Prevention through Design and the Triple Bottom Line

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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
- PtD Concept and Benefits
- Examples
- Processes and Tools
- PtD as a part of Integrated Lifecycle Engineering

Prevention through Design
= Design for Safety
= Safety by Design

PtD

- Work premises and facilities
- Tools and equipment
- Processes
- Work methods and organization of work
- Products
“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

Environmental

Sustainability

Economic Viability

Social Equity
Safety is good investment.
- Preventing accidents is more cost effective than incurring the direct and indirect costs of accidents when they occur.
- Average direct cost per injury is $39,000 and $1.42M for fatality.
- Indirect costs of injury are 2-17 times direct costs.
- $1 in safety investment returns $2-6 in benefits.

Productivity and morale gains often more valued than injury cost savings.

SOCIAL SUSTAINABILITY AND SAFETY

- Focus on people as much as on the environment
  - Meet the needs of people who can’t speak for themselves
Design and construction that doesn’t unfairly affect people who are not at the table

SOCIAL SUSTAINABILITY ISSUES FOR CONSTRUCTION PROJECTS

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?

- Users of buildings, airports, roads, bridges, etc.
- Local politicians and regulators
- Financiers
- Nearby residents
- Construction workers
- Maintenance workers
ANNUAL CONSTRUCTION ACCIDENTS IN U.S.

- Nearly 200,000 serious injuries
- 1,000+ deaths
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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”
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\(^3\)

\(^2\) European Foundation for the Improvement of Living and Working Conditions
\(^3\) NSW WorkCover, CHAIR Safety in Design Tool, 2001
DESIGN HAS MAJOR LEVERAGE

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

Elimination
Eliminate the hazard during design

Substitution
Substitute a less-hazardous material or form during design

Engineering Controls
“Design-in” engineering controls, Incorporate warning systems

Administrative Controls
Well-designed work methods & organization

PPE
Available, effective, easy to use

Prevention through Design
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”?
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
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
- ANSI Standard and Technical Report
- Adoption primarily in the process/industrial construction sector
- LEED Pilot Credit
- USACE pursuing implementation
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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
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.
EXAMPLES: PREFABRICATION

Bridge Trusses

Concrete Wall Panels

Pre-engineered buildings

Concrete Segmented Bridge

www.ultimateengineering.com

www.jedinstvo.com
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
TRUE STORY ABOUT SMALL-TOWN SCHOOL GYM CONSTRUCTION PROJECT

- ~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
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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 PROCESS

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

**Concept**
- Owner
- AE
- GC/CM
- Establish Ptd process
- Identify Ptd checklists, other tools
- Select primary materials
- Identify opportunities for prefab./modular.

**30% Design**
- Owner, AE, GC/CM
- Key trade contractors
- Key equip. manufact.
- Finalize design aspects to facilitate prefabrication
- Review design checklists
- Perform preliminary hazard analysis
- Apply multi-attribute decision tools
- Select secondary materials

**60% Design**
- Owner, AE, GC/CM
- Key trade contractors
- Use design checklists
- Draft erection plans
- Communicate critical hazards on plans and specs
- Identify needed anchorage points, work platforms

**90% Design**
- Owner, AE, GC/CM
- All trade contractors
- Review safety constructability of all plans, specs
- Identify safety expectations in all contract docs
- Identify safety parameters for subcontracts

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PTD TOOLS – BIM AND VISUALIZATION
BHP BILLITON’S PTD INITIATIVES

- Design reviews includes 3D models
- Communication and training
- PtD staff embedded in procurement and design
- PtD in technical specifications
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
Welcome to Prevention through Design!
CHAIR SAFETY IN DESIGN TOOL

Begin Concept Design

CHAIR-1

CHAIR-2

CHAIR-3

Commence Construction

Review of Concept Design

Review of Detailed Design

Project Phase

Construction Hazard Assessment and Implication Review (CHAIR)

(Source: NSW WorkCover, CHAIR Safety in Design Tool, 2001)
NIOSH Educational Modules on:
Steel design
Concrete design
MEP design
Architectural design
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INTEGRATED LIFECYCLE ENGINEERING ON CAPITAL PROJECTS

- Design professionals are informed of and consider the needs and wants of all stakeholders over a project’s lifecycle
  - Owner/developer
  - All design professionals on project
  - Construction workers
  - Material vendors and prefabricators
  - Government regulators and inspectors
  - Operating workers
  - Maintenance workers
  - People affected by the project’s environmental footprint, from resource extraction to construction to post-facility site remediation
Focused on Construction Projects

- Technical design professionals consider design feedback from individuals who will implement the design (i.e., construct the facility or infrastructure) as well as from those who will operate and maintain the finished facility over its service life.
BENEFITS OF ILE

- Improves design work product to better achieve organizational goals for the completed project
- Because it includes the tacit knowledge and lifecycle perspectives possessed by stakeholders
PROJECT OUTCOMES IMPROVED BY ILE

- Quality
- Cost
- Implementation duration
- Service life
- Environmental sustainability
- Occupational safety
ILE REQUIRES EFFECTIVE DESIGN REVIEWS

- Get the right people in the room
  - Specialty designers
  - Contractors: field ops, safety
  - Specialized equipment engineers
  - Operators
  - Maintenance: plant ops, safety

- Talking about the right things at the right time
  - Periodic, 2-4 days
  - Use visualization tools
  - Use decision-making and documentation tools
  - Establish norms to ensure all voices heard
ILE REQUIRES CHANGES IN PROCUREMENT PROCESSES AND CONTRACTS

- Traditional Design-Bid-Build does not allow ILE
- Design-Build *may* integrate construction knowledge into design
- Integrated Project Delivery’s use of Target-Value Design and Co-location facilitates integration
- Don’t leave out operators and maintenance professionals!
- Don’t prioritize initial costs over lifecycle costs!
SUMMARY

- Our clients and employees may increasingly demand that we proactively consider the triple bottom line in our organizations.

- Prevention through Design uses the Hierarchy of Controls to achieve economic, social and environmental sustainability.

- Prevention through Design is a critical part of Integrated Lifecycle Engineering.
THANK YOU FOR YOUR TIME!

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