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Please adjust your audio level at this time.

ACI UNIVERSITY *WEBINAR* 6

- For continuing education credit, attendance for the entire duration of the webinar will earn you a certificate of completion for 1 PDH (0.1 CEU). Your certificate will be available in ACI University under the Certificates tab within two days.
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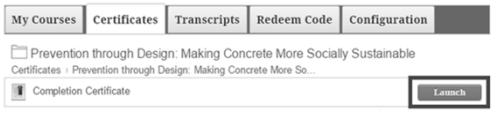
- Certificates will be available in ACI University under the Certificates tab.
- Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



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Prevention through Design

Course Description:

This session will focus on an important emerging topic within the construction industry: Prevention through Design (PtD), also known as Design for Construction Safety. Learn what PtD is and how it is directly connected to topics that are important to your customers: social sustainability, corporate social responsibility, and innovation. You will learn how PtD is both the right thing to do and the smart thing to do in terms of cost, time and quality. You will see common examples of PtD and hear about tools (including a resource focused on concrete available free from NIOSH) and contracts that enable it. PtD has been required in Europe for many years and is becoming common in other nations, too. In the U.S., PtD is often practiced by owners and large design-build firms in the process industry and is slowly moving into other segments of the design and construction industry. The session will conclude with tips associated with organizational culture, processes, and project partners that will help you implement PtD within your organization and gain a reputation as an innovative, sustainable, and ethical leader.

Prevention through Design

Learning Objectives:

- Define Prevention through Design (PtD).
- Describe common examples of PtD and examples specifically for concrete.
- Identify tools and processes that enable PtD.
- Summarize three sets of organizational actions necessary to implement PtD.

Dr. T. Michael Toole, P.E.

Mike Toole is Professor of Civil and Environmental Engineering and Director of the Grand Challenge Scholars Program at Bucknell University. He received his B.S. in Civil Engineering cum laude from Bucknell University and his M.S. in Civil Engineering and his Ph.D. in Technology Strategy from the Massachusetts Institute of Technology. His research includes construction safety (especially designing for safety), construction innovation, and project management. Dr. Toole is a professional civil engineer, a member of the Order of the Engineer, and a Fellow within the American Society of Civil Engineers.

He initiated and maintains www.designforconstructionsafety.org. His professional employment includes serving as a Company Commander in a Seabee Battalion and Assistant Resident Officer in Charge of Construction with the U.S. Navy Civil Engineer Corps, serving as the Purchasing and Construction Services Manager with a publicly traded homebuilder, and as a Vice President with a multidisciplinary engineering firm that specialized in forensics engineering.

Prevention through Design

Dr. T. Michael Toole, PE
Professor, Bucknell University
January 10, 2017

PREVENTION THROUGH DESIGN:
MAKING CONCRETE MORE SOCIALLY SUSTAINABLE

ACI UNIVERSITY WEBINAR
JANUARY 10, 2017

T. Michael Toole, PhD, PE
Professor, Civil and Env. Engineering, Bucknell University

Based on past presentations with
John Gambatese, PhD, PE
Professor, Civil and Construction Engineering, Oregon State University

PRESENTATION DESCRIPTION

- The presentation will summarize the PtD concept and the ethical and sustainability-related reasons for PtD, provide examples for concrete construction, and summarize tools and processes that enable PtD. The presentation will conclude with suggestions for how to move forward with implementing PtD in your organization.

LEARNING OBJECTIVES

- Participants will be able to:
  - Define Prevention through Design (PtD)
  - Describe common examples of PtD and examples specifically for concrete
  - Identify tools and processes that enable PtD
  - Summarize three sets of organizational actions necessary to implement PtD

OVERVIEW

- PtD Concept
- Motivation
- Concrete Examples
- Leaders
- Tools and Processes
- Moving forward in your organization

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/)

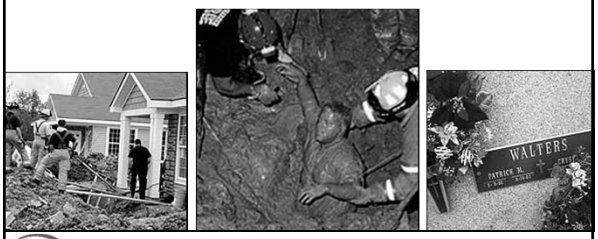
PTD IN CONSTRUCTION IS…

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

"Safety Constructability"

WHY PTD? ANNUAL CONSTRUCTION ACCIDENTS IN U.S.

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



WHY PTD? DESIGN-SAFETY LINKS

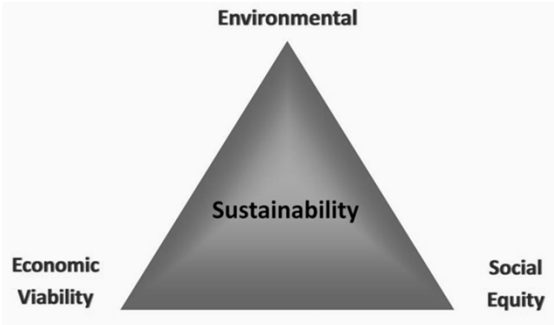
- **22%** of 226 injuries that occurred from 2000-2002 in Oregon, WA, and CA[1]
- **42%** of 224 fatalities in US between 1990-2003[1]
- **60%** of fatal accidents resulted in part from decisions made before site work began[2]
- **63%** of all fatalities and injuries could be attributed to design decisions 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

WHY PTD? PROFESSIONAL ETHICS

- National Society of Professional Engineers (NSPE) Code of Ethics:
  - **Engineers shall hold paramount the safety, health, and welfare of the public.**
- American Society of Civil Engineers (ASCE) Code of Ethics:
  - **Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering decisions ….**

WHY PTD? SUSTAINABILITY



PTD'S TIE TO 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


United Nations

Report of the World Commission on Environment and Development: Our Common Future

Table of Contents

CORPORATE SOCIAL RESPONSIBILITIES

- "Commitment by business to behave ethically and contribute to economic development;
- "Improve quality of life of the local community and society at large."
- "Improve quality of life of the workforce and their families;

Source: World Business Council for Sustainable Development

SUSTAINABILITY IS NOT JUST BEING GREEN

PTD AND SOCIAL SUSTAINABILITY/EQUITY

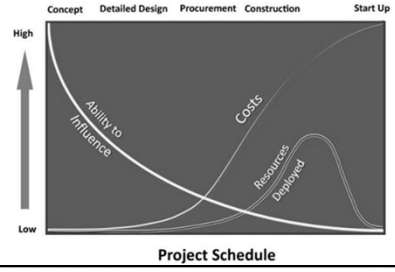
- Do not our duties include minimizing all risks that we have control over?
- Do not we have the same duties for construction, maintenance, line workers as for the "public"?
- Is it ethical to create designs that are not as safe as they could (practically) be?

DESIGN HAS MAJOR LEVERAGE

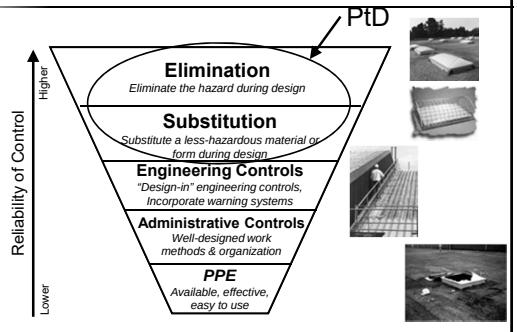
- PtD is the Right thing to do and…
- The Smart thing to do

WHY PTD? BANG FOR THE BUCK

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



HIERARCHY OF CONTROLS



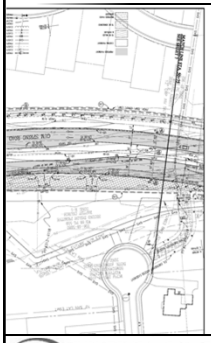
WHY PTD? TANGIBLE BENEFITS

- Reduced site hazards
  - **Fewer worker injuries and fatalities**
- Reduced workers' compensation premiums
- Increased productivity and quality
- Fewer delays due to accidents
- Encourages designer-constructor collaboration
- Improved operations/maint. safety

OVERVIEW

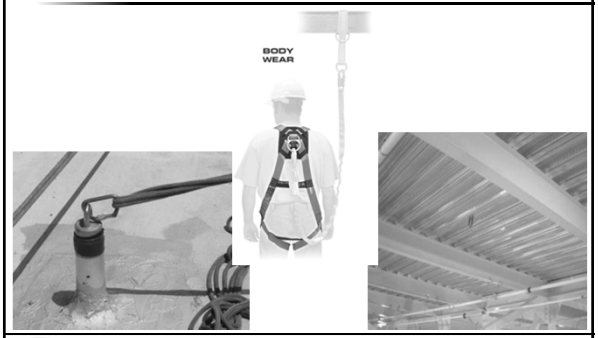
- PtD Concept
- Motivation
- **Concrete Examples**
- Leaders
- Tools and Processes
- Moving forward in your organization

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

Skylights

Upper story windows

Parapet walls

PTD EXAMPLE: PREFABRICATION

Structural Tees

Wall Panels

Segmented Bridge

Photo courtesy of Thinkstock

PtD Prevention through Design

Reinforced Concrete Design

EDUCATION MODULE

Developed by John Gambatese, Ph.D., P.E.
Ryan Lujan
School of Civil and Construction Engineering
Oregon State University

CDC NIOSH

WWW.CDC.GOV/NIOSH/DOCS/2013-135/

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

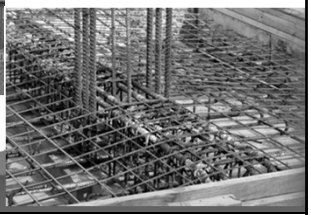
Photo courtesy of John Gambatese

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

Photo courtesy of Thinkstock

Foundations



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

Floor Surfaces

Photo courtesy of John Gambatese

Floor Surfaces

- Keep steps, curbs, blockouts, slab depressions, and other similar floor features away from window openings, exterior edges, and floor openings
- Design the covers over sumps, outlet boxes, drains, etc., to be flush with the finished floor
- Provide a non-slip walking surface on walkways and platforms that are adjacent to open water or exposed to the weather
- Locate floor openings away from passageways, work areas, and the structure perimeter
- Eliminate tripping hazards (changes in elevation, curbs, etc.) around floor openings

Elevated Slabs

Photo courtesy of John Gambatese

Elevated Slabs

- Note on the contract drawings the existing and new floor design loads
  - Help the constructor in determining material stockpile locations and heavy equipment maneuverability
- Provide permanent guardrails around floor openings.
- Design concrete members to be of similar size and regularly spaced to facilitate the use, and re-use, of pre-fabricated forms.
- Minimize the number of details to reduce costs and construction errors.
- Specify composite steel-form deck.
  - Eliminate formwork and minimize rebar in elevated slabs.

Beams and Girders

Source: www.archiproducts.com/en/products/14561/reinforced-concrete-beam-for-bridge-trave-ape.html

Concrete Beams and Girders

- Design members of consistent size and shape
  - Standardize the work environment
  - Facilitates the use, and reuse, of prefabricated forms
- Specify a minimum beam width of 6 inches
  - Provides a wide walking surface
- Minimize the use of cantilevers, which can be hard to form and finish.
- Design pre-fabricated members to be of one size and shape, or make them easily distinguishable to avoid incorrect placement.
- Design member depths to allow adequate head room clearance around stairs, platforms, valves, and all areas of egress.

OVERVIEW

- PtD Concept
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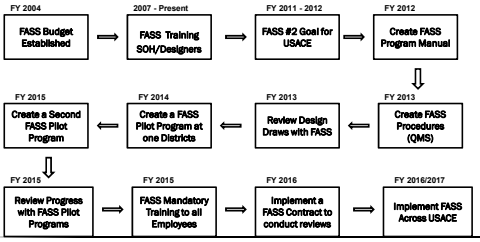
PTD IN PRACTICE: OWNERS

- USACE
- Southern Co.
- BHP Billiton
- Intel
- ExxonMobil
  - MWCS

USACE FACILITY SYSTEMS SAFETY

To incorporate systems safety engineering and management practices into a facility life cycle process used in the conceptual phase, planning stages, construction of facilities, and facility reduction (demolition).

FACILITY SYSTEMS SAFETY
PATH FORWARD



Facility Systems Safety

Program Manager 256-895-1583

U.S. ARMY CORPS OF ENGINEERS BUILDING STRONG®

The Facility Systems Safety (FASS) program works to integrate safety engineering and management practices into the facility life cycle process.

FASS is used to incorporate systems safety engineering and management practices into a facility life cycle process used in the conceptual phase, planning stages, construction of facilities, as well as in facility reduction (demolition) plans. The U.S. Army Engineering and Support Center, Huntsville is a Technical Center of Expertise for Facility Systems Safety for the Army.

The FASS process first examines specific hazards involved, the level of risk and the potential effectiveness of existing codes and standards. Following this discovery and analysis process, the FASS engineer works with the construction team and customer to implement solutions to either eliminate or reduce the risk through the use of controls set forth in codes and standards, specially designed controls or a mix of both control types.

The FASS program has been structured to guide USACE designers toward elimination and control of hazards – including those hazards not covered by codes and standards – during facility design criteria identification and development, as prescribed in Army Pamphlet 385-16, System Safety Management Guide, MIL–STD–882E Department of Defense Standard Practice for System Safety and new UFC 1-200-01 General Building Requirements.

The U.S. Army Corps of Engineers is responsible for the development and implementation of the Facility Systems Safety Program Plan (SSPP), which details the designer's plan for executing the systems safety program for a specific project from the concept design phase to the acceptance of the completed facility. An individually tailored approach based on the contract requirements, the anticipated hazards and the level of risk involved with the specific facility, the SSPP describes how each applicable safety element is to be implemented.

Defining facility system safety requirements at the earliest possible time through the FASS process is important for both the customer and the design/construction team. Identifying issues early can result in cost-savings for the customer, increase customer satisfaction and reduce post-construction project rework/ retrofitting to resolve safety issues.

Huntsville Center FASS program safety engineers work with Army Corps of Engineers Districts, installations and federal agencies during the conceptual phase, planning stages, construction of facilities, as well as in facility reduction (demolition) plans to implement FSS.

The Bassett Army Hospital facility manager spent $125,000 to install reels for accessing the ballasts in the lobby for future servicing of the lights, which are approximately 52 feet from the ground level. If reels had been designed in the conceptual phase and installed during construction, the cost would have been an estimated $25,000 - a savings of $100,000.

U.S. Army Corps of Engineers – Engineering and Support Center, Huntsville
P.O. Box 1600, Huntsville, AL 35807 Public Affairs Office 256-895-1694
www.hnc.usace.army.mil
Distribution A - Approved for Public Release - Unlimited Distribution - October 2016

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

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

NATIONAL INITIATIVES AND ACTIVITIES

- NIOSH
  - PtD National Initiative
  - PtD Workshops: July 2007 and August 2011
  - NORA Construction Sector Council CHPtD Workgroup
- OSHA Construction Alliance Roundtable
- ANSI/ASSE PtD Standard (Z590.3-2011)
- ANSI A10 PtD Tech. Report Working Group

OVERVIEW

- PtD Concept
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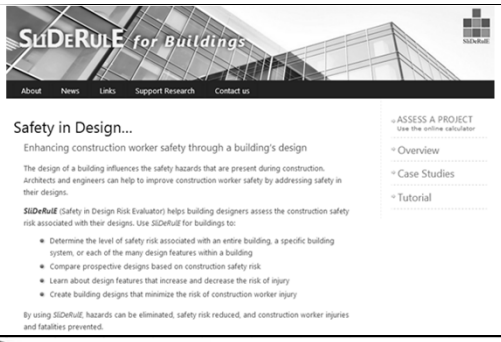
PTD DESIGN REVIEW

- 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 TOOL – DESIGN RISK ASSESSMENT

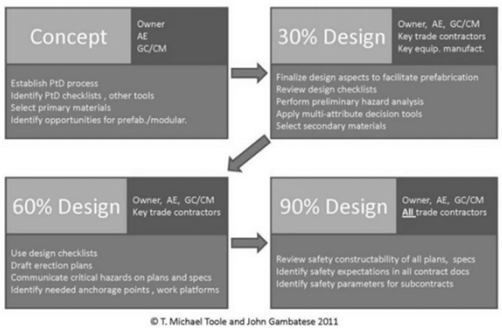


PTD PROCESS

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

www.seagrave.com/

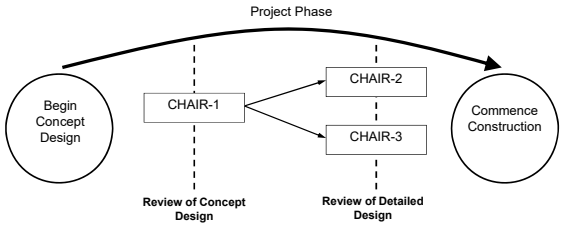
PTD PROCESS



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

CHAIR SAFETY IN DESIGN TOOL



Construction Hazard Assessment and Implication Review (CHAIR)

(Source: NSW WorkCover, *CHAIR Safety in Design Tool*, 2001)

PTD TOOLS – BIM AND VISUALIZATION

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.

OVERVIEW

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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

ESTABLISH A LIFECYCLE SAFETY CULTURE

- Instill the right safety values
- Secure management commitment
- Training
- Confirm Life Cycle Costing criteria
- 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

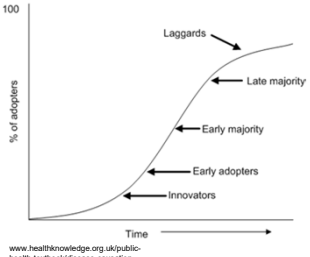
- Designer training and tools
- Qualifications-based contracting
- Negotiated or Cost-Plus contracting
- IPD or enabled safety constructability input
- Collaborative decision processes

CHOOSE YOUR PARTNERS WISELY

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

PTD: AN OPPORTUNITY FOR YOU

- All organizational change starts with individual initiative
- Will you and your firm be leaders or laggards?
- Will ACI be a leader in identifying PtD opportunities in concrete?



INITIATING PTD IN YOUR ORGANIZATION

- Leadership
- Sustainability and Social Responsibility
- Ethics
- Innovation

SUMMARY

- PtD is tied with sustainability, CSR, ethics
- Successful organizations have implemented PtD
- More resources for concrete PtD are needed
- Three first steps to implementing PtD
  - Culture, Processes, Partners
- You can be a leader in implementing PtD in your organization

THANK YOU FOR YOUR TIME!

Mike Toole
ttoole@bucknell.edu
www.designforconstructionsafety.org

Questions?

Prevention through Design

This webinar is sponsored by the American Concrete Institute (ACI).
Thank you to our presenter: **Dr. T. Michael Toole.**
Please use the question feature to submit your questions.
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Upcoming Webinars

January	Cold Weather Series
February	Presidents Series: "ACI 318: What's in Your Spec?"
March	Shotcrete ACI 506R/506.2
April	Chemical Admixtures
April	Repair Code (presented in Spanish)

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ACI 562-16 Repair Code
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Concrete Mix Design: Basics
Concrete Mix Design: Advanced
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