Overview of Presentation

- History
- The Concept
- Examples
- Tools
- Barriers
- Next Steps/ Implementing PtD
- Success Stories
- Candid discussion
- Resources
History

- NSC's Accident Prevention Manual-1955
- National Safety Council-Advisory Committee of the Institute for Safety through Design-Late 1990's
- NIOSH -national workshop 2007
- Mil-STD 882 Standard Practice for System Safety
- OSHA Alliance Construction Roundtable
- ANSI/AIHA Z10 OH&S Management Systems

OSHA Alliance Program Construction Roundtable: Members

- American Industrial Hygiene Association
- American Society of Safety Engineers
- Concrete Sawing and Drilling Association
- Construction Institute-American Society of Civil Engineers
- Independent Electrical Contractors
- Laborers’ Health and Safety Fund of North America
- National Association of Home Builders
- National Institute for Occupational Safety and Health
- Sealant Waterproofing and Restoration Institute
- National Safety Council
- Sealant Waterproofing and Restoration Institute
- Washington Division of URS Corporation
U.S. Construction Accident Statistics¹

- Nearly 200,000 serious injuries and 1,226 deaths each year
- 5.5% of workforce but 21.5% of fatalities
- Construction has one of the highest fatality rates of any industry sector

SIGNIFICANCE: NEARLY 100 DEATHS PER MONTH

¹ Bureau of Labor Statistics-2006

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U.S. Construction Fall Fatality Statistics¹

<table>
<thead>
<tr>
<th>Total Falls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>From roof edge</td>
<td>74</td>
</tr>
<tr>
<td>From scaffold, staging</td>
<td>70</td>
</tr>
<tr>
<td>From ladders</td>
<td>68</td>
</tr>
<tr>
<td>To lower level</td>
<td>48</td>
</tr>
<tr>
<td>Through floor opening, floor surface,</td>
<td>31</td>
</tr>
<tr>
<td>ground to lower level</td>
<td></td>
</tr>
<tr>
<td>From structural steel</td>
<td>24</td>
</tr>
<tr>
<td>Through skylight</td>
<td>23</td>
</tr>
<tr>
<td>From non-moving vehicle</td>
<td>22</td>
</tr>
<tr>
<td>Through roof surface, roof opening</td>
<td>20</td>
</tr>
</tbody>
</table>

¹ Bureau of Labor Statistics-2006
What research tells us...

- **22%** of 226 injuries that occurred from 2000-2002 in Oregon, WA, and CA\(^1\) linked partly to design
- **42%** of 224 fatalities in US between 1990-2003\(^1\) linked to design
- **60%** of fatal accidents resulted in part from decisions made before site work began\(^2\)
- **63%** of all fatalities and injuries could be attributed to design decisions or lack of planning\(^3\)

\(^2\) European Foundation for the Improvement of Living and Working Conditions
\(^3\) NSW WorkCover, CHAIR Safety in Design Tool, 2001

American National Standard

**ANSI/ASSE Z590.3 – 2011**

**Prevention through Design**

**Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes**
Basic components of Z590.3-2011

- Prevention through Design Standard
  - The Hazard Analysis and Risk Assessment Process
  - Hazard Analysis and Risk Assessment Techniques
  - Hierarchy of Controls
Prevention through Design
PtD
Fundamental Activity Related To Z590.3

Purpose:
To prevent or minimize the work related hazards and risks associated with the construction, manufacture, use, maintenance, and disposal of facilities, materials, and equipment.

How:
Thru hazard identification and analysis and making risk assessments throughout the design and redesign processes repeated as necessary.

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...
Early History … • 1750 B.C., Code of Hammurabi, Law 229: “If a builder builds a house for someone, and does not construct it properly, and the house which he built falls in and kills its owner, then that builder shall be put to death.” (a legal code)

1440 B.C.
Bible, Deuteronomy 22:8: “When you build a new house, make a parapet around your roof so that you may not bring the guilt of bloodshed on your house if someone falls from the roof.”

PtD Strategic Goals

- **Research** will establish the value of adopted PtD interventions, address existing design-related challenges, and suggest areas for future research.

- **Education** Designers, engineers, health and Safety Professionals, business Leaders, and workers understand PtD principles and apply their knowledge and skills to the design of facilities, processes, equipment, tools, and organization of work.

- **Practice** Stakeholders access, share and apply successful PtD practices.

- **Policy** Business leaders, labor, academics, government entities, and standard-developing and setting organizations endorse a culture that includes PtD principles in all designs affecting workers.

- **Small Business** Small businesses have access to PtD resources that are designed for or adapted to the small business environment.
Application

- 4 major stages of risk mgmt

- Pre-operational stage
  initial planning, design, specs, prototyping, and construction

Operational stage
  redesign or work changes

Post Incident stage
  incident review and interventions and acceptable risk levels

Post Operational stage
  demolition, decommissioning or reuse/rebuild

Considering Safety During Design Offers the Most Payoff

1 Szymberski (1987)
Constructability

Constructability is an evaluation of how reasonable the design is to construct in terms of:

- Cost
- Duration
- Quality
- Safety

Safety is an often neglected aspect of constructability.

Hazard Analysis and Risk Assessment

ALARP (as low as reasonably practical)

- That level of risk which can be further lowered only by an increase in resource expenditure that is disproportionate in relation to the resulting decrease in risk.
PtD – Safety

- HAZARDS ANALYSES AND RISK ASSESSMENT TECHNIQUES
- What-If/Checklist Analysis.
- Hazard and Operability Analysis (HAZOP).
- Failure Mode and Effects Analysis (FMEA).
- Fault Tree Analysis (FTA).
- Management Oversight and Risk Tree (MRT).
Hierarchy of Controls

• Engineers are vital to minimizing occupational risks through the application of the hierarchy of controls
• The engineering design process provides the framework for the application of prevention through design
New Construction – Lifetime Threat

Gauge 7’ from floor and 21” to wall – unreadable
Must be recorded each shift
Ladder must be used - cannot be fully extended

It’s Bad Designers

Designed Hazard - Ladder needed - lamp at 16’
Designed Hazard - Chicago
It's Bad Designers

One Roof – Two Lifetime Threats Designed by Professionals – new construction
Consider two feet of accumulated snow....

Share (and teach) What We Learn

We actually did it 30% faster than planned

ITSI - Allen Max Construction - MT
Benefits from PtD

- Reduced site hazards so fewer injuries
- Savings from reduced workers compensation insurance costs
- Increased productivity
- Fewer delays due to accidents
- Encourages designer-constructor collaboration

Business Value

- The AIHA Value Strategy* demonstrated the most significant business contributions result from...
  - Anticipating worker exposures and designing process improvements to reduce or eliminate these exposures
  - Aligning health and safety interventions with business goals
  - Integrating health and safety risk management requirements into the design process
    - Facilities, equipment, tools, processes, products and work flows
- ...resulting in significant contributions to business profitability

*www.ihvalue.org
• PtD takes the concept and intended value of the Project Specific Safety Plan (PSSP) being risk analysis and communication to a whole new level.

• 70% of the cost of HSE is fixed at the design stage! Think about it.

• Design is a significant contributor to 37% of work related injuries, illnesses and fatalities. What do we investigate for?

What PtD 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.
PtD and Sustainability

Sustainability

Environmental Equity
Economic Equity
Social Equity

Sustainability’s Social Equity Pillar

- Don’t our duties include minimizing all risks that we have control over?
- Don’t 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?
- Can we consider a building GREEN that cost the lives and livelihood of those who built it?
“The basic concept of sustainability has a social component to it, so safety of construction and maintenance is a natural fit,” he said. “Right now, however, the U.S. Green Building Council that certifies sustainable construction standards doesn’t explicitly consider construction safety. One project in Las Vegas that earned a high level of certification had six construction workers die on the job in an 18-month period.”

- John Gambatese, an associate professor of construction engineering at Oregon State University

“Sustainability is important, But rather than focusing solely on energy and the environment, or striving to gain points on a rating system, designers should also develop better designs that help prevent injuries during construction, operation and maintenance after project completion.”

- John Gambatese, an associate professor of construction engineering at Oregon State University
Examples in Practice

Examples: Anchorage Points
Tripping Hazards

Avoid having connections on top of beams and joists

Temporary ladder, platform and safety line

http://www.shingleberry.signs.com/design_icon/warning%20trip%20hazard.gif
Falls Through Skylights-Specify Guards

Falls From Ladders-Specify Fixed Ladders or Stairways

Specify fixed ladders or stairways whenever possible
Solutions = Efficiency

“Couldn’t we just drop a rope?”
VP of Safety

“Just Take the Stairs”

Modular Platforms
The Erector Friendly Column

- Include holes in columns at 21” and 42” for guardrail cables and at higher locations for fall protection tie-offs
- Locate column splices and connections at reasonable heights above floor
- Provide seats for beam connections

Constructability Tips for Steel Design

- *Detailing Guide for the Enhancement of Erection Safety* published by the National Institute for Steel Detailing and the Steel Erectors Association of America
Simple Solutions: Floor and Ground-Level Work

- Stand-up screw guns
- Powder-actuated tools with stand-up handles
- Motorized concrete screeds
- Rebar tying tools
- Kneeling creepers
- Adjustable scaffolding for masonry work

CPTED's 3 Core Strategies

- Natural Surveillance
- Natural Access Control
- Territorial Reinforcement

Designing the Age Friendly Worksite
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
Three Steps towards PtD

1. Establish an enabling culture
2. Establish enabling processes
3. Secure clients who value lifecycle safety

Establish Enabling Processes

- Provide designers with safety training
- Ensure designer-constructor interaction
- Provide designers with PtD tools
### PtD Checklists

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

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### DESIGN SAFETY CHECKLIST

**CIVIL**

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

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>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.)</td>
</tr>
<tr>
<td>2.</td>
<td>Discipline Lead Engineer and civil team understand our safety goal. All engineering drawings and specifications will be prepared with a consideration for safety and constructability.</td>
</tr>
<tr>
<td>3.</td>
<td>Construction people working near fiberglass manufacturing need to understand the toxic air pollutants.</td>
</tr>
<tr>
<td>4.</td>
<td>Locations are identified where guard posts, walls, or barriers should be provided to prevent access to potentially unsafe areas.</td>
</tr>
<tr>
<td>5.</td>
<td>Underground hazards and reference drawings locating any potential hazards are identified. (Examples: buried pipes, electrical cables, etc.)</td>
</tr>
<tr>
<td>6.</td>
<td>Process engineer, construction project manager, customer, and vendor representatives have identified special loads that should be considered in our design.</td>
</tr>
<tr>
<td>7.</td>
<td>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.)</td>
</tr>
</tbody>
</table>
Implications for Contracting

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

A/E Involvement Must be Encouraged

- Reality:
  - No regulatory requirement
  - No recognized duty
  - No immediate financial incentive

- Motivating mechanisms
  - Selection process
  - Contractual obligations
  - Financial incentives
Steps to PtD

1. **Education, training, and tools**
   - Safety in architecture/engineering education
   - Professional continuing education classes
   - Safety in professional licensure requirements
   - Visualization and work flow tools

2. **Right place, right time, right resources**
   - Safety review in project development process
   - Integrated project delivery methods
   - Co-locating design and construction staff
   - Supported by owner/client (resources)
Steps to PtD

1  2  3  4  5  PtD

- **Safety is a design criterion**
  - Part of standard design practice
  - Incorporated into design codes
  - Contractually prescribed by owner/client
  - Required by legislation

Steps to PtD

1  2  3  4  5  PtD

- **Safety is a cultural value**
  - Authorization to modify the design for safety
  - Designing out the hazard is first choice
  - Safety and health given high priority relative to other project criteria
Steps to PtD

1. Designing for safety has value
   - Lifecycle savings outweigh costs, and economically feasible for designers
   - Improvements in safety, quality, productivity
   - Morally/ethically responsible
   - Desired by owners/clients (priority)

2. PtD
   - Construction site hazards eliminated/reduced
   - Improvements in safety, quality, productivity
   - Improvements in maintenance safety
   - Design and construction integration/collaboration
Research Findings

- Priority of project criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Average Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>2.4</td>
</tr>
<tr>
<td>Deadlines</td>
<td>2.1</td>
</tr>
<tr>
<td>Project cost</td>
<td>3.7</td>
</tr>
<tr>
<td>Project schedule</td>
<td>4.2</td>
</tr>
<tr>
<td>Availability</td>
<td>4.2</td>
</tr>
<tr>
<td>Construction worker safety</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*Ranking:
1 = Highest priority
6 = Lowest priority
A smaller number represents higher priority.


Barriers

- Like many good ideas, PtD 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(PtD) without inappropriately shifting liability onto designers.

Barrier: Increased Designer Costs

- Barrier: PtD 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 PtD tools.

Design Builders who Practice PtD

- URS/Washington Group
- Jacobs
- Parsons
- Fluor
- Bechtel
Owners who are moving towards PtD

- Southern Company
- Intel
- Harvard University
- U.S Army Corps of Engineers
- Johnson and Johnson
- Kaiser Permanente
- The Dow Chemical Company
- Schneider Electric North America
- Gulf Petrochemical Industries Company

Success Stories

- National Asphalt Pavement Association- warm mix asphalt
- Kaiser Permanente- rubber flooring, cotton insulation, displacement ventilation
National Asphalt Pavement Association

Hazard:
Employee exposure to asphalt “fumes”

Hazard Control:
Design new technology to produce “Warm Mix”
- Reduced OD exposure and green house gases
- Lower fuel costs
- Better working conditions
  - Unintended consequences:
    - Extended paving season in cold climates and travel distances
    - Improved quality
- Lengthened lifespan of the pavement
- Allows the reuse of higher percentage of reclaimed material w/o compromising quality

Winner of U.S. DOT/U.S. EPA’s Green Highway Partnership award
www.warmmixasphalt.com
Kaiser Permanente

- **Hazard**: slips/falls of patients/staff/visitors, noise levels, leg fatigue etc.
- **Hazard Control**: replace PVC tile with synthetic rubber product. Benefits: reduced mercury to environment, reduced exp to asthma, elim waxing, better traction, absorbs sound, reduced leg fatigue, stain resistant

Kaiser Permanente

- **Hazard**: Fiberglass Insulation
- **Hazard Control**: replace with Cotton bat insulation
  - Benefits: mold mildew and pest resistant employee exposure during installation, elimination of halogenated fire retardants, reduced noise (-5dbA)
Kaiser Permanente

- **Hazard**- air quality
- **Hazard Control**- replace general dilution ventilation with Displacement ventilation
  
  Benefits: less air is needed to achieve comfort, better air quality, reduced exposure to infectious diseases, smaller fans thus energy savings

Recap

- Prevention through Design is an emerging process for saving lives, time and money.
- PtD is the smart thing to do. PtD is right thing to do.
- While site safety is ultimately the contractor’s responsibility, the designer has the most power to create drawings with good constructability.
- There are tools and examples to facilitate Prevention through Design.
We have the opportunity to effect change! What are we going to do with it?

Thanks for Listening

- Questions? Comments? Let’s talk!

“A journey of a thousand miles..begins with the first step”
The following slides highlight additional resources available

Design for Construction Safety Web Site

Screen Capture of Design for Construction Safety Web site
Alliance Program Construction Roundtable

In 2004, OSHA recognized that a number of alliance program participants shared a common interest in construction-related topics and issues and the participants' expertise could be leveraged by bringing them together to discuss these topics and develop related compliance assistance tools and resources. As a result, the agency formed the OSHA Alliance Program Construction Roundtable to provide participants with the opportunity to share construction-related information about Alliance-related activities and successes and network with others in the Program. As an outcome of the Roundtable, a Fall Protection and Design for Safety Workgroups were established. The Workgroups are meeting regularly and developing and disseminating construction-related compliance assistance tools and other resources to employers and employees in the workplace.

The Alliance Program Construction Roundtable met on July 6, 2004 and January 30, 2005.

Fall Protection Workgroup

The Fall Protection Workgroup is developing construction-related compliance assistance tools and other resources focusing on fall protection.

Fall Prevention Resources

OSHA

- Alliance Program Construction Roundtable Web Page
  http://www.osha.gov/dcsp/alliances/roundtables/roundtablesconstruction.html

Other

- Design for Construction Safety Web Site
  http://www.designforconstructionsafety.org

- NIOSH Prevention Through Design Web Page
  http://www.cdc.gov/niosh/topics/PTD

- Safety in Design
  www.safetyindesign.org

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- John Gambatese, PhD, PE
  School of Civil and Const. Engineering
  Oregon State University
  john.gambatese@oregonstate.edu
Links on www.designforconstructionsafety.org

Other PtD-related websites

- OSHA Construction Alliance Roundtable
- NIOSH's PtD Webpage
- Information about OSHA's Alliance Program
- Federal OSHA Standards for Construction
- Department of Labor Accident Data
- Homepage for the United Kingdom's Law Requiring Designing for Safety
- The Actual Text of the UK Law
- Design Best Practice (a non-profit group focusing on the UK CDM regulations)
- Australia’s Safe Design Webpage
- Hazard Information Foundation, Inc. - a non-profit group that recently completed a study on DfCS
- ASCE’s Site Safety Policy 350

Resources and Processes
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!

Benefits of PtD

- Reduced site hazards and thus fewer injuries
- Reduced workers’ compensation insurance costs
- Increased productivity
- Fewer delays due to accidents
- Increased designer-structor collaboration
- Reduced absenteeism

AIHA www.aiha.org
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/](http://www.cdc.gov/niosh/topics/PtD/)  
[www.cdc.gov/niosh/programs/PtDesign/](http://www.cdc.gov/niosh/programs/PtDesign/)

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References


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  www.asce.org/Content.aspx?id=7231

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  www.hse.gov.uk/guidance/index.htm
- National Society of Professional Engineers (NSPE)
  www.nspe.org/ethics
- NIOSH Fatality Assessment and Control Evaluation Program
  www.cdc.gov/niosh/face
- NIOSH Prevention through Design program Websites:
  www.cdc.gov/niosh/topics/PtD
  www.cdc.gov/niosh/programs/PtDesign