Achieving the Triple Bottom Line through Integrated Design and Construction

FECON Project Safe Webinar
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COLLEGE OF ENGINEERING
THE UNIVERSITY OF TOLEDO

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Based in part on past presentations with Dr. John Gambatese
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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

Secure | https://designforconstructionsafety.org

oogle Maps | Toledo, OH Forecast | Prevention through D | (10) LinkedIn | Executive Summary | USGS Current Condit | Mail - Michael.Toole | icare.co.lucas.oh.us/L | Manager's Toolkit | Social Equity in the B

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Prevention through Design

Spreading the word about Design for Construction and Maintenance Safety

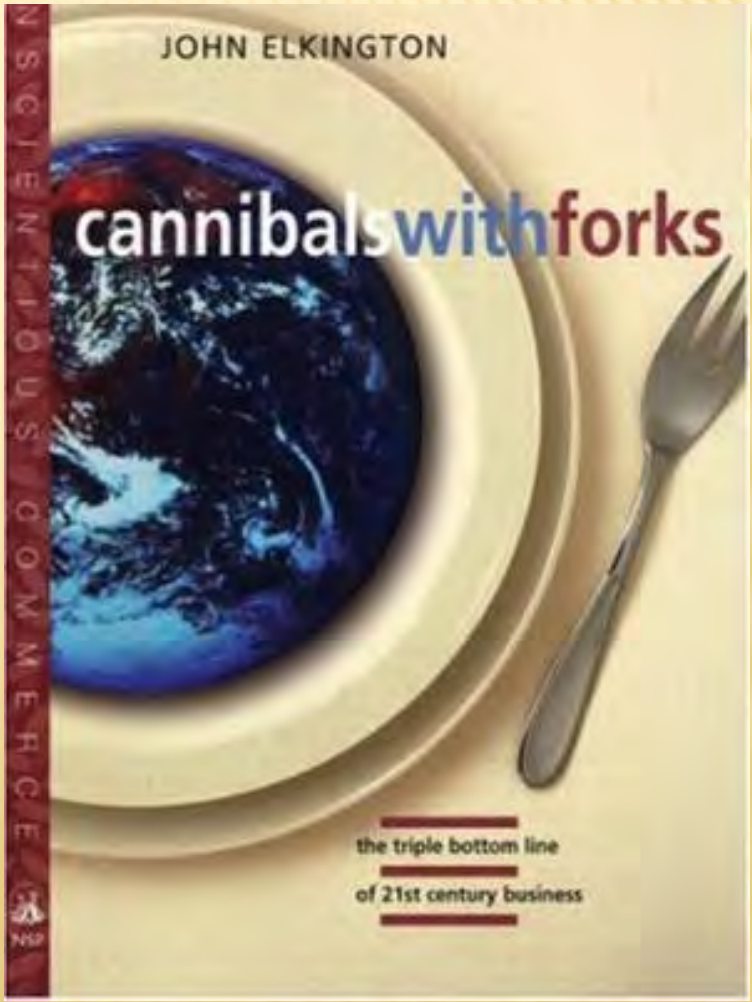
THE PTD CONCEPT | PROCESS AND WORK PRODUCT | HISTORY AND FUTURE OF PTD | CHALLENGES

PTD INFORMATION AND PUBLICATIONS | DESIGN TOOLS | INTERNATIONAL GUIDELINES | PRESENTATION FILES

ABOUT THIS WEBPAGE

TRIPLE BOTTOM LINE

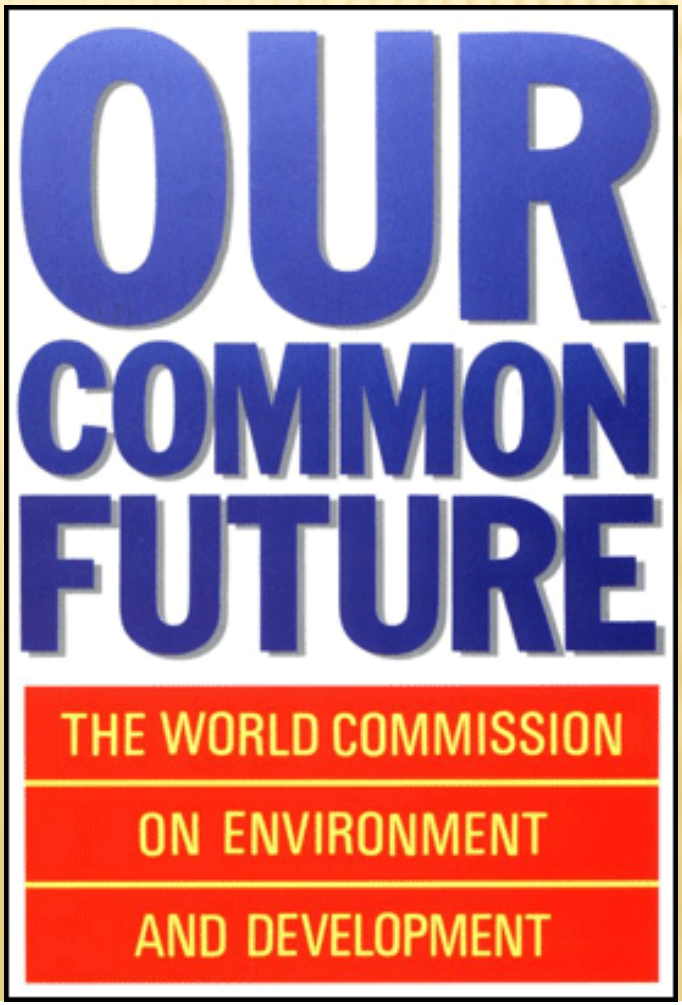
"All businesses can and must help society achieve three goals that are linked – **economic** prosperity, **environmental** protection and **social** equity."



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

- 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)

- "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

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

- 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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Prevention through Design

= Design for Safety

= Safety by Design

PREVENTION THROUGH DESIGN (PTD)

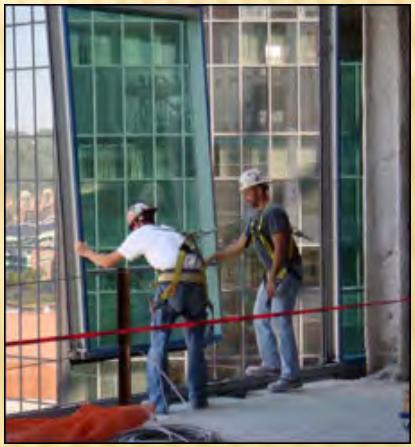
"Addressing occupational safety and health needs in the design process to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, and disposal of facilities, materials, and equipment."

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

PtD
Prevention through Design

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.



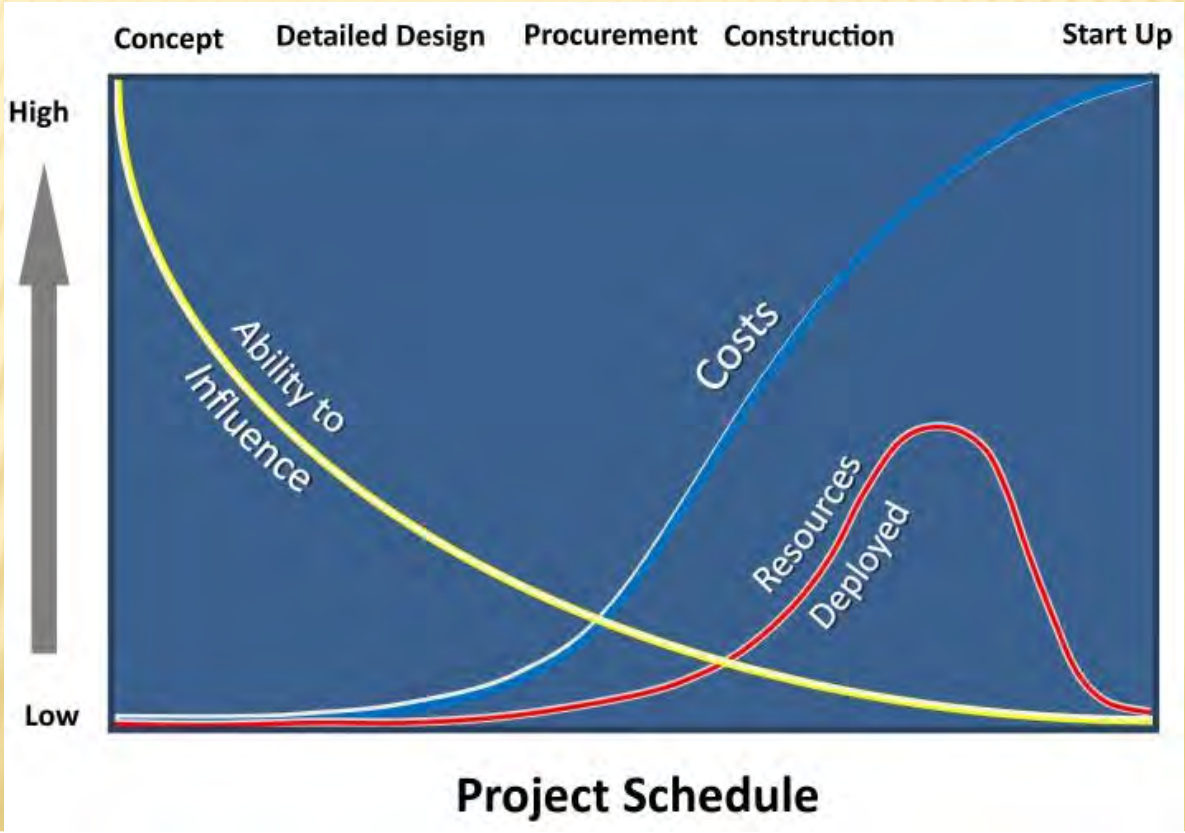
"Safety Constructability and Maintainability"

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.

DESIGN HAS MAJOR LEVERAGE

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



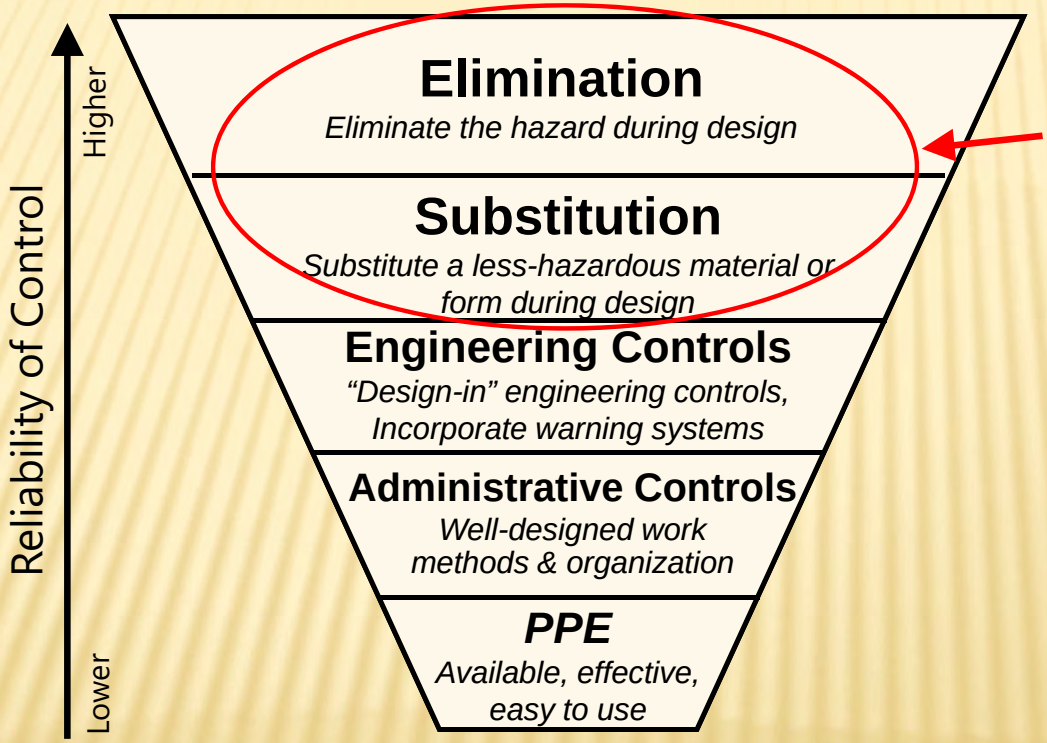
INTEGRATED DESIGN AND CONSTRUCTION

- 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



Prevention through Design

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

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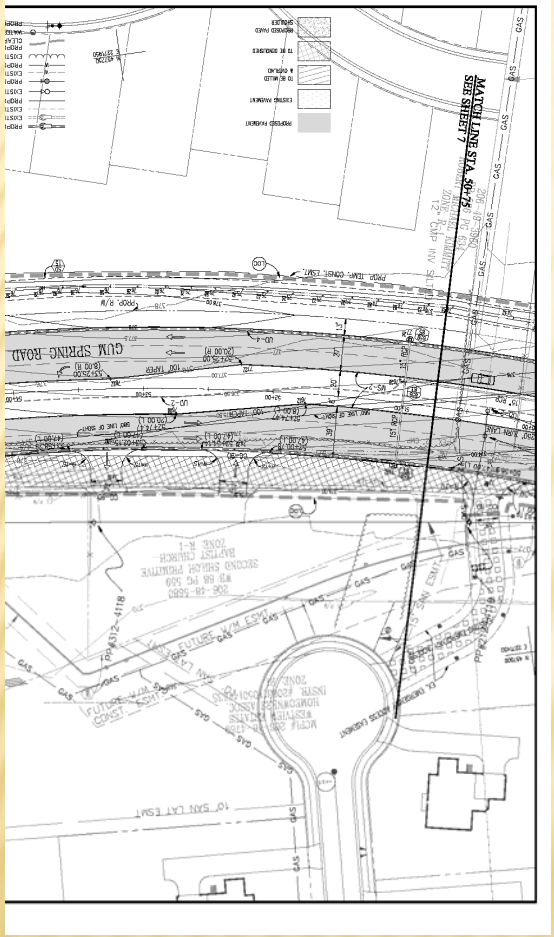
SITE CIVIL EXAMPLE



- 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.

TRUE STORY ABOUT SMALL-TOWN SCHOOL GYM PROJECT

- ~220’ x 65’ x 33’ tall masonry gym under construction
- Design included bond beams but no grouted cores, despite embedded “through-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

TRANSPORTATION EXAMPLE: SITE LAYOUT CAN BE CRITICAL

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,

BUILDING EXAMPLE: ANCHORAGE POINTS

BUILDING EXAMPLE: STRUCTURAL STEEL DESIGN

Detailing Guide for the Enhancement of Erection Safety

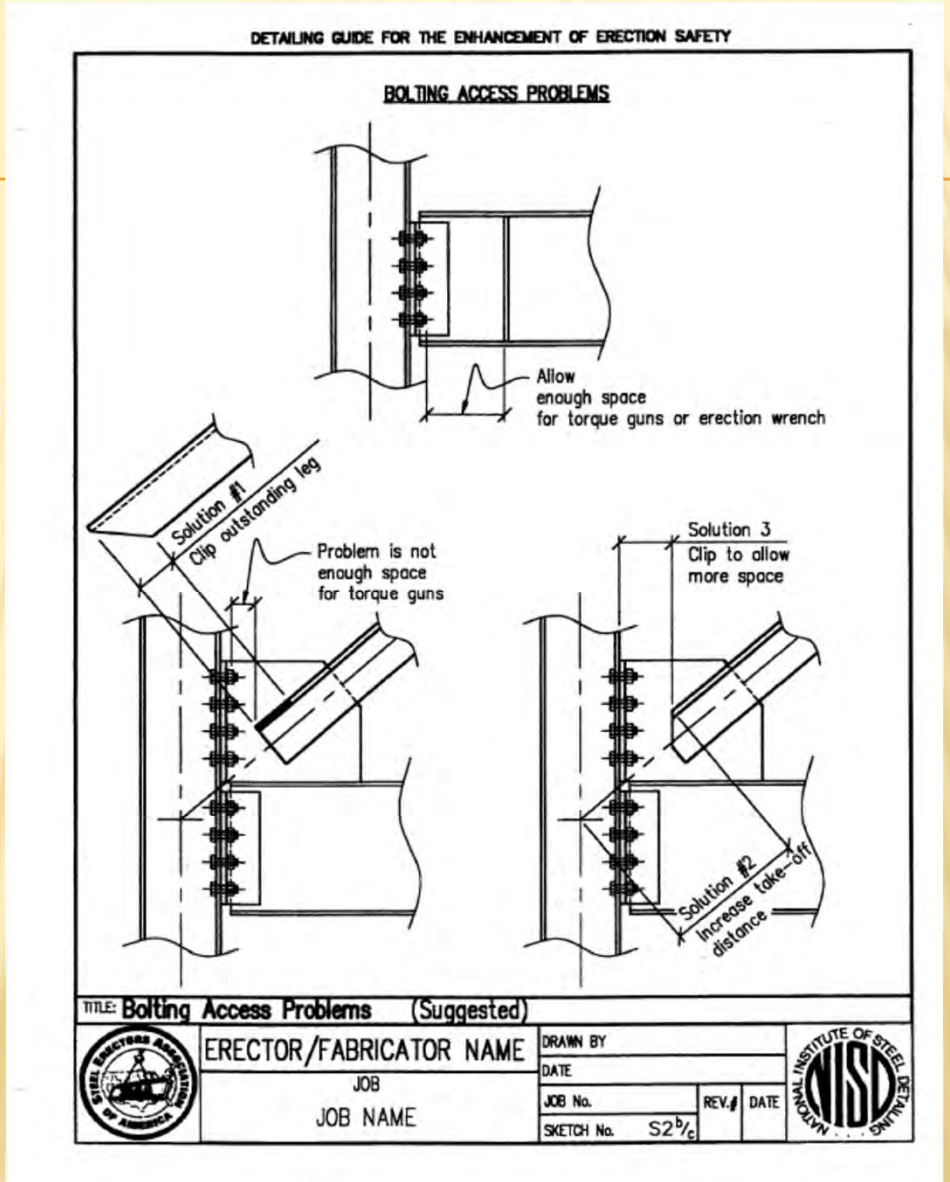
Published by the National Institute for Steel Detailing and the Steel Erectors Association of America

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

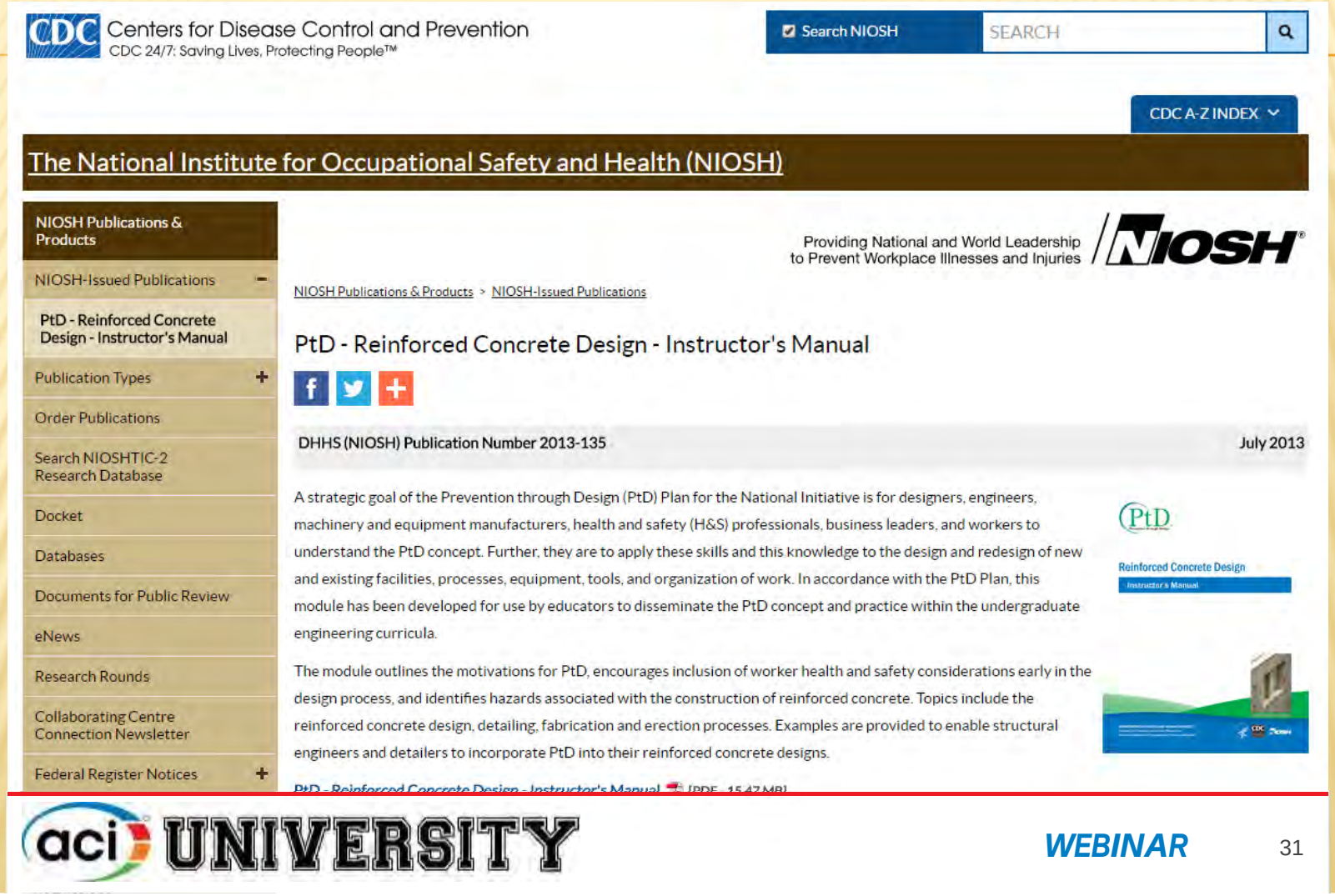
- Provide enough space for making connections



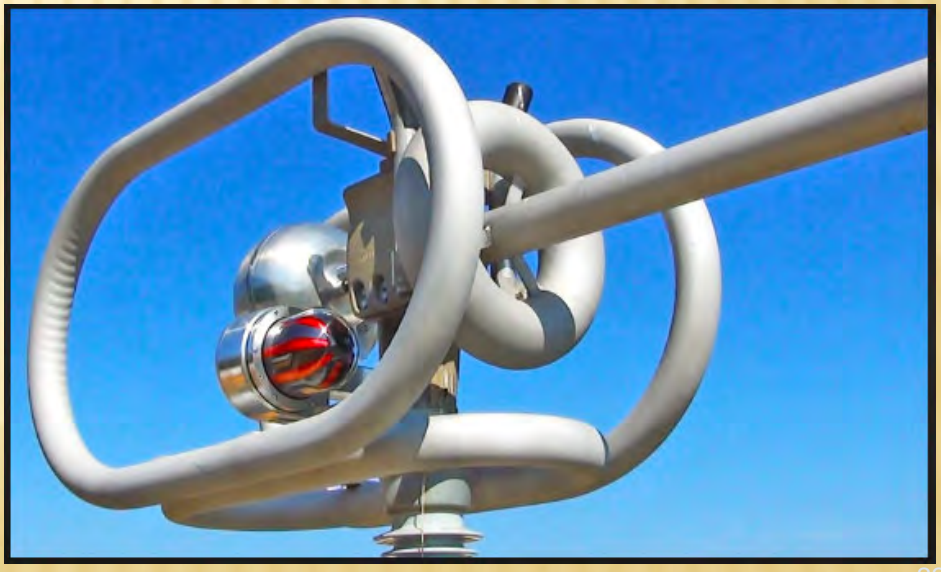
- Know approximate dimensions of necessary tools to make connections

Photo: AISC educator ppt

CONCRETE EXAMPLE: WWW.CDC.GOV/NIOSH/DOCS/2013-135/



ELECTRICAL DISTRIBUTION EXAMPLE: MACI SWITCH INDICATOR



EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ELECTRICAL DISTRIBUTION EXAMPLE: FALL PROTECTION

PREFABRICATION EXAMPLES

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
  - 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

- 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

American Road & Transportation Builders Association

LOGIN

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Safety Certification for Transportation Project Professionals™

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

- 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

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

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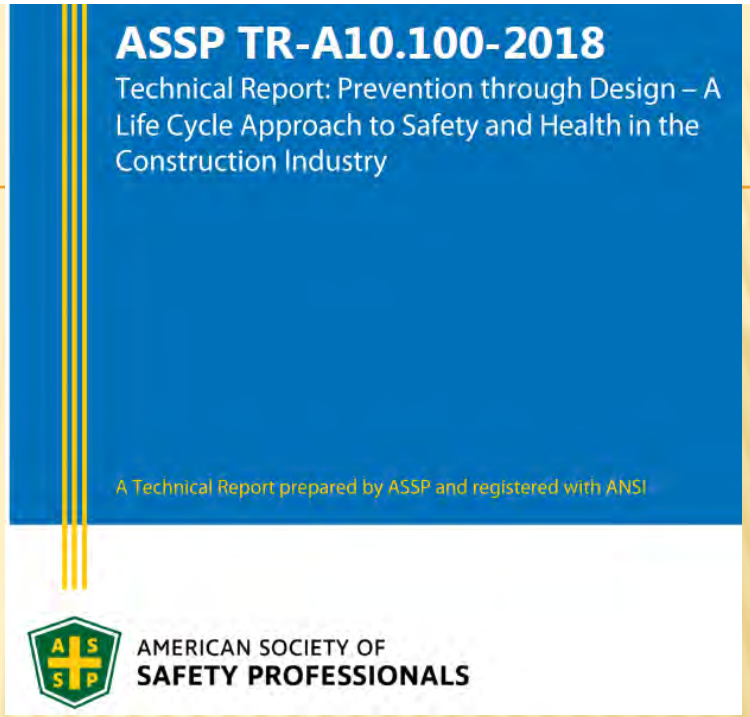
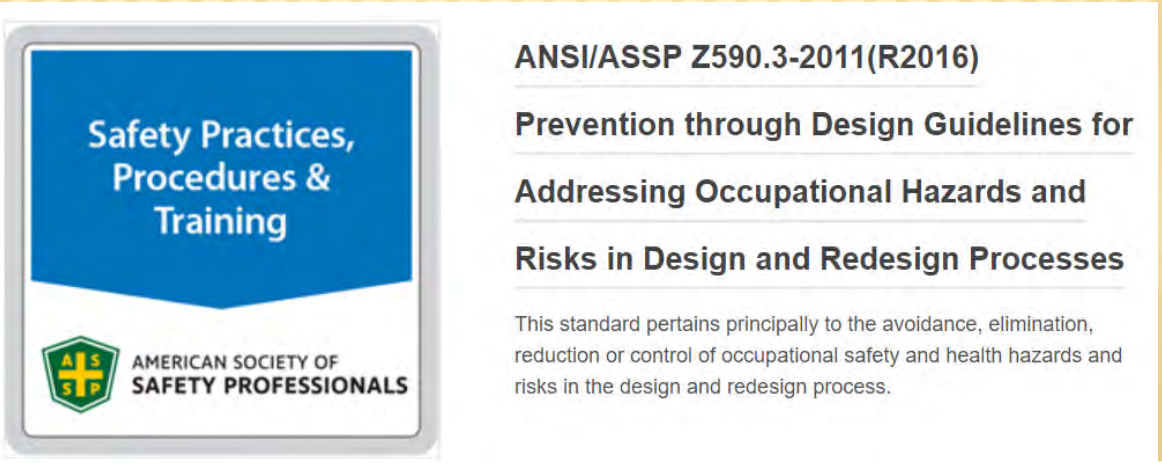
ANSI DOCUMENTS





MANY PTD PAPERS ARE AVAILABLE FREE ONLINE

tmichaeltoole.com

tmichaeltoole.com

Publications

(those with links to non-copyrighted text files)

Refereed Journal Articles

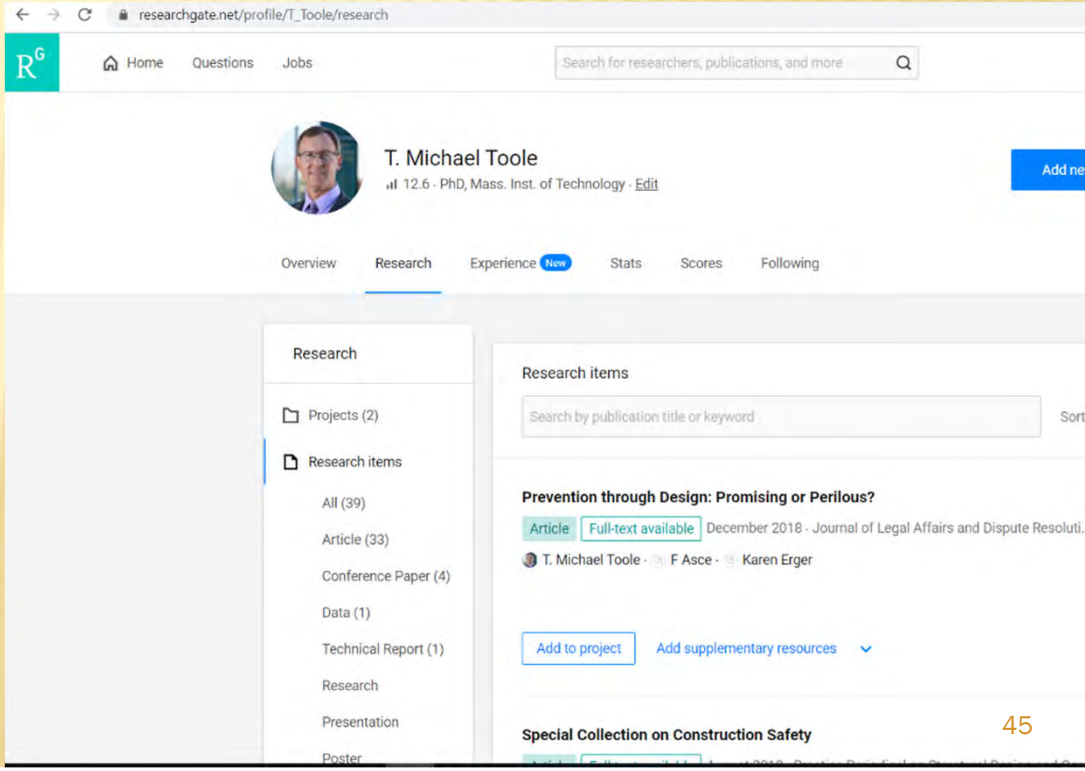
Toole, T. M. and Erger, K. (2018). "Prevention through Design: Promising or Perilous?" ASCE *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction. DOI: 10.1061/(ASCE)LA.1943-4170.0000284.*

Gambatese, J. A., T. M. Toole and D. Abowitz (2017). "Barriers to Prevention through Design." *J. of Construction Engineering and Management. DOI 10.1061/(ASCE)CO.1943-7862.0001296.*

Toole, T. M., J. A. Gambatese and D. Abowitz (2016). "Owners' Role in Facilitating Prevention through Design." *J. of Professional Issues in Engineering Education and Practice. DOI 10.1061/(ASCE)EI.1943-5541.0000295.*

Toole, T. M. and G. Carpenter (2013). "Prevention through Design as a Path Towards Social Sustainability." *J. of Architectural Engineering* 19(3):169-173.

ResearchGate.com



PTD DESIGN REVIEW

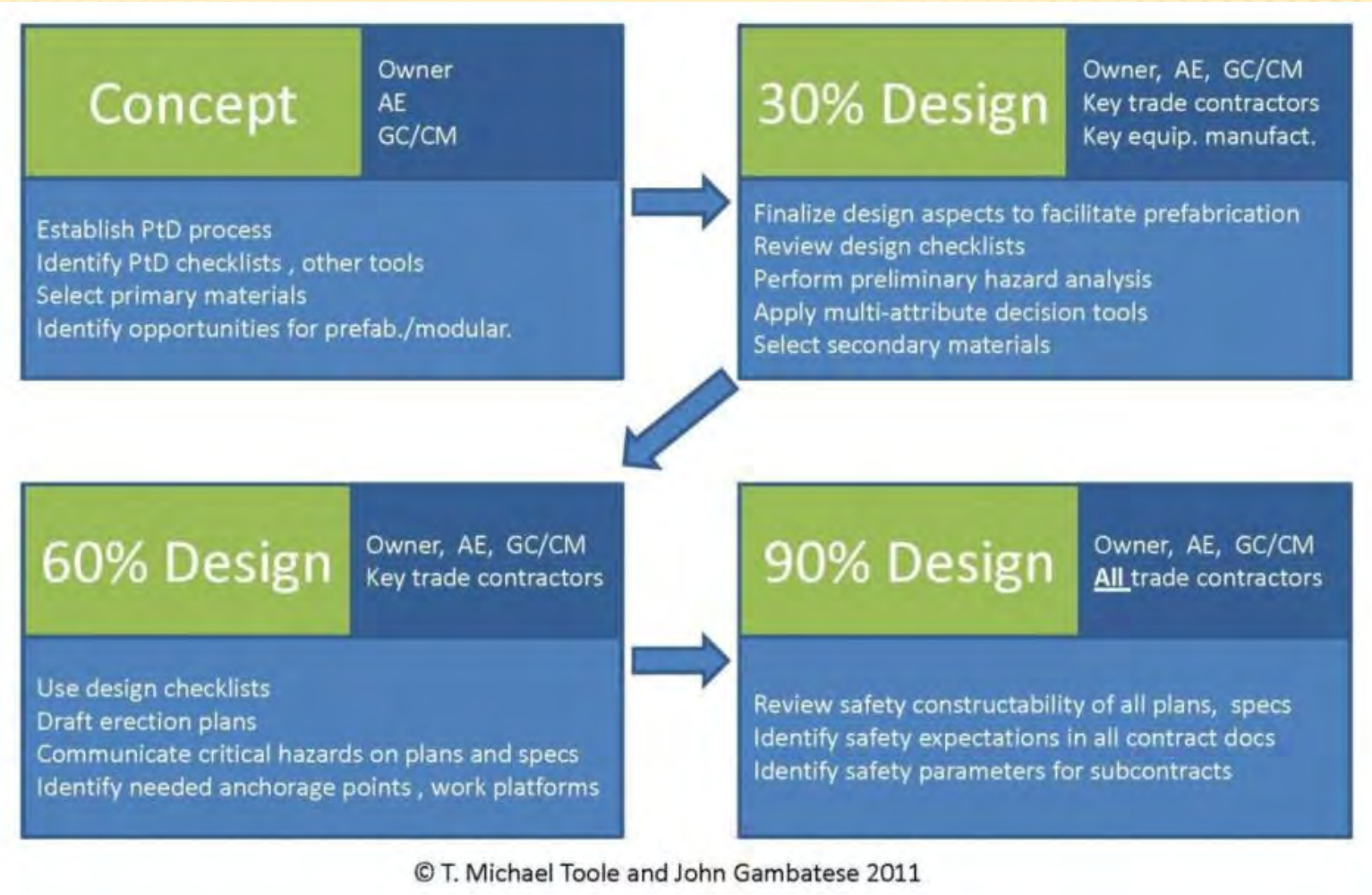
- Hazard identification
  - What construction safety hazards does the design create?
- Risk assessment
  - What is the level of safety and health risk associated with each hazard?
- Design option identification and selection
  - What can be done to eliminate or reduce the risk?
  - Remember the hierarchy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

PTD PROCESS

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

www.seagrave.com/

PTD PROCESS



SOUTHERN CO.'S DESIGN CHECKLISTS

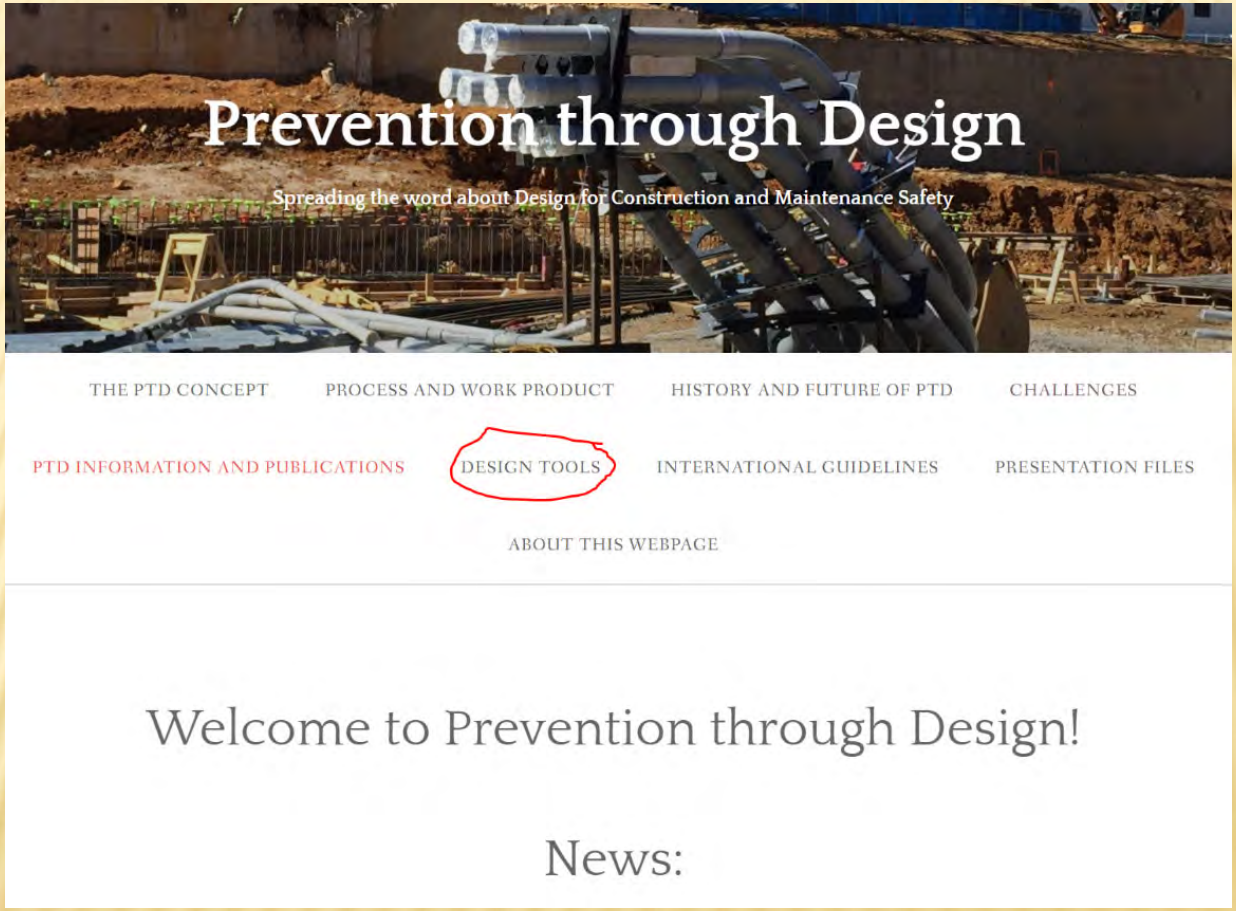
DESIGN SAFETY CHECKLIST
CIVIL

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.	
	☐	☐	☐	1.	Project Engineer has communicated "**HAZCOM**" **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.)
	☐	☐	☐	2.	Discipline Lead Engineer and civil team understand our safety goal: All engineering drawing and specifications will be prepared with a consideration for **safety and constructability**.
	☐	☐	☐	3.	Construction people working near **fiberglass manufacturing** need to understand the **toxic air pollutants**.
	☐	☐	☐	4.	Locations are identified where guard posts, walls, or barriers should be provided to **prevent access** to potentially unsafe areas.
	☐	☐	☐	5.	**Underground hazards** and reference drawings locating any potential hazards are identified. (Examples: buried pipes, electrical cables, etc.)
	☐	☐	☐	6.	Process engineer, construction project manager, customer, and vendor representatives have identified **special loads** that should be considered in our design.
	☐	☐	☐	7.	Required quality records will be identified, collected, filed, and stored with proper disposition for structural specified **materials**. (Examples: high strength bolts, U-drain grates, concrete cylinder breaks.)

PTD INFORMATION SOURCES



www.designforconstructionsafety.org

1700+ ITEM PTD CHECKLIST

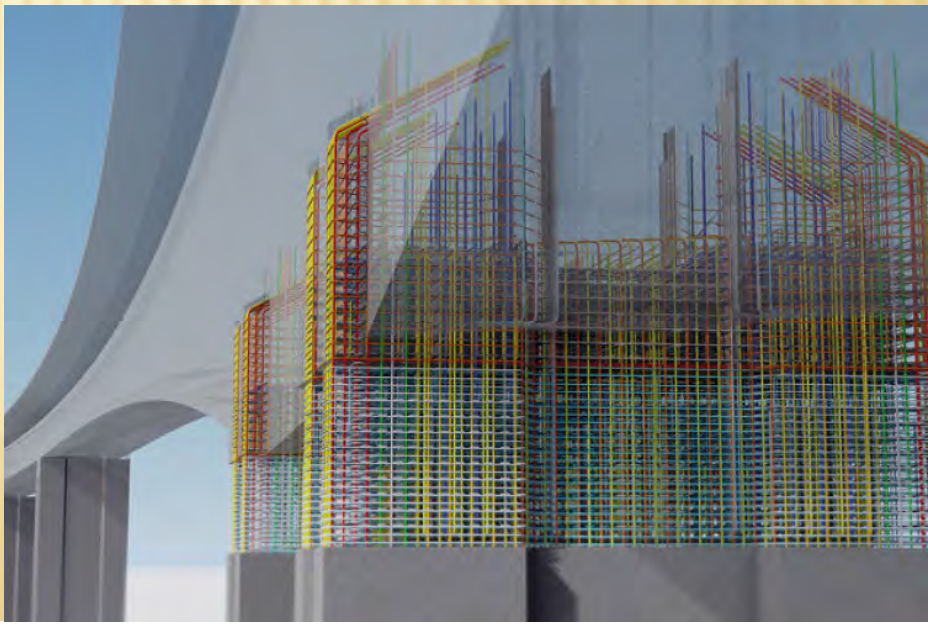
Item	Description
1.0	Structural Framing
1.1	Space slab and mat foundation top reinforcing steel at no more than 6 inches on center each way to provide a safe walking surface.
1.2	Design floor perimeter beams and beams above floor openings to support lanyards.
1.3	Design steel columns with holes at 21 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.

SUTTER HEALTH'S IPD PROCESS

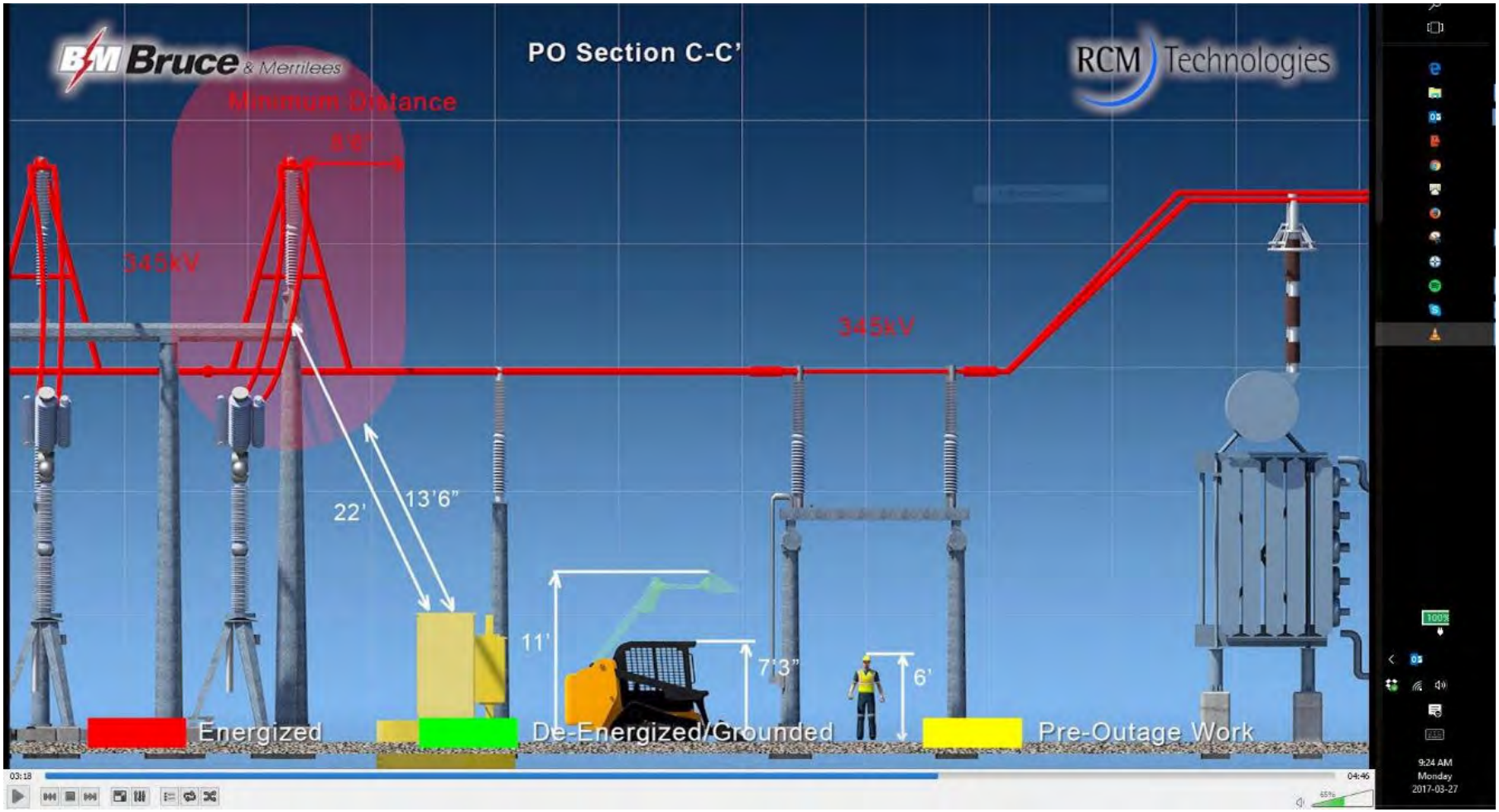
- Integrated Project Delivery (IPD) facilitates collaboration of design and construction professionals during design
  - Co-located
  - Processes and norms for candid feedback
  - Trust
  - Sufficient time
  - Life cycle costing criteria
  - Common success criteria

PTD TOOLS – BIM AND VISUALIZATION

www.theconstructionindex.co.uk/news/view/bim-for-bridges



Safety by Design / Integrated Design & Construction



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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

IMPLICATIONS FOR ALL INFRASTRUCTURE PROFESSIONALS

- 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

- Must demand that project participants actively pursue design for safety
- Must enable Integrated Design and Construction through procurement decisions
- Must prioritize safety and lifecycle perspectives over initial costs
- Must ensure operation and maintenance professionals play a meaningful role in design reviews

IMPLICATIONS FOR DESIGN PROFESSIONALS

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

IMPLICATIONS FOR CONTRACTORS

- Be prepared to compete for projects through non-traditional procurement processes
- 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

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 FECON's bold and commendable safety vision.

THANK YOU FOR YOUR TIME!

FECON: thank you for your leadership!

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www.designforconstructionsafety.org

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