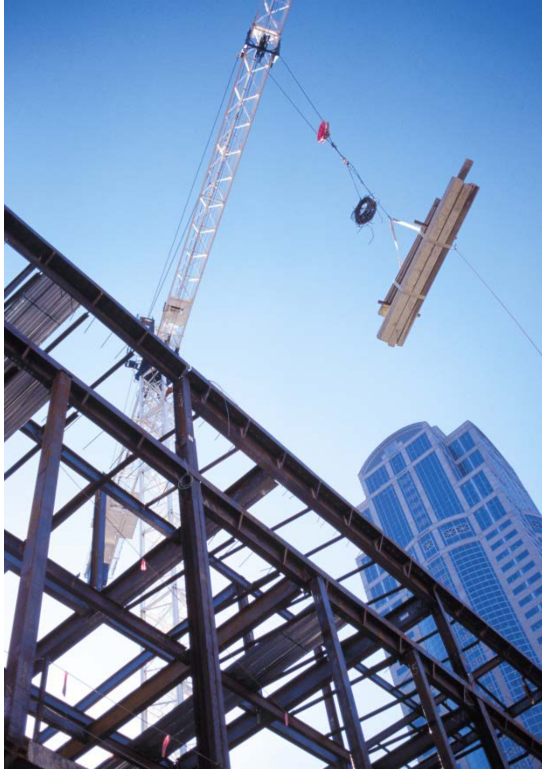


Photo courtesy of Thinkstock

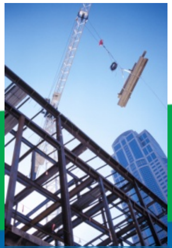
Structural Steel Design

EDUCATION MODULE

Developed by T. Michael Toole, Ph.D., PE
Daniel Treppel
Stephen Van Nosdall
Bucknell University

Guide for Instructors

Topic	Slide numbers	Approx. minutes
Introduction to Prevention through Design (PtD)	5–29	45
Design, Detailing, and Fabrication Process	30–36	10
Erection Process	37–41	10
Examples of Prevention through Design	42–77	50
Recap	78–79	5
References and Other Sources	80–86	—



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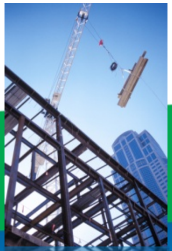
Learning Objectives

- Explain the Prevention through Design (PtD) concept.
- List reasons why project owners may wish to incorporate PtD in their projects.
- Identify workplace hazards and risks associated with design decisions and recommend design alternatives to alleviate or lessen those risks.



Overview

- PtD Concept
- Steel Design, Detailing, and Fabrication Process
- Steel Erection Process
- Specific Steel PtD Examples

Photo courtesy of Thinkstock

Introduction to Prevention through Design

EDUCATION MODULE

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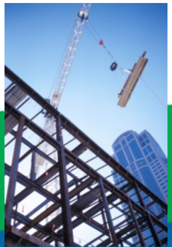
Occupational Safety and Health

- Occupational Safety and Health Administration (OSHA) www.osha.gov
  - Part of the Department of Labor
  - Assures safe and healthful workplaces
  - Sets and enforces standards
  - Provides training, outreach, education, and assistance
  - State regulations possibly more stringent
- National Institute for Occupational Safety and Health (NIOSH) www.cdc.gov/niosh
  - Part of the Department of Health and Human Services, Centers for Disease Control and Prevention
  - Conducts research and makes recommendations for the prevention of work-related injury and illness



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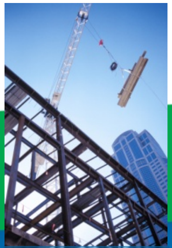
Construction Hazards

- Cuts
- Electrocution
- Falls
- Falling objects
- Heat/cold stress
- Musculoskeletal disease
- Tripping

[BLS 2006; Lipscomb et al. 2006]

Graphic courtesy of OSHA



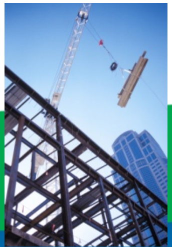
Construction Accidents in the United States

Construction is one of the most hazardous occupations. This industry accounts for

- 8% of the U.S. workforce, but 20% of fatalities
- About 1,100 deaths annually
- About 170,000 serious injuries annually

[CPWR 2008]

Photo courtesy of Thinkstock



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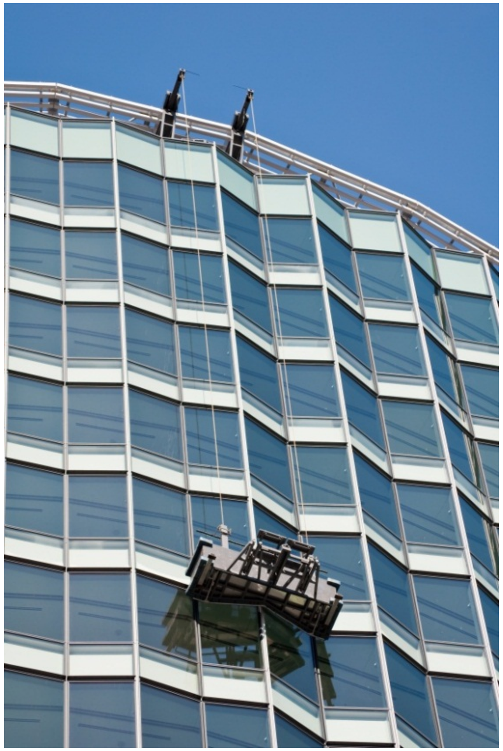
Design as a Risk Factor: Australian Study, 2000–2002

- Main finding: design contributes significantly to work-related serious injury.
- 37% of workplace fatalities are due to design-related issues.
- In another 14% of fatalities, design-related issues may have played a role.

[Driscoll et al. 2008]



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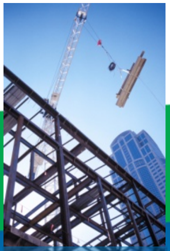

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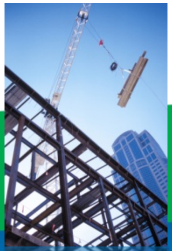
Accidents Linked to Design

- 22% of 226 injuries that occurred from 2000 to 2002 in Oregon, Washington, and California were linked partly to design [Behm 2005]
- 42% of 224 fatalities in U.S. between 1990 and 2003 were linked to design [Behm 2005]
- In Europe, a 1991 study concluded that 60% of fatal accidents resulted in part from decisions made before site work began [European Foundation for the Improvement of Living and Working Conditions, 1991]
- 63% of all fatalities and injuries could be attributed to design decisions or lack of planning [NOHSC 2001]



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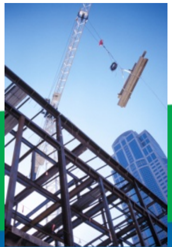
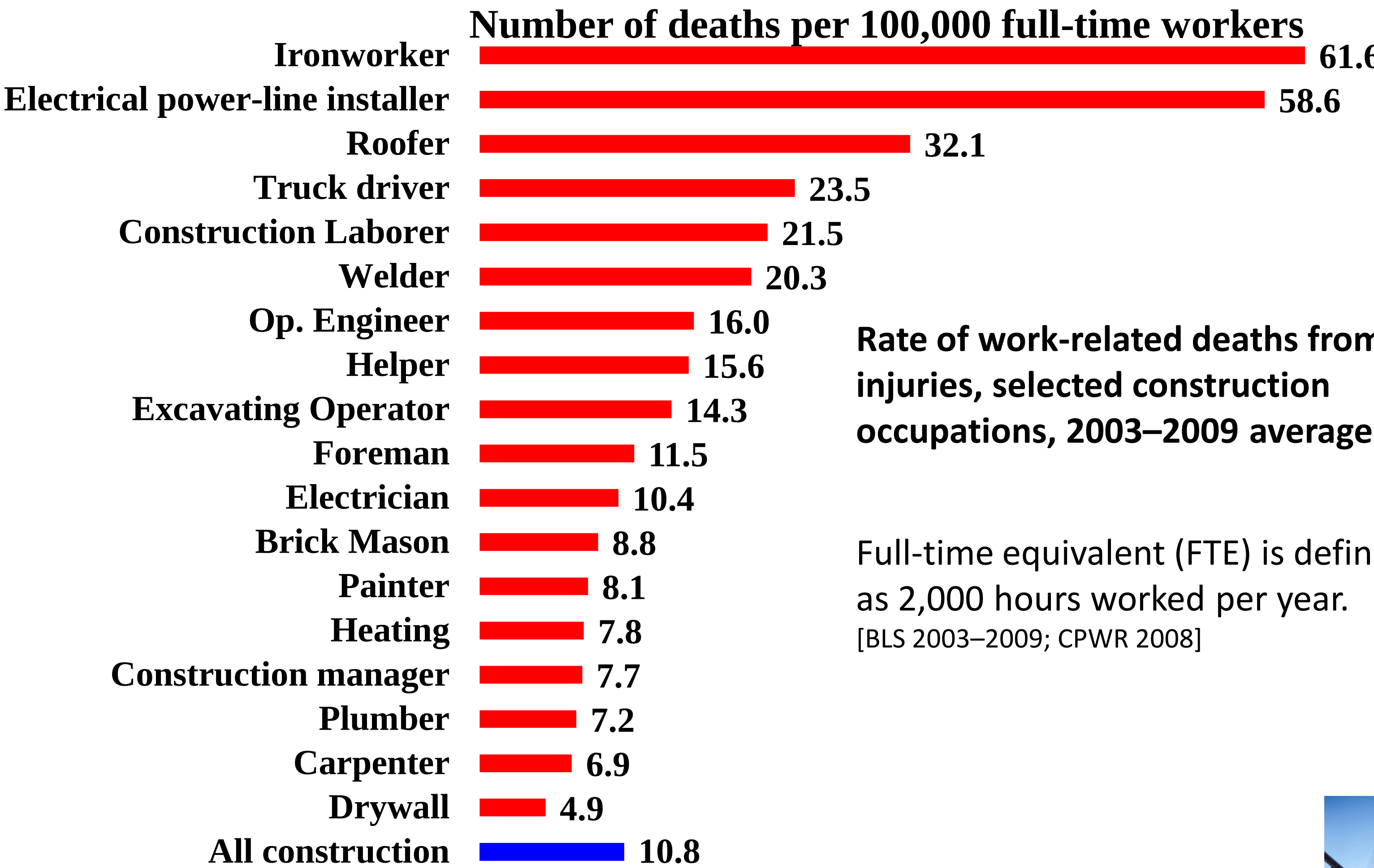
Falls

- Number one cause of construction fatalities
  - in 2010, 35% of 751 deaths
    www.bls.gov/news.release/cfoi.t02.htm
- Common situations include making connections, walking on beams or near openings such as floors or windows
- Fall protection is required at height of 6 feet above a surface [29 CFR 1926.760].
- Common causes: slippery surfaces, unexpected vibrations, misalignment, and unexpected loads

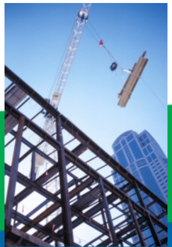


Death from Injury



Rate of work-related deaths from injuries, selected construction occupations, 2003–2009 average

Full-time equivalent (FTE) is defined as 2,000 hours worked per year.
[BLS 2003–2009; CPWR 2008]



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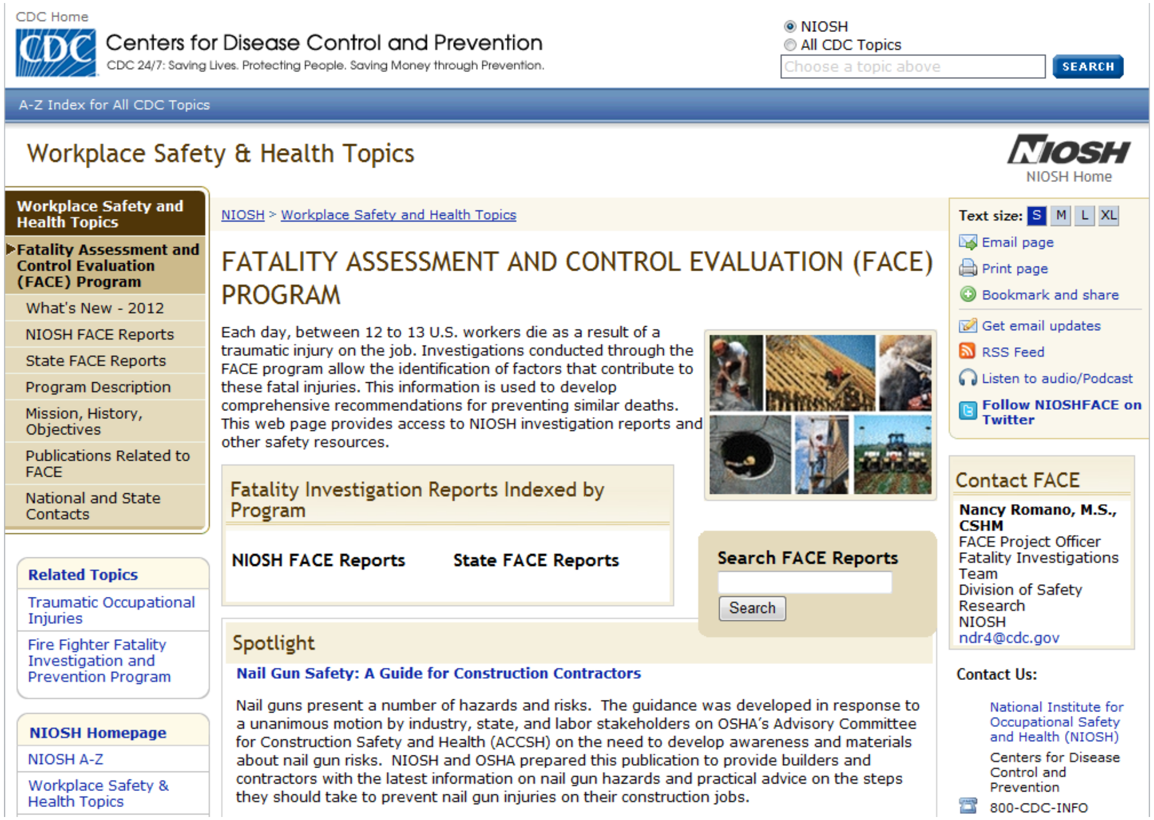
Fatality Assessment and Control Evaluation

NIOSH FACE Program www.cdc.gov/niosh/face


CDC Home

Centers for Disease Control and Prevention

CDC 24/7: Saving Lives. Protecting People. Saving Money through Prevention.

NIOSH | All CDC Topics | Choose a topic above | SEARCH

A-Z Index for All CDC Topics

Workplace Safety & Health Topics

NIOSH Home

Workplace Safety and Health Topics

- **Fatality Assessment and Control Evaluation (FACE) Program**
- What's New - 2012
- NIOSH FACE Reports
- State FACE Reports
- Program Description
- Mission, History, Objectives
- Publications Related to FACE
- National and State Contacts

Related Topics

- Traumatic Occupational Injuries
- Fire Fighter Fatality Investigation and Prevention Program

NIOSH Homepage

- NIOSH A-Z
- Workplace Safety & Health Topics

NIOSH > Workplace Safety and Health Topics

FATALITY ASSESSMENT AND CONTROL EVALUATION (FACE) PROGRAM

Each day, between 12 to 13 U.S. workers die as a result of a traumatic injury on the job. Investigations conducted through the FACE program allow the identification of factors that contribute to these fatal injuries. This information is used to develop comprehensive recommendations for preventing similar deaths. This web page provides access to NIOSH investigation reports and other safety resources.

Fatality Investigation Reports Indexed by Program

NIOSH FACE Reports | **State FACE Reports**

Search FACE Reports

Search

Spotlight

Nail Gun Safety: A Guide for Construction Contractors

Nail guns present a number of hazards and risks. The guidance was developed in response to a unanimous motion by industry, state, and labor stakeholders on OSHA's Advisory Committee for Construction Safety and Health (ACCSH) on the need to develop awareness and materials about nail gun risks. NIOSH and OSHA prepared this publication to provide builders and contractors with the latest information on nail gun hazards and practical advice on the steps they should take to prevent nail gun injuries on their construction jobs.

Text size: S M L XL

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Contact FACE

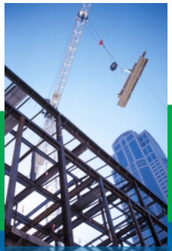
Nancy Romano, M.S., CSHM
FACE Project Officer
Fatality Investigations Team
Division of Safety Research
NIOSH
ndr4@cdc.gov

Contact Us:

National Institute for Occupational Safety and Health (NIOSH)

Centers for Disease Control and Prevention

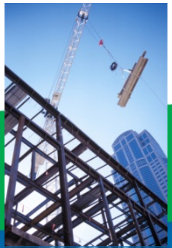
800-CDC-INFO


Structural Steel

What is Prevention through Design?

Eliminating or reducing work-related hazards and illnesses and minimizing risks associated with

- Construction
- Manufacturing
- Maintenance
- Use, reuse, and disposal of facilities, materials, and equipment



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Hierarchy of Controls per ANSI/AIHA Z10-2005

BEST

ELIMINATION
Design it out

SUBSTITUTION
Use something else

ENGINEERING CONTROLS
Isolation and guarding

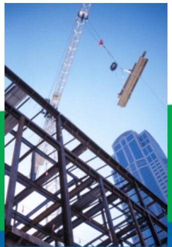
ADMINISTRATIVE CONTROLS
Training and work scheduling

PERSONAL PROTECTIVE EQUIPMENT
Last resort

Control effectiveness

BEST

Business value



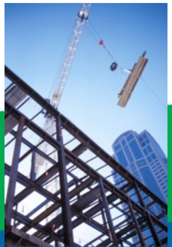
Structural Steel

Personal Protective Equipment (PPE)

- Last line of defense against injury
- Examples:
  - Hard hats
  - Steel-toed boots
  - Safety glasses
  - Gloves
  - Harnesses

Photo courtesy of Thinkstock

OSHA www.osha.gov/Publications/osha3151.html



PtD Process

[Hecker et al. 2005]

- Establish PtD expectations
- Include construction and operation perspective
- Identify PtD process and tools

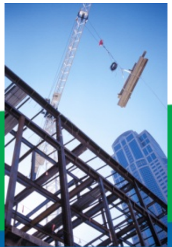
Design team meeting → **Design** → **Internal review** → **External review** → **Issue for construction**

Design team meeting
- Owner
- Architect
- Project Manager
- Health & Safety Professional

Design
- Trade contractor
- Health & Safety review

Internal review
- Quality Assurance/ Quality Control
- Health & Safety review
- Value Engineering review

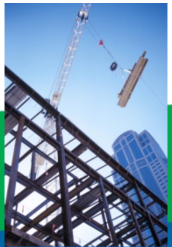
External review
- Focused Health & Safety review
- Owner review



Structural Steel

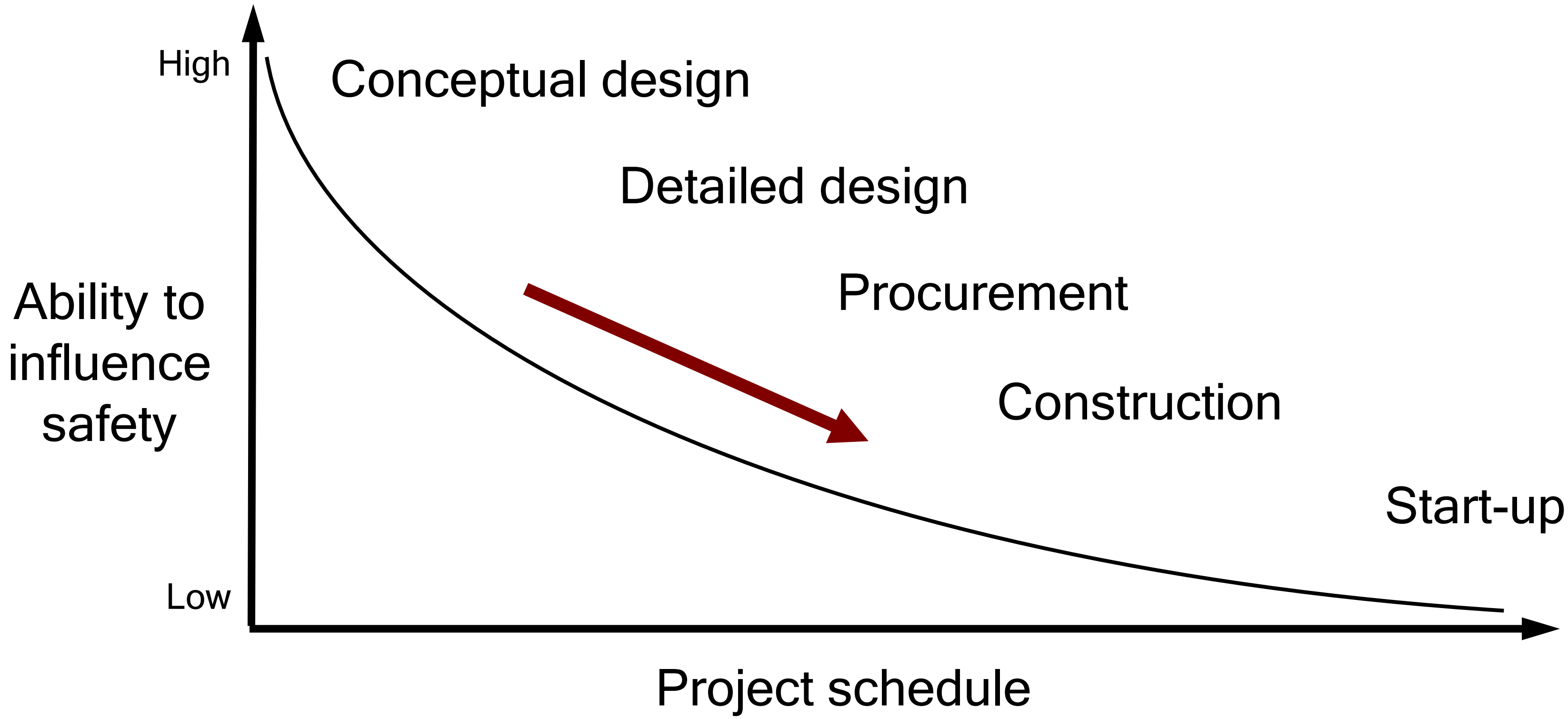
Integrating Occupational Safety and Health with the Design Process

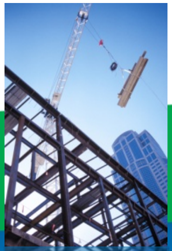
Stage	Activities
Conceptual design	Establish occupational safety and health goals, identify occupational hazards
Preliminary design	Eliminate hazards, if possible; substitute less hazardous agents/processes; establish risk minimization targets for remaining hazards; assess risk; and develop risk control alternatives. Write project specifications.
Detailed design	Select controls; conduct process hazard reviews
Procurement	Develop equipment specifications and include in procurements; develop “checks and tests” for factory acceptance testing and commissioning
Construction	Ensure construction site safety and contractor safety
Commissioning	Conduct “checks and tests,” including factory acceptance; pre–start up safety reviews; development of standard operating procedures (SOPs); risk/exposure assessment; and management of residual risks
Start up and occupancy	Education; manage changes; modify SOPs


Structural Steel

Safety Payoff During Design

[Adapted from Szymberski 1997]



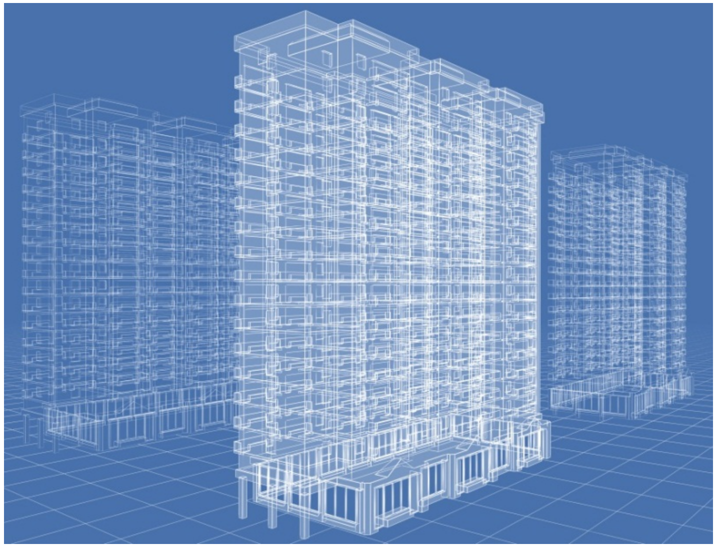


Structural Steel

PtD Process Tasks

[Adapted from Toole 2005; Hinze and Wiegand 1992]

- Perform a hazard analysis
- Incorporate safety into the design documents
- Make a CAD model for member labeling and erection sequencing



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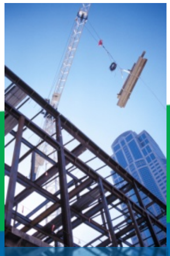
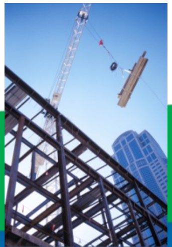


Designer Tools

- Checklists for construction safety [Main and Ward 1992]
- Design for construction safety toolbox [Gambatese et al. 1997]
- Construction safety tools from Australia
  - Construction Hazard Assessment Implication Review, known as CHAIR [NOHSC 2001]

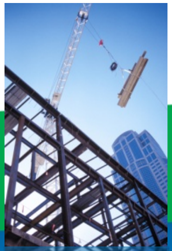


Structural Steel

Example Checklist

Item	Description
1.0	**Structural Framing**
1.1	Space slab and mat foundation top reinforcing steel at no more than 6 inches on center each way to provide a safe walking surface.
1.2	Design floor perimeter beams and beams above floor openings to support lanyards.
1.3	Design steel columns with holes at 21 and 42 inches above the floor level to support guardrail cables.
2.0	**Accessibility**
2.1	Provide adequate access to all valves and controls.
2.2	Orient equipment and controls so that they do not obstruct walkways and work areas.
2.3	Locate shutoff valves and switches in sight of the equipment which they control.
2.4	Provide adequate head room for access to equipment, electrical panels, and storage areas.
2.5	Design welded connections such that the weld locations can be safely accessed.

Checklist courtesy of John Gambatese

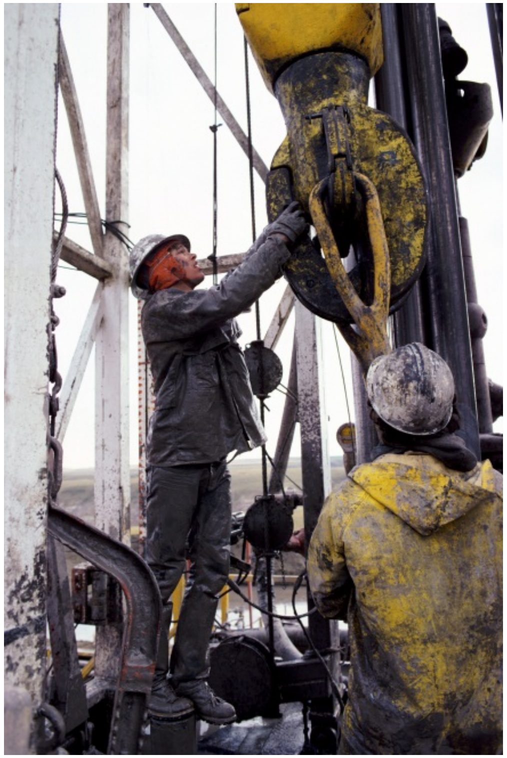


OSHA Steel Erection eTool

OSHA www.osha.gov/SLTC/etools/steelerection/index.html

Why Prevention through Design?

- Ethical reasons
- Construction dangers
- Design-related safety issues
- Financial and non-financial benefits
- Practical benefits



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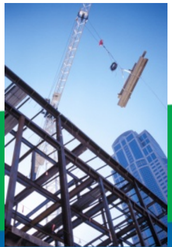


Ethical Reasons for PtD

- National Society of Professional Engineers' Code of Ethics:

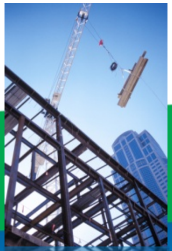
  "Engineers shall hold paramount the safety, health, and welfare of the public…"

- American Society of Civil Engineers' Code of Ethics:

  "Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering decisions…"

NSPE www.nspe.org/ethics

ASCE www.asce.org/content.aspx?id=7231

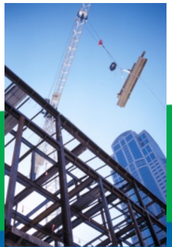


Structural Steel

PtD Applies to Constructability

- How reasonable is the design?
  - Cost
  - Duration
  - Quality
  - Safety

Photo courtesy of the Cincinnati Museum Center www.cincymuseum.org



Structural Steel

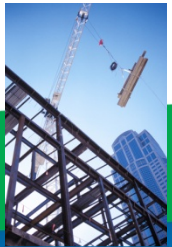
Business Value of PtD

- Anticipate worker exposures—be proactive
- Align health and safety goals with business goals
- Modify designs to reduce/eliminate workplace hazards in

Facilities	Equipment
Tools	Processes
Products	Work flows

→ Improve business profitability!

AIHA www.ihvalue.org



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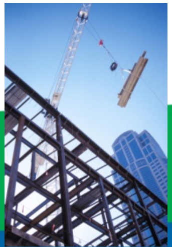
Benefits of PtD

- Reduced site hazards and thus fewer injuries
- Reduced workers’ compensation insurance costs
- Increased productivity
- Fewer delays due to accidents
- Increased designer-constructor collaboration
- Reduced absenteeism
- Improved morale
- Reduced employee turnover



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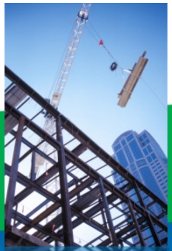
Industries Use PtD Successfully

- Construction companies
- Computer and communications corporations
- Design-build contractors
- Electrical power providers
- Engineering consulting firms
- Oil and gas industries
- Water utilities

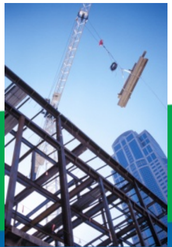
And many others



Structural Steel

STRUCTURAL STEEL DESIGN

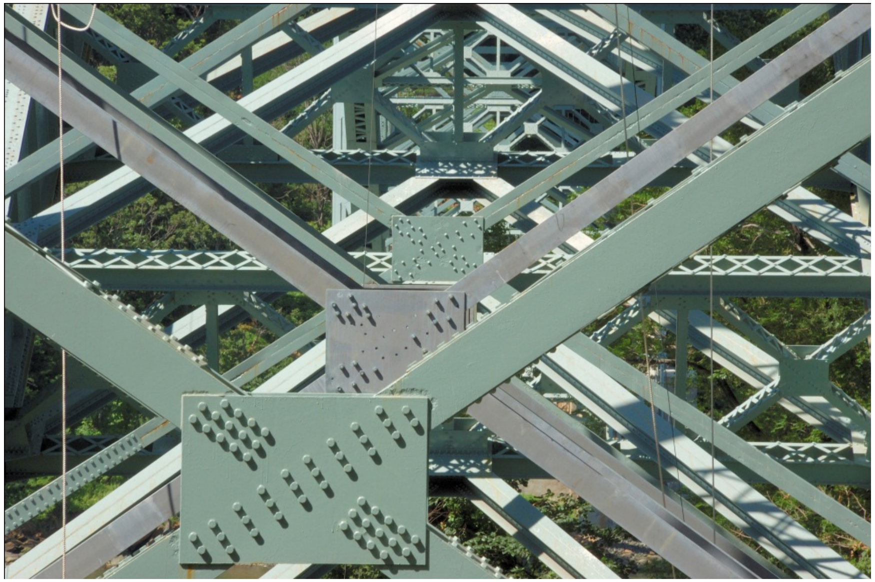
Design, Detailing, and Fabrication Process



Structural Steel

Three Entities Associated with Design

- Engineer
- Detailer
- Fabricator



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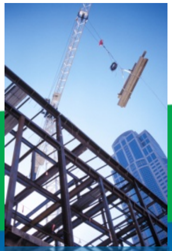
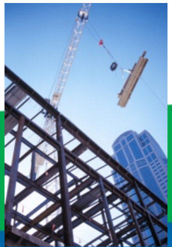


Design Phase

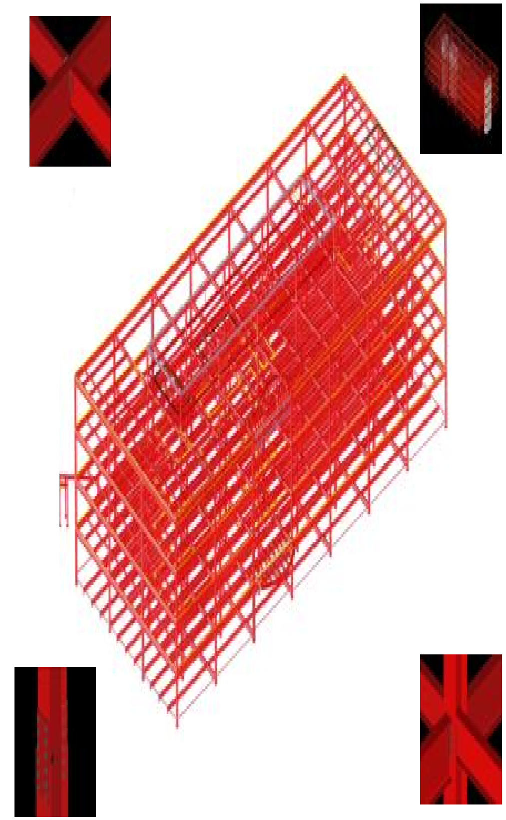
- Owner establishes architectural/engineering requirements for building
- Designer runs analysis on design according to building codes
- Building is designed for safety, serviceability, constructability, and economy
- Client receives final design specifications and drawings
- Designer stores the calculations

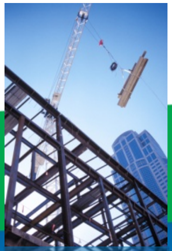


Detailing

Fabricator programs engineer's drawings with software to visualize connections

[Daccarett and Mrozowski 2002]



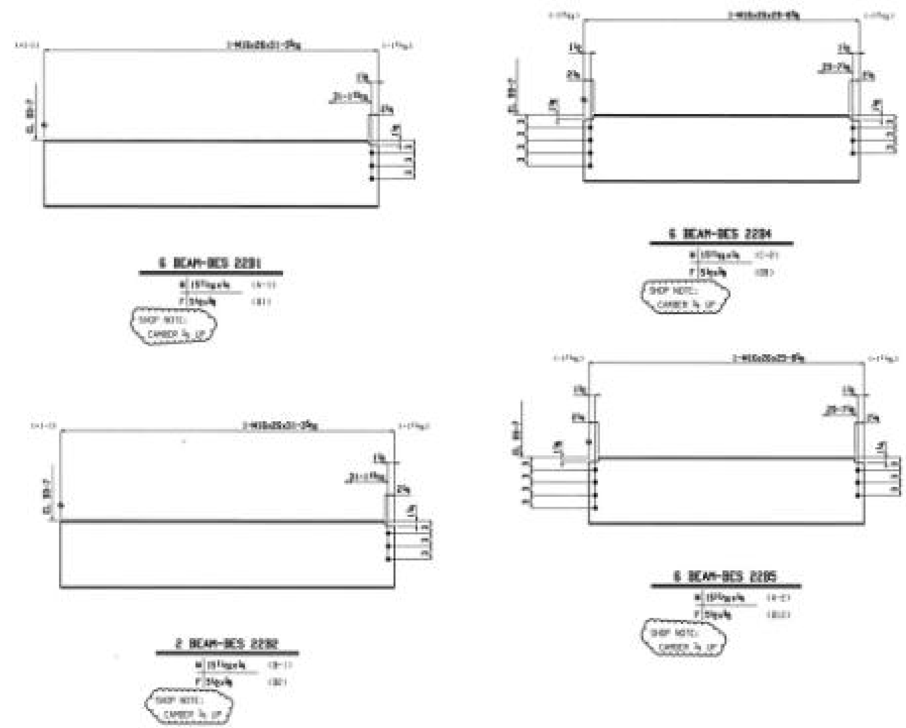


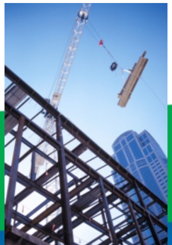
Structural Steel

Shop Drawings

While detailing, fabricator makes drawings containing specifics about how to fabricate each member

[Daccarett and Mrozowski 2002]





Fabrication

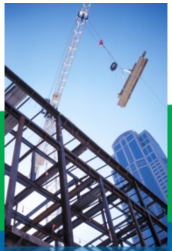
To achieve its final configuration, the steel may be

- Cut
- Sheared
- Punched
- Drilled
- Fit
- Welded

Photo courtesy of Thinkstock

Each final member is labeled with a piece mark, length, and job number for identification.

[Daccarett and Mrozowski 2002]



Transportation

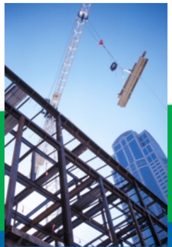
Members are transported via

- Flatbed truck
- Train
- Waterways

Photo courtesy Thinkstock

STRUCTURAL STEEL DESIGN

Erection Process

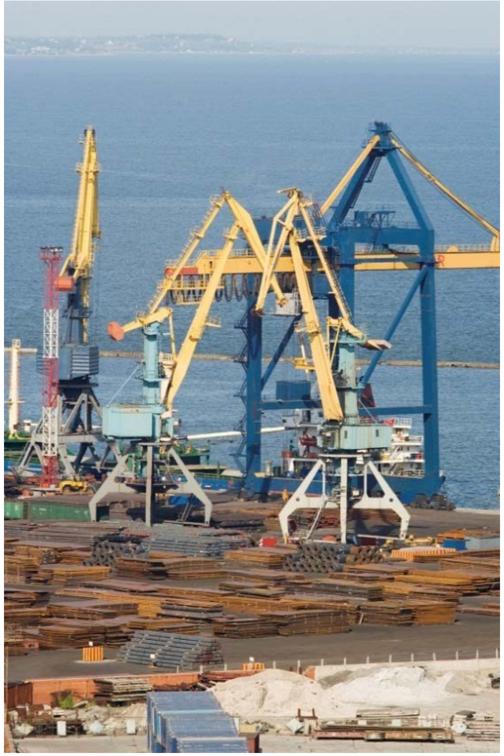


Structural Steel

Unloading and Shake-out

- Steel members are unloaded and placed on blocking to allow space for chokers to be easily attached.
- Shake-out: members are sorted on the ground to allow for efficient erection.

[Daccarett and Mrozowski 2002]



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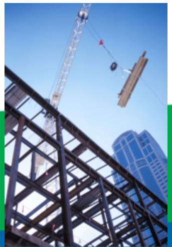
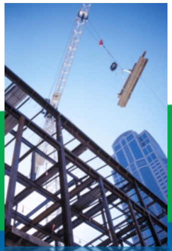


Picking and Hoisting

- Cranes lift members into place
- Hole at end of each column
- After a choker is tied around the center of gravity, multiple beams can be lifted at once

[Daccarett and Mrozowski 2002]

Photo courtesy of Thinkstock

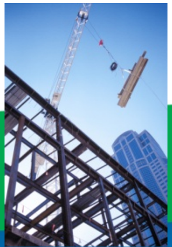


Positioning and Initial Bolting

- Each beam is lowered into place, and a worker lines it up correctly with drift pins. At least two bolts are attached before the crane releases the load.
  – OSHA requirement

[Daccarett and Mrozowski 2002]

Photo courtesy of Daccarett and Mrozowski

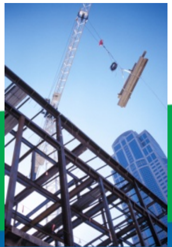


Final Bolting

- Once everything is in the correct position, the final bolting is performed with a torque wrench or similar tool.

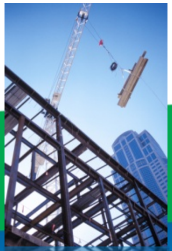
[Daccarett and Mrozowski 2002]

Photo courtesy of Daccarett and Mrozowski



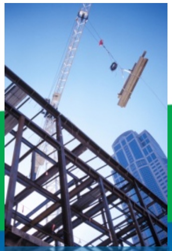
STRUCTURAL STEEL DESIGN

Examples of Prevention through Design



Structural Steel

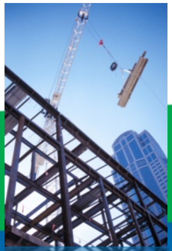
Topics



Prefabrication

- Shop work is often faster than field work.
- Shop work is less expensive than field work.
- Shop work is more consistent because of the controlled environment.
- Shop work yields better quality than field work.
- With prefabrication, less work is done at high elevations, which reduces the risks of falls and falling objects.

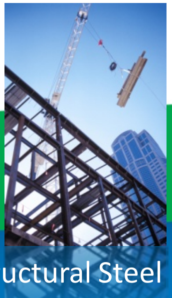
[Toole and Gambatese 2008]



Example: Prefabricated Truss

- Fewer connections to make in the air
- Safer and faster

Photo courtesy of Thinkstock



Access Help

- Shop-installed vertical ladders
- Bolts on ladders and platforms can be removed later or kept for maintenance

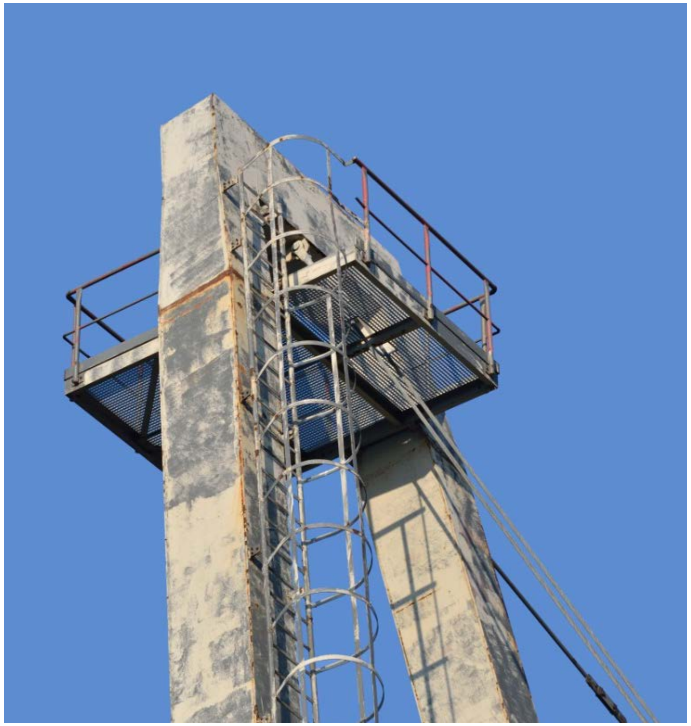
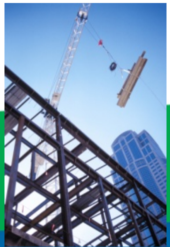


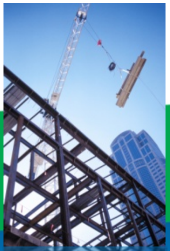
Photo courtesy of Thinkstock



Column Safety

- Column splices
- Tabs/Holes for safety lines
- Base plates

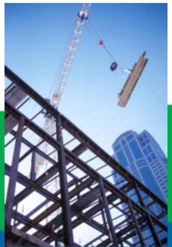
Photo courtesy of Thinkstock



Column Splices

- Have column splice around 4 feet above the working floor
  - OSHA requirement

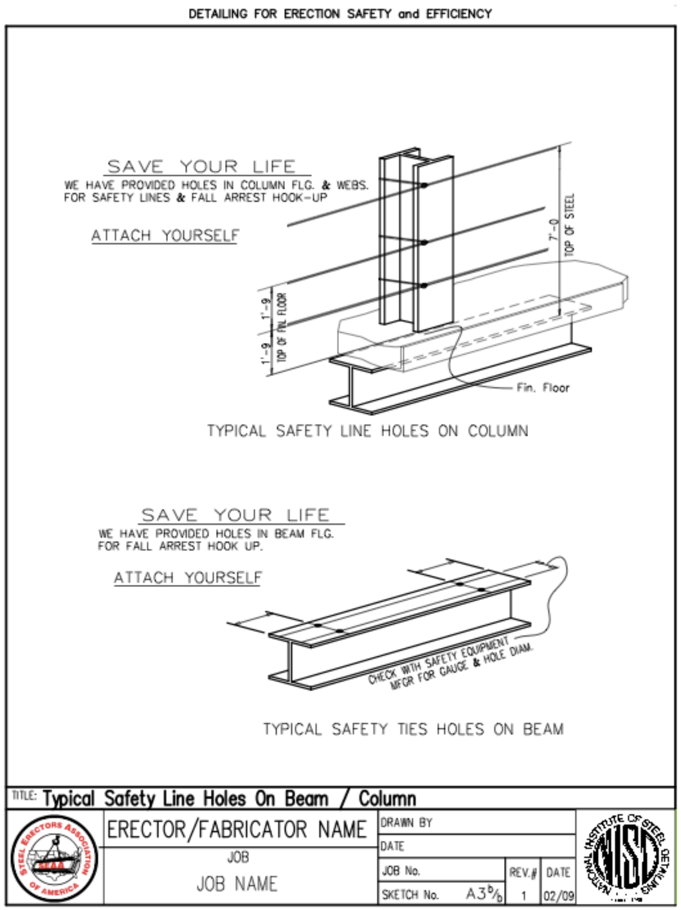
Photo courtesy of Bucknell University facilities

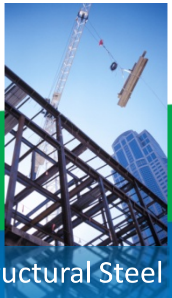


Holes for Safety Lines

- Include holes at 21 inches and 42 inches for guardrails
- Additional, higher holes can also be included for lifeline support

[Gambatese 1996; NISD and SEAA 2009]

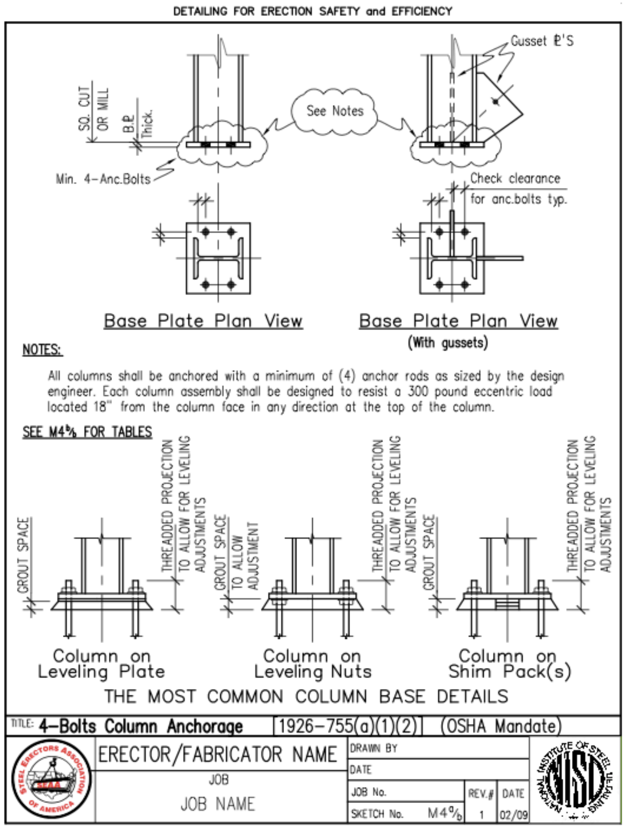


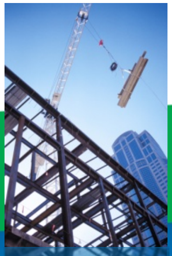


Base Plates

- Column **base plates** should always have at least 4 anchor rods bolted in
  - OSHA Requirement

[Gambatese 1996; NISD and SEAA 2009; OSHA 29 CFR 1926-755]





Beams and Girders

Workers walk on beams to get to connections or other columns, a common fall hazard. Increase safety by considering

- Beam width
- Use of cantilevers
- Ability to support lifelines

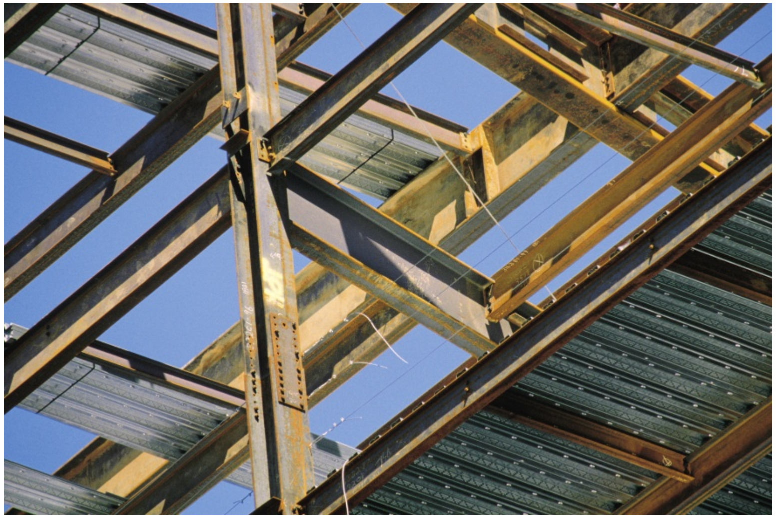
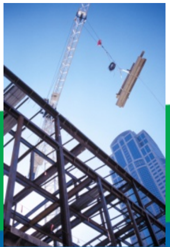


Photo courtesy of Thinkstock

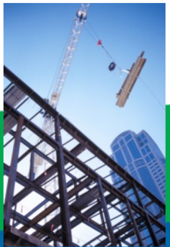


Beam Width

- For walking safely, use beams with a minimum beam width of 6 inches.

[Gambatese 1996]

Photo courtesy of Thinkstock



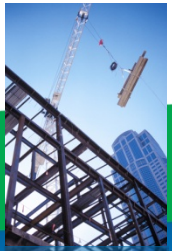
Use of Cantilevers

Minimize the use of cantilevers, which

- are not good for tying off
- pose connection difficulties

[Gambatese 1996]

Photo courtesy of Thinkstock

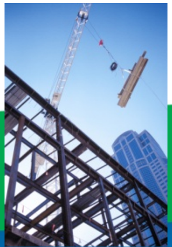


Ability to Support Lifelines

- Design beams near or above openings to be able to support lifelines
- Contract drawings should make clear how many lifelines each beam can support, and at what locations they can be attached

Photo courtesy of Thinkstock

[Gambatese 1996; NISD and SEAA 2009; OSHA 29 CFR 1926.502(d)(15)]

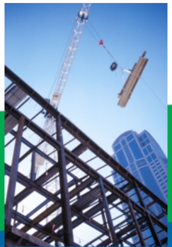


Connections

Connections are very important but can be very difficult to install. There are two main tools for making connections:

- Bolts
- Welds

Photos courtesy of AISC

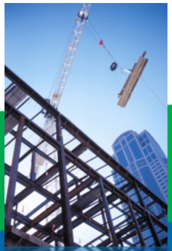


Bolts

For safe bolted connections, consider:

- Self-supporting connections
- Double connections
- Erection aid: “dummy holes”
- Bolt sizes
- Minimum number of bolts
- Awkward or dangerous connection locations

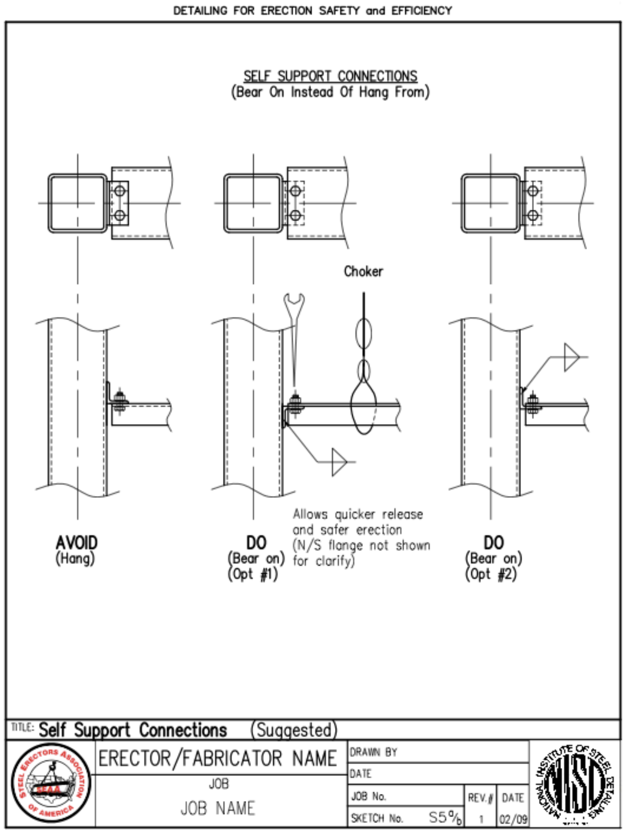
Photo courtesy of AISC

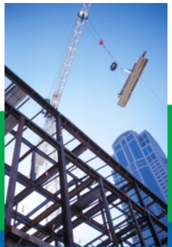


Self-Supporting Connections

- Avoid hanging connections
- Consider using beam seats

[Gambatese 1996; NISD and SEAA 2009]

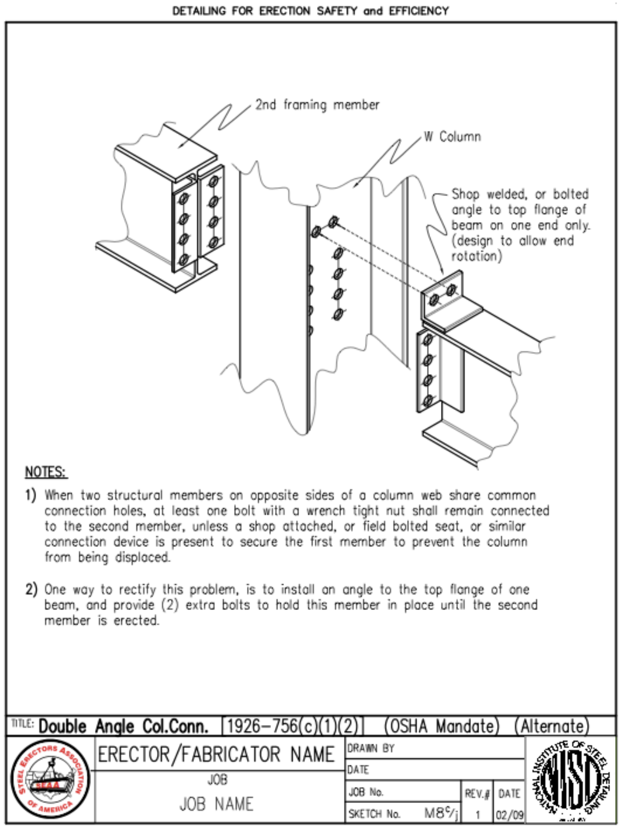


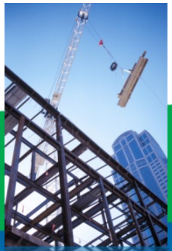


Double Connections

- Avoid beams of common depth connecting into the column web at the same location.
- If double connections are necessary, design them to have full support during the connection process.
  - OSHA requirement

[Gambatese 1996; NISD and SEAA 2009; OSHA 29 CFR 1926-756]





Structural Steel

Alternate Double Connection

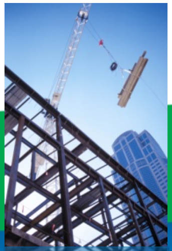
Photos courtesy of AISC

Erection Aids: “Dummy Holes”

- Provide an extra “dummy hole” in the connection, where a spud wrench can be inserted
- This is most appropriate when there are only two bolts

[Gambatese 1996]

Photo courtesy Bucknell University facilities

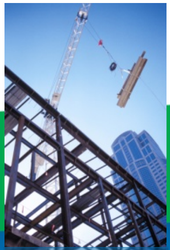


Bolt Sizes

- Use as few bolt sizes as possible

[Gambatese 1996]

Photo courtesy of Thinkstock



Minimum Number of Bolts

- Use a minimum of two bolts per connection
  - OSHA requirement

[Gambatese 1996]

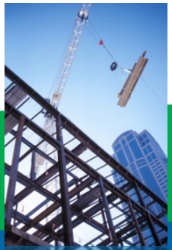
Photo courtesy of AISC

Immediate Stability

Provide pin-holed or bolted connections to provide immediate stability after placement of members

[Gambatese 1996]

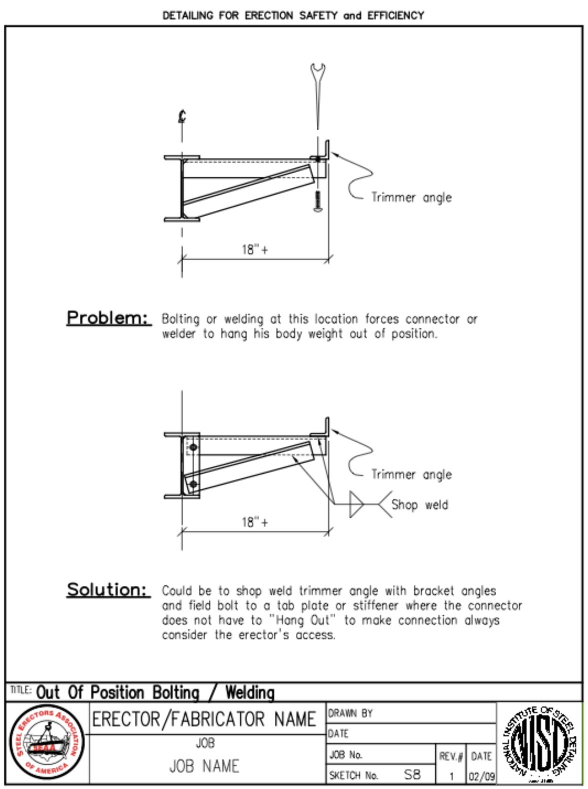
Photo courtesy of AISC

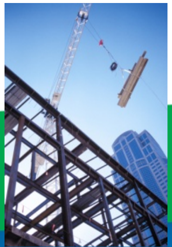


Avoid Awkward or Dangerous Connection Locations

- Time-consuming and dangerous
- Can cause strain

[Gambatese 1996; NISD and SEAA 2009]




Structural Steel

Welds

For safer welded connections:

- Avoid awkward or dangerous connection locations
- Immediate stability
- Welding location
- Welding material

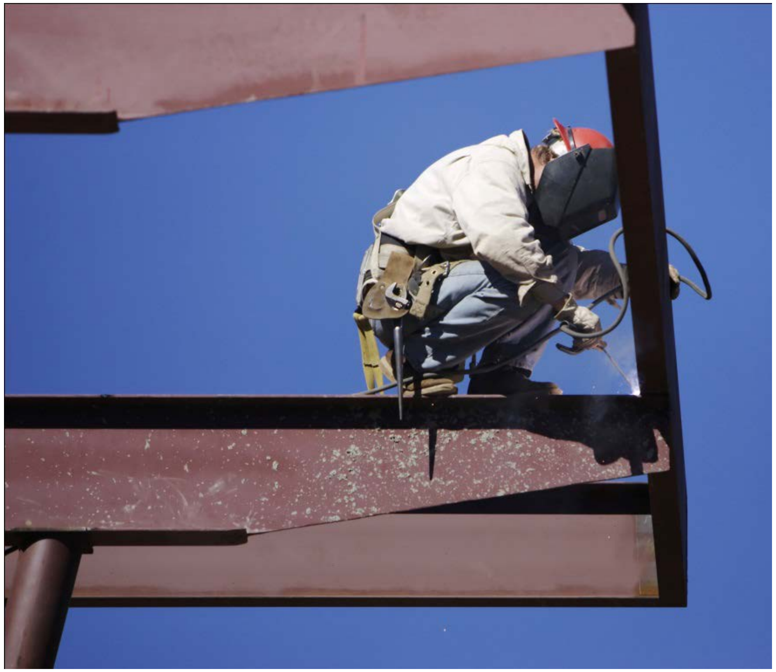
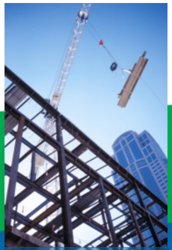


Photo courtesy of Thinkstock

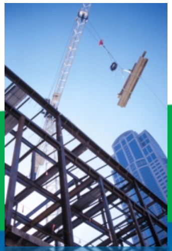


Welding Locations

- Specify shop welding rather than field welding
- If field welds are necessary, design them in convenient locations

[Gambatese 1996]

Photo courtesy of Thinkstock

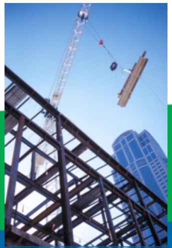


Welding Material

Welding can be a fire hazard and can emit toxic fumes. Always be aware of what material is being welded.

[Gambatese 1996; Sperko Engineering Services 1999]

Photo courtesy of Thinkstock

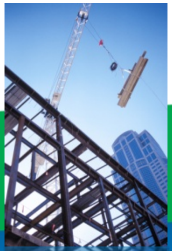


Other Methods for Safer Construction

Address these factors:

- Sharp corners
- Access problems
- Temporary bracing
- Crane safety
- Member placement
- Tripping hazards

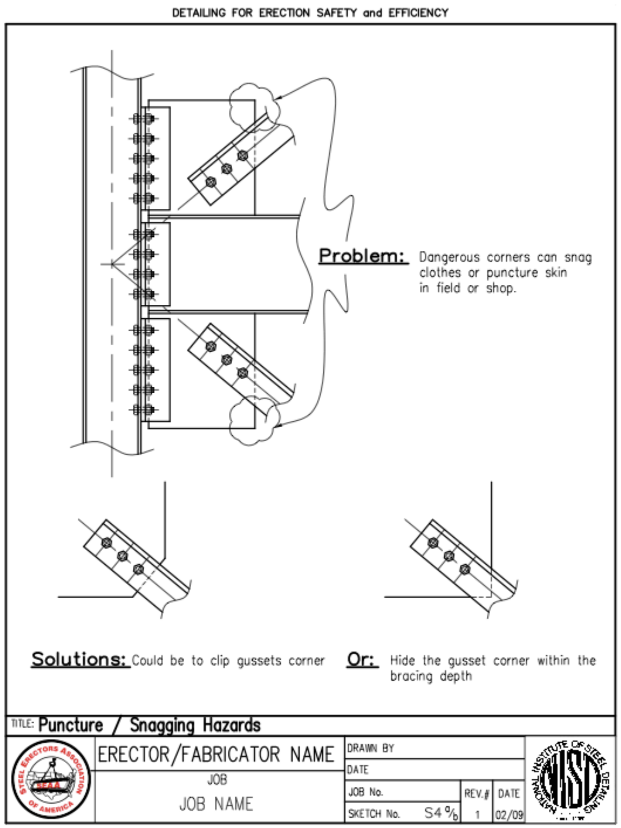
Photo courtesy of Thinkstock

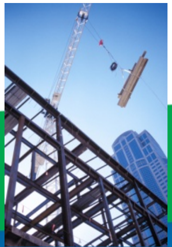


Avoid Sharp Corners

- Corners can cause clothing or wires to snag, resulting in falling objects or tripping hazards
- Corners can cause scratches or cuts

[NISD and SEAA 2009]



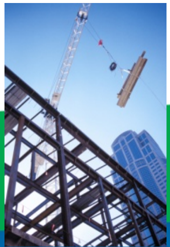

Structural Steel

Access Problems

Complicated connections take time to complete and are dangerous if they require awkward positioning, so consider

- Adequacy of space for making connections
- Small column size access
- Hand trap danger

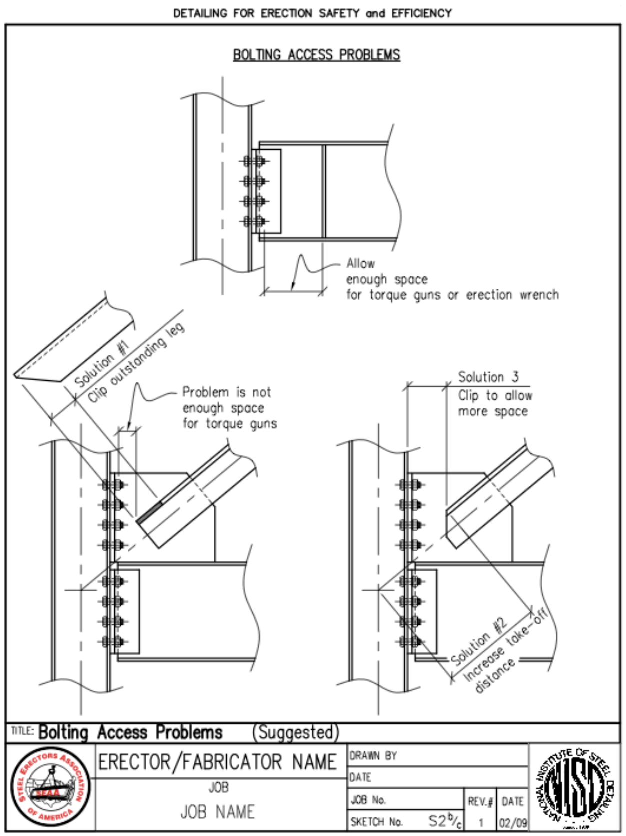
Photo courtesy of Thinkstock

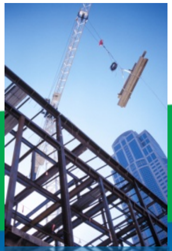


Provide Enough Space for Connections

- There may not be enough space for common tools
- These connections can be made better by clipping away portions or increasing distances

[NISD and SEAA 2009]

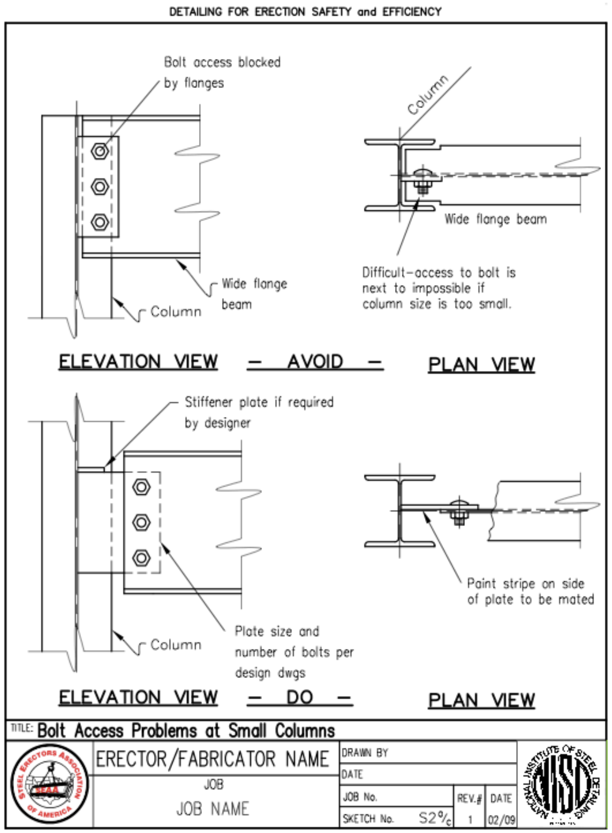


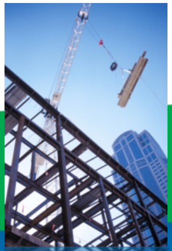


Small Column Size Access

- Small column depth can make connections difficult
- Access to bolts can be blocked by the column flanges
- Attach a tab to the column

[NISD and SEAA 2009]



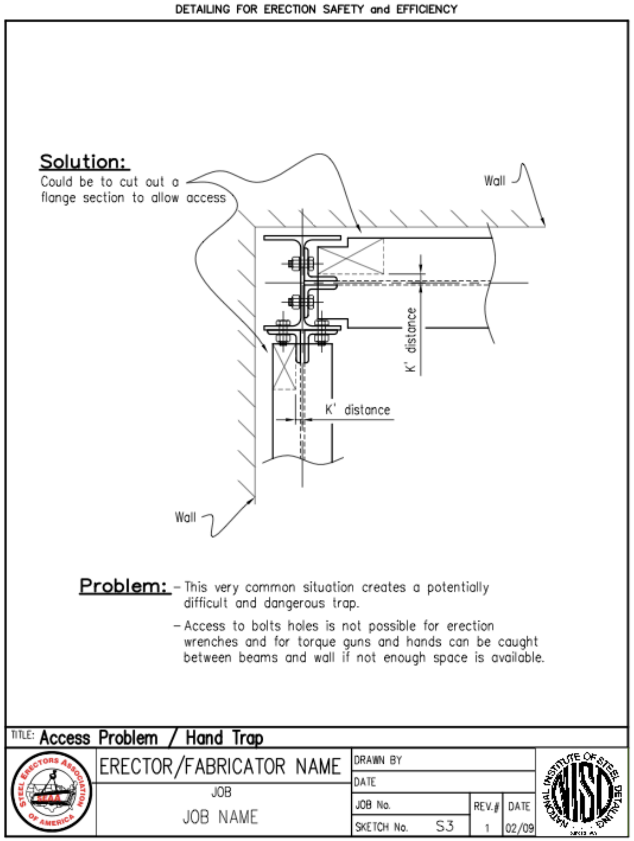


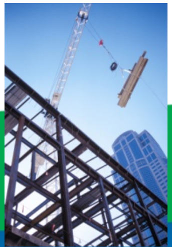
Structural Steel

Hand Trap

- The situation shown can create a dangerous hand trap
- A solution is to cut out a section of the flange to allow access to the bolts

[NISD and SEAA 2009]

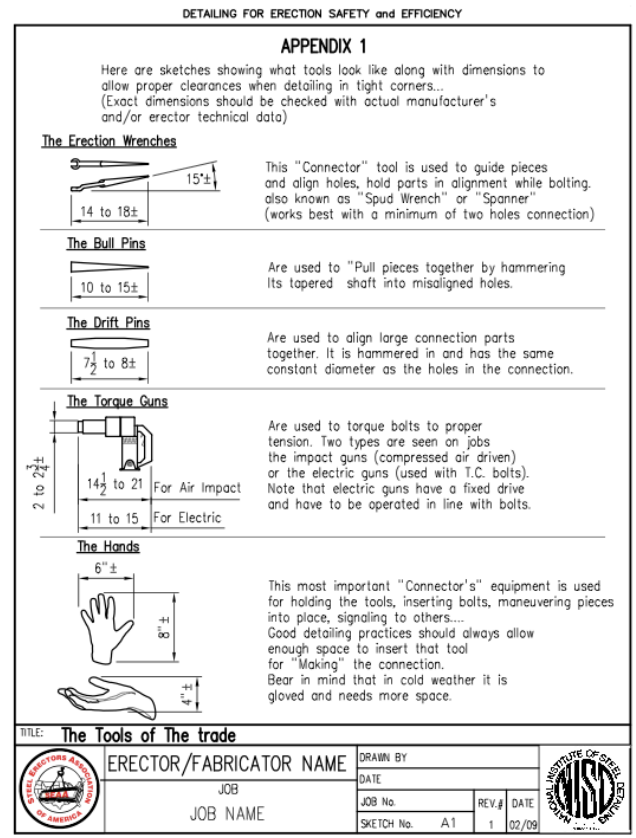




Know Approximate Sizes of Tools

"Knuckle-busting" – workers' knuckles get damaged from trying to fit their hands into a tight space

[NISD and SEAA 2009]



DETAILING FOR ERECTION SAFETY and EFFICIENCY

APPENDIX 1

Here are sketches showing what tools look like along with dimensions to allow proper clearances when detailing in tight corners...
(Exact dimensions should be checked with actual manufacturer's and/or erector technical data)

The Erection Wrenches

15°±

14 to 18±

This "Connector" tool is used to guide pieces and align holes, hold parts in alignment while bolting. also known as "Spud Wrench" or "Spanner" (works best with a minimum of two holes connection)

The Bull Pins

10 to 15±

Are used to "Pull pieces together by hammering Its tapered shaft into misaligned holes.

The Drift Pins

$7\frac{1}{2}$ to 8±

Are used to align large connection parts together. It is hammered in and has the same constant diameter as the holes in the connection.

The Torque Guns

2 to $2\frac{3}{4}$±

$14\frac{1}{2}$ to 21 For Air Impact

11 to 15 For Electric

Are used to torque bolts to proper tension. Two types are seen on jobs the impact guns (compressed air driven) or the electric guns (used with T.C. bolts). Note that electric guns have a fixed drive and have to be operated in line with bolts.

The Hands

6"±

8"±

4"±

This most important "Connector's" equipment is used for holding the tools, inserting bolts, maneuvering pieces into place, signaling to others....
Good detailing practices should always allow enough space to insert that tool for "Making" the connection.
Bear in mind that in cold weather it is gloved and needs more space.

TITLE: The Tools of The trade

ERECTOR/FABRICATOR NAME	DRAWN BY			
JOB	DATE			
JOB NAME	JOB No.		REV.#	DATE
	SKETCH No.	A1	1	02/09

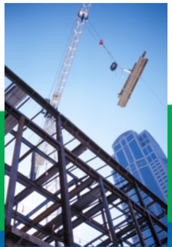
Structural Steel

Cranes and Derricks

- Erection and disassembly must be carefully planned.
- Site layout affects crane maneuverability.
- Show site utilities on plans.
- Comply with OSHA standards.

Photo courtesy of Walter Heckel

OSHA comprehensive crane standard: www.osha.gov/FedReg_osha_pdf/FED20100809.pdf.
Regulation text: www.osha.gov/cranes-derricks/index.html.



Member Placement

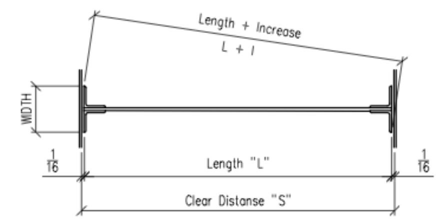
- Members need sufficient space to fit between columns

- Members without enough space could cause columns to tilt

[NISD and SEAA 2009]

DETAILING FOR ERECTION SAFETY and EFFICIENCY

Swinging Beams To Beams Horizontally



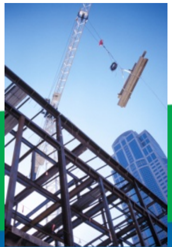
Note: If length plus increase exceeds clear span "S", beams cannot be swung without moving supporting beams or beating into place. This is objectionable and in some cases impossible. Refer such conditions to Project Manager.

Width in Inches	INCREASE "I"																		
	CLEAR DISTANCE "S" IN FEET																		
	6	8	10	12	14	16	18	20	22	24	26	28	30	35	40	45	50	55	60
6	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	0	0	0
7	3/8	1/4	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	0	0
8	1/2	3/8	1/4	1/4	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
9	5/8	1/2	3/8	3/8	1/4	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
10	3/4	1/2	1/2	3/8	3/8	1/4	1/4	1/4	1/4	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
11	7/8	5/8	1/2	1/2	3/8	3/8	3/8	1/4	1/4	1/4	1/4	1/4	1/4	1/8	1/8	1/8	1/8	1/8	1/8
12	1	3/4	5/8	1/2	1/2	3/8	3/8	3/8	1/4	1/4	1/4	1/4	1/4	1/4	1/8	1/8	1/8	1/8	1/8
13	1 1/4	7/8	3/4	5/8	1/2	1/2	3/8	3/8	3/8	3/8	1/4	1/4	1/4	1/4	1/4	1/4	1/8	1/8	1/8
14	1 3/8	1	7/8	3/4	5/8	1/2	1/2	1/2	3/8	3/8	3/8	3/8	1/4	1/4	1/4	1/4	1/4	1/8	1/8
15	1 5/8	1 1/4	1	7/8	3/4	5/8	5/8	1/2	1/2	3/8	3/8	3/8	3/8	1/4	1/4	1/4	1/4	1/4	1/4
16	1 3/4	1 3/8	1 1/8	7/8	3/4	3/4	5/8	5/8	1/2	1/2	1/2	3/8	3/8	3/8	1/4	1/4	1/4	1/4	1/4
17	2	1 1/2	1 1/4	1	7/8	3/4	3/4	5/8	5/8	1/2	1/2	1/2	1/2	3/8	3/8	1/4	1/4	1/4	1/4
18	2 1/4	1 3/4	1 3/8	1 1/8	1	7/8	3/4	3/4	5/8	5/8	5/8	1/2	1/2	3/8	3/8	3/8	1/4	1/4	1/4

TITLE: Swinging Beams To Beams Horizontally

ERECTOR/FABRICATOR NAME
JOB
JOB NAME

DRAWN BY
DATE
JOB No.
SKETCH No. A4
REV.# 1
DATE 02/09



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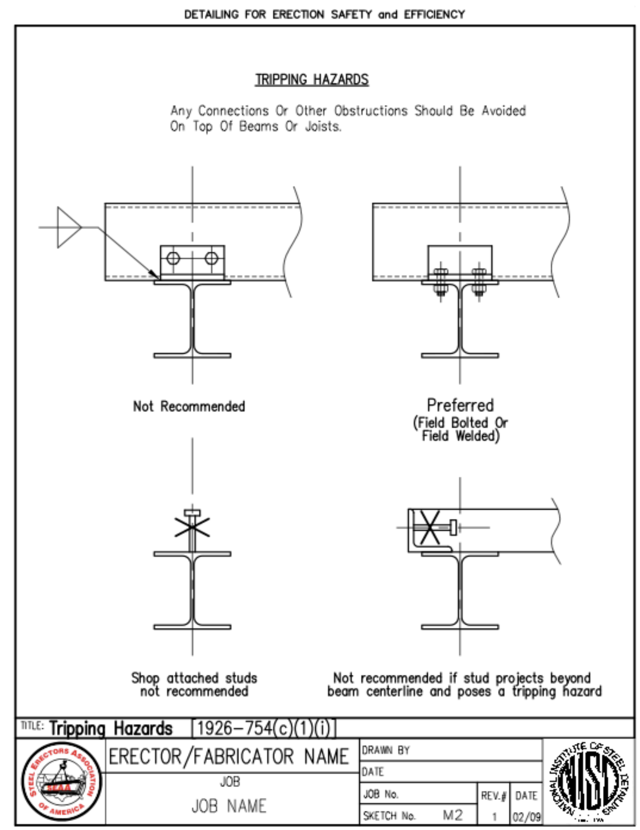
Tripping Hazards

Avoid having connections on top of beams and joists.

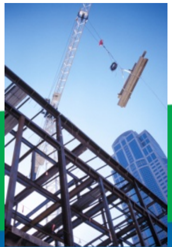
[NISD and SEAA 2009; OSHA 29 CFR 1926-754]

Image courtesy of Thinkstock



Recap

- **Prevention through Design (PtD)** is an emerging process for saving lives, time, and money.
- PtD is the smart thing to do and the right thing to do.
- Although site safety is the contractor’s responsibility, the designer has the ethical duty to create drawings with good constructability.
- There are tools and examples to facilitate PtD.



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Help make the workplace safer…

Include *Prevention through Design* concepts in your projects.

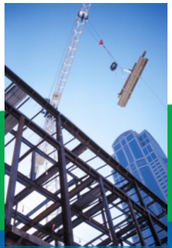
For more information, please contact the National Institute for Occupational Safety and Health (NIOSH) at

Telephone: (513) 533–8302
E-mail: preventionthroughdesign@cdc.gov

Visit these NIOSH Prevention through Design Web sites:

www.cdc.gov/niosh/topics/PtD

www.cdc.gov/niosh/programs/PtDesign



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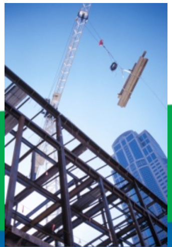

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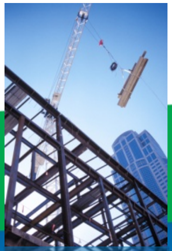

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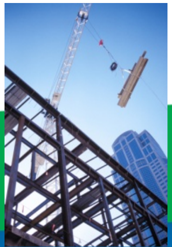

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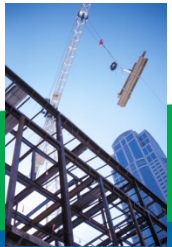

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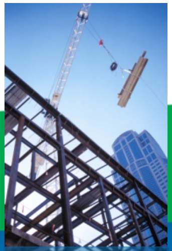

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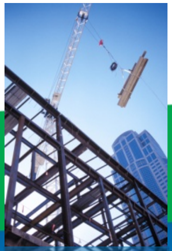

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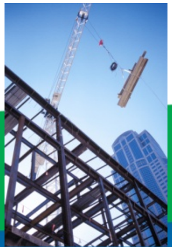

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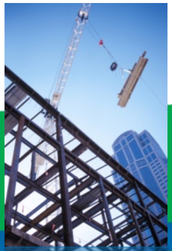

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  www.cdc.gov/niosh/programs/PtDesign
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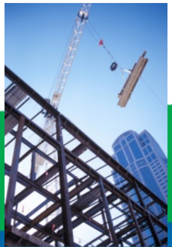

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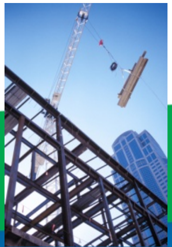

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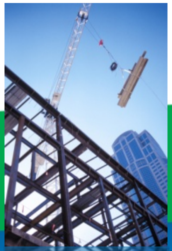

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