# Opportunities and Challenges for PtD Education

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

*Prevention through Design Workshop*
*March 11, 2020, Tempe, AZ*

**NIOSH Award #1 R13OH011707-01-00**

# Outline

- The Challenges for PtD Education
  - ABET General and Program Criteria
  - Competing emerging topics
- The Opportunities for PtD Education
  - Ethics
  - Social Sustainability
  - Integrated Design and Construction
  - Life Cycle Perspectives
  - Public Policy

# Adding Prevention through Design to Civil Engineering Educational Programs

T. Michael Toole, Ph.D., P.E., F.ASCE

Dean of the College of Engineering, Univ. of Toledo, Toledo, OH 43606-3339. E-mail: michael.toole@utoledo.edu

*Forum papers are thought-provoking opinion pieces or essays founded in fact, sometimes containing speculation, on a civil engineering topic of general interest and relevance to the readership of the journal. The views expressed in this Forum article do not necessarily reflect the views of ASCE or the Editorial Board of the journal.*

**DOI:** 10.1061/(ASCE)EI.1943-5541.0000344

## Introduction

Prevention through design (PtD) (also called design for construc-

influence how much it costs to build, how quickly it can be built, and how easily the quality attributes desired by the client can be achieved (Gambatese et al. 2005; Weinstein et al. 2005; Fonseca et al. 2014; Zhong et al. 2016). [The term "constructability" is mentioned four times in the current civil engineering body of knowledge (ASCE 2008) but is not defined.] Prevention through design adds a fourth criteria to constructability: the safety of the construction worker and maintenance worker. A design's safety constructability reflects the extent that the design can be constructed by a competent set of construction professionals and maintained without unnecessarily high inherent levels of risk (Tymvios and Gambatese 2015).

Proponents of the PtD concept point to the research performed in the United States (Behm 2005; Weinstein et al. 2005; Gambatese et al. 2008; Rajendran and Gambatese 2013) and around the globe (Bennett 2004; Haslam et al. 2005; Driscoll et al. 2008; Lingard et al. 2014) that shows a connection between design and the inher-

Toole, T. M. (2017). "Adding Prevention through Design to Civil Engineering Educational Programs." *J. of Professional Issues in Engineering Education and Practice*. DOI 10.1061/(ASCE)EI.1943-5541.0000344

# Challenges from ABET

- ✓ *And yet the fundamental ABET accreditation, heavily influenced by the ASCE Committee on Curriculum and Accreditation supports an engineering curriculum that is nearly devoid of safety education and training.*

ABET Engineering Accreditation Commission

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

# ABET General Criteria

- Criterion 3. Student Outcomes
- "Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program."
- "2. an ability to apply engineering design to produce solutions that meet specified needs ***with consideration of public health, safety, and welfare***, as well as global, cultural, social, environmental, and economic factors."

# Construction Eng. Program Criteria

- Lead Society: American Society of Civil Engineers
- "These program criteria apply to engineering programs that include "construction" or similar modifiers in their titles.
- The program must prepare graduates to apply knowledge of mathematics through differential and integral calculus, probability and statistics, general chemistry, and calculus-based physics; to analyze and design construction processes and systems in a construction engineering specialty field, applying knowledge of methods, materials, equipment, planning, scheduling, ***safety***, and cost analysis; to explain basic legal and ethical concepts and the importance of professional engineering licensure in the construction industry; to explain basic concepts of management topics such as economics, business, accounting, communications, leadership, decision and optimization methods, engineering economics, engineering management, and cost control."

# Civil Eng. Program Criteria

- Lead Society: American Society of Civil Engineers
- "These program criteria apply to engineering programs that include "civil" or similar modifiers in their titles.
- 1. Curriculum. The curriculum must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science; apply probability and statistics to address uncertainty; analyze and solve problems in at least four technical areas appropriate to civil engineering; conduct experiments in at least two technical areas of civil engineering and analyze and interpret the resulting data; design a system, component, or process in at least two civil engineering contexts; include principles of sustainability in design; explain basic concepts in project management, business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure."

# Competing Emerging Topics

- ✓ *"There are large pressures to embrace the increasing body of knowledge while decreasing the credits to earn a bachelor's degree."*

# ABET Civil Eng. Program Criteria

- Lead Society: American Society of Civil Engineers
- "These program criteria apply to engineering programs that include "civil" or similar modifiers in their titles.
- 1. Curriculum. The curriculum must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science; apply probability and statistics to address uncertainty; analyze and solve problems in at least four technical areas appropriate to civil engineering; conduct experiments in at least two technical areas of civil engineering and analyze and interpret the resulting data; design a system, component, or process in at least two civil engineering contexts; include principles of sustainability in design; explain basic concepts in project management, business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure."
- And what about virtual design and construction (BIM)?

# Outline

- The Challenges for PtD Education
  - ABET General and Program Criteria
  - Competing emerging topics
- **The Opportunities for PtD Education**
  - Ethics
  - Social Sustainability
  - Life Cycle Perspectives
  - Integrated Design and Construction
  - Public Policy

# Adding PtD to Programs

✓*"Fully support integration of Safety throughout our engineering curriculum. It has a place in every class …."*

- 1-2 hour introduction to PtD lecture*
- 10-hour OSHA course
- Add PtD emphasis to existing courses
- Add PtD modules to existing design courses*
- Add PtD requirement to senior design courses
- Offer PtD courses

* free on www

# Adding PtD to Programs

✓*"Fully support integration of Safety throughout our engineering curriculum. It has a place in every class …."*

- 1-2 hour introduction to PtD lecture*
- 10-hour OSHA course
- **Add PtD emphasis to existing courses**
- Add PtD modules to existing design courses*
- Add PtD requirement to senior design courses
- Offer PtD courses

* free on www

# The Ethics of PtD

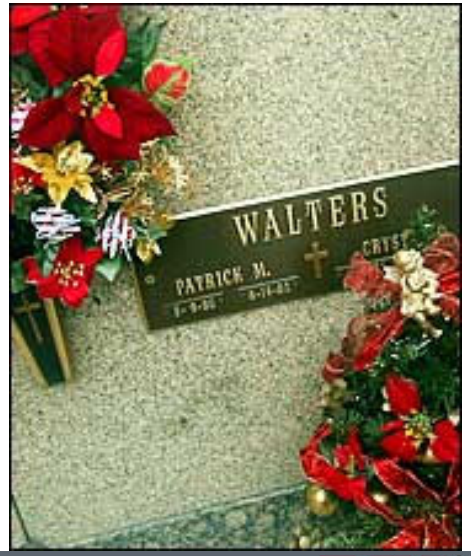
✓ *ASCE Code of Ethics Canon 1:*

*"Engineers shall hold paramount the safety, health and welfare of the **public** …."*

"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."

# Annual Construction Accidents in US

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



# The Ethics of PtD

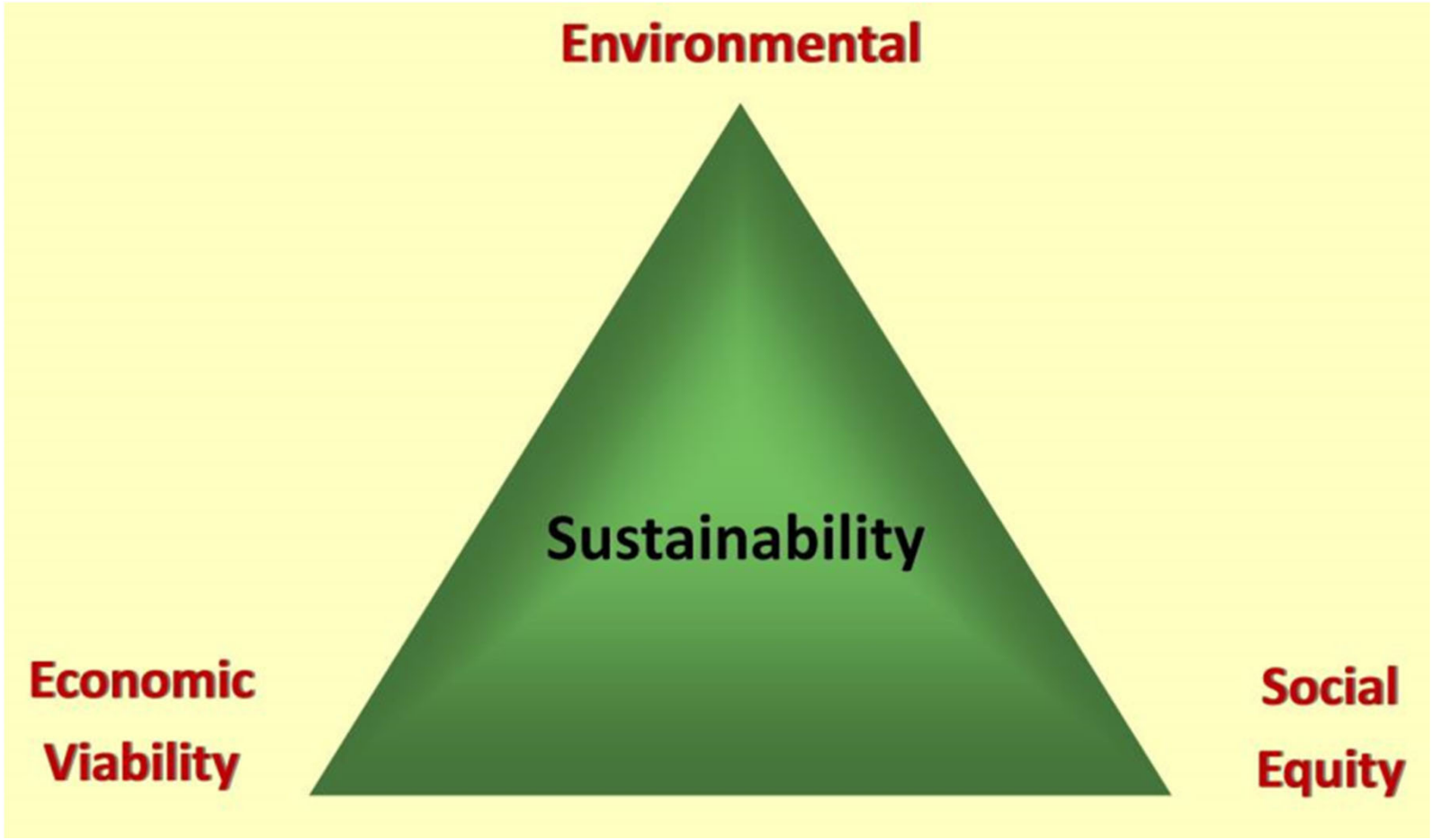
- Do not our duties include minimizing all risks (especially to people) that we have control over?
- Do not we have the same duties for construction and maintenance workers as for the “public”?

# The Ethics of PtD

- ASCE Code of Ethics Canon **8**:

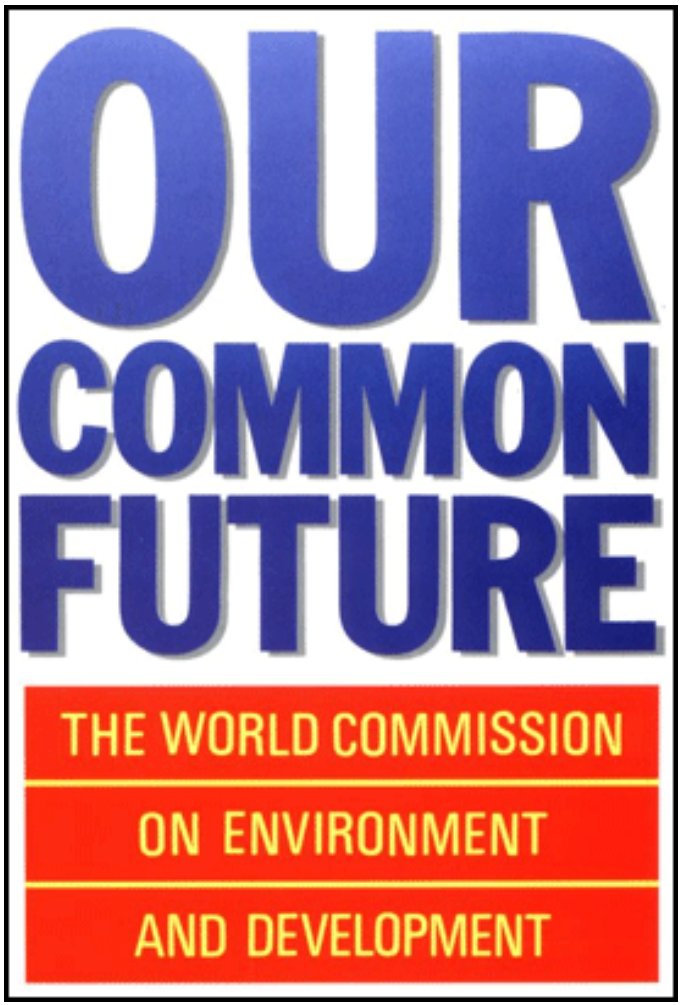
"Engineers shall, in all matters related to their profession, treat all persons fairly and encourage equitable participation without regard to gender or gender identity, race, national origin, ethnicity, religion, age, sexual orientation, disability, political affiliation, or family, marital, **or economic status.**"

# 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

# 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”?

# Outline

- The Challenges for PtD Education
  - ABET General and Program Criteria
  - Competing emerging topics
- The Opportunities for PtD Education
  - Ethics
  - Social Sustainability
  - **Integrated Design and Construction**
  - Life Cycle Perspectives
  - Public Policy

# Need for Integrated Design and Construction

- ✓ *"Contractors have superior understanding of construction means and methods, constructability, cranes, sequences of construction and shoring methods…."*
- ✓ *"Support Integration and Collaboration!"*
- ✓ *"Constructability reviews must be integrated into the overall design process during early design stages. "*
- ✓ *"Facilitate communication and collaboration between the designer and the contractor early and often."*
- ✓ *"Be an advocate for alternate contract delivery methods that embrace early contractor involvement and prevent isolation of the contractor and designer."*

# 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

# PtD Process

Get the right people

talking about the right things

at the right time!

www.seagrave.com/

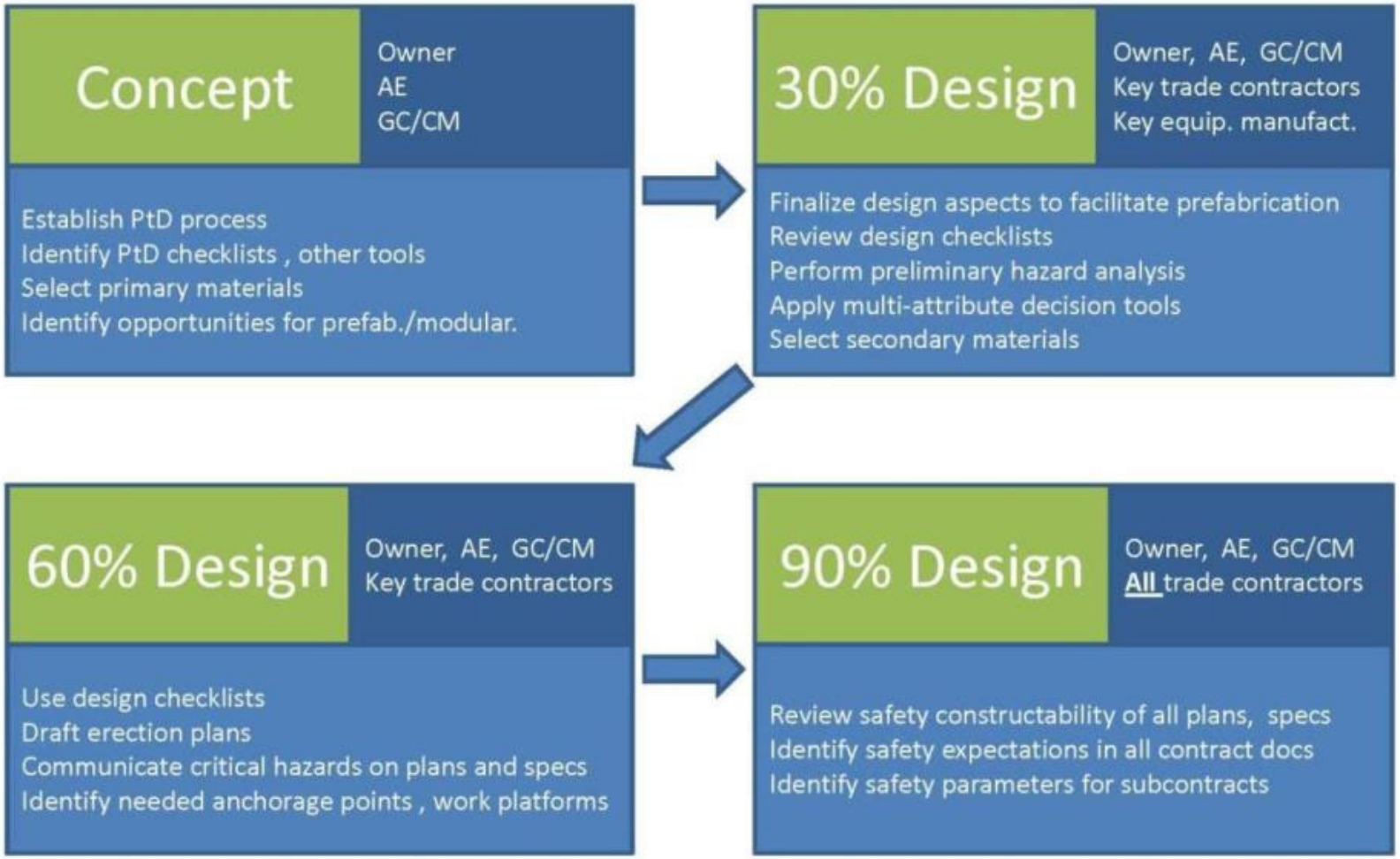
# PtD Design Review

- 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……

# 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

# PtD Process



# ABET General Criteria

- Criterion 3. Student Outcomes
- "Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program."
- "3. an ability to *communicate effectively with a range of audiences*
- 4. an ability to *recognize ethical and professional responsibilities* in engineering situations and make informed judgments, which must consider the *impact* of engineering solutions in global, economic, environmental, and *societal contexts*
- 5. an ability to *function effectively on a team* whose members together *provide leadership, create a collaborative and inclusive environment,* establish goals, plan tasks, and meet objectives"

# Outline

- The Challenges for PtD Education
  - ABET General and Program Criteria
  - Competing emerging topics
- The Opportunities for PtD Education
  - Ethics
  - Social Sustainability
  - Integrated Design and Construction
  - **Life Cycle Perspectives**
  - Public Policy

# 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 in electrical construction
  - Performing maintenance on switches and circuit breakers
  - Accessing terminal boxes and control panels
- Provide safe clearance for replacing units
  - Blower Units, Boilers, Compressors, Pumps
  - Isolation, Material handling, Path out and in

# Public Policy Issues

- Why is PtD required in European Union, Singapore and South Africa, and strongly encouraged in Australia and New Zealand, but not in the United States?
- Does the explanation include differing perceptions about the importance of occupational safety, the appropriate role of the government, or the balance of power of business versus labor in different nations?
- Does the lack of PtD regulations in US reflect pragmatic understanding that even well-intentioned laws can be abused in an excessively litigious society?
- These questions are best discussed with a liberal arts colleague in the room!

# Adding PtD to Programs

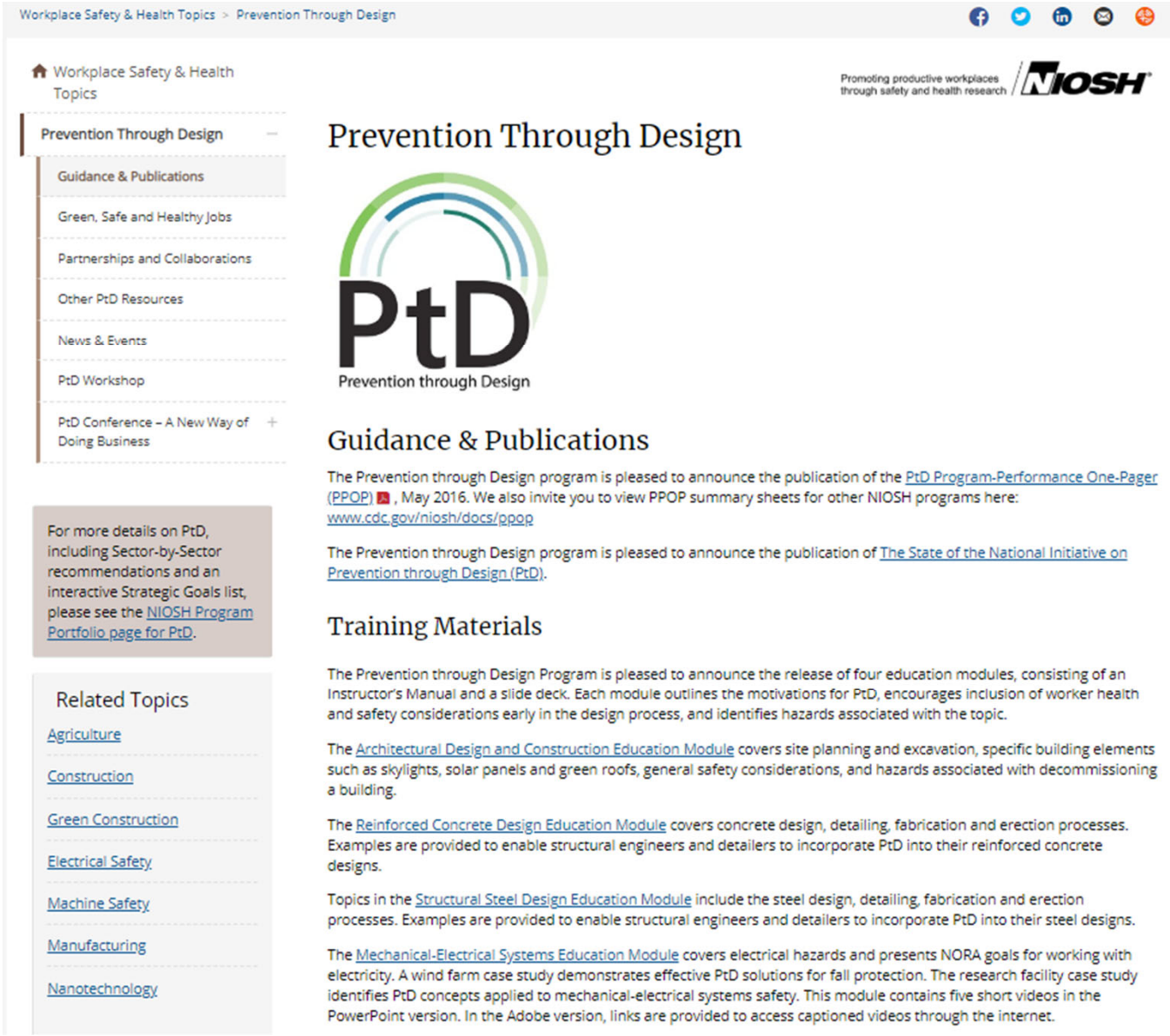
✓*"Fully support integration of Safety throughout our engineering curriculum. It has a place in every class …."*

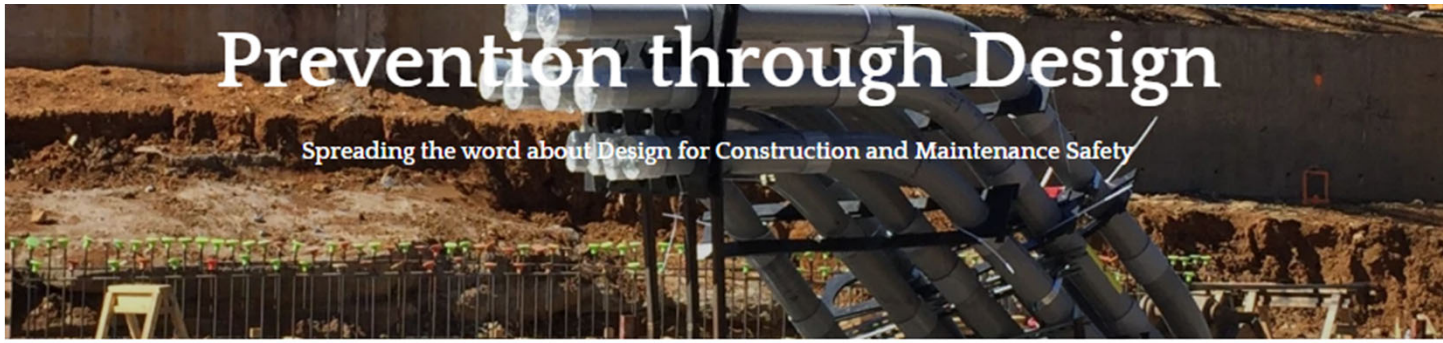
- 1-2 hour introduction to PtD lecture*
- 10-hour OSHA course
- Add PtD emphasis to existing courses
- **Add PtD modules to existing design courses***
- Add PtD requirement to senior design courses
- Offer PtD courses

* free on www

# Free PtD Educational Materials

- Concrete
- Steel
- MEP
- Architectural






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

www.designforconstructionsafety.org

# Welcome to Prevention through Design!

## News:

The first in a series of NIOSH-funded Prevention through Design (PtD) workshops will be hosted on March 11, 2020, 8 am – 3:30 pm in Tempe, Arizona. The theme of the first workshop is "CURRENT AND FUTURE STATE-OF-THE-ART ON RESEARCH, PRACTICE, & EDUCATION." With a roster of

# Wrap Up

- Adding PtD to civil & construction engineering curriculum will be challenging but required and emerging curricular topics provides promising opportunities
  - Ethics
  - Social Sustainability
  - Integrated Design and Construction
  - Life Cycle Perspectives
  - Public Policy
- Our students, our citizens and our project site/facility professionals deserve our best effort


Entrusted by society
to create a sustainable world and
enhance the global quality of life,
civil engineers
serve competently, collaboratively, and ethically as master:

- planners, designers, constructors, and operators of society's economic and social engine—the built environment;
- stewards of the natural environment and its resources;
- innovators and integrators of ideas and technology across the public, private, and academic sectors;
- managers of risk and uncertainty caused by natural events, accidents, and other threats; and
- leaders in discussions and decisions shaping public environmental and infrastructure policy.

# Thank you for listening!
# Please share your thoughts.

michael.toole@utoledo.edu

COLLEGE OF ENGINEERING
THE UNIVERSITY OF TOLEDO

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

NIOSH Award #1 R13OH011707-01-00

We built that.
Del E. Webb School of Construction
ASU Ira A. Fulton Schools of Engineering
Arizona State University

CDC Workplace Safety and Health
NIOSH

ASU Ira A. Fulton Schools of Engineering
Arizona State University