

*Leading the Way to Safety  
with the*

# LEADING EDGE FALL PROTECTION SYSTEM



*A Manual for Installation and Use*

*Leading edge work is among the most hazardous tasks in steel erection. Our research found that the Leading Edge Fall Protection System enabled self rescue and prevented the death or injury of six ironworkers on six sites. This DVD provides contractors with an introduction to this system, its installation and use.*

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# **LEADING EDGE FALL PROTECTION SYSTEM**

*A Manual for Installation and Use*

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# LEADING EDGE FALL PROTECTION SYSTEM

*An Manual for Installation and Use*

This manual describes how to install and use the Leading Edge Fall Protection System, which is designed to protect structural ironworkers from the unique fall hazards of metal decking installation. The manual and companion DVD, “A Leading Edge Fall Protection System for Metal Decking,” are intended for contractors, supervisors, ironworkers, engineers, fabricators, and others who design, evaluate, inspect, maintain, or use the Leading Edge Fall Protection System. The manual and DVD can also be used in OSHA-required fall protection training for steel erection (29 CFR 1926.761).

Although decking installation is a hazardous job, ironworkers have been reluctant to use personal fall-arrest systems for fear that harness lanyards could get tangled and cause their own safety problems. With anchors below shoulder level, there was a chance a worker would hit the deck below in a fall. No system sounded truly safe.

Researchers for CPWR-The Center for Construction Research and Training heard of an above-the-shoulder fall arrest system designed and used by Rhode Island-based Capco Steel Inc. The researchers evaluated studies over a 3.5-year period on six different construction sites. During that period, the Leading Edge Fall Protection System enabled six workers to perform self-rescue and to escape without injury.

CPWR, as a research, training and service institution, is now introducing this system to steel erection contractors and construction users nationwide. The Leading Edge Fall Protection System is easy to use, inexpensive and has been proven effective in arresting falls to ironworkers while installing metal decking.

Using available materials found on any steel erection site plus this manual, DVD, and trained personnel, contractors and owners can make one of the most hazardous tasks in construction into a safe one.

**Using materials already available on site, this system transforms a hazardous operation into a safe one – easily and inexpensively.**

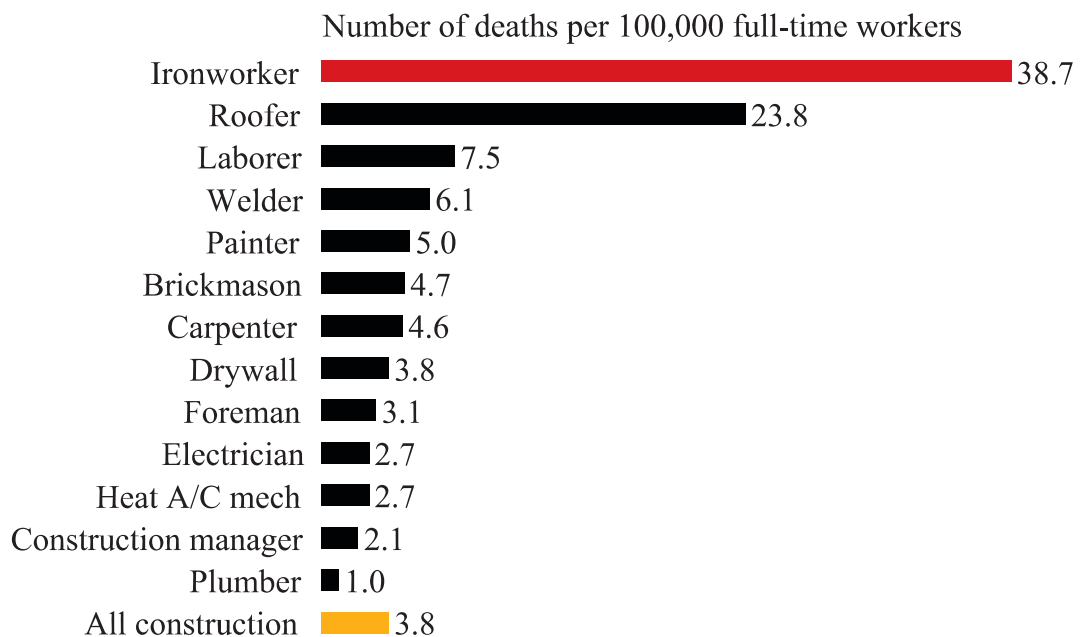
## Why is leading edge fall protection necessary?

Installing metal decking during construction of steel-frame buildings is one of an ironworker's most dangerous tasks. During this task, ironworkers spread metal sheets over narrow structural beams to form the building's flooring, constantly creating a new working surface called the "leading edge." Ironworkers risk falling off the unprotected sides of the work zone's leading edge. They also risk falling due to structural collapse. From 2000 to 2009, 25 union ironworkers died while installing decking.<sup>1</sup>

**Ironworkers die from falls at a rate 10 times higher** than the construction average.<sup>2</sup> Reducing the risk of falls from a leading edge is one of the most important tasks an engineer, architect or contractor can employ.

### Rate of Deaths from Falls

(Selected construction occupations, 2003-2005 average)



Source: *The Construction Chart Book*, fourth edition, Chart 37b. Published by CPWR – The Center for Construction Research and Training, 2008.

## How the leading edge fall protection system protects workers

Conventional fall protection methods are effective for many structural steel erection tasks, but they are impractical for leading-edge decking work.

- **Guardrails** cannot be attached at the leading edge because the decking work zone is constantly moving forward as new decking is laid down.
- **Safety nets**, which must be placed under the work zone, are not practical for use with the constantly moving work surface. In addition, in most cases, the required 25 feet of clearance for safety nets is not available due to the metal deck on the floor below. The lack of clearance between the nets and the floor means that a worker could fall and strike the structure, equipment, or floor below.
- With **conventional horizontal lifelines**, the worker's lanyard is attached below shoulder level, creating a fall distance that could allow the worker to hit the deck below. Workers may also entangle their lanyards when connected to the same horizontal lifeline.

Because no viable solutions were available for decking operations, the new negotiated rule on structural steel erection, Subpart R of OSHA's construction regulations, allows specially trained workers installing metal decking inside a controlled decking zone with fall hazards of less than 30 feet or two stories to work without fall protection.<sup>3</sup> Workers not installing decking are not allowed inside this controlled zone.

The leading edge fall protection system is designed to control the unique fall hazards posed by leading edge work. The system calls for a series of pre-punched holes in the metal columns for securing life-lines in an arrangement that protects the workers in the decking work zone. Because the holes must be punched by the fabricator BEFORE the columns are erected, *preplanning for this system is essential*. The leading edge fall protection system provides an anchor at seven feet above the deck, creating a smaller fall distance than conventional methods, which are anchored below shoulder level.

**NOTE** The leading edge fall protection system is only one piece of an effective fall prevention program. To ensure that workers are fully protected from falls, the program must also include:

- Preplanning, including job hazard analysis;
- Construction process plan;
- Task-specific fall protection and other personal protective equipment (PPE); and
- Training on the selection, use, maintenance, and limitations of fall protection and other PPE.

*These fall protection program elements are discussed in detail beginning on page 10.*

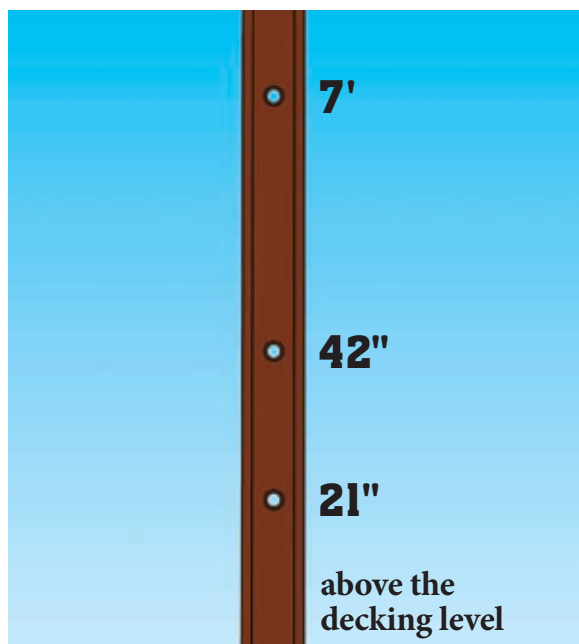
## How to install the leading edge fall protection system

### STEP 1:

**Before delivery, work with fabricator to pre-punch holes in columns.**

The system uses a series of holes that are pre-punched in the web or flange of the structural columns. The holes must be punched by the fabricator BEFORE the columns are delivered to the site, *thus preplanning is an essential step in the process*. The holes are punched three levels: 7 feet (84 inches), 42 inches and 21 inches above the decking levels.

- The holes at 7 feet (84 inches) above deck level are for horizontal lifelines. This height allows a lanyard to be attached to the lifeline above shoulder level, decreasing the fall distance and the likelihood that a falling worker will strike the deck below.
- The holes at 42-inches and 21-inches above deck level are available for attaching guardrails at the perimeter or for interior edge protection as needed.



*Ask your fabricator to pre-punch holes in metal columns.*

### STEP 2:

**Have a Qualified Person\* review design.**

Before the fall protection system is installed, a Qualified Person\* should review the site-specific design. In special circumstances, a registered professional engineer should evaluate or design the system.

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\*OSHA, 29 CFR 1926.32(l), defines "Qualified Person" as "one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project."





*Engineers and contractors can choose from one of three ways to install the horizontal lifelines.*

### **STEP 3:**

## **Select a method for installing the horizontal lifelines (cables).**

### **Installation Methods**

There are three different methods for installing the horizontal lifelines through the seven-foot high pre-punched holes, depending on the individual site conditions.

**METHOD 1:** Once the pre-punched columns have been erected, install the lifelines (cables) from aerial lifts. In this instance, the workers must be tied off to the aerial lift.

**METHOD 2:** Before the columns are erected into place, attach retractable lifelines to the columns to provide fall protection for the worker who is installing the leading edge fall protection system. A tag line is attached to the lifeline hook so that, after erection of the pre-punched column, the worker can pull out the line from the ground and attach it to his/her body harness. The worker can then climb the pre-punched column and perform the work of installing the lifelines with 100% fall protection.

**METHOD 3:** Before the beams are put into place, attach a Beam Post System, available from commercial suppliers, to the beam. This Beam Post method provides a pre-engineered horizontal lifeline system. The system is erected on the ground and is ready to use when the beam is lifted and secured in place. Safety net cables, where appropriate, can also be placed in the web of beams on the ground and lifted into place.

**NOTE** 100% fall protection must be provided for workers installing the fall protection system. Also, the exact erection sequence needs to be preplanned and erected under the supervision of a Competent Person.\*

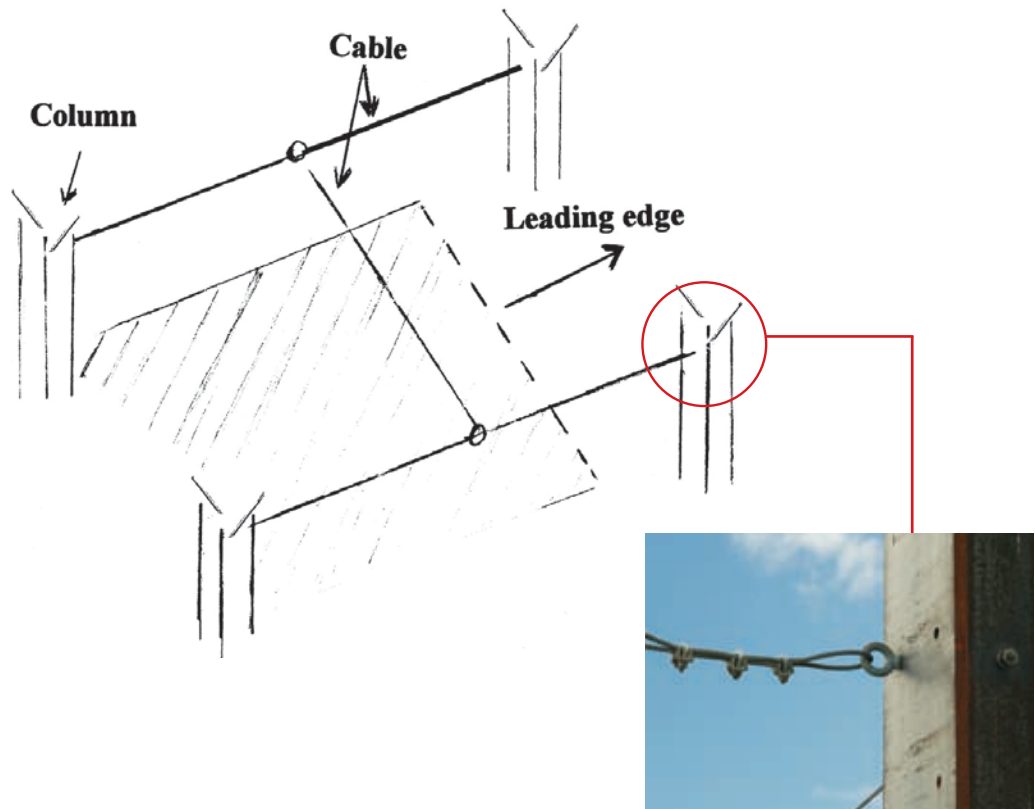
\* OSHA, 29 CFR 1926.32(f), defines Competent Person as “one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.”

#### STEP 4:

Attach the lifelines (cables) through the seven-foot high pre-punched holes.

1. String continuous cables through the pre-punched holes at the 7 foot level, parallel to the direction in which the leading edge is moving, as shown in the diagram below.
2. Attach a third cable perpendicular to the first two cables, with the two ends attached to these cables. The third cable can slide along the other two cables as the leading edge moves forward.

**TIP** Horizontal lifelines can be either engineered by a professional engineer or purchased as pre-engineered systems from manufacturers. When only two workers are engaged in installing the leading edge, you will not need the perpendicular cable, only the parallel cables.



*Leading edge fall protection system: cable configuration*

## STEP 5:

### Attach lanyards with shock absorbers.

Attach lanyards with shock absorbers to reduce the maximum arresting force and to minimize strain on the horizontal lifelines and on the worker. The lanyards can be connected to all three horizontal cables to provide fall protection for workers installing the decking. This arrangement prevents the tangling of lanyards that occurs with conventional waist-high systems. **Retractable lifelines should not be used because they should only be attached to a fixed anchorage point. Horizontal lifelines are not a fixed anchorage point.**



*Body harness, lanyard and shock absorber for tying off to leading edge fall protection.*

## Using the leading edge fall protection system

A decking crew typically consists of three people: one person on each end of the decking being positioned into place, and a third worker attaching the decking to the structure. **Only those workers actually performing decking operations are allowed into potential fall areas.**

Each of the three workers in the decking zone must be tied off to the leading edge fall protection system at all times, using the lanyards with shock absorbers described in Installation, Step 5. The two workers installing the decking tie off to the side horizontal lifelines and the worker attaching the decking to the structure ties off to the horizontal lifeline perpendicular to the other two lifelines.



*The three workers must be tied off to the system at all times.*

## Elements of an effective fall protection program

### *Preplanning*

Preplanning for fall prevention involves identifying hazards in advance, eliminating them where possible, and managing those that cannot be eliminated. Preplanning ensures that each contractor performing an operation will have the necessary materials and equipment on hand when needed. *Due to the speed of construction work, time does not allow a single operation to continue long enough to become safe through trial and error.*

The job hazard analysis (JHA), described in the ANSI A10.33 standard on health and safety programs,<sup>4</sup> can be used as a guide in preplanning. The method has three steps:

1. Describe the operation, task, or subtask
2. Describe any unsafe conditions or hazards associated with the operation
3. Identify the preventive or corrective action for the unsafe conditions.



A typical JHA for structural steel erection of high-rise buildings evaluates fall hazards in two major task categories:

- Erection tasks: Shake out of steel, lifting (hoisting), anchor bolts, setting of columns, beams, decking, joists and structural roofing.
- Subtasks: Connecting, bolting up, spreading decking, welding, crimping and screwing.

The information gathered during the JHA is used to select the most effective intervention. In addition, the findings can be used to develop site-specific fall protection training, required by OSHA. The table below presents typical fall and stability hazards associated with structural steel tasks and subtasks.

### Fall and Stability Hazards Associated with Steel Erection Tasks and Subtasks

TASK	HAZARD	SOLUTIONS
Shake out of steel (preparing steel for erection)	Collapse, rolling, crushing	Site layout; site specific erection plan construction sequence.
Lifting (hoisting)	Collapse, falls, unstable structure	Preplanning, protection for employees exposed to overhead hazards (hard hats), fall protection. (active -passive)
Setting (erection) of columns	Collapse, falls, unstable structure falls	Preplanning, anchor bolts, fall protection, guying of structure
Placing beams	Unstable structure, collapse, falls	Guying, fall protection, lifts
Decking including welding, crimping and screwing	Collapse, falls	Structural fall protection, preplanning
Joists	Collapse, falls	Fall protection, erection sequence, build on ground and lift
Structural roofing	Collapse, falls	Fall protection, guying
Connecting	Collapse, falls	Guying, lifts, fall protection, anchor bolts
Bolting up	Falls	Fall protection, lifts
Plumbing of structure	Collapse, falls	Preplanning, lifts, fall protection

*For solutions to other hazards such as sprains and strains, welding fume and noise in structural steel erection, please go to [www.cpwrConstructionSolutions.org](http://www.cpwrConstructionSolutions.org).*

## ***Construction process plan***

The construction process plan describes the “means and methods” of the project and goes hand-in-hand with preplanning for fall and stability hazards. The plan should detail the following:

- the erection sequence,
- wind loads,
- stability of components and structure; and
- procedures for safe construction of the project, including use of temporary structures and bracing.

Buildings and structures are often not designed to have structural integrity until they are completed. Therefore, the general contractor/construction manager or controlling contractor must ensure that:

1. subcontractors are aware of unstable component structures; and
2. the erection sequence plan affords adequate safety from collapse.

## ***Fall protection***

Fall protection must be designed to fit the specific task and must address the fall hazards identified for that task. When selecting fall protection, follow these basic principles of fall protection:

- First, eliminate as many hazards as possible by changing plans, erection sequences, or means and methods.
- Then, manage those hazards that cannot be eliminated using passive or active fall protection systems.

## ***Training***

“Lack of training” and “deficient training” are among the most frequently cited OSHA violations. Fall protection training must comply with the provisions of OSHA 29 CFR 1926.21 (Safety Training and Education) and 29 CFR 1926.503 (Fall Protection Training Requirements).<sup>5,6</sup> Training must be provided to each worker who might be exposed to fall hazards. Also, each worker must have a written training certification record before being allowed to perform an assigned decking task. According to 29 CFR 1926.503, the employer must assure that each employee receives training by a Competent Person qualified in the following areas:

- Nature of the fall hazards at the site;
- Correct procedures for erecting, maintaining, disassembling, and installing the fall protection systems to be used;
- The use and operation of guardrail systems, personal fall arrest systems, safety net systems, warning line systems, safety monitoring systems, controlled access zones, and other protection to be used;
- The role of each employee in the safety monitoring system when this system is used;
- The correct procedures for the handling and storage of equipment and materials and the erection of overhead protection; and
- The role of employees in fall protection plans.

Further, the employer is required to ensure that each employee is retrained, according to the provisions in 1926.503(c).

## ***Leading Edge Fall Protection Training Topics***

In order to comply with OSHA training requirements, employees expected to use the leading edge fall protection system must receive training on the following topics:

1. Pre-phase planning and recognition of the hazards involved in the decking operation.
2. “Means and methods” employed, from the delivery and staging of the decking, to the spreading and attaching of the deck, until the project is turned over to the controlling contractor as a finished floor.
3. Installation, use, and disassembly of all fall protection systems to be employed for the decking operation, as well as the limitations of the fall protection systems.
4. Inspection, care, use and maintenance of all components of the fall protection equipment, passive as well as active fall protection equipment.
5. Choosing, fitting, and donning of fall protection equipment, such as the harness and lanyard, as well as manufacturers’ warnings and instructions for equipment inspection, care, and use.
6. Inspection, care, use, and maintenance of additional equipment such as vertical or horizontal lifelines, either engineered for the application or pre-engineered by a manufacturer.
7. How to safely approach the leading edge and attach to the horizontal lifeline.
8. How to remain 100% protected from falls during the decking operation.
9. Rescue procedures in the event of a fall, including employees’ individual roles and responsibilities.
10. Basic first aid.



*OSHA requires that training be provided to each worker who might be exposed to fall hazards.*

## Not just safety: Business reasons for using this system

The leading edge fall protection system does more than save lives and prevent injuries to workers. Contractors using the system could find that it can help them avoid serious financial and business issues, such as:

- Avoid increases in insurance rates
- Reduce the number of costly workers' compensation claims
- Litigation stemming from accidents and wrongful death suits
- Bad publicity
- Loss of company reputation
- Being placed on a "no bid" list

Frank Migliaccio, executive director of safety and health for the International Ironworkers Union, knows that union-owned companies that accumulate a number of injuries and safety problems on jobsites can find skilled ironworkers may refuse to work for an unsafe company.

### Economic Costs\*

(Fatal and nonfatal injuries in the construction industry)

*These figures do not include employer costs for workers' compensation premiums.*

**\$13 Billion** total estimated annual cost

**\$7.8 Billion:** Injuries and illnesses

**\$5.2 Billion:** Deaths

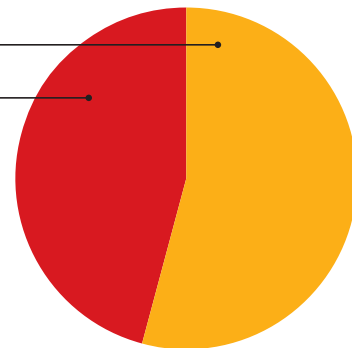
*These estimates include:*

**Direct costs** (medical, wage replacement)

**Indirect costs** (production/household losses)

**Quality-of-life costs** (pain and suffering )

**NOTES:** Calculating an accurate estimate of costs is difficult because some costs like pain & suffering are extremely difficult to quantify.



#### Estimated costs for structural steel workers:

**\$239 Million:** Injuries and illnesses

**\$161 Million:** Deaths

Source: *The Construction Chart Book*, fourth edition. Page 48. Published by CPWR – The Center for Construction Research and Training, 2008.

\*All numbers are in 2002 dollars.





*Berlin Steel's Vice President and Corporate Safety Director James E. Bass Jr. talks over plans for filming his decking crew using the new fall protection system with Dave Ogden of MetaMedia, Dan Paine of Innovative Safety, and Michael McCann of CPWR.*

*“Six sites, six self-rescues. That speaks for itself in the usefulness of this system.”*

— **DAN PAINE**  
Innovative Safety

*“Over a three-and-a-half year period, the [leading edge fall protection] system itself has saved from injury or fatalities six ironworkers. That alone is why I think you, as a company, should use this system.”*

— **FRANK MIGLIACCIO**  
International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers

*“If we can send people home and have ironworkers at the end of their 20 or 30-year career not limping or bent over and beat up, that’s the name of the game.”*

— **MIKE CAPARCO**  
Owner, Capco Steel Inc., the company that created the Leading Edge Fall Protection System

*“Safety performance is always best when it’s done proactively. We are very proactive in our safety program, and we start with safety planning long before the steel ever hits the site.”*

— **JAMES E. BASS JR.**  
Vice President and Corporate Safety Director, Berlin Steel Construction Company

*“The system is cost effective because it eliminates the potential for fall exposure and, as we all know, falls produce a lot of cost to the bottom line of contractors.”*

— **WAYNE RICE**  
Former Vice President of Association Services, TAUC: The Association of Union Constructors

## References

1. Migliaccio, F. Personal communication. Washington, DC: International Union of Ironworkers, 2010.
2. CPWR—The Center for Construction Research and Training. The Construction Chart Book. 4th edition. Chart 37b. Silver Spring, MD: CPWR, 2008. [http://www.cpwr.com/pdfs/CB%204th%20Edition/31\\_50%20Safety%20and%20Health.pdf#page=13](http://www.cpwr.com/pdfs/CB%204th%20Edition/31_50%20Safety%20and%20Health.pdf#page=13)
3. Occupational Safety and Health Administration. 29 CFR 1926. Safety Standards for Steel Erection; Final Rule. Federal Register 66 (January 18, 2001): 5196-5280. [http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=FEDERAL\\_REGISTER&p\\_id=16290](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=16290)
4. American Society of Safety Engineers. ANSI A10.33-1998 (R2004) Safety and Health Program. Chicago: ASSE, 2004. (No URL available.)
5. Occupational Safety and Health Administration. 29 CFR 1926.21 Safety Training and Education. Subpart C - General Safety and Health Provisions. [http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=10607](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10607)
6. Occupational Safety and Health Administration. 29 CFR 1926.503 Training Requirements. Subpart M - Fall Protection. [http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=10759](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10759)

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