



Fall Protection

Susan Harwood Grant Training Program

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Introduction

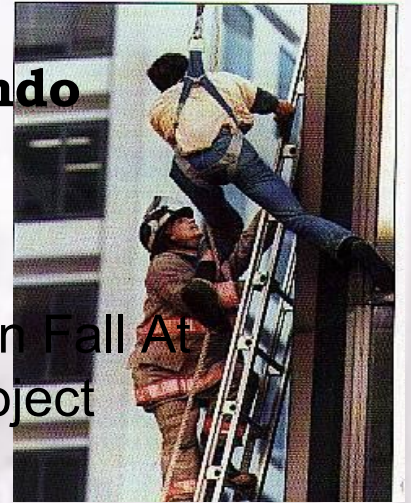
Why Fall Protection?

Why Now?



Construction worker dies in fall from condo project

Bridge construction accident injures



Worker Hurt In Fall At University Project



Element accident

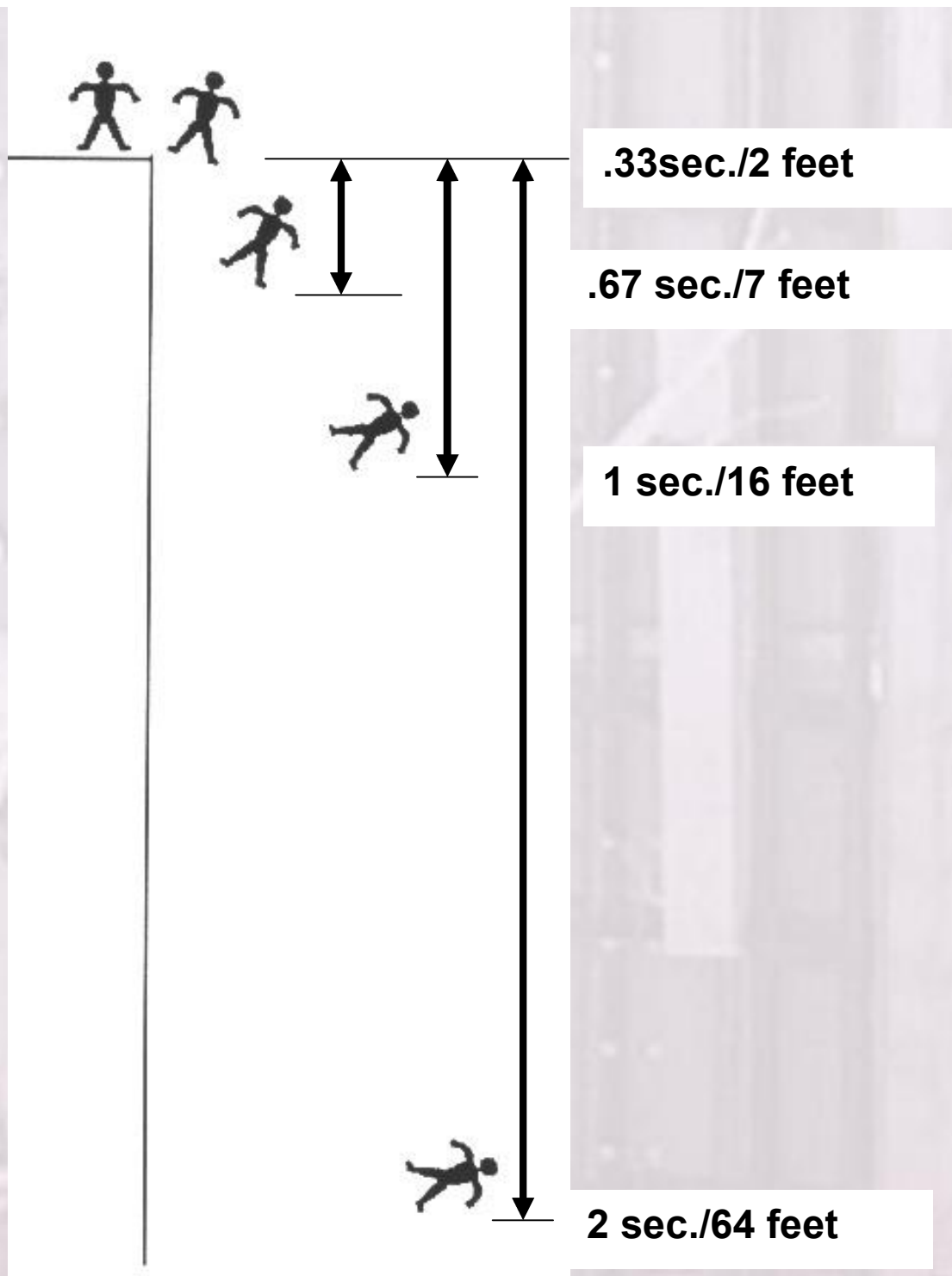


Worker in ... for fall



... fell had been on job only 3 weeks

These headlines are all from the third and fourth quarter of 2003

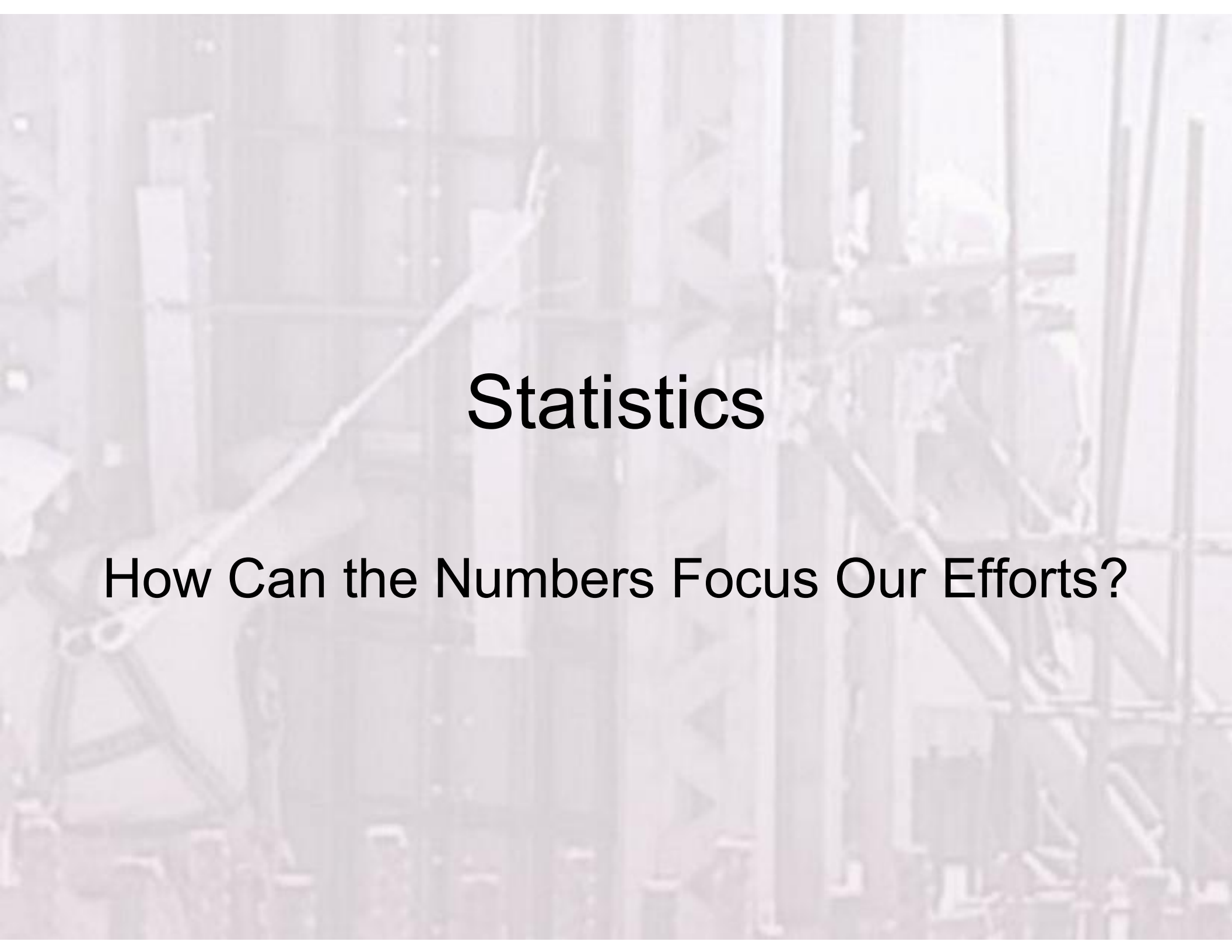


Anatomy of a Fall

- It takes most people about 1/3 of a second to become aware.
- It takes another 1/3 of a second for the body to react.
- A body can fall up to 7 feet in 2/3 of a second.

Acceleration = 32 ft/sec^2
Deceleration = 0 ft/sec^2





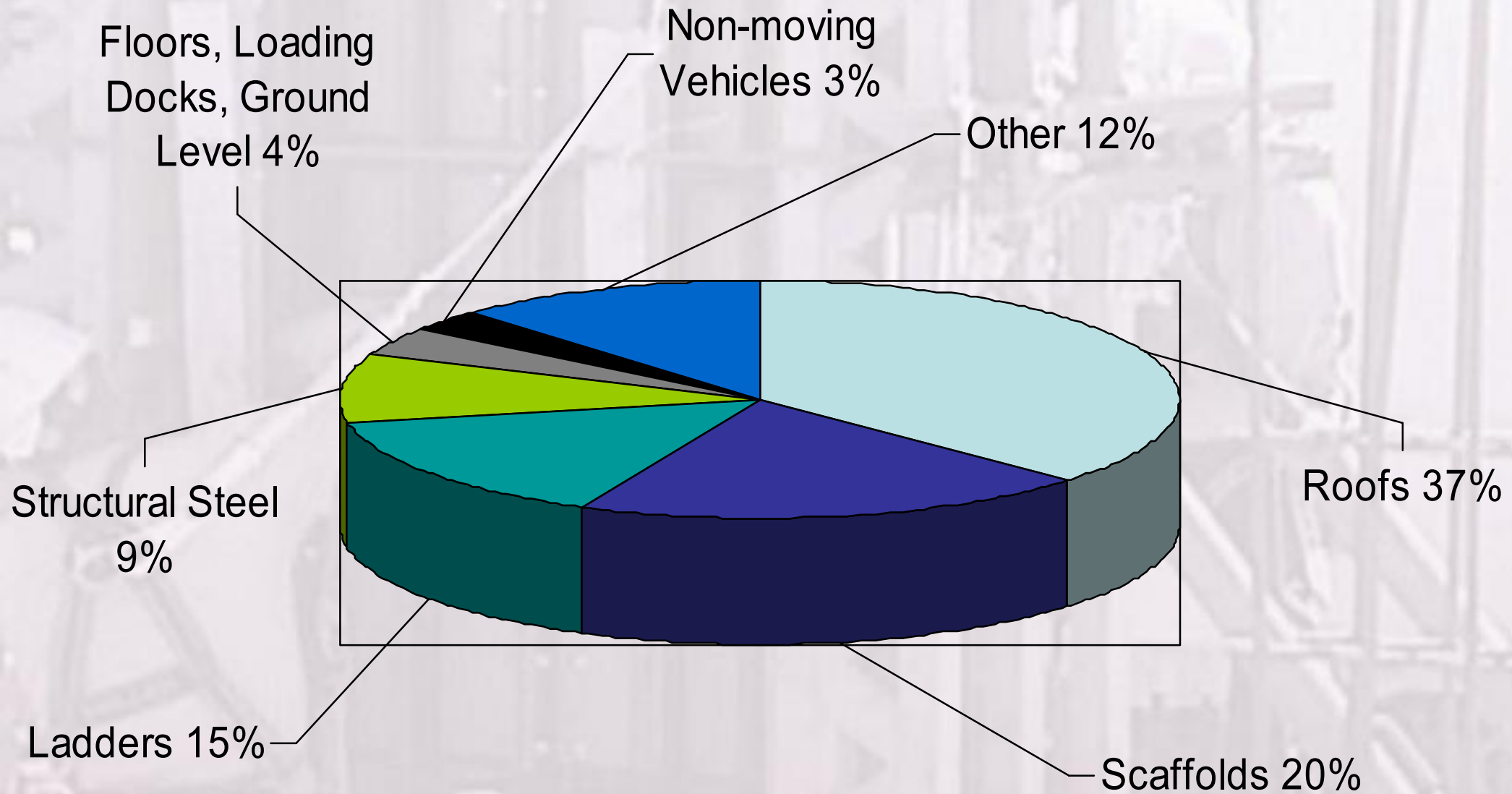
Statistics

How Can the Numbers Focus Our Efforts?

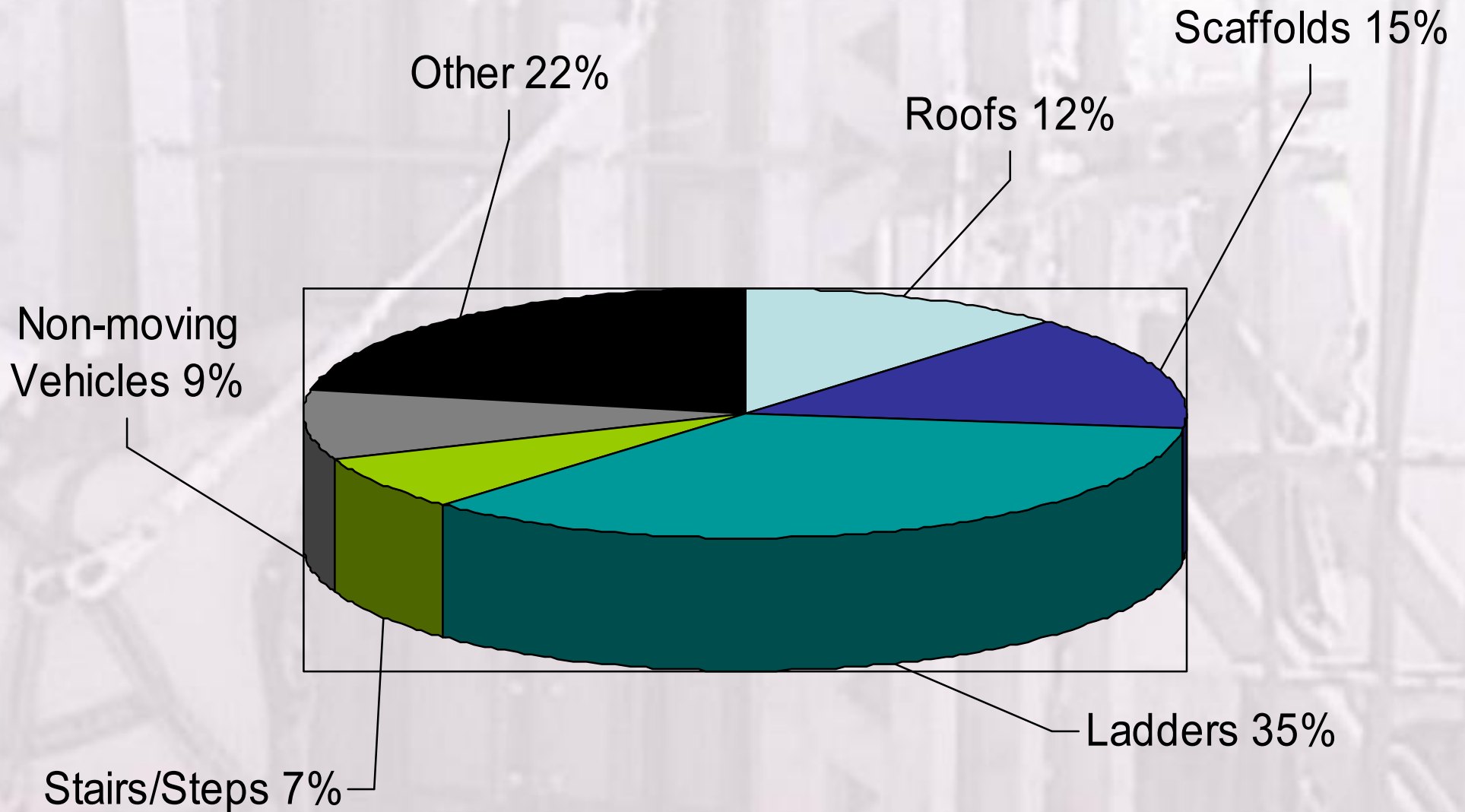
Falls

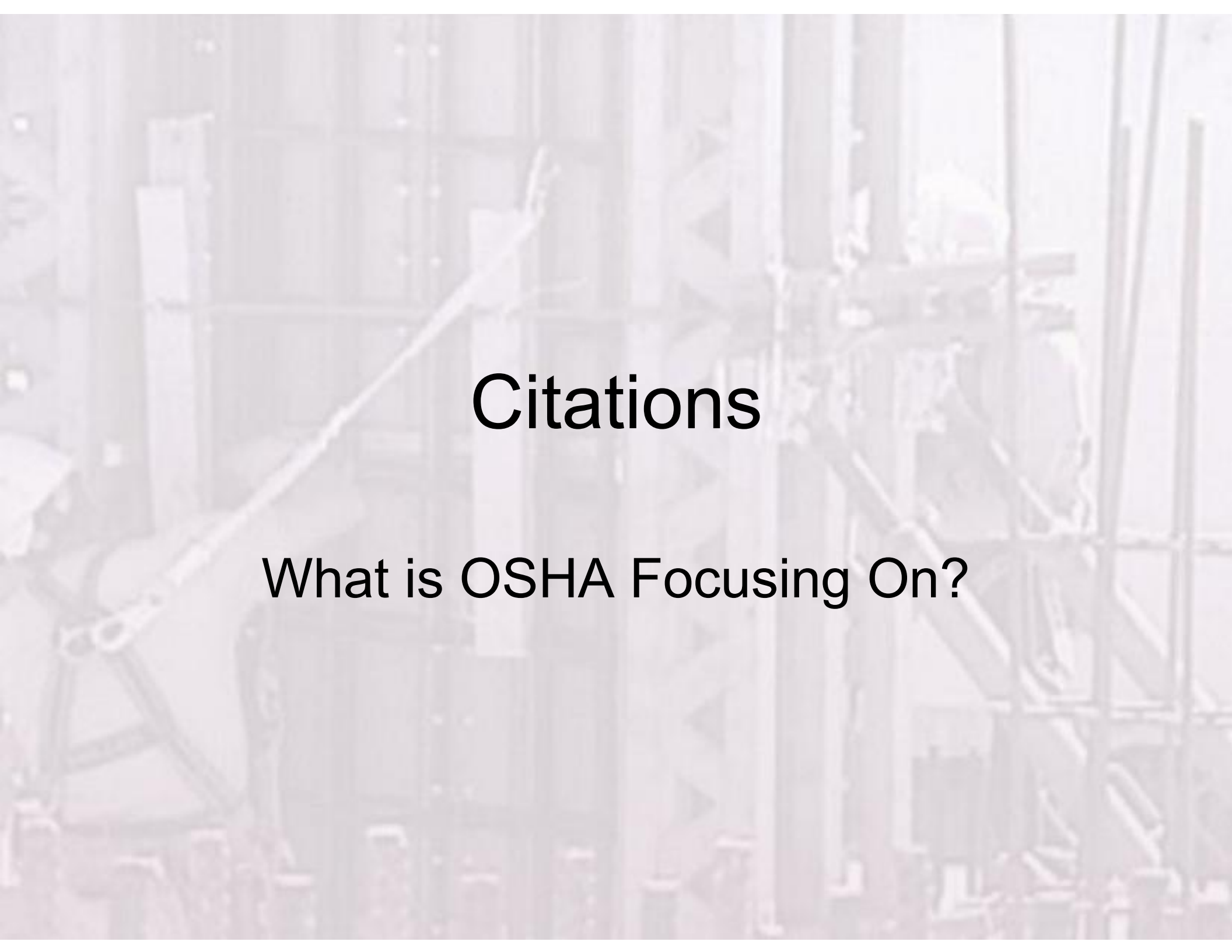
- **Falls** are the *leading cause of fatalities* in the construction industry.
- An average of *362 fatal falls occurred each year* from 1995 to 1999, with the trend on the increase.
- The cost of care for injuries related to falls is a financial burden for the entire construction industry

Fatal Falls Most Often From



Non-Fatal Falls Most Often From

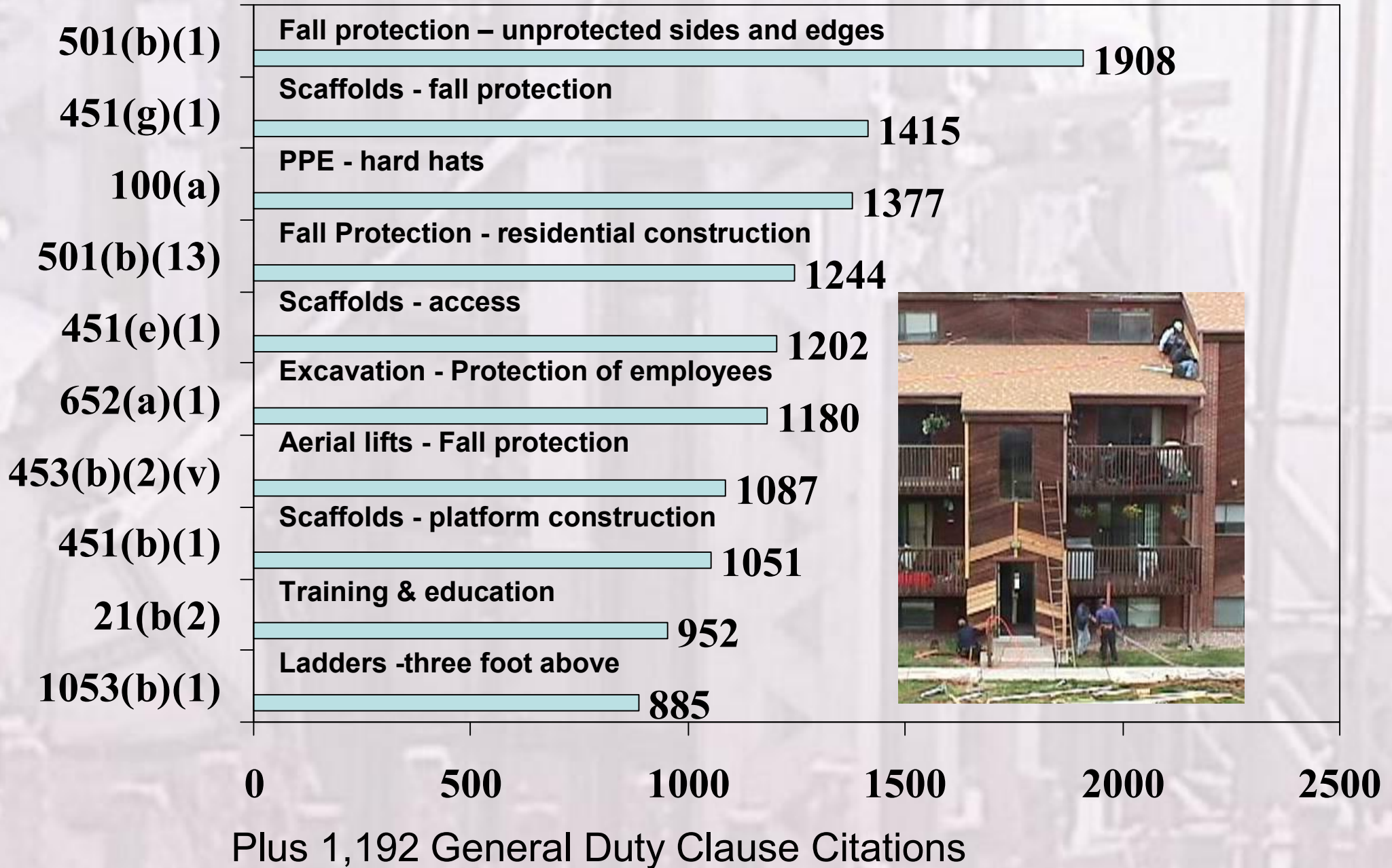




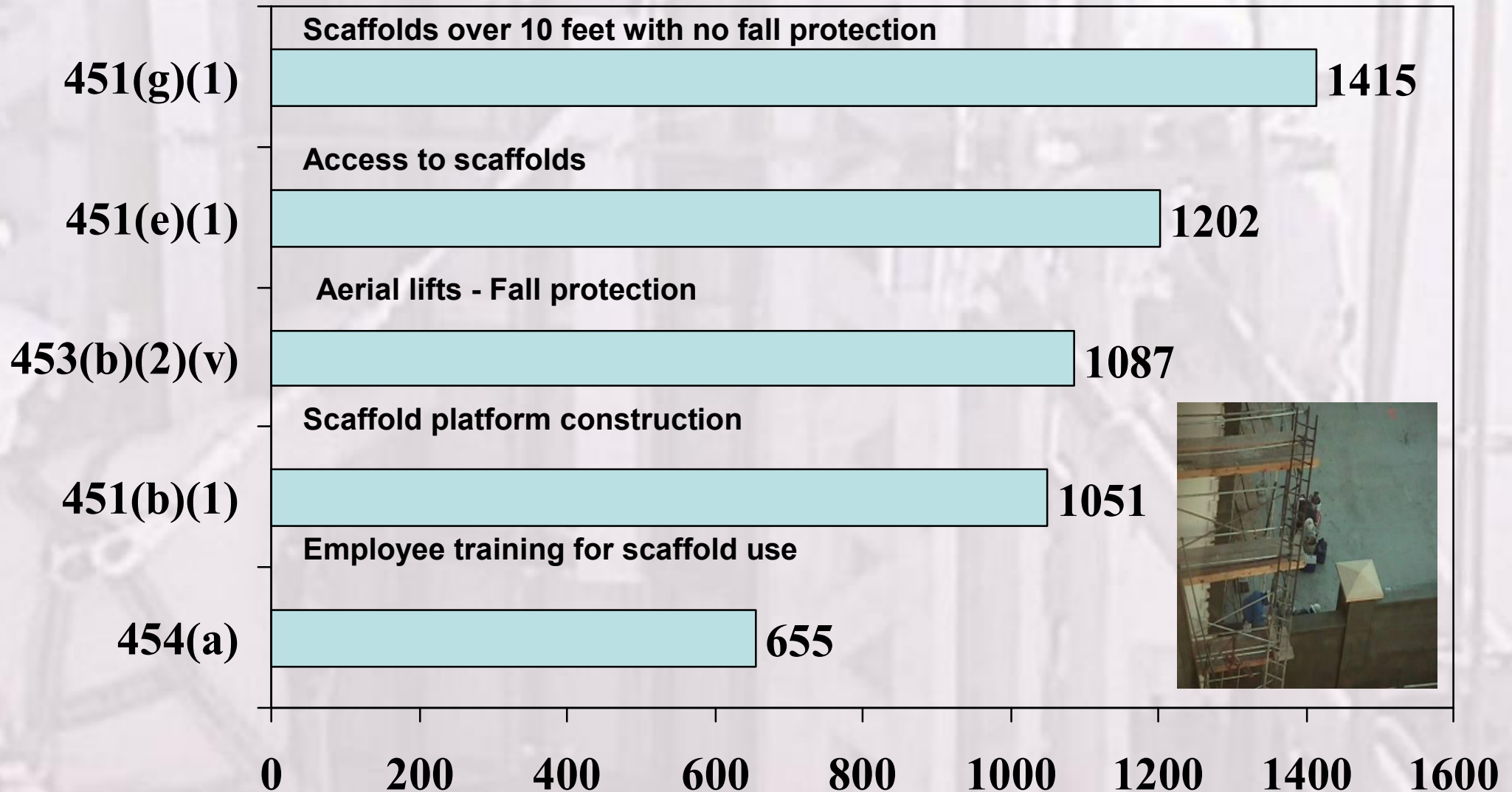
Citations

What is OSHA Focusing On?

2003 Most Frequently Cited Construction Standards

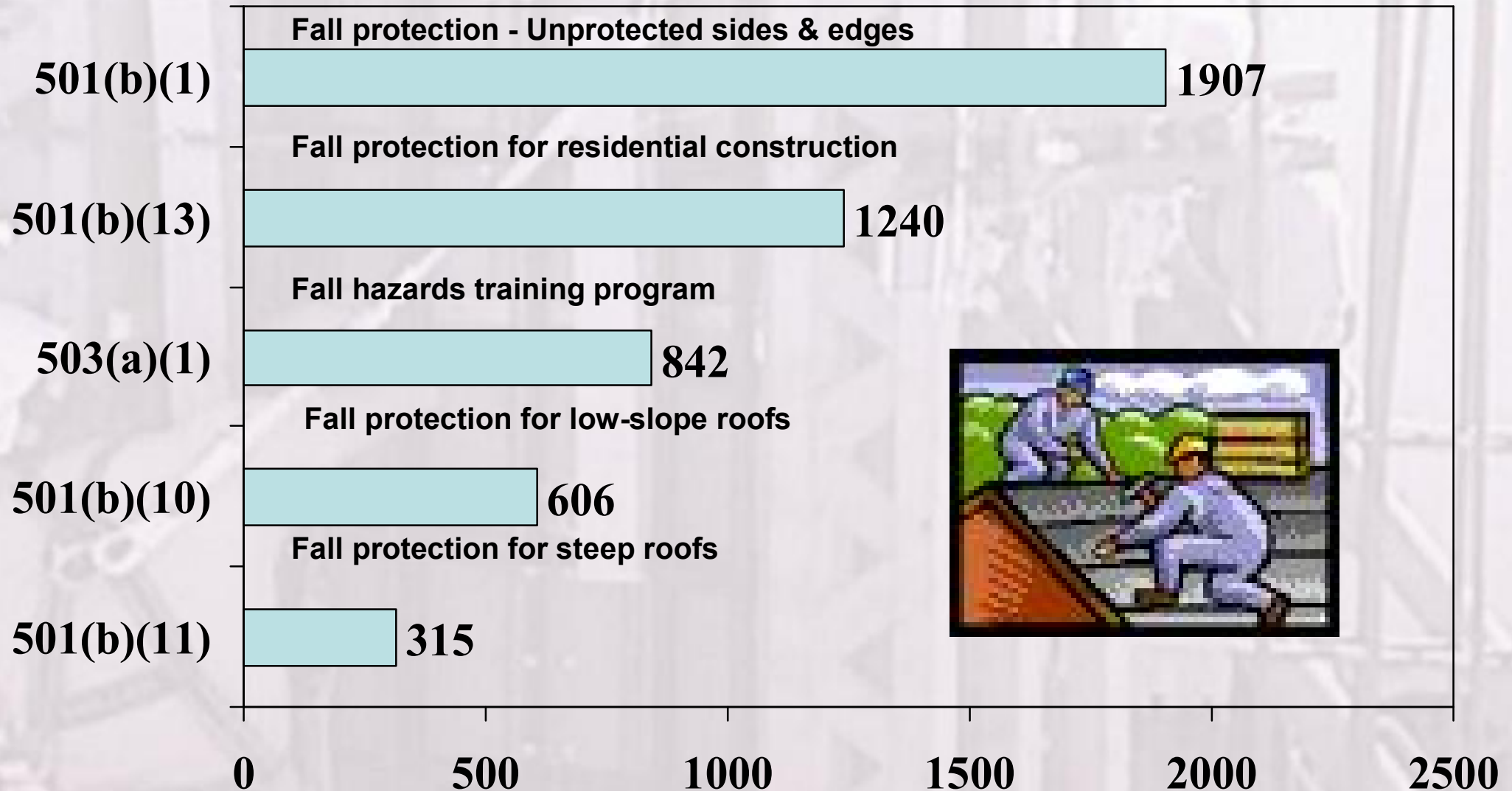


2003 Subpart L 1926.450-454 Scaffolds



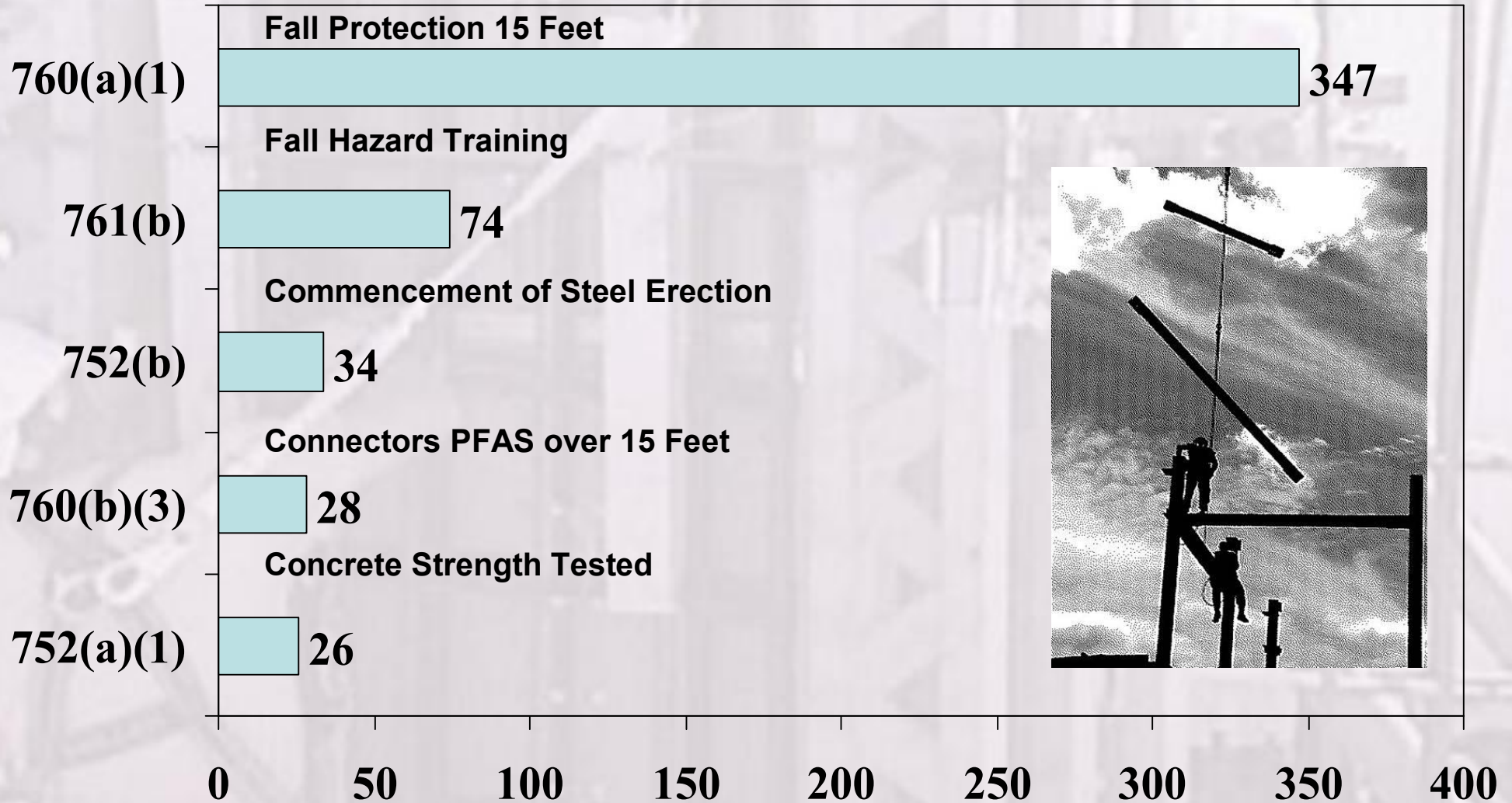
2003 Subpart M 1926.500-503

Fall Protection



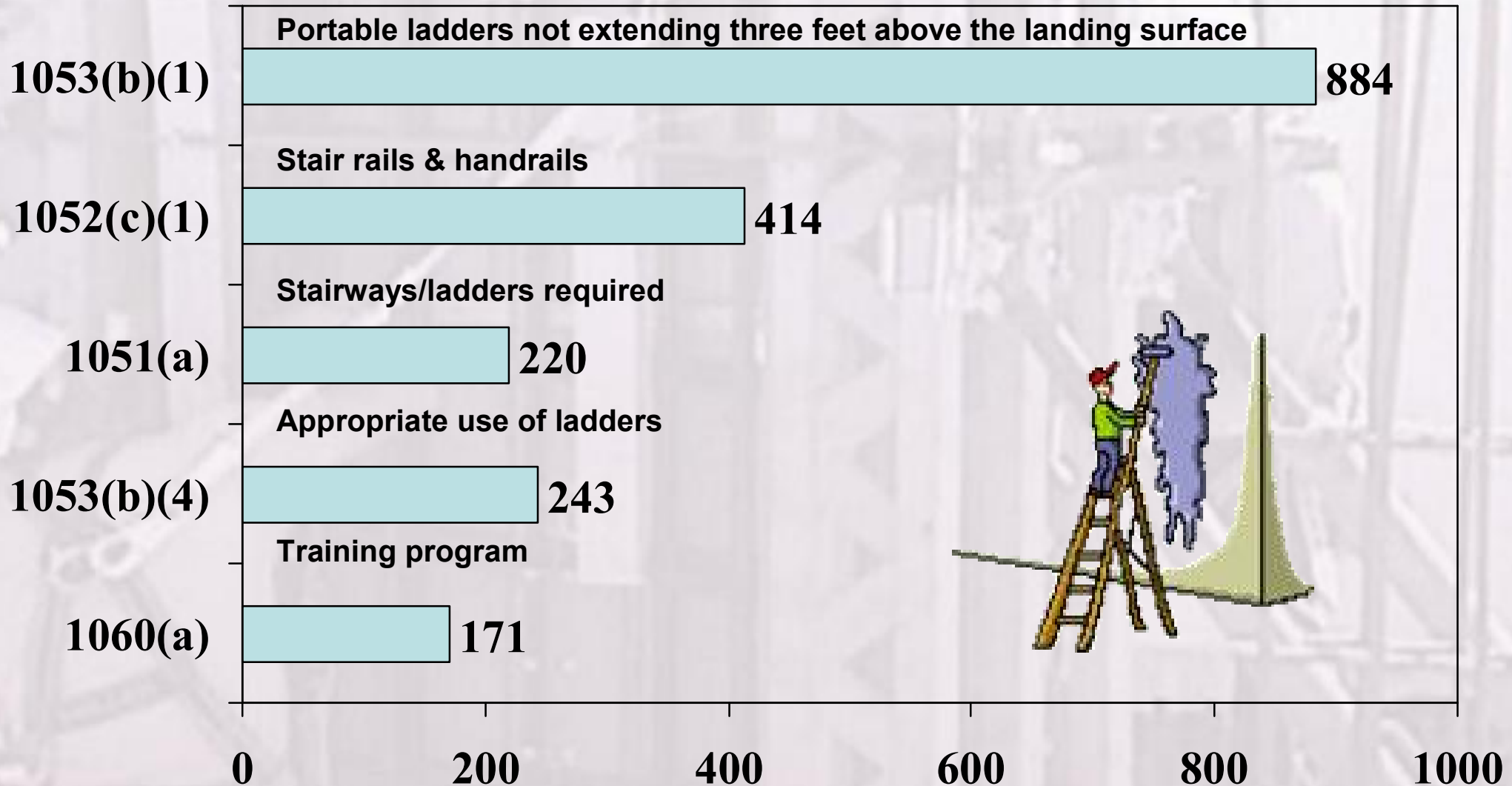
2003 Subpart R 1926.750-761

Steel Erection



2003 Subpart X 1926.1050-1060

Ladders



2003 Most Frequently Cited Construction Standards

- **In Fiscal Year 2003, 50% of the top 25 OSHA Construction standards violated were *Fall Related*.**

What Is Fall Protection?

- **A series of reasonable steps taken to cause elimination or control of the injurious effects of an unintentional fall while accessing or working at height**

Philosophies of Fall Protection

Stop/Prevent The Fall



Restraint/Positioning

Guardrails

Warning Lines

Controlled Access Zones

Controlled Decking Zones

Safety Monitors

Catch The Fall



Fall Arrest

Safety Nets

Catch Platforms

Do these stop/prevent the fall?

Planning for Fall Protection

- Best practice dictates that fall protection becomes an integral part of the project planning process, from constructability, to systems installation, to use and maintenance
- A project cannot be truly safe unless fall protection is incorporated into every phase of the construction process
- Planning will keep workers safe and minimize liability for all parties involved

The Steps of Fall Protection?

**Fall
Arrest**



1

**Fall
Prevention**



2

Positioning



3

Retrieval



4

- Is this the correct order?

Controlling Fall Exposures

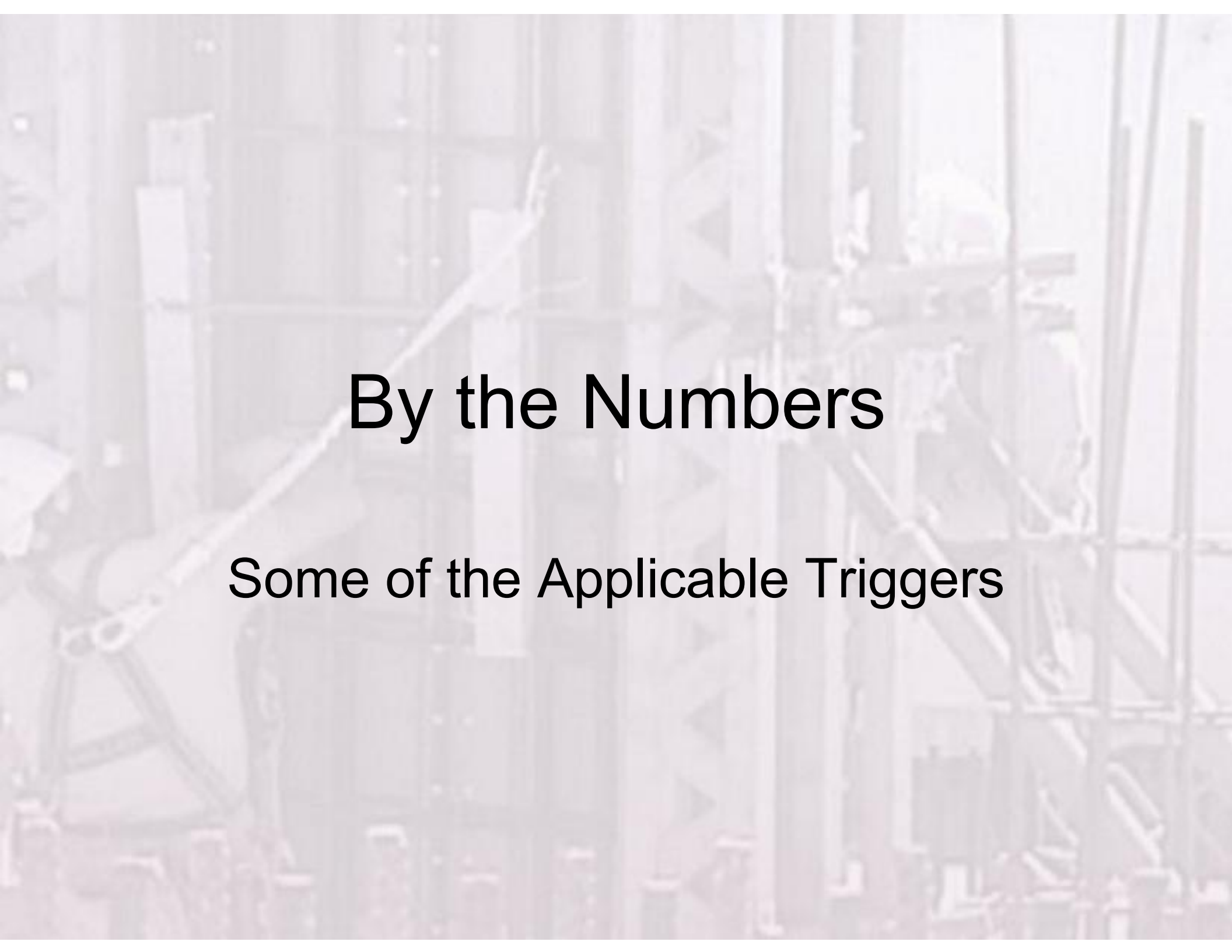
- Select fall protection systems appropriate for given situations.
- Use proper construction and installation of safety systems.
- Supervise employees properly.
- Use safe work procedures.
- Train workers in the proper selection, use, and maintenance of fall protection systems.
- Evaluate the effectiveness of all steps

Competent Person

- means one who is capable of identifying existing and predictable hazards in the the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has the authorization to take prompt corrective measures to eliminate them.

Qualified Person

- means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated his/her ability to solve or resolve problems related to the subject matter

A faded, high-angle photograph of a construction worker wearing a hard hat and safety harness, standing on a steel beam and working on a large, complex steel structure, likely a bridge or a large industrial building. The image is desaturated and serves as a background for the text.

By the Numbers

Some of the Applicable Triggers

Falls onto dangerous equipment

- 0' Allowable Fall Distance
- (You Must Be Protected)



Break in elevation without a step

- 19"



First step onto a scaffold system

- 2'



Work on forms or steel reinforcing

- 6'



Work on surfaces such as decks, non-residential roofs, ramps, etc

- 6'



Scaffold platforms without guardrails

- 10'



Vertical fixed ladders without cages, etc.

- 24'



Climbing steel reinforcing

- 24'



Steel erection work

- 15-30', or two stories, whichever is less



Roofs with pitches 8:12 or less in residential-type (wood frame) construction

- 25'



Falls into safety nets

- 30'



Height of scaffold ladders requiring rest platforms

- Over 35'



Falls from portable extension ladders

- No Limit



A faded background image showing a construction worker in a hard hat and safety gear, working on a complex steel structure, likely a bridge or large building frame. The worker is positioned on a horizontal beam, surrounded by vertical and diagonal steel supports.

Which Standards Apply?

It's Not Just Subpart M!

Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



Which Standards Apply?



A faded background image showing a construction worker in a hard hat and safety harness, working on a complex steel framework of a building under construction.

Hazard Recognition

Allowable Controls
and
Best Practices

Vertical Exposures

- Rebar
- Formwork



Vertical Rebar

- OSHA allows:
 - Climbing to 24'
 - Tie-off at work location over 6'
- Recommended:
 - Tie during the climb



Formwork

- Required Fall Protection at 6'
- Recommended:
 - Use scaffold brackets
 - Ensure safety over/on top of the wall



Steel Erection

- Connectors
- Detail Work
- Decking
- *Fall Protection Systems in Accordance With Subpart M Systems Criteria (1926.502)*



Connector Safety

- Personal Fall Arrest Systems required at 15'
- Connector option to 30' or two stories, whichever is less
- Best Practice:

NO OPTION



Detail Work

- Fall Protection Required at 15'
- Guardrails
- Nets
- Personal Fall Arrest Systems



Decking

- PFAS
- Controlled Decking Zones
- Guardrails (after leading edge work is complete)



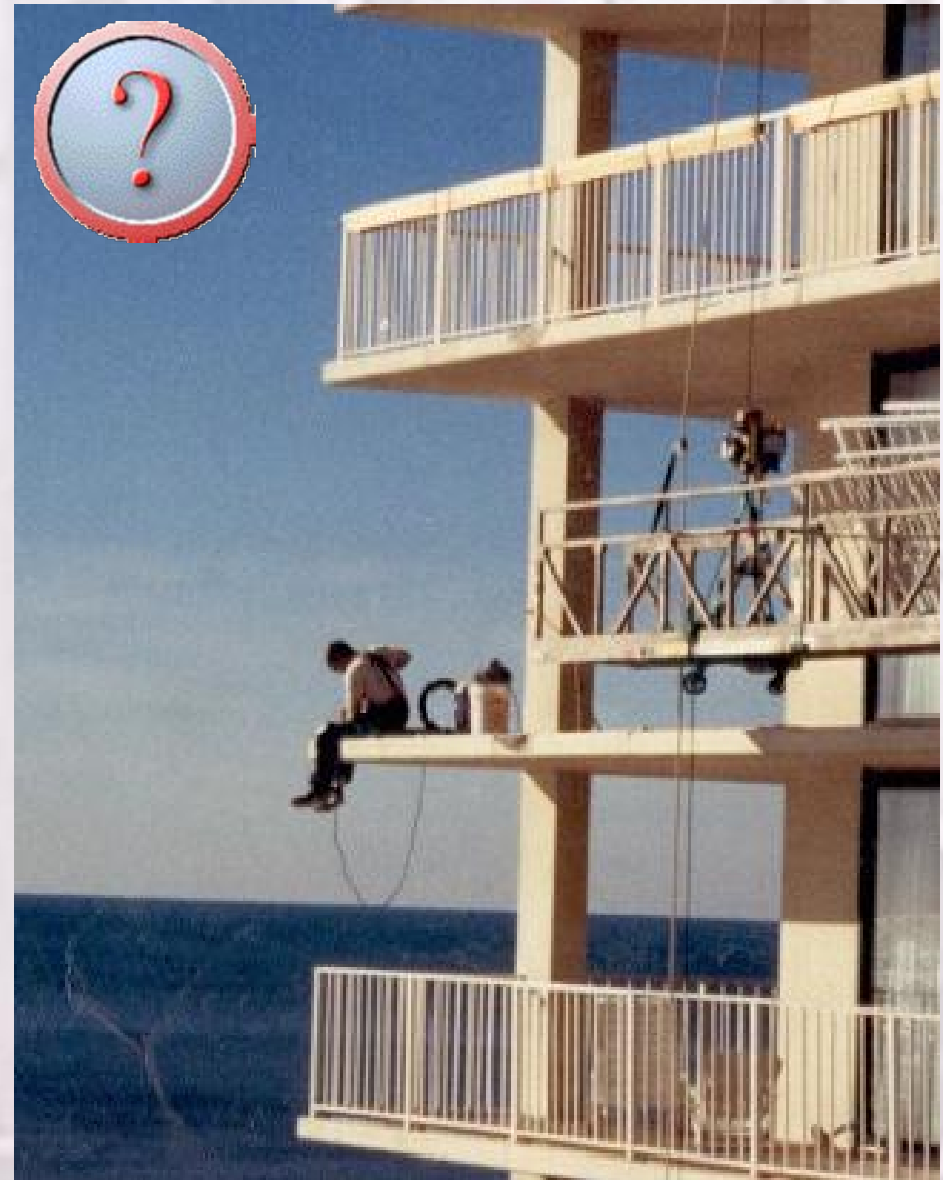
Controlled Decking Zones

- Required where PFAS cannot be used, from 15-30'
- Limited in size
- Must be marked
- Training required
- Not applicable over 30', or two stories, whichever is less



Decks (Walking & Working Surfaces)

- Open-sided Floors
- Holes
- Leading Edges



Open Sided Floors

- Guardrails
- Catch Platforms
- Restraint Devices
- Safety Nets



Guardrails

- Primary Issues
 - Complete System
 - Full coverage
 - Accessways/Ladderways
 - Material Handling Areas
 - Proper construction
 - Strength
 - Deflection
 - Maintenance
 - Custody & Control



Coverage

Bad



Better



Accessways/Ladderways

Bad



Better



Material Handling



When areas have been opened, PFAS is required
Gates are preferred to removable rails

Wood Guardrail Construction

Proper Height

Midrails

Toeboards

Adequate Strength



Cable Guardrail Construction

- Proper Height
- Cannot deflect below 39"
- Marked every 6'
- Terminations and Attachments
- Maintenance!



Holes

- Covers
- Guardrails



Skylights



Must be protected

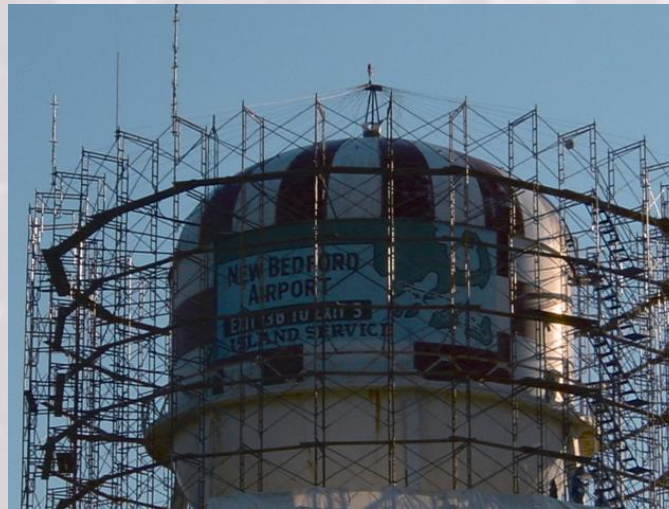
Leading Edges

- Catch Platforms
- PFAS
- Nets
- In some instances (residential construction and pre-cast concrete), a site-specific fall protection plan



Scaffolds

- Supported
 - Fabricated Frame
 - Tube & Coupler
 - Wall Brackets
 - Form Brackets
 - Ladder Jacks
 - Pump Jacks



Scaffolds

- Suspended
 - Swings
 - Multi-point
 - Catenary



Scaffolds

- Access
- Planking
- Guardrails
- Erection & Dismantling
- Training



Scaffold Access

Bad



Better



Scaffold Platform Construction

Bad

Better



Scaffold Guardrails

Bad

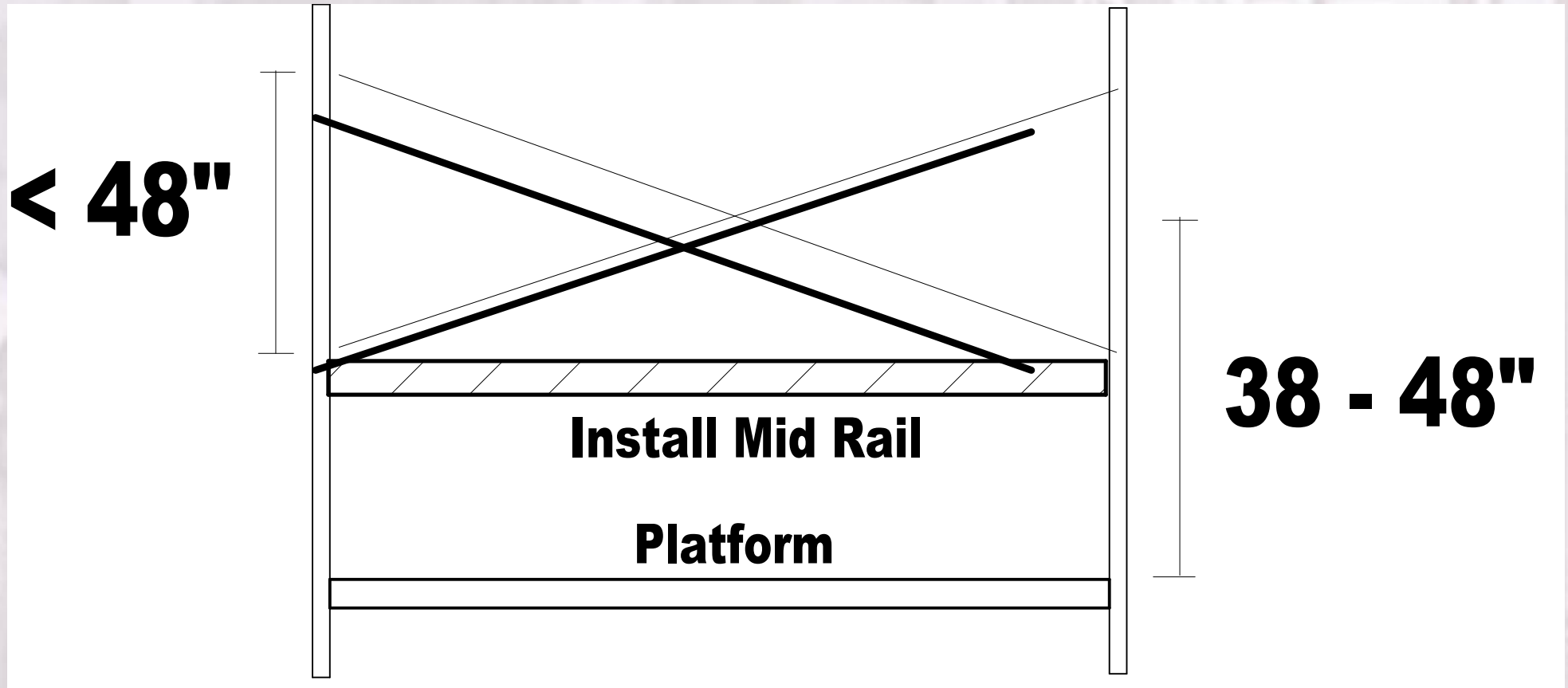


Better



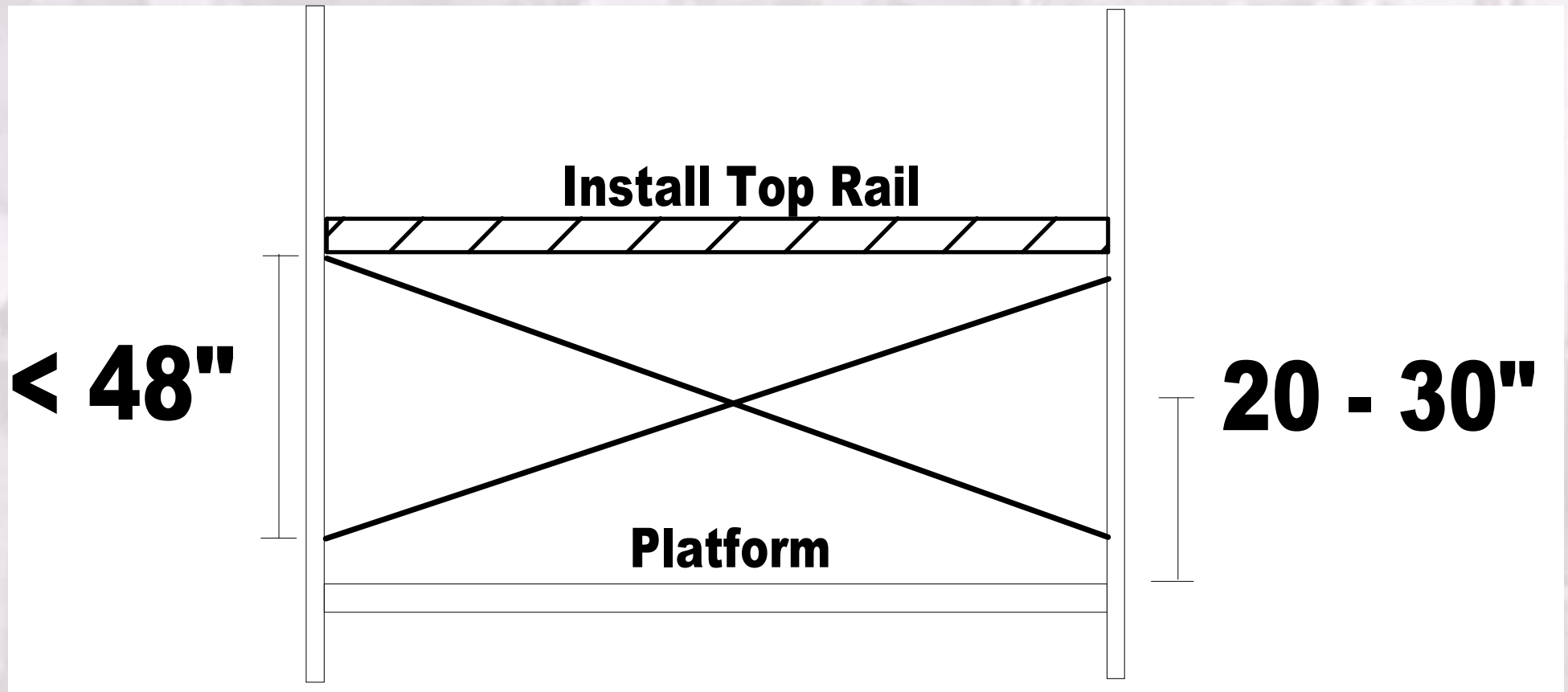
Be especially aware of scaffold ends!

Use of Braces for Guardrails



- **Brace can be used as a Top Rail.**

Use of Braces for Guardrails



- **Brace can be used as a Mid Rail**

Braces as Guardrails



- The guardrails are *in compliance* using a 2x4 as one rail and the brace as the other rail.
- May not be the safest way

Scaffold Erection & Dismantling

- “Competent Person” Determines Where Fall Protection is “Feasible” and Does Not Create a Greater Hazard
- Using Scaffolds as Anchorage Points?

Aerial Work Platforms

- Boomlifts
- Scissorlifts
- Boom Trucks (Cherry Pickers)
- Mast Climbers

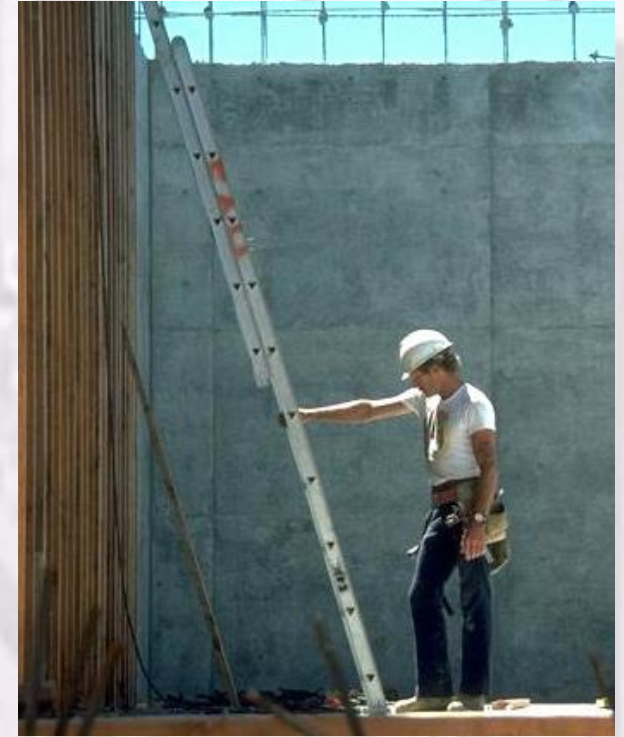
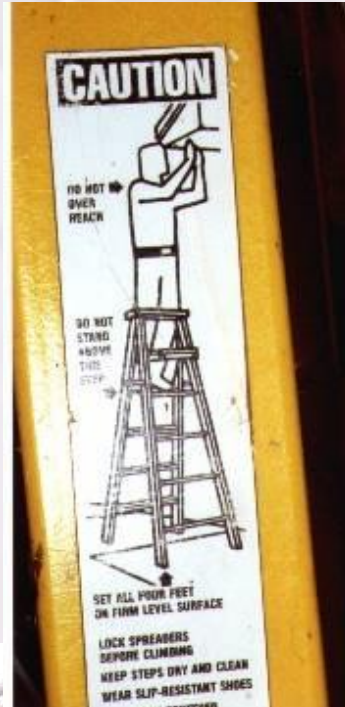


Stairs



Ladders

- Extension
- Step
- Vertical Fixed
- Job-built



Ladders

- Extension



Ladders

- Step



Roofs

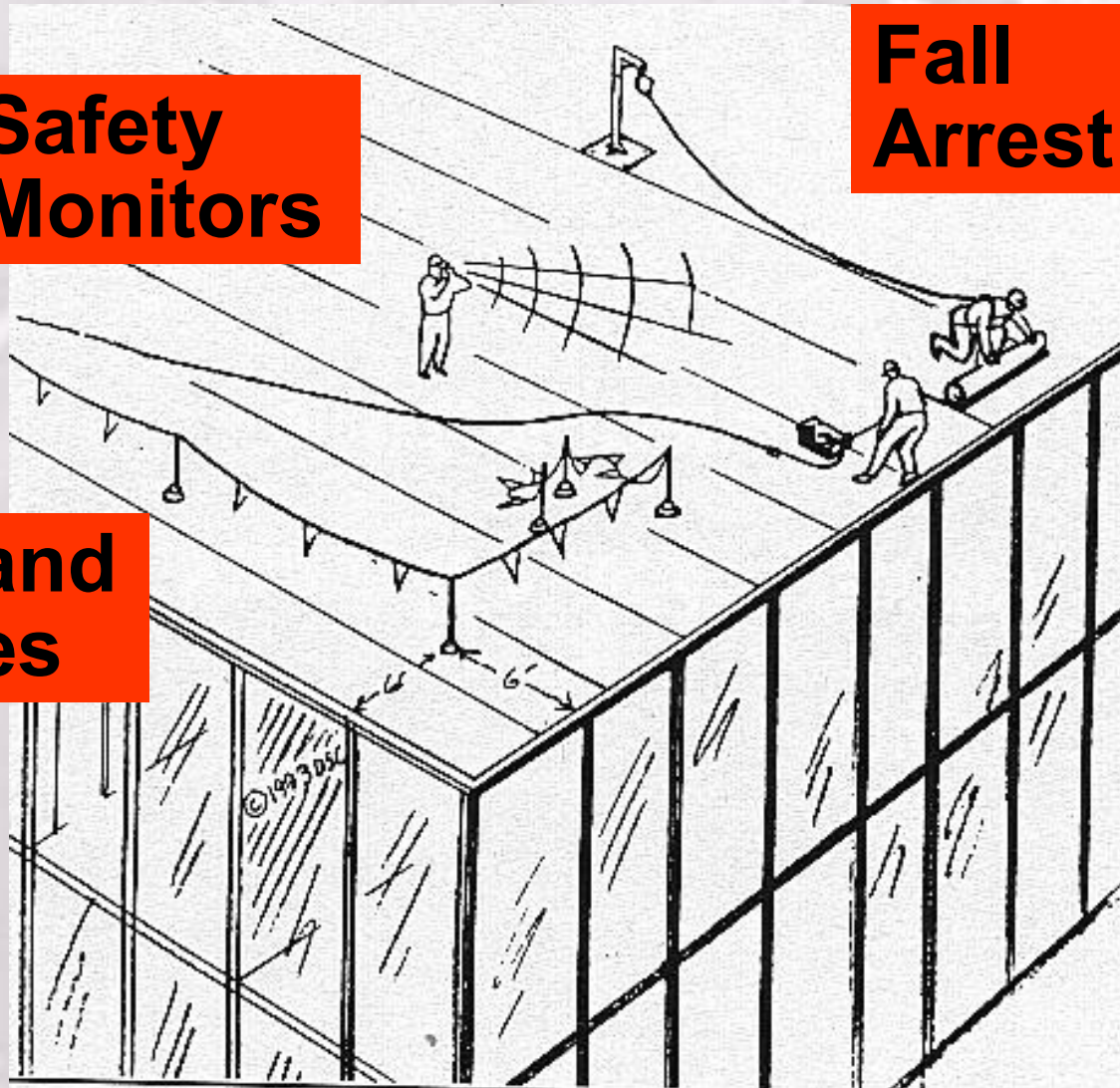


Methods of Roof Fall Protection

**Safety
Monitors**

**Fall
Arrest**

**Guardrails and
warning lines**



Flat/Low Slope

- 4:1 Slope or Less
- Beyond the Use of Guardrails, OSHA Allows the Use of
 - Warning Lines
 - Safety Monitors
- Recommended:
 - Guardrails or PFAS where feasible
 - *Limited* use of lines and monitors on flat roofs only

Roof Warning Lines

- Must be 6 feet back from edges (10' with equipment)
- ***NO CAUTION TAPE!***



Roof Warning Lines

- These lines are down.
- Warning lines must be maintained at 34 - 39" above the working surface



Safety Monitor

- Oversees work outside the warning lines.
- Establishes the procedure to protect.
- Workers must receive special training.
- *Use should be extremely limited*



High Slope

- Over 4:1 Slope
- OSHA Mandates
 - Guardrails
 - Catch Platforms
 - Nets
 - Restraint Devices
 - Personal Fall Arrest Systems (PFAS)

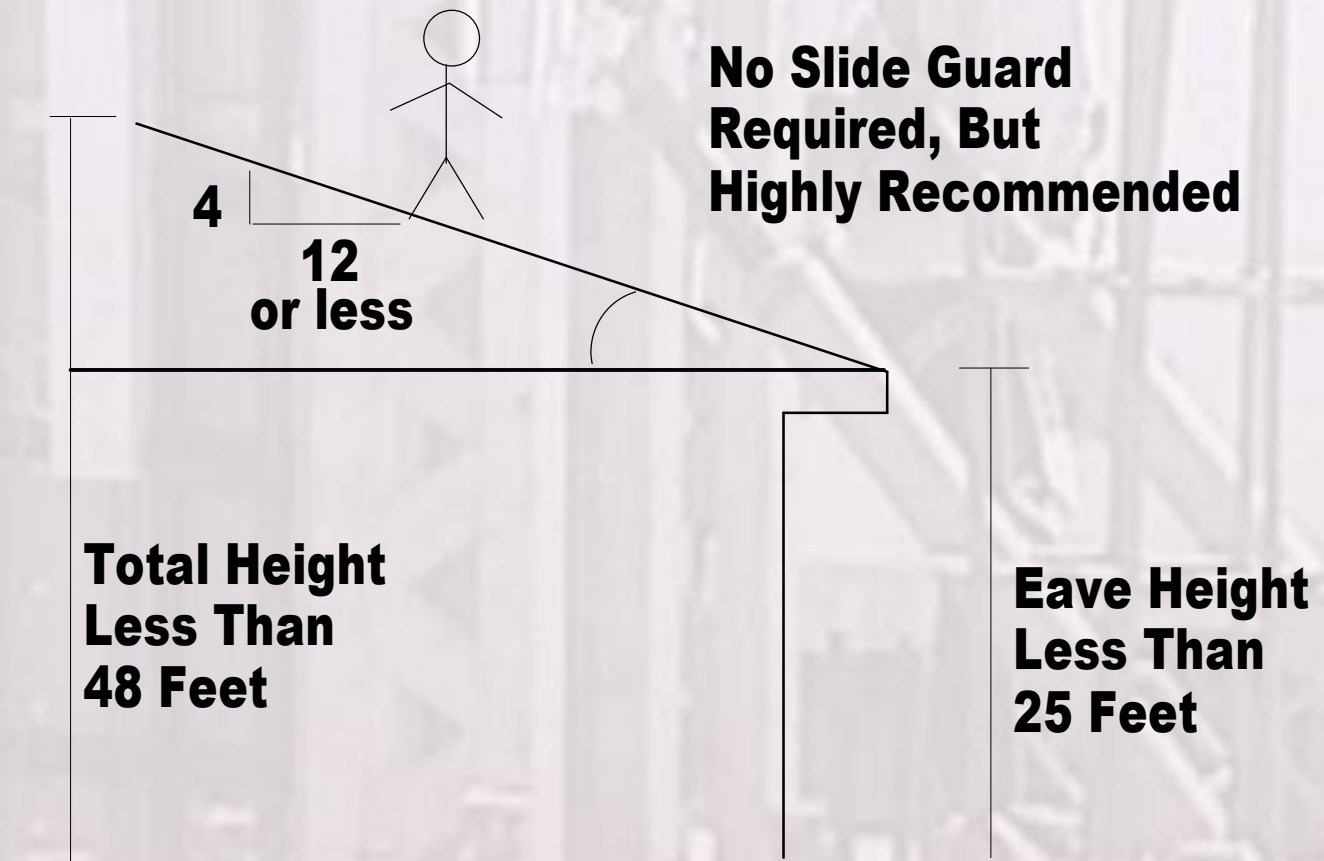


Residential-type Construction

- Wood frame
- Maximum eave height 25'
- Maximum total building height 48'
- *Additional definitions*

Residential-type Roof Requirements (4:12 or less)

- Safety Monitors must not be performing work.
- Warning lines are OK 6 feet back.

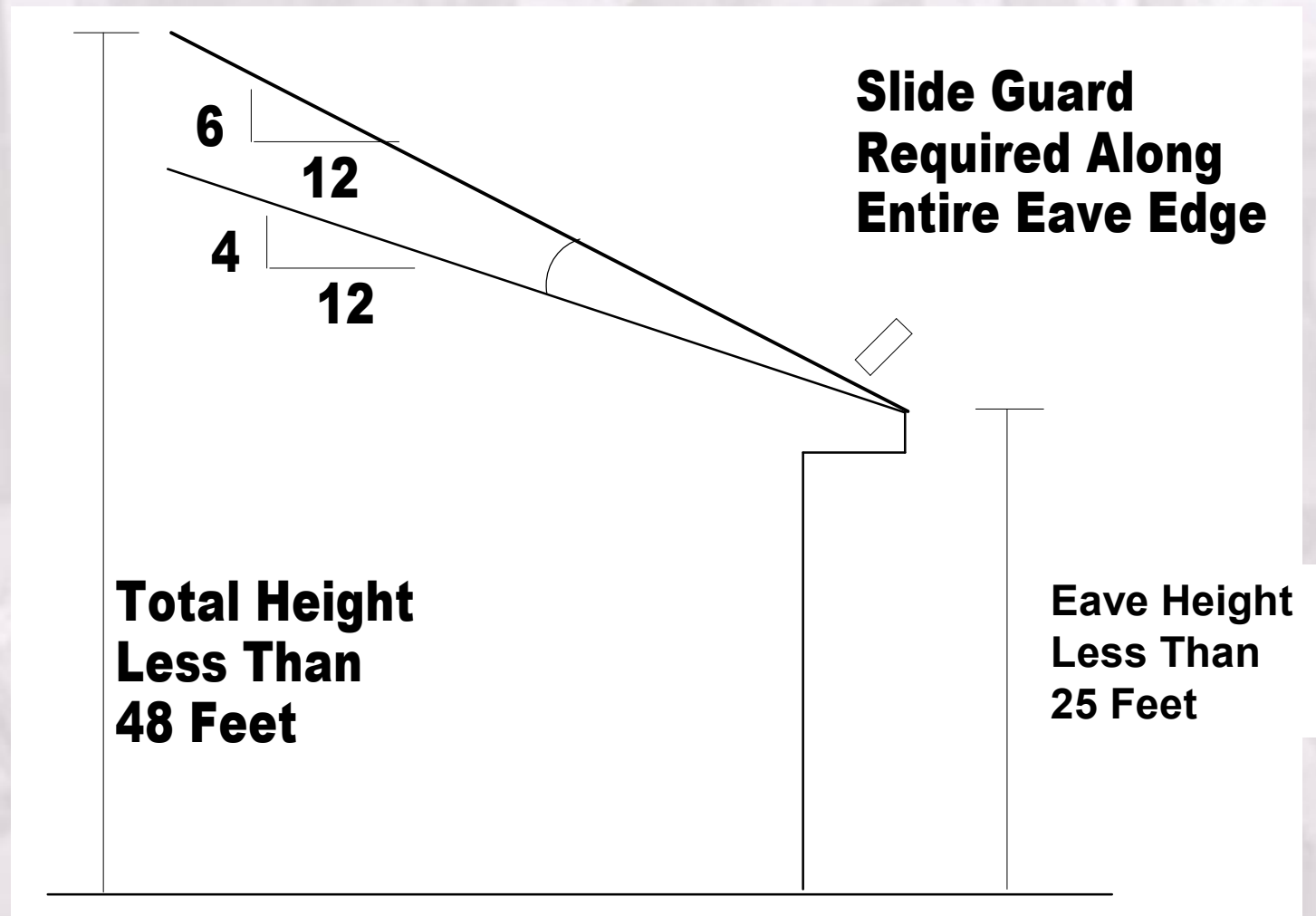


Roof Edge Slide Guards



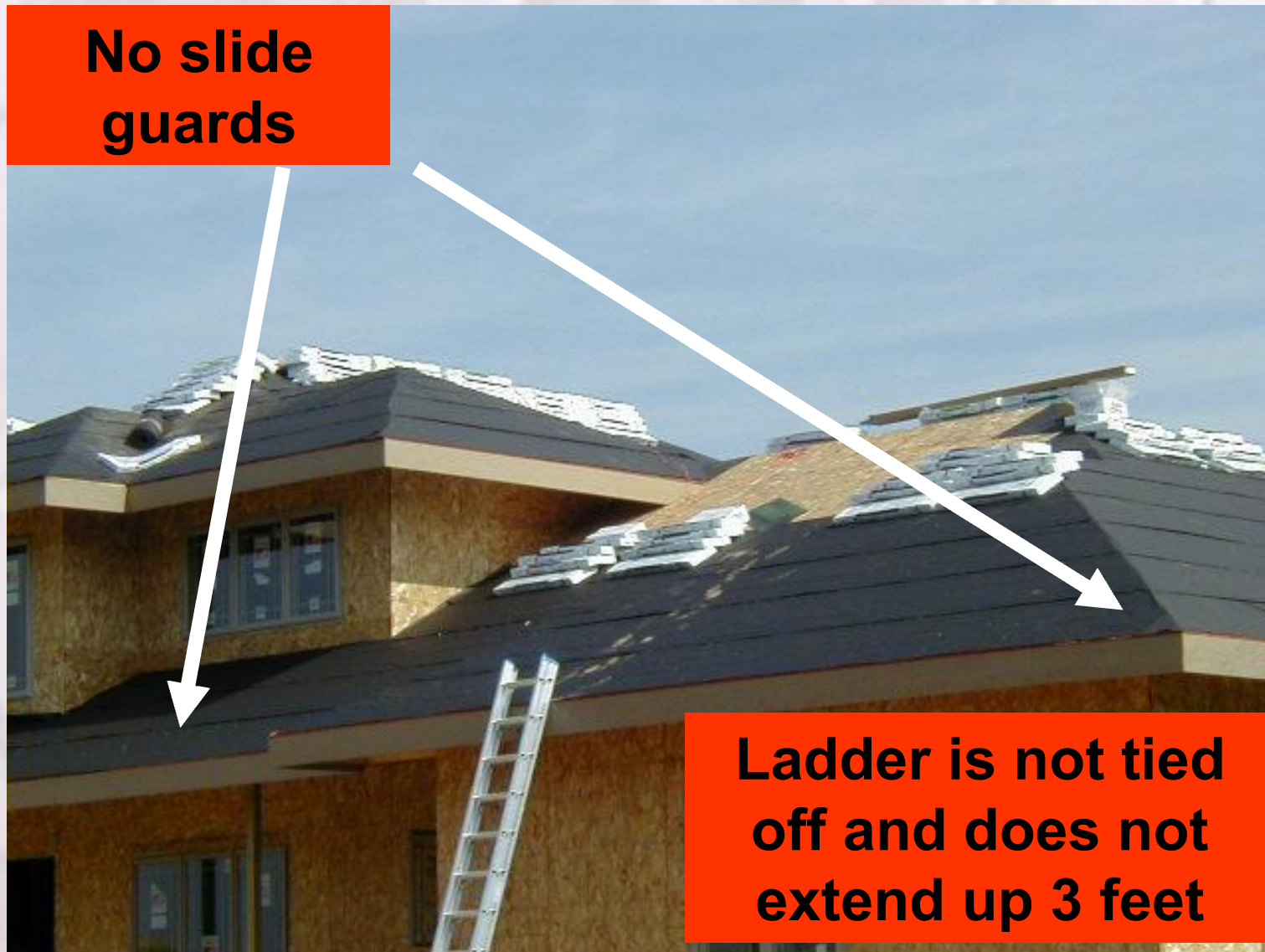
- Slide guard must extend across the entire eave.

Residential-type Roof Requirements (4:12 - 6:12)



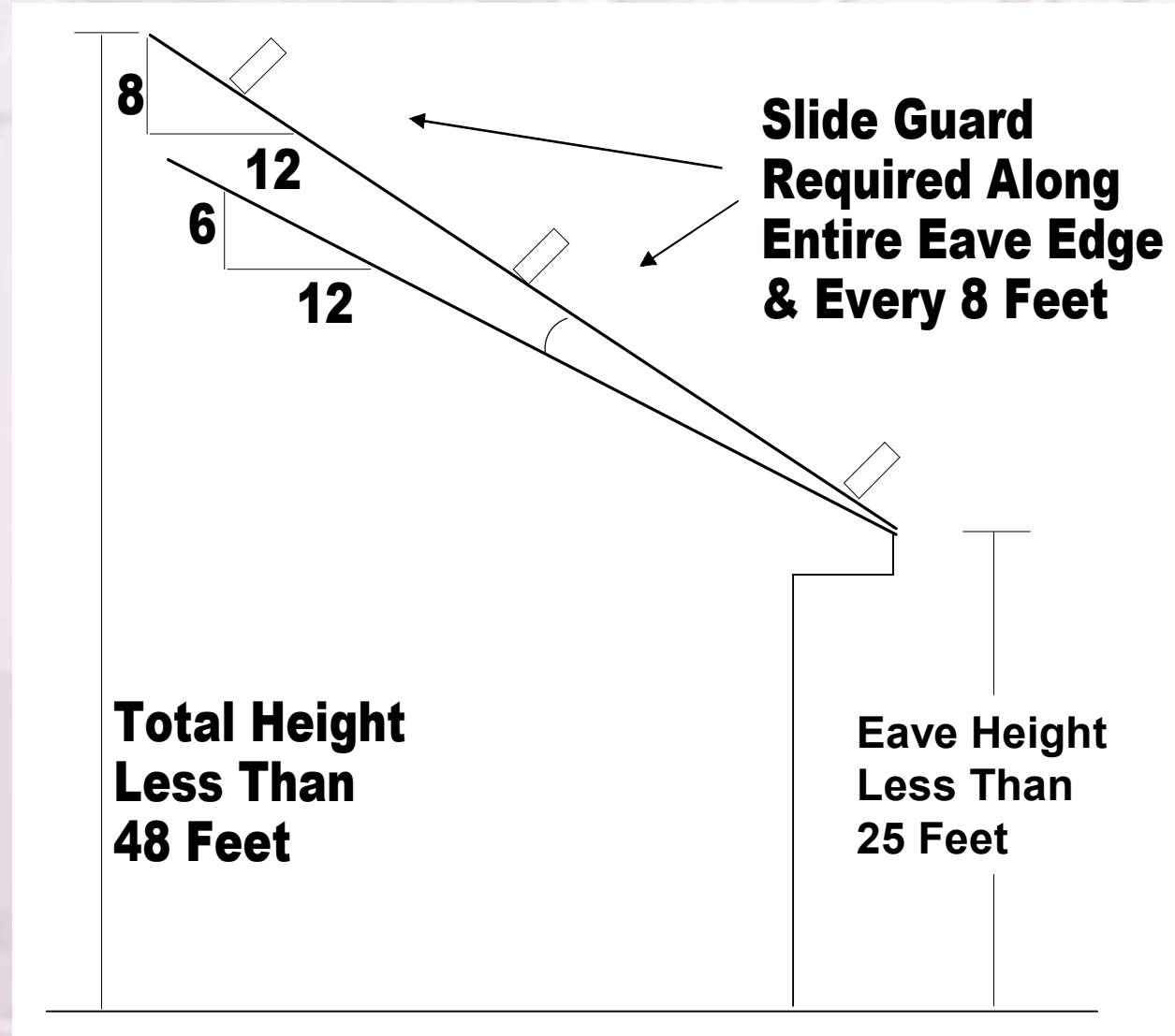
- Guards must be extend across entire eave.

What's Wrong on this 6:12 Roof?



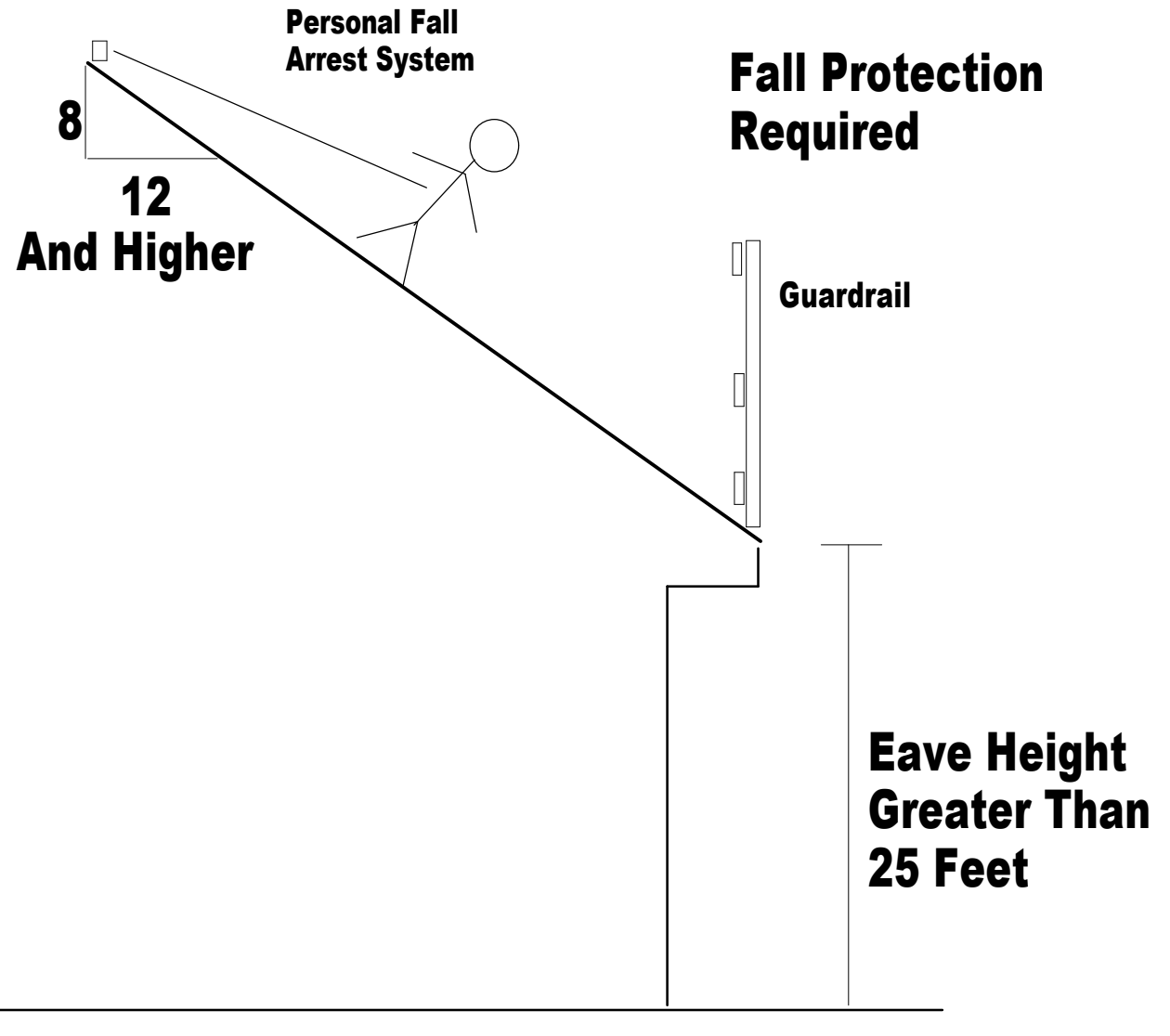
Residential-type Roof Requirements (6:12 - 8:12)

- While standing on the plank below, the employee must secure roof jacks, then climb up to the plank and continue to install the roof.
- Remove in reverse order.



Residential-type Roof

(Over 8:12 pitch or over 25 feet high)



- Conventional fall protection must be utilized.

Roof Guardrails



Guardrails are a positive option on high slope roofs



Personal Fall Arrest Systems Nets

As a Last Resort

Primary Concerns

- Impact Force to the Body Less Than 1800# (with a harness)
- Maximum 6' Free Fall Distance
- May Not Hit Structures Below
- Maximum Weight of Individual w/Tools of 310#

Impact Force

- Minimize Fall Distance
 - Tie off at or above D-ring height wherever possible
- Use Shock Absorbers
- Choose appropriate harnesses, and wear them properly

Fall Distances

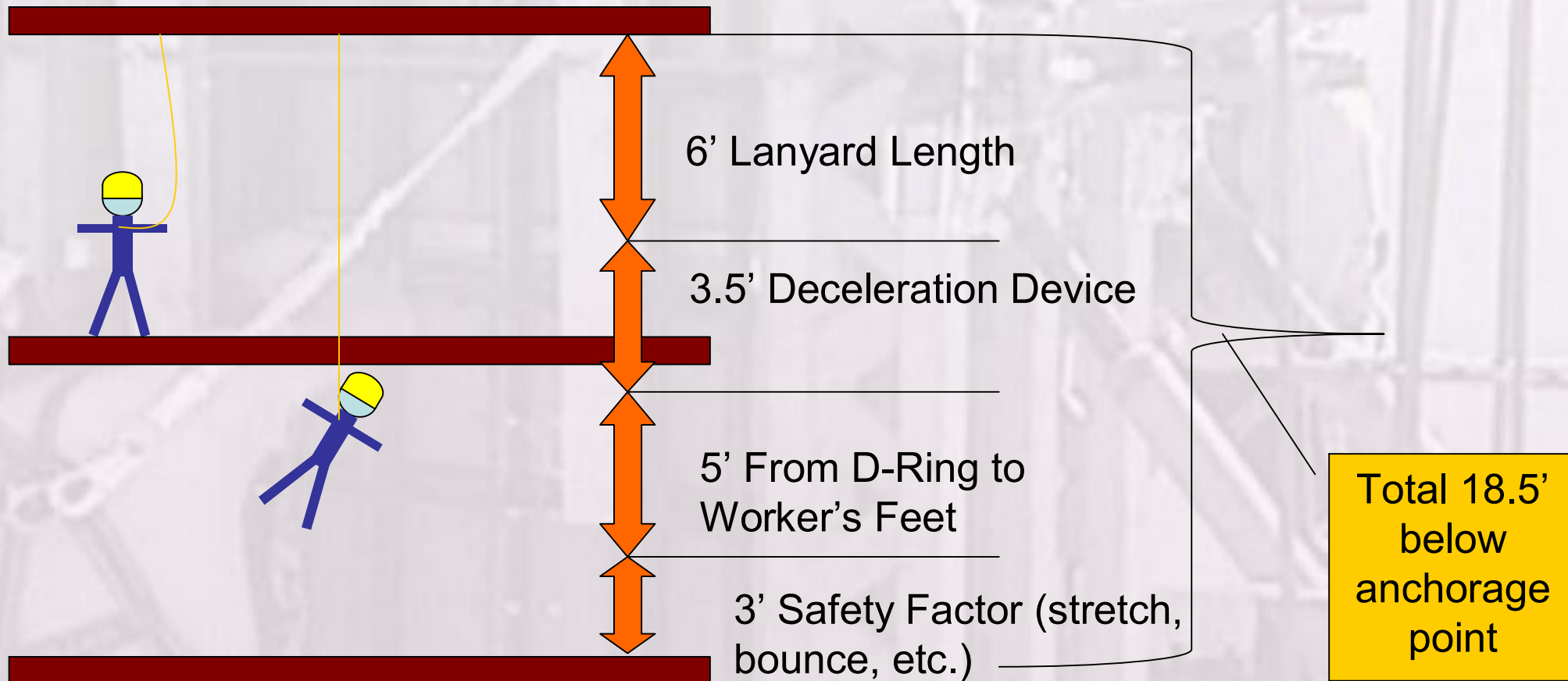
- Total Fall Distance
- Free Fall Distance



Impacting Structures Below (Total Fall Distance)

- Consider:
 - anchorage point location in relation to D-ring height
 - lanyard length,
 - harness elongation,
 - shock absorber opening length,
 - body below D-ring
 - body viscosity (soft tissue injuries!)

Impacting Structures Below (Total Fall Distance)

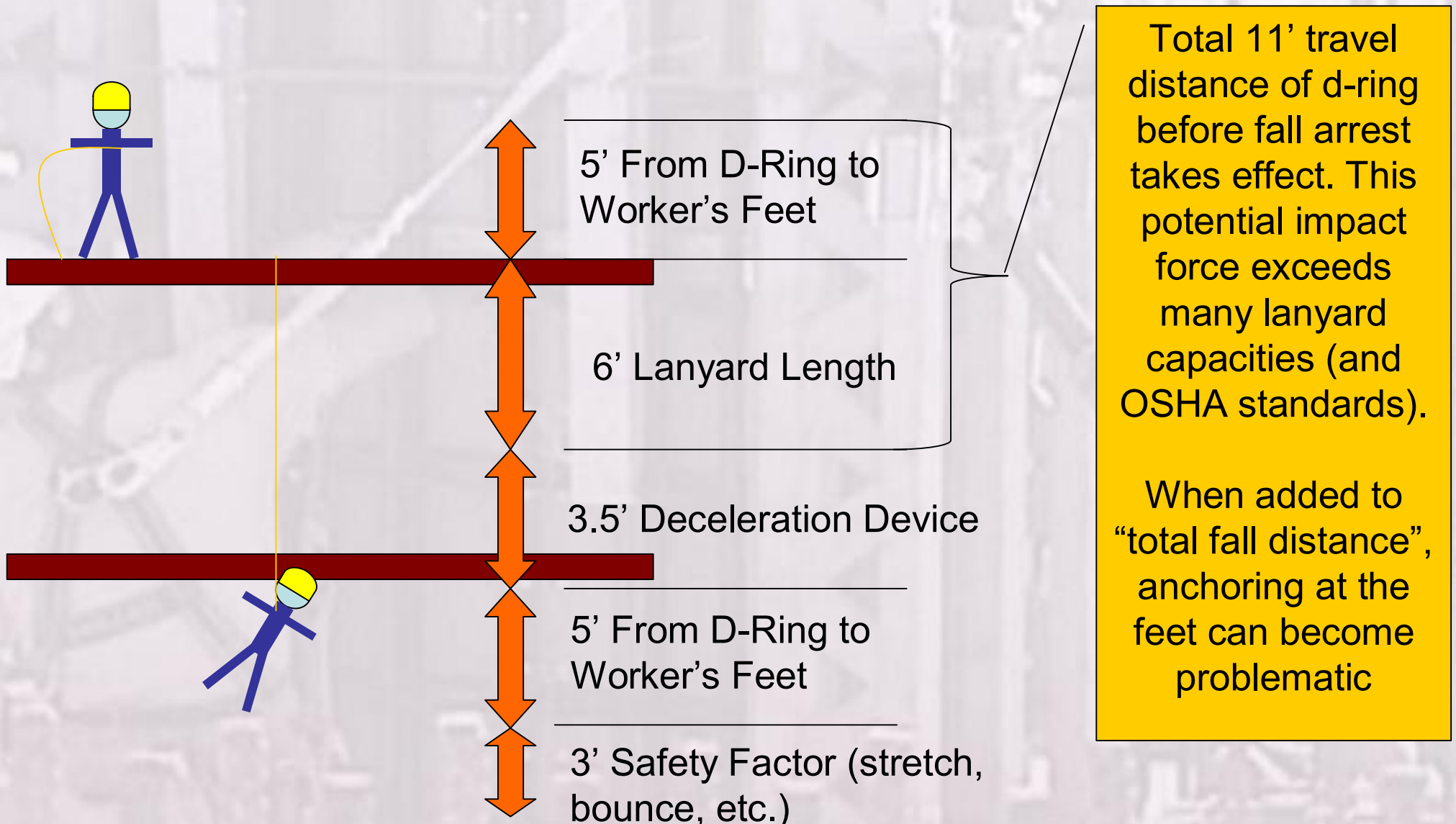


All distances are approximate, and shown for illustration only. This is why it is critical to maintain the safety factor distance!

Free Fall Distance

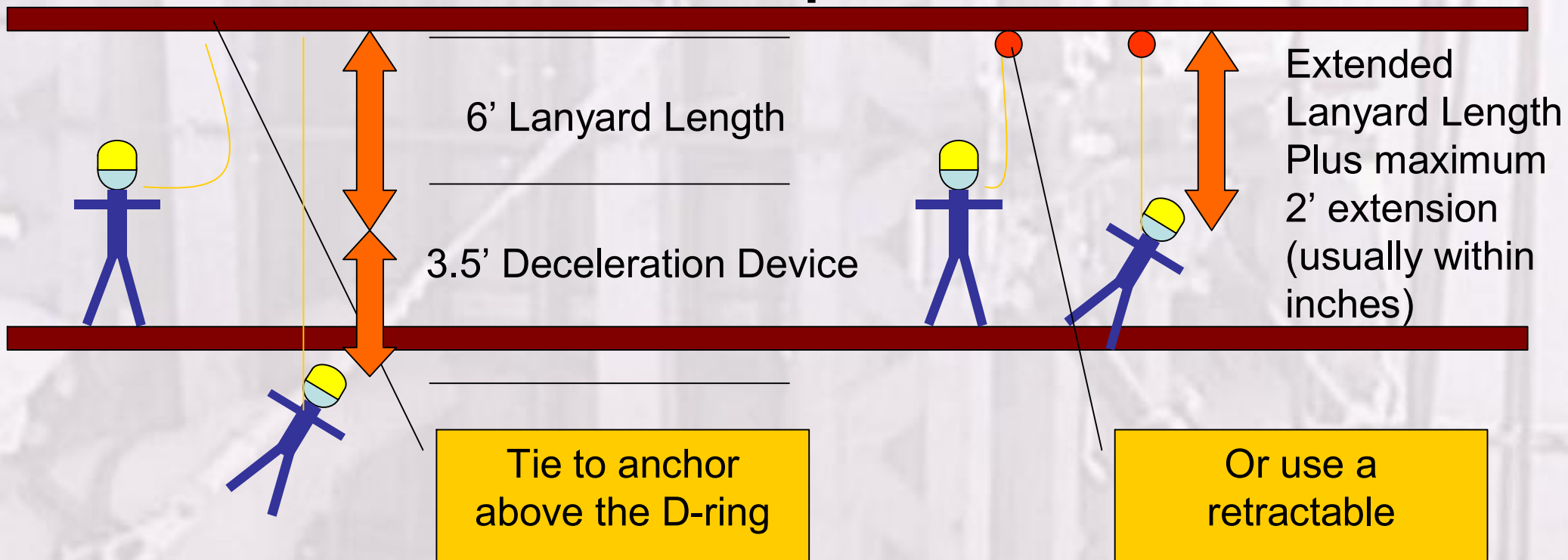
- How far a worker falls before shock absorbing or deceleration equipment begins to take effect
 - Affects both impact forces and total fall distance
- Anchorage point location in relation to D-ring height
 - Below the D-ring allows excessive falls
 - Above the D-ring minimizes free fall to less than 6'

Free Fall Distance or “Vertical Displacement”



All distances are approximate, and shown for illustration only. This is why it is critical to maintain the safety factor distance!

Minimizing Free Fall Distance or “Vertical Displacement”



Using an anchorage above the D-ring and a standard lanyard may still allow an employee to fall a distance that may be difficult to rescue from. Using a retractable minimizes forces on the body, and may make rescue easier (and therefore more timely)

All distances are approximate, and shown for illustration only. This is why it is critical to maintain the safety factor distance!

Practical Implications of Total & Free Fall Distance Added Together

- These workers are tied to the beams they are standing on with choker slings.
- How far will they fall?



Watch Swing Falls

- This worker is tied off using a retractable lifeline.
- There is a major swing fall potential if he fell to either side.



Personal Fall Arrest Systems

- Anchorage
- Body
- Connector

Harnesses



Caribiners



Rope Grabs



Beam Wraps



Positioning

Lanyards



Anchorage

- Must support 5000# per employee attached,
 - Or as part of a complete personal fall arrest system which maintains a safety factor of at least two
 - Or 3000# when using fall restraint or a Self-Retracting Lifeline (SRL, Retractable, or “yo-yo”) which limits free fall distance to 2 feet
- Should always be at or above D-ring height

Roof & Deck Anchors



**Permanent
Anchors**



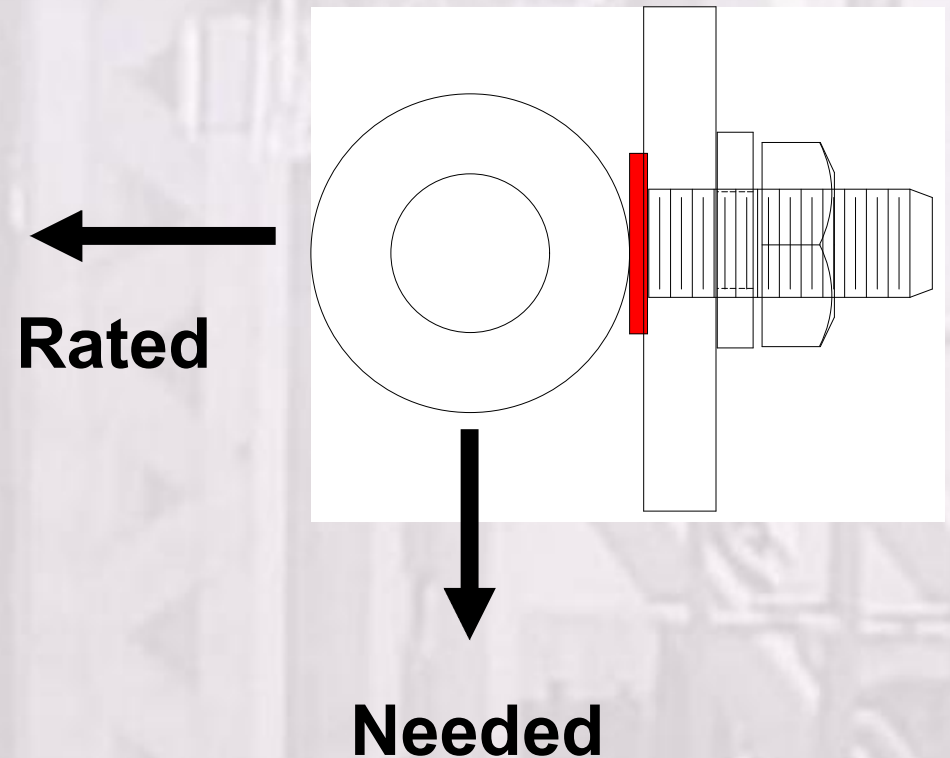
**Wood Roof
Anchor**



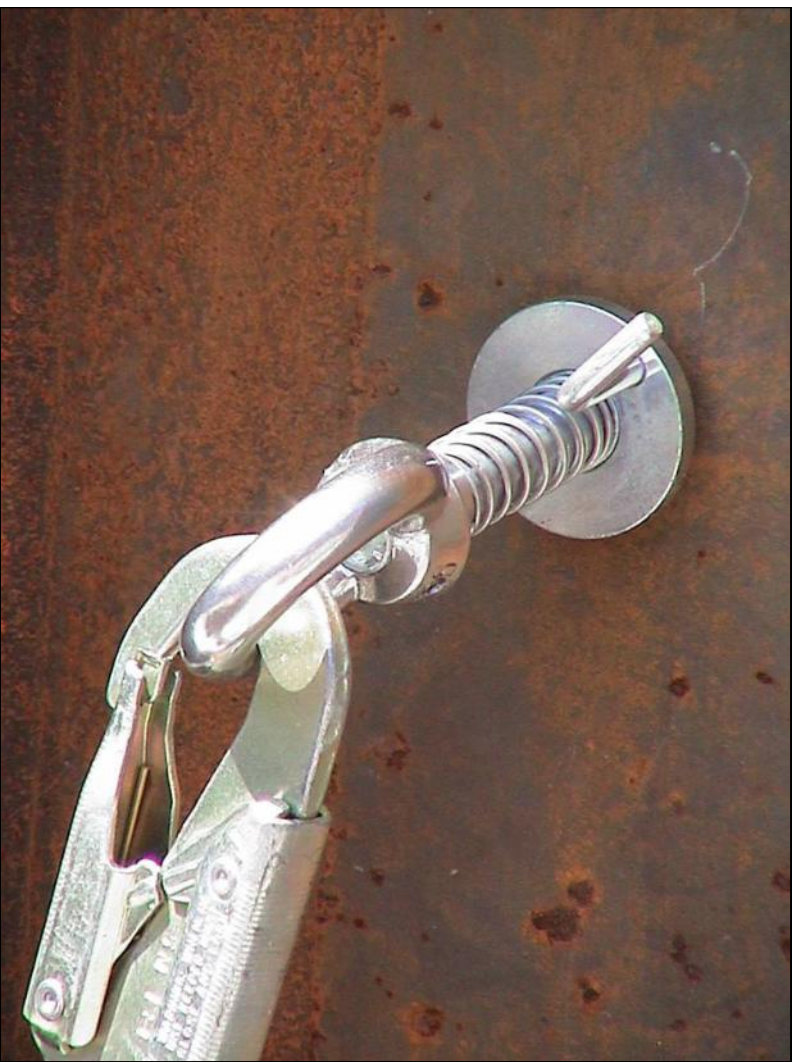
**Metal Roof
Anchor**

Use of Eye Bolts

- Rated for loading parallel to the bolt axis.
- If wall mounted, the rating perpendicular to the axis must be good for 5,000 lbs. per employee



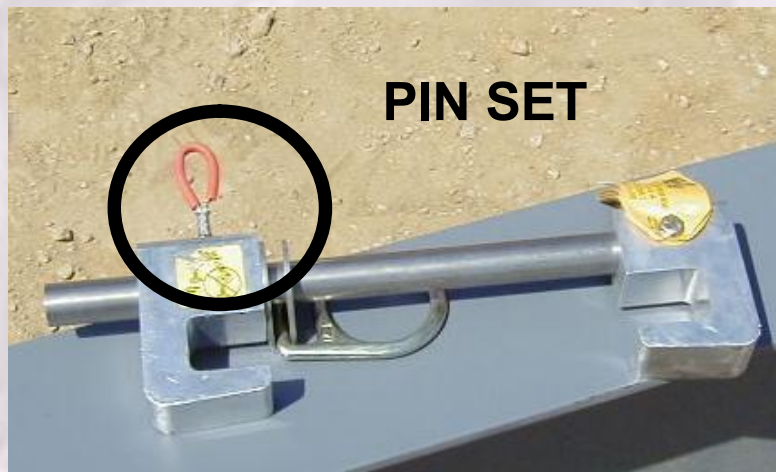
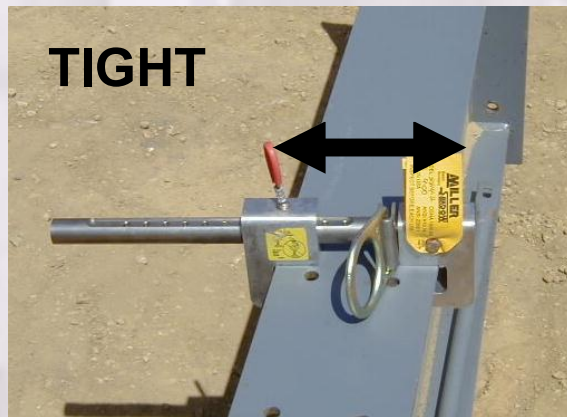
Girder Grip Anchorage Rings



- These attachments can be mounted through bolt holes on steel members.
- They are rated at 5,000 lbs. in all directions

Beam Clamps

Beam clamps can make an effective anchorage when used properly, and with the correct lanyard



Be sure pin is inserted full length and clamp is tight.



***Beware of potential for pulling off of coped ends
on filler beams!***

Horizontal Life Lines



- **Provide maneuverability.**
- **Must be designed, installed and used under the guidance of a qualified person**
 - This could be interpreted as requiring the use of manufactured systems, which is *recommended*

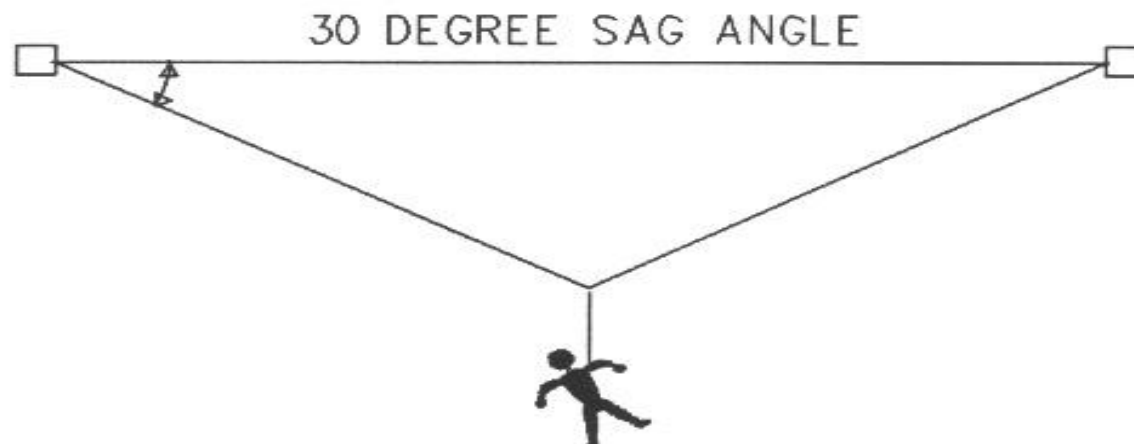
Horizontal Line Engineering

72,000 lb



72,000 lb

5,000 lb

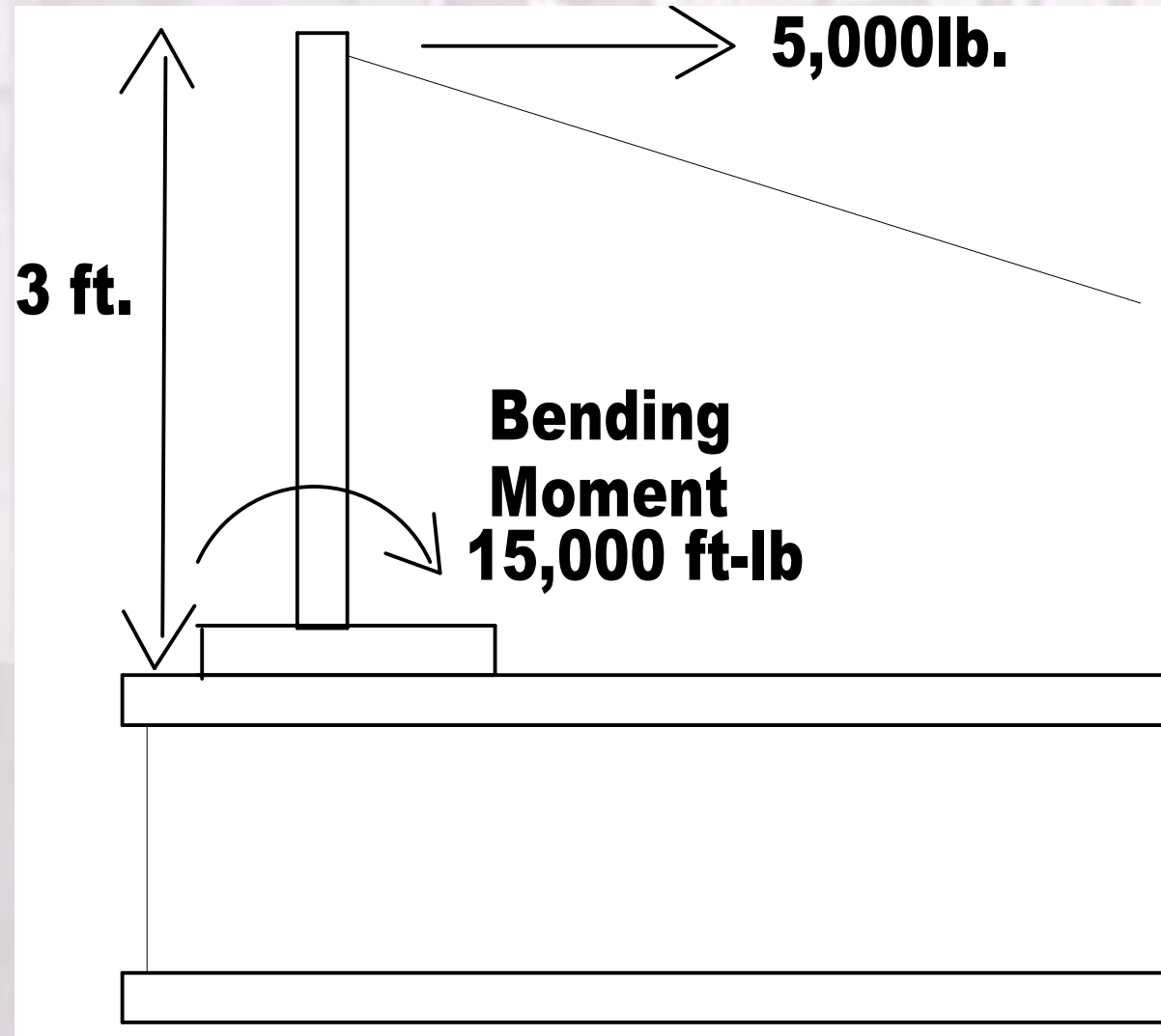


5,000 lb

Anchor stress depends on the sag angle of the line.

Line Stanchions

- The connection of the line stanchion to the flange must support the bending moment applied to the base.



Body (Harnesses)

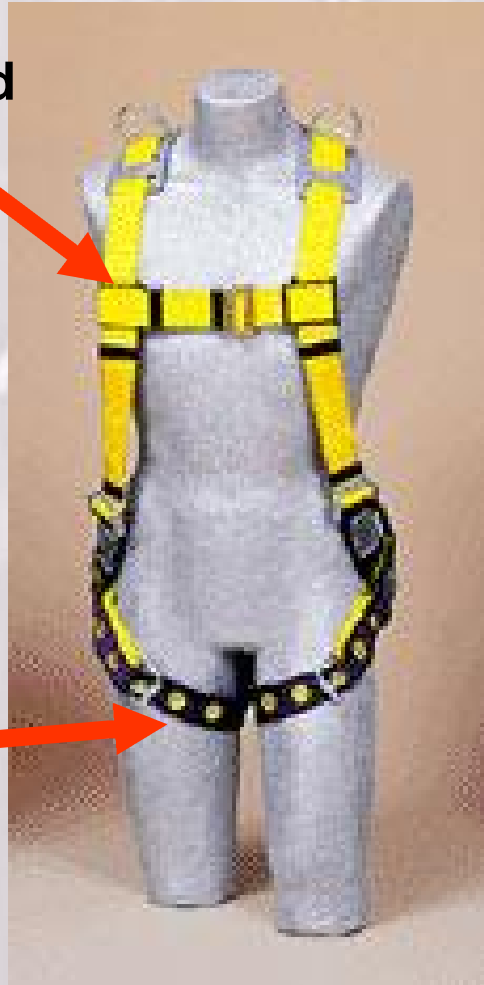
- Need to be inspected frequently (daily before use by the worker, at least monthly by a Competent Person)
- Should never be modified
- Should be taken out of service immediately if defective or exposed to an impact

Harness Fitting

**Chest strap tightened
at mid chest**

**Proper snugness
shoulder to hips**

**Leg straps snug but
not binding**



**“D” ring between
shoulder blades**

**Butt strap
supports the load**



- Harness must be sized for the worker

Proper Adjustment Is Key

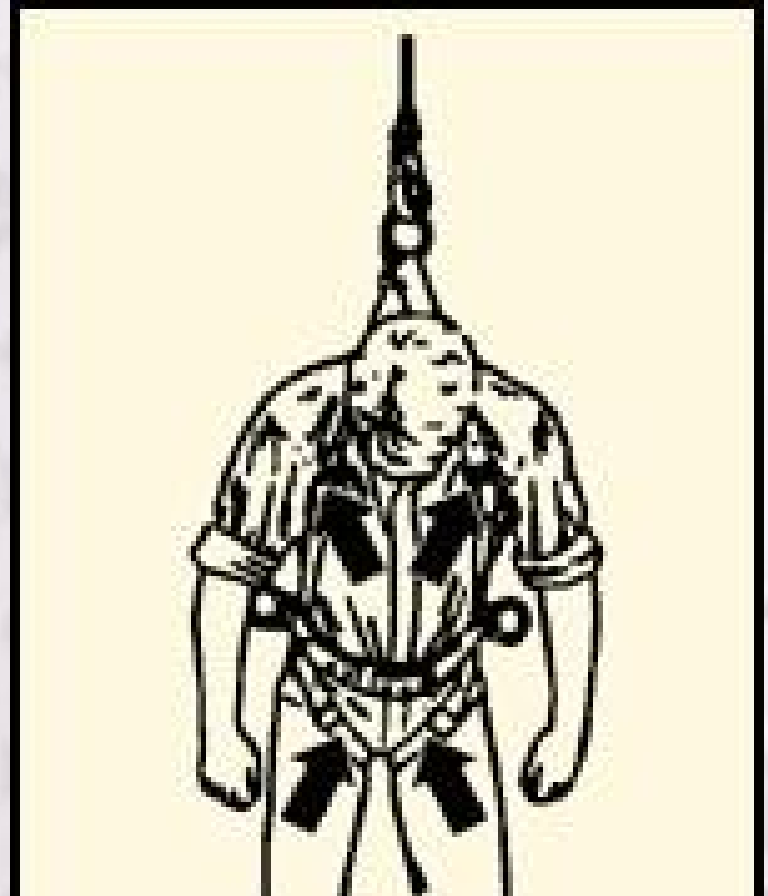
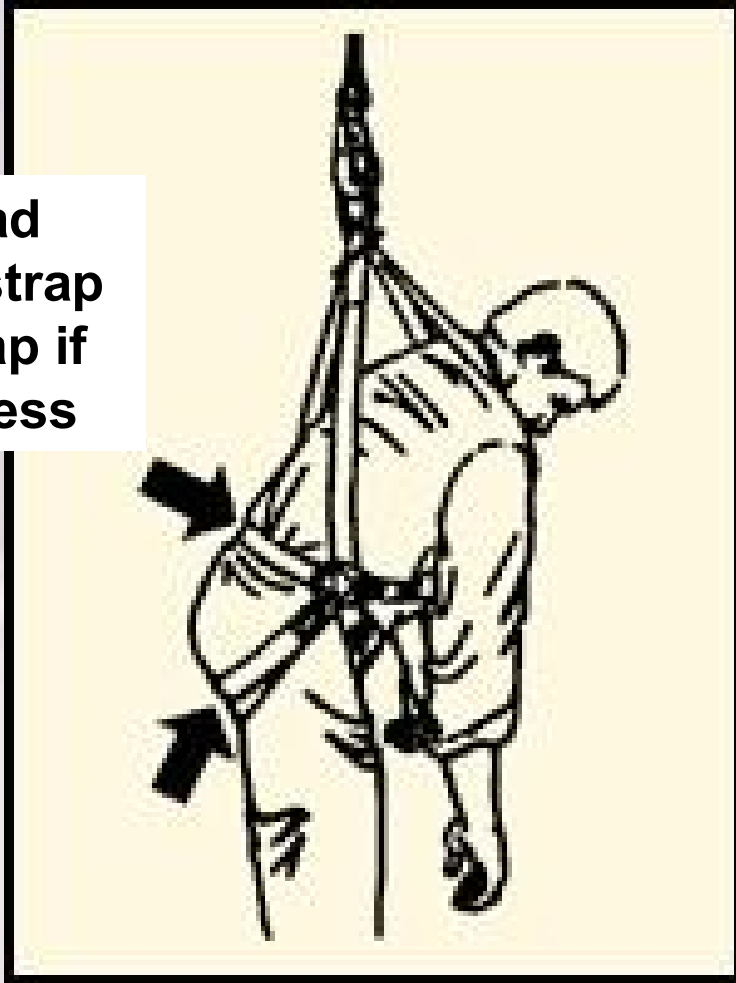


“Rules of Thumb”

- Be able to reach your D-ring with your thumb
- Maximum Four (flat) Fingers of Slack at the legs, straps as high as comfortably possible
- Ensure chest strap is across the chest/breastbone
- Have a buddy double check for twists, etc...

Harness Pressure Points

**Spread load
across butt strap
and belt strap if
on the harness**



**Excess pressure here can
cut blood flow to the legs**

Some studies have indicated permanent damage to the lower extremities when the worker hangs for more than twenty (20) minutes

Connectors (Lanyards)

- Should be inspected before each use
- Should not be tied back to themselves (unless specifically designed for such use)
- Should be worn with the impact absorber/shock pack at the d-ring
- Should have the appropriate clip for the intended anchorage points
 - Do not use large climbing/rebar/ladder hooks with “beamers”

Retractable Lifelines



- Very effective for vertical applications.
- Will normally lock up in 1 –2 feet, minimizing total fall distance and impact forces on the worker's body



Do Not Hook Lanyards to Retractable

- This worker is hooked to a retractable lifeline with his lanyard.
- This can cause hook failures and affect the locking capability of the retractable.
- The retractable should be attached directly to the “D” ring.



Positioning Systems

- Positioning Devices Provide Hands-free Work
 - Additional Fall Protection (tie-off) may be required to move or access



Positioning



Restraint Devices

- Provide Access but Prevent the Fall
- Limit anchorage requirement to 3000#
- May be more suitable for loading areas, scaffold erection and dismantling
- Should be installed and used under the supervision of a Competent Person

Fall Restraint



- Fall restraint assumes the employee cannot reach the edge.
- He is basically on a short leash.
- If the employee could reach to the edge and fall over the edge, he must be in fall arrest.

Use of Restraint Cables

Example of restraint cables used during deck anchoring.



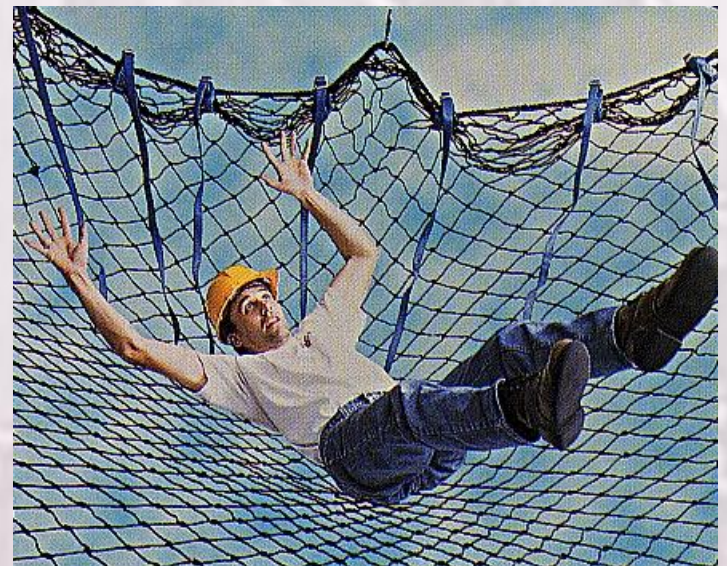
RESTRAINT CABLE

Will This Work?

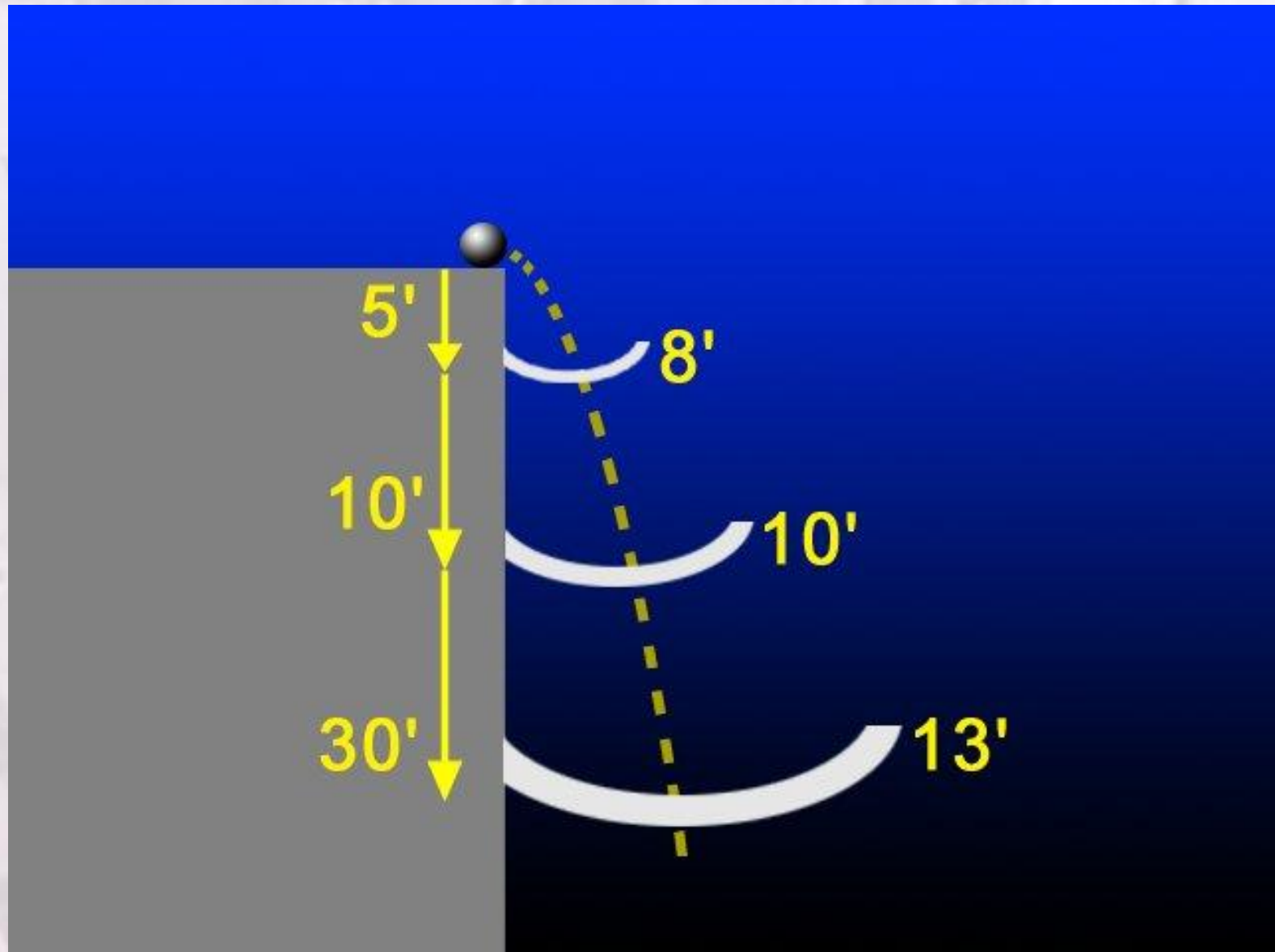


Use of Safety Nets

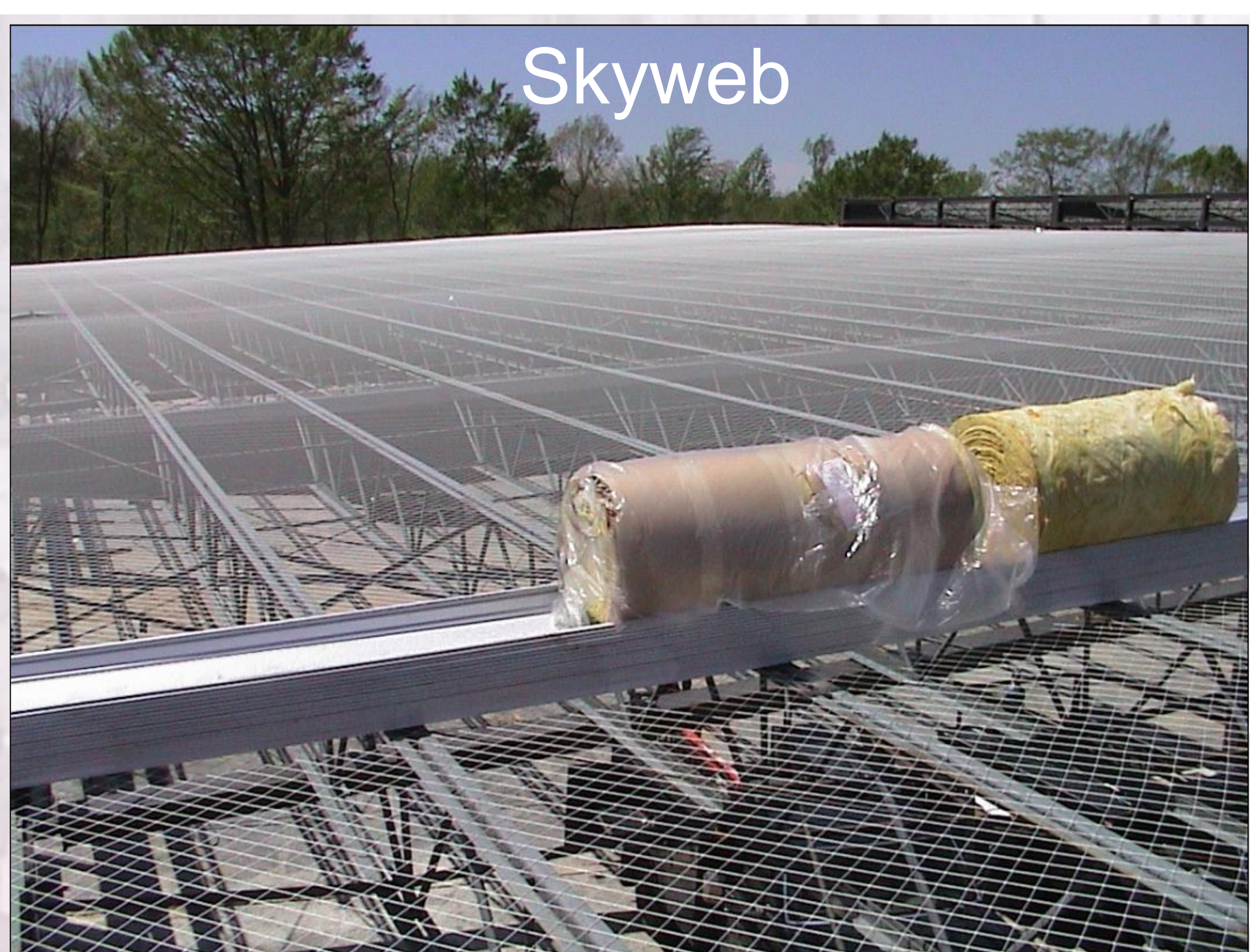
- Assumes the fall will occur
- Assumes adequacy of the system (or requires testing)



Nets



Skyweb





Planning For Rescue

Worst-case Scenario?

When All Works!



Rescue Plan Put Into Motion

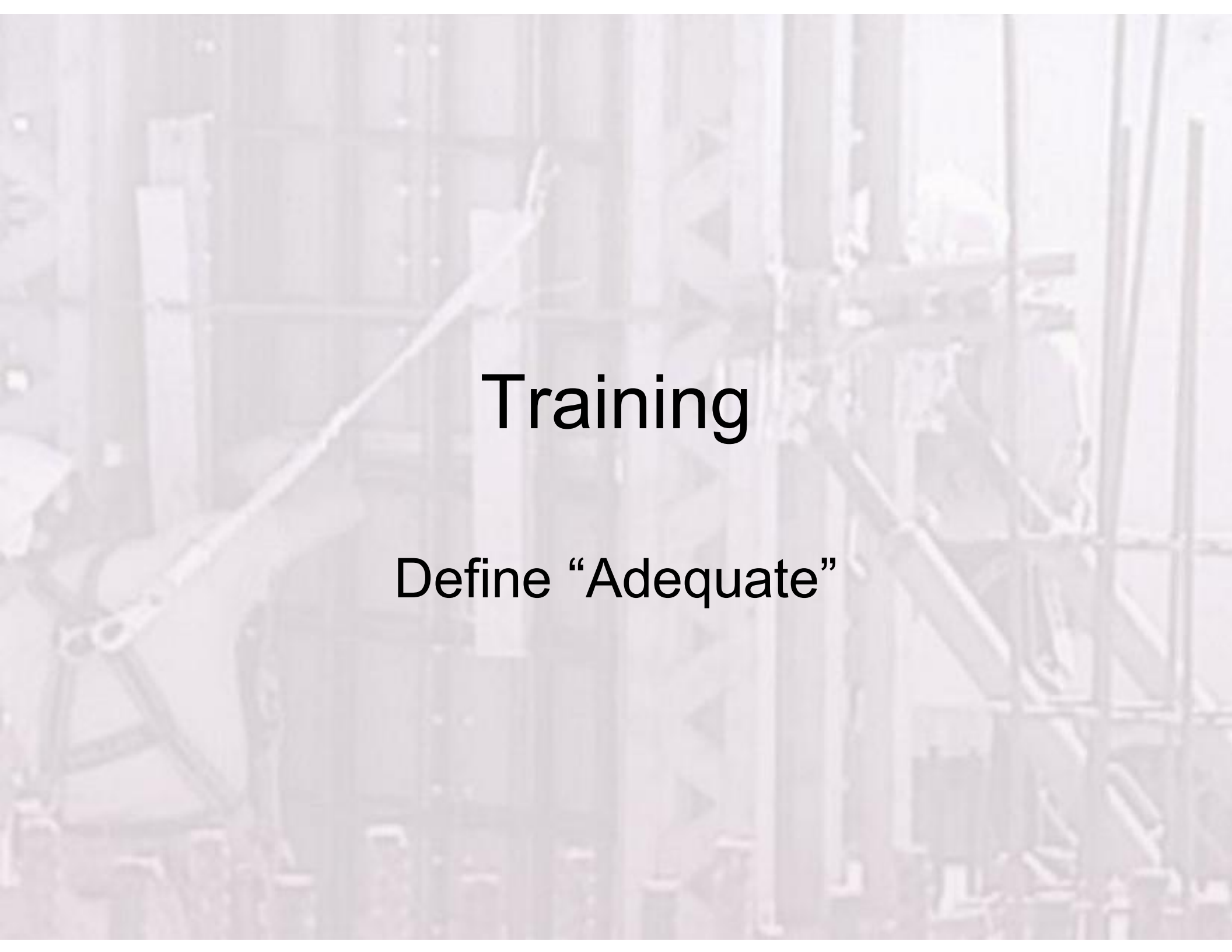


Safe



On The Ground And Still Alive!





Training

Define “Adequate”

Training

- By a “qualified” or “competent” person
- The nature of hazards
- Appropriate systems and use
- Limitations
- Evaluated
- Re-training
- Documentation/Certification?

Classroom



Hands-on



Site Specific



Planning for Fall Protection

- Best practice dictates that fall protection becomes an integral part of the project planning process, from constructability, to systems installation, to use and maintenance
- A project cannot be truly safe unless fall protection is incorporated into every phase of the construction process
- Planning will keep workers safe and minimize liability for all parties involved