

# Achieving the Triple Bottom Line through Integrated Design and Construction

FECON Project Safe Workshop  
March 10, 2020



COLLEGE OF ENGINEERING  
THE UNIVERSITY OF TOLEDO

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Based in part on past presentations  
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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**





# Prevention through Design

Spreading the word about Design for Construction and Maintenance Safety

THE PTD CONCEPT

PROCESS AND WORK PRODUCT

HISTORY AND FUTURE OF PTD

CHALLENGES

PTD INFORMATION AND PUBLICATIONS

DESIGN TOOLS

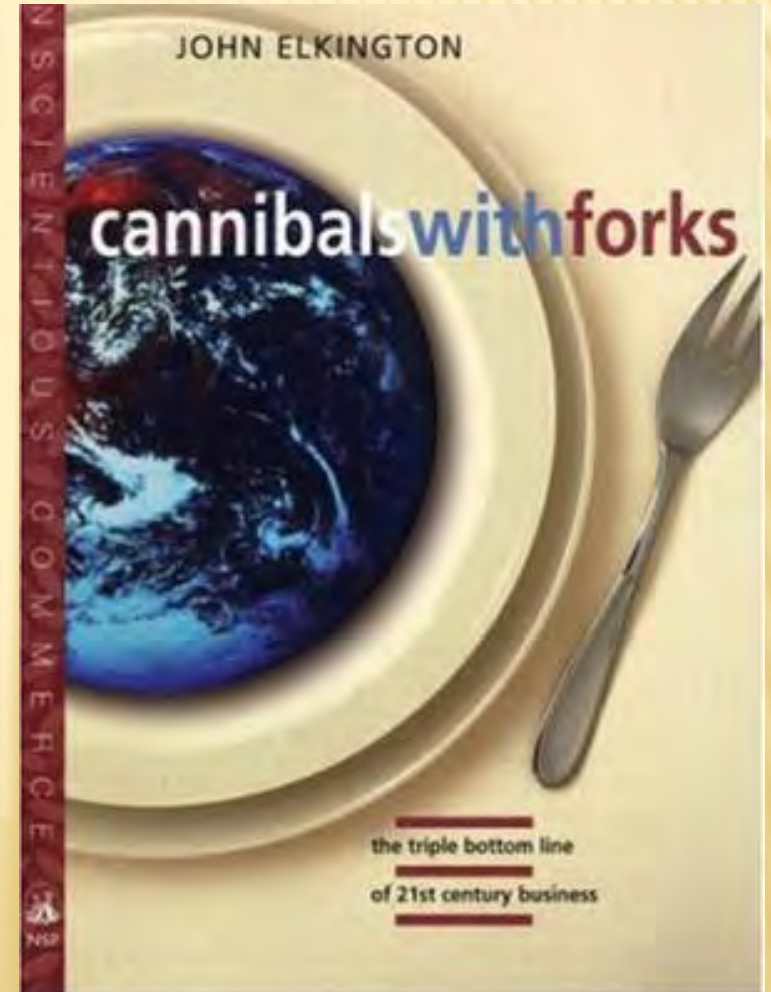
INTERNATIONAL GUIDELINES

PRESENTATION FILES

ABOUT THIS WEBPAGE

# TRIPLE BOTTOM LINE

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



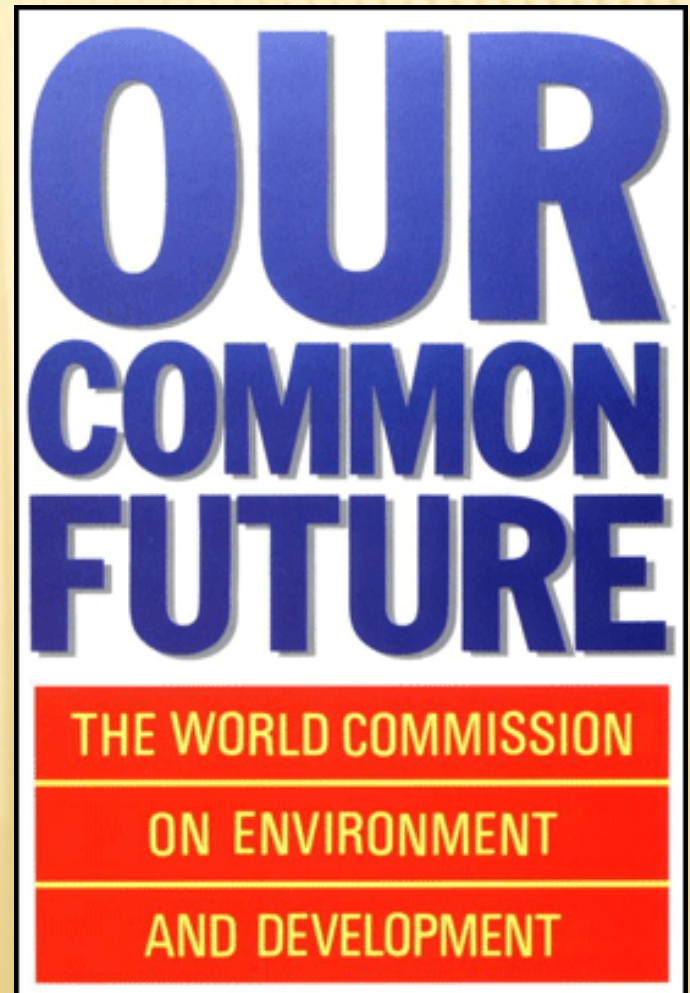


# SUSTAINABILITY AND THE TRIPLE BOTTOM LINE



# 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





# 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.

# SOCIAL SUSTAINABILITY ISSUES

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- ❑ 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



# ANNUAL CONSTRUCTION ACCIDENTS IN U.S.

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



## ASCE CONSTRUCTION SITE SAFETY POLICY (PS 350)

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- ❑ “The American Society of Civil Engineers (ASCE) believes site safety is paramount during construction, and requires attention and commitment from all parties involved during project planning, design, construction, and commissioning.”



# ASCE CODE OF ETHICS

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## 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.

# SOCIAL SUSTAINABILITY ISSUES

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- ❑ 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”?
- ❑ We need to ask ourselves, “What am I going to do today to save a life?”



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- ❑ 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/>)





## 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

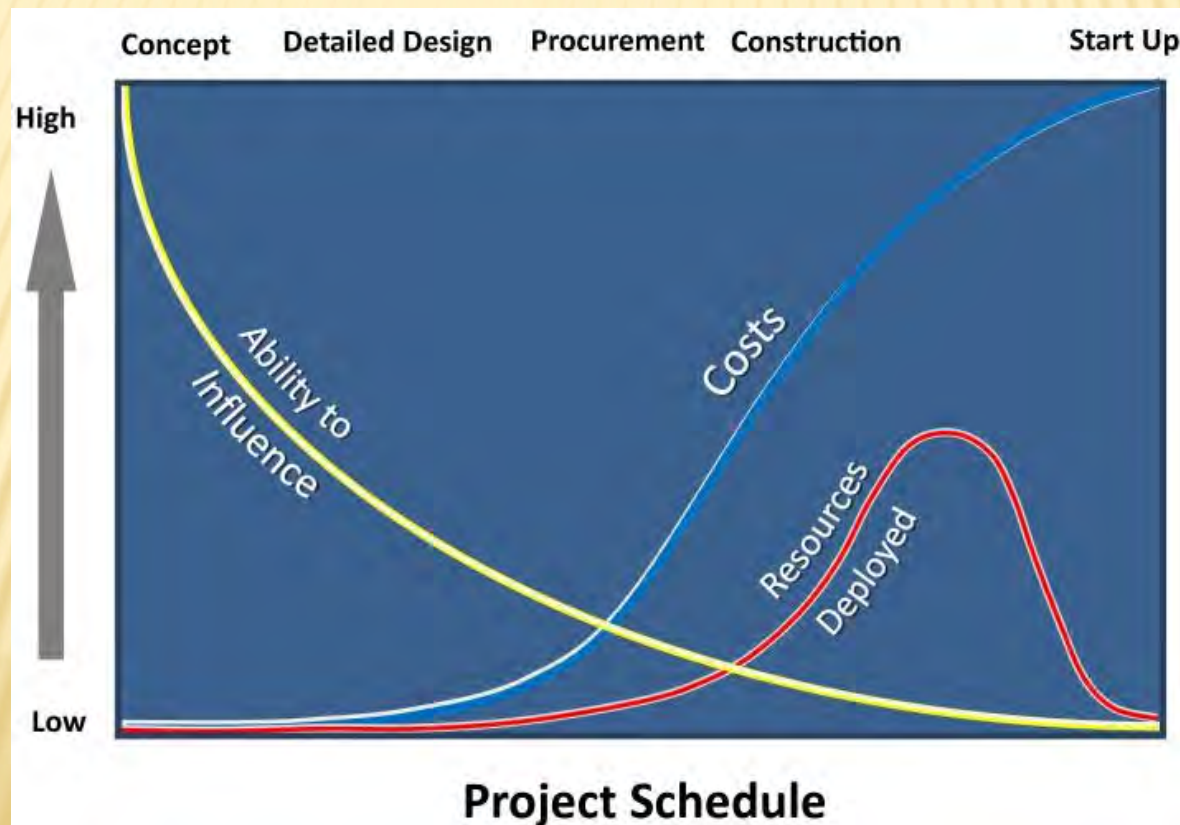
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- ❑ Having designers take an active role in construction safety **DURING** construction.
- ❑ An endorsement of future legislation mandating that designers design for construction safety.
- ❑ An endorsement of the principle that designers can or should be held partially responsible for construction accidents.



# 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

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- ❑ 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

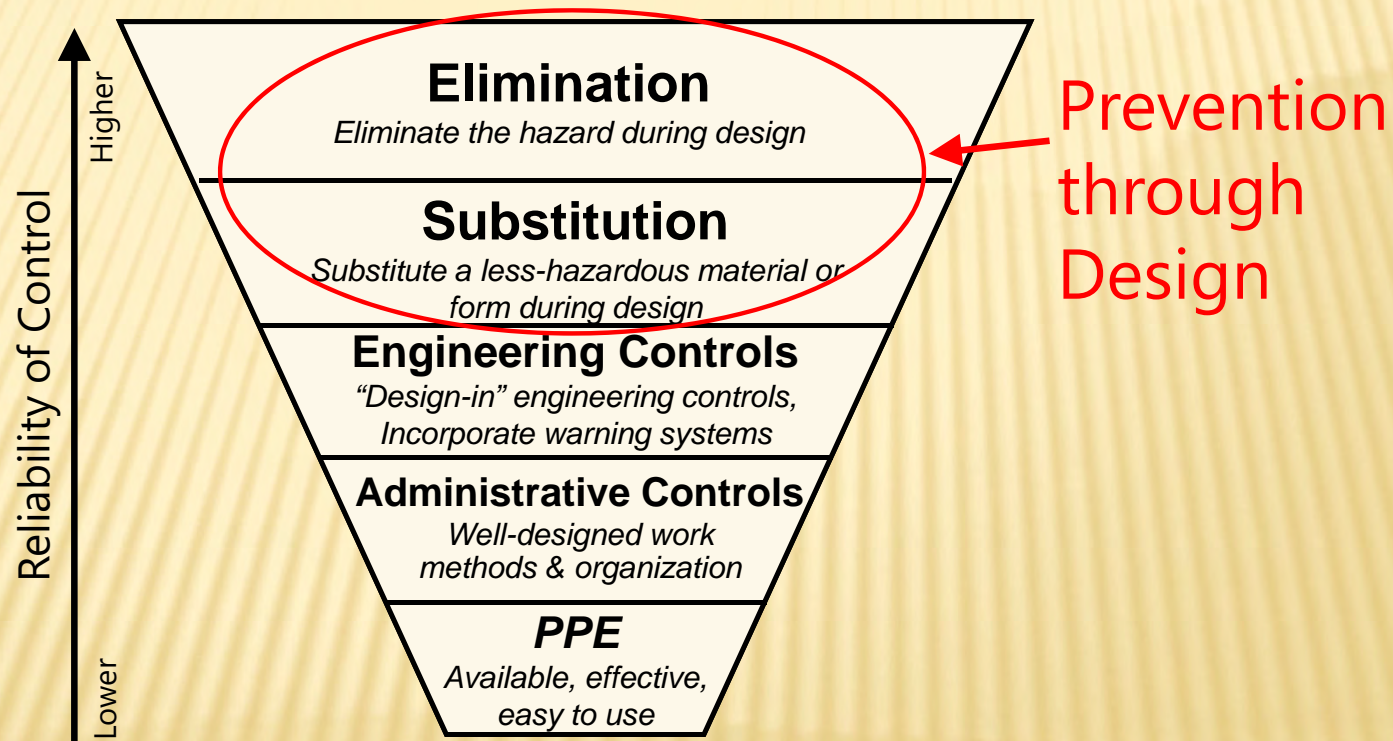


# BENEFITS OF INTEGRATED DESIGN AND CONSTRUCTION

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

# HIERARCHY OF CONTROLS





# ECONOMIC BENEFITS OF PTD

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- ❑ 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

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**Prevention through Design**

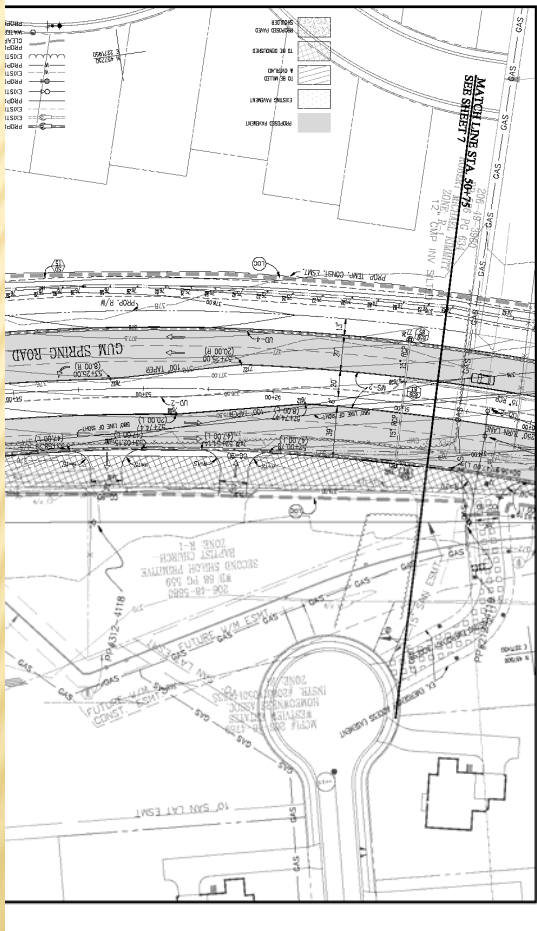
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**= Safety by Design**



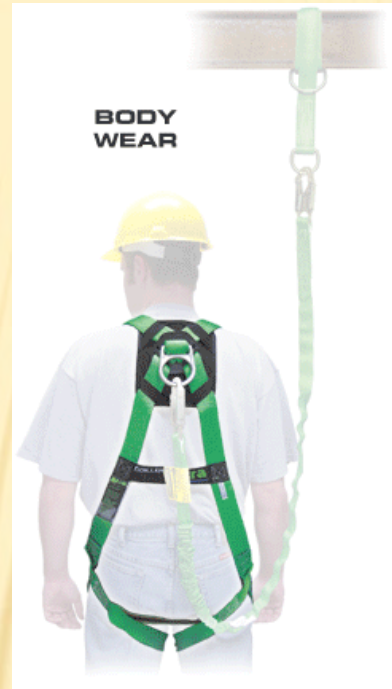


# EXAMPLE OF THE NEED FOR PTD



- ❑ 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: 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

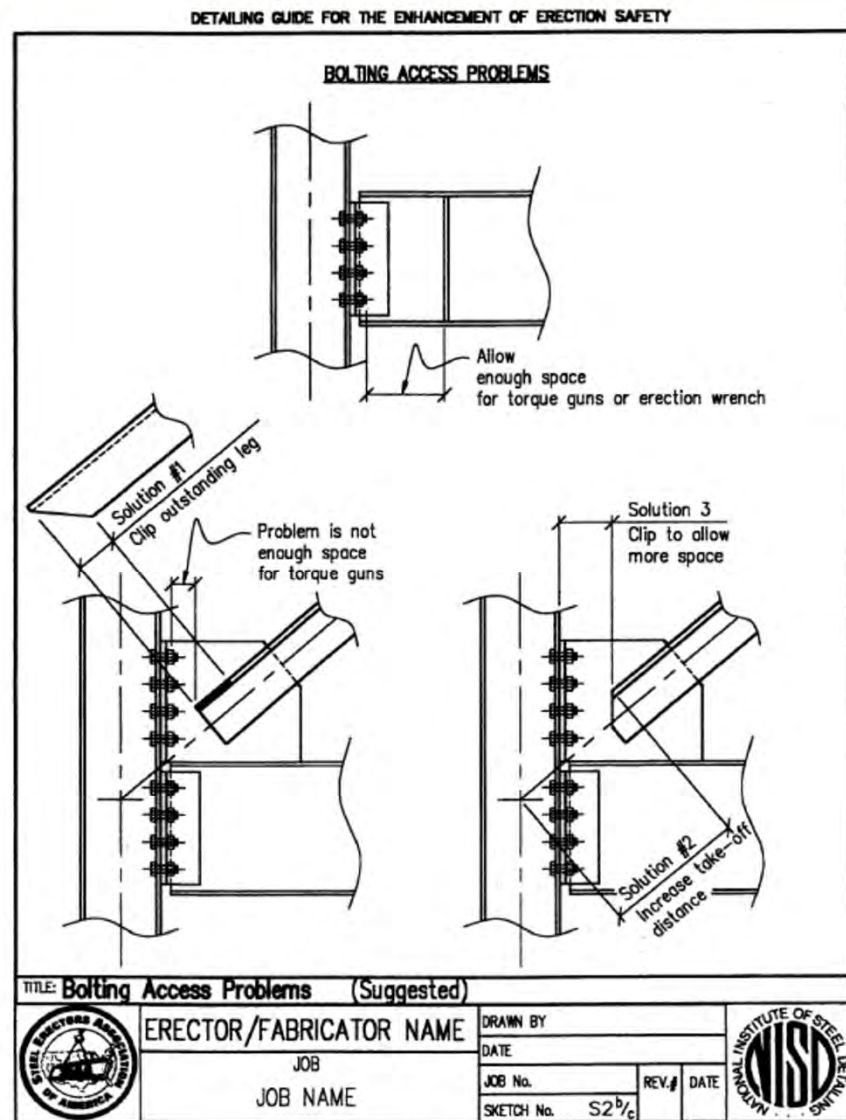
- + Include holes in columns at 21" and 42" for guardrail cables and at higher locations for fall protection tie-offs
- + Locate column splices and connections at reasonable heights above floor

Photo: AISC educator ppt





- ❑ Provide enough space for making connections



- ❑ Know approximate dimensions of necessary tools to make connections

Photo: AISC educator ppt





# [WWW.CDC.GOV/NIOSH/DOCS/2013-135/](http://WWW.CDC.GOV/NIOSH/DOCS/2013-135/)

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CDC 24/7: Saving Lives, Protecting People™

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Providing National and World Leadership to Prevent Workplace Illnesses and Injuries



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**PtD - Reinforced Concrete Design - Instructor's Manual**



DHHS (NIOSH) Publication Number 2013-135

July 2013

A strategic goal of the Prevention through Design (PtD) Plan for the National Initiative is for designers, engineers, machinery and equipment manufacturers, health and safety (H&S) professionals, business leaders, and workers to understand the PtD concept. Further, they are to apply these skills and this knowledge to the design and redesign of new and existing facilities, processes, equipment, tools, and organization of work. In accordance with the PtD Plan, this module has been developed for use by educators to disseminate the PtD concept and practice within the undergraduate engineering curricula.

The module outlines the motivations for PtD, encourages inclusion of worker health and safety considerations early in the design process, and identifies hazards associated with the construction of reinforced concrete. Topics include the reinforced concrete design, detailing, fabrication and erection processes. Examples are provided to enable structural engineers and detailers to incorporate PtD into their reinforced concrete designs.



Reinforced Concrete Design

Instructor's Manual



[PtD - Reinforced Concrete Design - Instructor's Manual](#)  (PDF, 15.47 MB)

# CONCRETE CONSTRUCTION HAZARDS

- Tripping
- Muscle strain caused by repeated lifting
- Structural collapse
- Falling materials
- Manipulation and erection of reinforcing steel and formwork
- Silicosis
- Falls
- Obstructions
- Cave-in during foundation construction
- Lung or skin irritation from exposure to cement or admixtures
- Jack, cable, or fitting failure during tensioning

*Photo courtesy of John Gambatese*





# REBAR

- ❑ Use one grade of rebar throughout the whole job
- ❑ Prefabricate column and wall cages when feasible
- ❑ Utilize welded wire fabric (WWF) (flat sheets) for area paving reinforcement
- ❑ Show splice location and splice lengths on the drawings
- ❑ Standardize use of a few sizes of rebar such as #5, #7, and #10



# FOUNDATIONS

- ❑ Use 4" × 4" mat mesh or welded wire fabric (WWF) on top of more widely spaced top rebar
  - Provides walking surface
- ❑ Review clearances between forms, anchor bolts, sleeves, and rebar at congested pier locations
  - Ensure sufficient room for equipment
- ❑ Standardize foundation sizes for pumps, pipe racks, structures, and miscellaneous supports
  - Standard, regular work environment helps workers
- ❑ Dimension concrete foundations and structures to maximize use of commercial form sizes
  - Custom forms may be under-designed or difficult to install



# SOUTHERN STATES MACI SWITCH INDICATOR





# FALL PROTECTION





# PTD AND PREFABRICATION



**Pipe Spools**

[www.wermac.org/documents/fabrication\\_shop.html](http://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

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- ❑ Provide safe access for recurring maintenance/preventive maintenance
  - Lamps, Air Filters, Belts, Valves
  - At height, confined space, awkward ergonomics
- ❑ Provide safe minimum approach distance
  - Performing maintenance on switches and circuit breakers
  - Accessing terminal boxes
  - Accessing control panels
- ❑ Provide safe clearance for replacing units
  - Blower Units, Boilers, Compressors, Pumps
  - Isolation, Material handling, Path out and in

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# PTD IS GAINING MOMENTUM

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



## ARTBA Transportation Development Foundation

### The Vision:

***“To ensure the safety and well-being of construction workers, motorists, truck drivers, pedestrians and their families by making transportation project sites worldwide zero-incident zones.”***

“The Safety Certification for Transportation Project Professionals” (SCTPP) program – identification of the target audience, core competencies to test, and the exam itself – was developed by leading executives and safety professionals in the transportation infrastructure industry. Thus, the SCTPP credential shows your employer and peers that you can identify common hazards found on transportation project sites and correct them to prevent safety incidents that could result in deaths or injuries. Earning the professional certification also provides you with a competitive edge in the work place because it demonstrates your command of internationally-recognized core competencies for safety awareness and risk management on transportation projects.



# ARTBA SAFETY CERTIFICATION FAQ

<https://puttingsafetyfirst.org/>

## Why should a transportation planning and design firm support their designers earning the Safety Certification for Transportation Project Professionals™?

- Because safety incident mitigation can be worked into transportation project plans and designs, if designers know what causes safety incidents on project sites.
- It shows owners and contractor partners that your firm understands safety can be designed into transportation projects and that it shares their commitment to ensuring the safety of on-site workers and those travelling through the projects you design.
- 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.
- It makes your firm a more desirable partner to contractors with a world-class safety culture.

## PTD IN PRACTICE: OWNERS

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- ❑ 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 (Mining)



# BHP BILLITON'S PTD INITIATIVES

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

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# PTD PROCESS

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



# PTD DESIGN REVIEW

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## ❑ 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.....



# SITE LAYOUT CAN BE CRITICAL

[www.pe.com/2015/10/11/corona-3-workers-critical-in-91-overpass-collapse-investigation-under-way/](http://www.pe.com/2015/10/11/corona-3-workers-critical-in-91-overpass-collapse-investigation-under-way/)

<https://www.abam.com/blog/2014/07/turning-over-a-new-leaf-improving-a-cloverleaf-interchange>



- Traffic maintenance, diversion, barriers near workers
- Material delivery, storage, staging, movement
- Equipment access to site, movement, load radii, weight and clearance issues,



# LEED PTD PILOT CREDIT

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- ❑ 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



# LEED CREDIT PROCESS

## ❑ Baseline:

- Describe the baseline assumptions and construction plan for each relevant topic prior to the safety constructability review.

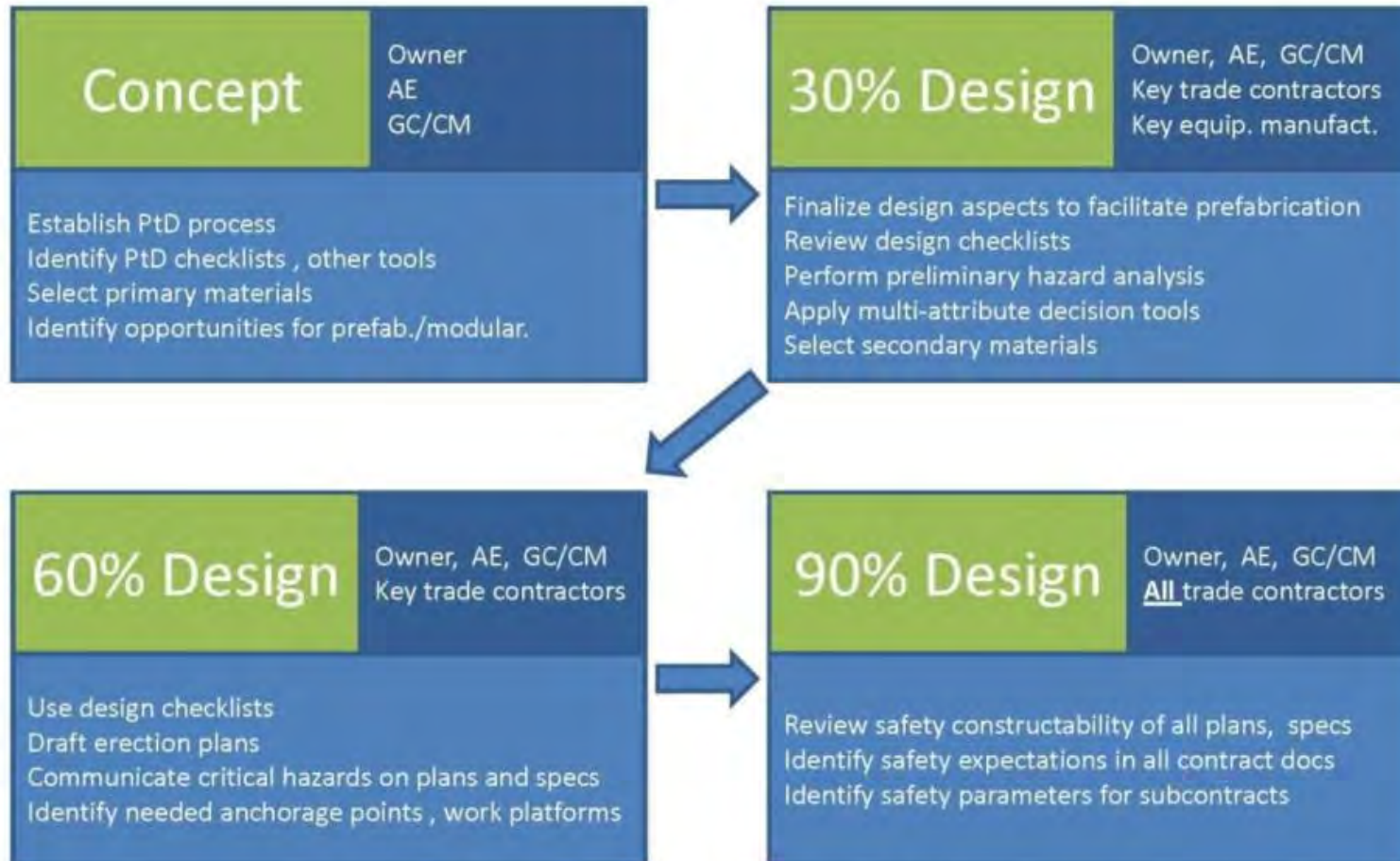
## ❑ Discovery:

- Describe the key tasks involved with the construction plan for each topic, along with expected hazards and exposures.
- Describe potential strategies identified during the safety constructability review that could be used to eliminate or reduce hazards and exposures for topic area.

## ❑ Implementation:

- Describe how the safety constructability review resulted in at least one protective measure change made to any of the relevant plans.
  - ❖ Building and temporary structure design
  - ❖ Construction Plan
  - ❖ Construction Safety Plan
  - ❖ Construction Activity Pollution Prevention Plan
  - ❖ Construction Indoor Air Quality Management Plan
  - ❖ Construction and Demolition Waste Management Plan

# PTD PROCESS





# SUTTER HEALTH'S IPD PROCESS

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- ❑ 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

# ANSI DOCUMENTS

## **ASSP TR-A10.100-2018**

Technical Report: Prevention through Design – A Life Cycle Approach to Safety and Health in the Construction Industry

A Technical Report prepared by ASSP and registered with ANSI



AMERICAN SOCIETY OF  
**SAFETY PROFESSIONALS**



### **ANSI/ASSP Z590.3-2011(R2016)**

#### **Prevention through Design Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes**

This standard pertains principally to the avoidance, elimination, reduction or control of occupational safety and health hazards and risks in the design and redesign process.



# SOUTHERN CO.'S DESIGN CHECKLISTS

## DESIGN SAFETY CHECKLIST CIVIL

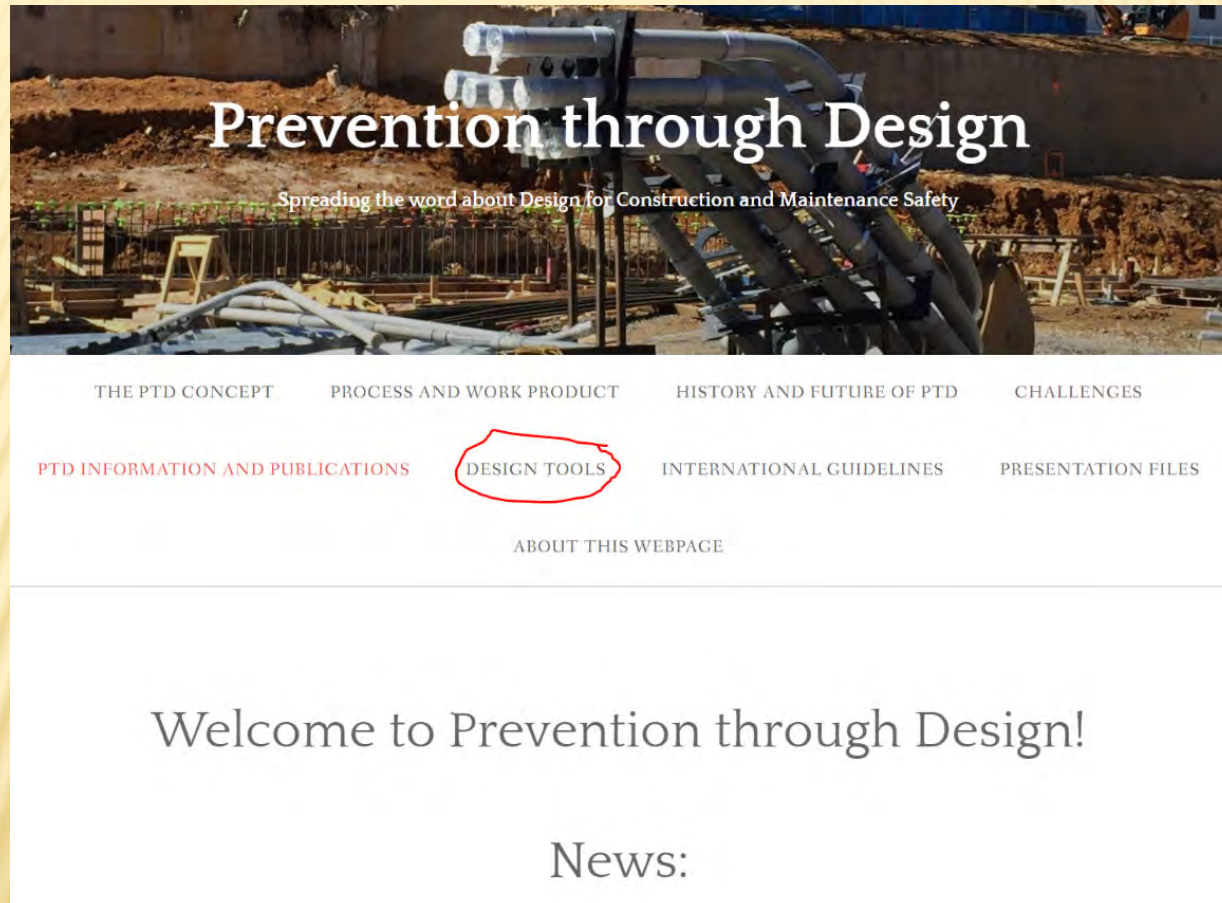
THIS HAZARD OR CONCERN NEEDS TO BE ADDRESSED ON THIS PROJECT? Y=YES; N=NO

↓ THIS HAZARD OR CONCERN:  
↓ HAS BEEN ADDRESSED IN OUR DESIGN  
↓ WILL BE ADDRESSED IN OUR DESIGN  
↓ OTHER  
↓

Design Lead: \_\_\_\_\_  
Project No.: \_\_\_\_\_  
Plant: \_\_\_\_\_  
Date: \_\_\_\_\_

Double-click to add "x" to boxes. ↓				Item No.	
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.	Project Engineer has communicated " <b>HAZCOM</b> " 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.)
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.	Discipline Lead Engineer and civil team understand our safety goal: All engineering drawing and specifications will be prepared with a consideration for <b>safety and constructability</b> .
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.	Construction people working near <b>fiberglass manufacturing</b> need to understand the <b>toxic air pollutants</b> .
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.	Locations are identified where guard posts, walls, or barriers should be provided to <b>prevent access</b> to potentially unsafe areas.
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.	<b>Underground hazards</b> and reference drawings locating any potential hazards are identified. (Examples: buried pipes, electrical cables, etc.)
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.	Process engineer, construction project manager, customer, and vendor representatives have identified <b>special loads</b> that should be considered in our design.
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.	Required quality records will be identified, collected, filed, and stored with proper disposition for structural specified <b>materials</b> . (Examples: high strength bolts, U-drain grates, concrete cylinder breaks.)

# PTD INFORMATION SOURCES



[www.designforconstructionsafety.org](http://www.designforconstructionsafety.org)



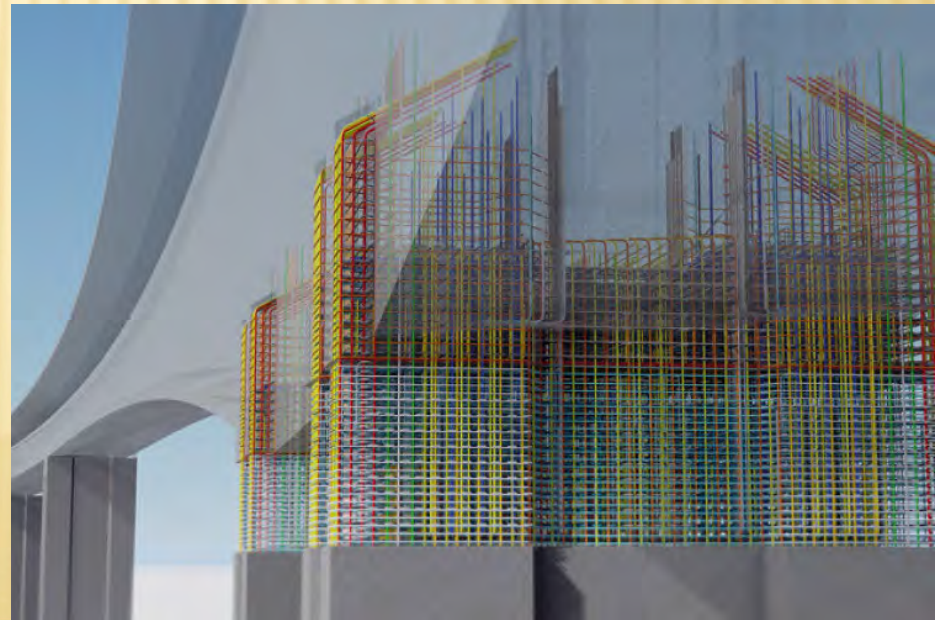
# 1700+ ITEM PTD CHECKLIST

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

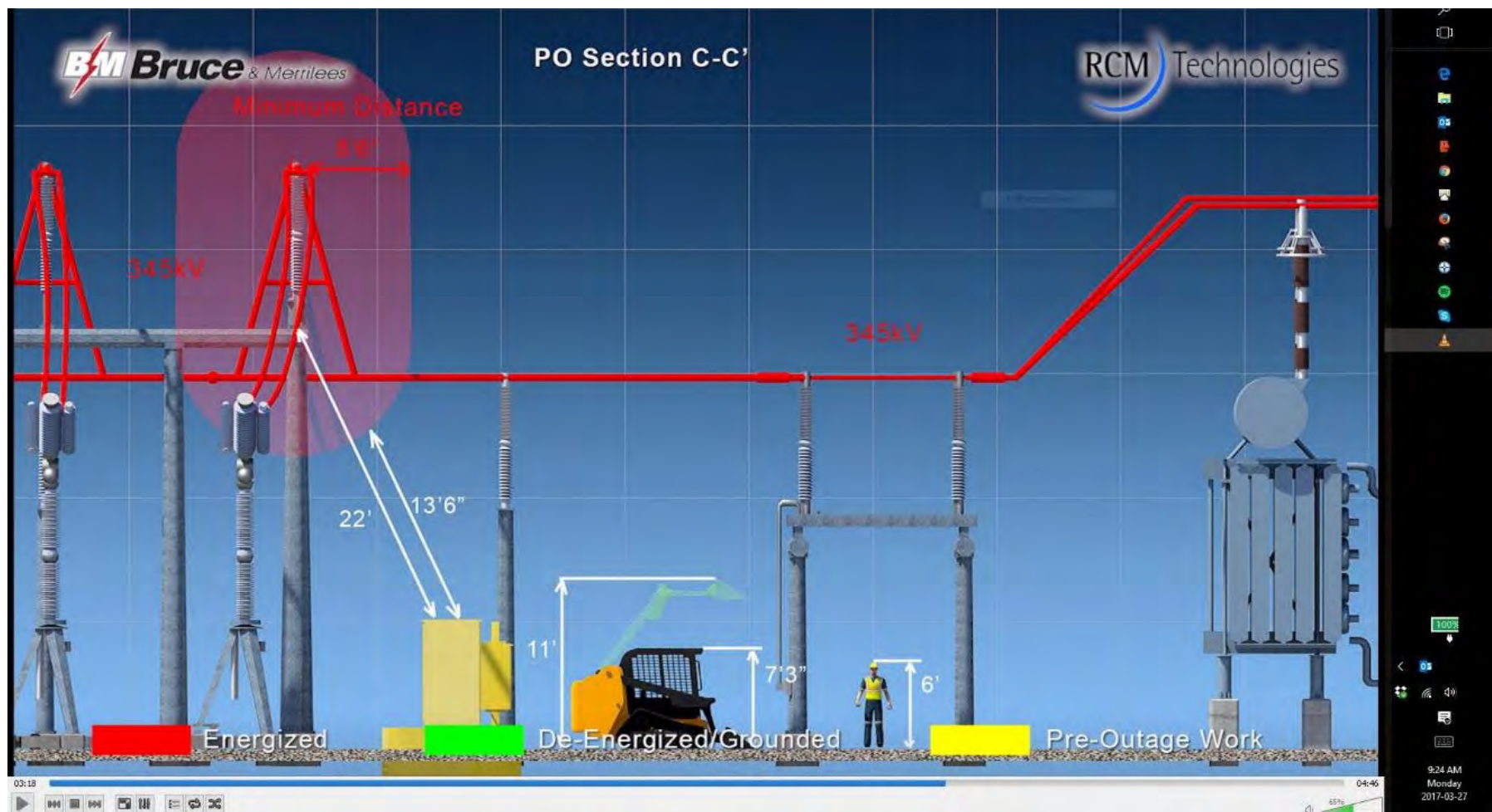


[www.theconstructionindex.co.uk/news/view/bim-for-bridges](http://www.theconstructionindex.co.uk/news/view/bim-for-bridges)





## Safety by Design / Integrated Design & Construction



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# THREE STEPS TOWARDS PTD

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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

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- ❑ Secure management commitment to safety and to a life cycle approach
- ❑ Training
- ❑ Instill the right safety values
- ❑ 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

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- ❑ 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



# IMPLICATIONS FOR ALL INFRASTRUCTURE PROFESSIONALS

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- ❑ Every one (owners, designers, constructors) shares responsibility for all three aspects of sustainability on our projects.
- ❑ We must be educated about and committed to construction safety.

*“What am I going to do today to save a life on this project?”*

- ❑ We must collaborate DURING DESIGN to maximize a project's sustainability.
- ❑ We should allow Design-Assist and similar processes to enable needed collaboration on Design-Bid-Build projects.
- ❑ We should consider enabling design-build and integrated project delivery projects.

## IMPLICATIONS FOR OWNER CLIENTS

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- ❑ Must enable Integrated Design and Construction through procurement decisions
- ❑ Must ensure operation and maintenance professionals are involved in design reviews
- ❑ Must prioritize lifecycle perspectives over initial costs
- ❑ Operations and maintenance managers must be ready to interact with design professionals, to communicate why their perspective is important for achieving lifecycle project goals



# IMPLICATIONS FOR DESIGN PROFESSIONALS

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- ❑ Must be genuinely willing to accept input and feedback on in-progress designs
- ❑ All designers should have field experience
- ❑ Must have system for documenting standard of care that balanced cost, schedule, operational risk and occupational safety
- ❑ Be prepared to compete for projects through non-traditional procurement processes based on collaborative experiences

# IMPLICATIONS FOR CONTRACTORS

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- ❑ Must be ready to interact with design professionals and to communicate how a 30/60% design could be improved in terms of cost, quality, schedule, service life, and safety
- ❑ Must be aware of prefabrication options and prepared to coordinate multi-trade modules
- ❑ Be prepared to compete for projects through non-traditional procurement processes



## TRUE STORY ABOUT SMALL-TOWN SCHOOL GYM PROJECT

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- ❑ ~220' x 65' x 33' tall masonry gym under construction
- ❑ Design included bond beams but no grouted cores, despite through embedded wall flashing
- ❑ Structural engineer's calculations showed design met code requirements for lateral forces once four walls secured by roof trusses
- ❑ One 65'x33' tall end wall collapsed in high winds, killing 4 craft workers because wall lacked grouted cores

# SUMMARY

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- ❑ 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 FECON's bold and commendable safety vision.



THANK YOU FOR YOUR TIME!

FECON: thank you for your leadership!

Mike Toole  
michael.toole@utoledo.edu  
[www.designforconstructionsafety.org](http://www.designforconstructionsafety.org)



COLLEGE OF ENGINEERING  
THE UNIVERSITY OF TOLEDO

## WHAT DO YOU THINK?

What aspects of the PtD concept or process are unclear?

What experiences related to PtD have you had?

How might the PtD process work on your projects?

What ideas do you have for moving PtD forward?

Does the safety vision for FECON seem appropriate?