



BUILDING INNOVATION

Conference

Prevention through Design in the Construction Industry

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NIOSH Office of Construction Safety
and Health

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health, and should not be construed to represent any agency determination or policy.



BUILDING INNOVATION

Conference

- What is Prevention through Design (PtD)?
- How does PtD fit into safety and health programs for workers?
- Why should we think about PtD in Construction?
- Hazards in the Construction Industry – example – Falls
- Resources to help implement PtD
- Case Example
- PtD and Sustainability



Department of
Labor

Mine Safety
and Health
Administration
MSHA

Occupational
Safety and Health
Administration
OSHA



Research, Training, and
Prevention Recommendations

Department of Health and
Human Services

Centers for Disease
Control and Prevention
CDC

National Institute for
Occupational
Safety and Health
NIOSH

NIOSH Construction Safety and Health Program

Intramural Research

- Basic Research
- Surveillance
- Methods Research
- Exposure Assessment
- Controls Development
- Applied Research
- Research to Practice

National Construction Center

- Industry Characterization
- Applied Research
- Industry Liaison
- Intervention
- Research to Practice

Extramural Investigators & Partners

- Innovative Ideas
- Opportunities
- State Initiatives
- Research
- Research to Practice

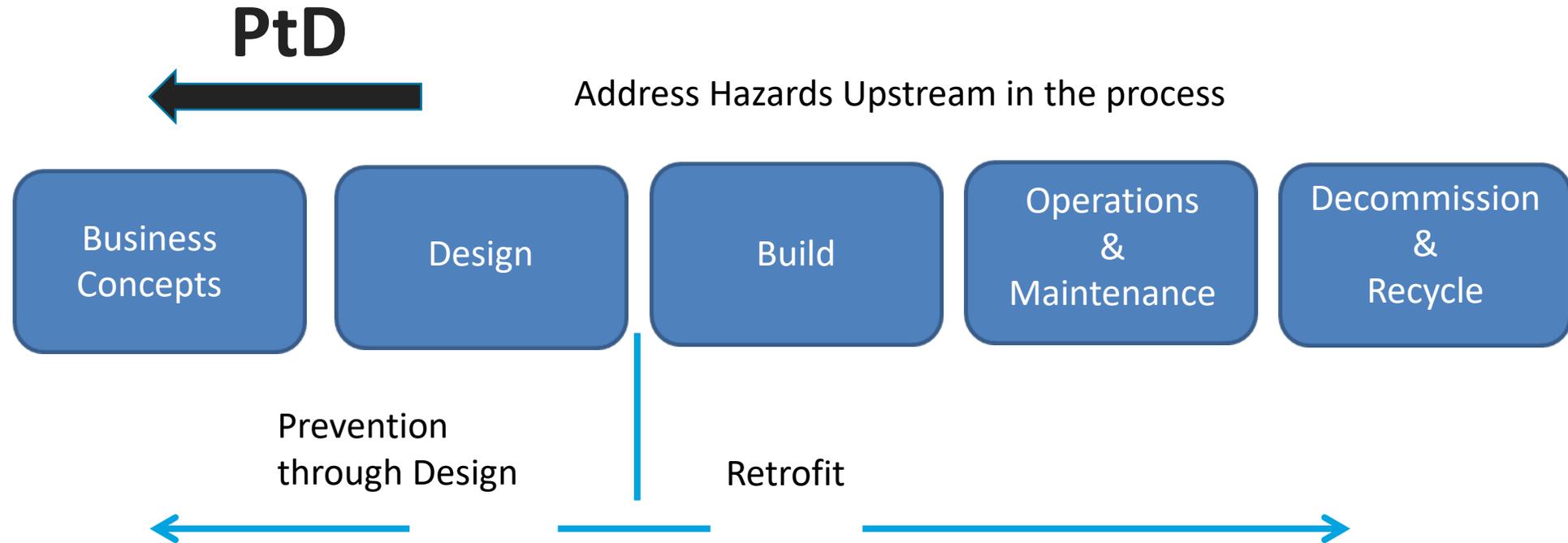


ACADEMIA/PROFESSIONALS/PARTNERS

Why PtD?

- *Prevention through Design is intended to prevent or reduce occupational injuries, illnesses, and fatalities through the inclusion of prevention considerations in all designs that impact workers:*
 - *Also known as ‘Design for Safety’ and other terms*
- **“Anticipating and *DESIGNING OUT* hazards in tools, equipment, processes, materials, structures, and the organization of work is *the most effective way to prevent occupational injuries, illnesses, and fatalities.*”**
 - John Howard, M.D.
Director, National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention

PtD - Moving Upstream

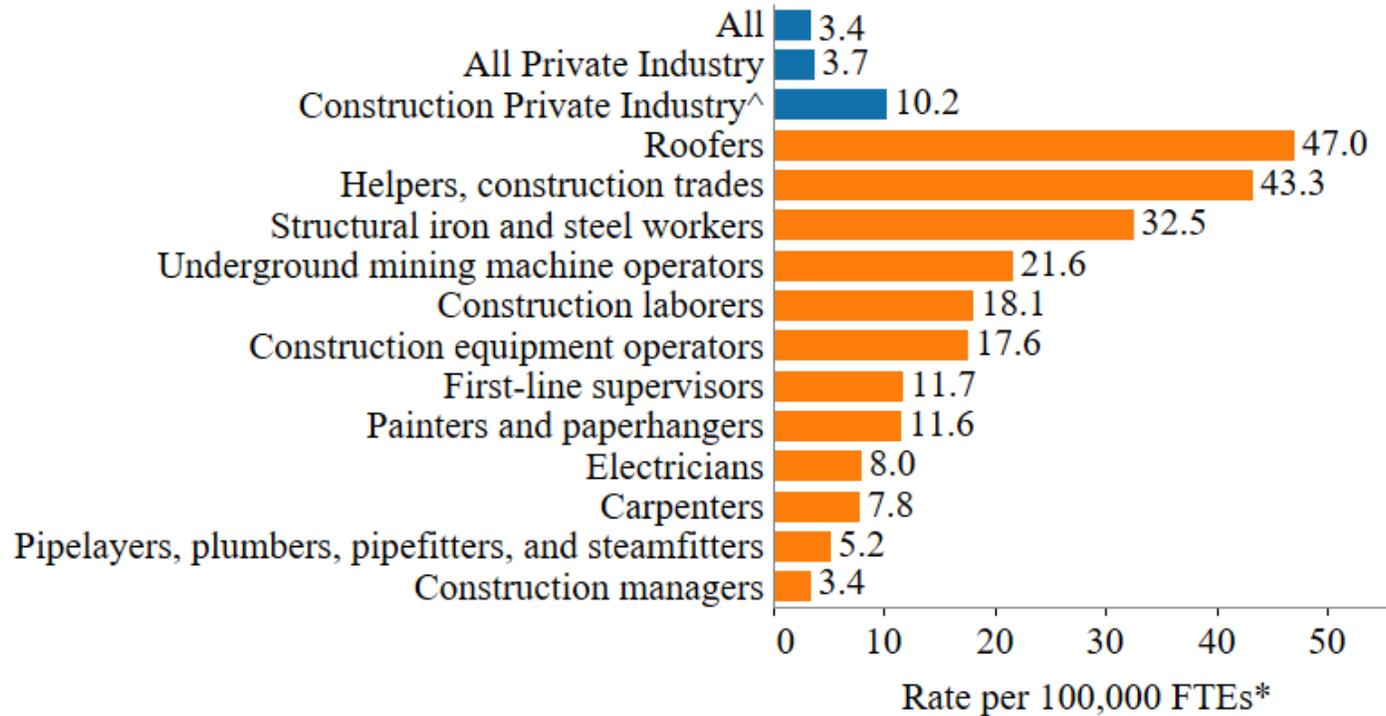


Move worker protection from an afterthought to a forethought in process, product and facility design

Fatal Injuries Among Worker by Industry



4. Rate of fatal injuries in construction and extraction occupations, 2020*



Sources: U.S. Bureau of Labor Statistics, Total hours worked and rate of fatal occupational injuries by selected worker characteristics, occupations, and industries, civilian workers, 2020.

https://www.bls.gov/iif/oshwc/foi/cfoi_rates_2020hb.xlsx. Accessed April 2022.

*BLS calculates the rate per 100,000 full-time equivalent workers as Number of Fatal Injuries/Total Hours Worked X 200,000,000.

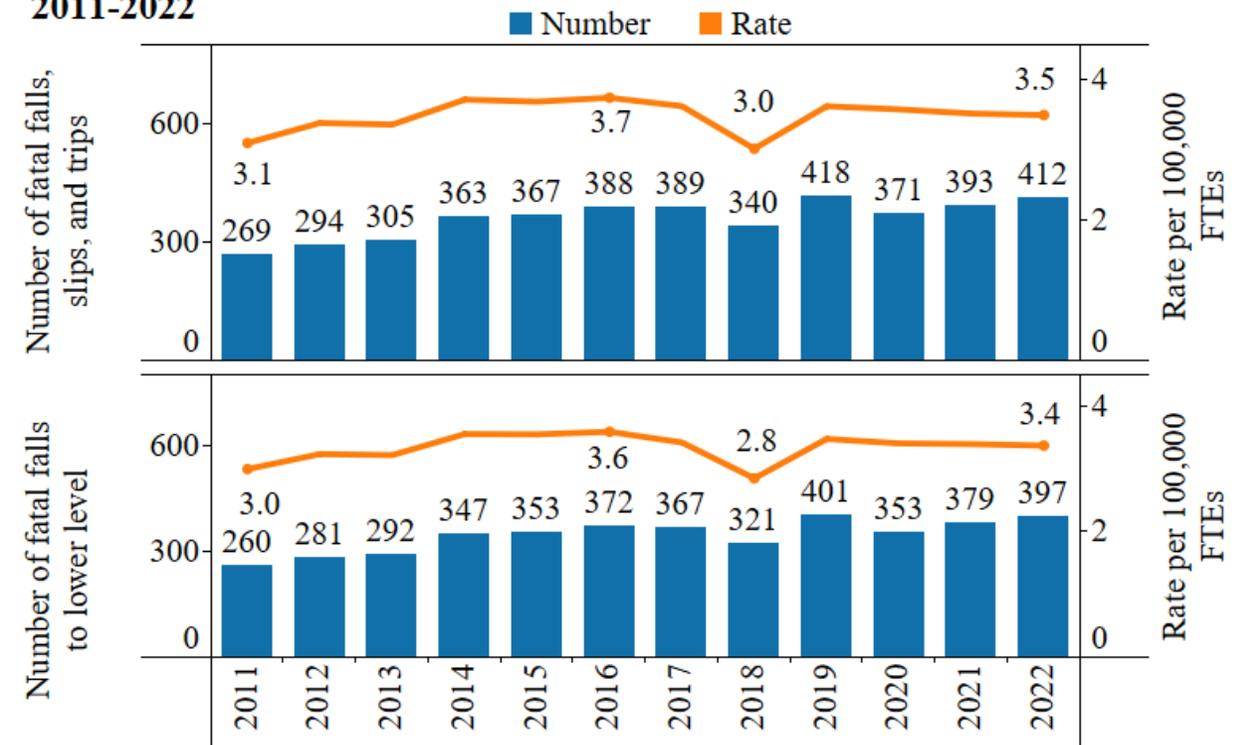
^Due to differences in rate calculations and underlying data this rate varies slightly from Chart 1.

Fatal Falls in Construction



- In 2022, there were 412 fatal falls, slips, and trips in construction
- From 2011 to 2022, the number of these fatal falls increased 53%, while rates increased 13%
- Common ‘factors responsible’ include roofs, ladders, and scaffolds and staging rose

1. Number and rate of fatal falls, slips, trips and falls to lower level, 2011-2022



Source: U.S. Bureau of Labor Statistics, 2011-2022 Census of Fatal Occupational Injuries and 2011-2022 IPUMS Current Population Survey. Calculations by the CPWR Data Center.

Individual Workers



Case 1: A demolition laborer fell 19 feet to his death while working on the roof of a building that was undergoing demolition - 2022

Case 2: A roofing contractor performing building construction stepped on a fiberglass skylight and fell 30 feet to the surface below - 2022

Case 3: A roofing project manager was performing a post-purchase roof inspection and fell 25 feet to the surface below – 2023



HAZARD ALERT

Kentucky Occupational Safety and Health Surveillance—May 2023



**FATALITIES
CAUSED BY FALLS
THROUGH
SKYLIGHTS**

The Hierarchy of Controls



Elimination
hazard removed

Substitution
hazard replaced

Engineering Controls
hazard isolated

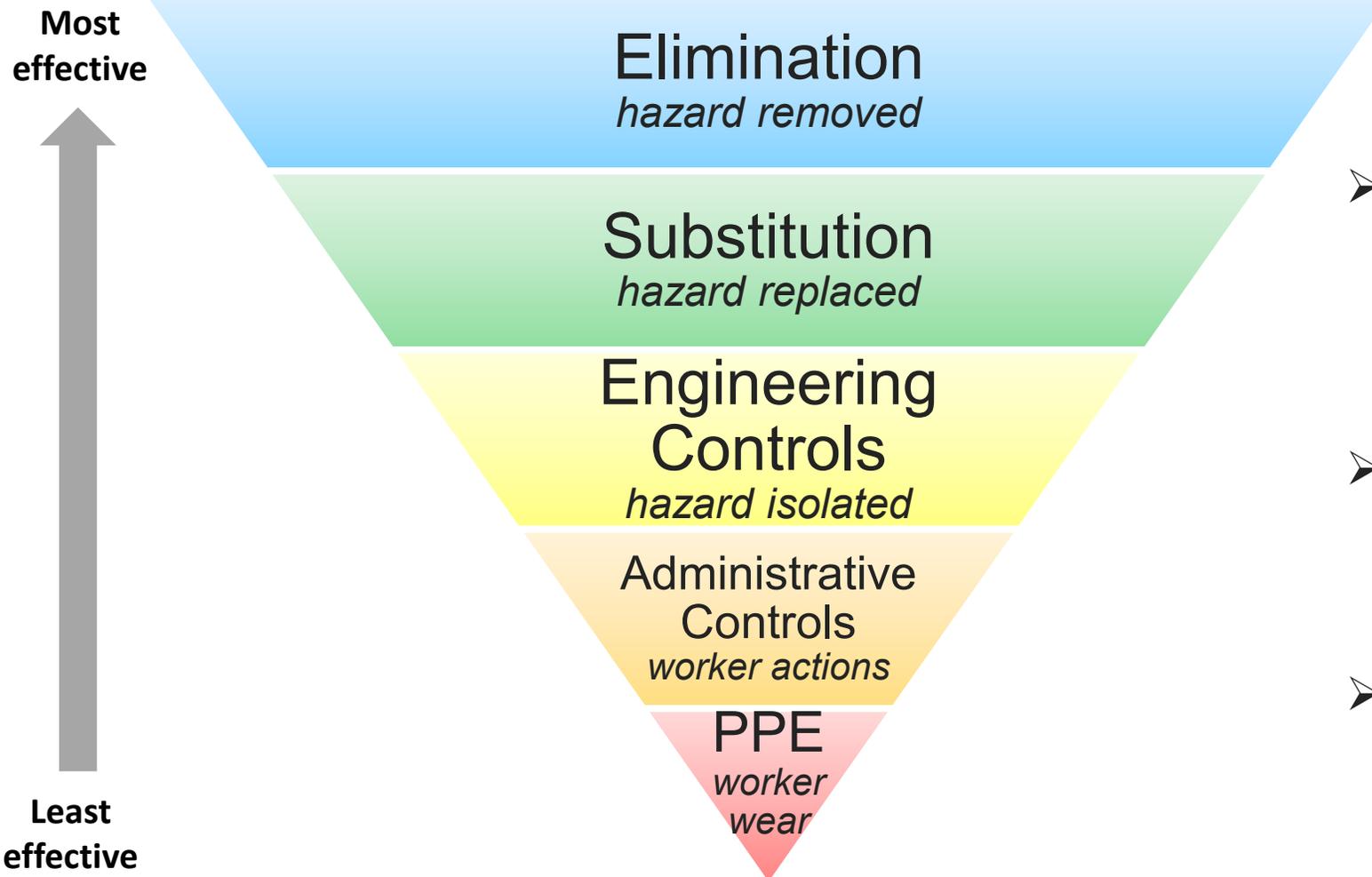
Administrative Controls
worker actions

PPE
worker wear

Controlling exposures to hazards in the workplace is vital to protecting workers. The hierarchy of controls is a way of determining which actions will best control exposures. Preferred order of action based on general effectiveness is top to bottom:

- Elimination
- Substitution
 - ❑ Elimination and substitution are best used at the design or development stage of a work process, place, or tool.
- Prevention through Design is an approach to proactively include prevention when designing work equipment, tools, operations, and spaces.

The Hierarchy of Controls



- Prevention through Design is a thoughtful process of choosing hazard controls from the levels of the *Hierarchy of Controls*.
- Elimination, at the top of the Hierarchy, is the PtD **priority**, when possible.
- *Prevention* of hazards keeps a worker safe with no further action.

Implementing the Hierarchy of Controls to Reduce Falls in Construction Involves All Parties



Most effective

Elimination
hazard removed

Substitution
hazard replaced

Engineering Controls
hazard isolated

Administrative Controls
worker actions

PPE
worker wear

Least effective

- Designing permanent building features so that fall protection is not needed can meet requirements and provide improved safety for workers, decreasing likelihood of fall incidents.
- Employers'/contractors' responsibility to identify and mitigate potential hazards with safety and health program.
- Workers' responsibility to apply provided training and implement aspects of worksite safety and health program.

Support for PtD

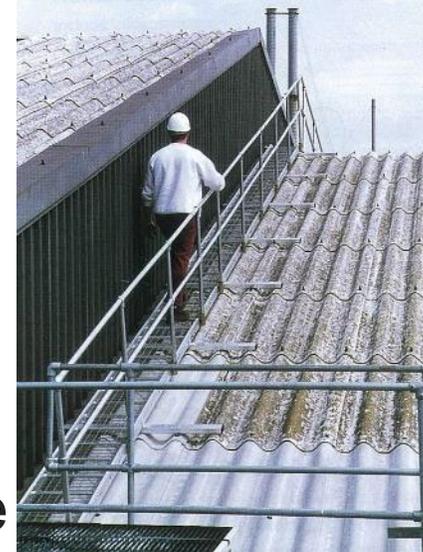


22% of 226 injuries that occurred from 2000-2002 in Oregon, WA, and CA related to design¹

42% of 224 fatalities in US between 1990-2003 related to design¹

Changes in the design of the permanent structure could have reduced the likelihood of **47%** of construction site incidents²

60% of fatal accidents resulted in part from decisions made before site work began³



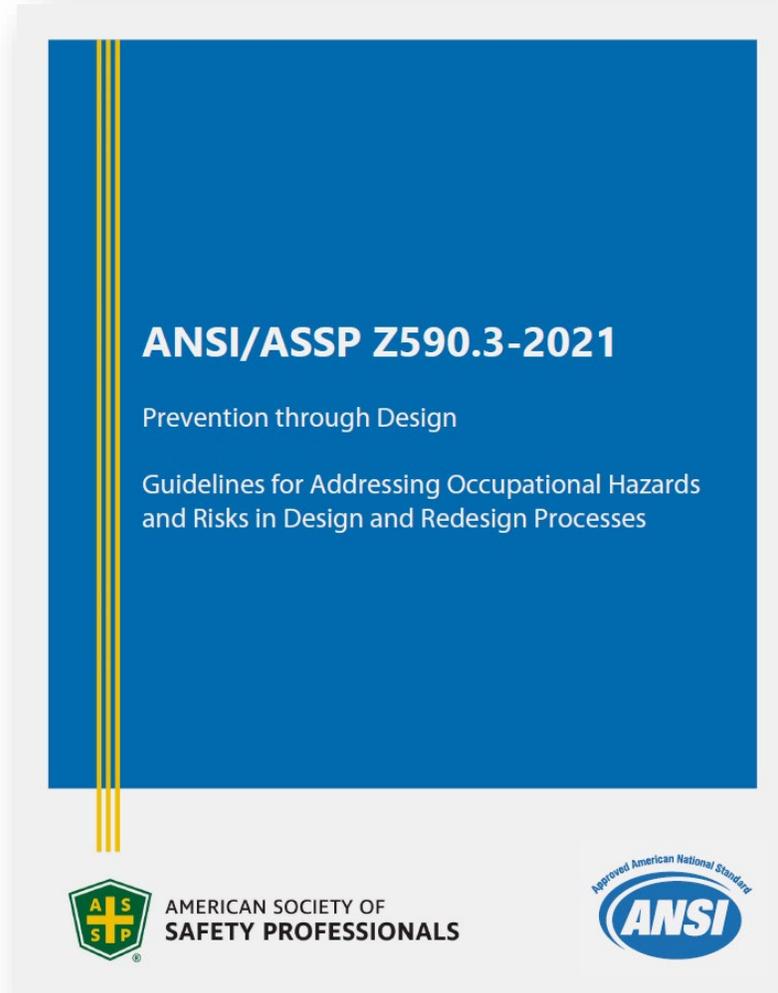
¹ Behm, M., "Linking Construction Fatalities to the Design for Constr. Safety Concept" (2005)

² Gibb et al. (2004). "The Role of Design in Accident Causality."

³ Lorent, P. (1987). European Foundation for the Improvement of Living and Working Conditions

PtD Resources

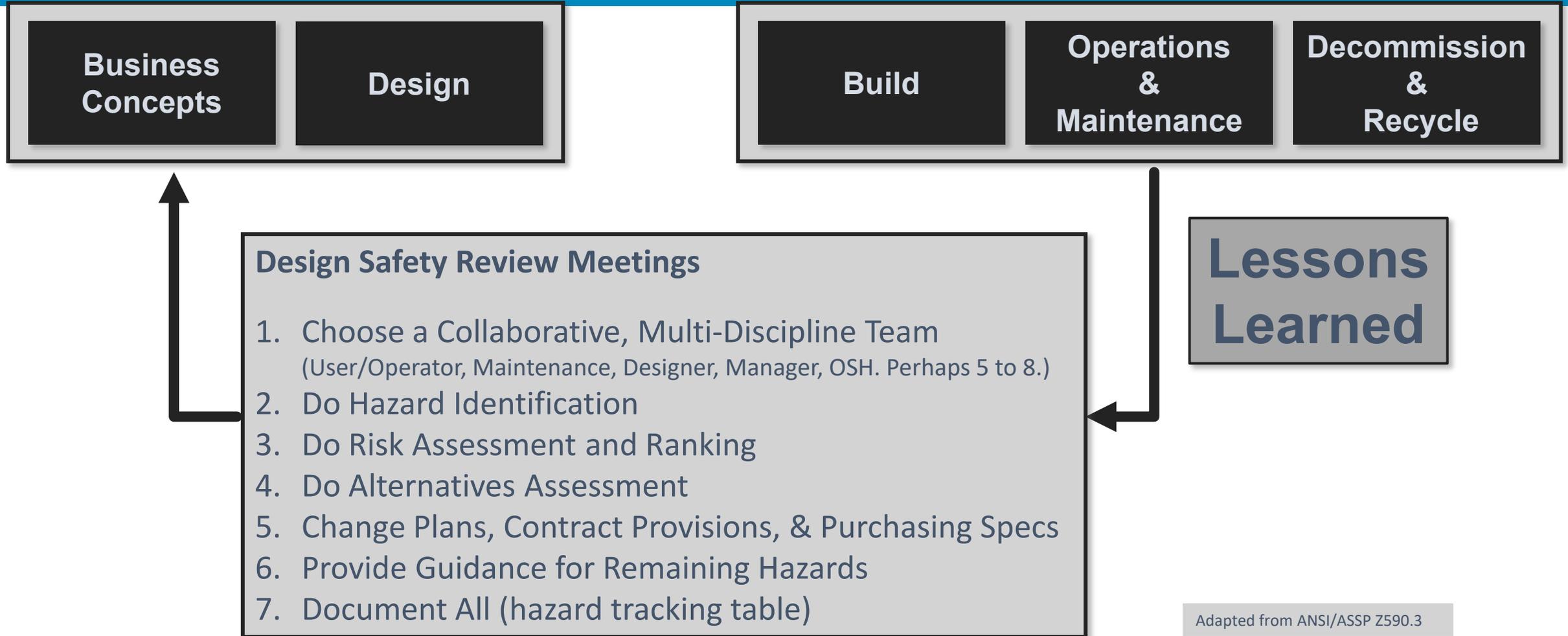
- ANSI/ASSP Z590.3 PtD Standard



- The Z590.3 PtD Standard provides help for a team wanting to do Design Safety Reviews, or other PtD methods.
- The standard itself is short, yet there are many appendices.



Design Safety Review meetings (ANSI/ASSP Z590.3)

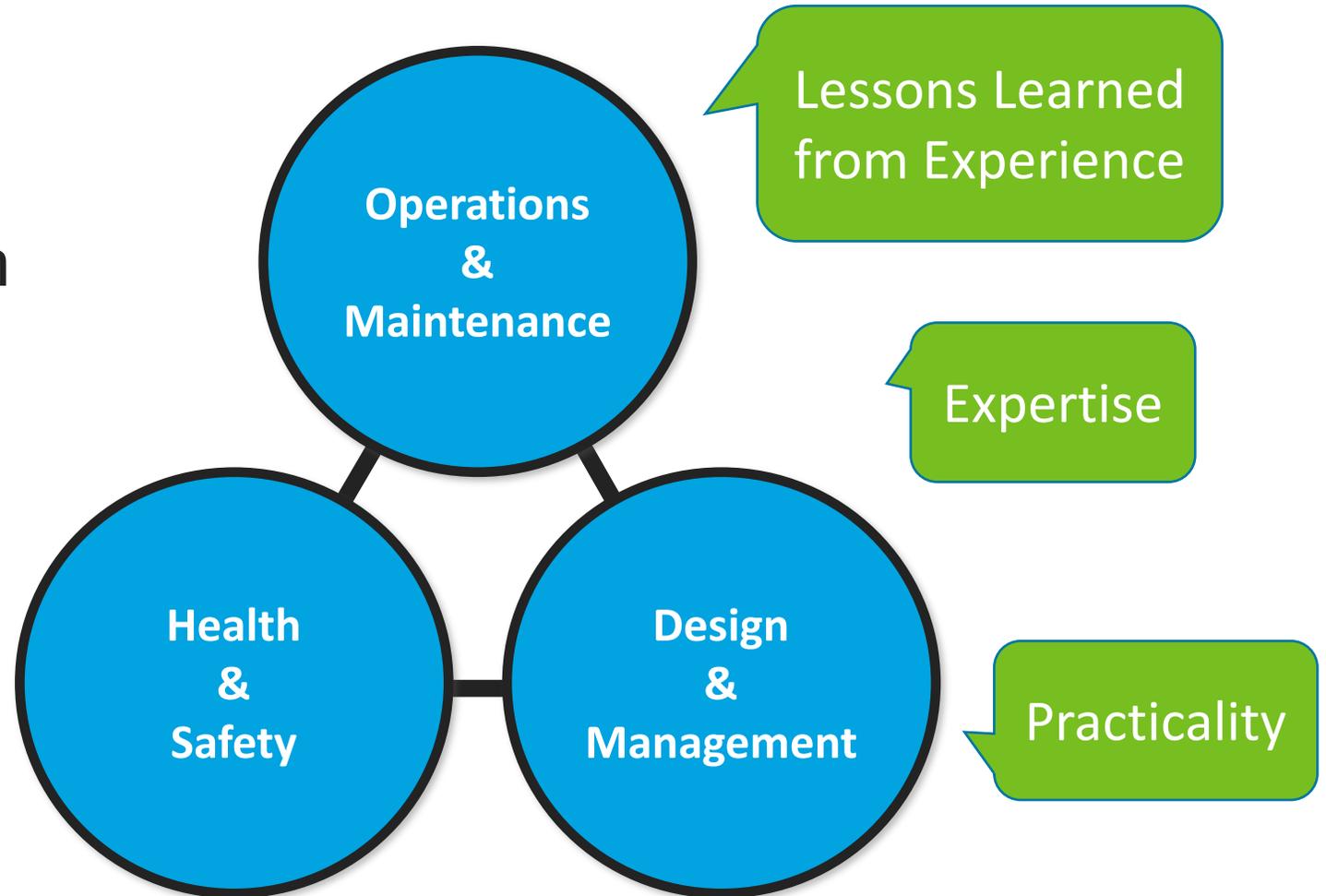


Adapted from ANSI/ASSP Z590.3

Collaborate in Design Safety Review meetings



- Choose people with experience and expertise in your business.
- Meet to do *Design Safety Review(s)* of designs or planned changes.
- Better solutions often come during discussions or between meetings.



Constructability (Design) Review Opportunities



- A chance to review plans and drawings with a PtD eye (reduce/eliminate risk)
 - Any design expectations not met?
 - What tasks and/or design components could add risk to the work?
 - Are there options to design out hazards or risk?
 - Who has control over design decision making?
 - What perspective(s) is the design review taking into account?
 - Public
 - End users
 - Construction Workers
 - All?

Other PtD Resources



➤ NIOSH PtD Website

<https://www.cdc.gov/niosh/topics/ptd/default.html>

➤ Includes, for example, “Workplace Design Solutions”



**Preventing Falls from Heights
through the Design of
Embedded Safety Features**



**Preventing Falls through the
Design of Roof Parapets**

Other PtD Resources



- Intended to support PtD implementation in practice.
- Addresses PtD from perspective of those implementing it in practice, with wide range of topics addressing Ptd implementation. Examples of Appendices include:
 - A1 Example Organizational PtD Policy
 - A3 Owner's Guide to Implementing PtD
 - A4 Contract Modifications to Incorporate PtD
 - A5 Professional Liability (PL) Insurance Guidance

PREVENTION THROUGH DESIGN (PTD) IN THE PROJECT DELIVERY PROCESS

A PtD Sourcebook for Construction Site Safety

By:
John Gambatese, PhD, PE(CA)
School of Civil and Construction Engineering
Oregon State University

January 2019

<https://designforconstructionsafety.org/wp-content/uploads/2019/09/ptd-in-the-project-delivery-process.pdf>



➤ What PtD is:

- Including worker safety considerations in the constructability review process.
- Including project's inherent risk to construction and maintenance workers in design decisions.
- Leveraging concepts captured in the Hierarchy of Controls.

➤ 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.
- Implying that the vast majority of U.S. design professionals are currently equipped to design for construction safety.

FROM: <https://designforconstructionsafety.org/ptd-concept/>



The Prevention through Design Annual Award

- Recognizes individuals, teams, businesses, and other organizations that have eliminated or reduced hazards through design or re-design efforts or have contributed to the body of knowledge that enables PtD solutions.
- NIOSH presents the award in partnership with the American Industrial Hygiene Association (AIHA), the American Society of Safety Professionals (ASSP) and the National Safety Council (NSC).
- [The Port of Portland won the 2023 Prevention through Design Award for their work at the PDX/Next airport.](#)

The screenshot shows the NIOSH website page for Prevention through Design. At the top, there is a search bar and the NIOSH logo. The main heading is 'Prevention through Design' with a 'Print' link. Below this is the PtD logo and the text 'Prevention through Design'. The 'Overview' section states: 'One of the best ways to prevent and control occupational injuries, illnesses, and fatalities is to "design out" or minimize hazards and risks. NIOSH leads a national initiative called Prevention through Design (PtD). PtD's purpose is to promote this concept and highlight its importance in all business decisions.' The 'Program Mission' section states: 'The mission of the Prevention through Design National Initiative is to prevent or reduce occupational injuries, illnesses, and...'. A sidebar on the left lists various resources: PtD Award, Guidance & Publications, Green, Safe and Healthy Jobs, Partnerships and Collaborations, Other PtD Resources, News & Events, PtD Workshop, and PtD Conference - A New Way of Doing Business.

Project Background



- Port of Portland Parking and Rental Car Center (PACR) project value was \$325 million and included construction of 5 building structures. The PACR project is part of the PDX Next \$2.5B program. <https://pdxnext.com/>
- **PDX Next Overview:** PDX Next is the Port of Portland's program to deliver a convenient, comfortable, uniquely PDX experience for travelers and employees now and into the future.

Material on PACR Project Provided By:

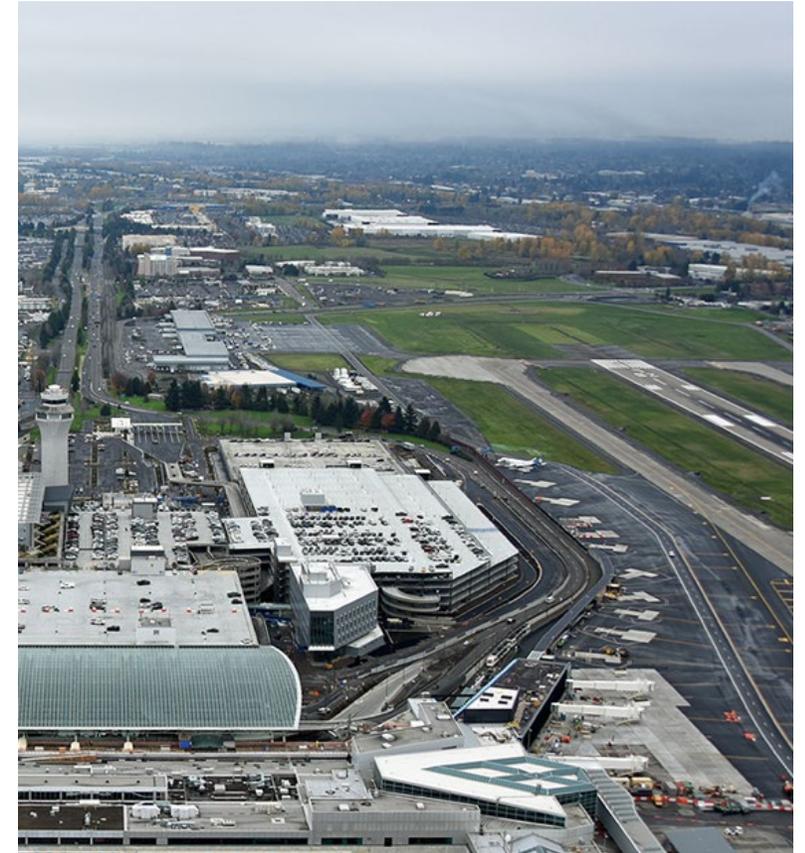
Dave Stanton
Port of Portland Construction Safety Manager
david.stanton@portofportland.com



Project Background



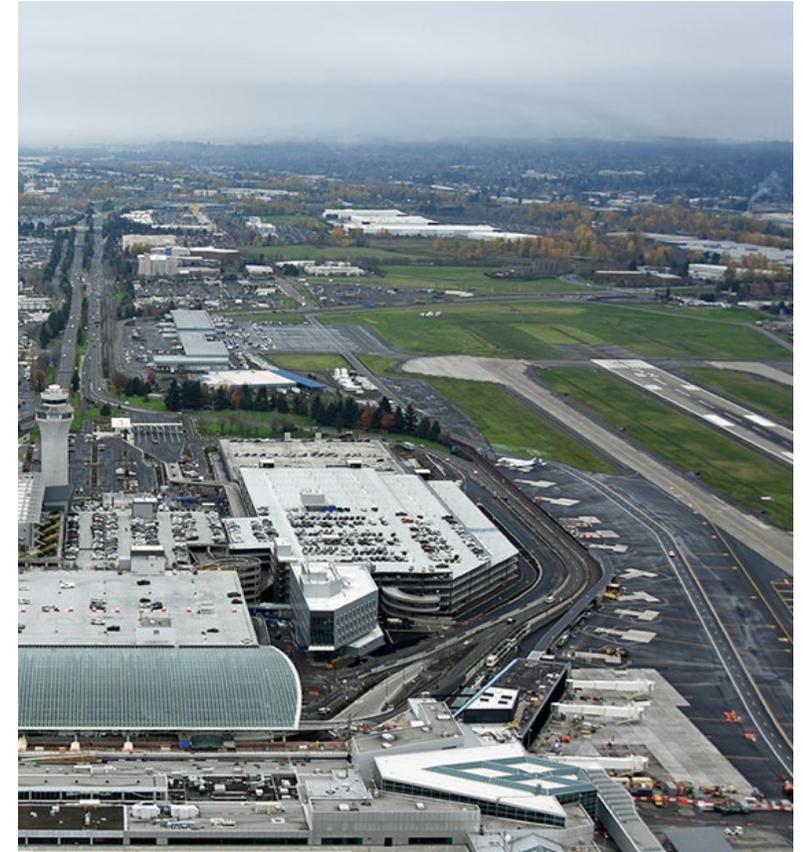
- 90,000 SF rental car and office building
- 5 +1 stories in height
- LEED Gold certification. This included a Pilot point for the project PtD program
- Earthquake resilient structure, skin and MEP systems
- A Dynamic Isolated Floor for a data and communication center in order to withstand a major earthquake with no disruption in services
- 1.65 million SF steel parking structure, seismically resilient (P3)



Project Background



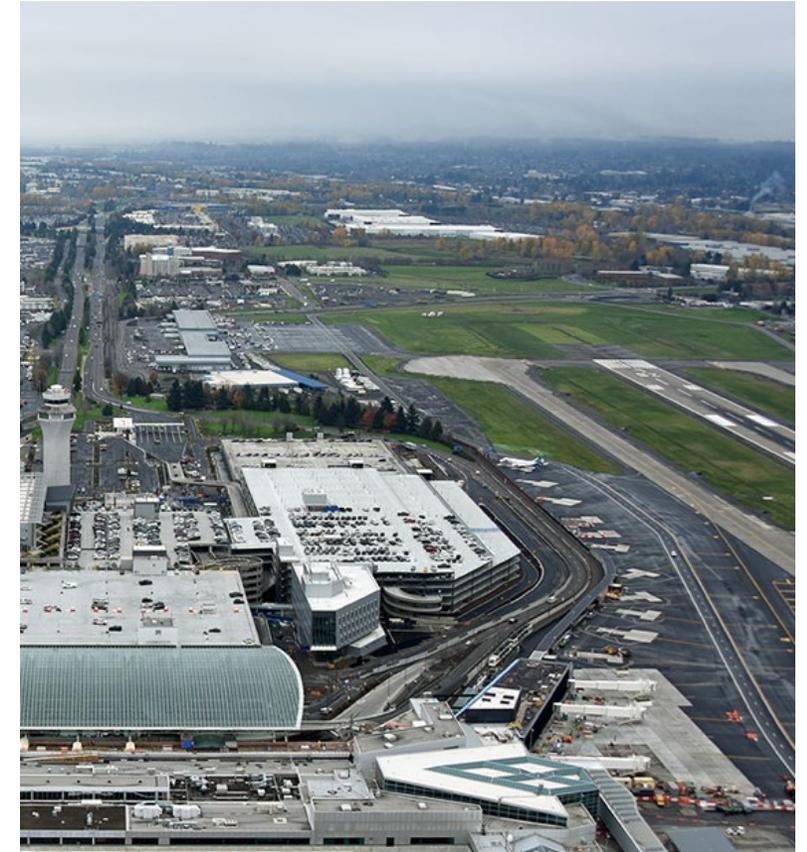
- Intent of PtD process - control the inherent risks involved in constructing, operating, and maintaining a complex multi-use/multi-level facility.
- Traditional construction projects do not often include an integrated design safety focus on the constructability, maintainability, and operability of a completed project.
- Required a formal PtD process for the project, informed by:
 - ❑ Prior successes with internal Port of Portland PtD efforts during smaller Capital and Tenant Improvement projects
 - ❑ The principles of the ANSI/ASSP Z590.3 Standard



Project Background



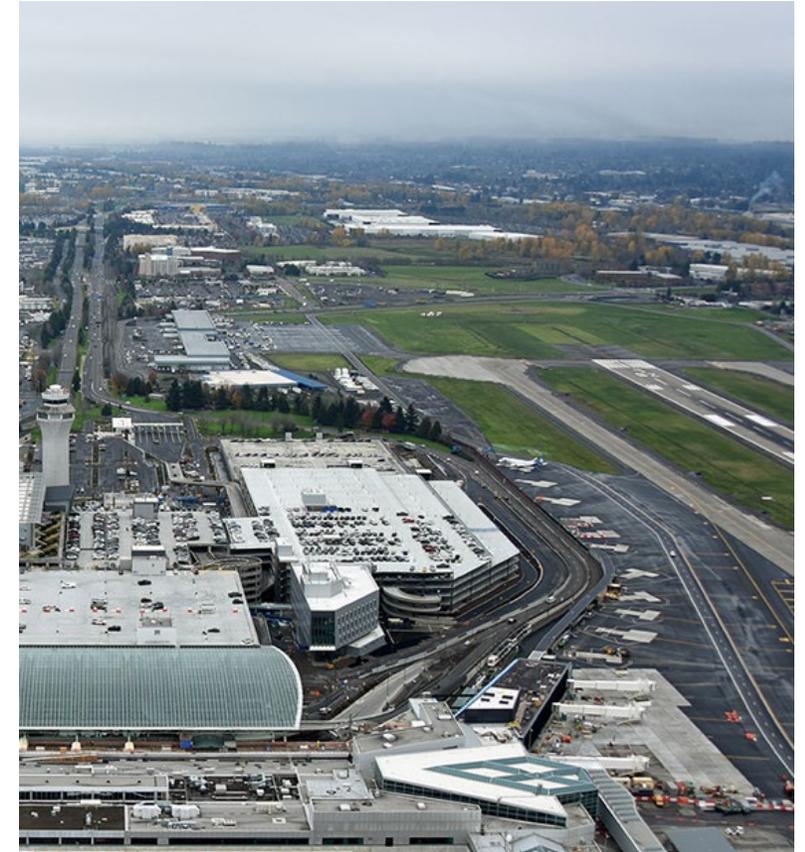
- Formal PtD Team Established – Critical in ensuring focus is at the forefront.
- Monthly Meetings were held and all performed design review via Bluebeam sessions.
- Members included:
 - Maintainers
 - Design Team
 - Construction Superintendents
 - Project Managers
 - Project Engineers
 - Safety Professionals
 - Formal documentation of issues



Project Background



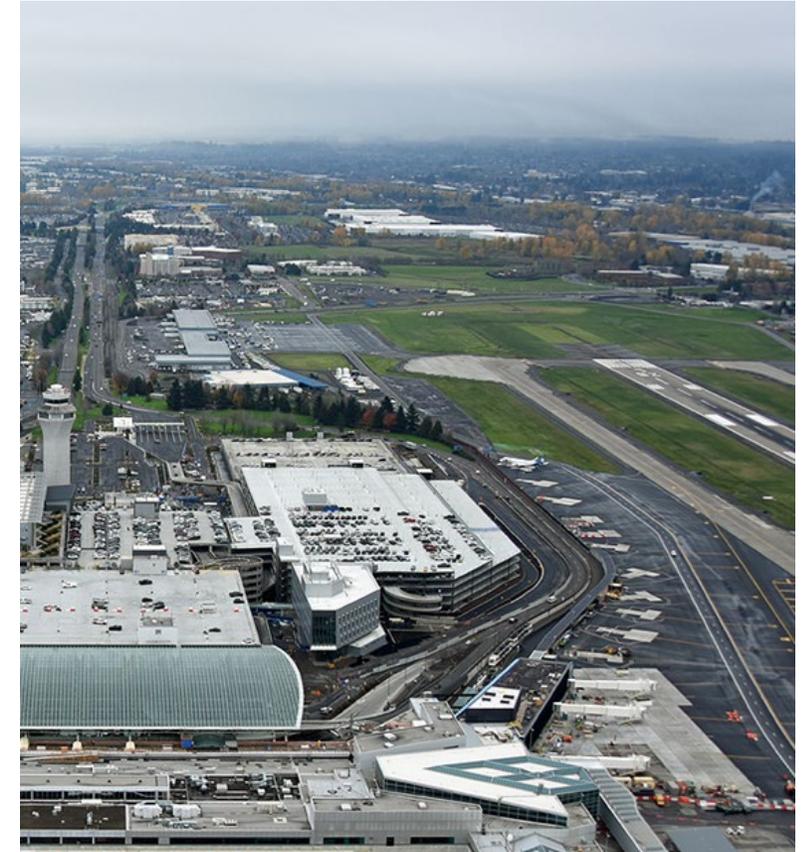
- Key goals of the ANSI Prevention through Design standard aligned with the Port's PtD goals:
 - ❑ Achieve acceptable risk levels
 - ❑ Prevent or reduce occupationally related injuries, illnesses, and fatalities
 - ❑ Focus on a smooth handoff to beneficial occupancy for Tenants, Operations, and Maintenance. This would contrast with experienced “Handoff Headaches” of prior capital turnovers from the O&M perspective
 - ❑ Eliminate the cost of retrofitting necessary to mitigate hazards and risks that were not sufficiently addressed in the design and construction processes



Selected PtD Features In Project



- Installation of permanent guardrails during construction instead of installing temporary guardrails. This eliminated the need to install/remove temporary guardrails, reducing worker exposure to falls from heights.
- Increasing parapet wall heights to make them OSHA compliant guardrails.
- Relocating a roof antenna farm to inside permanent guardrails, easing installation, access and maintenance for IT personnel.
- HVAC unit placed on the ground vs. traditional roof top. This eliminated the need for fall arrest protection for maintenance personnel during routine servicing of the unit.



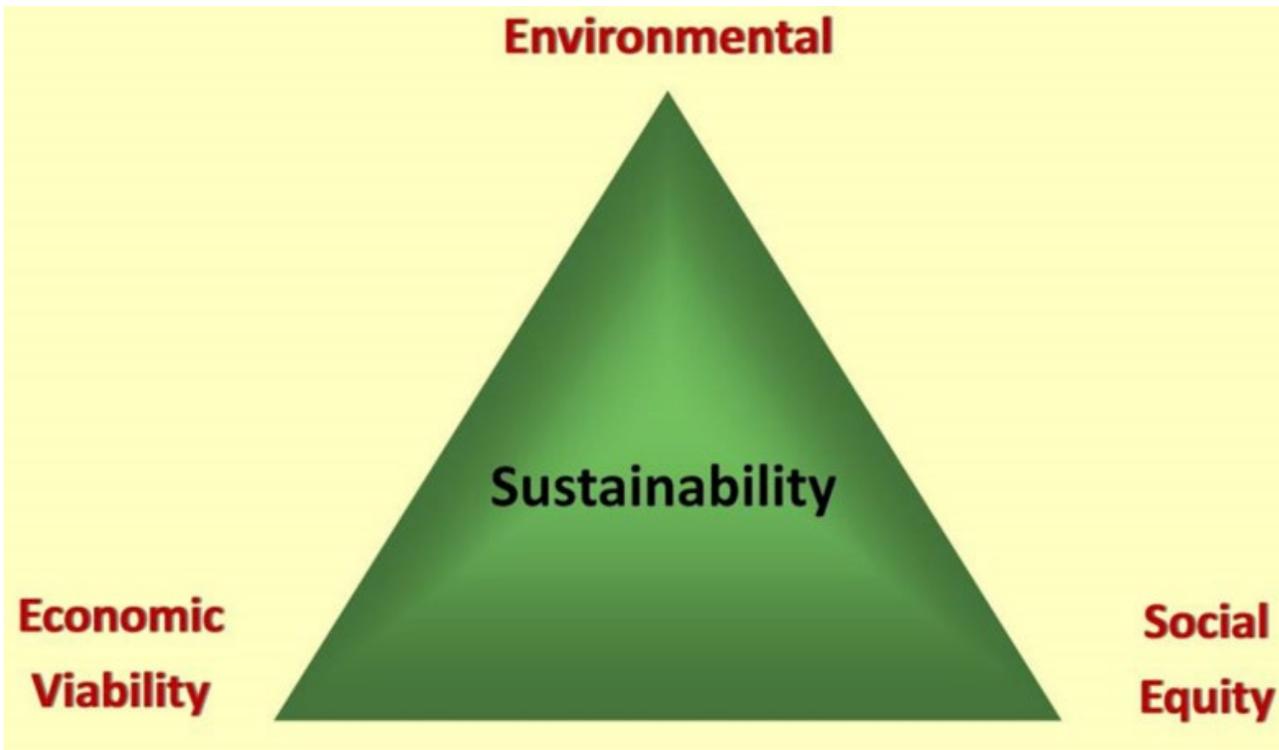
Using PtD on Current Projects



- The Port of Portland PtD efforts are continuously applied to other Capital Improvement projects.
- Terminal Core (TCORE) expansion project currently underway.
- The TCORE project includes a new 9-acre roof with multiple skylights for natural lighting.
 - ❑ Traditionally a guardrail, fall arrest anchors, or skylight covers are used to protect workers from falling through skylights
 - ❑ In order to achieve the vision of the one-of-a-kind roof, the design team used an alternate solution to traditional skylight protection
 - ❑ The design team used an ASTM International design standard to develop skylights that would withstand a worker falling onto them



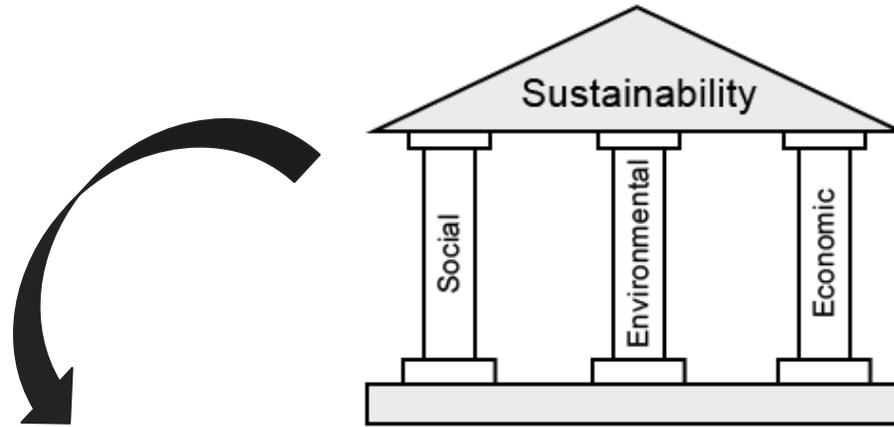
PtD and Sustainability



- Sustainability encompasses not just environmental equity but also social equity and economic equity.
- PtD should be a required aspect of social equity on capital projects.

Toole, T. M. and G. Carpenter (2013). "Prevention through Design as a Path Towards Social Sustainability." ASCE Journal of Architectural Engineering 19(3):169-173. <https://ascelibrary.org/doi/10.1061/%28ASCE%29AE.1943-5568.0000107>

PtD and Sustainability



Safety and health are dimensions of sustainability

“A sustainable product, process or technology should not only protect the environment and the consumer but also the worker. Green jobs must be safe jobs”

NIOSH Science Blog: *Going Green: Safe and Healthy Jobs*, 1/4/2010
<http://blogs.cdc.gov/niosh-science-blog/2010/01/green-2/>

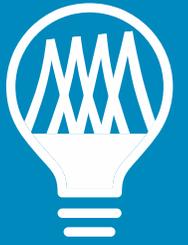
Sustainability also means addressing disproportionate impacts - 1



Fall exposures during solar panel installation
Photo: California Department of Public Health

- Building construction workers face disproportionately higher risks than general building occupants.
 - ❑ Fall exposure during roofing work

Sustainability also means addressing disproportionate impacts - 2



- Building maintenance workers also face disproportionately higher risks than general building occupants.
 - ❑ Fall exposures during atrium maintenance work

PtD and Sustainability – Current Example From the Literature



Civil Engineering



A new behavioural approach for the sustainable design of the built environment

Ray Coleman BEng, CEng, MIEI
Senior Associate Director, Jacobs, Dublin, Ireland
(corresponding author: Ray.Coleman@jacobs.com)

Ian Thomas BEng, MSc, CEng, MICE
Senior Associate Director, Jacobs, London, UK

Coleman R and Thomas I (2023)
A new behavioural approach for the sustainable design of the built environment.
Proceedings of the Institution of Civil Engineers – Civil Engineering, 176(4): 184–192
<https://doi.org/10.1680/jcien.23.00002>

PtD and Sustainability - Example



Civil Engineering



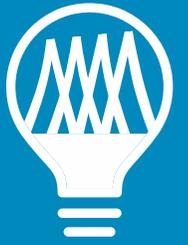
A new behavioural approach for the sustainable design of the built environment

Ray Coleman BEng, CEng, MIEI
Senior Associate Director, Jacobs, Dublin, Ireland
(corresponding author: Ray.Coleman@jacobs.com)

Ian Thomas BEng, MSc, CEng, MICE
Senior Associate Director, Jacobs, London, UK

‘... new behavioural management process for the sustainable design of the built environment. The process changes designer behaviour from focusing purely on technical and legal compliance, to a culture that leaves a lasting positive legacy, to benefit the health and safety of people who will construct or interact with the designs as well as benefitting the environment, climate and sustainability. The paper introduces the process and tools and explains how it was successfully applied on part of the High Speed Two railway project in the UK.

Prevention through Design



Mission: Design out hazards and minimize risks associated with:



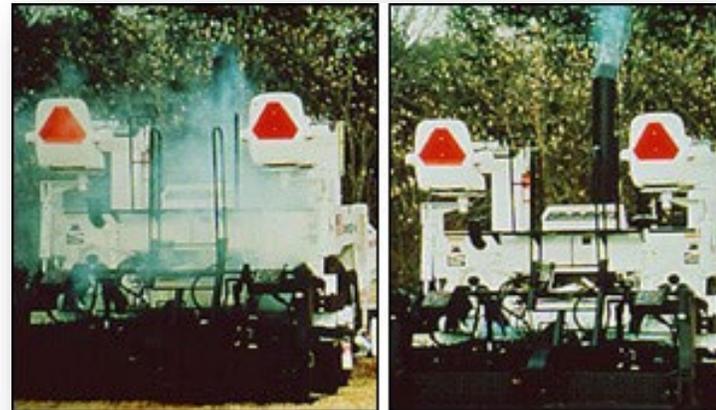
Facilities



Work methods



Processes



Equipment



Products & new technologies

3D Concrete Printing (3DCP)



- Various material extrusion technologies that involve using 3D printers to create structures, components, or architectural elements using concrete or cement-based materials.
- Layer-by-layer deposition of concrete or cementitious materials, guided by CAD models and selectively dispensed through a nozzle or orifice, to create complex structures.
- Concrete printers include gantry systems and robotic arm systems, with the systems differing in size, flexibility, and precision.



Opportunity for PtD as these technologies develop



Next ASU PtD Workshop – Planning for August 27, 2024 Washington, DC



ASU Ira A. Fulton Schools of Engineering
Arizona State University **Prevention through Design**

🏠 PtD Workshop 2023 PtD Workshop 2022 PtD Workshop 2021 PtD Workshop 2020 **PtD 5-year Initiative**

A wide-angle photograph of the Golden Gate Bridge in San Francisco, viewed from a low angle looking down the length of the bridge towards the water. The sky is blue with some clouds.

**Prevention through Design Initiative
(2020-2024)**

<https://ptd.engineering.asu.edu/>



Thank You

NIOSH Office of Construction Safety and Health



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<https://www.cdc.gov/niosh/construction/>

Selected Resources



[Prevention through Design | NIOSH | CDC](#)

[CPWR Prevention through Design Resources](#)

ASSP TR-A10.100-2018 Technical Report: Prevention through Design - A Life Cycle Approach to Safety and Health in the Construction Industry

[Designforconstructionsafety.org](https://designforconstructionsafety.org)

ANSI/ASSP Z590.3 PtD Standard