Using Prevention through Design (PtD) to Help Reduce Risk in Construction

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Lecture Topics

- What is PTD?
- How PTD applies to construction.
- New PTD Tool that incorporates Risk Assessment Techniques.
What is Prevention through Design?

◆ Prevention through Design (PtD) is an emerging risk management technique that is being applied successfully in many industries, including manufacturing, healthcare, telecommunications and construction.

◆ We consider the safety of workers throughout the life cycle while the product and/or process is being designed.

◆ This is only done voluntarily in the U.S.- while risk assessment is required in the U.K. and Australia.

◆ PtD concept applies only to the design of the permanent facility- the aspects of the completed building that make a project inherently safer to build.

◆ PtD does not focus on how to make different methods of construction engineering safer.

➢ For example, it does not focus on how to use fall protection systems, but it does include consideration of design decisions that influence how often fall protection will be needed.
Why Prevention through Design?

Construction is one of the most hazardous occupations.

This industry accounts for:

- 7% of the U.S. workforce, but 21% of fatalities
- About 1,000 deaths annually
- About 200,000 serious injuries annually.
Accidents Linked to Design

- 22% of 226 injuries that occurred from 2000 to 2002 in Oregon, Washington, and California were linked partly to design.²

- 42% of 224 fatalities in U.S. between 1990 and 2003 were linked to design.²

- In Europe, a 1991 study concluded that 60% of fatal accidents resulted in part from decisions made before site work began.³

- 63% of all fatalities and injuries could be attributed to design decisions or lack of planning.⁴

Therefore, engineers are encouraged to consult with EH&S professionals early in the design process to identify and design out hazards associated with similar types of structures.
PtD Applies to Constructability

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

- Most architects know that what may look great on paper might not be safely constructible.
- An important part of the design process is to evaluate the design’s constructability, can be constructed at a reasonable price, quickly, and with high quality?
  - Safety is an important part of constructability.
- Accidents cost money, delay construction, and may result in bad publicity rather than acclaim for the owner.
PtD Process

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

Design kickoff → Design → Internal review → External review → Issue for construction

- QA/QC
- Cross-discipline review
- Focused safety review
- Owner review

Trade contractor involvement
Safety Payoff During Design

- Conceptual design
- Detailed engineering
- Procurement
- Construction
- Start-up

Ability to influence safety vs. Project schedule
Benefits from PtD

• Reduced site hazards and thus fewer injuries
• Reduced workers compensation insurance costs
• Increased productivity
• Fewer delays due to accidents
• Increased designer-constructor collaboration
• Safer design ➔ fewer project delays ➔ better value!!
PtD Process

Tasks¹¹, ¹²

- Perform preliminary hazard analysis where the designer meets with field professionals to review constructability, look through the entire design for any hazards, and address those hazards.

- **Incorporate** safety, health and environmental recommendations into the design documents.

- Construction documents can be supplemented with graphic models and tables that contribute to safe erection.
  
  - EXAMPLE: Make a computer-aided design (CAD) model for member labeling and erection sequencing or use a Building Information Modeling (BIM) to identify spatial problems before construction.
Our Inspiration...PtD Standard

- *The Prevention through Design standard* addresses occupational safety and health needs in the design and redesign processes to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, materials and equipment.

- One of the goals is to educate designers, engineers, machinery and equipment manufacturers, SH&E professionals, business leaders, and workers to understand and implement PtD methods and apply this knowledge and skills to the design and re-design of new and existing facilities, processes, equipment, tools, and the organization of work.
SH&E professional could play a significant role in incorporating PtD principles into the risk management process. PtD principles could also be successfully integrated into ISO 31000 Clause 5.

- ANSI/ASSE Z690.2-2011 (ISO 31000) includes three main sections:
  - (1) Risk Management Principles (Clause 3);
  - (2) Framework (Clause 4),
  - (3) Process (Clause 5).

- ISO 31000 (ANSI/ASSE Z690.2-2011) is not one of the incorporated standards in ANSI/ASSE Z590.3 -2011, the PtD standard.
Possible ANSI/ASSE Z690.2-2011 (ISO 31000) and ANSI/ASSE Z590.3 -2011 Integration

Establish the Context 5.3

RA 5.4

Communications and control

Risk Identification

Risk Analysis

Risk Evaluation

Risk Treatment 5.5

Monitoring and Review

The Hazard Analysis and Risk Assessment Process

7.1 Management Direction
7.2 Select a Risk Assessment Matrix
7.3 Establish the Analysis Parameters
7.4 Anticipate/Identify the Hazards
7.5 Consider the Failure Modes
7.6 Assess the Severity of Consequences
7.7 Determine Occurrence Probability
7.8 Define the Initial Risk
7.9 Select and Implement Risk Reduction and Control Methods
7.10 Assess the Residual Risk
7.11 Risk Acceptance Decision Making
7.12 Document the Results
7.13 Follow Up on Actions Taken
Hierarchy of Controls per ANSI/AIHA Z10-2012

**ELIMINATION**
Design it out

**SUBSTITUTION**
Use something else

**ENGINEERING CONTROLS**
Isolation and warnings

**ADMINISTRATIVE CONTROLS**
Training and policies

**PERSONAL PROTECTIVE EQUIPMENT**
Last resort

Control effectiveness

Business Value
Risk Assessment and PtD Tools

- SH&E professionals should learn how to develop tools and models to incorporate appropriate hazard identification and risk assessment techniques into the risk management process.

- At UCM a new tool has been developed based on the recommended risk assessment techniques referenced in both standards.

- Our risk assessment tool has been successfully utilized to demonstrate effective risk assessment methodology for construction projects.
Risk Assessment Process

ANSI/ASSE Z590.3-2011

- Identify tasks and hazards
  - FMEA
  - 5x5 Matrix

- Assess Risk – Initial Risk Scoring System
  - Bow Tie Analysis: Current State

- Reduce Risk – Hazard Control Hierarchy
  - FMEA / Bow Tie: Future State

- Assess Risk – Residual Risk Scoring System
  - 5x5 Matrix
FMEA: Define the Risk / ID Hazards

- Consider failure modes.
- Assess the severity of consequences.
- Determine occurrence probability.

<table>
<thead>
<tr>
<th>Part or Process Name</th>
<th>Reinforcing concrete</th>
<th>Suppliers &amp; Departments Affected</th>
<th>Prepared By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design/ Mfg Responsibility</td>
<td>Model Date</td>
<td>FMEA Date</td>
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<tr>
<td>Other Areas Involved</td>
<td>Engineering Change Level</td>
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</table>

**Assess Risk - Initial Scoring System: Current State**

<table>
<thead>
<tr>
<th>Process Operation, Function or Purpose</th>
<th>Potential Exposure Mode</th>
<th>Potential Effect(s) of Exposure</th>
<th>SE</th>
<th>Potential Cause(s) of Exposure</th>
<th>OCC</th>
<th>Current Controls Evaluation Method</th>
<th>P</th>
<th>S</th>
<th>O</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforcing concrete, Rebar tying using hammers.</td>
<td>Low-back WMSDs</td>
<td>Low-back injuries</td>
<td>4</td>
<td>Lack of controls</td>
<td>4</td>
<td>Training</td>
<td>4</td>
<td>16</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoulders, neck WMSDs</td>
<td>Shoulder/neck injuries</td>
<td>3</td>
<td>Lack of controls</td>
<td>3</td>
<td>Training</td>
<td>4</td>
<td>9</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reinforcing concrete. Pile and a tie wire wheel used to pull, wrap, twist, and cut the tie wire around two or more concrete reinforcing bars</td>
<td>Hand/feet/shoulders WMSDs, rapid and repetitive hand, wrist, and forearm movements while gripping the piles</td>
<td>4</td>
<td>Lack of controls</td>
<td>3</td>
<td>Training</td>
<td>4</td>
<td>12</td>
<td>48</td>
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</tr>
</tbody>
</table>
Select a Risk Assessment Matrix

Risk Assessment Matrix: Numerical Gradings

Severity Ranking: 4
Probability Ranking: 5

Occurrence Probabilities and Values

<table>
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<tr>
<th>RA Matrix</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
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<td>1</td>
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<td>5</td>
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</tbody>
</table>

Very high risk: **15 or greater**  High risk: **9 – 14**  Moderate risk: **4 – 8**  Low risk: Under 4

PtD Standard Ratings
Severity, Probability/Occurrence & Prevention Effectiveness Scoring

Severity: 1-5 scale.
1-Insignificant
2-Negligible
3-Marginal
4-Critical
5-Catastrophic

Occurrence: 1-5 scale.
1-Unlikely
2-Seldom
3-Occasional
4-Likely
5-Frequent

Prevention Effectiveness: 1-5 scale.
1- Avoid, eliminate, substitute
2- Engineering control
3- Warning, administrative
4- PPE
5- None
So...How difficult is it to do Bowtie analysis?
“Bow tie analysis is a simple diagrammatic way of describing and analyzing the pathways of a risk from causes to consequences. It can be considered to be a combination of the thinking of a fault tree analyzing the cause of an event (represented by the knot of a bow tie) and an event tree analyzing the consequences.”
New Equipment Testing – Improved design

High Risk

Let’s work SMARTER not harder…

Moderate Risk

Low Risk
Questions?
References


ANSI/ASSE. (2011). *Prevention through Design guidelines for addressing occupational hazards and risks in design and redesign processes ANSI/ASSE Z590.3-2011*


CHAIR safety in design tool [2001]. New South Wales, Australia: NSW WorkCover.


