Prevention through Design

2018 GOVERNOR'S OCCUPATIONAL SAFETY & HEALTH CONFERENCE
October 29, 2018

Mike Toole, PhD, PE, F.ASCE
Dean, College of Engineering
University of Toledo

Based in part on past presentations with Dr. John Gambatese Professor, Civil and Const. Engineering, Oregon State Univ.

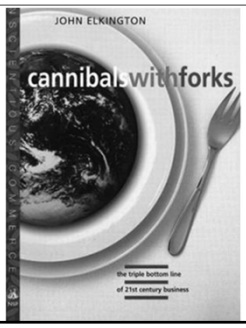
OVERVIEW

- Triple Bottom Line and Social Sustainability
- We all have a Role to Play in Site Safety
- PtD Concept and Benefits
- Integrated Design and Construction
- PtD Examples
- PtD has Momentum
- PtD Processes and Tools
- Implementing PtD

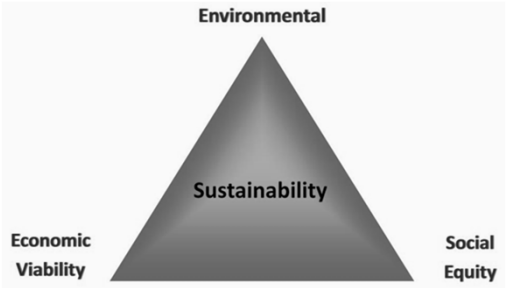
Prevention through Design
= Design for Safety
= Safety by Design

TRIPLE BOTTOM LINE

"All businesses can and must help society achieve three goals that are linked – **economic** prosperity, **environmental** protection and **social** equity."



SUSTAINABILITY AND THE TRIPLE BOTTOM LINE



SOCIAL SUSTAINABILITY

- Definition of Sustainable Development in Brundtland Commission Report (1987)
- Focus on people as much as on the environment
  - Meet the needs of people who can't speak for themselves

5

Sustainable Development

Design and construction that doesn't unfairly affect people who are not at the table

Further reading:
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.

6

SOCIAL SUSTAINABILITY ISSUES

- How will we convince all stakeholders that our project will not unfairly affect people who are not at the table during the concept development, design and construction planning?
  - Building occupants
  - Nearby residents
  - Local politicians and regulators
  - Our employees
  - Construction workers
  - Maintenance workers

7

ANNUAL CONSTRUCTION ACCIDENTS IN U.S.

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

ASCE CODE OF ETHICS

Canon 1: Hold Safety Paramount

- Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.
- a. Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgments, decisions and practices incorporated into structures, machines, products, processes and devices.

ASCE SITE SAFETY POLICY (350)

- The American Society of Civil Engineers (ASCE) believes improving construction site safety requires attention and commitment from all parties involved.
- Design engineers have responsibility for: Recognizing that safety and constructability are important considerations when preparing construction plans and specifications;
- Educators are encouraged to: … Emphasize engineer's role in providing a safe and healthy environment to personnel engaged in project activities through proper planning and design; and

10

SOCIAL SUSTAINABILITY ISSUES

- Do not our duties include minimizing all risks (especially to people) that we have control over?
- Do not we have the same duties for construction and maintenance workers as for the "public"?

OVERVIEW

- Triple Bottom Line and Social Sustainability
- We all have a Role to Play in Site Safety
- PtD Concept and Benefits
- Integrated Design and Construction
- PtD Examples
- PtD has Momentum
- PtD Processes and Tools
- Implementing PtD

Prevention through Design
= Design for Safety
= Safety by Design

PREVENTION THROUGH DESIGN (PTD)

"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."

(http://www.cdc.gov/niosh/topics/ptd/)

DESIGN-SAFETY LINKS

- **22%** of 226 injuries that occurred from 2000-2002 in Oregon, WA, and CA[1]
- **42%** of 224 fatalities in US between 1990-2003[1]
- **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]

[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
[3] NSW WorkCover, *CHAIR Safety in Design Tool*, 2001

PTD IN CONSTRUCTION IS…

- Explicitly considering construction and maintenance safety in the design of a project.
- Being conscious of and valuing the safety of construction and maintenance workers when performing design tasks.
- Making design decisions based in part on a design element's inherent safety risk to construction and maintenance workers.

"Safety Constructability and Maintainability"

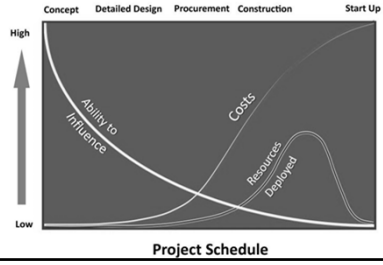
WHAT PTD IN CONSTRUCTION IS NOT

- Having designers take an active 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.

16

DESIGN HAS MAJOR LEVERAGE

- Ability to influence key project goals is greatest early in the project schedule during planning and design (Szymberski, 1997)



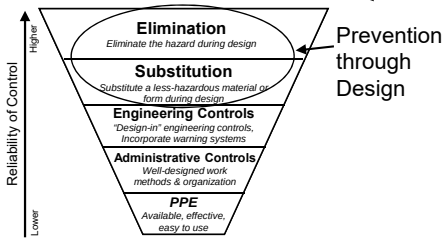
INTEGRATED DESIGN AND CONSTRUCTION

- Project success requires that design reflects input from all stakeholders, including:
  - Users/occupants
  - Owner facility management personnel
  - Contractors
- Constructability feedback must start early in the design process

BENEFITS OF INTEGRATED DESIGN AND CONSTRUCTION

- Obvious: Cost, Schedule, Quality
- Accepted: Sustainability
- Emerging: Prefabrication
- Emerging: Safety

HIERARCHY OF CONTROLS



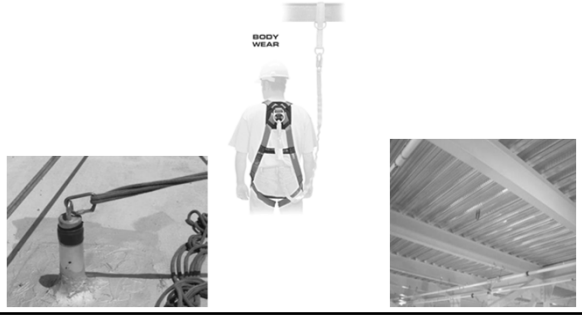
ECONOMIC BENEFITS OF PTD

- Reduced site hazards
  - **Fewer worker injuries and fatalities**
- Reduced workers' compensation premiums
- Increased productivity and quality
- Fewer delays due to accidents
- Improved operations/maintenance safety

EXAMPLE OF THE NEED FOR PTD

- Design spec:
  - Dig groundwater monitoring wells at various locations.
  - Wells located directly under overhead power lines.
- Accident:
  - Worker electrocuted when his drill rig got too close to overhead power lines.
- Engineer could have:
  - specified wells be dug away from power lines; and/or
  - better informed the contractor of hazard posed by wells' proximity to powerlines through the plans, specifications, and bid documents.

PTD EXAMPLE: ANCHORAGE POINTS



PTD EXAMPLE: ROOFS AND PERIMETERS

Upper story windows

Skylights

Parapet walls

https://cdn.simplifiedsafety.com/images/parapet-railing/non-penetrating-parapet-railing.jpg

PTD EXAMPLE: STRUCTURAL STEEL DESIGN

Detailing Guide for the Enhancement of Erection Safety

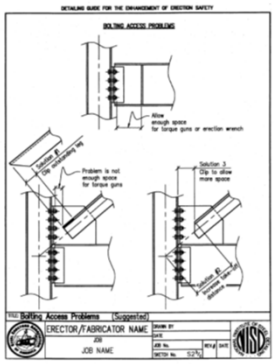
Published by the National Institute for Steel Detailing and the Steel Erectors Association of America

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

Photo: AISC educator ppt

- Provide enough space for making connections

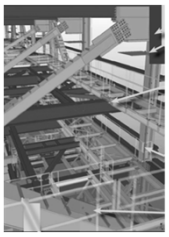


- Know approximate dimensions of necessary tools to make connections

Photo: AISC educator ppt

PTD EXAMPLE – STEEL DESIGN

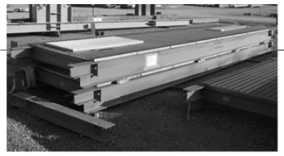
- Bechtel's steel design process
- PTD elements:
  - Temporary access platforms
  - Lifting lugs
  - Shop installed vertical brace ladders
  - Bolt-on column ladders and work platforms



Photos courtesy of Bechtel Corp.

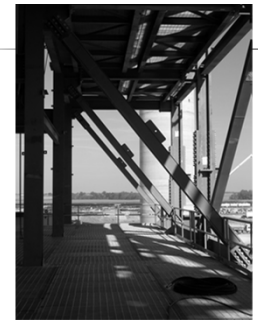
Temporary Ladder, Platform, and Safety Line

Modular Platforms



Photos courtesy of Bechtel Corp.

Brace Lifting Clips and Rungs

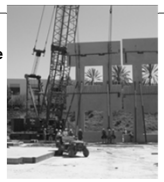


Photos courtesy of Bechtel Corp.

PTD AND PREFABRICATION

Pipe Spools www.wermac.org/documents/fabrication_shop.html

Concrete Wall Panels



MEP Corridor Racks

Concrete Segmented Bridge

PREFABRICATION: THE LINK BETWEEN ENVIRONMENTAL SUSTAINABILITY AND SAFETY

- Prefabricated construction is inherently safer than "stick-built."
- Work is shifted from dangerous work environments to engineered work environments and processes.
  - at height
  - in trenches
  - in confined spaces
  - exposed to weather (wind, water, ice, mud, lightning)
- Prefabricated construction has
  - lower construction waste
  - lower embodied energy
  - lower embodied greenhouse gases

DESIGN FOR MAINTENANCE SAFETY

- Provide safe access for recurring maintenance/preventive maintenance
  - Light Bulbs, Air Filters, Belts, Valves
  - At height, confined space, awkward ergonomics
- Provide safe clearance for replacing units
  - Blower Units, Boilers, Compressors, Pumps
  - Isolation, Material handling, Path out and in

35

WHAT DO YOU THINK?

- **What do you think about the Triple Bottom Line concept?**
- **Do codes of ethics apply to construction and maintenance workers?**
- **What do you think about the Prevention through Design concept?**
- **What are your experiences in design for safe construction and design for safe maintenance?**

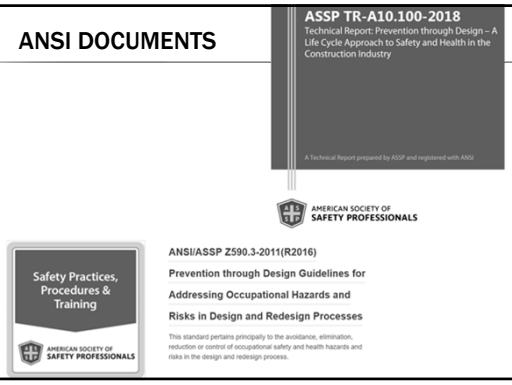
36

PTD IS GAINING MOMENTUM

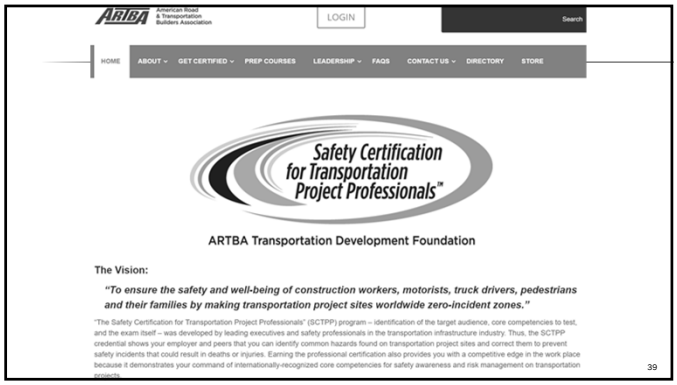
- Required in UK, Europe for since 1995
- Required in Australia, S. Africa, Singapore
- OSHA DfCS Workgroup since 2005
- NIOSH PtD Workshops and Funding
- Adoption primarily in the process/industrial construction sector

37

ANSI DOCUMENTS



38



39

ARTBA SAFETY CERTIFICATION FAQ

https://puttingsafetyfirst.org/

Why should a state or local transportation department support their managers, inspectors and designers earning the Safety Certification for Transportation Project Professionals™?

- Because as custodians of the public's tax dollars and trust, project safety is the top priority for transportation agencies and your personnel. Having SCTPP recipients on your team demonstrates that commitment.
- It shows your employees that project safety is the agency's top priority.
- Having professionally certified personnel involved at all stages of a project—from inception through completion—should help reduce safety incidents, thus saving lives and preventing disabling injuries.
- Because safety incident mitigation can be worked into transportation project plans and designs, if designers know what causes safety incidents on project sites.

40

LEED PTD PILOT CREDIT

- Identify and document the items found for the following two stages:
  - Operations and Maintenance
  - Construction
- For each stage, complete three stages of analysis:
  - Baseline
  - Discovery
  - Implementation

41

PTD IN PRACTICE: OWNERS

- Southern Co. (power)
- Intel (computer chips)
- San Fran. Public Utilities Commission (water infrastructure)
- Marine Well Containment System (Gulf Oil Drilling)
- US Army Corps of Engineers (Water Infrastructure)
- BHP Billiton (Mining)

BHP BILLITON'S PTD INITIATIVES

- PtD staff embedded in procurement and design
- PtD in technical specifications
- Required designer PtD training
- Design reviews includes 3D models

43

OVERVIEW

- Triple Bottom Line and Social Sustainability
- We all have a Role to Play in Site Safety
- PtD Concept and Benefits
- Integrated Design and Construction
- PtD Examples
- PtD has Momentum
- PtD Processes and Tools
- Implementing PtD

PTD DESIGN REVIEW

- Hazard identification
  - What construction safety hazards does the design create?
- Risk assessment
  - What is the level of safety and health risk associated with each hazard?
- Design option identification and selection
  - What can be done to eliminate or reduce the risk?
  - Remember the hierarchy of controls……

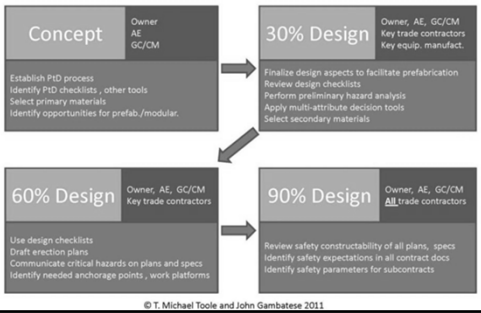
PTD PROCESS

Get the right people
talking about the right things
at the right time!

www.seagrave.com/

46

PTD PROCESS



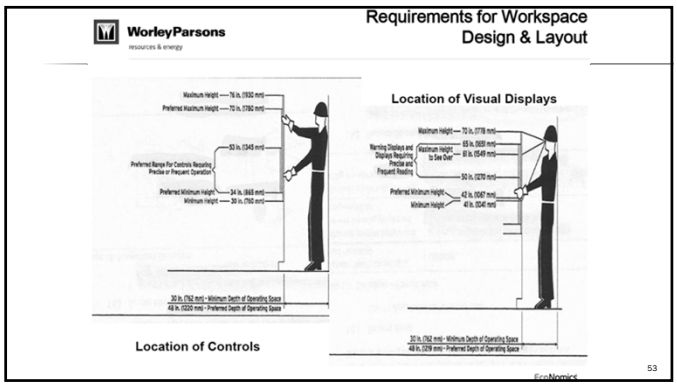
SUTTER HEALTH'S IPD PROCESS

- Integrated Project Delivery (IPD) facilitates collaboration of design and construction professionals during design
  - Co-located
  - Processes and norms for candid feedback
  - Trust
  - Sufficient time
  - Life cycle costing criteria
  - Common success criteria

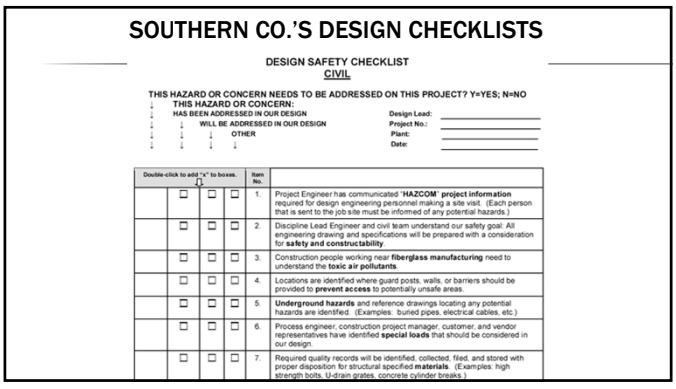
PTD TOOLS – DESIGN RISK ASSESSMENT

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



SOUTHERN CO.'S DESIGN CHECKLISTS



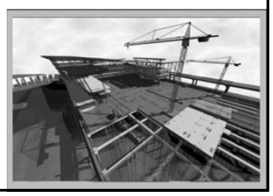
PTD INFORMATION SOURCES

www.designforconstructionsafety.org

1700+ ITEM PTD CHECKLIST

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.

PTD TOOLS – BIM AND VISUALIZATION



THREE STEPS TOWARDS PTD

1. Establish a lifecycle safety culture
2. Establish enabling processes
3. Team with organizations who value lifecycle safety

Culture | Processes | Partners

ESTABLISH A LIFECYCLE SAFETY CULTURE

- Secure management commitment to safety and to a life cycle approach
- Instill the right safety values
- Training
- Ensure recognition that designing for safety is the smart thing to do and the right thing to do
  1. Professional Codes of Ethics
  2. Payoff data

ESTABLISH ENABLING PROCESSES

- Qualifications-based contracting
- Negotiated or Cost-Plus contracting
- IPD or enabled safety constructability input
- Collaborative decision processes
- Designer training and tools

CHOOSE YOUR PARTNERS WISELY

- PtD capability in designer RFP
- Designer interaction experience in GC RFP
- Consider Design-Builders with industrial and international project experience
- Collaborative culture and experiences
- Open to change

WHAT EACH ENTITY NEEDS TO DO TO ENABLE PTD 1

- Owner
  - Require PtD on projects
  - Allow project delivery methods other than DBB
  - Involve construction and maintenance safety staff in constructability reviews
- AE
  - Acquire PtD capability
  - Work on PtD projects
  - Participate in safety constructability discussions and revise project documents as appropriate

62

WHAT EACH ENTITY NEEDS TO DO TO ENABLE PTD 2

- GC/CM and Subcontractors
  - Encourage clients to require PtD on projects
  - Collaborate with owner and staff on constructability reviews
  - Persist if safety is not prioritized

63

INITIATING PTD IN YOUR ORGANIZATION

- Leadership
- Sustainability
- Ethics
- Innovation
- Change management

64

SUMMARY

- Our clients and taxpayers may increasingly be demanding that we deliver integrated design and construction and proactively consider the triple bottom line on our projects.
- Prevention through Design is a promising way to achieve economic, social and environmental sustainability and increase safety and health.
- Management commitment, training and client engagement are necessary first steps.
- PtD can be an important part of achieving the Pennsylvania Governor's safety and health vision.

THANK YOU FOR YOUR TIME!

Mike Toole
michael.toole@utoledo.edu
www.designforconstructionsafety.org

COLLEGE of ENGINEERING
THE UNIVERSITY of TOLEDO