Designing for Construction Safety: Concepts and Practice

John Gambatese, PhD, PE
School of Civil and Construction Engineering
Oregon State University

2009 DOE ISM Conference
Knoxville, TN
August 24-27, 2009

Bio – John Gambatese

- John Gambatese is an Associate Professor in the School of Civil and Construction Engineering at Oregon State University. Dr. Gambatese's educational background includes Bachelor and Master of Science degrees in Civil Engineering from the University of California at Berkeley with emphases in structural engineering, and a Ph.D. in Civil Engineering from the University of Washington in the area of construction engineering and management. He has worked in industry as a structural engineer, and as a project engineer for a construction management firm. Dr. Gambatese has taught courses on construction contracts and specifications, construction safety and productivity improvement, planning and scheduling, structural analysis and design, temporary construction structures, and engineering economics. He has performed research and published numerous articles on construction worker safety, constructability, innovation, construction contracting, and life cycle properties of civil engineering facilities. He is a member of the American Society of Civil Engineers (ASCE) and American Society of Safety Engineers (ASSE), and actively participates on ASCE's Construction Site Safety Committee, Constructability Committee, and Construction Research Council. He is a licensed Professional Civil Engineer in California.

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/)

What is Designing for Construction Safety (DfCS)?

- Application of Prevention through Design concepts to construction worker safety
  - The process of addressing construction site safety and health in the design of a project
- Recognizes construction site safety as a design criterion
- "Safety Constructability"

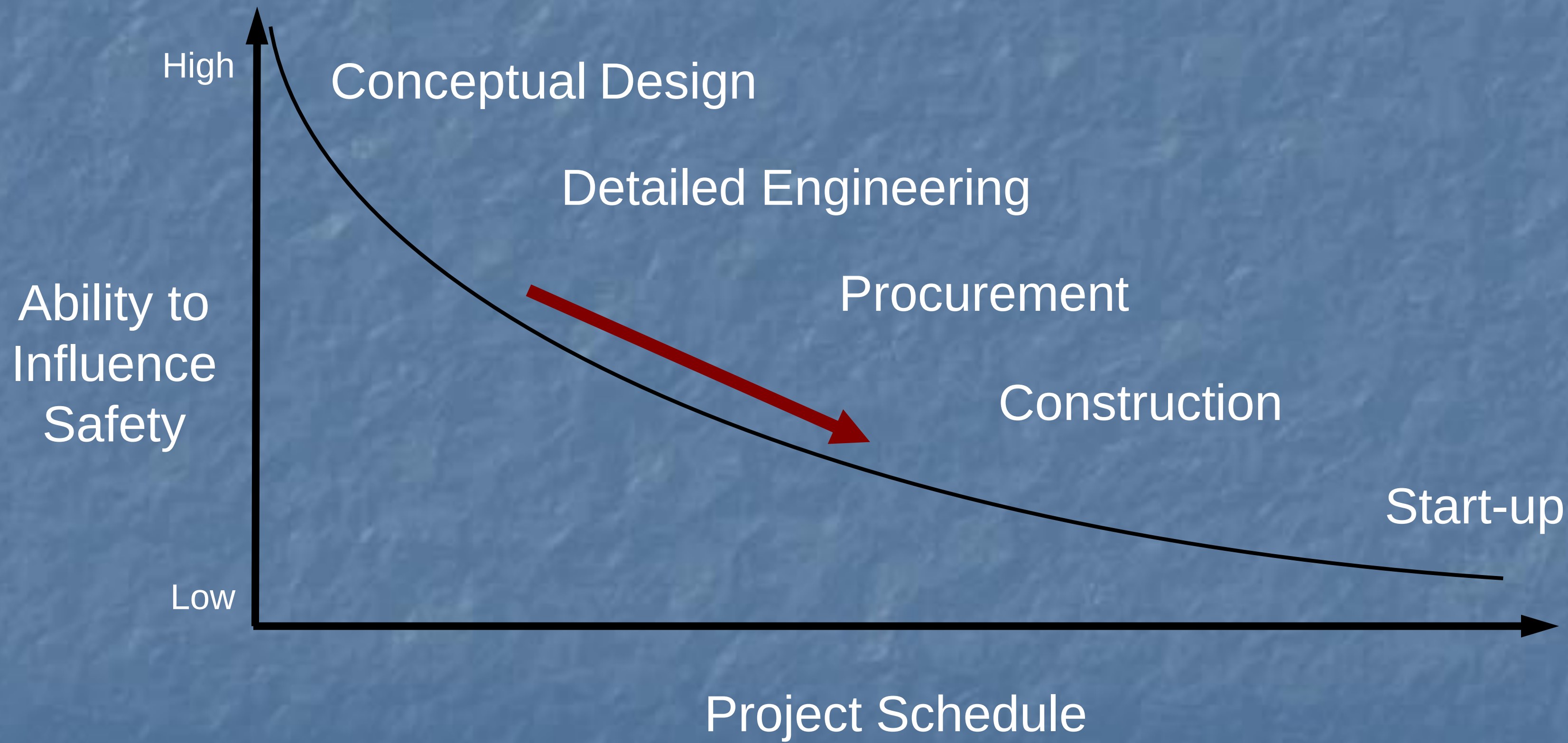
Why Design for Construction Safety?

- 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]
- In Europe, a 1991 study concluded that 60% of fatal accidents resulted in part from decisions made before site work began[2]

[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

Ability to Influence Safety



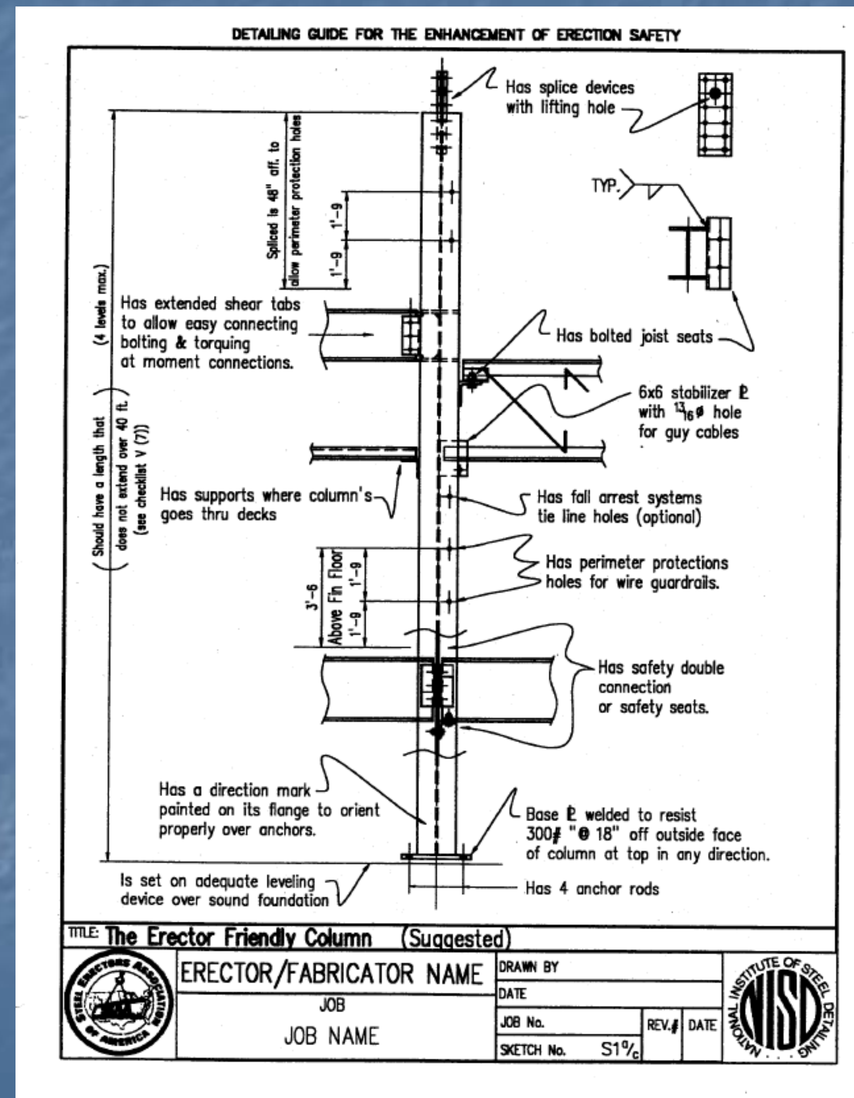
(Source: Szymberski, 1987)

Hierarchy of Controls

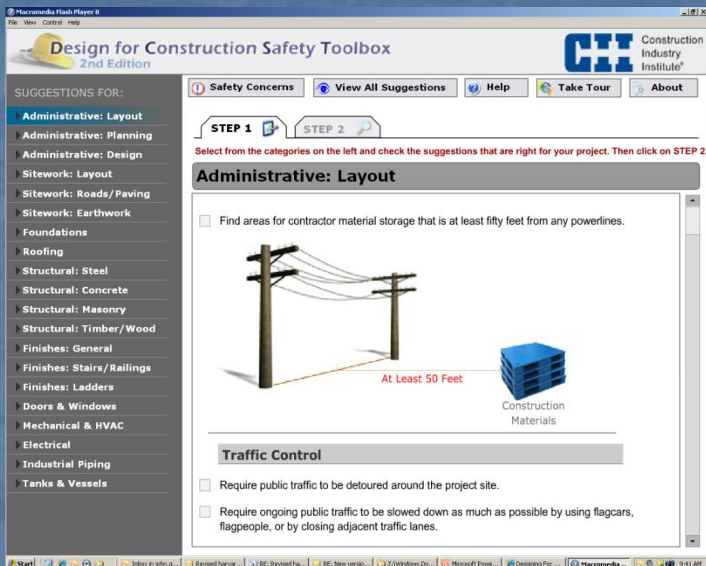
1. Eliminate the hazard (Design for Safety)
2. Reduce the hazard
3. Isolate the hazard
4. Use engineering controls
5. Use administrative controls
6. Use personal protective equipment (PPE)

(Sources: Manuele, 1997; Andres, 2002)

Design Examples

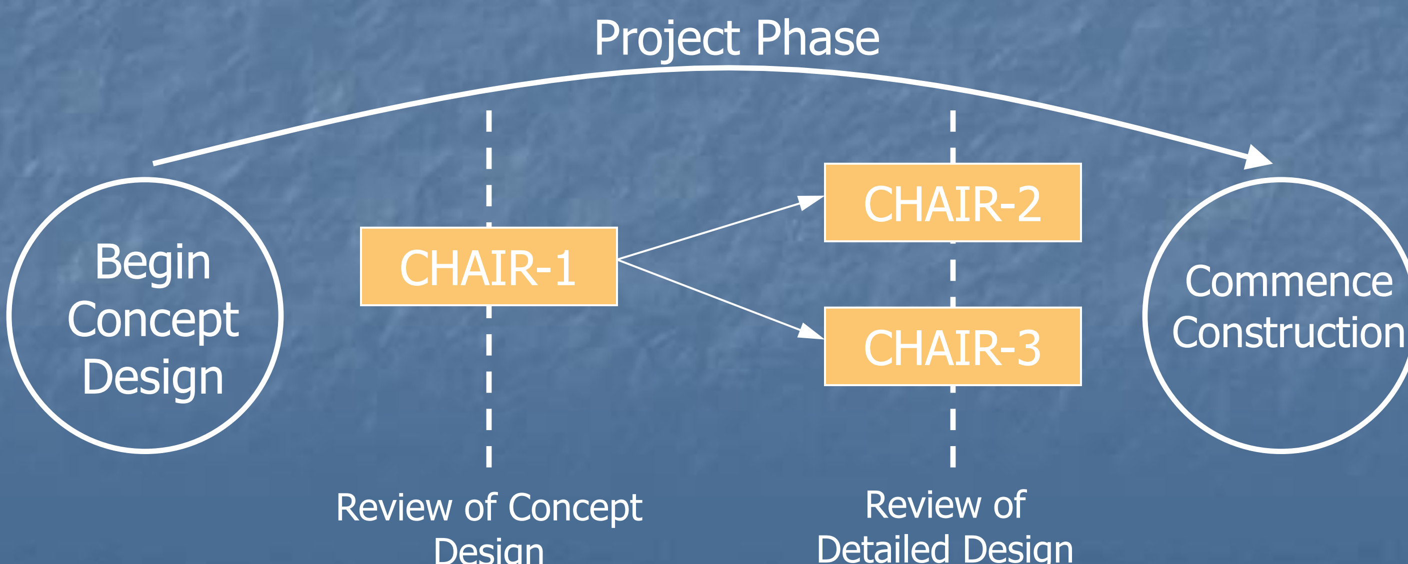


Example Tools and Processes



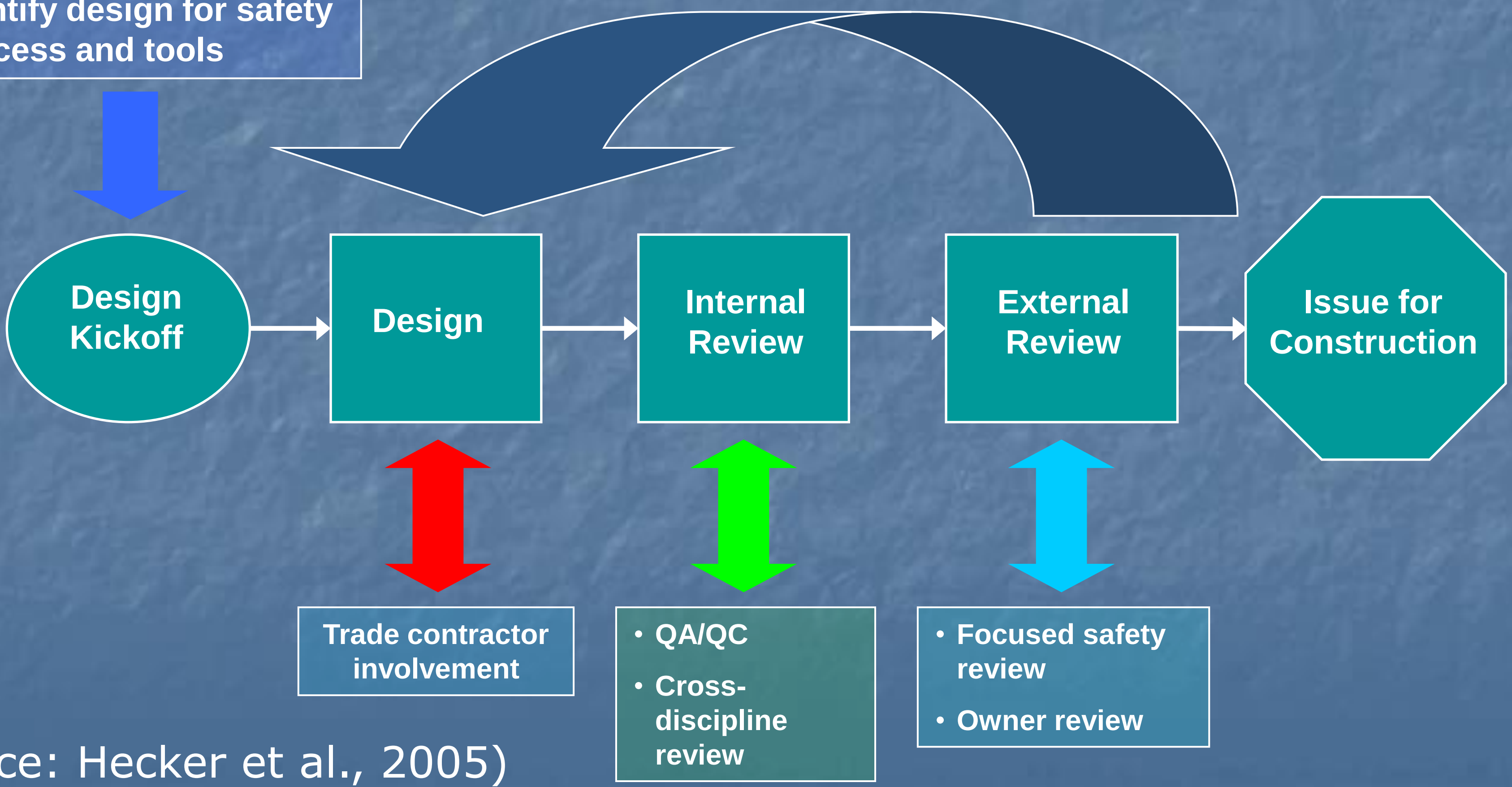
Design for Construction Safety ToolBox

Construction Hazard Assessment and Implication Review (CHAIR) process



Example Tools and Processes

- Establish design for safety expectations
- Include construction and operation perspective
- Identify design for safety process and tools



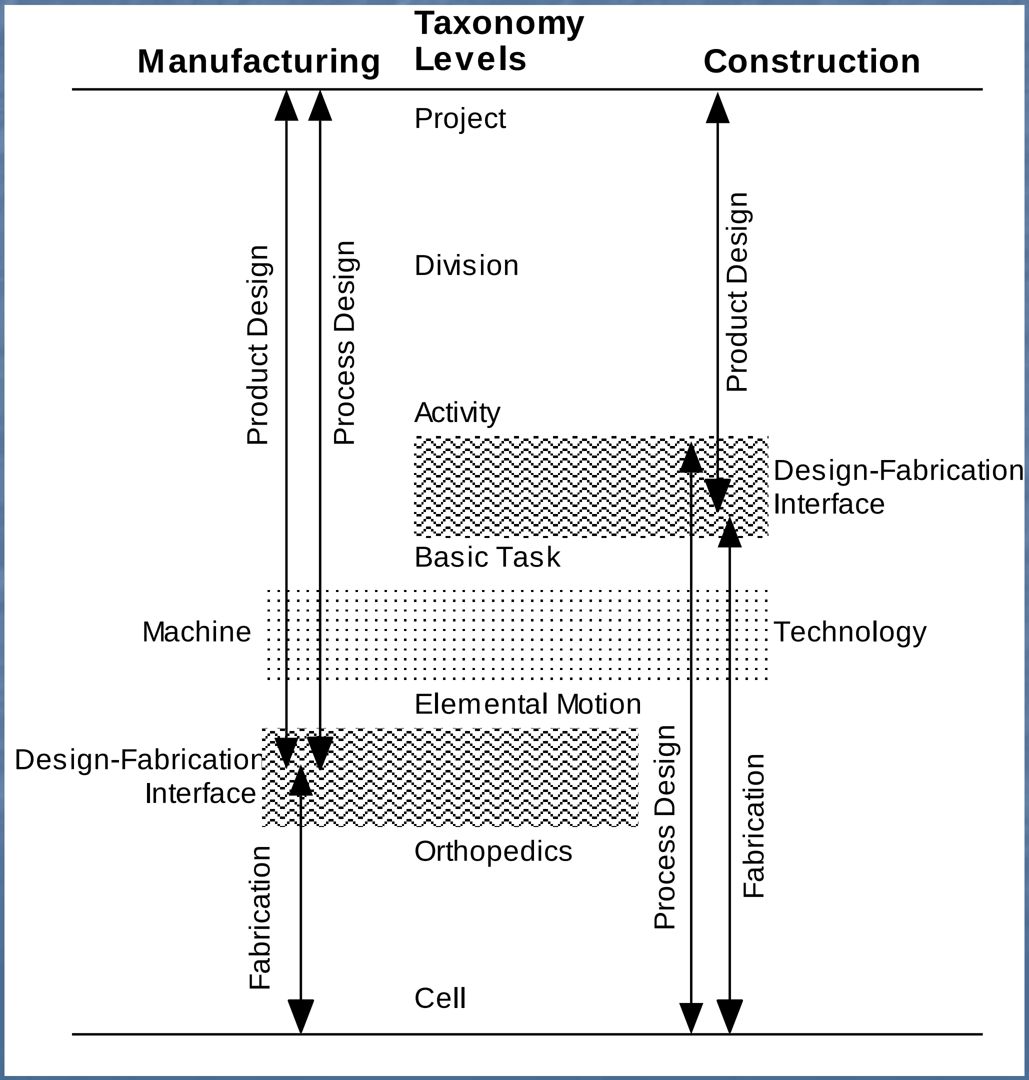
(Source: Hecker et al., 2005)

Example Training and Safety Alert System

- All A/E’s attend training courses for:
  - Construction site safety
  - Designing inherently safe buildings
- Safety Alert System (SAS):
  - Safety reviews during document preparation
  - Safety symbols placed on drawings at locations of potential hazards

(Source: The Haskell Company, 2004)

Integration of Product and Process Design



(Source: Everett, J.G. and Slocum, A.H. , 1994. "Automation and Robotics Opportunities: Construction versus Manufacturing." *Journal of Construction Engineering and Management*, ASCE, Vol. 120, No. 2, pp. 443-452).

Benefits of DfCS

- Safer jobsites
  - Safety hazards eliminated/reduced
  - Fewer injuries and fatalities
- Reduced workers' compensation premiums
- Increased productivity and quality
- Fewer delays related to accidents during construction
  - Allows for continued focus on quality
- Designer-constructor collaboration

Challenges/Barriers to DfCS

- Change in project team mindset
  - Collaboration
  - Upfront involvement of all stakeholders
- Contracting:
  - Revised model contracts
  - Alternative contracting methods
- Availability of visualization and work flow tools
- Education and training:
  - From separate to integrated

DfCS Research Study

- Designer willingness to design for safety

Response	# of Respondents	% of Respondents
Interested / Willing	7	37%
Neutral	9	47%
Not interested / Not willing	3	16%

(Source: Gambatese, Behm, and Hinze, 2005)

DfCS Research Study

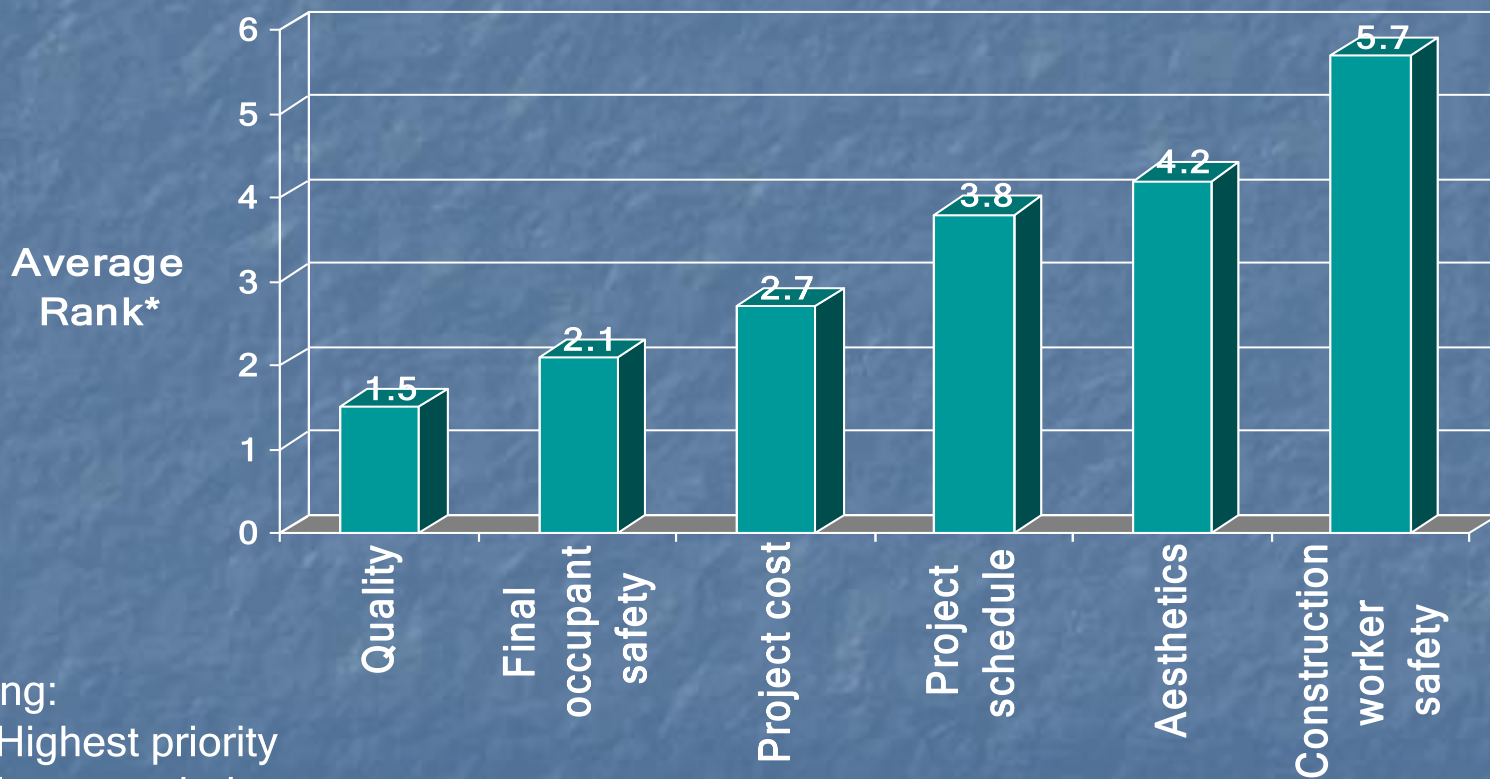
- Barriers to designing for safety

Barrier	# of Times Mentioned	% of Respondents
Interferes with the constructor’s means and methods	7	37%
Increased liability	5	26%
Designers have limited or no construction experience	4	21%
Time constraints; “Have enough to deal with”	4	21%
No control over who gets the bid	4	21%

(Source: Gambatese, Behm, and Hinze, 2005)

DfCS Research Study

- Priority of project criteria



*Ranking:
1 = Highest priority
6 = Lowest priority
A smaller number represents higher priority.

(Source: Gambatese, Behm, and Hinze, 2005)

Expected Impacts: “Trajectories”

- Increased prefabrication
- Increased use of less hazardous materials and systems
- Increased construction engineering
- Increased spatial investigation
- Increased collaboration and integration

(Source: Toole, T.M. and Gambatese, J.A., 2008. “The Trajectories of Prevention through Design in Construction.” *Journal of Safety Research*, Special issue on Prevention through Design, Elsevier and the National Safety Council, 39, 225-230).

Implications

- Designers need knowledge of construction safety and construction processes
  - More safety in architectural and engineering curricula
  - Engineering licensure requirements
- Designers need to become better gatherers and communicators of project safety information
  - For example: existing site utilities, availability of prefabricated components, likely methods to be used, working clearances.

Implications for Education of Design Engineers

- Shift in mindset
- Holistic view
- Exposure to DfCS fundamentals
- Training in system-specific DfCS opportunities
- Engineering course-specific DfCS modules

Implications for Contracting

- New contract terms needed
- Design-bid-build process typically hinders collaboration during design
  - Integrated Project Delivery (IPD) methods better facilitate collaboration

Implications for Use of Information Technology

- IT represents efficient means for providing designers with information needed to perform DfCS
- Manufacturers must make DfCS information available
- All entities will need IT to facilitate communication, collaboration, integration

DfCS Resources

- Construction Industry Institute (CII) database
  www.construction-institute.org/scriptcontent/more/rr101_11_more.cfm
- CHAIR
  www.workcover.nsw.gov.au/Publications/OHS/SafetyGuides/chairsafetyindesigntool.htm
- United Kingdom Health & Safety Executive design guides
  www.hse.gov.uk/construction/designers/index.htm
- *Detailing Guide for the Enhancement of Erection Safety* (NISD/SEAA):
  www.seaa.net/store/product_info.htm
- DfCS website: www.designforconstructionsafety.org

Thanks for Listening

- Questions?   Comments?

- For more information:
  - john.gambatese@oregonstate.edu