

Suffolk County Fire Academy
 Medium Level Structural Collapse Concepts
 Session 1





Suffolk County Fire Academy

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House-Keeping


- Instructors
- Students
- Paperwork (SCFA, NYS)
- Student Manuals
- Exits
- Cell Phones and Pagers.



2

Structural Collapse Series

- Basic Structural Collapse = Awareness Level
- Medium Level Structural Collapse Concepts
- Medium Structural Collapse Operations: Exterior Shoring
- Medium Structural Collapse Operations: Interior Shoring
- Medium Structural Collapse Operations: Tools
- Medium Structural Collapse Operations: Void Search and Rescue.




3

Course Overview

2 Sessions

- **Session 1**
 - **Building Construction**
 - Components and Theory
 - Construction Types
 - Special Considerations
 - **Structural Shoring Concepts**
 - Theory
 - Shoring Team Members
 - Components and Types (Interior)
 - **Hands-on Stations.**



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Course Objectives

- Recognize the need for structural collapse search and rescue (NFPA 1670 6.2.2)
- Identify the resources necessary to conduct structural collapse search and rescue operations (NFPA 1670 6.2.2)
- Recognize general hazards associated with structural collapse incidents, including the recognition of applicable construction types and categories and the expected behaviors of components and materials in structural collapse (NFPA 1670 6.2.2)
- Identify the types of collapse patterns and potential victim locations (NFPA 1670 6.2.2)
- Recognize the potential for secondary collapse (NFPA 1670 6.2.2)
- Describe the procedure for identifying and establishing collapse safety zones (NFPA 1670 6.2.2)

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Course Objectives (Cont'd)

- Discuss the need for reconnaissance of the structure(s) and surrounding area (NFPA 1670 6.2.2)
- Size-up existing and potential conditions at structural collapse incidents (NFPA 1670 6.3.3)
- Recognize unique collapse or failure hazards (NFPA 1670 6.3.3)
- Describe hasty primary and secondary search operations (low and high coverage) intended to locate victims trapped on, inside, and beneath collapse debris (NFPA 1670 6.3.3)
- Describe and demonstrate the procedures involved in simple rescue shoring operations using shores that include T shores, two post vertical shores (Double T), horizontal shores, and cribbing, constructed of both lumber and pneumatic shoring equipment (NFPA 1670 6.3.3)

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Session Objectives

- Garner A More In Depth Understanding of Building Construction and Structural Collapse
- Understand Shoring Theory and Purpose
- Identify Components and Types of Interior Emergency Shoring Using Lumber and Alternative Shoring Systems
- Demonstrate The Use of Tools and Equipment To Build Emergency Shoring.



7


Building Construction Components and Theory



8

Building Construction and Structural Collapse

Structural Building Collapse Is One Of The Most Dangerous Situations We As Firefighters Will Encounter.



9


Building Construction and Structural Collapse



10

Building Construction and Structural Collapse


*A Structure Is An Arrangement Of Building Materials That Are Constantly Working To Defy **Gravity**.*



11

Building Components Load Transfer


All loads generated within a structure, or received from any source outside that structure, **must be transmitted** from the point received **to the earth**, without any discontinuity in the load transference to its structural supporting elements.



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Building Components Load Transfer


If there is any break of continuity, or if the structure's foundation yields to any compression or shear forces the structure will fail.



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Building Components Load Transfer



- All loads must be transmitted to the ground
- Live loads applied to buildings floors
- Structural supporting floor elements generally act as beams (floor joists).



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Building Components Load Transfer


- Loads transmitted to:
 - Girders
 - Bearing walls
 - Columns
 - Arches
 - Combination thereof
- Load delivered to each support point depends on the distance from which point the load is applied to each end.

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**Building Components
Engineered Construction**


- Larger buildings (commercial structures)
- Extensive testing and inspection (material / workmanship)
- Onsite engineers / architects
- Building design and loads carefully engineered.



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**Building Components
Vernacular Construction**


- Smaller type wood frame or URM buildings
- "Hand-me-down" construction techniques
- Little engineering practices
- Almost no on site inspection
- Dangerous type of structure from a collapse standpoint due to the unknown quality of its construction features.



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**Building Components
Alteration**


Construction on a building consisting of revisions which may change the structural elements of the building, including the moving of mechanical equipment, columns, bearing walls, or locations of openings. However, it does not increase the overall area or dimensions of the building.



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Building Components Renovation


Is the restoration of an existing structure, however, it does not affect any structural changes of that building. **Usually cosmetic in nature** such as window replacement or new ceiling or wall coverings. Probably the majority of the accidents we respond to are due to alterations not renovations.



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Building Components Primary Structural Element

A structural element that supports another structural member in the same building, such as a bearing wall, column, or girder. The collapse of a primary member **WILL** cause the collapse of the structural member it supports.



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Building Components Hierarchy of Structural Elements

DECKS **LEAST**



BEAMS

GIRDERS

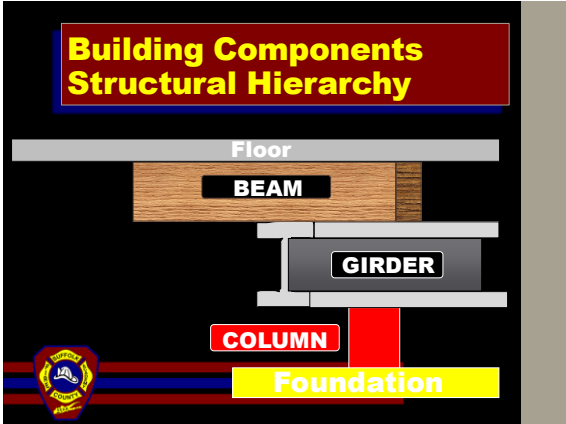
COLUMNS

BEARING WALLS

FOUNDATIONS **MOST**

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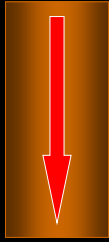
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Building Components Column

- Structural member which transmits a compressive force along a straight path in the direction of the member.
- Any structural member under compression acts as a column whether it is horizontal, vertical, or diagonal.



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Building Components Column

- The most efficient shape for a column is one which distributes the material equally around the axis as far as possible from center.
- The most efficient column is **circular**
- For simple building techniques, rectangular or square columns are used.



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Building Components Column



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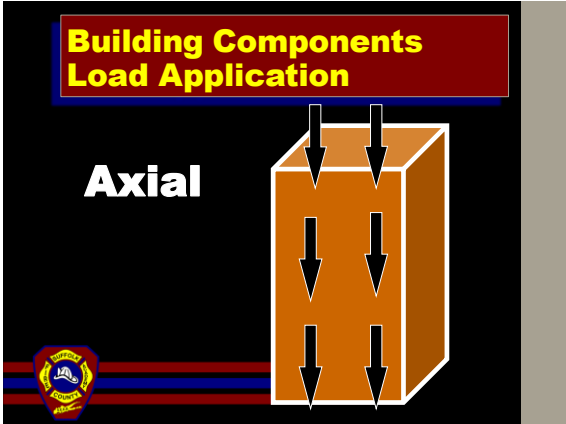
Building Components Columns

Euler's Law of Columns

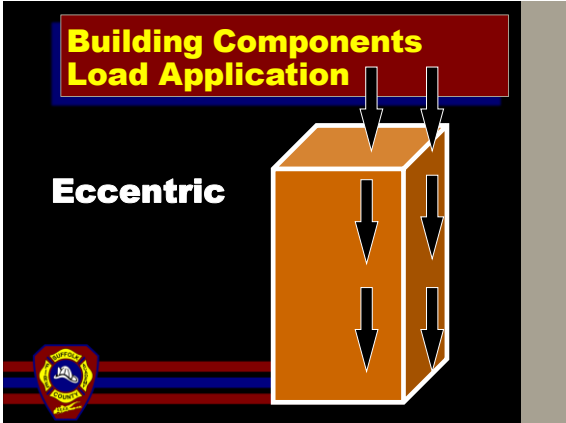
Long thin columns will hold up until a critical load is reached at which time the column will buckle causing an **eccentric load on one end** and thus the entire column will fall. The axial load changes causing a distributed load to become concentrated on one point causing that point to buckle.



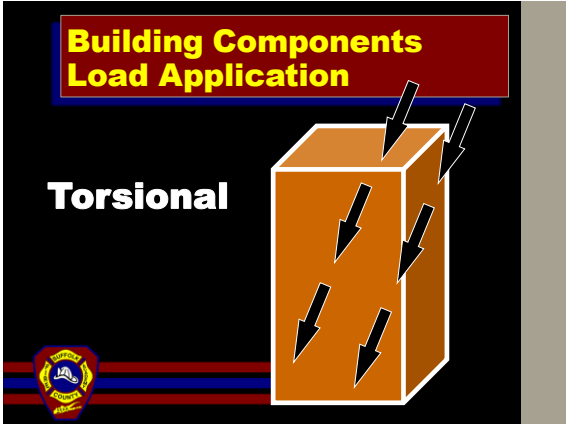
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Building Components Bearing Wall

An interior or exterior wall that **supports a load in addition** to its own weight. Part of the skeletal framework of a structure, it most often supports the floors and roof of a building. The collapse of a bearing wall is more serious than the collapse of a column, floor or non-bearing wall.



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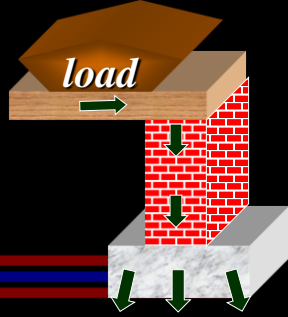
Building Components Bearing Wall

The load received by a **bearing wall** is delivered directly to the foundation and thus to the ground.



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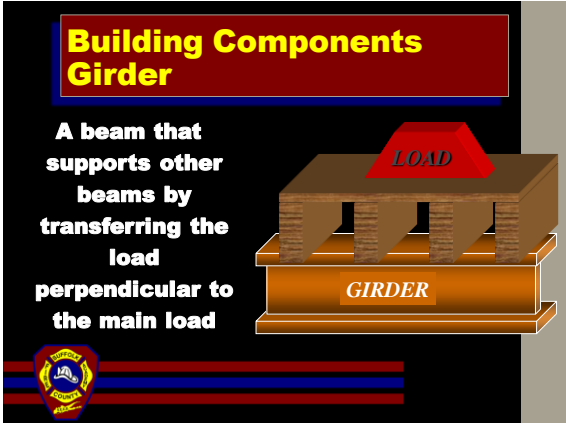
Building Components Bearing Wall



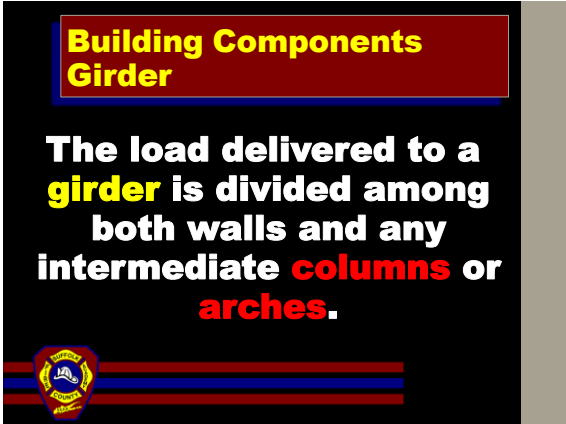
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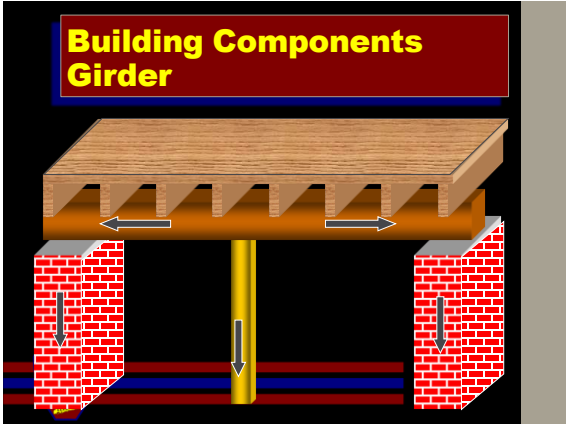
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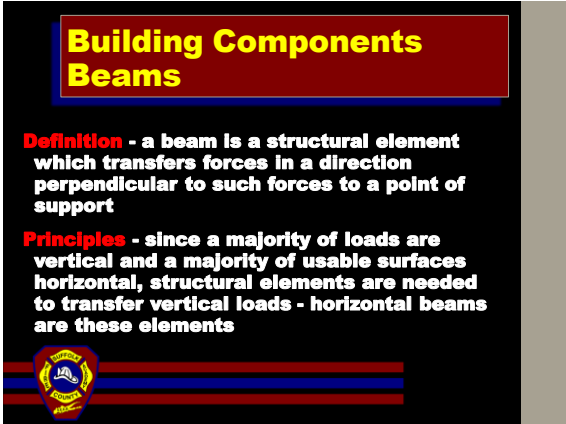
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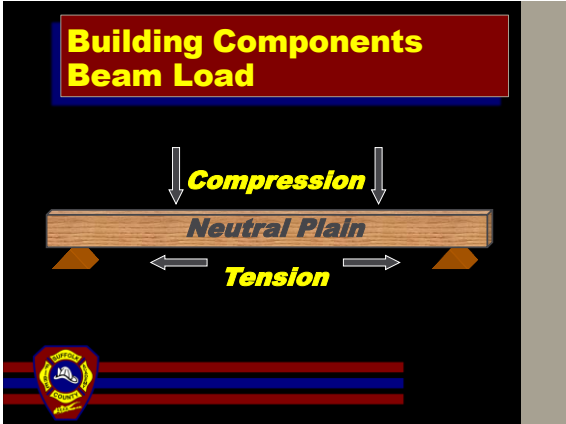
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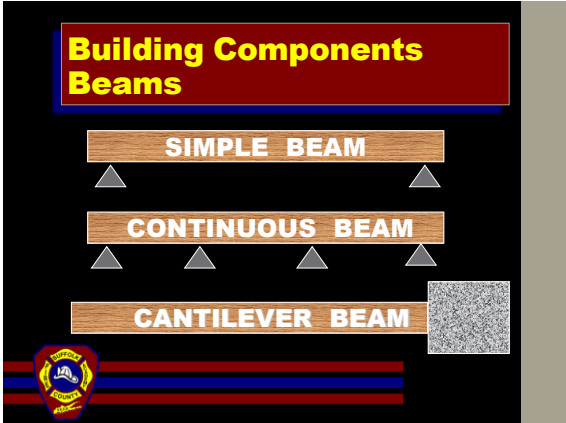
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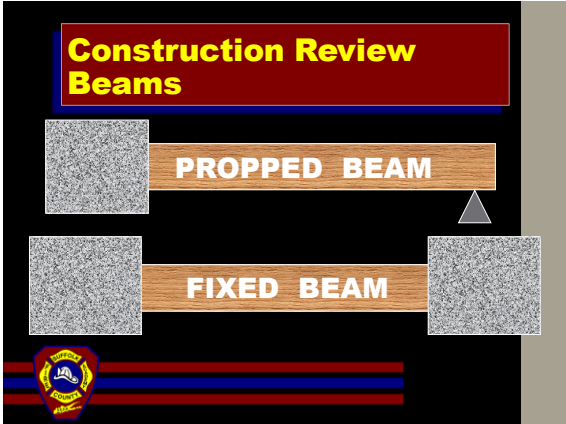
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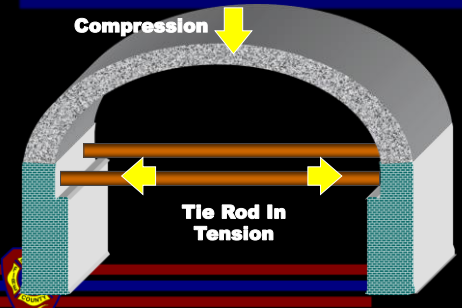
Building Components Arches

- Combine the function of a beam and column simultaneously
- Under pressure over entire length
- Tend to push outward at base
- Most braced or tied
- Removal of any part can cause a collapse.




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Building Components Arches



Compression

Tie Rod In Tension



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Building Components Arches



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Building Components Structural Loads

- **Dead load** – permanent structural material, built in, stationary objects
- **Live load** – people, furnishing, items not built in, partitions
- **Dynamic load** – elevators, people on escalators, large moving objects.



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Building Components Structural Loads

- **Wind load** – the force that is trying to shear the building from the ground
- **Thermal load** – the expansion and contraction on the structure due to weather conditions
- **Static load** – load that is constant but applied slowly. May change with time, stock.



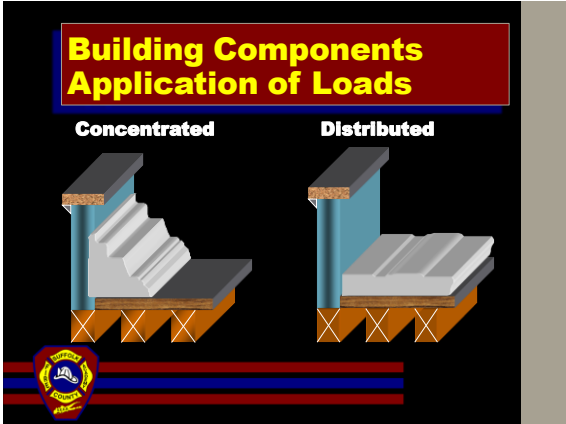
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Building Components Structural Loads

- **Impact load**
 - Load delivered in short period of time
 - Although weight may be resisted as static load, could cause collapse as impact load
 - Sudden impact = units stress twice as great
 - Increased height of load = increased stress.



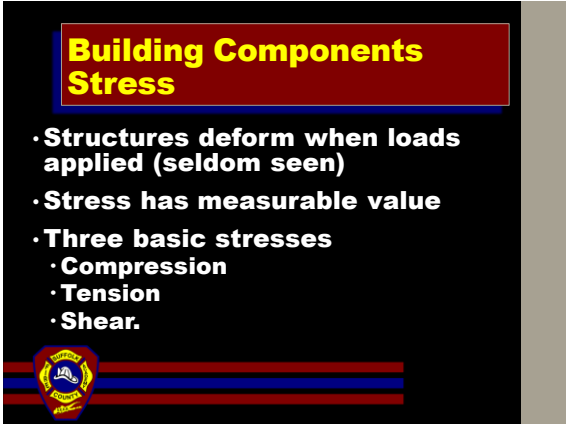
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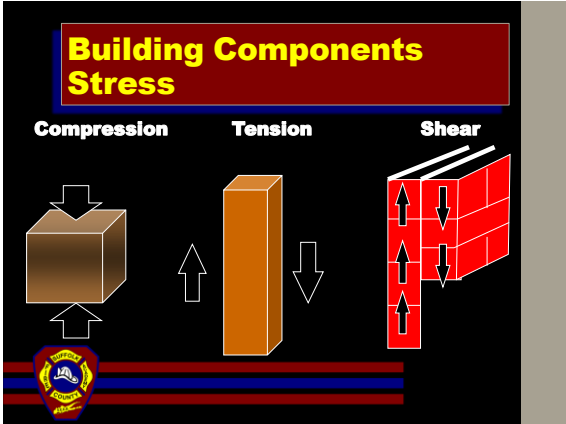
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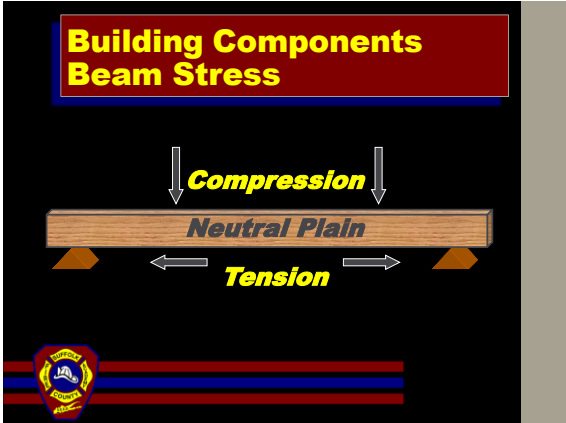
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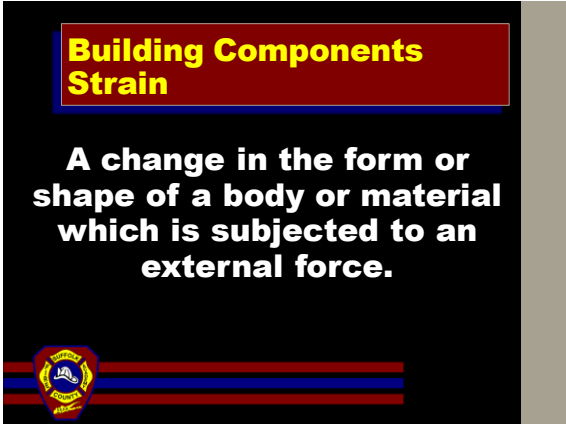
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Building Components Deflection

A bend, twist, or curve of a structural element under a load. **All structures deflect slightly when supporting a load**, but a structural element is designed to withstand a load without showing signs of deflection. When **you notice** the deflection of a column, beam, or wall, this condition indicates structural overload and should be reported.



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Building Components Deflection




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Building Construction Construction Types



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**Building Construction
Construction Types**

**FIRE-RESISTIVE
NON-COMBUSTIBLE
HEAVY TIMBER
ORDINARY
WOOD FRAME.**



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**Building Construction
Fire Resistive – Class 1**

- Steel and/or concrete material
- Structural elements protected with fire-resistive material.



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**Building Construction
Fire Resistive – Class 1**



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**Building Construction
Fire Resistant – Class 1**



- Empire State Building
- All concrete and steel
- Minimum 2 hour fire rating everywhere.




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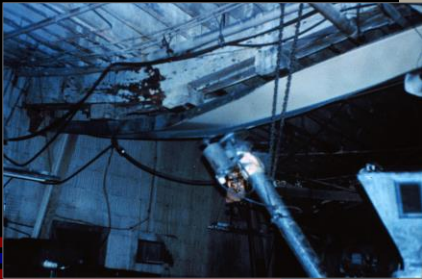

**Building Construction
Non-Combustible – Class 2**

- Interior / exterior structural components non-combustible
- Fire resistant covering on limited combustible materials.

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**Building Construction
Non-Combustible – Class 2**

63


Building Construction Ordinary – Class 3

- All or part of interior structural components are combustible
- Exterior walls non-combustible
- AKA: URM (un-reinforced masonry) or brick and joist construction.

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Building Construction Ordinary – Class 3

65

Building Construction Heavy Timber – Class 4

- Exterior walls are of brick or stone
- Interior structural members are of dimensions specified in NFPA standards (≥ 6”).

66

Building Construction Heavy Timber - Class 4



67

Building Construction Wood Frame - Class 5

- Interior / exterior walls made entirely of wood
- Typically common cockloft if in a row.



68

Building Construction Wood Frame - Class 5



69

***Building Construction
Special Considerations***



70

Building Construction Framed


- Walls do not support the floors or roof
- They are hung from or rest on a steel or concrete skeleton
- Collapse typically localized to area of failure.



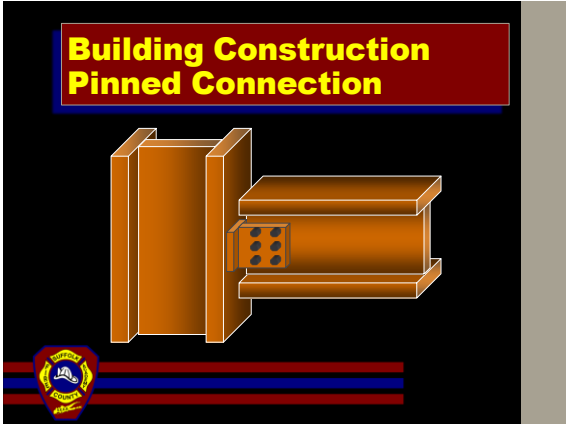

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Building Construction Pinned Connection

- Series of simple connectors (nails, bolts, rivets) anchor structural components
- Rotation of the joint is possible
- One member does not necessarily bend with the other.
- Connections do not have strength to transfer stress during failure
- Collapse of any part of the structure that is supported by the failing member is possible.



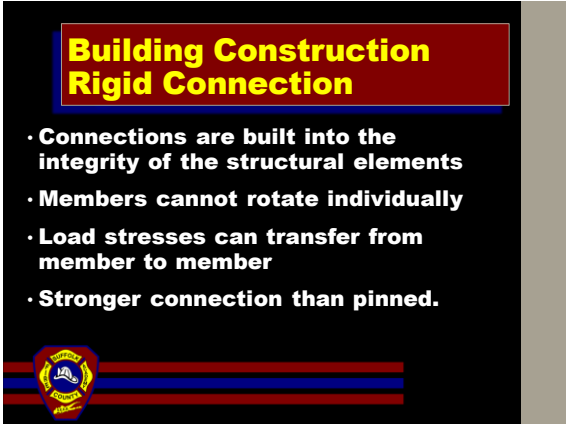
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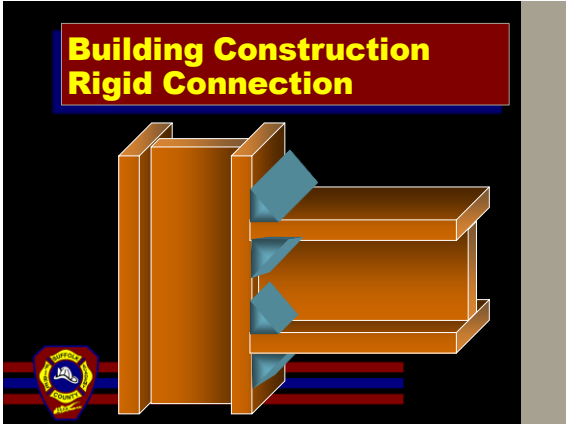
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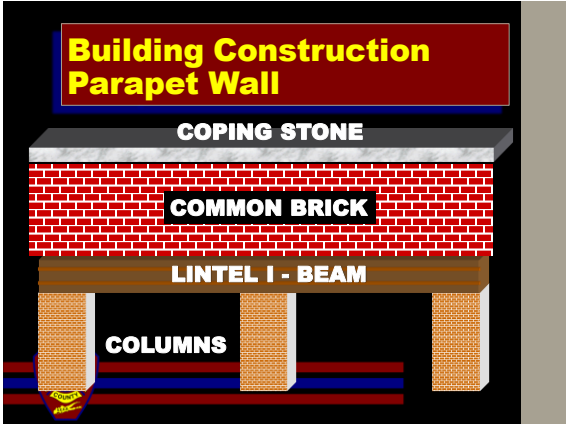
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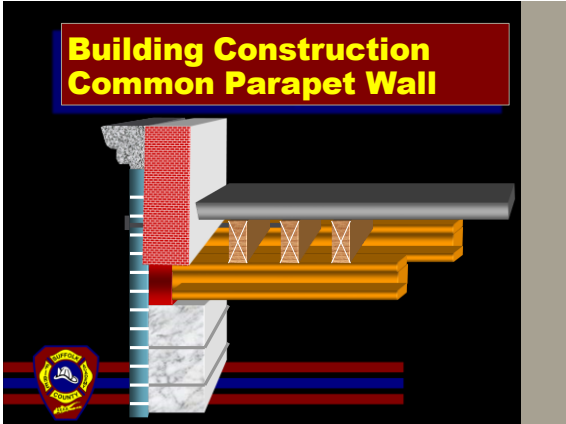
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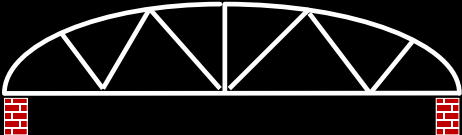
Building Construction Truss Hazards

- Lack of redundancy, tightly engineered
- Fail in 5 to 10 minutes
- Gusset plate nails (1/4")
- Workmen alterations
- Integral system, failure of any portion of the truss could fail the entire system
- High Surface to mass ratio.



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Building Construction Bowstring Truss



83

Building Construction Bowstring Truss



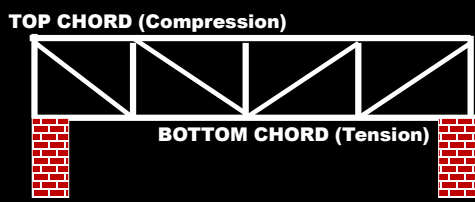
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Building Construction Bowstring Truss



85

Building Construction Parallel Truss



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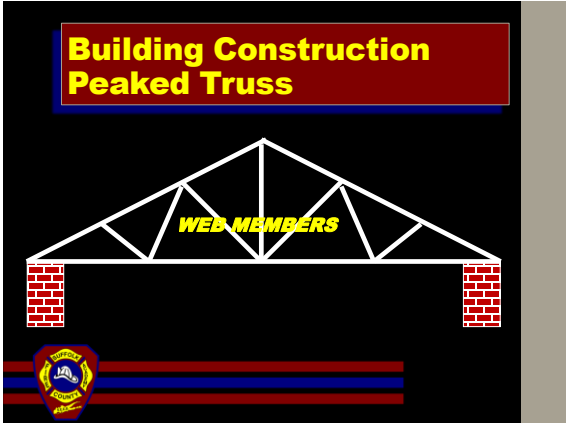
Building Construction Parallel Truss



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Building Construction Peaked Truss



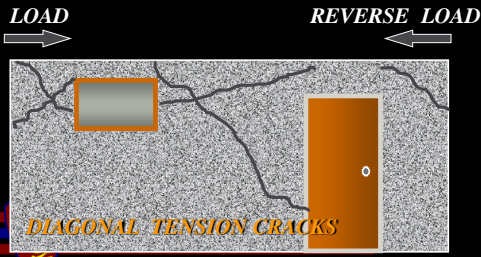
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Building Construction Gusset Plate (Gang Nails)



92

Building Construction Concrete Shearwall



93

Building Construction Concrete Shearwall



94

Structural Shoring Concepts Theory



95

Structural Shoring Concepts Rescue Shoring


• The temporary support of a partially collapsed structure for the search and rescue of trapped victims.



96

**Structural Shoring Concepts
Principals**


Shoring is performed in order to reduce the risk of potential secondary collapse to give victims and rescuers some degree of safety during rescue operations.



97

**Structural Shoring Concepts
Objectives**


- Maintain the integrity of all structurally unstable elements
- Properly transmit or redirect the collapse loads to stable ground or other suitable structural elements capable of handling the additional loads.



98

**Structural Shoring Concepts
Basic Points**

- Shoring should be built as a **complete** system
- Lateral brace to prevent system from buckling
- **Minimum level** of lateral strength in vertical support should be 2%
- **Ideal** would be 10%.



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**Structural Shoring Concepts
Basic Points**

**Lateral
Bracing**



The diagram shows a cross-section of a shoring system. It consists of three vertical posts supported by a base. Diagonal bracing members are attached to the posts to provide lateral stability. A sign on the left side of the structure reads "3 Post Vertical Shoring". Two red arrows point to the diagonal bracing members, highlighting their role in lateral bracing.

100

**Structural Shoring Concepts
Consideration**

**Shore
Mitigate
Avoid.**




The slide features a black background with a red and blue horizontal stripe at the bottom. The Suffolk County Fire Academy logo is positioned in the bottom left corner. The text is centered and reads "Shore Mitigate Avoid." in a large, bold, white font.

101

**Structural Shoring Concepts
LD Ratio**

**The length to diameter ratio of all
our shoring material is **very
critical**, the strength of our shores
depends on keeping it within
excepted limits.**



The slide features a black background with a red and blue horizontal stripe at the bottom. The Suffolk County Fire Academy logo is positioned in the bottom left corner. The text is centered and reads "The length to diameter ratio of all our shoring material is very critical, the strength of our shores depends on keeping it within excepted limits." in a large, bold, white font.

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**Structural Shoring Concepts
LD Ratio**


Maximum 50

D 4x4 = 3.5"

50 x 3.5 = 175" (14' 7" - max post height w/o cross bracing)

Ideal 25

25 x 3.5 = 87.5 (7' 3" + 8' w/o cross bracing)




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**Structural Shoring Concepts
Post Capacity**

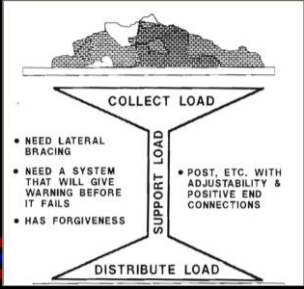
2 to 1 Safety Factor

4X4'S	6X6'S
6' - 12,000 LB	10' - 24,000 LB
8' - 8,000 LB	12' - 20,000 LB
10' - 5,000 LB	16' - 12,000 LB
12' - 3,500 LB	20' - 7,500 LB



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**Structural Shoring Concepts
Double Funnel Principle**




- NEED LATERAL BRACING
- NEED A SYSTEM THAT WILL GIVE WARNING BEFORE IT FAILS
- HAS FORGIVENESS
- POST, ETC. WITH ADJUSTABILITY & POSITIVE END CONNECTIONS

105

**Structural Shoring Concepts
Shoring Size-up**

- **Determine the type & placement of shoring systems in relation to structural hazards and potential victim location**
- **It must be extensive, accurate and continue throughout the rescue operation.**



106

**Structural Shoring Concepts
Shoring Size-up Considerations**

- **Victim location**
- **Six sided approach**
- **Structural elements.**



107

**Structural Shoring Concepts
Shoring Size-up Considerations**

- **Age and condition of structure**
- **Location of collapse in building**
- **Collapse warning signs.**



108

**Structural Shoring Concepts
Shoring Placement**

All Shoring In Wood and Steel Framed Structures Should Be Started At Least 1 Floor Below Any Damage


And In Concrete Structures At Least 3 Floors Below The Level Of Any Damage



109

**Structural Shoring Concepts
Shoring Placement**

- Below any damage
- Support unstable structural elements
- Under main debris pile
- Under victim location.



110

**Structural Shoring Concepts
Shoring Placement**

- Shores to bear on each other
- From the outside in
- Team access & egress.




111

***Structural Shoring
Concepts
Shoring Team Members***



112


**Structural Shoring Concepts
Shoring Team**

Shoring Squad

Shoring Officer

Measuring FF

Shoring FF

113

**Structural Shoring Concepts
Shoring Team**

Cutting Squad

Layout FF

Cutting FF

Tool and Equip. FF




114

Structural Shoring Concepts
Shoring Team

Cutting Squad

Layout FF

Cutting FF

Tool and Equip. FF




115

Structural Shoring
Concepts
Components and Types
(Interior)




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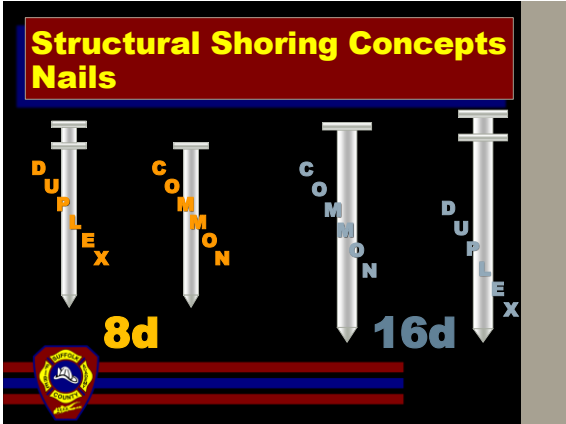
Structural Shoring Concepts
Lumber

- Standard construction grade
- Doug Fir and Southern Pine
- Compression strength (parallel grain) = **1100 psi**
- Compression strength (perpendicular to grain) = **600 psi**

This is the theory behind our vertical post strengths (i.e. 8,000 lbs at 8' length)



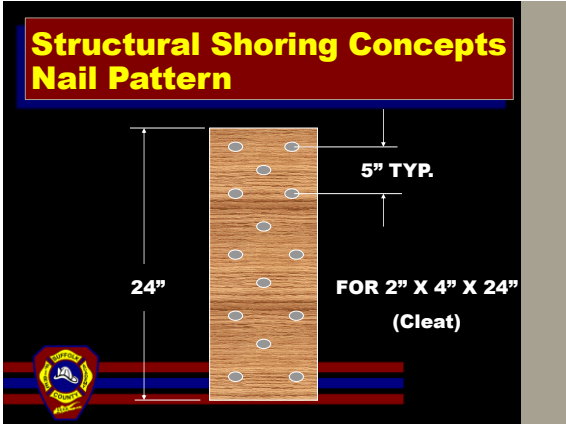
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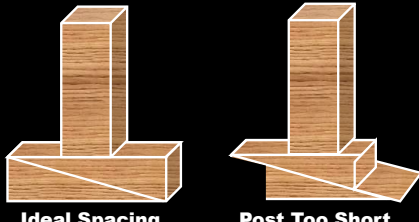
Structural Shoring Concepts Shoring Tools

- 16 & 25' tape's
- Hammers
- Levels
- Squares
- Nail pullers
- Utility knife
- Markers
- Hand saws
- 10 1/4" circular saw
- Chainsaws
- Air nailers
- Rotary hammers
- Ladders
- Sawzall's
- Sledge hammers
- Surveyors transit.




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Structural Shoring Concepts Wedges

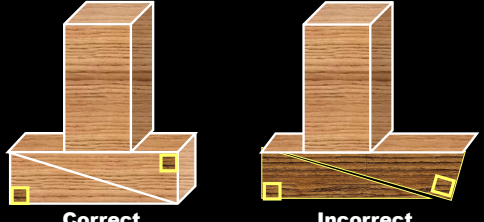


Ideal Spacing **Post Too Short**




122

Structural Shoring Concepts "Marrying" Wedges



Correct **Incorrect**



123

Structural Shoring Concepts Cut Station Board

3 1/2" Space
3 5/8" Opening
1 5/8" Opening
5 5/8" Opening

The diagram shows a cross-section of a wooden shoring board with four sections. The first section is 1 foot wide, followed by an 18-inch opening, a 2-foot section, and a final 3-foot section. Below the board, four horizontal lines indicate the spacing between the sections: 3 1/2 inches, 3 5/8 inches, 1 5/8 inches, and 5 5/8 inches.

124

Structural Shoring Concepts Shoring Tools

A photograph showing several construction workers in hard hats and safety gear working on a concrete slab. They are using long wooden beams and metal shoring equipment to support the structure. A ladder is visible in the background.

125

Structural Shoring Concepts Alternative Shoring Systems



- Pneumatic Shoring Systems
- Mechanical Shoring Systems.

The left side of the slide features a photograph of workers in red hard hats using pneumatic shoring systems. A red arrow points from the text above to the shoring equipment. The right side features an advertisement for 'Airshore' pneumatic shoring systems, showing various models and the company website: www.airshore.com.

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Structural Shoring Concepts Pneumatic Shores

- Aircraft aluminum
- 18" extending to 16'
- We normally do not use air to set these struts in a structural collapse (trench)
- Average working load = 25,000 lbs.



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Structural Shoring Concepts Paratech Struts

Acme Thread

Permits "soft" placement with sensitive positioning

- 15.5 - 21.4" / 6" stroke
- 23.9 - 35.5" / 12" stroke
- 35.5 - 57.5" / 24" stroke
- 54.6 - 86.5" / 36" stroke

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Structural Shoring Concepts Paratech Strut Extensions



3' 2' 1'



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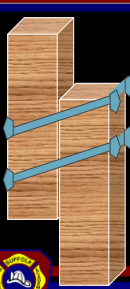


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Structural Shoring Concepts Ellis Clamps



- Maximum height 14'
- Max height, bottom leg 7'
- Clamps 12" apart
- Minimum 2" from top
- Minimum 6" from bottom



133

Structural Shoring Concepts Ellis Clamps

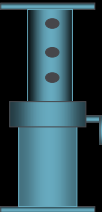


Ellis
MANUFACTURING
COMPANY INC.




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Structural Shoring Concepts Pipe Shores / Trench Shores



- Several types, adjustable
- Pin anchor and screw are the most common
- 1 1/2" and 2" are the norm
- Minimum is schedule 40
- Capacity is based on L/D ratio



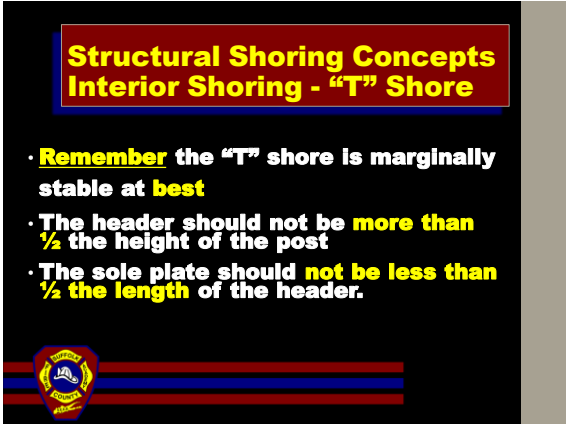
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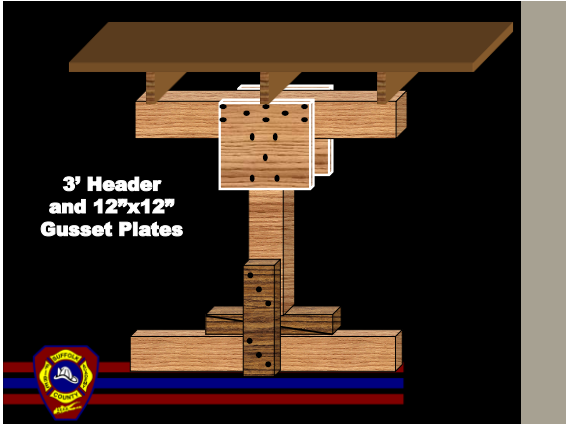
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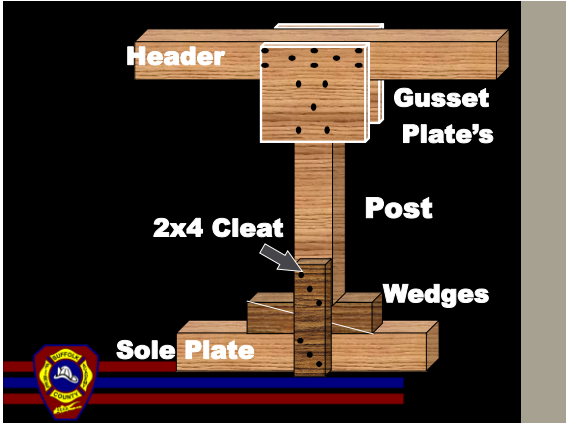
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