Examples of Prevention of Accidents in the Design Phase on Construction

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Motivation

- European Directive 92/57
- Coordinator
- Design and Execution
- About 2/3 accidents
- Where is the research
- PhD student
- Preliminary results: 25%

Safety by Design (extract)

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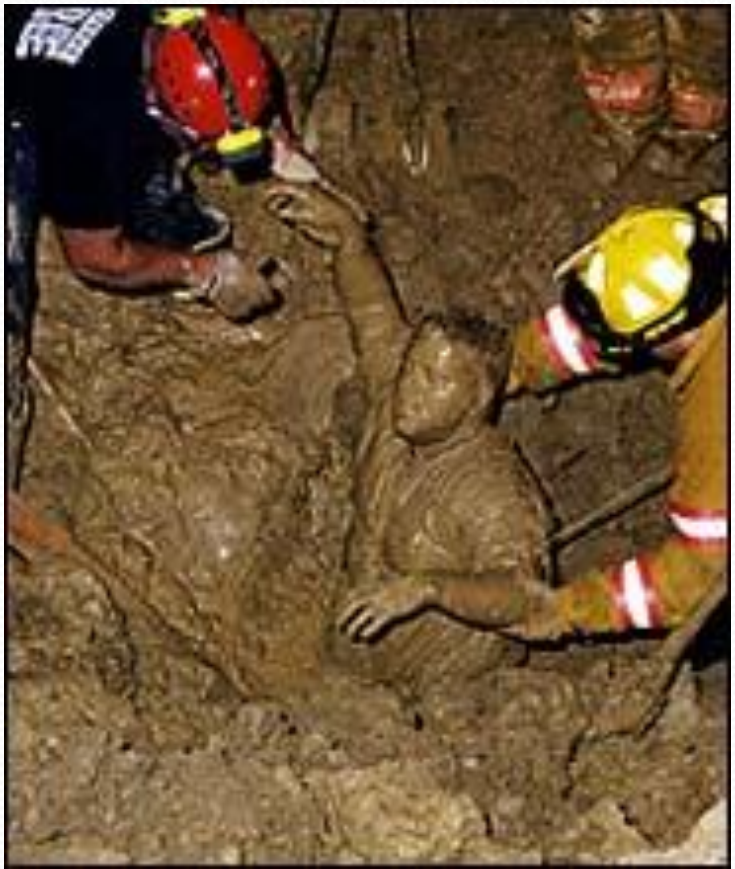
alliance
An OSHA Cooperative Program

Typical Annual Construction Accidents in U.S.

- Nearly 200,000 serious injuries
- 1,000 deaths



What is Safety by Design?

Aka Designing for Construction Safety

- The process of considering construction site safety and health in the design of a project

- Designing for safety constructability

Prevention through Design

- "Addressing occupational safety and health needs in the design process to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, and disposal of facilities, materials, and equipment."

(NIOSH)

What Safety by Design is NOT

- Having designers take a role in construction safety **DURING** construction.
- An endorsement of future legislation mandating that designers design for construction safety.
- An endorsement of the principle that designers can or should be held partially responsible for construction accidents.

Accidents Linked to Design[1,2]

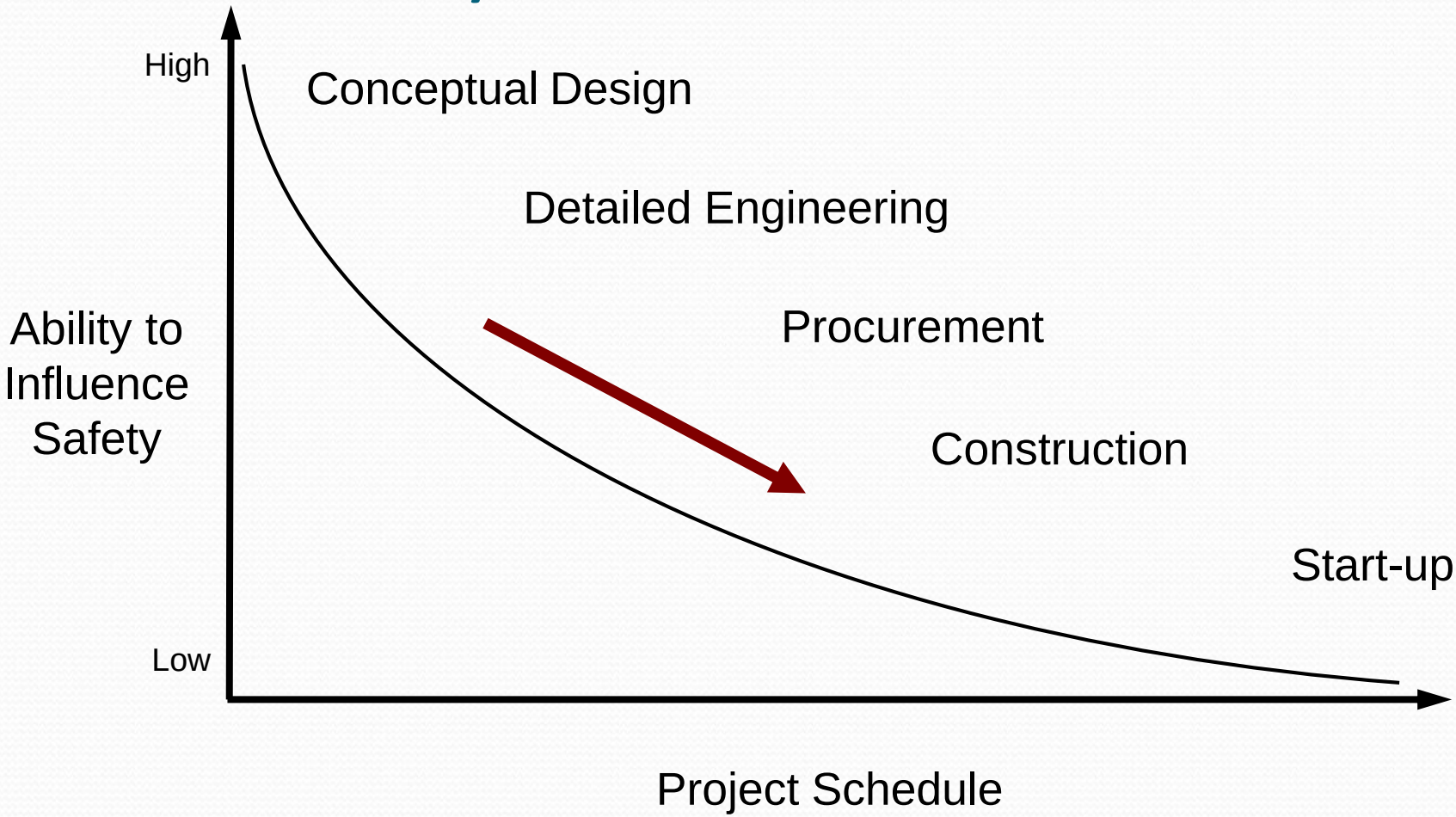
- 22% of 226 injuries that occurred from 2000-2002 in Oregon, WA, and CA
- 42% of 224 fatalities in U.S. between 1990-2003
- In Europe, a 1991 study concluded that 60% of fatal accidents resulted in part from decisions made before site work began

[1] Behm, M., "Linking Construction Fatalities to the Design for Construction Safety Concept" (2005)
[2] European Foundation for the Improvement of Living and Working Conditions

Ethical Reasons for SbD

- 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 ….

Considering Safety During Design Offers the Most Payoff



[1] Szymberski (1987)

Sustainability's Social Equity Pillar

- Do not our duties include minimizing all risks that we have control over?
- Do not we have the same duties for construction workers as for the "public"?
- Is it ethical to create designs that are not as safe as they could (practically) be?

Benefits of Safety by Design

- Reduced site hazards → fewer injuries and fatalities
- Reduced workers compensation premiums
- Increased productivity
- Fewer delays due to accidents during construction allow continued focus on quality
- Encourages designer-constructor collaboration

Examples: Anchorage Points

Examples: Prefabrication

Bridge Trusses

www.ultimateengineering.com

Roof Trusses

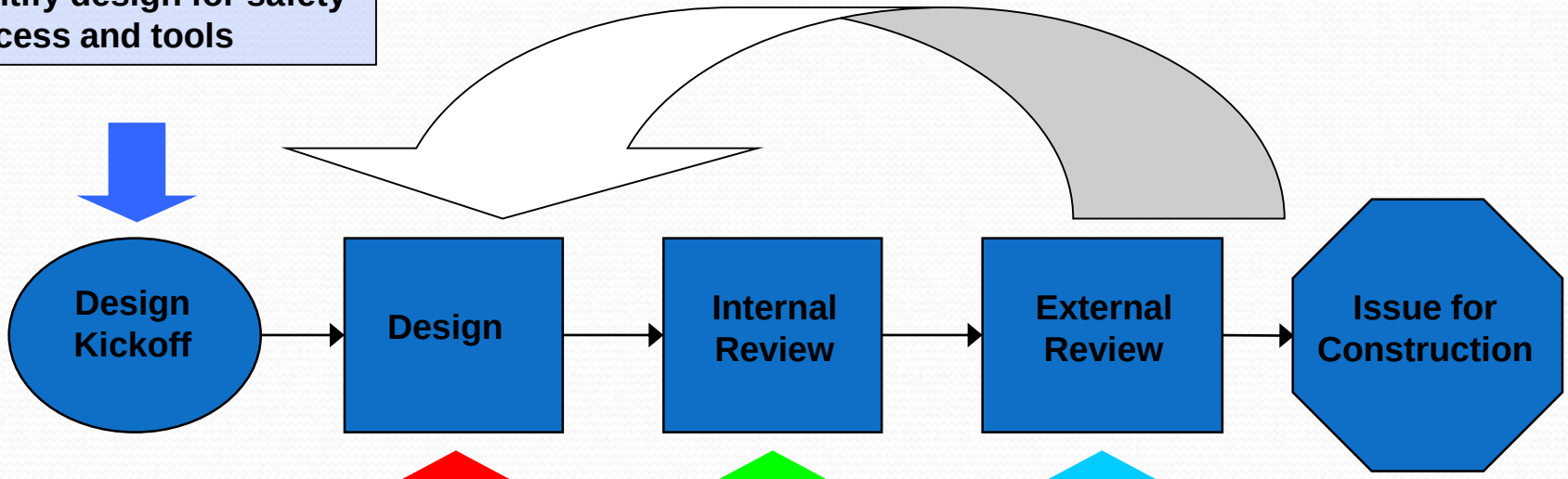
PEB

test.jedinstvo.com

www.niconengineering.com

DfCS Process[1]

- Establish design for safety expectations
- Include construction and operation perspective
- Identify design for safety process and tools



Trade contractor involvement

- QA/QC
- Cross-discipline review

- Focused safety review
- Owner review

[1] Gambatese

alliance
An OSHA Cooperative Program

SbD Practices Around the Globe

- Designers first required to design for construction safety in the United Kingdom in 1995 (revised 2007)
- Other European nations have similar requirements
- Australia also leading in SbD

  http://www.ascc.gov.au/ascc/HealthSafety/SafeDesign/Understanding

Barriers

- Like many good ideas, SbD faces a number of barriers that will likely slow its adoption.

- Potential solutions to these barriers involve long-term education and institutional changes.

Barrier: Designers' Fear of Liability

- Barrier: Fear of undeserved liability for worker safety.
- Potential solutions:
  - Clearly communicate we are NOT suggesting designers should be held responsible for construction accidents.
  - Develop revised model contract language.
  - Propose legislation to facilitate DfCS without inappropriately shifting liability onto designers.

Barrier: Increased Designer Costs

- Barrier: SbD processes will increase both direct and overhead costs for designers.

- Potential solution:
  - Educate owners that total project costs and total project life cycle costs will decrease.

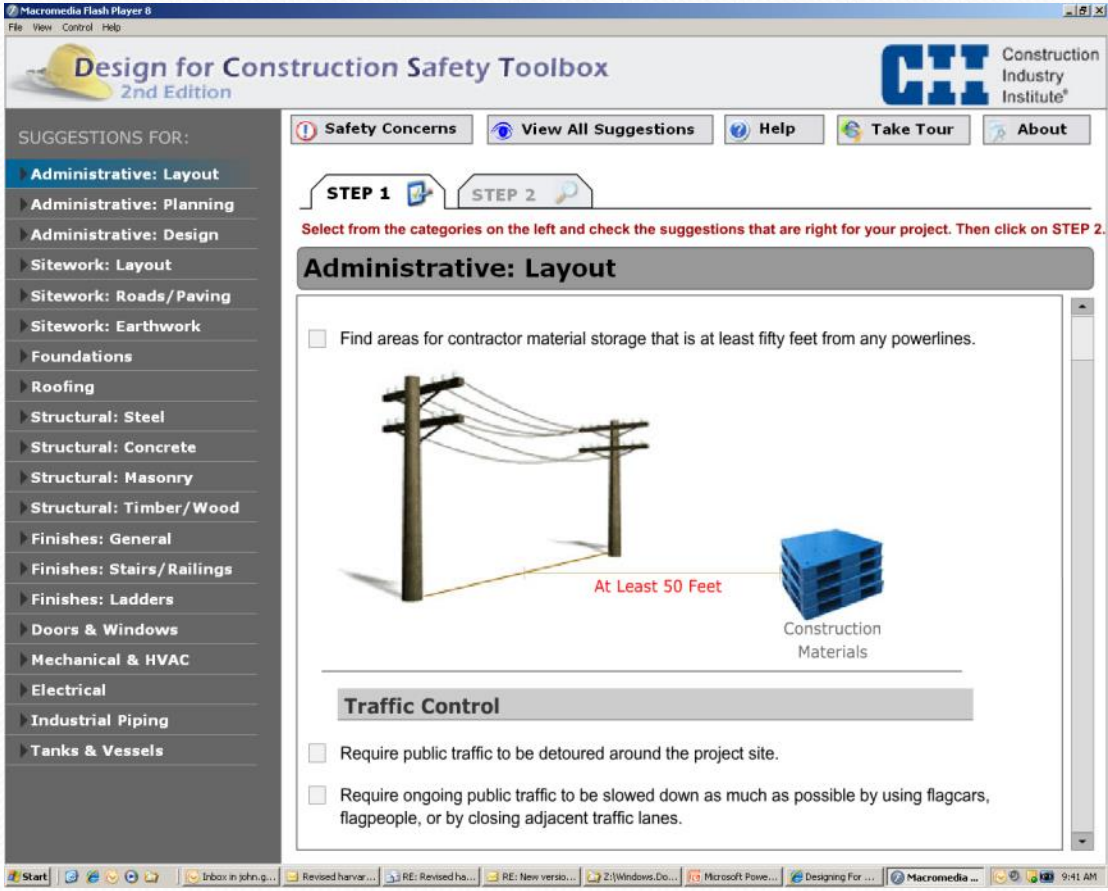
Barrier: Designers' Lack of Safety Expertise

- Barrier: Few design professionals possess sufficient expertise in construction safety.

- Potential solutions:
  - Add safety to design professionals' curricula.
  - Develop and promote 10-hour and 30-hour OSHA courses for design professionals.
  - Disseminate SbD tools.

Design for Construction Safety Toolbox

- Created by Construction Industry Institute (CII)
- Interactive computer program
- Used in the design phase to decrease the risk of incidents
- Over 400 design suggestions



Safety by Design Checklists

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.

Construction Industry Council
CDM Guidance for Designers

Technical Guidance Note

T 20.009

Designing to make management of hazards associated with working on roofs easier

INTRODUCTION

1. Designers can play a major part in making it easier to manage the hazards associated with roof working.

2. Roofs are hazardous places to work, because they are at height and have coverings, which are lightweight and often fragile and deteriorate over time through being exposed to the elements.

3. While work on roofs is an infrequent activity, the opportunity for a fatal or serious accident is very high. And, designers who see roofs only as a means making the building watertight, exacerbate the situation. They forget that people have to construct roofs and maintain them. Consequently, little provision is made for this.

4. People are often killed or injured when falling from roofs. Therefore, designers need to consider alternative designs to ensure roof work can be eliminated or significantly reduced where reasonably practicable.

5. This guidance note makes designers aware of the issues and gives information on how they can help to make roof work safer through their designs.

HAZARDS ASSOCIATED WITH WORK ON ROOFS

6. Workers on roofs are exposed to the hazard of falling from height. This can either be off an unguarded edge or through a fragile surface.

7. Manual handling and premature collapse hazards also exist.

WHAT DESIGNERS SHOULD DO

8. Designers should consider two phases: the construction phase and the maintenance phase

The construction phase

9. During this phase, it is inevitable that people will need to be on the roof and designers should consider providing for systems that will help a contractor to manage the hazard of falling from height.

Falls though roof assemblies

12. Specify liners and top sheets, which are individually non-fragile when fixed down. Information about non-fragility is given in the Advisory Committee for Roofwork's publication ACR[M]001:2000.

Falls caused by premature collapse of structures

13. Individual roof sheets do not weigh a lot. However, the weight of a stack of sheets is significant. Therefore, ensure that the roof structure can carry these loads.

Providing for deliveries

Locate the building to ensure that there is enough space to site a crane so that every part of the building is within its lifting capacity and for incorporating dedicated loading bays, for storing roofing materials, in the scaffolding.

The maintenance phase

14. For this phase, it may not be necessary for people to be on the roof if designers consider solutions, which eliminate the need to go on a roof.

Designing to minimise the need to go on a roof

15. This can be achieved either by minimising the number of items requiring maintenance on a roof or minimising the number of times people have to go on a roof by, for example by:

a) Routing vent stacks through the building side instead of the roof;
b) Combining exhaust flues into a single vent;
c) Ensure that process by-products are effectively removed and discharged high enough above the roof to allow effective dissipation;
d) Having serious concerns about materials where the manufacturer's guarantee requires annual inspections;
e) Optimising the number and position of rooflights, taking into consideration the requirements in other legislation for providing natural light; – see **28.** Note that rooflights will require periodic cleaning to maintain correct light levels within a building;
f) Positioning gutters so that cleaning can be carried out using either cherry-pickers or from other designed safe access routes– but see **20** b) and **24** b)

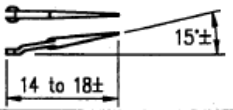
- Know approximate dimensions of necessary tools to make connections

DETAILING GUIDE FOR THE ENHANCEMENT OF ERECTION SAFETY

APPENDIX 1

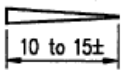
Here are sketches showing what they look like along with dimensions to allow proper clearances when detailing in tight corners...
(Exact dimensions should be checked with actual manufacturer's and/or erector technical data)

The Erection Wrenches



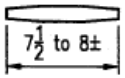
This "Connector" tool is used to guide pieces and align holes, hold parts in alignment while bolting. also known as "Spud Wrench" or "Spanner" (works best with a minimum of two holes connection)

The Bull Pins



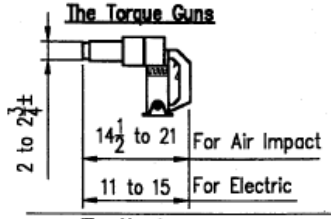
Are used to "Pull pieces together by hammering Its tapered shaft into misaligned holes.

The Drift Pins



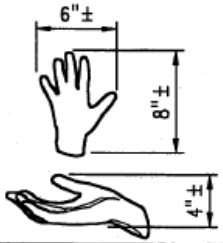
Are used to align large connection parts together. It is hammered in and has the same constant diameter as the holes in the connection.

The Torque Guns



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 has a fixed drive and has to be operated in line with bolts.

The Hands



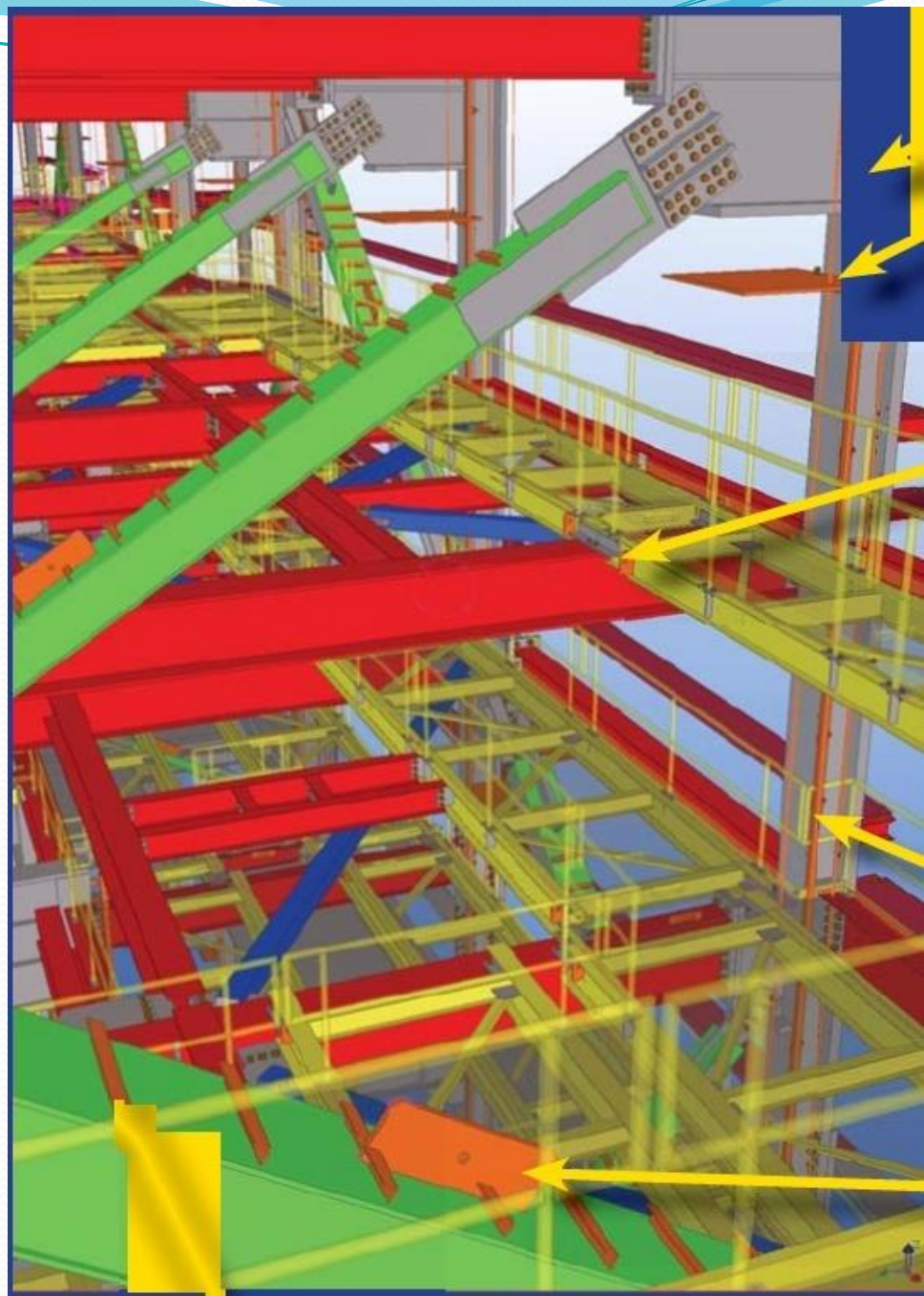
This most important "Connector's" equipment is used for holding the tools, inserting bolts, maneuvering pieces into place, signaling to others....
Good detailing practices should always allow enough space to insert that tool for "Making" the connection.
Bear in mind that in cold weather it is gloved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

TITLE: The Tools of The trade

STEEL ERECTORS ASSOCIATION OF AMERICA	ERECTOR/FABRICATOR NAME	DRAWN BY		NATIONAL INSTITUTE OF STEEL DETAILING NISD
	JOB	DATE		
	JOB NAME	JOB No.	REV.# DATE	
		SKETCH No. A1		

Bechtel's Steel Design Process

- Temporary access platforms
- Lifting lugs
- Shop installed vertical brace ladders
- Bolt-on column ladders & work platforms



Temporary ladder, platform and safety line

Modular Platforms

Brace Lifting Clips and Rungs

DESIGN SAFETY CHECKLIST
CIVIL

THIS HAZARD OR CONCERN NEEDS TO BE ADDRESSED ON THIS PROJECT? Y=YES; N=NO

↓ **THIS HAZARD OR CONCERN:**

↓ **HAS BEEN ADDRESSED IN OUR DESIGN**

↓ ↓ **WILL BE ADDRESSED IN OUR DESIGN**

↓ ↓ ↓ **OTHER**

↓ ↓ ↓ ↓

Design Lead: _____

Project No.: _____

Plant: _____

Date: _____

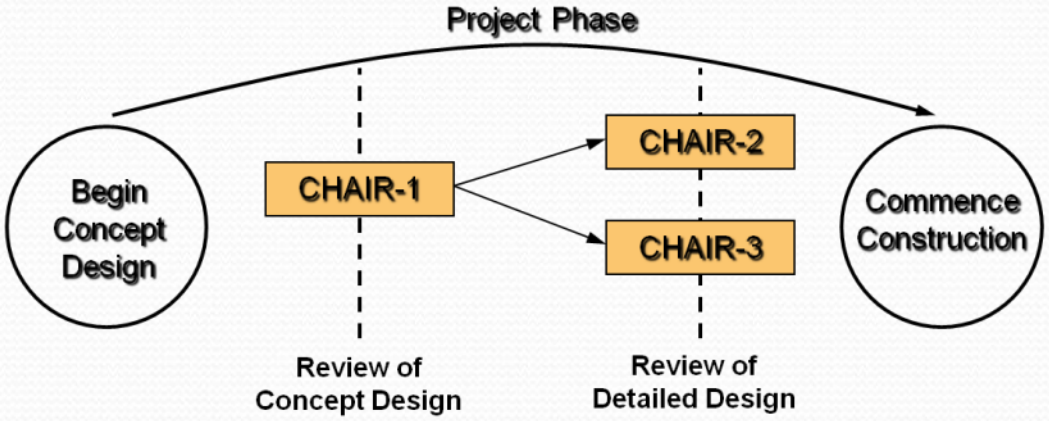
Double-click to add "x" to boxes. ⇩				Item No.	
	☐	☐	☐	1.	Project Engineer has communicated "**HAZCOM**" **project information** required for design engineering personnel making a site visit. (Each person that is sent to the job site must be informed of any potential hazards.)
	☐	☐	☐	2.	Discipline Lead Engineer and civil team understand our safety goal: All engineering drawing and specifications will be prepared with a consideration for **safety and constructability**.
	☐	☐	☐	3.	Construction people working near **fiberglass manufacturing** need to understand the **toxic air pollutants**.
	☐	☐	☐	4.	Locations are identified where guard posts, walls, or barriers should be provided to **prevent access** to potentially unsafe areas.
	☐	☐	☐	5.	**Underground hazards** and reference drawings locating any potential hazards are identified. (Examples: buried pipes, electrical cables, etc.)
	☐	☐	☐	6.	Process engineer, construction project manager, customer, and vendor representatives have identified **special loads** that should be considered in our design.
	☐	☐	☐	7.	Required quality records will be identified, collected, filed, and stored with proper disposition for structural specified **materials**. (Examples: high strength bolts, U-drain grates, concrete cylinder breaks.)

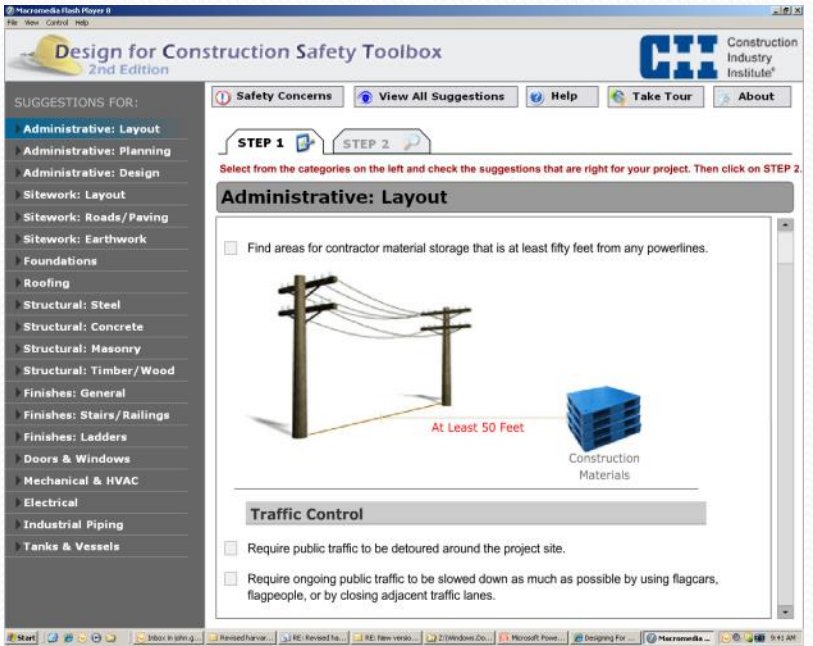
Establish a Lifecycle Safety Culture

- Instill the right safety values
- Secure management commitment
- Ensure all employees are motivated
  1. Professional Codes of Ethics
  2. Payoff data

Establish Enabling Processes

- Provide designers with safety training
- Ensure designer-constructor interaction
- Provide designers with DfCS tools





Summary

- Safety by Design is the right thing to do and the smart thing to do
- Significant barriers are slowly eroding
- Steel design has a fantastic design tool
- Large design-builders and owners are implementing SbD
- Three first steps to implementing SbD

Thanks for Listening

- Questions? Comments? Let's talk!

- For more information:
  - mike.toole@bucknell.edu
  - www.designforconstructionsafety.org
  - http://saferdesign.org/Videos.aspx

Five SbD Trajectories[1]

1. Increased prefabrication
2. Increased use of less hazardous materials and systems
3. Increased application of construction engineering
4. Increased spatial investigation and consideration
5. Increased collaboration and integration

[1] Toole and Gambatese, Journal of Safety Research, 2008

Implications of the 5 Trajectories

- Designers need knowledge of construction safety and construction processes
  - More safety in architectural and engineering curricula
  - Engineering licensure requirements

- Designers need to become better gatherers and communicators of project safety information
  - For example: existing site utilities, availability of prefabricated components, likely methods to be used, working clearances.

Implications for Education of Design Engineers

- Shift in mindset
- Holistic view
- Exposure to SbD fundamentals
- Training in system-specific SbD opportunities
- Engineering course-specific SbD modules

Implications for Contracting

- New contract terms needed
- Design-Bid-Build typically hinders collaboration during design
- Design-Build and Design+Negotiated construction better facilitate collaboration

Implications for Use of Information Technology

- IT represents efficient means for providing designers with information needed to perform SbD
- Manufacturers must make SbD information available
- All entities will need IT to facilitate communication, collaboration, integration