

# Prevention through Design in Construction Engineering Education

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# Presentation Outline

- Design for Hazard Control – Course Overview
- PtD Definition
- Course Composition
- Course Goals
- Structure of Course
- Topics Covered

A photograph of a wooden saw and a white pipe resting on a wall with peeling paint. The paint is chipped away, revealing a red and blue underlayer. The saw is positioned vertically, and the pipe is horizontal, leaning against it.

# Design for Hazard Control

- Virginia Tech CEE 4064/5064
- Created Fall 2007
- Offered Annually
- **COURSE DESCRIPTION:** Design of construction projects, materials, equipment and systems to control inherent hazards to the health and safety of construction workers, inhabitants of the built environment, and the general public. The emphasis of this course is on Prevention through Design (PtD). The course will provide students with in-depth knowledge of the regulatory and legal drivers pertinent to construction, the chemical and physical health hazards, the major classes of safety hazards, the design processes to control safety and health hazards. Format of the course will involve lecture and participatory activities.

# PtD Definition

*The optimal method of preventing occupational illnesses, injuries, and fatalities is to “design out” the hazards and risks; thereby, eliminating the need to control them during work operations. This approach involves the design of tools, equipment, systems, work processes, and facilities in order to reduce, or eliminate, hazards associated with work.*





## **PtD Definition**

Any design of tools, equipment, materials, processes, or facility/infrastructure components that will substantially reduce or eliminate the hazard.



## Course Composition

- Graduate Students (MS and PhD)
- Advanced Undergraduate Students
- Civil Engineering
- Building Construction
- Architecture
- Design teams: mix of all of the above!

A vertical image on the left side of the slide shows a wooden ladder leaning against a wall. The wall has peeling red and blue paint, suggesting a construction or renovation site. The ladder is made of light-colored wood and has a metal hinge at the top.

# Course Goals

**EDUCATIONAL OBJECTIVES:** Having successfully completed this course, the student will demonstrate the ability to:

- identify risks to the health and safety of construction workers and the general public
- analyze exposure situations to quantify safety and health hazards
- design noise and vibration control systems, excavations, fall protection, fire control and ventilation systems
- develop conceptual design solutions for tools, materials, equipment, cranes, and processes to mitigate hazards
- synthesize the existing scientific literature on PtD innovations for construction safety and health

A wooden saw with a white pipe resting on its blade is positioned against a wall. The wall has a textured, multi-colored appearance with patches of red, blue, and white, suggesting peeling paint or a layered surface. The lighting is bright, creating a high-contrast scene.

## Structure of Course

- Lecture and Participation
- Participation:
  - Design Innovation Groups
  - Researcher Presentations
  - Student-led Discussions of Literature
- Lectures organized by hazard
- Student design projects
- Field project



# Topics Covered

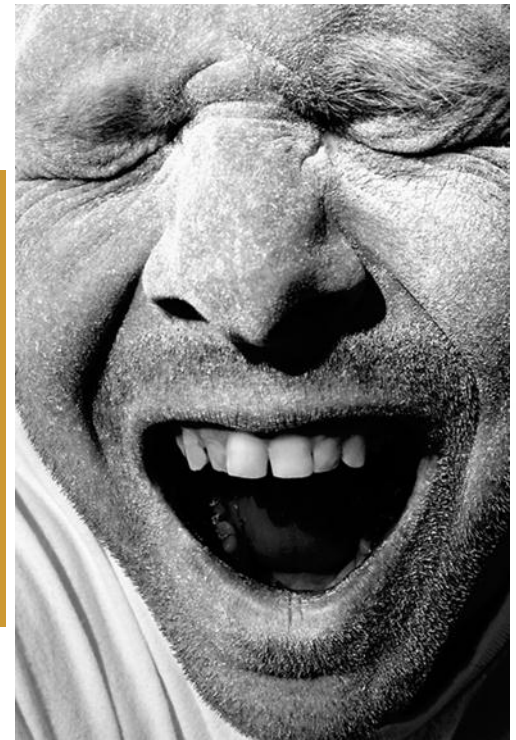
- History
- Regulations
- Hazard Recognition
- PtD Solutions
  - **Chemical Health Hazards**
  - **Physical Health Hazards**
  - **Excavation**
  - **Falls**
  - **Heavy Equipment**
  - **Cranes**
  - **Fire**



# Topics Covered

## Hazard Recognition: Chemical Health Hazards

- **Particulates**
  - Dusts, Mists, Fumes, Smoke
- **Vapors**
- **Gases**



# Topics Covered

## PtD Solutions: Chemical Health Hazards

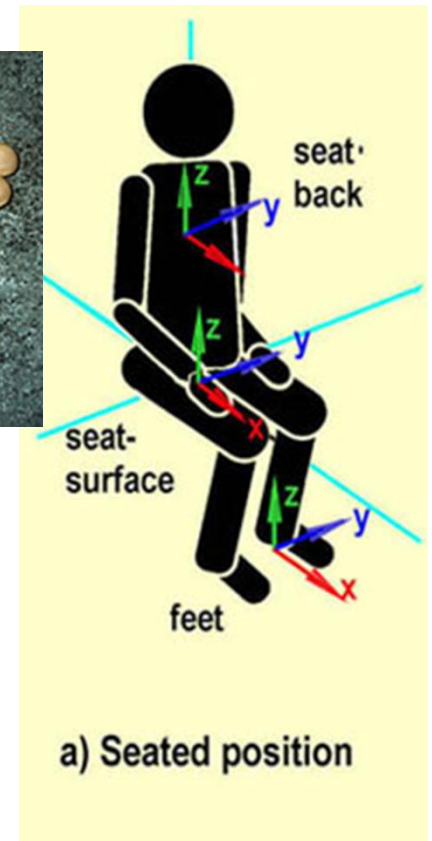
- 1) Materials Substitution
- 2) Process Design
  - Wet Methods
  - Ventilation
  - Tool Design
- 3) Material/Worker Isolation
- 4) Alarm systems



# Topics Covered

## Hazard Recognition: Physical Health Hazards

- Noise
- Vibration:
  - Hand/Arm
  - Whole Body
- Thermal Extremes
- Non-ionizing Radiation
- Ergonomic Stresses
- Pressure
- Ionizing Radiation



# Topics Covered

## PtD Solutions: Physical Health Hazards

### Noise

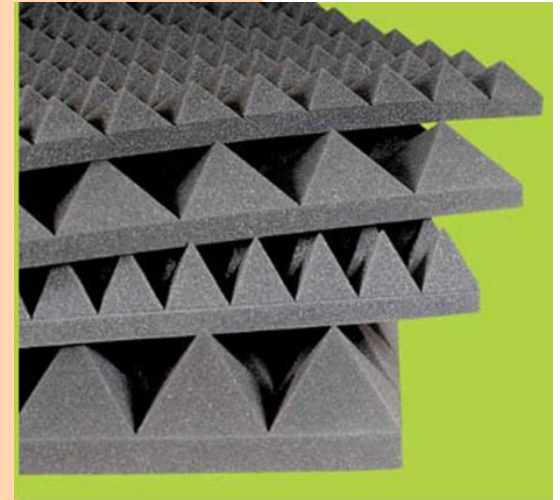
#### Solid Vibration Control

- Control of driving force vibration
- Control of responsiveness of surface to driving force
- Control of radiation efficiency of surfaces

#### Air Turbulence Control

- Absorptive materials
- Enclosure of equipment
- Enclosure of personnel
- Barriers or shielding
- Lagging (wrapping with damping material)
- Mufflers

#### Distance Attenuation

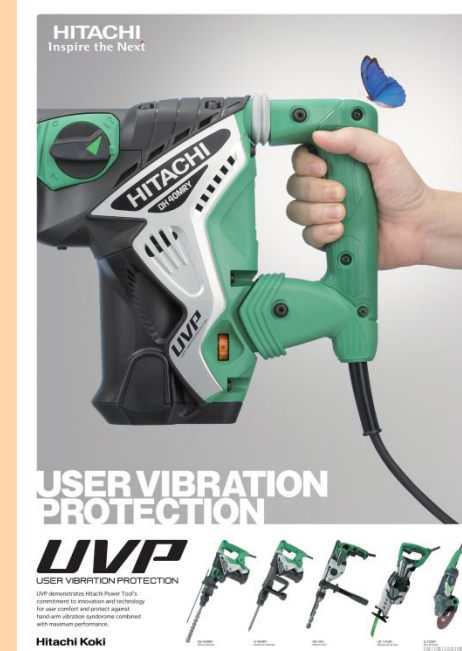


# Topics Covered

## PtD Solutions: Physical Health Hazards

### Vibration

- Vehicle/Equipment seat design
- Low-vibe tools
- Anti-vibe gloves
- Vibration damping
- Driving force reduction
- Isolation
- Resonant frequency interference/isolation



# Topics Covered

## PtD Solutions: Physical Health Hazards

### Ergonomic Hazards

- **Work re-design**
  - Panelization
  - Prefabrication
- **Tool re-design**
- **Automation**

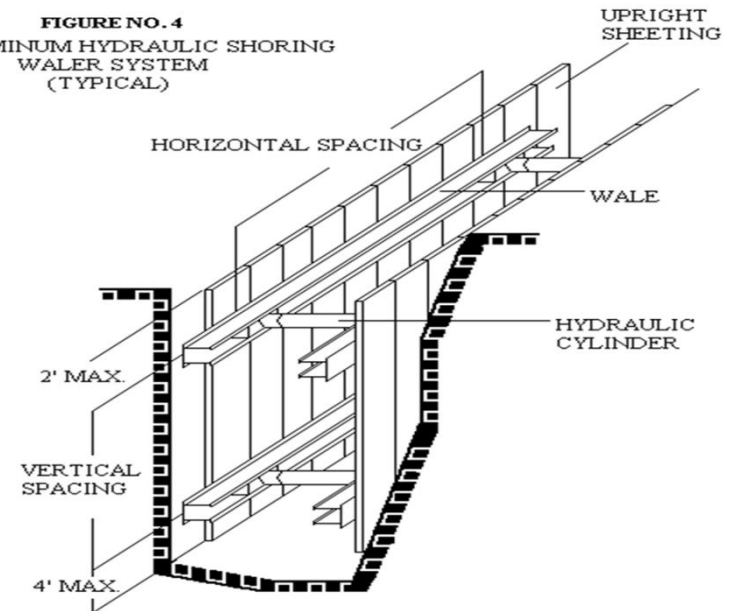


# Topics Covered

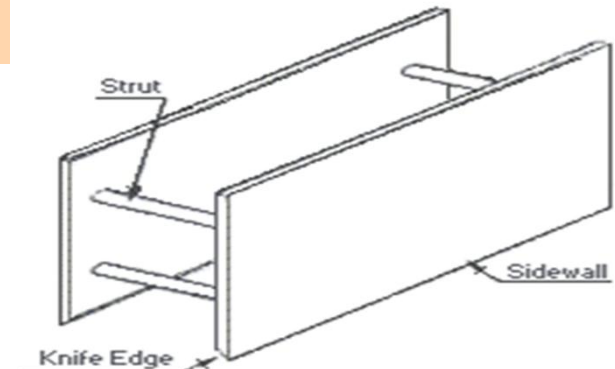
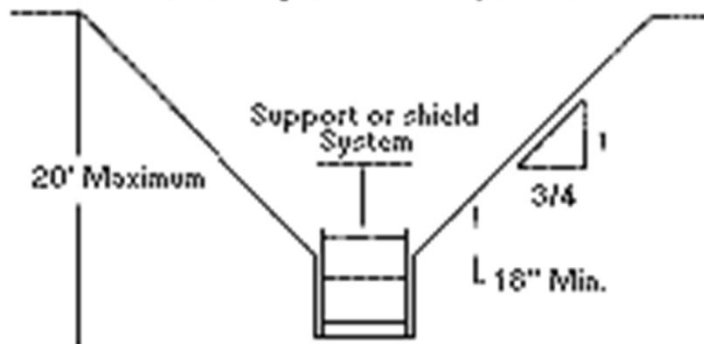
## PtD Solutions: Excavations

- Sloping
- Benching
- Support Systems
  - Trench boxes
  - Shielding
  - Shoring (hydraulic, whaler)

FIGURE NO. 4  
ALUMINUM HYDRAULIC SHORING  
WALER SYSTEM  
(TYPICAL)



TYPE A SOIL  
Supported or shielded  
Vertically sided lower portion



# Topics Covered

## PtD Solutions: Falls

### Passive Systems

- Aerial Lifts
- Powered Platforms
- Nets
- Guardrails
- New Designs

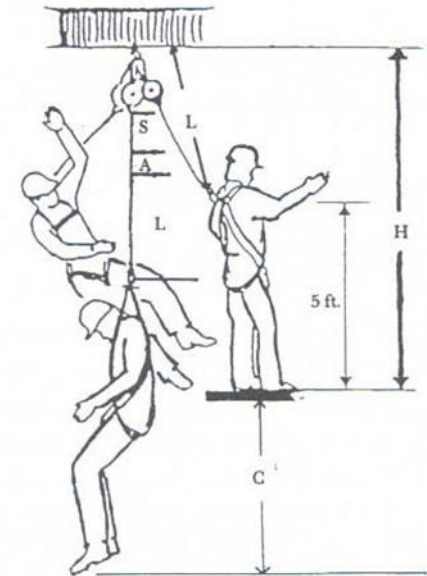


### Active Systems

- Body support equipment
  - Belts
  - Harnesses
- Anchorage points
- Connecting hardware
  - Shock absorbing lanyards
  - Self retracting lanyards
  - Body positioning systems



### Minimum Anchorage-Point Height (Self-Retracting Lanyard/Lifeline Device)



#### Free Fall

$$5' + L - H + A = A = 2 \text{ ft.}$$

#### Clearance

$$5' + L - H + A + S$$

$$[S = 3.5' \text{ max. and } A = 2' \text{ max. (OSHA)}]$$

$$= S + A = 3.5' + 2' = 5.5 \text{ ft.}$$

A = activation distance

C = clearance

S = deceleration distance ("elongation")

H = 5' + L for harness users

L = total length of lifeline

# Topics Covered

## PtD Solutions: Heavy Equipment

- Carnegie Mellon University Robotic Excavator
- Autonomous Vehicles
- Proximity Monitoring and Alert Systems
- On-Guard Vehicle Warning System



# Topics Covered

## PtD Solutions: Cranes

Power-line Avoidance (Proximity Alarms)

Boom angle control

Operator Visualization

Robotics (NIST Robocrane)

Rigging

Leveling/Stability



# Topics Covered

## PtD Solutions: Fire

- Fire resistance of structural elements
- Control of movement through structural design
  - **Containment**
  - **Venting**
- Design for structural stability in event of fire damage
- Active Fire Protection:
  - **Detection**
  - **Signaling**
  - **Suppression**

