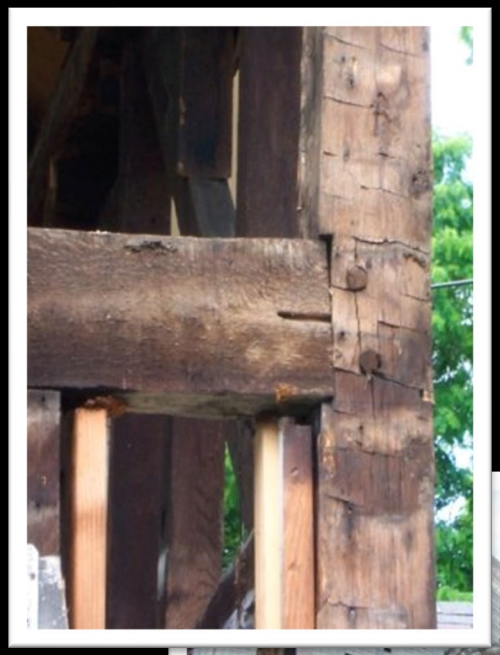
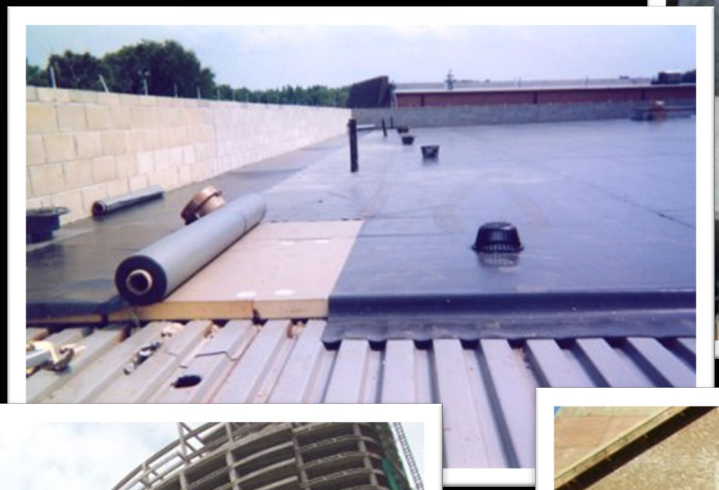
Building Construction/Fire Behavior

Module 4

Building construction is an ongoing and perpetual learning experience





Fighting

fires in buildings is inherently dangerous

Structural

integrity is attacked as the fire burns

Photo courtesy of A. Avillo

Knowledge

and understanding is essential for fireground safety

Much

has changed in the history of firefighting

Photo courtesy of www.brettsfirephotos.com

Strategies

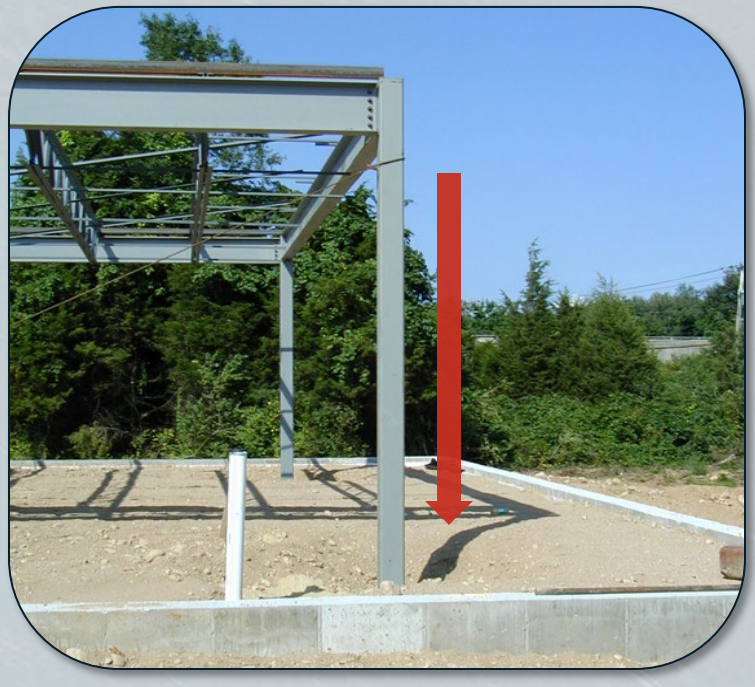
still require us to enter the building, locate, and extinguish the fire

Four Types of Force

Forces and Loads Acting on a Building

Compression:

Squeezing or pushing of a component



Tension:

Stretching or pulling of a component

Four Types of Force

Forces and Loads Acting on a Building

Torsion:

Twisting of a component

Shear:

Condition causing two structural members to slide past each other

Designed Load

Forces and Loads Acting on a Building

Engineered

into building design

- Based on sound engineering principles
- Vary based on region
  - New England – snow loads
  - Florida – wind loads

Loads

that were not anticipated or calculated

Result

of unauthorized construction

Non-Fixed

Variable load added to structure

- People
- Materials
- Transportable items

Dead Load

Forces and Loads Acting on a Building

Weight

of structure and anything permanently attached

May Change

due to renovations and additions

Environmental Loads

Forces and Loads Acting on a Building

Loads introduced by the environment

- Snow
- Rain
- Wind
- Earthquakes
- Varies by region

Photo courtesy of Dave Hemp

FEMA News Photo

FEMA News Photo

Impact Load

Forces and Loads Acting on a Building

Force delivered in motion

- A moving object striking a fixed object

Static Load

Forces and Loads Acting on a Building

Force

applied slowly over an extended period of time

Relatively

unchanging

In Motion

when applied to a building

Photo courtesy of NOAA

Concentrated Load

Forces and Loads Acting on a Building

Applied

to a relatively small area

Distributed Load

Forces and Loads Acting on a Building

Load

distributed over a large area

Supporting

a uniform load over the area

Total

amount of combustible material used or stored in a building

Photo courtesy of Jim Duffy

Expressed

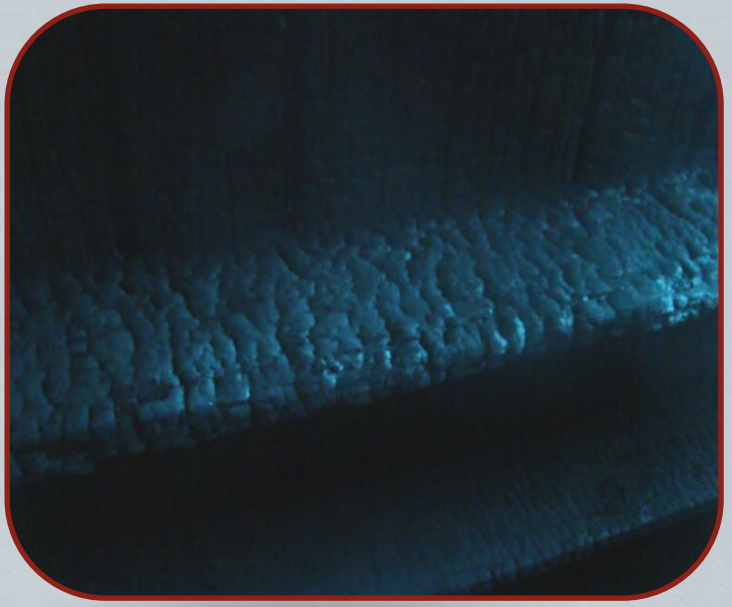
in heat release rate or formerly in Btu's

Effects of Heat

How Common Building Materials are Affected by Fire

Some

lose mass as they burn



Others

lose strength when heated

Wood

How Common Building Materials are Affected by Fire

Primary

structural elements in wood framed buildings

Loses Mass

as it burns until it fails

Structural Steel

How Common Building Materials are Affected by Fire

Used in many forms

- Columns, beams, and bar joists
- Must be protected in fire resistive buildings

Loses strength when heated

- Expands when heated
- Strength varies with age

Cast-in-Place Concrete

How Common Building Materials are Affected by Fire

Uses

- Footings
- Foundations
- Beams
- Floors
- Columns

Great

insulating material

Subject

to spalling when heated

Significant

factor in a building's ability to resist collapse

Older

buildings were constructed with larger dimensional lumber

Math

has replaced mass allowing designers to use smaller materials

Examples

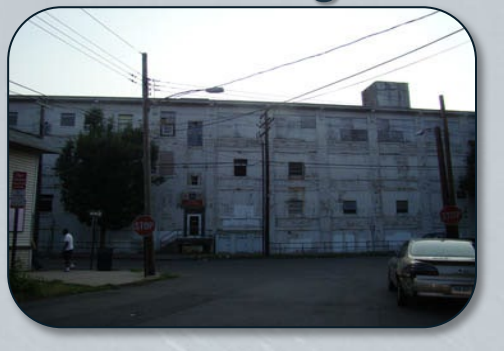
Fire Resistive - Type I

Common Fire Resistive Occupancies

High Rise

Residential Mid Rise

Cold Storage Buildings



Hospitals

Old Style Warehouses

Common Occupancies

Non-Combustible - Type II

Office buildings

5-6 stories high

Large single-story warehouses

Small two- and three-story buildings

Common Occupancies

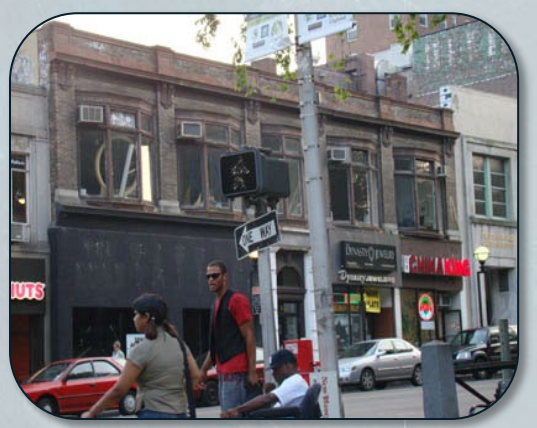
Ordinary - Type III

Multiple Dwellings

Garden Apartments

Strip Malls

Commercial



Manufacturing

Typical Construction

Heavy Timber/Mill - Type IV

Brick

exterior walls

Wood

joisted floors

Massive

interior wood columns and beams

Lightweight Wood Frame Construction

Wood Frame - Type V

Utilizes engineered components

- Lightweight parallel floor trusses
- Lightweight peaked roof trusses
- Engineered wood I-beams

Understanding fire behavior is absolutely crucial to successful firefighting operations

Importance of Fire Behavior

Introduction

Photo courtesy of Mike Musicant

Critical

that firefighters understand how fire behaves

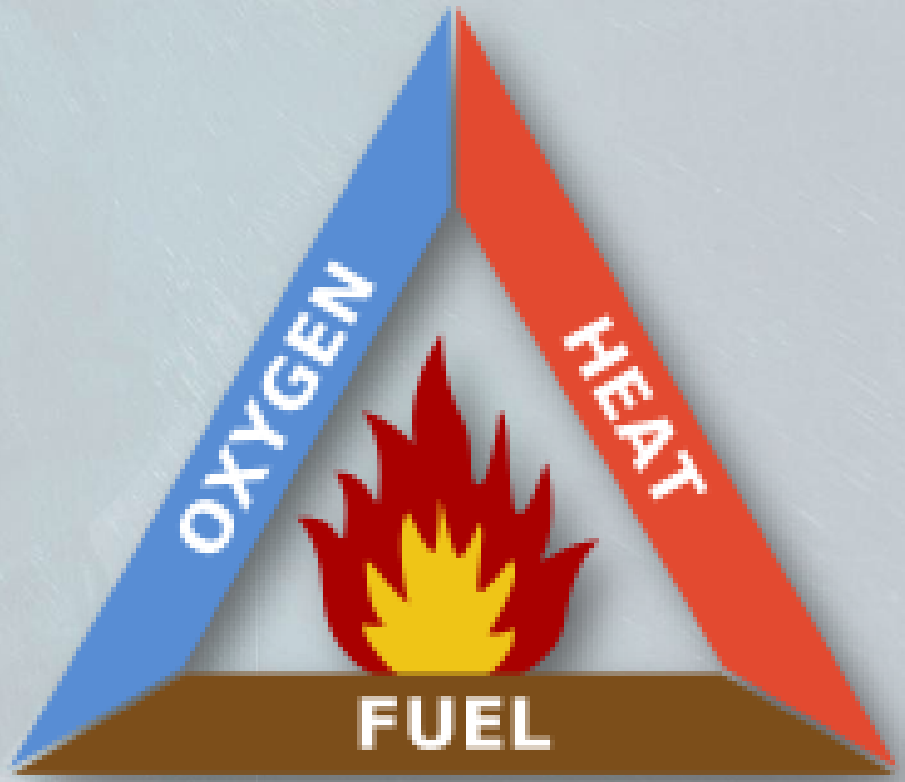
Better decisions can be made

- Interior vs. exterior attack
- Amount of water to use
- Required apparatus and equipment

Fire Triangle

Fire Triangle and Fire Tetrahedron

Remove Any Part and the Fire Goes Out



Burning process

- Fuel must be in a gaseous state to burn
  - Solids must decompose or pyrolyze
  - Liquids must vaporize
- Vaporization and pyrolytic actions absorb heat – endothermic reaction

Ignition Temperature

Minimum temp at which a fuel will ignite without the need of an outside ignition source

This depends on the physical arrangement of the fuel

Surface-to-Mass Ratio

- The greater the ratio:
  - Easier for solid to absorb heat
  - Reach its ignition temp
  - And ignite

Based on this concept – wood dust can be extremely dangerous under fire conditions

Flammable Gases

Ignition

will not occur if the mixture in air is too rich or too lean

Gases

can have narrow and wide ranges

Gasoline vs. Carbon Monoxide

Types of Heat Sources

Types of Heat

Chemical

Electrical

Photo courtesy of Chris Zak

Mechanical

Nuclear

Photo courtesy of Atomic Energy of Canada, Limited

Methods of Heat Transfer

Heat Release & Transfer

Conduction

Convection

Radiation

Ignition – 1st Stage

Compartment Fire Development

- Ignition source unites with ignitable vapors in a oxygen sufficient atmosphere (21% to 20%)
- Fuel supply is adequate
- Typically the fire is small and limited

Growth – 2nd Stage

Compartment Fire Development

- Fire growth is self sustained
- Objects on fire transfer heat to other objects which in turn begin to ignite

Fully Developed – 3rd Stage

Compartment Fire Development

- Fire has involved the entire compartment
- Oxygen level 20% - 18%
- Adequate fuel supply

Fully Developed – 4th Decay

Compartment Fire Development

- Diminished
- Heat release rate has dropped
- Oxygen levels below 15%
- Glowing embers and no visible flames