PtD Research: Why Implement Prevention through Design?

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Prevention through Design Workshop
March 11 of 2020, Tempe, AZ

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Outline

- The Importance of Design
- Research: Connecting Design to Safety
- Research: Identification of Practice Impediments
- Research: Development of Supporting Tools and Resources
The Importance of Design

• Design is a powerful ability.

“Things alter for the wrong spontaneously, if they be not altered for the better designedly.”

Francis Bacon (1561–1626), British author, statesman, philosopher, and scientist
The Importance of Design

The ability to influence safety is greatest early in the project schedule during planning and design. (Szymberski, 1997)


The Importance of Design

An academic argument for PtD:

1. We create designs.
2. Designs impact safety.
3. Therefore, we impact safety through designs.

Yes, but……

Are there impediments in design practice and/or culture that prevent PtD implementation?

Hierarchy of Controls

- Elimination
- Substitution
- Engineering Controls
- Administrative Controls
- PPE

Most effective

Prevention through Design Workshop
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Research Focus

- What are we designing and whose safety are we considering.

<table>
<thead>
<tr>
<th>Design of what?</th>
<th>Safety of who?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Constructor</td>
</tr>
<tr>
<td>Permanent facility</td>
<td></td>
</tr>
<tr>
<td>Permanent equipment</td>
<td>✓</td>
</tr>
<tr>
<td>Temporary construction structures</td>
<td>✓</td>
</tr>
<tr>
<td>Construction equipment</td>
<td>✓</td>
</tr>
<tr>
<td>Construction process</td>
<td>✓</td>
</tr>
<tr>
<td>Other…</td>
<td></td>
</tr>
</tbody>
</table>

The focus of greatest interest, concern, and research in construction

Impact of Design on Safety

22% of 226 injuries that occurred from 2000-2002 in Oregon, WA, and CA related to design\(^1\)

42% of 224 fatalities in US between 1990-2003 related to design\(^1\)

Changes in the design of the permanent structure could have reduced the likelihood of 47% of construction site incidents\(^2\)

60% of fatal accidents resulted in part from decisions made before site work began\(^3\)

\(^1\) Behm, M., "Linking Construction Fatalities to the Design for Constr. Safety Concept" (2005)
\(^3\) Lorent, P. (1987). European Foundation for the Improvement of Living and Working Conditions
Impact of Design on Safety

• Is the time-safety curve correct?

• Evaluation using Sustainable Construction Safety and Health (SCSH) rating system
  • Comparison of SCSH credits earned and TRIR

• Analysis: [Poisson, a.k.a., log-linear, regression]
  • Influence of safety input (explanatory variable) on the incident rate (response variable) after accounting for project phase in which the safety input is implemented

Impact of Design on Safety

Recordable Injury Rate (RIR)

• Number of OSHA recordable injuries per 200,000 worker hours

1.15
2.35
0
0.5
1
1.5
2
2.5
RIR

Design-Build
General Contract
(Design-Bid-Build)


Impact of Design on Safety

• Physical energy and injury severity

Graphic source: CII, RT-321, Precursor Analysis.
Impact of Design on Safety

Design elements that prohibit workers from using conventional tools can lead to:
- Risk-taking
- Risk discounting


Impact of Design on Safety

Perspectives of the impact of design decisions on safety by:
- Engineers (n = 244)
- Architects (n = 221)
- Owners (n = 121)

Benefits

- Reduced site hazards
- Increased productivity
- Increased quality
- Fewer delays due to accidents
- Designer-constructor collaboration
- Improved operations and maintenance safety
- Reduced workers' compensation premiums
- Marketing, recognition

Expected Impacts

Survey of design and construction professionals in the UK:
- Change as a result of implementing PtD (% of respondents)

<table>
<thead>
<tr>
<th>Item</th>
<th>Decrease</th>
<th>No Change</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design cost (n=35)</td>
<td>6%</td>
<td>46%</td>
<td>49%</td>
</tr>
<tr>
<td>Construction cost (n=38)</td>
<td>34%</td>
<td>24%</td>
<td>42%</td>
</tr>
<tr>
<td>Design duration (n=37)</td>
<td>8%</td>
<td>57%</td>
<td>35%</td>
</tr>
<tr>
<td>Construction duration (n=39)</td>
<td>38%</td>
<td>44%</td>
<td>18%</td>
</tr>
<tr>
<td>Construction quality (n=39)</td>
<td>8%</td>
<td>28%</td>
<td>64%</td>
</tr>
<tr>
<td>Construction worker productivity (n=30)</td>
<td>13%</td>
<td>33%</td>
<td>53%</td>
</tr>
<tr>
<td>Construction worker health &amp; safety (n=45)</td>
<td>4%</td>
<td>9%</td>
<td>87%</td>
</tr>
<tr>
<td>End-user health and safety (n=42)</td>
<td>5%</td>
<td>10%</td>
<td>86%</td>
</tr>
</tbody>
</table>

Source: Final Report, NIOSH PtD in the UK study, May 2013.
Expected Impacts

- Innovation

![Diagram showing innovation, safety, and elimination efforts]


Interest in PtD

- Owner attitudes toward PtD

<table>
<thead>
<tr>
<th></th>
<th>Industry Surveys (n = 103)</th>
<th>Case Study Surveys (n = 79)</th>
<th>All Surveys (n = 182)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The potential benefits of PtD do not seem compelling to me.</td>
<td>5%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>The benefits of PtD sound promising but there are too many barriers to try implementing it.</td>
<td>11%</td>
<td>3%</td>
<td>7%</td>
</tr>
<tr>
<td>The benefits of PtD sound like a good idea. I would consider trying it.</td>
<td>68%</td>
<td>46%</td>
<td>58%</td>
</tr>
<tr>
<td>PtD sounds like a winner. I have already or will likely try to implement it.</td>
<td>17%</td>
<td>48%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Ability to Address Safety during Design

HOC = Hierarchy of Control
5 = Elimination
4 = Substitution
3 = Engineering
2 = Administrative
1 = PPE


Ability to Address Safety during Design

Industry survey: PtD knowledge in the US construction industry

Addressing Safety in the Design

- Which building is safer to build? How much safer?

Concrete-framed building  Steel-framed building

Building systems
- Design elements
  - Design element options

Construction tasks

Injury incident history
- Frequency
- Severity

Safety risk (severity/unit)

Productivity
Addressing Safety in the Design

www.constructionsliderule.org

![Diagrams and images related to safety in design and project assessment]
Addressing Safety in the Design

Addressing Safety in the Design

• Results: Risk visualization


Addressing Safety in the Design

• Results: Daily risk schedule

Impediments to PtD

• No or minimal designer education and training in:
  - Site safety
  - Designing for safety
• Difficult to assess risks during design
• Contractual separation of design and construction
• Cost and time required to design for safety
• Fear of increased liability
• Competing priorities: Safety vs. cost/schedule/aesthetics

(Source: http://www.btea.com/2016/11/28/comparing-project-delivery-methods/)

Impediments to PtD

• How frequently do you consider each of the following criteria during facility design?

<table>
<thead>
<tr>
<th></th>
<th>Always (5)</th>
<th>Often (4)</th>
<th>Sometimes (3)</th>
<th>Rarely (2)</th>
<th>Never (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of design</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of construction</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner demand</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building aesthetics</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction schedule</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>End-user safety</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker safety</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>

Impediments to PtD

- Does worker safety receive a level of priority that is equal to other design criteria?

### Challenges to Adoption of PtD

<table>
<thead>
<tr>
<th>Challenges to Adoption of PtD</th>
<th>Rank</th>
<th>Relative Index (RI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No immediate financial incentive for Architects/Engineers</td>
<td>1</td>
<td>0.89</td>
</tr>
<tr>
<td>2. Lack of regulatory requirement of Architects/Engineers</td>
<td>2</td>
<td>0.83</td>
</tr>
<tr>
<td>3. Lack of recognizable duty of Architects/Engineers</td>
<td>3</td>
<td>0.74</td>
</tr>
<tr>
<td>4. Reluctance to change the standard contracts to enable the adoption of PtD</td>
<td>4</td>
<td>0.71</td>
</tr>
<tr>
<td>5. Lack of knowledge and training about PtD among Architects/Engineers</td>
<td>5</td>
<td>0.68</td>
</tr>
<tr>
<td>6. Resistance from Architects/Engineers to adopt PtD</td>
<td>6</td>
<td>0.67</td>
</tr>
<tr>
<td>7. Resistance from Owners to adopt PtD</td>
<td>6</td>
<td>0.67</td>
</tr>
<tr>
<td>8. Lack of knowledge and training about PtD among Owners</td>
<td>8</td>
<td>0.64</td>
</tr>
</tbody>
</table>


PtD Diffusion

- Next step…putting PtD into practice

**Attributes**

- Knowledge
  - PtD concept
  - Hierarchy of controls
  - Expected impacts

- Desire (motivation)
  - Contract
  - Business case – ROI
  - Recognition
  - Regulation
  - Duty
  - Morals/Ethics
  - Innovation

- Ability
  - Resources and tools
  - Safety hazard recognition
  - Identification of safe designs
  - Timing
  - Foreseeability

- Execution
  - Priority
  - Standard practice
  - Authority
  - Innovation


Thank you!

[https://ptd.engineering.asu.edu/](https://ptd.engineering.asu.edu/)

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