____
   ____
   ____

   c. Has anything happened that could affect the structural integrity of the building? If yes, what?

   ____
   ____
   ____
   ____
   ____

   d. Is firefighter safety a concern? If yes, why?

   ____
   ____
   ____
   ____
   ____

Scenario 1: 2 Main Street

An explosion and fire has been reported on the first floor of a 13-story building at 2 Main Street. The caller states that workers were preparing to start construction work inside the store and had moved in several large tanks containing 3,000 pounds per square inch (psi) of compressed air. The explosion caused several of the tanks to rocket around the inside of the structure before the fire started. The caller states that it appears that part of the second floor may be sagging in the middle of the building. Due to the repairs, the store on the first floor was closed, but the offices above are fully occupied. Several construction workers inside the store area are unaccounted for. Upon arrival you observe heavy smoke conditions, but only limited fire.

Previous inspections of the structure revealed that the building is served by two elevators, side by side, and by two open-shaft stairwells. The first floor is a clothing store, and the upper 12 floors are used as offices. The offices are partitioned off to form a long corridor from the front to the rear of the structure, with offices on either side. The stairs are at the front and rear and the elevators are at the front.

The time is 0745 on a Monday morning, temperature is 55 degrees, and winds are from the west at 5 mph.

Quick Access Prefire Plan

Building Address*:* *2 Main Street*

Building Description:
13-story noncombustible Type II Unprotected, 50' by 100', masonry exterior, load-bearing side walls support part of floor and roof load.

Roof Construction:
Concrete slab with asphalt and tar covering--front stairwell has a bulkhead door onto roof.

Floor Construction:
Concrete slab supported by cast-iron columns. Basement used for utility services, maintenance, elevator motors, etc.

Occupancy Type:
Commercial first floor. Offices second to thirteenth floors.

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

Location of Water Supply:
2 Main Street and 18 Main Street

Available Flow:
3,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*415*	*830*	*1,245*	*1,660*

**Estimated fire flow based on 50' by 100' with no exposures--add exposures.*

Fire Behavior Prediction:
Fire extension on floor easy via 100' hall, fire extension to floors above will be slowed by concrete floors. Smoke will travel open stairwells, and elevators are unreliable under fire conditions. Exterior fire extension likely.

Predicted Strategies:
Offensive operations likely, evaluate safety of structure, many voids require checking for fire extension. Evacuation may be challenging with open stairwells requiring aggressive interior attack to protect stairwells.

Problems Anticipated:
Open stairwells, cast-iron columns supporting floors, many voids and chases, glass transoms over office doors, many unoccupied offices used for storage.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Front and rear stairwell	*Basement and stairwells*	*Smoke and heat direct wired to 911*

Scenario 2: 47 Cigar Alley

A fire has been reported in a four-story office building housing insurance company offices. The building was constructed about 1880 using a new "modern" technology called cast-iron fronts and supports. The insurance company employs about 300 people, with nearly 200 data entry staff located on the first and second floors. The third floor is the accounting department, with about 85 employees, and houses the computer hardware. The fourth floor is the file storage area. Previous inspections have revealed nearly 40 years' supply of records stacked in cardboard boxes from the floor to the ceiling. They employ about 15 filing clerks who research old records and make copies of them for processing.

The cast-iron exterior wall has been repaired several times in the past 100 years with straps, bolts, and screws. The interior support columns are original. Originally the building was designed and constructed as a lightweight occupancy, drying tobacco leaves on the top two floors, rolling cigars on the second floor, and a retail drug store on the first floor. The basement is used for coal storage, a boiler, and maintenance.

The fire is located on the third and fourth floors. While the building is sprinklered, the system was not activated, which has provided for extensive fire spread via the exterior windows. The first company has attached to the fire department connection, and the water motor gong has activated, indicating that water now is flowing.

The temperature is 38 degrees, winds are 15 mph from the north, and freezing rain is forecast within an hour.

Quick Access Prefire Plan

Building Address: *47 Cigar Alley*

Building Description:
Four-story 50' by 100' noncombustible Type II Unprotected office building with basement.

Roof Construction:
Concrete with asphalt and tar covering, bulkhead door on front stairwell.

Floor Construction:
Concrete on cast-iron columns.

Occupancy Type:
Insurance company offices

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

Location of Water Supply:
42 Cigar Alley and 15 Front Street

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*415*	*830*	*1,245*	*1,660*

**Estimated fire flow based on 50' by 100' with no exposures--add exposures.*

Fire Behavior Prediction:
Due to heavy floor loads of paper files on the fourth floor, fire extension will be severe, piles of boxes will collapse, and papers will become water soaked, increasing their weight. Open stairwells will allow heat and smoke travel.

Predicted Strategies:
Rescue and account for employees; if more than 50 percent involved, use defensive operations. Use special caution for outside cast-iron walls.

Problems Anticipated:
Heavy fire load on third and fourth floors, cast-iron columns may not support much additional load, such as water absorbed in cardboard boxes.

[X] **Standpipe:**
Type 3 in stairwells

[X] **Sprinklers:**
Wet pipe system
No record of system being tested in past 10 years

[X] **Fire Detection:**
Heat detection tied into an automatic dialer

Scenario 3: 28 Clark Boulevard

A fire has been reported in a four-story building which houses a store on the first floor and apartments on the top three floors. There are four apartments on the second and third floors, and three on the fourth floor. The building was constructed around 1880, with masonry exterior walls, cast-iron columns for support, and concrete slab floors and roof. Several years ago the front wall on the first floor was damaged, and repairs were made using cast-iron columns to support the second floor and above along the exterior wall. The apartments are served by two open stairwells. The stair risers and frames are made from cast iron.

The call is placed from a police patrol car. It is 0530 on a Saturday, with the temperature at 10 degrees and winds from the north at 15 mph. The police officer went inside the upper floors to alert tenants of the apartments and has not been seen since. His patrol car is outside with the motor running. Many occupants of the apartments have exited from the rear stairwell. It appears that an arsonist has spread flammable liquids on the first floor, which has major fire involvement. The sprinklers are only in the hallways and stairwells of the upper floors, and in the basement.

Quick Access Prefire Plan

Building Address: *28 Clark Boulevard*

Building Description:
Four-story 50' by 100'. Commercial first floor and apartments on top three floors.

Roof Construction:
Concrete floor slabs supported on cast-iron columns.

Floor Construction:
Concrete slab on cast iron columns.

Occupancy Type:
Commercial and apartments

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

Location of Water Supply:
20 and 40 Clark Boulevard

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*415*	*830*	*1,245*	*1,660*

**Estimated fire flow based on 50' by 100' with no exposures--calculation for one floor only--add exposures.*

Fire Behavior Prediction:
Rapid fire spread on first floor, retail clothing store; open stairwells will allow heat and smoke travel upward.

Predicted Strategies:
Building renovations pose some risk. If fire on first floor, evaluate exposure to cast-iron structural supports. Rapid primary search needed for upper floors.

Problems Anticipated:
Limited sprinkler protection, limited access and egress to upper floors.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class 1 in stairwells	*Stairwells and halls on upper floors*	*Single station detectors in apartments*

Scenario 4: 2 Knob Hill Road

A fire has been reported on the second floor of a four-story office building. The building was constructed originally as a retail clothing store around 1880, and was converted into offices around 1970. The building has been well maintained. During the renovations into office space, construction personnel removed about one-third of the cast-iron columns on the third and fourth floors in order to open up floor space. The floors and roof are poured concrete. Two open stairwells to the upper floors are made from cast iron. The steam pipes for the heating system travel up through the center of the cast-iron columns into the various floor spaces to the radiators.

A heating contractor was trying to repair a leaking pipe inside a column and was using a torch just before the fire was reported. Workers in the area stated that the contractor left the area to go to his truck for parts.

It is 0930 on a Tuesday with a temperature of 80 degrees and no wind.

Quick Access Prefire Plan

Building Address*:* *2 Knob Hill Road*

Building Description:
Four-story office building 75' by 150.'

Roof Construction:
Concrete covered with asphalt-based tar and paper.

Floor Construction:
Concrete slab supported on cast-iron columns.

Occupancy Type:
Corporate offices

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

Location of Water Supply:
2 and 22 Knob Hill Road

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*935*	*1,870*	*2,805*	*3,740*

**Estimated fire flow based on 75' by 150' with no exposure--calculation for one floor only--add for exposures.*

Fire Behavior Prediction:
Rapid fire extension through structure through open stairwells.

Predicted Strategies:
Primary search is major concern. If fire is on third or fourth floors consider structural stability, since many cast-iron support columns were removed during renovations.

Problems Anticipated:
Rapid heat, smoke, and fire spread through open stairwells.

[X] **Standpipe:**
Class 1 in stairwells

[X] **Sprinklers:**
Wet system in basement only

[X] **Fire Detection:**
Heat detection connected to master box

Activity 3.2

Lightweight Steel Construction, Part I

Purpose

To evaluate lightweight steel construction features and to evaluate the concerns associated with these buildings under fire conditions.

Directions

1. You will be divided into small groups.

2. Each group should read its assigned scenario and view the fire scenario slides.

3. You have 30 minutes to evaluate the problems and answer the questions.

    a. Are there any unusual problems with the structure or occupancy?

    ____
    ____
    ____
    ____

    b. Is there a fire load inside the structure that could cause early relaxation of the structural members?

    ____
    ____
    ____
    ____

    c. Would interior firefighting operations pose any safety concerns? If so, why?

    ____
    ____
    ____
    ____

    d. Would vertical ventilation pose any special risk to the ventilation team? If yes, why?

    ____
    ____
    ____
    ____

    e. Would you consider the operational mode for this fire to be offensive or defensive? Why?

    ____
    ____
    ____
    ____

4. Select a spokesperson to report the results of your group's findings.

Scenario 1: 474 Shaker Road

A fire has been reported in a new car showroom of a local auto dealership. The showroom typically has eight new vehicles displayed. The caller reports that a jack lift was being used to move a car into its designated showroom position when it slipped and punctured the gasoline tank. About 12 gallons of gasoline leaked across the concrete floor before it was ignited by a hot water heater.

There is a firewall between the showroom and the garage in the back. Prior inspections have revealed that the firewall had several openings for wiring and utility services. In addition the two steel fire doors are typically blocked open.

It is 0830 on a Friday, and all persons are outside and accounted for. The weather is 45 degrees and winds are from the east at 15 mph.

Quick Access Prefire Plan

Building Address: *474 Shaker Road*

Building Description:
One-story 35' by 100' automobile showroom and offices connected to a 150' by 200' repair facility--firewall separates two structures.

Roof Construction:
Metal decking over steel bar joist covered with asphalt roofing.

Floor Construction:
Concrete floor--no basement.

Occupancy Type:
Automobile showroom

Initial Resources Required:
2 engines, 1 tanker, 1 rescue

Location of Water Supply:
Nearest hydrant 2 miles

Available Flow:
2 additional tankers available of 2,500 gallons each

	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 35' by 100' with one exposure included.*

Fire Behavior Prediction:
Open floor space with several automobiles inside will make fire spread rapidly. Suspended ceiling protects the steel bar joist rafters and sheet metal roofing material.

Predicted Strategies:
If fire has burned in excess of 15 minutes, consider exterior attack due to the amount of exposed steel.

Problems Anticipated:
Firewall penetrated in several places, fire doors often blocked open between garage and showroom.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Heat detection--local alarm only

Scenario 2: 47 Southgate Road

A fire has been reported in a realty office, a one-story structure, 30' by 70' with no basement. The office normally is staffed by four to six realtors and two secretaries. A rear portion of the building is used to store furniture that is used to furnish rental units. The fire has started in the rear storage room, which is separated from the office area by a vinyl draw curtain. The caller states that she smelled smoke and she found the storeroom on fire. The manager is trying to put the fire out with a garden hose.

The time is 0930 on a Saturday morning, the temperature is 75 degrees, and wind is from the west at 5 mph.

Quick Access Prefire Plan

Building Address: *47 Southgate Road*

Building Description:
One-story office building, 30' by 70', that houses realtors' offices and a large furniture storeroom.

Roof Construction:
Sheet steel placed over steel bar joist rafters covered with an asphalt covering.

Floor Construction:
Concrete slab with no basement.

Occupancy Type:
Office and storeroom

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

Location of Water Supply:
40 and 60 Southgate Road

Available Flow:
1,250 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*175*	*350*	*525*	*700*

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

Fire Behavior Prediction:
Office subdivided with small cubicles will allow for fast fire spread. A storeroom houses as many as 12 rooms of furniture in storage--often stacked to the ceiling.

Predicted Strategies:
Standard procedures--if fire burns for 15 minutes or more the failure of the steel roof structure should be considered.

Problems Anticipated:
Furniture storage will cause deep-seated fire and will be difficult to gain access to control.

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

Scenario 3: 18 Dorwood Drive

A fire has been reported in an automobile repair facility. The fire is located in a sales and waiting area of the facility. The caller stated that a delivery of acetylene and oxygen tanks had been delivered about 1 hour earlier and left in the sales area of the building. A child had turned on a valve from one of the tanks and left the store. The manager reports that no one was in the sales area when the explosion occurred, and the sales area is heavily involved. The sales area also is used to store tires and auto parts. There are seven vehicles in the garage in different stages of repair.

It is 1030 on a Thursday, the temperature is 65 degrees, and wind is from the west at 5 mph.

Quick Access Prefire Plan

Building Address: *18 Dorwood Drive*

Building Description:
One-story automobile repair garage, 70' by 125', with a 70' by 30' sales showroom area. Separation wall is not fire-resistance rated.

Roof Construction:
Lightweight sheet steel over steel bar joist supported on a steel box frame system.

Floor Construction:
Concrete slab--no basement.

Occupancy Type:
Automobile repair and sales

Initial Resources Required:
2 engines, 2 tankers

Location of Water Supply:
Town pond--1-1/2 miles away

Available Flow:
2 additional tankers available

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*900*	*1,800*	*2,700*	*3,600*

**Estimated fire flow based on 70' by 155' with no exposures.*

Fire Behavior Prediction:
Building has a great deal of tire and auto parts storage which will provide large fire load and rapid fire extension.

Predicted Strategies:
Offensive if discovered in early stages of fire, consider structural stability of steel roof support system after 15 minutes of fire and heat travel.

Problems Anticipated:
Garage used acetylene and oxygen to cut and weld steel.

❑ **Standpipe:**

❑ **Sprinklers:**

❑ **Fire Detection:**

Scenario 4: 231 Briarwood Road

A fire has been reported in a one-story 40' by 40' bank office that also has a drive-through window, which is under the same steel-supported roof. The caller states that the natural gas furnace exploded and has set the office on fire. She states that all the personnel are out of the structure.

It is 1130 on a Wednesday, the temperature is 80 degrees, and wind is from the east at 10 mph.

Quick Access Prefire Plan

Building Address: *231 Briarwood Road*

Building Description:
One-story 40' by 40' bank office with drive-through window.

Roof Construction:
Lightweight sheet steel over steel bar joist, which are supported on steel "H" columns. Roofing is asphalt paper and tar covering.

Floor Construction:
Concrete slab--no basement.

Occupancy Type:
Bank office

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

Location of Water Supply:
224 and 255 Briarwood

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*140*	*280*	*420*	*560*

**Estimated fire flow based on 40' by 40' no exposures.*

Fire Behavior Prediction:
Open floor space with 48-inch dividers to create cubicles. A car fire in the drive-through lane could provide sufficient heat to cause roof failure.

Predicted Strategies:
Standard strategies if fire is discovered early. Check for structural stability after 15 minutes of free burning.

Problems Anticipated:
Easy fire travel through structure, suspended ceiling failure will allow steel roof structure to be at risk.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Monitored by alarm company

Activity 3.3

Lightweight Steel Construction, Part II

Purpose

To evaluate lightweight steel construction features for buildings higher than one story and to evaluate the concerns associated with these buildings under fire conditions.

Directions

1. You will be divided into four small groups.

2. Each group should read its assigned scenario and view the slides associated with it.

3. Allow 30 minutes for each group to evaluate the problems and answer the questions.

   a. Are there any unusual problems with the structure or occupancy?

   ____
   ____
   ____
   ____

   b. Is there a fire load inside the structure that could cause early relaxation of the structural members?

   ____
   ____
   ____
   ____

   c. Would interior firefighting operations pose any safety concerns? If yes, why?

   ____
   ____
   ____
   ____

   d. Would vertical ventilation pose any special risk to the ventilation team? If yes, why?

   ____
   ____
   ____
   ____

   e. Would you consider the operational mode for this fire to be offensive operations or defensive operations? Why?

   ____
   ____
   ____
   ____

4. Select a spokesperson to report the results of your group's findings.

Scenario 1: 1221 Shaker Road

A fire has been reported on the top floor of a new, unprotected, steel box frame office building under construction. The caller states that workers were in the process of cleaning and stripping the concrete floor slabs with a flammable degreaser when a worker dropped a lamp, broke the bulb, and a fire started. A large portion of the floor was being used to store approximately 4,000 pounds of excess vinyl roofing material that was rejected and could not be used. The roofing material now is involved in fire.

The building was nearly completed with only the carpet, a few curtain wall panels, and some suspended ceiling left to install. The building has concrete floors poured over corrugated sheet steel forms that were placed over steel bar joist trusses. The roof is a steel bar joist system with corrugated sheet steel covered with a vinyl roof covering. Workers tried to extinguish the fire with several extinguishers before calling for help. The sprinkler system was not turned on.

It is 1645 on a Friday, the temperature is 98 degrees, the humidity is high, and winds are calm.

Quick Access Prefire Plan

Building Address: *1221 Shaker Road*

Building Description:
Five-story unprotected steel office building 100' by 150' with no basement.

Roof Construction:
Sheet corrugated steel over steel bar joist covered with vinyl roof system.

Floor Construction:
Concrete poured over corrugated steel sheets supported on steel bar joist.

Occupancy Type:
Under construction--will be five-story office building--open floor plan

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

Location of Water Supply:
1202, 1220, and 1430 Shaker Road

Available Flow:
2,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*1,250*	*2,500*	*3,750*	*5,000*

**Estimated fire flow based on building 100' by 150' with no exposures--add exposure to fire flow.*

Fire Behavior Prediction:
Fire should be compartmentalized to a floor on interior, fire spread will likely be vertically outside windows.

Predicted Strategies:
Standard strategic goals--evaluate time and if fire is affecting unprotected steel structural members for 15 minutes consider change to defensive operations.

Problems Anticipated:
Large number of workers will occupy building, access limited to two main entrances.

[X] **Standpipe:**
Class 1 in each stairwell

[X] **Sprinklers:**
Wet system throughout

[X] **Fire Detection:**
Smoke and heat detection with autodialer

Scenario 2: 47 Broadway

A vehicle fire has been reported in the parking garage of an office building. The gasoline tank of the vehicle involved in the fire has failed, and about 15 gallons of gasoline spilled on the garage floor before it ignited. The law offices on the floor above are served by two steel stairwells on each end of the parking garage; normally there are about 10 persons in these offices.

The building was designed to become part of a larger complex that was never built. There is a special variance to have the unprotected stairways exit directly into the parking garage area. The local building department was in the process of rescinding its certificate of occupancy until the stairwells were protected, and at least one redesigned to lead directly outside rather than terminating in the garage area.

It is a Wednesday at 1445, the temperature is 75 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *47 Broadway*

Building Description:

Two-story structure with first floor being a parking garage and the second floor occupied as law offices. The structure is 30' by 80' and has no basement.

Roof Construction:

Sheet corrugated steel on steel bar joist supports covered with asphalt paper and tar coating.

Floor Construction:

Concrete poured on corrugated sheet steel supported by steel bar joist.

Occupancy Type:

Parking first floor, office on second floor

Initial Resources Required:

2 engines, 1 truck, 1 rescue

Location of Water Supply:

35 and 50 Broadway

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 80' with no exposures.*

Fire Behavior Prediction:

Fire in office will be hard to access--open office space will allow fast fire spread. If vehicle fire occurs on first floor it may gain access quickly into curtain wall and cut off means of egress for occupants.

Predicted Strategies:

Rescue occupants and evaluate structural stability of structure.

Problems Anticipated:

Access and egress to offices above parking garage.

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

Scenario 3: 44 Campus Drive

A fire has been reported in a two-story unprotected steel college classroom facility on the community college campus. The fire originated in a first-floor chemistry laboratory during a chemical experiment. Four students were burned slightly when a 5-gallon container of a flammable liquid spilled across the work table and across the floor. A nearby burner ignited the material.

A previous fire in an identical building resulted in significant structural damage to the unprotected steel box frame when the weight of the concrete floor slabs and the additional floor load caused structural failure.

It is Thursday at 1045, the temperature is 80 degrees, and winds are from the north at 10 mph.

Quick Access Prefire Plan

Building Address: *44 Campus Drive*

Building Description:
Two-story college classroom building 80' by 200' housing eight classrooms. Partial basement for boiler and utilities.

Roof Construction:
Concrete slabs supported on steel box beam and columns.

Floor Construction:
Concrete slab.

Occupancy Type:
College classrooms (8)

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

Location of Water Supply:
Campus View and Telegraph Street

Available Flow:
2,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	110%
Estimated Fire Flow in gpm	*1,325*	*2,650*	*3,975*	*5,300*

**Estimated fire flow based on 80' by 200' one floor and no exposures--add exposures.*

Fire Behavior Prediction:
Fire in chemistry lab could have significant fire load, other classrooms have light fire load. Open stairwells at each end of building will allow fire, heat, and smoke to travel up stairs and down hall.

Predicted Strategies:
Primary search critical and standard operations after.

Problems Anticipated:
Hazardous materials in chemistry lab on first floor.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Local alarm*

Scenario 4: 37 Maria Parkway

A fire has been reported in the drive-through lane of a bank. The building is a two-story box frame structure that has a drive-through lane that runs the entire length of the structure in the rear. The building houses teller windows, loan offices, and other normal bank facilities on the first floor. The second floor houses the credit card division with approximately 40 staff assigned there.

A large pick-up truck drove into the drive-through lane and stopped in the center of the building to conduct business at the teller window. While waiting, a fire started under the truck and the driver was unable to extinguish it. In the back of the truck was a 118-gallon diesel fuel tank that he had just filled, and perhaps overfilled, which was a factor in the cause of the fire. The tank has failed and the burning fuel oil has formed a puddle under the truck. The manager activated the internal fire alarm and employees have evacuated. There is no basement.

It is a Friday at 1115, the temperature is 78 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *37 Maria Parkway*

Building Description:
Two-story 40' by 100' bank and offices on second floor--no basement.

Roof Construction:
Concrete slabs supported on structural steel box frame.

Floor Construction:
Concrete slab on structural steel box frame for second floor, first floor is concrete slab.

Occupancy Type:
Bank first floor, office second floor

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

Location of Water Supply:
34 and 54 Maria Parkway

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*335*	*675*	*1,010*	*1,350*

**Estimated fire flow based on 40' by 100' one story no exposures--add exposures.*

Fire Behavior Prediction:
Structural steel frame is unprotected which may require critical evaluation for structural failure. Drive-through lane has ventilation grates that lead into building, and structural steel columns that support second floor are adjacent to the lane and are unprotected.

Predicted Strategies:
Rescue is critical consideration--use normal strategic goals.

Problems Anticipated:
Vehicle fire in drive-through lane along with flammable liquids could compromise structural elements.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Smoke detection--local alarm

Activity 3.4

Special Steel Applications

Purpose

To evaluate rigid-frame or long-span steel construction features and to evaluate the concerns associated with these buildings under fire conditions.

Directions

1. You will be divided into four small groups.

2. Each group should read the scenario and view the slides associated with it.

3. You have 30 minutes to evaluate the problems and answer the questions.

    a. Are there any unusual problems with the structure or occupancy?

    ____
    ____
    ____
    ____

    b. Is there a fire load inside the structure that could cause early relaxation of the structural members?

    ____
    ____
    ____
    ____

    c. Would interior firefighting operations pose any safety concerns? If yes, why?

    ____
    ____
    ____
    ____

    d. Would vertical ventilation pose any special risks to the ventilation team? If yes, why?

    ____
    ____
    ____
    ____

    e. Would you consider the operational mode for this fire to be offensive or defensive? Why?

    ____
    ____
    ____
    ____

5. Select a spokesperson to report the results of your group's findings.

Scenario 1: 1234 Polly Lane

A fire has been reported in a commercial building that does custom printing. The business has large copying machines and a small offset press for custom invitations and so on. The caller states that a mechanic was cleaning the press and it flashed with a fire when he dropped his light. The press is located in the center of the structure.

The owner buys copying paper in bulk quantities (1/2 railroad car) and stockpiles boxes of paper in the rear of the building. The 60- by 100-foot building has three small offices, restrooms, and a small lunchroom for employees.

It is Thursday at 1000, the temperature is 55 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *1234 Polly Lane*

Building Description:
One-story 60' by 100'commercial rigid steel frame structure housing a printing business.

Roof Construction:
Rigid steel frame supports covered with steel purlins and corrugated sheet steel.

Floor Construction:
Concrete pad.

Occupancy Type:
Commercial printing

Initial Resources Required:
2 engines, 2 tankers, 1 rescue

Location of Water Supply:
River access 1 mile

Available Flow:
2 additional tankers available

	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 building 60' by 100' with no exposures.*

Fire Behavior Prediction:
Building contains heavy fire load, and fire will spread rapidly. Exterior roof and wall sheet steel covering should auto vent quickly. Structural failure should be evaluated early under fire conditions.

Predicted Strategies:
Rescue and standard strategic goals--evaluate structural integrity frequently.

Problems Anticipated:

❑ **Standpipe:**

❑ **Sprinklers:**

❑ **Fire Detection:**

Scenario 2: 1 Shoppers Park Lane

A fire has been reported in a new restaurant and entertainment center. The building houses a restaurant and a young adult entertainment center with games, interactive video games, and other entertainment venues. The building was constructed with a steel rigid-frame structure to support the structure. The curtain walls are steel studs covered with a fire-resistive fiberboard and finished with a masonry stucco covering. The kitchen is protected by an automatic sprinkler system, and the cooking surfaces are protected by a dry chemical system. The roof is covered with steel bar joists covered with corrugated steel and finished with a vinyl roof covering.

The caller stated that the building was being readied for a grand opening in 2 hours. The restaurant was finished in combustible interior finish and was just decorated with combustible materials such as streamers, balloons, and other decorative materials. An employee was using a lighter to search a dark area for an item that was dropped, and apparently ignited the decorations.

Quick Access Prefire Plan

Building Address: *1 Shoppers Park Lane*

Building Description:
One-story steel rigid-frame restaurant and entertainment center 100' by 200' and no basement.

Roof Construction:
Sheet corrugated steel placed over steel bar joist and covered with a vinyl system.

Floor Construction:
Concrete slab.

Occupancy Type:
Restaurant and entertainment center

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

Location of Water Supply:
At edge of drive leading into parking lot

Available Flow:
2,500 gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*1,675*	*3,350*	*5,025*	*6,700*

**Estimated fire flow based on building 100' by 200' and no exposures.*

Fire Behavior Prediction:
Interior finish and decorations are combustible. Fire will spread rapidly due to an open area floor plan.

Predicted Strategies:
Rescue and then standard strategic goals--if fire is free burning after 15 minutes evaluate structural integrity.

Problems Anticipated:
Occupancy is rated for 300 with many of occupants being children.

☐ **Standpipe:**	☒ **Sprinklers:**	☒ **Fire Detection:**
	Kitchen only	*Smoke detection on auto dialer*

Scenario 3: 54 Clark Lane

A fire has been reported in the community water pumping and treatment building. The building houses two 1,000-gallon electrical pumps and a 1,500-gallon natural gas-powered pump. The building houses the chlorinating equipment which uses 150-pound cylinders of chlorine gas. The 50- by 75-foot structure is a rigid-frame structure covered with sheet corrugated steel placed over sheet steel purlins which are attached to the frame. The building sits on a concrete slab.

A mechanic was working on the natural gas pump and broke a gas line. The fire is being fed by a free-burning broken pipe. Everyone is accounted for.

It is Tuesday at 0930 with a temperature of 75 degrees and a calm wind.

Quick Access Prefire Plan

Building Address: *54 Clark Lane*

Building Description:
One-story 50' by 75' rigid-frame steel structure on a concrete slab used to house community water pumping and treatment equipment.

Roof Construction:
Corrugated sheet steel over steel purlins which are attached to the rigid-frame structure.

Floor Construction:
Concrete slab--no basement.

Occupancy Type:
Water pumping and treatment facility

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

Location of Water Supply:
Just outside gate to facility

Available Flow:
2,000 gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*300*	*625*	*950*	*1,250*

**Estimated fire flow based on building one story 50' by 75' with no exposures.*

Fire Behavior Prediction:
Limited combustible materials inside building except for natural gas heater and natural gas fueled pump engine. Gas shutoff sits 15' from SE corner of building.

Predicted Strategies:
Standard strategic goals--building has 20 or more 150-pound cylinders of chlorine gas.

Problems Anticipated:
Building has 20 or more 150-pound cylinders of chlorine gas in storage and in use. Heat applied to cylinders could cause relief valve to open.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Heat detection--local alarm bell*

Scenario 4: 24 Military Parkway

A fire has been reported in a military vehicle repair facility. Vehicles repaired inside range from tanks to trucks. The facility is a steel rigid-frame building with purlins spanning the frame to which sheet corrugated steel is attached for the exterior walls and the roof. The building typically has three to five large vehicles inside in some stage of repair. The building is 50- by 75-feet and has a concrete slab floor.

The caller stated that he/she was welding on a tank when some insulation caught fire. He/She thought it was out and went to lunch. About 20 minutes later a great deal of smoke was observed coming from the structure.

It is 1230 on a Friday with the temperature at 80 degrees and calm winds.

Quick Access Prefire Plan

Building Address: *24 Military Parkway*

Building Description:
One-story 50' by 75' rigid-frame steel repair garage for military equipment--no basement.

Roof Construction:
Sheet corrugated steel attached to purlins which are supported on the rigid frame.

Floor Construction:
Concrete slab.

Occupancy Type:
Military vehicle repair garage

Initial Resources Required:
2 engines, 2 tankers, 1 rescue

Location of Water Supply:
1000 Main St. City of Peekskill

Available Flow:
2 additional tankers available

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*300*	*625*	*925*	*1,250*

**Estimated fire flow based on building one story 50' by 75' with no exposures.*

Fire Behavior Prediction:
Due to nature of repair garage and equipment that may be under repair inside the fire load could be considerable. If fire is not extinguished quickly structural failure may occur early.

Predicted Strategies:
Quick primary search and evaluate fire load and structural stability. The fire load could be considerable.

Problems Anticipated:
Difficult to maneuver inside due to equipment being repaired.

❑ **Standpipe:**

❑ **Sprinklers:**

❑ **Fire Detection:**

MODULE 4:

PROTECTED NONCOMBUSTIBLE BUILDINGS

OBJECTIVES

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

1. *Identify the structural elements of protected steel frame construction and identify the safety concerns associated with this method of construction under fire conditions.*

2. *Identify the structural elements of reinforced concrete frame construction and identify the safety concerns associated with this method of construction under fire conditions.*

3. *Identify and justify critical construction features for structural integrity under fire conditions and for heat and smoke travel when given a scenario for both methods of protected steel frame and concrete construction.*

CHARACTERISTICS OF PROTECTED NONCOMBUSTIBLE BUILDINGS

The concept and practice of constructing buildings that will withstand the effects of fire for a given period of time has been a viable method of fire and life safety protection. In some instances fire resistance requires the application of selected materials to protect noncombustible materials such as steel, and in other instances the materials themselves, such as concrete, are inherently fire resistant.

The first fire-resistant structure was constructed in Cincinnati, Ohio, in 1903. Skeptics were sure that the concrete structure would simply collapse once the forms were removed. The skeptics were wrong and, since 1903, fire-resistant construction has become an important method of construction for a wide variety of occupancies. Since 1903 structural steel with fire-resistant protective coating, reinforced concrete, and concrete using tension cables have become common structural materials.

The National Fire Protection Association (NFPA) Standard 220, *Standard on Types of Building Construction,* provides a rating and classification system for buildings. Both Type I and Type II buildings require some level of fire resistance for their structural elements. NFPA 220 defines Type I buildings as those whose structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs are of approved noncombustible or limited-combustible materials and shall have fire-resistance ratings not less than those specified in Table 3-1. Type II construction is that not qualifying as Type I construction in which the structural members including walls, columns, beams, girders, arches, floors, and roofs, are of noncombustible or limited-combustible materials and shall have fire-resistance ratings not less than Table 3-1. Type II constructed buildings must have materials of noncombustible or limited-combustible capability but do not have a fire-resistance rating as stringent as that required in a Type I building. Both Type I and Type II buildings also have two subclass ratings. Local building codes and regulations will determine the appropriate Type and Subclass for a particular occupancy, height of a building, or special restrictions within a given area of the community.

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.

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Protected steel frame structure

PROTECTED STEEL FRAMED STRUCTURES

Protected steel framed structures are constructed in a manner similar to those discussed in Module 3: Unprotected Noncombustible Buildings, which described unprotected steel framed buildings. Since the building is typically taller or has a different life safety concern than an unprotected steel framed building, the steel uses a fire-resistance method that provides from 1 hour to as much as 4 hours of fire resistance.

Fire resistance required for a structure under Table 3-1 also will vary, depending on whether the structural elements are supporting floors above or simply supporting a roof. As an example, columns supporting multiple floors in Subclass 443 of Type I construction require a 4-hour rating, while columns supporting only one floor or a roof only require a 3-hour fire-resistance rating. In many instances in concrete structures the same forms are used for all floors, including the top floor, which provides the same level of fire resistance.

Construction materials, or a variety of construction materials in an assembly, are evaluated under provisions of a standard fire-resistance test. One such test is the American Society for Testing and Materials (ASTM) E119 wall test. This test has been in use for over 50 years. Materials or assemblies of materials are placed against a rated heat source for a given period of time. If, after the time has elapsed, the material still is intact and has not allowed fire and heat to pass through to the other side, it becomes a rated structural material or assembly. In some tests, such as the wall panel test, a hose stream with a straight-stream nozzle is applied at the conclusion of the test and the panel must stay intact for a given period of water application.

The most common methods of protecting noncombustible construction materials are encasement, membrane protection, or sprayed-on protection.

Encasement typically uses masonry materials or fire-rated gypsum board applied in multiple layers. Masonry materials used to protect structural elements include concrete block installed around steel columns or placing concrete around the steel elements. Several layers of gypsum can be applied with reinforcement for the corners and installed so that all screws connecting the elements are covered with a protective covering.

Membrane protection most typically is used to protect steel beams, bar joist, floor joist or roof rafters, and metal roof decking. The purpose is to protect the steel elements from flames and heat from fires below the membrane protection. Depending on the required time the material must resist fire, the membrane could be a special fire-rated suspended ceiling or could be several layers of gypsum board attached to the bottom of the steel bar joist and steel beams. A suspended ceiling requires all elements to be fire-resistance rated, including the tile and the metal frame. The areas around any openings such as light fixtures also must be enclosed with a rated material. Finally ceiling tiles must be installed in such a manner that they will not be lifted out of the frame by the thermal drafts created by a fire underneath. The most common method of locking tile is with metal clips that hold the tiles into the metal framework.

Sprayed-on protection is the most common method in areas that are out of sight. Several types of materials are used, including a cement-like mixture or an intumescent mastic coating which expands when heated to provide added protection and to seal any areas where the steel is exposed. The concern with this method is that material may have been knocked off inadvertently or intentionally to attach hangers for fixtures or plumbing materials, leaving the steel exposed. This material can be used both vertically and horizontally.

Floor and roof systems for steel framed buildings typically use one of two construction methods. Steel joists called "bar joist" are used for support for roof decking or lightweight precast concrete slabs.

Steel joists are placed on a steel box frame or on masonry walls. Masonry exterior walls often are used to support one end of the joist. In narrow structures the steel joist simply may span the two exterior load-bearing masonry walls. In larger structures the box beam concept is used to support the roof or floors above. The box concept can be expanded to accommodate what is called the "big box" store today, those that house building supply stores, home furnishings stores, or large warehouses. On top of the steel joist, sheet steel decking is applied to provide a base or form to pour a concrete floor or roof. Reinforcing rods are placed a short distance above the decking, and concrete is poured over the reinforcing rods. If utilities such as electrical wiring will need to be placed in the floor it is common to place a lightweight steel channel in the concrete as it is poured, which will provide a channel to run electrical wires without having to cut or drill the floors. Lightweight concrete typically is used for floors and roofs. The aggregate is supplemented with a material such as vermiculite which weighs less than other types of aggregate, such as stones. The roof then would be covered with either an asphalt covering or a vinyl roof material. Floors typically would be covered with carpet.

Another quick method of construction is to use precast concrete slabs for floors or roof decks. The concrete slabs are formed and poured at a concrete fabrication plant. The forms include tubes that will be removed after the concrete is cured. The hollow tubes in the concrete reduce the weight, while reinforcing rods placed between the tubes provide additional support. The slabs are transported to the construction site, lifted into place, and secured.

A unique method of installing a concrete roof and floors is called the "lift slab" procedure. Steel columns are installed to the entire height of the structure. If it is intended to be a 10-story structure the steel columns will reach 10 stories. Pulleys and cables are attached to the top of the columns which will be used to lift all the floors and roof deck into place. The floors are poured around the columns one floor at a time. As soon as one floor has set up, another floor is poured on top of the one below. This process is continued until the floors and roof are stacked on top of each other. Once the concrete is cured the lifting begins. Hydraulic devices pull the cable which is run over the top of the columns and attached to the bottom floor slab. Once the floor slabs are lifted to the position where they are to be located they are fastened in place. The process is continued until all floors and roof have been raised in place. This process is dangerous, and arrangements should be made for the fire department to be notified before the lifting process begins. In Bridgeport, Connecticut, 28 construction workers were killed when the slabs being raised fell and crushed the workers between the slabs. Other failures during the lifting process also have been reported in Ohio and California.

CONCRETE FRAMED BUILDINGS

Concrete framed structure

Reinforced concrete structures became popular after the first modern structure was formed and poured in 1903. Concrete construction gained in popularity from 1920 to 1940, when cities started to grow using concrete to build buildings taller and bigger. Since buildings constructed during this era did not have air conditioning, it was necessary to arrange the floor plans so that rooms had exterior windows that could be opened for ventilation. Typically over the entrance door to the office or apartment was a small window called a transom. The purpose was to allow an opening high on the interior wall that would allow for cross ventilation, with the cooler air coming at the lower exterior windows and the warm air exiting from the higher transom window. This transom and air flow also would let a fire gain entry easily into the hallway.

In 1931, the famous 102-story Empire State Building was opened. This building is constructed from reinforced concrete and tops out at 1,250 feet above the street. With television and other towers on the roof it towers over neighboring buildings at 1,472 feet. The most significant test of its structural stability came in 1945, when a U.S. Air Force B-25 bomber flew into the structure between the 72nd and 73rd floors. The fuel and parts of the plane caused a massive fire on the two floors where the plane collided with the building, but there was very limited structural damage. One of the plane's engines went completely through the building and out the opposite side only to fall onto a building below and set that building on fire. Reinforced concrete passed the test, and poured concrete buildings created the skyline in most cities.

Concrete has its greatest strength in compression and is very weak under tension and shear forces. Steel rods are installed in the concrete to provide tensile and shear strength. The rods can be simple reinforcing bars or specially hardened steel, which will provide additional strength. When the rods or cables are placed in the concrete forms at a production site and the concrete is poured it is called precast concrete. Precast concrete can be made into floor and roof slabs, columns, beams, and other structural elements.

Concrete is a mixture or aggregate of sand, gravel, slag, or vermiculite along with water and cement. The strength of the mixture can be adjusted by adding more Portland cement and controlling the rate at which the concrete cures or dries. The drying process is called dehydration and is affected by time and temperature. At 28 days, concrete is cured to nearly 100 percent of its total strength.

Concrete columns must transmit the entire weight and load of the structure from the highest point to the foundation. The size and spacing of the columns are calculated to carry the load. The anticipated load also will determine the size of the column or pier. Since concrete has little strength against shear loads it also will have reinforcing rods to provide both tensile and shear strength. Axial loading also is critical to the ability of the column to support the load without twisting or turning. Column forms are prepared and reinforcing rods are placed inside the forms. The reinforcing rods typically are prepared off site and tied together with wire or welded together before being transported to the construction site and placed in the forms. If horizontal elements are to intersect with the vertical columns, reinforcing rods also are placed at the intersection and extend outside the forms to tie into the horizontal element when it is poured.

Another form of pouring exterior walls with concrete is called "slip forming." This process uses forms that are jacked or raised by a crane every few hours, or as soon as the concrete is cured enough to support its own weight. The reinforcing rods are placed in the forms and concrete is poured. In a few hours, or typically at least once a day, the forms are raised nearly the height of the form and preparations are made to pour the next level. In some instances the forms are one story high, which allows pouring a column one story a day. Typically these forms are steel sections bolted together which can be loosened to make the lift to the next level.

Precast columns are also a popular construction technique where the structural elements are made at a production facility and transported to the construction site. The reinforcing rods extend from the end, and will be welded to the rods extending from the column below. A form is placed around the missing section of the column and concrete is poured to complete the column around the reinforcing rods.

Horizontal support beams can be poured in place or be made in a precast production facility. Forms are prepared for the beam and reinforcing rods are placed in the form. Concrete is poured in the form and allowed to cure before the forms are removed. Steel rods are very important to the tensile strength of the concrete. Under a load the top of the beam is under compression which concrete can easily support. The bottom of the beam is under tension and the weight is trying to pull it apart. Concrete in this area has very little strength. The steel rods provide the tensile strength and hold the concrete together; this gives it the ability to carry the loads applied. However, when concrete deteriorates and the reinforcing rods are exposed to heat and the elements, corrosion can occur.

In post-tensioned concrete, steel cables are encased in a tube. Once the concrete is cured, the cable is pulled with a hydraulic tension device. After the desired tensile strength has been attained, the cables are locked in place, and the pulling device is removed. In some instances, if the loads applied will exceed the tension previously applied to the cables, it is possible to weld another cable onto the cable in the concrete and put more tensile strength on the cable. Cold-drawn special alloy steel is capable of holding 150,000 pounds per square inch of tensile strength. The same concept can be used in pre-tensioned concrete, but most often is used in poured-in-place concrete for horizontal elements such as beams or floors.

Concrete floor construction most typically uses reinforced concrete which can be installed in a variety of methods. The simplest method is to pour concrete over reinforcing rods or bars; another method is the waffle slab floor. When additional strength is required either a pre-tensioned floor or post-tensioned floor system can be installed.

The most basic concrete floor uses concrete poured over forms that contain reinforcing bars or rods. Several rods are placed in the forms at right angles; concrete is poured over them and finished off to a smooth finish. The reinforcing rods provide tensile strength as well as shear strength. At upper levels where weight is a concern, the concrete used for floors or the roof can be made with light aggregate to reduce the weight.

Precast concrete floor slabs are similar to those in steel framed buildings, i.e., the slabs are poured with tubes, which, when removed, make a hollow-core slab reinforced between the cores with steel reinforcing bars. Slabs that carry heavy loads are made in the form of a "T". The bottom leg of the "T" provides additional support to the slab. These "T" slabs typically are seen where a long span is required or when excessive weight is expected such as in an automobile parking garage. On some "T" slabs there are multiple "T's" on one slab for additional strength. The bottom of the "T" is heavily reinforced with steel rods or cable similar to that used in post-tensioned concrete. Once the forms are built and the concrete is poured it is as strong as it will be. If the load has not been anticipated correctly, the structural element will sag and could crack or fail. The rods and/or cables are placed near the top of the "T" at the ends and go nearly to the bottom of the "T" in the center of the slab. This provides a pulling support method from the center of the "T" slab toward the ends. If pre-tension support uses cables, the cable locks may be observed at the end of the slab. The round circles typically will be filled with cement, but are easily seen on the ends.

Reinforced floors often contain metal trays poured in the concrete that are used to extend electrical utilities through the floor area. These trays can allow fire or smoke to travel throughout the channels. A fire in one area may allow smoke to exit some distance away, similar to balloon construction.

Waffle slab concrete floors use plastic or metal tube-shaped forms in the concrete to form a "waffle" appearance when looking at the underside of the floor. The forms are placed where the floor is to be poured. Typically, the forms are supported on wood or light metal posts that, under fire conditions, can lose their strength quickly and allow the concrete to fail if it is not cured enough to hold its own weight. On top of the forms plastic or metal tubes are placed upside down and steel reinforcing rods are placed between the tubes for strength. Concrete is poured over the steel rods and the tubes and then finished smooth. When the concrete is cured enough to support its own weight, the forms are removed and the tubes are pulled free of the concrete floor. The appearance from the underside is the waffle or eggcrate look. There is a mass of concrete between the areas where the tubes were placed on the forms, and the steel provides the tensile strength for the floor.

Pre-tensioned and post-tensioned concrete floors are constructed similar to the process previously discussed for concrete beams. In post-tensioned concrete, first responders typically can identify the location of the steel cable by the 2- to 4-inch round circles located at the ends of the floors or beams.

Concrete floors usually are not poured to the exact point where the curtain wall panels will attach to the floor slabs so that exterior curtain walls can expand and contract due to warming and cooling and to allow for minor variance of floors. The gap between the floor and curtain wall may be as little as 1/4 of an inch, or more. This gap should be sealed with a fire-resistant material after the exterior curtain wall is attached. In some instances firefighters have reported fire extension between the curtain wall and the floor or, most often, report smoke and heat travel.

Special construction techniques can use either a tip-up method of construction or panel slabs for exterior walls. (Tip-up construction also is called tilt-up construction.) The exterior concrete walls are poured on the ground adjacent to where they will be placed on the foundation. Forms are placed on the ground and reinforcing rods are placed in the forms at right angles for tensile and shear strength. If window or door openings are to be in the wall they are secured in the correct location and the concrete is poured. After the concrete cures the forms are removed and the concrete panels are tipped or tilted up with a crane into their final position on the foundation. Until they are locked and secured into position by the other structural elements, such as the steel roof bar joist, they are propped in place with wooden or steel supports. Until they are finally locked into an integral part of the structure they are a special risk for firefighters. Should a strong wind blow on the wall or should fire attack the integrity of the bracing, the walls could fall. The joints between the panels are caulked or grouted and the building is completed. Once it is finished it may be difficult to tell tilt-up construction from other methods such as poured-in-place construction.

Panel construction is similar to tip-up construction except that the wall panels are fabricated at a fabrication facility and transported to the construction site. At the site they are raised and attached to other panel components, such as floor panels, on upper floors. Entire buildings can be constructed from this "erector-set" method. Critical elements are the connection of one panel to the next and the integrity of the connection materials. Typically, steel corner braces are bolted from floor slabs to wall panels. The wall panels are connected at the floor and ceiling levels as well as to the panels on either side. This method of construction is fast to erect and there are several variations of it. For example, one common variation is concrete block walls and concrete slab floors laid into the block walls. The floor slabs are attached to the block walls and supporting walls, and exterior curtain walls are attached.

Roof construction is similar to floor construction. Steel bar joists, which will be protected for fire resistance with a membrane or sprayed-on coating, can support sheet steel decking which will have concrete poured over the steel forms. The concrete then is sealed with an asphalt roof system, or more typically, a vinyl membrane roof. Precast concrete slabs also can be used for steel framed buildings. Concrete roofs cannot readily be opened for ventilation. Alternate means such as bulkhead doors on stairwells or other vents such as skylights should be considered.

Fire resistance of concrete floors and roofs comes from the concrete itself and the insulation provided by the concrete surrounding the steel reinforcing material. One concern is the tensile strength of the steel rods or cable should the concrete reach 600ºF (316ºC) or more. All steel starts to lose strength at about 600ºF; cold-drawn steel used for post-tension concrete can lose a significant amount of its strength between 600ºF and 1,000ºF (538ºC). If concrete reinforced with steel is heated to 600ºF or above, it should be anticipated that it will start to lose its strength and ability to support loads. At excessive temperatures the steel can expand and the concrete can sag. This can be even more significant where the concrete has failed and the steel is exposed and unprotected. Under prolonged fire conditions firefighters should be aware of sagging floors, especially in the center of spans with heavy loads.

BUILDING FEATURES AND CONSIDERATIONS

Plumbing in new construction typically uses the stacked approach, that is, all bathrooms are stacked one above the other, all kitchens are stacked one above the other, and other rooms such as laundry rooms also would be stacked. This allows a utility shaft for plumbing materials to be extended the entire height of the building. In residential buildings with multiple floors, items such as hot water heaters can be provided in each occupancy, or centralized systems may be located at different levels in the structure and serve multiple tenants. Typically, the pipes used to supply water, drain waste water, and provide a ventilation stack are galvanized steel, copper, or black iron. Some building codes may allow the use of polyvinyl chloride (PVC) pipe. Drain and water supply pipes in areas remote from the utility shaft often are placed below the floor and run to the utility shaft. In buildings where hollow-core floor slabs are used, the cores in the slabs make an ideal place to extend plumbing lines. A core drill is used to drill into the core opening where the pipe has been placed.

Electrical service is run through conduit from the basement or mechanical room to each floor where a subpanel controls the circuits. If the building is only a few stories tall pipes will be placed in the concrete forms before the concrete is poured so that there is a natural opening in the concrete floor to extend conduit for the electrical service. In some buildings steel pans have been placed in the concrete floor in which to extend electrical wiring. The pans extend in several different directions across the floor area in anticipation of fixture placement. An electrical fire in a pan at one location may extend smoke to areas remote from the fire's origin.

Heating can be provided by a centralized system or individual units. Central heat typically uses steam, hot water, or forced air, which may be used in conjunction with the air conditioning system as well. Firefighters should be aware of the type of fuel used in the structure and where the fuel supply can be shut off. A special concern is raised for forced-air systems because the fans and ducts can spread smoke, heat, and fire to other parts of the structure. Ductwork may penetrate several floors and may be the weak link in the fire-resistive rating of the floors. In many systems, especially for buildings other than residential, the entire area above the suspended ceiling is used for a return air plenum. This is noticeable when one observes grates in the suspended ceiling that are not connected to any ductwork. Smoke, heat, and fire can enter the area above the suspended ceiling easily and be drawn to the duct pulling the return air to the air handling system. Another specialty method of providing heat is to use high-pressure steam purchased from a utility company. Many cities use steam lines from a vendor, such as a utility company, that produces electricity with steam; pipes enter the structure and, through a heat exchanger, provide heat or chilled water for cooling. The location of a remote shutoff should be noted on the building preincident plan.

Air conditioning for centralized systems usually requires heavy equipment for chilling and cooling. Most often, since these units require fresh air and release hot air, they are located on the roof of the structure. If not planned for in the original design, this can provide an additional dead load that the structure must support. The same concerns for ductwork and air plenums above suspended ceilings apply to the ductwork for air conditioning systems. In many systems the ductwork is equipped with fire dampers that are activated by a fusible link. In other systems smoke detection equipment is placed inside the duct to shut off the fan motors and stop the air movement. In sophisticated systems the direction of the fans can change and, instead of drawing fresh air into the system and building, the fans actually reverse to remove the contaminated air from the building. In many buildings one large air handling system controls the air movement on many floors. The air handling equipment and fans may be located several floors above or below the fire floor.

Most ventilation for bathrooms is provided by a duct that runs the entire height of the structure connecting each bathroom to a fan on the roof that exhausts air from the building. Typically, the makeup air to replace the air removed will enter the bathrooms through a vent from another area of the building, such as the hallway outside the bathroom. Many buildings use louvered restroom doors to allow the makeup air to enter the room from outside the restroom. The danger in this system is that if a fire occurs and the fan stops operating, smoke or heat can enter restrooms on other floors of the structure, creating a smoke condition several floors above the fire floor.

Stair systems are critical for occupants to be able to evacuate the structure and for firefighters to gain entry to the various floors of the structure. The placement of the stairwells most often is dictated by local building codes. While codes require two remote means of egress, the interpretation of remote may be that they are in the same general area of the structure, but separated by a fire-resistive material. In older buildings it is common to find stairways near exterior walls or built on the outside of the structure in stair towers. In modern construction the use of a center core concept brings the elevators, restrooms, utility closets, and stairways into the center of the structure. The most common center core design is called scissors stairs, where two sets of stairs share the same shaft but are separated by a fire-resistive wall. In the scissors stair concept, one stairwell opens on one side of the center core and the other opens on the opposite side of the core. This method is a distinct advantage for the builder: only one large shaft has to be planned and constructed in the center of the structure to accommodate all the building's services. An advantage for the building's owner is that all exterior walls are open and not blocked with restrooms, elevators, or stairwells. Center core designs commonly have only one stairway leading directly to the outside while the other stairway exits inside the building on the first floor.

Elevators also can be a challenge for firefighters when occupants become trapped and need to be rescued from stalled elevator cars. Special fire department controls are required to allow firefighters to operate the doors and control the direction of the car. Without a fire service control system the elevator car may go directly to the fire floor where the doors open onto the fire, and may not close. Elevators in low-rise buildings may operate with a hydraulic cylinder that raises and lowers the car. These systems must have a reservoir for the hydraulic fluid that is exhausted from the cylinder when the car is at its lowest point. Safety concerns for firefighters include the flammability of the oil and the danger of hydraulic hoses burning through with the oil heated, expanded, and pressurized inside the hose. Other elevators typically use a cable system which is attached to an electric motor. To assist the elevator in moving the weight up and down, balance weights are attached to a cable and pulley arrangement so that when the car goes up, the counterbalance weights go down. The motor provides the additional power for the weight of the load in the elevator car.

Elevator shafts can pose some unique challenges as well. Some fire departments have used the elevator shafts as a vertical ventilation shaft to the roof. The penthouse elevator room tends to be well ventilated since the elevator car acts as a plunger as it travels up and down and the air pushed by the car must be ventilated. This is done at the elevator room at the top. Once doors open without the benefit of a car at the floor landing, firefighters could fall into the open shaft. Tall buildings usually have two sets of elevators: one would service floors 1 through 10, the other, floors 10 through 20. The elevator shaft for floors 1 through 10 typically would terminate at the 10th floor since this is as far as the car travels. The elevator for floors 10 through 20 would have a shaft for all 20 stories of the structure. One opening would be on the first floor and the other in the shaft would be at the 10th floor. This creates a blind shaft in floors two through nine that would make the rescue from stalled elevator cars difficult. Rescues most often are accomplished by bringing another car alongside and using a side door to move the trapped occupants from the stalled car into the operable car. If the power fails, the structure's backup generators may power only one elevator. Your preincident plan should indicate which elevator car is powered by the backup generator. This problem is even greater for buildings of 60, 80, or 100 stories that may have several banks of elevators serving multiple floors. There could be blind shafts for 60 or 80 stories.

Fire protection features of Type I and Type II structures may include standpipe systems, automatic sprinkler systems, smoke and heat detection systems, and fans that pressurize stairwells. Standpipe systems are designed to provide the fire service with 500 gallons per minute at a minimum of 100 pounds of pressure at the highest point with a 2-1/2-inch valve-and-hose connection. In tall buildings, in order to gain the 100 pounds of pressure at the top floor connections, a building fire pump is typically used. In older buildings the pressure may be required to be at only 65 pounds pressure.

Sophisticated heat and smoke detection systems can isolate the area of the alarm activation, initiate a selected evacuation of the floors in a priority sequence, and announce which stairwells not to use (the one closest to the alarm activation.) This type of system provides responders with specific information, e.g., the method of alarm activation (smoke, heat, manual), and will provide a clear stairwell close to the alarm activation for them to use. The system also can shut down motors, such as fans, and start others, such as pressure fans in the stairwells. The advantage of exercising an evacuation of only a few selected floors at a time (typically the fire floors, one floor below, and three floors above) is to allow the people in the most danger to have a chance to exit safely without congestion in the stairwell. If the fire was reported on the 20th floor of a 20-story building, and all floors were evacuated at the same time, the stairwells would fill with the occupants of the 19 floors below; then the people who most need to leave would be unable to do so. Congested stairwells can lead to trampling and falling, further hampering egress.

Automatic sprinklers provide a sophisticated method of extinguishing a fire. Of special interest to responders is any information about the incident that could have compromised the system's ability to do its job. Such information could include reports that the system is out of service, that an explosion has damaged the equipment, or that an accident has caused the system to lose its water supply.

Some buildings are equipped with fans in the stairwell designed to provide a positive pressure there should a fire occur on one of the floors. Most systems are designed to accommodate multiple floors per fan. The amount of pressure must be restricted in order to be able to open the doors from the floors of the building into the stairwell and still have an automatic closer slowly close the door. The intent is to have the fans provide a pressure level in the stairwell that is greater than that of the fire floor. Instead of the smoke coming from the fire floor into the stairwell when the door is opened to exit, the stairwell remains smokefree.

Center-core design buildings place all the utilities, restrooms, elevators, and stairwells in the center of the structure. This can create difficult fire extinguishment problems when attacks are made from more than one stairway. This usually results in opposing hoselines. In addition, many modern office buildings do not have solid walls from floor to ceiling outside the center core. Office cubicles are created with dividers 48 or 60 inches tall. Without a firestop, extinguishment efforts may result in pushing the fire around the entire floor area and firefighters' backs. Specialized tactical procedures must be used for fires in this type of structure.

SUMMARY

Protected noncombustible construction requires the use of encasement, membrane, or sprayed-on materials to protect structural elements that are subject to heating and failure.

Type II construction has two subclasses generally requiring either a 1-hour or 2-hour rating of all structural elements.

Type I construction has two subclasses generally requiring either a 3-hour or a 4-hour rating for all structural elements except the floors and roof, which require as little as a 1-1/2 hour rating.

It is critical that all items installed to support the structure, such as the plumbing, heating, electrical, and ventilation systems, be evaluated carefully to determine their ability to spread heat, smoke, and fire from floor to floor.

Activity 4.1

Protected Steel Construction Elements

Purpose

To apply the principles of protected steel construction elements under fire conditions.

Directions

1. In small groups review the scenario assigned by the instructor.

2. Using the information provided, and after reviewing the slides of your building, you will have 30 minutes to answer the questions below.

3. Select a spokesperson to represent the group and report your findings to the questions.

   a. Are there any steel structural elements in the structure? If yes, what?

   b. Was there any unusual activity inside the building prior to the fire that is a concern? If yes, what?

   c. Has anything happened that could affect structural integrity? If yes, what?

   d. Is firefighter safety a concern? If yes, why?

   e. What is/are the required hour(s) of fire-resistance rating for the class of construction listed?

      Exterior bearing wall: ____

      Interior bearing wall: ____

      Columns: ____

      Beams, girders, trusses, and arches: _______________________________

      Floor construction: ____

      Roof construction:____

Scenario 1: 22 Cortland Hill Road

A fire has been reported at a medium-sized automobile dealership. The caller stated that a fire started in a sales booth and the car next to it also is burning. The caller states that there is smoke going up the stairwell to the second floor, and he/she is unsure if everyone has been able to escape. The building was inspected recently and all fire-resistance protections were found to be in place. The owner was directed to stop blocking open the doors to the second floor and to the repair garage. They were informed about the importance of the fire doors being closed. The caller further states that one mechanic was burned slightly while trying to extinguish the fire.

It is 1000 on a Friday, the temperature is 70 degrees, and wind is from the west at 5 mph.

Quick Access Prefire Plan

Building Address: *22 Cortland Hill Road*

Building Description:
Type II Subclass 111, two-story auto showroom on first floor and offices of the auto dealership on second floor--connected by 2-hour firewall to an auto repair garage and parts room. Showroom and office section is 100' by 100'.

Roof Construction:
Steel bar joist supported on masonry exterior walls and steel box frame for interior support. Metal decking covered with insulation and asphalt roof. Roof joist protected by membrane enclosure. Columns protected by encasement.

Floor Construction:
First floor concrete slab, second floor is steel bar joist supported in same manner as roof. Second-floor joist protected with membrane rated enclosure. Support columns protected by encasement.

Occupancy Type:
Auto dealership

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

Location of Water Supply:
18 and 38 Cortland Hill Road

Available Flow:
2,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*1,041*	*2,083*	*3,124*	*4,166*

**Estimated fire flow based on 100' by 100' with 25%-exposure for side "C".*

Fire Behavior Prediction:
Fire load on first floor can be heavy since there are from 4 to 6 automobiles on display in showroom. This could quickly threaten fire-resistance protection for steel framework supporting second floor. Fire may extend quickly to second floor. On prior inspections the door to the second floor has been found blocked open and the door from the showroom to the garage frequently has been blocked open, which could allow fire extension into second floor of garage exposure.

Predicted Strategies:
Offensive operations to conduct primary search and then evaluate fire growth, fire extension, and ability to control fire with handlines. If fire has compromised membrane fire-resistive protection, consider defensive operations.

Problems Anticipated:
Rapid fire spread due to fire load on showroom. Due to intensity of fire load in area of automobiles the structural integrity may be compromised.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Heat and smoke* *Local alarm only*

Scenario 2: 1444 Park Street

A fire has been reported on the second floor of a law office. The call was received by 911 from an automatic recording reporting the fire. First-arriving units report an extensive fire on the second floor and some windows have autoventilated.

It is 0630 on a Sunday, the temperature is 20 degrees, and there is no wind.

Quick Access Prefire Plan

Building Address: *1444 Park Street*

Building Description:
Type II Subclass 222, two-story offices for a large law firm. The building was constructed in 1984 and is 125' by 75' with no exposures. The exterior and interior walls are masonry block and the floors are precast lightweight concrete slabs.

Roof Construction:
Steel trusses with sprayed-on protection covered with experimental lightweight concrete slabs, which are finished with asphalt covering.

Floor Construction:
First floor is poured concrete slab, second floor is lightweight concrete slabs.

Occupancy Type:
Law offices' daily occupancy is about 50 employees and visitors

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

Location of Water Supply:
Hydrant at RT 9 and Osborn Road--1-1/2 miles

Available Flow:
2 additional tankers available
Fill hydrant 500 gpm

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*975*	*1,950*	*2,925*	*3,900*

Estimated fire flow based on 100' by 75'--with one floor added for 25% exposure.

Fire Behavior Prediction:
Fire extension from first floor to second likely will be via exterior glass windows. Second-floor structural elements are fire resistive and two enclosed stairwells have 2-hour fire doors. Building has one elevator which is hydraulic and has 2-hour rated exterior fire doors.

Predicted Strategies:
Standard strategic goals.

Problems Anticipated:
Standard fire load for offices.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Smoke tied into 911 with automatic dialer

Scenario 3: 218 Clark Place

A fire has been reported by a maintenance worker who stated that he/she was doing some remodeling work and a fire started in the autoparts department. He/She further stated that the sprinkler system was turned off in order to move some piping. The maintenance worker states that he/she turned the system back on and even though there was an open 3-inch pipe flowing, it appeared to be stopping the fire. Upon arrival there is primarily heavy smoke and little visible flame.

It is 1130 on a Sunday, the temperature is 80 degrees, and there is little wind.

Quick Access Prefire Plan

Building Address: *218 Clark Place*

Building Description:

Type II Subclass 222, one-story retail "big box" store. Steel box frame protected by encasement on first floor and steel joist roof is protected by sprayed-on fire-resistive material. The building is 400' by 500' with a 3-hour firewall separating this building from another "big box" retail store. There are no openings in the firewall. Suspended ceiling covers entire store area.

Roof Construction:

Steel decking covered with insulation and vinyl covering. The roof is supported on steel box frame and steel bar joist rafters. All elements are protected.

Floor Construction:

Concrete slab.

Occupancy Type:

Retail store

Initial Resources Required:

2 engines, 1 ladder, 1 rescue

Location of Water Supply:

22 and 40 Clark Way

Available Flow:

1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*16,625*	*33,250*	*49,875*	*66,500*

Estimated fire flow based on 400' by 500' with one exposure.
Note for practical application 5% or 10,000 sq. ft. Involvement equals 3,325 gpm.

Fire Behavior Prediction:

Due to high panel display of merchandise and the amount of merchandise, fire extension could be considerable if sprinkler is ineffective.

Predicted Strategies:

Primary search will take considerable resources under fire and smoke conditions. A minimum of one full alarm assignment will be required to complete the primary search.

Problems Anticipated:

Heavy fire load--sprinklers should control.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Eight connections inside	*Wet system*	*Water flow alarm*

Scenario 4: 444 Jeffery Lane

A fire has been reported in theater four of Cinema 10. The caller states that shortly before the movie was to end a patron took a cigarette lighter and started a torn seat cushion on fire. Patrons said that it was a small fire for a short time and then spread very quickly. The exits were choked with patrons, and the caller reports that he/she is not sure everyone got out.

It is 1930 on a Saturday, the temperature is 95 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *444 Jeffery Lane*

Building Description:
Type II Subclass 111, one-story 10-screen movie theater with masonry walls and interior steel box beam support for roof. The building is 175' by 175' with one main entrance and a second exit from each theater. Total occupancy load for all units is 1,750 patrons.

Roof Construction:
Steel decking covered with insulation and vinyl roofing which is supported on steel bar joist resting on steel box frame on the interior and on masonry block exterior walls. Columns are protected by encasement, and roof structural members are protected by a membrane ceiling.

Floor Construction:
Concrete slab.

Occupancy Type:
Movie theater--10 screens

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

Location of Water Supply:
440 and 480 Jeffery Lane

Available Flow:
1,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*2,500*	*5,100*	*7,600*	*10,200*

Estimated fire flow based on 175' by 175' and no exposures.
Note: For practical application 10% or 3,062 sq. ft. equals 1,020 gpm.

Fire Behavior Prediction:
Fire loading of 1,750 thick, foam-padded seats will produce a significant fire load. Partitions between 10 theaters are not fire rated and end at the suspended ceiling.

Predicted Strategies:
Rescue under fire and smoke conditions will be very difficult and labor intensive. Call for additional alarms immediately if building is occupied.

Problems Anticipated:
Rapid fire extension from rows of seats to other rows--thick black smoke anticipated.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Smoke and heat--local alarm only*

Activity 4.2

Concrete Construction Elements

Purpose

To apply the principles of concrete construction elements under fire conditions.

Directions

1. Your instructor will assign your group a scenario.

2. In your group review the scenario, the Quick Access Prefire Plan (QAP), and the slides of the building.

3. As a group, evaluate the structure and answer the questions in the next 30 minutes.

4. Select a spokesperson to report the group's findings.

   Are there any concrete structural elements in the structure? If yes, what?

   a. Was there any unusual activity inside the building prior to the fire that is a concern? If yes, what?

   b. Has anything happened that could affect structural integrity? If yes, what?

   c. Is firefighter safety a concern? If yes, why?

   d. What is/are the required hour(s) of fire-resistance rating for the class of construction listed?

      Exterior bearing wall: ____________________

      Interior bearing wall: ____________________

      Columns: ____________________

      Beams, girders, trusses, and arches: ____________________

      Floor construction: ____________________

      Roof construction:____________________

Scenario 1: 47 Wade Road

A fire has been reported at 47 Wade Road by a worker who stated that there has been an accident with a forklift and a fire was started. The caller further states that the forklift tipped over two racks of paper storage, which hit a support column with a standpipe station attached and broke a lot of piping. Water is pouring out of broken pipes. It appears that the sprinklers are barely operating and the fire is spreading. The caller states that two workers are unaccounted for, and the driver of the forklift is partially trapped by the overturned forklift.

The time is 0930 on a Saturday, the temperature is 75 degrees, and winds are calm. There is a mass casualty exercise underway at the nearby Albany County Airport with seven engines and two ladders participating.

Quick Access Prefire Plan

Building Address: *47 Wade Road*

Building Description:

Type I Subclass 332, one-story tilt-up concrete with steel box beam support for concrete slab roof panels. Building is 150' by 700' with one 4-hour-rated firewall separating, creating two 350' by 150' sections. The building houses printing machines for government printing. The building has an exposure along one 700' wall which is 100' by 700' precast concrete supports with an aluminum curtain wall. The adjoining wall has protected openings as does the firewall separating the printing area. Columns are protected by encasement, and beams by a membrane.

Roof Construction:

6" precast concrete slabs covered with a vinyl roof covering and supported on steel box frame on the exterior and on the tilt-up exterior walls.

Floor Construction:

Concrete slab.

Occupancy Type:

Printing shop and offices

Initial Resources Required:

2 engines, 1 ladder, 1 rescue

Location of Water Supply:

12, 36, and 69 Wade Road

Available Flow:

1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*6,500*	*13,000*	*19,500*	*26,000*

Estimated fire flow based on 350' by 150' and two exposures--for practical application 10%-involvement equals 2,600 gpm.

Fire Behavior Prediction:

Print shop has bulk paper storage with thousands of cases and rolls of paper stored 20' high on racks. There are mechanical presses as well as large photocopying equipment. Due to the amount of paper used, dust from the paper is a constant maintenance issue. There are normally 20 propane-powered forklifts that work in the printing area. Should the sprinklers fail to contain a fire, it would be fast spreading and deep seated.

Predicted Strategies:

Normal strategic goals if sprinkler system is operating. If the sprinkler is not operational, primary search may be difficult due to the high rack storage and equipment. Collapse of unprotected steel storage racks should be anticipated.

Problems Anticipated:

Very significant fire load, limited access through two loading dock doors and four personnel doors in each section. Previous inspections have shown fire doors are kept closed and clear of storage.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class 1 with 14 connections in each section	*Wet system in each section--none in exposure*	*Heat detection and sprinkler flow to 911*

Scenario 2: 288 River View Center

A fire has been reported on the eighth floor of the River View office center. The caller states that the fire was started by a worker thawing a frozen sprinkler pipe. Because the floor is unoccupied, the heat to the entire floor was shut off.

A recent inspection less than 1 week ago revealed that the eighth floor was being used for miscellaneous storage, and there was a large accumulation of trash. It also was observed that all the stairwell doors had been removed and the elevator doors on the eighth floor had been blocked open in an effort to gain enough heat to keep the sprinklers from freezing. A code violation was issued with 10 days to comply.

It is 2130 on a Wednesday, the temperature is minus 5 degrees, and winds are from the north at 15 miles per hour.

Quick Access Prefire Plan

Building Address: *288 River View Center*

Building Description:

Type 1 Subclass 443, eight-story 150' by 600' poured-in-place concrete office building. The building was originally a warehouse and retail sales area. It has been converted into offices on the first five floors. The top three floors are still vacant. It has a six-story exposure on the rear of the building that is rented by a large moving company and is used for temporary furniture storage. The exposure is separated by a protected firewall.

Roof Construction:

Poured-in-place concrete covered with asphalt.

Floor Construction:

Poured-in-place reinforced concrete.

Occupancy Type:

Government offices

Initial Resources Required:

2 engines, 1 ladder, 1 rescue

Location of Water Supply:

288 River View--4 yard hydrants

Available Flow:

2,000 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*9,375*	*18,759*	*28,125*	*37,500*

Estimated fire flow based on 150' by 600' with one exposure added--note additional exposure floors may need to be added--for practical application 5% equals 1,875 gpm.

Fire Behavior Prediction:

Interior fire spread should be contained to one floor, since all floor openings are protected. The building has four protected stair towers with positive-pressure ventilation. The work-day census is about 1,000 employees.

Predicted Strategies:

Rescue and accountability will be a major strategy and will require extra resources to accomplish. Each stairwell is equipped with a standpipe connection at every other floor. The office layout is an open floor plan with very few private offices.

Problems Anticipated:

Elevators and two scissors stairs are center core design. Two additional stair towers have been installed at the ends of the building on the interior. Any fire attack will need to be coordinated to avoid opposing hoselines.

[X] **Standpipe**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class III in all stairwells with connections every other floor	*Wet pipe system*	*Heat, smoke, and water flow tied to 911*

Scenario 3: 27 Airline Drive

A fire has been reported at 27 Airline Drive. The caller stated that a fire was started by static electricity in the spray booth where varnish is applied to the wire. The fire is spreading in the booth and out the booth's exhaust system, and is visible on the roof. The caller states that the sprinkler system is running, but the fire isn't going out.

Previous inspections have revealed that the structure itself is protected by a wet system. The paint spray booth, which is about 20 feet by 30 feet and comes within about 1 foot of the protected roof supports and the sprinkler heads, is not protected with a sprinkler system. The inspection also has revealed that there is a significant accumulation of varnish on the walls and ceiling of the spray booth. An exhaust system from the booth has four vent pipes that connect above the spray booth into one sheet steel duct that goes to the roof where a large fan is located.

It is 1630 on a Friday, the temperature is 98 degrees, the humidity is 90 percent, and there is no wind.

Quick Access Prefire Plan

Building Address: *27 Airline Drive*

Building Description:

Type I Subclass 332, one-story light industrial manufacturing and office space 400' by 300' with one protected firewall in the center, creating two sections 200' by 300'. The structure is a tilt-up slab construction building with protected steel box interior framing to support a concrete slab roof. Steel columns are protected by encasement, and the steel beams are protected by sprayed-on fire-resistive material.

Roof Construction:

Precast 6"-concrete hollow-core slabs covered with a vinyl roof and supported on steel box beams.

Floor Construction:

Concrete slab.

Occupancy Type: *Manufacturing of electric motors and offices*	**Initial Resources Required:** *2 engines, 1 ladder, 1 rescue*
Location of Water Supply: *20 and 40 Airline Drive*	**Available Flow:** *1,000 gpm each*

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*6,250*	*12,500*	*18,750*	*25,000*

Estimated fire flow based on 200' by 300' with one exposure. For practical application 10%-involvement equals 2,500 gpm.

Fire Behavior Prediction:

Manufacturing and storage uses a great deal of wire which is coated with a varnish. Metal motor housings are received and the components for the motor are made on location. The walls used to create offices are nonrated and have glass looking onto the manufacturing area. Should a fire occur, maneuverability will be difficult due to the manufacturing and storage in the building.

Predicted Strategies:

Standard strategies--normal census during the first shift is 40, and 5 on the second shift (no third shift).

Problems Anticipated:

Maneuverability of hoselines will be difficult.

☐ **Standpipe:**	☒ **Sprinklers:** *Wet system*	☒ **Fire Detection:** *Heat detection and water flow to 911*

Scenario 4: Smith Towers

A fire has been reported on the eighth floor of a 30-story office building. The caller reports that a copy machine malfunctioned and now the entire reproduction room is on fire. One worker tried to extinguish the fire with a fire extinguisher, but it did not go out. Upon arrival you find the building being evacuated; all four stairwells are full of workers exiting the structure.

The evacuation plan indicates that there are 12 physically challenged individuals in wheelchairs or who use walkers and cannot walk downstairs. It appears that eight of these workers are on floors above the fire.

It is 1130 on a Thursday, the temperature is 45 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *Smith Towers*

Building Description:

Type I Subclass 443, 30-story poured-in-place stepped concrete construction government office building. The building has two levels of subbasement used for storage and maintenance. The building is 100' by 400' with no exposures. The building has two remote protected stairwells, two scissors stairs located in the center core and four elevators located in the center of the building. The building has been subdivided on most floors with 6-foot nonrated metal partitions. Major renovations have included centralized air and heating systems which required two 48" by 48" shafts to all 30 floors.

Roof Construction:

Poured-in-place concrete covered with asphalt.

Floor Construction:

Poured-in-place reinforced concrete.

Occupancy Type:

Government offices

Initial Resources Required:

2 engines, 1 ladder, 1 rescue

Location of Water Supply:

30 and 50 Swan Street

Available Flow:

1,250 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*4,175*	*8,350*	*12,525*	*16,700*

Estimated fire flow based on 100' by 400' with one exposure--for practical application 1/4 of one floor equals 4,166 gpm.

Fire Behavior Prediction:

Should be able to contain fire to one floor on the interior due to fire-resistance ratings and protected openings. Primary search will require additional resources, as normal work-day census is 4,500 workers. Elevator shaft and air handling duct may allow fire extension. Area above suspended ceiling is return air plenum which could spread fire.

Predicted Strategies:

Standard strategic goals.

Problems Anticipated:

Additional resources needed to conduct primary search. Since only the subbasement levels are protected by sprinklers, fire suppression will be by hoselines. The fire pump must be started manually from lobby control room. Twelve physically challenged individuals work in the building.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class 1 in all stairwells at all levels	*Subbasement only*	*Heat detection--local alarm only*

MODULE 5: CULMINATING ACTIVITY

OBJECTIVE

While working in small groups and given a scenario of a noncombustible building, the students will be able to identify critical construction elements and determine if fire resistance is required. If it is, identify the time required for fire resistance and critical safety issues for the particular type of construction.

Activity 5.1

Culminating Activity

Purpose

To identify important characteristics of a noncombustible building.

Directions

1. The instructor will assign each group a scenario.

2. Read the incident scenario and review the Quick Access Prefire Plan (QAP) for the assigned scenario.

3. After reviewing the scenario, answer the questions regarding the structure. Your group will have 60 minutes to evaluate the scenario and answer the questions.

4. Select a spokesperson to report your group's answers.

    a. Does the structure have a steel structural frame?

    b. Does the structure have a masonry/concrete structural frame?

    c. Does the structure have a combination of steel and masonry frame?

    d. If the structure has structural steel, is the steel protected with fire-resistive materials?

    e. If the structure is required to have fire-resistive protection, complete the fire-resistance ratings for the structural elements listed below.

        Exterior bearing walls: ______________________________

        Interior bearing walls: ______________________________

        Columns: ______________________________

        Beams, girders, trusses, and arches: ______________________________

        Floor construction: ______________________________

        Roof construction: ______________________________

        Exterior nonbearing wall: ______________________________

    f. Is firefighter safety a concern? Why or why not?

Scenario 1: 42 Cobble Hill Road

A fire has been reported at 42 Cobble Hill Road. The building is occupied as a branch office of a bank. The call was received by dispatch via an automatic dialer that reported that a fire was in progress within the structure. The structure was unoccupied at the time.

It is 0830 on a Sunday morning, the temperature is 75 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *42 Cobble Hill Road*

Building Description:
Type 1, Subclass 443, one-story, precast concrete columns, beams, and curtain walls of masonry and glass--75' by 75'.

Roof Construction:
Concrete slab covered with asphalt supported on precast concrete columns and beams.

Floor Construction:
Concrete slab with no basement.

Occupancy Type:
Bank offices and customer service area

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

Hazards to Personnel:

Location of Water Supply:
28 and 65 Cobble Hill Road

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 75' by 75' no exposures.*

Fire Behavior Prediction:
Normal fire growth anticipated for office occupancy. Masonry support and curtain walls will contain heat.

Predicted Strategies:
Standard strategic goals.

Problems Anticipated:
Ventilation will be limited. Concrete roof and mostly solid masonry curtain walls will make ventilation difficult.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Smoke--connected to auto dialer*

Scenario 2: 1 Southgate Road

A fire has been reported at a local restaurant and lounge located at 1 Southgate Road. The building was occupied at the time of the fire. The caller reports that a fire started in the kitchen and quickly extended into the dining room area. An evacuation has been initiated, but the caller was unsure if everyone was out or accounted for. The cook, manager, and two patrons were trying to help people escape and also trying to extinguish the fire. The caller estimated that there were about 40 customers and a staff of 12 inside at the time of the fire.

It is a Saturday evening at 1945, the temperature is 85 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *1 Southgate Road*

Building Description:
Type II, Subclass 111, one-story 100' by 75' masonry exterior load-bearing walls and steel box frame interior support for roof.

Roof Construction:
Steel decking covered with insulation, and vinyl roof supported on steel bar joist resting on steel box frame.

Floor Construction:
Concrete slab.

Occupancy Type:
Restaurant and lounge

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

Hazards to Personnel:

Location of Water Supply:
1 and 28 Southgate Road

Available Flow:

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*675*	*1,250*	*1,825*	*2,500*

**Estimated fire flow based on 100' by 75' one-story with no exposures.*

Fire Behavior Prediction:
Interior furnishings of combustible materials, kitchen with deep fryers and broilers could cause rapid fire spread. Previous visits indicated that they have a tendency to exceed posted occupancy limits of 250 by at least 50%.

Predicted Strategies:
Rescue and accountability will require additional resources for fire conditions. Kitchen has double bottle dry powder system with manual pull located by rear door.

Problems Anticipated:
Rescue and accountability of occupants.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Local alarm only*

Scenario 3: 28 Campus View Drive

A fire has been reported at 28 Campus View Drive, a college dormitory. The caller reports a fire on the third floor. At the same time, you receive Box 321 from the facility. Upon arrival, you observe fire as well as smoke coming from the far right side of the "U"-shaped building. You hear the water motor gong operating, but the fire is burning freely from the third-floor room.

The time is 0530 on a Saturday, the temperature is 55 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *28 Campus View Drive*

Building Description:
Type 1, Subclass 332, college dormitory. "U" shaped with two side wings 150' by 75' and center section 250' by 75'. Each of three sections separated by rated firewall with protected openings.

Roof Construction:
Steel rafters covered with corrugated sheet steel, insulation, and asphalt shingles. A double membrane ceiling separates third floor and roof area.

Floor Construction:
Concrete slab for first floor and precast hollow-core slabs for second and third floors.

Occupancy Type:
College dormitory

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

Hazards to Personnel:

Location of Water Supply:
12 and 65 College View Drive

Available Flow:
1,750 each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*1,560*	*3,125*	*4,685*	*6,250*

**Estimated fire flow based on center section of "U" 250' by 75' one floor. No exposures added to above flows. For practical application, 10%-involvement for one floor equals 625 gpm.*

Fire Behavior Prediction:
Should be able to confine fire internally to floor of fire origin due to noncombustible construction, ratings of separation walls of rooms, and protected openings. Note--have observed fire doors separating wings blocked open by furniture and other equipment such as laundry carts. Fire extension may be through windows to floors above.

Predicted Strategies:
Primary search; mark rooms searched.

Problems Anticipated:
College dormitory rooms have been observed to be heavily loaded with combustibles on past inspections. Fire load in individual rooms could be extensive.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class I in stairwells	*Wet system in halls and stairwells*	*Smoke detection and water flow tied into master box*

Scenario 4: 474 Northway Mall

A fire has been reported by the store manager at 474 Northway Mall, an office supply and equipment store. The manager states that they had just unloaded supplies from a truck with a forklift. They drove the forklift inside the store with the boxes of materials when the operator hit an 8' storage rack and it fell onto the forklift. The shelving appeared to hit the propane fuel tank and the hose from the tank. It appeared that the tank was punctured, or the hoseline broke. The manager reports that two of his employees are still under the shelving.

It is 1630 on a Tuesday, the temperature is 80 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *474 Northway Mall*

Building Description:
Type II, Subclass 000, one-story 200' by 300' steel box frame and masonry exterior curtain walls. Building has a storage area in rear third of building with nonrated separation wall.

Roof Construction:
Corrugated sheet steel covered with insulation, and asphalt covering supported on steel box beam.

Floor Construction:
Concrete slab.

Occupancy Type:
Office supply store and storeroom

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

Hazards to Personnel:

Location of Water Supply:
4 and 44 Northway Road

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*5,000*	*10,000*	*15,000*	*20,000*

**Estimated fire flow based on 200' by 300' area with no exposures. For practical application, 5%-involvement equals 500 gpm.*

Fire Behavior Prediction:
Due to occupancy and storage, fire will spread rapidly with no fire separations to stop it. Small fire will rapidly become major fire.

Predicted Strategies:
Rescue and accountability for staff and customers will require additional help under fire conditions. After rescue is completed consider structural stability before commencing offensive operations.

Problems Anticipated:
Early failure of structural elements.

☐ Standpipe:	☐ Sprinklers:	☒ Fire Detection: *Smoke detection--local alarm only*

Scenario 5: 22 Washington Avenue

A fire has been reported in a manufacturing and office facility at 22 Washington Avenue by an automatic dialer. A second call is received from the facility stating that a fire occurred in a plastics cementing area on the first floor and spread quickly to cardboard boxes and other computer parts nearby. The first-floor fire has generated considerable smoke on the second floor and staff are unsure if all employees are accounted for.

It is 1515 on a Friday, the temperature is 65 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *22 Washington Avenue*

Building Description:
Type I, Subclass 332, two-story 250' by 250'. Light manufacturing on first floor and half of second floor. Second half of second floor is office space. Four enclosed rated stairwells provide access to second floor along with two freight elevators (hydraulic) and one passenger elevator (cable).

Roof Construction:
Concrete slab covered with insulation and vinyl covering supported on steel box frame.

Floor Construction:
First-floor concrete slab and second floor is precast hollow-core concrete slab.

Occupancy Type:
Computer assembly and sales offices on second floor. Computer assembly and shipping on first floor.

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

Hazards to Personnel:

Location of Water Supply:
18 and 47 Washington Avenue

Available Flow:
1,750 each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*5,125*	*10,250*	*15,375*	*20,500*

**Estimated fire flow based on one floor of 250' by 250' light industrial with no exposures added. For practical application 5%-involvement of one floor equals 500 gpm.*

Fire Behavior Prediction:
Building has large fire load of plastic computer cases and parts as well as cardboard shipping containers. Fire will likely spread rapidly and quickly consume entire floor. Fire should be contained on interior to one floor due to fire-rated separation between first and second floors.

Predicted Strategies:
Rescue and accountability will require additional resources. Normal strategic goals based upon resources available.

Problems Anticipated:
Accountability of occupants and visitors.

☐ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:** *Smoke and heat alarm on auto dialer*

Scenario 6: 55 Broadway

A fire has been reported in a six-story office building at 55 Broadway. At the same time, a call from Box 444 is received for the structure. The caller states that a fire has been reported on the fourth floor. The caller stated that there was a small explosion and a fire resulted shortly after the explosion. He/She is sure that some employees were injured by the explosion and have not been able to escape.

It is 0900 on a Tuesday, the temperature is 90 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *55 Broadway*

Building Description:
Type 1, Subclass 332, six-story office building 400' by 200' with center-core design on all floors. Scissors stairs in center core.

Roof Construction:
Poured concrete on corrugated sheet steel decking covered with insulation and vinyl covering supported on steel box beams.

Floor Construction:
Poured concrete poured on corrugated sheet decking supported on steel box beams.

Occupancy Type:
Office building

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

Hazards to Personnel:

Location of Water Supply:
18, 39, and 72 Broadway

Available Flow:
1,250 each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*6,675*	*13,375*	*20,050*	*26,750*

**Estimated fire flow based on 200' by 400' for one floor with no exposures. Add exposures accordingly. For practical application 5% of one floor equals 1,335 gpm.*

Fire Behavior Prediction:
Large open center-core floor concept with 48" dividers used to create over 100 cubicles per floor. Fire will develop quickly and primary search may be difficult to accomplish. Consider additional personnel for primary search and accountability for staff.

Predicted Strategies:
Rescue and accountability of occupants. Plan confinement and extinguishment tactical objectives carefully to limit opposing hoselines from stairwells of fire floor.

Problems Anticipated:
Large fire flow requirements may require master stream attack on interior floors.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class I in one stairwell	*Wet system*	*Smoke, heat and water flow connected to master box*

Scenario 7: 22 Cambias Drive

A fire has been reported at 22 Cambias Drive, a 16-unit apartment building. The caller states that there is a fire on the third floor. The caller also states that he/she heard children calling for help in the apartment just to the right of the one that is on fire. A resident tried to get to the children but was unable to because of the heat.

It is 1830 on a Sunday, the temperature is 80 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *22 Cambias Drive*

Building Description:
Type II, Subclass 222, three-story "L"-shaped building with each section 150' by 75' precast columns and precast beams supporting floors. Rated firewall with rated enclosures separate two sections.

Roof Construction:
Wooden rafters and plywood covered with asphalt shingles. The wooden elements are protected by a membrane covering.

Floor Construction:
Poured concrete slab first floor and pre-cast hollow-core concrete floor slabs for second and third floors, and ceiling of third floor.

Occupancy Type:
16 apartments--Senior Citizens' residence

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

Hazards to Personnel:

Location of Water Supply:
10 and 47 Cambias Drive

Available Flow:
1,250 each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*1,175*	*2,350*	*3,225*	*4,700*

**Estimated fire flow based on one floor 150' by 75' with one exposure of firewall. Add additional exposure charge for other floors. A 10%-involvement of one floor equals 470 gpm.*

Fire Behavior Prediction:
Fire should be able to be contained to one floor internally. Fire extension may occur through exterior windows.

Predicted Strategies:
Rescue and accountability of senior citizens will require additional resources for fire conditions. Normal strategic goals should be used once rescue is accomplished.

Problems Anticipated:
Ability of physically challenged senior citizens to exit structure quickly. On previous inspections, occupants have been observed in walkers and using canes to walk.

☒ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:**
Type III in stairwells		*Smoke and heat local alarm only*

Scenario 8: 57 Industrial Drive

A fire has been reported at 57 Industrial Drive, a 12-story office and cold storage building. The caller reports that a fire has been discovered on the fifth floor and is extending inside the structure. The caller informed the dispatcher that the cold storage section had been cleared and purged of its refrigeration, chemicals had been removed, and the building now is used for furniture and dry goods storage.

It is 0830 on a Wednesday, the temperature is 10 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *57 Industrial Drive*

Building Description:

Type I, Subclass 443, 12-story 400' by 400' poured reinforced concrete structure with offices on first five floors and cold storage lockers on next seven floors. Building currently is used for dry goods storage on the top seven floors. A firewall and rated protected openings separate the building into two 200' by 200' sections on each floor. The five floors of offices are vacant. Note: four open-shaft freight elevator shafts are on floors 6 through 12, with a sealed shaft on floors 2 through 6.

Roof Construction:

Poured reinforced concrete covered with asphalt covering.

Floor Construction:

Poured reinforced concrete.

Occupancy Type:

Vacant offices and storage

Initial Resources Required:

2 engines, 1 ladder, 1 rescue

Hazards to Personnel:

Location of Water Supply:

38 and 75 Industrial Drive

Available Flow:

2,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*4,200*	*8,400*	*12,600*	*16,800*

**Estimated fire flow based on one floor 200' by 200' with one horizontal exposure. Note: additional exposure charges need to be added accordingly. For practical application 5% of one floor equals 840 gpm.*

Fire Behavior Prediction:

Structure is loaded with combustible storage on floors 6 through 12. First five floors are littered with trash in hundreds of vacant offices. Firefighter accountability will be a critical concern to assure that responders do not become lost in structure.

Predicted Strategies:

Fire suppression will be very difficult; floors 6 through 12 are nearly impossible to ventilate. After rescue and accountability of occupants the fire suppression efforts must be evaluated and coordinated carefully.

Problems Anticipated:

Accessibility to upper floors is difficult. Open elevator shafts (two in each section) from floors 6 to 12 will quickly extend fire.

☒ **Standpipe:**	☐ **Sprinklers:**	☒ **Fire Detection:**
No water supply		*Water flow--local alarm bell*

Scenario 9: 32 Bridge Street

A fire has been reported at 32 Bridge Street, a four-story office building. At the same time the call was received, Box 555 was received for the structure. The caller states that a fire started on the fourth floor and is burning out of control. The caller states that two employees who work in the area are restricted to wheelchairs, and he/she is not sure they have been able to escape without the elevators.

The time is 1115 on a Monday, the temperature is 45 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *32 Bridge Street*

Building Description:
Type I, Subclass 332, four-story office building 400' by 250' steel box frame structure with poured concrete floors. Rated firewall separates structure in center for two sections 200' by 250'. Each section has center core design.

Roof Construction:
Poured reinforced concrete covered with insulation and vinyl protected by sprayed-on insulation.

Floor Construction:
Poured reinforced concrete over corrugated sheet steel placed on steel joist protected with sprayed-on insulation.

Occupancy Type:
Four-story office building

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

Hazards to Personnel:

Location of Water Supply:
30 and 50 Bridge Street

Available Flow:
1,500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*5,200*	*10,400*	*15,600*	*20,800*

**Estimated fire flow based on one floor 400' by 250' and no exposure charge added in. Note: Add exposures accordingly. For practical application 5% of one floor equals 1,040 gpm.*

Fire Behavior Prediction:
Open center-core office building. Building is divided into two sections by rated firewall. Each section is center-core design. Very few private offices, most work stations use 48" dividers. Fire growth could be fast and cover entire floor area.

Predicted Strategies:
Primary search and accountability of occupants. Coordinate fire suppression tactical objectives from two center-core stairwells.

Problems Anticipated:
Accountability of occupants and fire attack from center core.

[X] **Standpipe:**
Class III in both stairwells

[ ] **Sprinklers:**

[X] **Fire Detection:**
Smoke and heat detection tied into master box

Scenario 10: 21 Lake View Road

A fire has been reported at 21 Lake View Road, a five-story office building. The first call was received by an automatic dialer reporting the fire. Soon after, another call was received from the facility. The caller stated that maintenance workers were replacing sprinkler heads and were using a torch when sparks fell on a desk and a fire started. The caller states that the worker was burned slightly while trying to extinguish the fire with an extinguisher.

It is 1030 on a Thursday, the temperature is 25 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *21 Lake View Road*

Building Description:
Type II, Subclass 222, five-story office building 300' by 300' steel box frame structure. Structure is subdivided into three sections by rated firewalls and protected openings creating three sections 100' by 300'.

Roof Construction:
Precast concrete slabs placed on steel box frame supports covered with vinyl roof material.

Floor Construction:
Precast concrete floor slabs supported on steel box frame.

Occupancy Type:
Government offices

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

Hazards to Personnel:

Location of Water Supply:
21 and 36 Lake View Road

Available Flow:
1,250 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*2,500*	*5,000*	*7,500*	*10,000*

**Estimated fire flow based on 100' by 300' with no exposures added in. Note: add appropriate exposure charge. For practical application 5% of one floor involvement equal 500 gpm.*

Fire Behavior Prediction:
Rescue and accountability will require additional resources. Fire most likely will extend by exterior windows. Floor area is divided into work stations with 48" dividers.

Predicted Strategies:
Standard strategic goals.

Problems Anticipated:
Rapid fire growth on fire floor.

[X] **Standpipe:**	[X] **Sprinklers:**	[X] **Fire Detection:**
Class III in all six stairwells	*Wet system for entire building--3 zones*	*Smoke and water flow tied into auto dialer*

Scenario 11: 33 Ridge Road

A fire has been reported at 33 Ridge Road, a one-story store. The caller states that someone entered the store with what appeared to be a 5-gallon container, walked toward the center of the store, poured something from the container, and lit it. It appears that it may have been gasoline or another flammable liquid. The customers in the store at the time have escaped.

It is 1330 on a Saturday, the temperature is 90 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *33 Ridge Road*

Building Description:
Type II, Subclass 000, one-story steel box and masonry structure 300' by 300' with no exposures.

Roof Construction:
Steel decking covered with insulation and asphalt covering supported on steel joist supported on steel box frame and masonry walls. Note: Exterior masonry walls support exterior end of joist.

Floor Construction:
Concrete slab.

Occupancy Type:
Retail sales store

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

Hazards to Personnel:

Location of Water Supply:
15 and 45 Ridge Road

Available Flow:
500 gpm each

	Estimated Fire Flow*			
Level of Involvement	25%	50%	75%	100%
Estimated Fire Flow in gpm	*7,500*	*15,000*	*22,500*	*30,000*

**Estimated fire flow based on one floor 300' by 300' with no exposures. For practical application 5% of fire area equals 1,500 gpm.*

Fire Behavior Prediction:
Large open area with high shelf storage (8') with large inventory. Fire will spread rapidly and shelving could fail, closing aisles. Rescue and accountability under fire conditions will require additional resources.

Predicted Strategies:
Rescue and accountability first. Evaluate fire growth and structural stability before implementing offensive operations.

Problems Anticipated:
Large fire load, unprotected steel roof support system, high shelf storage, and potential for steel shelving to fail and closing aisles behind firefighters.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Smoke with local alarm

Scenario 12: 2 Wolf Road

A fire has been reported at 2 Wolf Road, an automobile parts showroom and automobile repair garage. The caller states that there was an electrical short in an auto parts display and it caught fire. The fire quickly spread to other auto parts on display and combustible materials in the area. A mechanic was last seen trying to extinguish the fire and has not come outside.

It is 1415 on a Friday, the temperature is 85 degrees, and winds are calm.

Quick Access Prefire Plan

Building Address: *2 Wolf Road*

Building Description:
Type II, Subclass 000, automobile parts showroom 200' by 100' with adjoining auto repair garage.

Roof Construction:
Corrugated sheet steel covered with asphalt covering supported on unprotected steel box frame.

Floor Construction:
Concrete slab.

Occupancy Type:
Automobile parts store

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

Hazards to Personnel:

Location of Water Supply:
6 and 26 Wolf Road

Available Flow:
1,000 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 200' by 100' with one exposure.*

Fire Behavior Prediction:
Due to storage and sales the fire load is significant and fire will develop quickly. Roof structure is unprotected steel with potential for early failure due to the fire load. On previous inspections the two personnel doors from the store into the garage area have been blocked open.

Predicted Strategies:
Rescue and accountability for occupants of store area. Reassess fire growth and structural stability before implementing offensive actions.

Problems Anticipated:
Fast fire growth and large fuel load.

☐ **Standpipe:**

☐ **Sprinklers:**

☒ **Fire Detection:**
Smoke detection local alarm

SUGGESTED READINGS

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American Iron and Steel Institute. "McCormick Place Fire An Engineering Report." January 16, 1967.

Avillo, Anthony. "Chart House Restaurant Fire Weehauken, NJ." *Fire Engineering,* Oct. 1998.

Burns, Robert. "Firefighters Thwart 7-Alarm Fire Sweep of Philadelphia Warehouse." *Firehouse Magazine,* Sept. 1988.

Eisner, Harvey. "Update K-Mart Report: Rebuilt warehouse's new fire protection features." *Firehouse Magazine,* Oct. 1994.

"Fact Sheet--Warehouse Fire Dayton, Ohio 32 Million Dollar Loss." National Fire Protection Association, May 27, 1987.

Ford, Jim, Asst. Chief. "Automatic Sprinklers--a 10 year study: A detailed history of the effects of the automatic sprinkler code in Scottsdale, AZ." Scottsdale: Rural/Metro Fire Department, 1997.

Messersmith, Joseph, Jr., P.E., Portland Cement Association. "Concrete Facts." *Firehouse Magazine,* Jan. 1988.

NFPA Charles S. Morgan Library. "Bulk Retail Store Fire Tempe, AZ." National Fire Protection Association Summary, March 19, 1998.

Reese, Shelly. "Decisions, Decisions--New Developments in the Glazing Industry." NFPA *Fire Journal*, Nov/Dec 1998.

Smith, James P. "Large Building Fires." *Firehouse Magazine,* Aug. 1991.

Smith, James P. "Lightweight Steel Construction." *Firehouse Magazine,* Dec. 1990.

BIBLIOGRAPHY

BIBLIOGRAPHY

Brannigan, Francis L. *Building Construction for the Fire Service*. 3rd ed. National Fire Protection Association.

Federal Emergency Management Agency, National Fire Academy. *Building Construction for Fire Suppression Forces--Principles, Wood Frame and Ordinary.*

Federal Emergency Management Agency, National Fire Academy. *Building Construction for Fire Suppression Forces--Noncombustible and Fire-Resistive Construction.*

International Fire Service Training Association. *Building Construction--Related to the Fire Service*. 1st ed.

National Geographic Society. *The Builders--Marvels of Engineering*, 1992.