# PREVENTION THROUGH DESIGN (PTD) IN THE PROJECT DELIVERY PROCESS

*A PtD Sourcebook for Construction Site Safety*

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## DEDICATION

This document is dedicated to those workers who have been injured or lost their lives while working on construction projects and to those individuals who bestow their personal and professional lives to improving safety on construction sites. Our work is dedicated to preventing additional worker injuries and fatalities, finding and implementing new ways to further improve safety, and educating others how they can play a role in enhancing safety on construction sites.

**Prevention through Design (PtD) in the Project Delivery Process**

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# PREFACE

Prevention through design (PtD), also referred to as "design for safety" and "safety in design," starts with the premise that the design of a facility or product impacts the safety and health risk of those who are exposed to the design in all its forms, and concludes with the proposition that we can mitigate safety and health risk through design and, as a result, prevent injuries and fatalities. PtD acknowledges that we have the ability to proactively design out potential hazards to eliminate or minimize the risk and improve safety and health. PtD is founded on the belief that creating designs so that humans are not exposed to hazards is the most effective and reliable approach to safety management.

For the construction industry, implementation of PtD is a complex issue. Over the past several decades, much has been written about PtD from both practice and academic communities. PtD is being regularly implemented in practice in some sectors of the industry and by select organizations. There is clearly interest in PtD throughout the industry. However, while its benefits are recognized and enablers are present, inhibitors of PtD implementation have limited its widespread diffusion throughout the industry. Efforts are being undertaken to promote its use, overcome barriers, and educate industry professionals about the topic.

This sourcebook is designed to support PtD implementation in practice. It addresses PtD from the perspective of those implementing it in practice and answers the questions: "What should be done in each phase of project delivery?" and "What resources are available to assist with implementation in each phase?" PtD is presented as it relates to the construction industry, and especially to the design of a permanent facility (building, bridge, roadway, or other element of our civil infrastructure) for the safety and health of those who construct the facility. The Introduction provides a general overview of PtD, its merits, and general issues associated with implementation. Subsequent sections focus on each individual phase of project delivery, starting with Conceptual Design and ending with Decommissioning. Each section includes a description of the phase, how PtD can be implemented in the phase, key components and considerations during the phase, and available supporting resources and tools. While PtD is primarily suited to implementation during facility planning and design, it may also be implemented during later project lifecycle phases as the facility design is maintained, revised, upgraded, and eventually recommissioned/decommissioned. Lastly, the Appendix contains a variety of supporting resources and tools to assist with PtD implementation including example PtD policies, contract/insurance guidance, design examples, case studies, and a bibliography.

It is hoped that this sourcebook will ultimately help improve safety throughout the construction industry. If successful, further injuries and fatalities will be prevented – our top priority.

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# 1 INTRODUCTION

## 1.0 What is Prevention through Design (PtD)

Prevention through design (PtD) is a comprehensive approach for addressing safety and health issues by "designing out" hazards and minimizing residual risks. The concept involves the consideration of safety and health in the design of a product, process, or system. During planning and design, the safety and health of those impacted by the design in each downstream lifecycle phase is considered. The lifecycle starts with concept development, and continues through design, construction or manufacturing, operations, maintenance, and eventual disposal. The PtD concept applies to the design of a facility, a material, a process, and a piece of equipment. PtD includes anticipating manufacturing, construction, operations, and maintenance tasks, identifying related hazards, and developing designs and engineering controls to eliminate hazards and protect employees. PtD is a risk management technique that has been applied successfully in many industries, including manufacturing, healthcare, telecommunications, and construction. PtD protects humans and eliminates the need to control exposures during operations by designing out the hazards using best design practices, risk management, and lessons learned.

For the construction industry specifically, PtD has been found to be beneficial. Design in the construction industry encompasses the design of the permanent facility, temporary structures, permanent and construction equipment, design and construction processes, and many other aspects of a facility's lifecycle. The PtD concept applies, and is being implemented to varying extent, to all aspects of design. For example, when a facility (building, roadway, bridge, industrial plant, etc.) is designed, one design objective is the safety and health of the end-user of the facility such as the building occupant, motorist, or plant operator. Industry-standard design codes are used to eliminate known hazards (e.g., fires, falls, and slips/trips) that may arise when the facility is being used. Similarly, when designing tools and equipment, design features are incorporated (e.g., guards) that mitigate safety hazards and prevent workers from getting injured when using the tools and equipment on the job. In both cases, the targeted safety is that of the user of the design in its final form. These instances of implementing PtD are common throughout the industry, and are expected of designers (architects and design engineers). Less common, and often more difficult, is the implementation of PtD for the safety and health of those who will construct, maintain, and renovate the design.

Implementation of the PtD concept with regard to the permanent facility and construction worker safety and health, however, is currently limited (Tymvios et al. 2012). For the construction industry, traditional practice places the role and responsibility for worker safety and health implementation and oversight on the constructor's shoulders. Standard industry contracts, project delivery methods, design professional education and training, and management of liability exposure are some of the reasons among others that shape current practice and lead to minimal implementation of PtD with respect to the design of the permanent facility in the construction industry (Gambatese 2008; Hecker et al. 2005; Gambatese et al. 2005; 2017; Hinze and Wiegand 1992; Toole 2005; Toole et al. 2017; Tymvios and Gambatese 2015). It is clear that the current structure and culture of much of the construction industry inhibit application of the PtD concept in regard to construction site safety. As a result, architects and engineers who design the permanent features of a facility commonly focus solely on the safety and health of the facility's end-user. Consequently, the impacts of their designs on construction site safety and health are often left up to the constructor to address and mitigate after the design is complete and, as a result, safety management is limited to those controls that are lower on the hierarchy of controls.

## 1.1 Why Implement PtD?

The impact of project planning and design, however, have been found to influence safety on the construction site. Studies of injury and fatality incidents suggest that many of the reasons for the incidents can be traced upstream from the building process itself and are connected to such processes as planning, scheduling, and design of the facility (Behm 2004; Whittington et al. 1992; Suraji et al. 2001). In a study of design decisions related to a microchip manufacturing facility, for example, Weinstein et al. (2005) found that decisions made during design and material selection contributed to both safe and unsafe working conditions for workers during construction. Multiple studies have been conducted over the years in an attempt to confirm, and quantify the level of, the impact that planning and design have on safety. The results of some noteworthy studies are listed below:

- Jeffrey and Douglas (1994) reviewed the UK construction industry's safety performance and concluded that 35% of the site fatalities reviewed were related to falls and could have been prevented through design decisions.
- In an analysis of 100 construction accidents conducted by industry experts, Gibb et al. (2004; Haslam et al. 2003) found that in 47% of the incidents, changes in the permanent design would have reduced the likelihood of the accidents.
- Behm attempted to link the design for construction safety concept to construction injuries and fatalities through a review of OSHA and NIOSH incident reports. Using OSHA and NIOSH fatality reports from 1990-2003, Behm (2005) linked the design to the fatal injury in 92 (42%) of the 224 NIOSH FACE reports (Behm 2005). Behm also reviewed 226 OSHA injury reports in California, Oregon, and Washington from 2000-2002 and found that in 49 (22%) of the reports, a connection to the design could be made (Behm 2004). As part of a subsequent study, an expert panel confirmed Behm's results that there is a link between the design and the incidents that resulted in injury and fatality on the site (Gambatese et al. 2008).
- In a study of the contractor's perspective, approximately 50% of the 71 contractors interviewed identified the design as an aspect or factor that negatively affects health and safety on the construction site (Smallwood 1996). Supporting this finding, when compared to other project components, the contractors ranked the design the highest with regard to impact on safety.
- Churcher and Alwani-Starr (1996) attributed design decisions or lack of planning to 63% of all fatalities and injuries that the researchers investigated in the UK.

- In a study of the relationship between design issues and work-related injuries in Australia from 2000 to 2002, Driscoll et al. (2004) found that there was either a definite or possible connection to the design in 63% of the 43 cases reviewed.

Based on studies like those mentioned above and firsthand experiences of construction workers, it is clear that decisions made during the planning and design of a facility impact the safety and health of those downstream in the facility's lifecycle. It is easy to envision, for example, that the hazards and risk associated with constructing a brick façade on the exterior of a building are different than those for a precast concrete panel façade. The choice of which type of exterior to include is made prior to the start of construction by the owner and/or architect. The extent of potential impact can be significant. Design is a powerful ability. It affords us the opportunity to create an environment to our liking. Conducted with care, design can be extremely beneficial; without critical thought and ethical guidance, design may unintentionally cause harm.

It is important to understand that PtD focuses on the design. That is, implementing PtD entails designing in such a way that safety and health hazards are eliminated or mitigated. PtD with respect to the permanent facility is **not** about designing the means and methods of construction such that the work is performed safely. According to the hierarchy of controls (described below), designing the way the work is conducted is an administrative control. An understanding of what PtD is, and what PtD is not, is important to its acceptance and implementation. The lists below provide additional clarification of what PtD is and is not with respect to its application by architects and design engineers when designing the permanent facility for the safety and health of construction workers (www.designforconstructionsafety.org/):

- What PtD is:
    - Including worker safety considerations in the constructability review process.
    - Making design decisions based in part on how the project's inherent risk to construction and maintenance workers may be affected.
    - Explicitly considering and placing high value on the safety of construction and maintenance workers during the design of a project, when the inherent safety risks can best be addressed.

- What PtD is **not**:
    - Having designers take an active role in construction safety during construction.
    - Designers specifying the means and methods of construction.
    - An endorsement of the principle that designers can or should be held partially responsible for construction accidents.

When implemented, the outcomes of PtD can take many forms. It is expected that the design drawings and specifications will incorporate features, materials, and processes that mitigate potential safety and health risk to workers. Many examples of safe designs exist and are described in subsequent sections in this document. As PtD diffuses throughout the industry, aspects of the design and project delivery will likely change. These changes are likely to include: (1) increased prefabrication; (2) increased use of less hazardous materials and systems; (3) increased application of construction engineering; and (4) increased spatial investigation and consideration (Tool and Gambatese 2008).

Given its connection to design, PtD requires designer involvement. It provides an opportunity for design professionals to participate, within their scope of work, in safety as it relates to construction workers. PtD also requires knowledge of construction. Those performing the design must know the safety and health hazards associated with construction operations and design elements. Therefore, either the designer must be knowledgeable about the construction phase activities and the impacts of their designs on the construction phase, or designers must receive that knowledge from others. As a result, constructor involvement is commonly a part of PtD implementation. Constructors know the safety and health hazards that exist on projects and how design elements create hazards. Designer and constructor collaboration is an important component of PtD.

The collaboration and implementation needed for PtD take place throughout the project delivery process with primary focus during planning and design. In fact, as depicted in Figure 1.1, the greatest ability to influence project success is present during the early phases of a project. Addressing safety during construction is very important, however the ability to eliminate hazards before they appear on a construction site is greatest prior to construction. In addition, the cost of integrating safety, and of changing a design to incorporate safety, increases as the project progresses (Hagan et al. 2009; PMI 2008; Szymberski 1997).

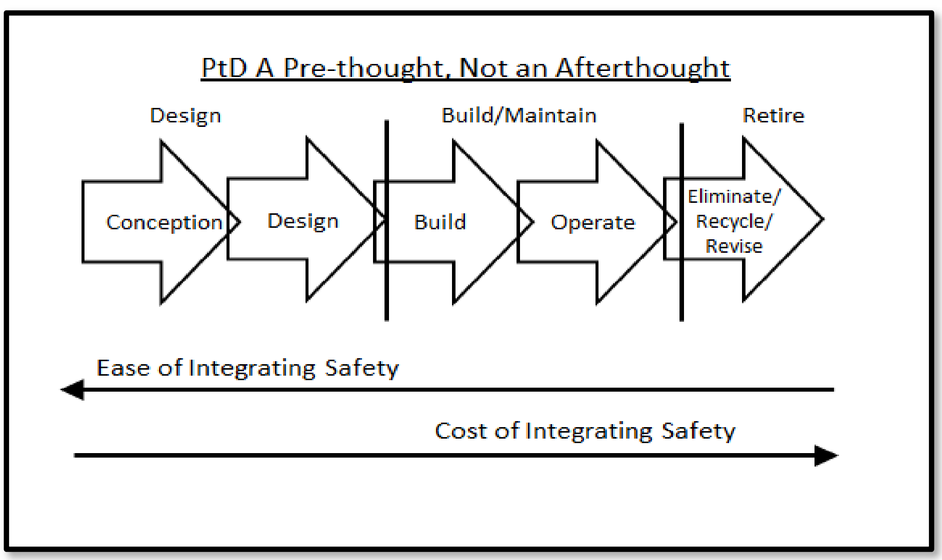


Figure 1.1: Integrating Safety relative to Project Phases (Hagan et al. 2009)

This sourcebook is designed to support PtD implementation at each phase of a project. Provided for each phase are recommendations for what to do to implement PtD, who should be involved, important components and considerations, and useful resources and tools. In addition, the Appendix contains additional supporting resources including PtD processes, contract and insurance guidance, checklists, case studies, and design examples, along with a PtD bibliography and list of related links for further information.

## 1.2 Key PtD Components and Considerations

Prevention through design is founded on basic safety concepts and practice. This section describes important PtD-related components of safety management and considerations specific to the construction industry that should be understood to gain a complete understanding of how PtD can be implemented on construction projects.

### 1.2.1 Hierarchy of Controls

The "hierarchy of controls" or "order of precedence" is well-known by safety and health professionals as a guide to follow to provide and manage a safe and healthy work environment. The hierarchy is a list of actions for reducing risk of injury that is ordered based on the reliability and effectiveness of each action. This order of precedence is illustrated in Figure 1.2 and can be stated as follows, with the items listed from 1 to 5 in order of decreasing priority, reliability, and effectiveness:

1. Eliminate the hazard,
2. Utilize a different material, process, or product to reduce the hazard,
3. Provide engineering controls to protect workers from the hazard,
4. Warn workers of the hazard and train them how to act safely, and
5. Provide personal protective equipment.

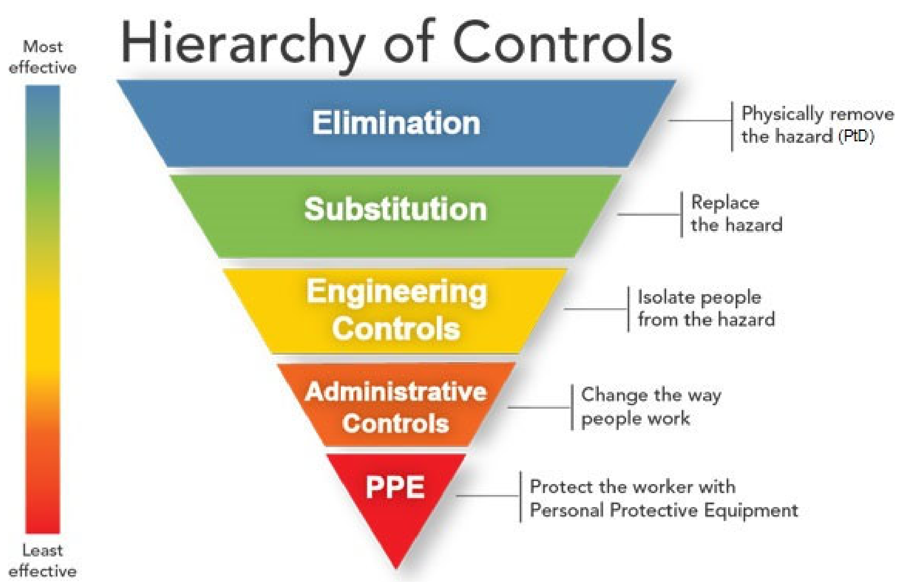


Figure 1.2: Hierarchy of Controls (NIOSH, www.cdc.gov/niosh/topics/hierarchy/default.html)

PtD targets the two highest levels of control. The above lists indicate that it is best to eliminate the hazard if possible, as doing so will remove the risk associated with the hazard. In addition, the reliability of the control in regards to assurance that workers will not get injured and the effectiveness of the control, increase with the higher level of action taken. If it is not possible to eliminate the hazard, mitigation measures that are lower in the list may be employed with a corresponding assumption of risk due to their lower reliability and effectiveness. Taking no action whatsoever will expose those who interact with the design to uncontrolled risk.

#### 1.2.2 Management Commitment

Architects and engineers can protect workers by integrating safety and health best practices into all stages of the design process. An important step in implementing PtD is to secure support from management personnel within the design firm. Management support of designers implementing PtD practices encourages improving worker safety and health, especially when worker safety and health are being considered along with other priorities such as cost, schedule, and quality. PtD concepts can be applied to all of the work activities required to complete the capital project process. The success of this approach depends on management support for a culture that promotes safety. NIOSH recommends the adoption of a company safety policy which describes the dedication, components, and resources to ensure worker safety: incident investigation, retrofit or replacement of hazardous equipment, engineering and administrative controls to manage residual risks and limit exposures, and personal protective equipment when necessary. The creation of a company's PtD policy signifies its organizational commitment to building a culture of safety through design. A sample organizational PtD policy statement is provided in the Appendix.

#### 1.2.3 Project Owner Involvement and Buy-in

While there are many parties involved in capital projects, the project owner is the focal point. The owner identifies the need for the facility, provides funding, establishes the timeline, and occupies and maintains the facility after it is complete. The owner plays an important role in PtD as well. The owner is in a position to influence and dictate how safety and health are addressed on a project and the extent to which hazards are eliminated through the design. Owner involvement and buy-in are key components of PtD. A guide for owner involvement in PtD is provided in the Appendix.

#### 1.2.4 Collaboration and Involvement

Buildings, bridges, roads, and the many other parts of our built environment are complex. It is rare that one person is knowledgeable about all aspects related to planning, design, construction, operations, and maintenance of these facilities. A team of experts is needed. Similarly, for PtD, input and collaboration from **all** project team members is important. Those creating the design need input from constructors and maintainers regarding the hazards associated with the design during construction and maintenance operations. Worker safety during facility operations requires input about workplace operations and hazards from those who will be operating the facility. To effectively implement PtD, it is important to include those affected by the design in discussions during the planning and design process. In addition, their input should be solicited early enough, and given a high level of importance, so that changes in the design can be made easily and without great costs and additional time.

### 1.2.5 PtD and Innovation

Innovation is an exciting and attractive proposition, and potentially financially rewarding. Those driven to innovate may expend significant amounts of time and energy in the pursuit of something new. Implementing PtD has been recognized as a means to enhance innovation. That is, as project teams study designs with the intent to optimize the design for worker health and safety, new designs and new construction methods can arise. The positive impacts that PtD can have on innovation are recognized as one of the beneficial outcomes of PtD. Safe design can be a source of innovation. Likewise, the ability to innovate may be necessary in order to design out hazards. In some cases, when a hazard is identified, it may be difficult to initially identify design alternatives to mitigate the risk. The ability to visualize and create alternative designs can facilitate designing out the hazards as opposed to defaulting to an administrative control, PPE, or other lower level control measure. Figure 1.3 illustrates the relationship between design effort, the hierarchy of controls, and creative potential (Culvenor 2006).

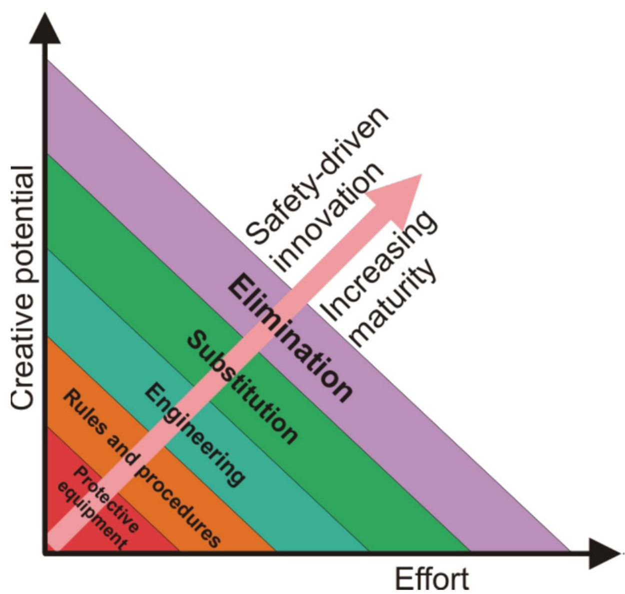


Figure 1.3: Relationship between Hierarchy of Controls, Effort, and Creative Potential (Culvenor 2006)

## 1.3 Important Steps for PtD Implementation

Implementation of a worker safety and health intervention such as PtD within an organization or on a project requires attention to certain essential elements: ability to implement PtD, opportunity to implement PtD, responsibility and authority for implementing PtD, and motivation to implement PtD. Each essential element addresses a fundamental need for affecting positive change and enabling desired outcomes. In addition, each of the elements needs to be fulfilled in some way to realize PtD success. Practical and efficient steps for addressing and accentuating each element should be taken. Descriptions of each essential element and suggested steps for PtD implementation are provided below (Gambatese 2009):

1. Provide education, training, and tools to designers:
    a. Include safety in architecture/engineering educational programs and professional continuing education classes.
    b. Encourage designer participation in safety events and activities.
    c. Incorporate design visualization tools in the design process (e.g., 4D-CAD)
    d. Incorporate risk assessment pro forma as part of design reviews
2. Optimize the process: right place, right time, right resources
    a. Conduct safety reviews periodically during the project development process (planning and design).
    b. Utilize integrated project delivery methods if possible to integrate design and construction knowledge.
    c. Co-locate design and construction staff.
3. Establish safety as a design criterion:
    a. Include safety as a design criterion along with cost, quality, schedule, sustainability, and other project performance criteria.
    b. Integrate safety into design standards
    c. Include safety in contracts for design.
4. Make safety a high priority:
    a. Make safety a high priority relative to other project performance goals.
    b. Assign responsibility for safety amongst the project team members.
    c. Provide authorization to modify the design for safety reasons.
5. Place value on designing for safety:
    a. Emphasize the desire to design out hazards rather than address the hazards through controls lower on the hierarchy of controls.
    b. Create a culture where design innovation to eliminate hazards is promoted.
    c. Highlight the moral and ethical responsibility to consider the safety and health of workers and the social aspects of sustainability.

Pursuit of each step depends on the resources available, commitment, and dedication of the organization and project team. Careful consideration should be given to the selection, pursuit, and timing of steps included in a PtD action plan.

## 1.4 Barriers to PtD Implementation

While the PtD concept is well-known and recognized as a best practice in the field of occupational safety and health, numerous systemic conditions and practices may exist within a company or on a project which limit its formal and widespread implementation in the construction industry with respect to construction safety and the design of the permanent facility. The following are potential barriers to PtD in regard to construction worker safety that have been identified:

- A lack of designer education and training with respect to: construction worker safety and health, construction site means and methods, the impact of design features on worker safety and health, and alternative designs that are less hazardous to build.
- A fear of potential liability associated with worker injuries related to a design.
- A lack of support for implementing PtD by the organizational and/or project culture or contracting method.
- Minimal access to tools that assist with evaluating a design to expose potential hazards.
- Additional initial cost to conduct design reviews for safety.
- Competing company and/or project priorities (e.g., cost, schedule, and quality).
- Unclear authority and responsibility for implementing PtD on a project.
- Difficulty in foreseeing hazards and assessing the associated risk during the design phase.
- Contractual separation of design and construction that inhibits early and timely communication from the constructor to the designer about potential safety hazards related to the design.
- A lack of motivation to design out safety hazards instead of relying on lower levels of control such as administrative controls or the use of personal protective equipment.

### 1.5 Enablers of PtD Implementation

Companies and project personnel can enable implementation of PtD in a variety of ways. The list below presents actions and resources that have received attention as enablers of PtD in practice.

- An owner/client who is committed to the PtD concept and its implementation on the project. This commitment should be demonstrated verbally and by the actions of the owner/client as soon as possible, and regularly, on a project.
- A positive design and safety culture that values PtD as a means to mitigate hazards rather than just defaulting to other safety controls.
- The use of project delivery methods that integrate the construction and design expertise on the project.
- The availability and use of design/construction visualization tools such as 4D-CAD and BIM.
- Integration of construction knowledge within the design scope and during the design phase.
- Incorporating trade contractor reviews of the design during the design phase.
- Starting the PtD process as soon as the project is conceptualized or as soon as possible in the project delivery process.
- Inclusion of contractual language and insurance policy language that enable and promote PtD.

## 1.6 Resources and Tools

PtD implementation is enabled by design resources and tools which assist project teams with visualizing the construction, manufacturing, and maintenance processes, identifying hazards, assessing risk, and selecting safe designs. The following are resources and tools which are particularly useful for implementing PtD.

### 1.6.1 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Examples of design review checklists are provided in the Appendix.

### 1.6.2 Example PtD Processes

Addressing workers safety through the design typically differs from one project phase to another. For example, PtD reviews in earlier project phases likely address general aspects of the design before the many details of the design are known. Examples of how to address worker safety during the different phases of a project are available. One example, which targets PtD during the pre-design phase, conceptual and schematic design phase, and design development phase, is provided by Safe Work Australia (www.safeworkaustralia.gov.au/safe-design).

### 1.6.3 Risk Assessment Pro Forma

Part of the PtD process typically involves evaluating and comparing the risk associated with different safety and health controls. Risk assessment forms and worksheets assist with quantifying the risk and comparing different design alternatives to select the optimal solution. Examples of risk assessment pro forma are provided in the Appendix.

### 1.6.4 Computer Visualization and 4D-CAD Systems

Those involved in the design need to be able to foresee the safety and health hazards associated with the expected construction, manufacturing, operations, and maintenance. Identifying the hazards can be difficult when looking at simple design drawings, especially for very complex structures. Electronic visualization, virtual reality, and 4-D drawing tools greatly assist in this effort.

### 1.6.5 Database of Safe Designs

Knowing how to design the project features for safety is a key part of PtD. Many examples of safe designs have been developed and implemented. Access to a database of safe designs enables PtD implementation. Examples of safe designs and PtD case studies are provided in the Appendix. Safe design guides can also be found on the Internet (for example, see: www.safetyindesign.org.uk/design-guides). Case studies of PtD design solutions on projects are also available (for example, see: www.dbp.org.uk/welcome.htm and www.researchbank.rmit.edu.au/view/rmit:2663).

### 1.6.6 Lessons Learned Databases

In many cases, safe designs arise out of problem-solving on a project. The knowledge learned from solving problems on one project can be very useful for tackling problems on another project. A database of lessons-learned within an organization provides valuable knowledge which can be used as part of the PtD process.

### 1.6.7 Design Risk Calculators

Capital projects contain many different design features and elements, each with its own impact on worker safety and health. The ability to quantify the risk associated with each feature, and for the entire facility, allows designers an opportunity to optimize their design in terms of worker safety and health. Tools are available which allow architects and engineers to evaluate the safety and health risk associate with their designs based on the design features, layout, size, shape, etc. The following are examples of design risk calculators available on the Internet:

- SliDeRulE (Safety in Design Risk Evaluator): www.constructionsliderule.org
- ToolSHeD™ (Tool for Safety and Health in Design): www.emeraldinsight.com/doi/abs/10.1108/09699980810886847

## 1.7 Impacts of PtD in Construction

When PtD practices are implemented on a project, the construction industry has recognized beneficial impacts. The primary objective of PtD is to prevent construction worker injuries and fatalities. Those companies that have implemented PtD have indicated a decrease in hazards and risk on jobsites. This result is expected to lead to fewer worker injuries and fatalities. Additional positive impacts have been recognized as well. The following are examples of benefits that have been recognized from the implementation of PtD on projects:

- Increased worker productivity
- Increased quality of the work
- Fewer delays due to safety incidents
- Greater designer-constructor collaboration
- Improved operations and maintenance safety
- Reduced workers' compensation premiums
- A greater amount of prefabrication and modularization
- Innovation in design and construction

## 1.8 Additional References and Resources

Many articles and reports on PtD are available that provide more information about the topic and its implementation in practice. A PtD bibliography is provided in the Appendix to assist with searching for further information about PtD. In addition, multiple PtD resources are available online that provide helpful guidance on the topic. Below are links to some available PtD resources:

- NIOSH PtD website: www.cdc.gov/niosh/topics/ptd/
- OSHA Design for Safety website: www.osha.gov/dcsp/products/topics/businesscase/designsafety.html
- Prevention through Design (Design for Construction Safety) website: www.designforconstructionsafety.org/
- Design Best Practices website: www.dbp.org.uk/welcome.htm

# 2 CONCEPTUAL DESIGN

## 2.0 What is Conceptual Design?

The Conceptual Design phase is the first stage in the process to take the project from an idea to reality. At this point in the process a general idea for a project has been identified by the owner/client and further evaluation and development are desired. The project owner undertakes the activities or enlists the services of a consultant(s) to provide planning and feasibility studies. At the completion of the Conceptual Design phase it is expected that a decision will be made regarding the merits of going ahead with the project. It typically desired and beneficial to make this decision before substantial effort is put into detailed design of the project.

Activities at this stage focus on identifying needs and defining the scope of a project. The project team considers design alternatives, functionality, performance levels, regulatory requirements, and other characteristics to determine project feasibility both technically and within cost constraints. On complex projects, this phase may take many months or even years to complete. Activities associated with conceptual design include:

1. Determining feasibility;
2. Estimating space needs;
3. Determining the basis of design;
4. Developing capital budget estimates;
5. Gaining stakeholder and regulatory approval;
6. Selecting design professionals; and
7. Planning for facility decommissioning and obsolescence

The requirements developed in this phase form the foundation of the project for the remainder of the design process.

## 2.1 PtD in Conceptual Design

The primary PtD activities in this phase are to establish safety and health goals for the project, to develop a plan to protect workers from hazards, and to generate the basis of the design. Those involved in PtD efforts at this stage should include the owner (including representatives from both operations and maintenance of the facility), architect/engineer, and construction manager if on-board as part of the project team at this stage.

In Conceptual Design, the design is typically not far enough along to make detailed safety analyses. However, there are important activities needed to review the overall project scope and set up the PtD process for the project. An operations and manufacturing project team should examine all required tools, equipment, and spaces to identify all potential hazards during operations and maintenance and provide suggestions for modifying the plan accordingly. A construction project team should review a site plan showing existing buildings and utilities, topographical surveys, and geotechnical reports. A design review should look at the general location of the project, traffic and vehicular flow in the surroundings, type of building/structure, and other general constraints. The entire project team should: (1) establish and agree on the PtD process to be implemented; (2) identify PtD checklists and other tools to be used; (3) select the primary materials of construction and evaluate the materials in terms of safety and health; and (4) identify opportunities for prefabrication and modularization.

A systematic process should be established through which the risks of the design are highlighted, reviewed, and mitigated if possible at each following phase in the lifecycle. The costs/benefits to eliminate specific hazards through the design can be compared against the lifecycle costs of controls that are lower on the hierarchy of controls such as providing personal protective equipment, operating engineering controls, and enforcing administrative controls.

## 2.2 Key PtD Components and Considerations during Conceptual Design

### 2.2.1 Essential Activities to Start the Process

As the first phase in the project development process, there are several essential activities which should take place in Conceptual Design to set the foundation for PtD implementation throughout the project. These are (Renshaw 2011):

- *Setting policy and standards*: The decision to implement PtD on a project should be formalized and communicated within the policies and standards established for the project. Raising PtD to the level of a "guiding principle" gives PtD the visibility and top management support that is needed.
- *Establishing work processes and procedures*: Design and re-design processes and procedures that incorporate PtD should be "hard-coded" into the project development process. Each stage of the project development process should include some aspect of PtD and accommodate critical review of the design with regard to occupational safety and health. Training of project personnel may be needed to ensure comprehensive and consistent application of the processes and procedures.
- *Applying tools and best practices*: This step involves the application of hazard identification and risk assessment tools and practices which promote PtD. The tools should be: robust, in sync with the project development process, easy to understand and apply, and applied properly and consistently by trained personnel working together.

### 2.2.2 Contractor Input

Knowledge of the construction activities and safety hazards associated with a design is a critical component of the PtD process. The earlier in which this knowledge is available and utilized, the more opportunity designers have in creating safe designs. Contractor involvement during the Conceptual Design phase can provide this needed input. One way to involve contractors during conceptual design is to employ an alternative project delivery method, such as CM-at-risk or design-build. If a traditional design-bid-build process must be used, key trade contractors can be hired as consultants during conceptual design to review the design on a periodic basis.

### 2.2.3 Designer Selection

Conceptual Design may begin with the selection of a design team for the project. The PtD process can be enhanced with the inclusion of PtD requirements in the Request for Proposals (RFPs) for design services. RFPs can be written which require proposers to submit information detailing previous PtD experience and success. Also, one of the decision criteria for design firm selection can be the extent to which the firm integrates PtD within its design process. The nature and structure of the design contract should accommodate the design firm's involvement in PtD.

As described above, mitigation of exposure to liability associated with construction site safety is of concern for design professionals. Their involvement is facilitated through affirmation of their specific role and responsibility related to PtD, and protection against third-party lawsuits resulting from construction worker injuries and fatalities. To facilitate designer selection and participation in PtD efforts, the designer's role and responsibilities with respect to PtD on a project should be formally addressed in the contract documents. Provided in the Appendix are example modifications to standard design documents to incorporate PtD in the design contracts. Example modifications are provided for contract documents provided by the American Institute of Architects (AIA) and the Engineers Joint Contract Documents Committee (EJCDC).

In addition to addressing PtD in contract documents, guidance on Professional Liability (PL) insurance coverage as it relates to PtD is needed. PL insurance provides, to the insured party, protection from third-party claims that result from alleged wrongful acts by the insured. Provided in the Appendix is guidance to help clarify and inform designers about how PL insurance coverage may or may not provide liability protection associated with PtD implementation, and provide designers with recommended actions to take in order to maintain professional liability protection when implementing PtD. Prior to implementing PtD, designers should consult with their PL insurance provider with respect to the specific coverage provided by their PL insurance policy.

### 2.2.4 PtD and Sustainability

Sustainability is a key consideration of many capital projects and its consideration begins in the conceptual design phase. Safety and health are part of the social aspect of sustainability as depicted in Figure 2.1. Like the protection and conservation of environmental resources, sustainability incorporates the stewardship of human resources throughout the project lifecycle. PtD is directly related to social equity. PtD offers an opportunity for designers to participate in improving the sustainability of projects by designing the projects to enhance safety and health. Designers can ensure that construction, operations, and maintenance workers are able to work in conditions that are as minimally hazardous as reasonably possible.

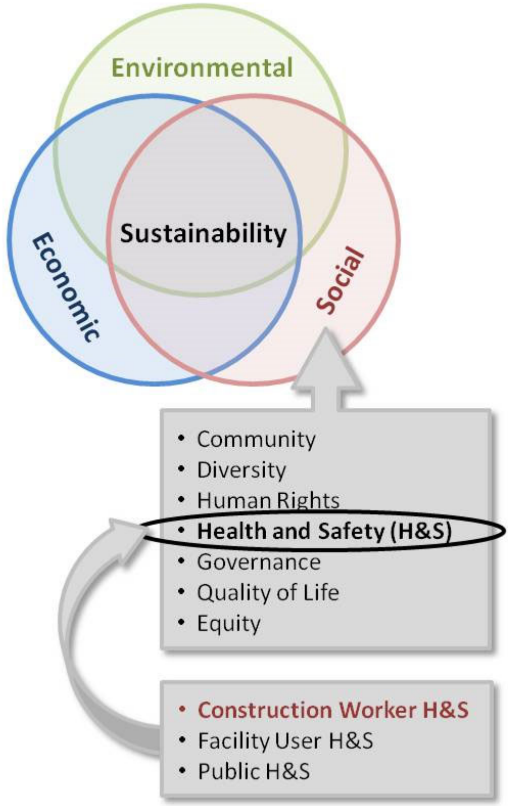


Figure 2.1: Safety as a Component of Sustainability (www.sustainablesafetyandhealth.org/scsh-overview/)

## 2.3 Resources and Tools

### 2.3.1 Project-specific PtD Policy

A project-specific policy statement is useful for formalizing and communicating commitment to PtD by all parties on a project. The PtD policy statement provides direction to those charged with PtD implementation and a basis for evaluating performance related to PtD. An example project-specific PtD policy is provided in the Appendix.

### 2.3.2 PtD Program and Process

Formal PtD programs implemented on projects support a PtD initiative and enable consistent evaluation of safety in design. Processes to ensure frequent and effective interaction between the owner, designer, and contractor should be established early in the Conceptual Design phase. Processes should be established for identifying, tracking, and fully investigating each PtD suggestion, whether the suggestion is initiated during a formal design-constructor meeting, during an informal conversation, or while one party is reviewing design documents online. After the project is completed, the results of PtD decisions should be analyzed and incorporated into a corporate lessons-learned database to allow future projects to benefit from the project participants' PtD experiences. Initial training to ensure that everyone understands the value and principles of the PtD process will likely be required. Informal teambuilding exercises will help establish needed trust.

A variety of PtD programs and processes have been created and implemented by companies or developed by industry organizations for public use. For example, DuPont starts its PtD process at the beginning of every new product, process, or building development cycle. Project team members (engineers and EHS professionals) along with other stakeholders collaborate using PtD software to identify safety and health risks to workers of any new initiative. During this process, the project team also determines the feasibility of using renewable energy sources or environmentally friendly materials without affecting safety and health (Safety and Health Magazine, 2014).

The following are examples of PtD programs that have been developed and implemented by various companies. Descriptions of the examples are provided in the Appendix.

- Intel *Life Cycle Safety* (LCS) process
- Bovis Lend Lease (BLL) *Risk and Opportunity at Design* (ROAD) program
- Foster and Partners Safety in Design Program
- The Haskell Company "Design for Safety" Program
- Southern Company *Design for Safety* (DfS) Program
- BHP Billiton Prevention through Design Program
- Port of Portland PtD Program

A template describing a process for integrating OHS into the capital project process that includes PtD is also provided in the Appendix.

The following are examples of PtD processes that have been developed by organizations for public access and use:

- *Construction Hazard Assessment Implication Review* (CHAIR) process (www.dynamic.architecture.com.au/i-cms_file?page=8548/CHAIR_Safety_in_Design_Tool.pdf)
- *Workplace Safety and Health Guidelines: Design for Safety* (www.wshc.sg/files/wshc/upload/infostop/attachments/2016/IS2016062900000000406/WSH_Guidelines_Design_for_Safety.pdf)

Safe Work Australia has created a PtD process that targets activities to undertake during conceptual design (www.safeworkaustralia.gov.au/safe-design).

Processes may be designed for application at the project level and/or at the organization level. Some may incorporate a variety of tools and resources, and also include designer education and training. While several processes exist to implement PtD on a project, the commonality between them is early intervention, a deliberate consideration of construction safety and health, and the utilization of construction knowledge in the conceptual and design phases.

#### 2.3.3 PtD Standards and Technical Reports

ANSI/ASSP Z590.3-2011 standard, titled "Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes," provides guidance on including PtD within an occupational safety and health management system. By using the standard, decisions pertaining to occupational hazards and risks can be incorporated into the process of design and redesign of work premises, tools, equipment, machinery, substances, and work processes including their construction, manufacture, use, maintenance, and ultimate disposal or reuse. The standard provides guidance for a lifecycle assessment and design model that balances environmental and occupational safety and health goals over the lifespan of a facility, process, or product. Review and implementation of the standard as part of a project's conceptual design provides a foundation on which PtD can be effectively implemented during later lifecycle phases. The ANSI/ASSP Z590.3-2011 standard is available at: www.assp.org/standards.

ANSI/AIHA Z10-2012 standard, titled "Occupational Health and Safety Management Systems," complements the ANSI/ASSP Z590.3-2011 standard. According to ANSI, the ANSI/AIHA Z10-2012 standard contains management principles and systems to help organizations design and implement approaches to continuously improve their occupational health and safety performance. It is compatible with relevant OHS, environmental, and quality management standards, such as ISO 9000 and 14000. The ANSI/AIHA Z10-2012 standard is available at: www.assp.org/standards.

The ASSP Technical Report titled "Prevention through Design – A Life cycle Approach to Safety and Health in the Construction Industry," ASSP TR-A10.100-2018, is an additional nationally-developed PtD resource. The report provides information and guidance on PtD implementation with respect to the construction industry and is intended as a resource for the design community. It is a compilation of PtD research, examples, and educational resources, and promotes applying PtD principles early in the project delivery process to positively impact safety throughout the lifecycle of the facility. The report is available from ASSP at: www.assp.org/.

#### 2.3.4 PtD in Green/Sustainability Rating Systems

Rating systems have been developed by industry associations to rate projects in regards to sustainability. Designing a project for safety can positively affect the sustainability of projects. The US Green Building Council (USGBC), for example, incorporates PtD in its Leadership in Energy and Environmental Design (LEED$^{TM}$) rating system through a pilot credit. The pilot credit promotes incorporating safety as part of design and constructability reviews to address the occupational safety and health needs of workers during construction, operations, and maintenance. Up to 1 credit may be earned for addressing and modifying the design of the building or designing the construction systems and operations to enhance safety. A description of the LEED pilot credit is available at: www.usgbc.org/credits/preventionthroughdesign. An example of a rating system credit that incorporates PtD is also available in the Appendix.

#### 2.3.5 Benefit-Cost Model

Understanding the implications of decisions at this early stage in the design process can be extremely beneficial to the future success of a project. Benefit-cost models can be used to compare different design alternatives and select an alternative for the project. Benefit-cost models take into consideration all of the benefits associated with a particular design as well as the costs. Based on the relationship between benefits and costs, an optimal design alternative can be selected. Such a model is very useful when comparing different safety and health controls, especially when the controls are at different levels in the hierarchy of controls. An example benefit-cost model is available in the Appendix.

#### 2.3.6 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on the conceptual design phase. Examples of design review checklists are provided in the Appendix.

### 2.4 Additional References and Resources

NIOSH PtD Green, Safe, and Healthy Jobs website:
www.cdc.gov/niosh/topics/ptd/greenjobs.html

# 3 PRELIMINARY DESIGN

## 3.0 What is Preliminary Design?

The Preliminary Design phase follows the development and confirmation of the project scope that took place in Conceptual Design. In Preliminary Design, the project team initiates design of the physical aspects of the project with a focus on the overall project features. Overall facility size, orientation, layout, number of stories, number of lanes of traffic, and materials of construction are examples of parameters initially considered. At this point determining overall system configuration may require environmental assessments, topographic surveys, metes and bounds surveys, geotechnical investigations, hydrologic analysis, hydraulic analysis, utility engineering, traffic studies, financial plans, and revenue estimates. Depending on project scope, the project team may: identify hazardous materials; estimate quantities of materials, electrical demand, and water usage; identify necessary equipment; develop procedures for security, operations, and maintenance; identify applicable standards; and develop release permits, building permits, and other regulatory documents. From these studies and characteristics, preliminary drawings and possibly a physical or computer model are created to illustrate the physical characteristics of the project.

Focus on project budget continues in Preliminary Design. The drawings and model developed are used to plan the scope of work, confirm budget and timeline, and generate information for project stakeholders. The representations provide valuable tools for displaying the scope and size of a project to get a feel for it at completion. In this phase the drawings and models may still be somewhat basic and artistic in nature without giving tremendous numerical detail. They are predominantly intended to provide representations with which to further conceptualize the project, perform preliminary cost estimates and budget confirmations, and generate interest from possible investors.

## 3.1 PtD in Preliminary Design

Preliminary Design gives a first glimpse at how specific safety and health hazards can be eliminated through the design. By reviewing the preliminary drawings, the project team identifies potential safety and health hazards, brainstorms alternative designs, and tests and selects less hazardous designs.

As with the other phases, selecting a safety control should take into consideration the hierarchy of controls (see Figure 1.2). Applying the hierarchy of controls, the review focuses on eliminating risks by changing the design or by avoiding processes that create health hazards such as toxic fumes, dust, vapors, vibration, and noise. A PtD maintenance plan might be considered which provides safe permanent access for operations, cleaning, and maintenance with specific provisions for safe access to roofs and windows. Consideration of the hierarchy of controls in the application of hazard elimination and risk minimization methods reinforces management’s commitment to safety. Specifications, including design life, facility dimensions, maintenance provisions, operating parameters and reliability requirements are also written. Opportunities for off-site prefabrication and modularization are also identified.

## 3.2 Key PtD Components and Considerations during Preliminary Design

### 3.2.1 Level of Review

Given the basic level of the design at this point, the design reviews typically are based on general design features, safety concepts, and hazard characteristics. It may be difficult for the project team to suggest specific alternative design details when the design has not progressed to a level of detail that allows for such focus. As a result, suggested design changes for improved safety and health often relate to such characteristics as overall layout, general shape and size, and material selection. It may be unrealistic, and also impractical, to expect significant detail in the suggested design changes at this point. More detailed reviews and design changes occur in later phases as the design detail increases.

### 3.2.2 Focus of Review

Conducting a design review for a large project with many design components can be daunting. The review process is facilitated by the use of “guidewords”. Guidewords describe features, characteristics, and processes that are impactful to those constructing the facility. The project team takes into consideration each guideword when reviewing the design to focus on those physical aspects of a design which can present safety and health hazards. For example, when considering “orientation,” a reviewer might pay close attention to how mechanical equipment is oriented on a project to permit safe access. Mechanical equipment which is oriented such that it is difficult to place, operate, or maintain can create safety hazards. The following are useful guidewords for conducting design reviews:

- Dimensions:
  - Size, weight, height, depth, shape, clearance
- Actions/Interactions:
  - Access, support, sequence, placement, connection
- Position:
  - Orientation, location
- Surroundings/Exposures:
  - Perimeters, openings, surfaces (coatings), obstructions
- Design-Human Interface:
  - Poka-yoke (mistake-proofing), buffers
- System Performance:
  - Reliability, redundancy, resiliency

## 3.3 Resources and Tools

### 3.3.1 Review Process using Guidewords

WorkCover, the occupational safety and health regulatory authority of the State of New South Wales, Australia, has developed a safety in design tool titled "Construction Hazard Assessment Implication Review" (CHAIR). CHAIR's goal is to identify risks in a design as soon as possible in the life of a project and considers construction, operations, and maintenance activities. CHAIR provides a framework for a facilitated discussion that is stimulated by guidewords or prompts such as size, height, and energy. The CHAIR process specifies that all stakeholders review the design in a prescribed and facilitated method to ensure that the occupational safety and health issues of the stakeholders are considered in the design phase of the project. It includes a conceptual design review (CHAIR - 1) and detailed design reviews for construction (CHAIR - 2) and maintenance activities (CHAIR - 3). Documentation on the CHAIR process is available at: www.dynamic.architecture.com.au/i-cms_file?page=8548/CHAIR_Safety_in_Design_Tool.pdf.

Other example PtD processes are available that include activities pertaining specifically to preliminary design. The PtD process developed by Safe Work Australia is one example (www.safeworkaustralia.gov.au/safe-design).

### 3.3.2 Risk Assessment Processes and Pro-Forma

During Preliminary Design, the design review process includes comparing different design alternatives based on the risk associated with design. Risk assessment, processes, forms, and worksheets assist with quantifying the risk and comparing different design alternatives to select the optimal solution. Examples of risk assessment pro forma are provided in the Appendix.

The process of conducting a risk assessment contains multiple steps and is founded on the concept of situational awareness. Situational awareness is a motivated, active, and continuous extraction of information from an environment and the ability to use knowledge to anticipate trajectories and act effectively (Artman 2000). It is used in every situation to which humans are exposed, including when assessing the safety and health risk associated with a design. As shown in Figure 3.1, situational awareness comprises the following steps: Level 1 – Detection, Level II – Comprehension, and Level III – Projection. After projecting the risk associated with a situation (Level III), a decision is made on how to act, and then the action is taken and feedback received. For PtD, the hazards associated with a design are identified and comprehended, the associated risk quantified, design alternatives developed, and then a preferred alternative selected and implemented. Preferably, the selected alternative is higher on the hierarchy of controls and leads to the elimination of the hazard. An example of a form that can be used to supplement the process is provided in the Appendix.

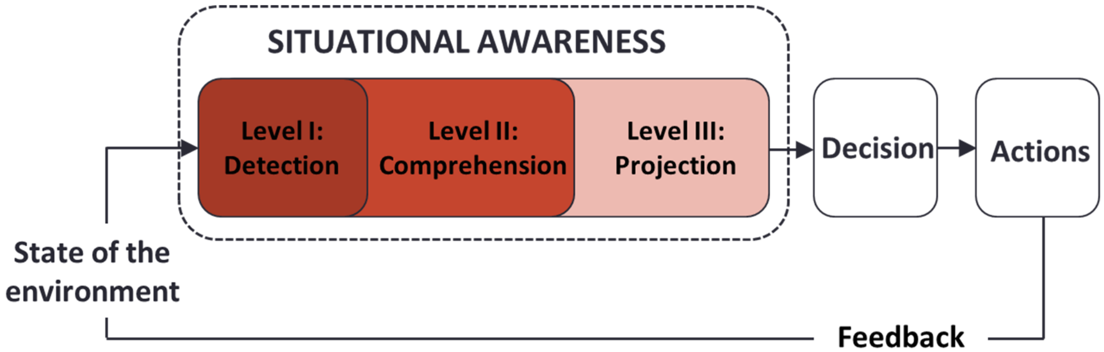


Figure 3.1: Situational Awareness

Failure Mode and Effects Analysis (FMEA) is a well-known, structured process that follows similar steps. FMEA is a step-by-step process for identifying and analyzing all possible failures in a design, process, product, or service (Zanoli et al. 2015). An FMEA that focuses on a design (DFMEA) incorporates situational awareness and risk quantification. The steps to undertake an FMEA can be summarized as follows (iSixSigma 2017):

- Detection and Comprehension:
  1. Identify each design component and its relation with other components
  2. Brainstorm potential failure modes
  3. List potential failure modes
  4. List potential effects of failure modes
- Projection:
  5. Assign a severity (S) rating to each failure mode
  6. Assign an occurrence (O) rating to each failure mode
  7. Assign a detection (D) rating to each failure mode
  8. Calculate the Risk Priority Number (RPN) for each failure mode where: RPN = S*O*D
- Decision and Action:
  9. Develop an action plan to reduce the RPN for each failure mode
  10. Implement the actions/improvements identified
  11. Re-calculate the RPNs based on the improvements

Whether performing an informal design review or conducting a formal DFMEA, PtD implementation at this phase of a project should include some level of risk assessment. When conducting the analysis, care should be taken to incorporate the perspectives and expertise of different disciplines to ensure an unbiased assessment of the associated risk and the selection of the optimal solution.

### 3.3.3 Multi-attribute Decision Tools

When designing a facility, product, or system, designers take into consideration many design criteria. In addition to safety and health, designers commonly consider cost, quality, durability, sustainability, and many other performance criteria. Each of these criteria is important to overall project success. For the multiple design alternatives under consideration, it may not be clear which is the optimal alternative. A design alternative may, for example, be highly durable but also very expensive and therefore not desired. Multi-attribute decision tools assist designers with determining and selecting the optimal design alternative. Some simple decision tools have been developed to accompany PtD processes which allow for consideration of occupational safety and health in conjunction with multiple other project performance criteria. An example of a multi-attribute decision tool for PtD is provided in the Appendix.

### 3.3.4 Benefit-cost Model

Benefit-cost models can be used to compare different design alternatives and select an alternative for the project. Benefit-cost models take into consideration all of the benefits associated with a particular design as well as the costs. Based on the relationship between benefits and costs, an optimal design alternative can be selected. Such a model is very useful when comparing different safety and health controls, especially when the controls are at different levels in the hierarchy of controls. An example benefit-cost model is available in the Appendix.

### 3.3.5 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on the preliminary design phase. Examples of design review checklists are provided in the Appendix.

# 4 DETAILED DESIGN

## 4.0 What is Detailed Design?

Detailed Design is the phase within the design process in which extensive detail is added to the design documents. Starting with the preliminary drawings and models produced in the Preliminary Design phase, the designer performs detailed analysis and calculations to design each and every part of the project in detail and then creates a set of detailed drawings and specifications for the project. The goal of Detailed Design is to develop a set of drawings and specifications that completely describe the project so that it can be constructed. The project may be described through solid modeling and drawing using large-scale drawings, mock-ups, and detailed plans. These present a clear view of the project's vital features with respect to HVAC, architectural, structural, mechanical, electrical, plumbing, equipment, civil, landscape, and utility infrastructure. Detailed design reviews are conducted to examine design attributes, application/misapplication of design features, energy control systems, human interaction, and compliance with codes, permits, and standards. Drawings, diagrams, and computer models are updated as more information becomes available for space and equipment locations, dimensions, elevations, etc. Landscaping plans, including the installation of plants, ponds, parking, and sculptures, are finalized. Internal quality assurance checks are performed. At the end of this phase, the detailed drawings and specifications should be developed to an extent in which they are sufficient for a construction firm to accurately and completely estimate the project cost and submit a bid for construction services.

## 4.1 PtD in Detailed Design

Detailed Design is an important phase for PtD implementation. It is in this phase in which the design is developed to a high level of detail and potential safety and health hazards can be clearly identified and mitigated. Project teams should not forego or minimize PtD implementation in this phase.

During the Detailed Design stage, PtD activities focus on designing and selecting control systems to mitigate hazards. As the design work is conducted, designs are created which eliminate or mitigate hazards. The architectural and structural design elements are reviewed to identify risks related to construction, operations, and maintenance. Mitigation strategies are developed, which may involve engineering and administrative controls. If hazards cannot be practicably eliminated through the design, the residual hazards should be noted and communicated to all affected downstream stakeholders (i.e., constructors, operators, and maintainers).

Safety management plans are also developed as part of Detailed Design. Hazard classification and fire compartmentalization plans are developed. A construction safety plan is developed and approved. The plan may forewarn the contractor of the residual hazards that will need to be managed during construction. Addressing construction safety during design can have a substantial impact on reducing injuries, workman's compensation costs, and injury-related project delays. If the hazards cannot be eliminated by engineering design, or reduced by incorporating safety devices, then warnings, instruction, and training are needed.

All contractors should have an approved safety and health plan that is consistent with the project goals. The plan should ensure appropriate PPE is available for every worker. The plan may recommend specific work methods to improve safety, such as prefabrication and assembly of structural components to eliminate working at heights. Requests for Bid may require bidders to provide specific safety program information, such as worker's compensation experience modification ratings, OSHA 300 logs for the past three years, and affirmation that they have a written safety plan and designated safety officer.

## 4.2 Key PtD Components and Considerations during Detailed Design

### 4.2.1 Total Project and Lifecycle Perspective

In some cases multiple options may exist to mitigate safety and health hazards. Some may be design alternatives that eliminate the hazards, others may be lower on the hierarchy of controls. Initial cost to design out the hazards may be high and therefore not selected. However, when considering the entire project lifecycle from design through construction, operations, maintenance, and decommissioning, the high initial cost alternative may be preferred. Design teams and owners should adopt a total cost and lifecycle cost approach when comparing alternatives. Design costs may be higher on projects in which PtD is implemented, yet the total lifecycle costs may be lower as a result of lower workers' compensation insurance costs, fewer delays due to injuries, and less time required to implement temporary safety measures during construction and future maintenance. When implementing PtD concepts, construction productivity commonly increases as well. As a result, construction duration may be shorter, leading to higher and earlier return on investment. An example benefit-cost model which considers costs and benefits from a lifecycle perspective is provided in the Appendix.

### 4.2.2 Constructability Reviews

Project development processes typically include constructability reviews during the design phase. The reviews are often conducted periodically during design at, for example, the 30%, 60%, and 90% points in design completion. Constructability reviews provide opportunities for integrating construction knowledge and expertise into the design process to optimize the design for construction purposes. Including a safety and health perspective in the constructability reviews both enables PtD and allows for construction knowledge to filter into the design.

### 4.2.3 Design Review Process

A formal design review process is helpful to provide a good structure for implementing PtD as different portions of the design are created. For each design package, a structured process may consist of internal reviews within the design team, followed by trade contractor reviews and a stakeholder (owner personnel) review. Review comments are then collected and the design modified accordingly. If needed, the process is repeated with additional reviews of the revised design. Examples of design review processes are provided in the Appendix. PtD checklists provide useful tools to assist the project team with conducting focused and comprehensive reviews. The checklists should be tailored to match the level of detail in the design at which the checklist is implemented. Example PtD checklists are provided in the Appendix.

#### 4.2.4 Effective Management of Design Input

Design and constructability reviews for safety commonly involve many parties reviewing and commenting on design documents and providing suggestions for alternative, safe designs. To facilitate an effective process, owner, designer, and constructor personnel must be able to easily access draft design documents and share PtD-related and other constructability comments. A system must exist that facilitates tracking specific design suggestions from inception to closure. As such, a project collaboration software package or similar tool should be set up and made available to the project team at the beginning of the design process to provide this capability.

### 4.3 Resources and Tools

#### 4.3.1 Design Risk Calculators

Capital projects contain many different design features and elements, each with its own impact on worker safety and health. The ability to quantify the risk associated with each feature, and for the entire facility, allows designers an opportunity to optimize their design in terms of worker safety and health. As described in the previous section, formal processes are available, e.g., Failure Mode and Effects Analysis, that support risk assessment. Tools are also available which allow architects and engineers to evaluate the safety and health risk associate with their designs based on the design features, layout, size, shape, etc. These types of tools are especially useful during Detailed Design when the design is developed to a level that allows for detailed review and evaluation. The following are examples of design risk calculators available on the Internet:

- SliDeRulE (Safety in Design Risk Evaluator): www.constructionsliderule.org
- ToolSHeD™ (Tool for Safety and Health in Design): www.emeraldinsight.com/doi/abs/10.1108/09699980810886847

#### 4.3.2 Design Best Practices

The Design Best Practice website (www.dbp.org.uk/welcome.htm) provides a long list of example cases of specific design features that are particularly beneficial to construction safety. The site is especially relevant as the examples are provided by construction industry professionals who have firsthand knowledge and exposure to the design elements.

For structural steel, the National Institute of Steel Detailing (NISD) and the Steel Erectors Association of America (SEAA) have developed a useful guide to designing steel structures. The guide, which is available from the SEAA website at www.seaa.net/, describes best practices for designing steel members and connections to enhance the safety of steel erectors.

OSHA provides helpful suggestions for designers as well. The OSHA Alliance Program Construction Roundtable developed a set of Construction Workplace Design Solutions that provide guidance on how to design to prevent falls during construction and future operation and maintenance. The design suggestions can be found on the OSHA website at: www.osha.gov/dcsp/alliances/roundtables/roundtables_construction.html#top.

The following are additional on-line resources from other countries that contain examples of design best practices:

- Designers' Initiative on Health and Safety (DIOHAS), United Kingdom: www.diohas.org.uk/index.php?p=1_16
- *Guidelines on Design for Safety in Buildings and Structures*, Workplace Safety and Health Council, Singapore: www.wshc.sg/
- Safe Design, Australian Government, Department of Employment, Office of the Federal Safety Commissioner: www.fsc.gov.au/sites/fsc/resources/pages/safedesign
- *Safe Design of Structures: Code of Practice*, Safe Work Australia: www.safeworkaustralia.gov.au/resources_publications/model-codes-of-practice. This is an example of a PtD process that includes activities specific to the detailed design phase.

### 4.3.3 Databases of Design Suggestions

The Construction Industry Institute (CII) has developed an electronic database of design-for-safety suggestions titled "Design for Construction Safety Toolbox" (www.construction-institute.org/scriptcontent/index.cfm). The software contains over 400 design suggestions that will help to eliminate hazards and reduce risk when implemented. In addition, as part of the effort to educate designers, the software alerts designers to the safety and health hazards related to their designs. Safe design guides can also be found on the Internet (for example, see: www.safetyindesign.org.uk/design-guides).

### 4.3.4 Design Review Processes

Formal review processes are commonly implemented during Detailed Design to conduct peer design reviews. These review processes are ideal opportunities to incorporate PtD reviews and address safety issues in the design. The PtD reviews typically include some level of involvement by contractors to address safety during construction along with input from owners/stakeholders regarding operations and maintenance safety. Several examples of PtD design review processes are available in the Appendix.

### 4.3.5 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on the detailed design phase. Examples of design review checklists are provided in the Appendix.

### 4.3.6 Benefit-Cost Model

Benefit-cost models can be used to compare different design alternatives and select an alternative for the project. The benefit-cost model takes into consideration all of the benefits associated with a particular design as well as the costs. Based on the relationship between benefits and costs, an optimal design alternative can be selected. Such a model is very useful when comparing different safety and health controls, especially when the controls are at different levels in the hierarchy of controls. An example benefit-cost model is available in the Appendix.

# 5 PROCUREMENT

## 5.0 What is Procurement?

At the completion of Detailed Design, the project is ready for construction. The bidding process begins with a comprehensive set of documents containing specifications and drawings to construct the project and support the acquisition of necessary permits. Construction and environmental permits are obtained. Construction funds are released, contractor and supplier services secured, and then construction begins.

Materials, products, services, and equipment are purchased during various stages of the project development process from conception through disposal. The selection of a specific site for a new facility may initiate the design process. During Preliminary Design, required products and services are identified and requests for bids may be solicited. PtD requirements are added to existing guidelines and new specifications, which may be referenced on purchase orders. The purchaser and supplier agree on a delivery date, including time to test purchased equipment for compliance with specifications. Acceptance testing during commissioning may be conducted at the vendor's facility. Products are received and stored either on- or off-site. Acceptance tests are performed after equipment is installed on site, before it is placed into operation. Upon acceptance, payments are approved and issued.

## 5.1 PtD in Procurement

PtD activities are undertaken as part of procuring both services and products. Designers can develop specifications that incorporate PtD content. The specifications can require those providing the services and/or products to incorporate PtD into their design and construction/manufacturing processes. PtD can also be included within procedures for factory acceptance testing and for commissioning of equipment. Specifications which promote prefabrication and modularization are particularly beneficial to PtD. A visit to the manufacturing site to observe safety practices during the manufacturing of the products can provide a valuable opportunity to ensure and promote worker safety and health during the manufacturing process.

When selecting contractors, safety records and safety programs can be required from bidders and used in the selection process. The extent to which each bidder incorporates PtD concepts in their services can be added as a selection criterion. Past performance history is an indication of a contractor's overall efficiency and commitment to safety in the conduct of the work.

## 5.2 Key PtD Components and Considerations during Procurement

### 5.2.1 Contractor Selection

Contractor firms submitting bids on projects should be made fully aware of their expected role in PtD. The contractors may be asked to participate in PtD reviews and provide input on how the design can be modified to improve safety. The RFP for construction services should include requirements to submit information detailing previous PtD experience within the firm overall and the previous PtD experience of key personnel to be assigned to the project. The RFP should also delineate expectations about the frequency and type of designer-constructor interaction. The contract for construction must account for the additional time required for the constructor to participate in PtD activities.

### 5.2.2 Contract Clauses

Current standard contract agreements and general conditions, such as those promulgated by the American Institute for Architects (AIA) and the Engineers Joint Contract Document Committee (EJCDC), do not contemplate designer and constructor involvement in PtD. These documents must be revised to allow the designer and constructor to consider construction worker safety in design decisions without exposing the parties to liability for accidents that occur as a result which they would not shoulder otherwise.

### 5.2.3 Contracting Methods

The contracting method represents the project team structure and how the project team members are contractually connected for the project. The design-bid-build, general contracting method is traditionally used on construction projects and predominantly on publicly-funded projects. Alternative contracting methods, such as design-build, CM-at-risk, and integrated project delivery, combine the design and construction expertise in different ways. Those contracting methods which allow and promote constructor involvement during design are particularly beneficial to PtD. Owners should consider these alternative contracting methods during procurement of design and construction services.

### 5.2.4 Suppliers and Manufacturers

Many features and equipment for projects are manufactured off-site, transported to the site, and then installed during construction and future maintenance. Injuries that occur off-site as part of the manufacturing process can be eliminated through PtD as well. Suppliers and manufacturers can be asked to describe their design and manufacturing processes and certify that they include PtD efforts. In addition, for custom-made items, the manufacturers should be included in the design reviews to provide input related to those design features with which the manufactured items integrate on the project.

### 5.2.5 Product Specifications

Design specifications provide an opportunity for designers to integrate PtD into products and materials used on the project. The specifications should be written such that they promote safety and health, including requiring the use of non-toxic materials.

## 5.3 Resources and Tools

### 5.3.1 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on PtD recommendations during the procurement phase. Examples of design review checklists are provided in the Appendix.

# 6 PROJECT EXECUTION

## 6.0 What is Project Execution?

The Project Execution phase takes the design from the drawings and specifications to its physical form. The objective of the Project Execution phase is to build the project according to the drawings and specifications at the level of quality required by the contract documents within the budget, schedule, and scope defined. The project may be an object, a facility, a process, equipment, or a tool. Inspections are performed to document conformance with the contract documents. At substantial completion, a punchlist is prepared which identifies items that must be completed before the project is accepted. Final completion occurs when all of the punchlist items have been taken care of.

Budgets, schedule, materials, equipment, and crews are tracked to monitor and manage project performance during Project Execution. Various quality control and quality assurance procedures are performed. Replacement parts and materials are ordered if needed. Paperwork during Project Execution may include a “Notice to Proceed”, change orders, equipment orders, submittals, payment requests, Requests for Information (RFIs), the “Notice of Substantial Completion”, and many others. The project owner/client occupies the facility or begins use of the product/equipment at the conclusion of Project Execution.

## 6.1 PtD in Project Execution

Given that the facility, product, or equipment design is completed prior to Project Execution, PtD activities with respect to the design are limited during Project Execution. Where site impacts cause changes in the design during Project Execution, PtD concepts should be included when developing the revised design. Similarly, PtD practices should be incorporated to revise the design when the workforce finds constructing, manufacturing, or maintaining the original design to be hazardous.

In an industrial setting, best practices for safety apply to both processes and equipment. PtD activities similarly apply to the design of safety plans, work practices, engineering controls, and protective equipment. As part of safety management plans, steel-toed boots, safety glasses, a hard hat and other personal protection equipment (PPE) should be required for every person on the site. Per OSHA 1926.16, the primary contractor assumes responsibility for construction site safety; however, all contractors should have a safety plan that supports the project safety goals. The plans should require worker training and PPE to minimize residual risks associated with construction of the facility. The plans should also ensure that traffic control and site access plans are enforced and that accident investigations occur. Accident investigations often identify these root causes of accidents such as: unsafe equipment, unsafe methods or sequencing, unsafe site conditions, lack of proper training, deficient enforcement of safety, not using available safety equipment. These are all indicators of a poor attitude towards safety and can be mitigated through the safety management system designed for the project.

## 6.2 Key PtD Components and Considerations during Project Execution

### 6.2.1 Contractor Input

The Project Execution phase provides another good opportunity to get constructor input on the design. As the work on the project is being planned by the general and trade contractors, challenges may come up regarding how to construct the work safely. Overcoming these challenges may best be accomplished by revising the design rather than adding more PPE or an administrative control. Additionally, design changes made during construction should be reviewed and designed for safety before issuing the changes to the contractor.

### 6.2.2 Lessons Learned

Construction sites provide an excellent opportunity to learn about how a design impacts construction. Designers who take time to visit the site, observe the work, and talk with the contractors/manufacturers will learn how to create better designs to reduce the risk to worker safety and health. This learning can be incorporated into a database of lessons learned for incorporation on future projects.

### 6.2.3 Tracking PtD Effectiveness

Maintaining and promoting a PtD program can require demonstration that the program is effective at eliminating safety and health risks. The Project Execution phase provides an opportunity to evaluate the effectiveness and impact of PtD efforts. Data can be collected on how the workers interact with PtD-enhanced design features, whether injuries were related to the design, whether features designed for safety have any impact on other project criteria such as quality, and any other information that reflects the impact and quality of a PtD program. This data can then be compared to similar data from past projects to determine the value of implementing a PtD program. Additional data on the costs associated with implementing the safe designs can be collected to determine the overall benefit-cost ratio.

## 6.3 Resources and Tools

### 6.3.1 AIA (2007) Integrated Project Delivery: A Guide

This document provides guidance on integrated project delivery (IPD) which is recognized as a delivery method which can benefit the implementation of PtD. The guide can be found at the following link: www.info.aia.org/SiteObjects/files/IPD_Guide_2007.pdf.

### 6.3.2 Benefit-Cost Model

Benefit-cost models can be used to compare different design alternatives and select an alternative for the project. The benefit-cost model takes into consideration all of the benefits associated with a particular design as well as the costs. Based on the relationship between benefits and costs, an optimal design alternative can be selected. Such a model is very useful when comparing different safety and health controls, especially when the controls are at different levels in the hierarchy of controls. An example benefit-cost model is available in the Appendix.

#### 6.3.3 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on PtD recommendations during the project execution phase. Examples of design review checklists are provided in the Appendix.

# 7 COMMISSIONING AND CLOSEOUT

## 7.0 What is Commissioning and Closeout

Project commissioning, closeout, and turning the project over to the owner/client occur after construction. Commissioning is a phase in which building system operation and performance are evaluated and verified as meeting the project specifications. The facility systems are started up and checked to verify that they function as the design intended. Independent commissioning agents are often hired to provide a third-party, independent verification of the systems. Commissioning efforts typically focus on HVAC, electrical and fire alarm systems, although other systems such as plumbing, roofing, security, elevators, exterior enclosure, and communication are included as well. The objective of this phase is to facilitate and coordinate occupancy and maintenance of the facility to the client.

Project closeout officially begins following substantial completion. Closeout includes organizing and turning over documents to the owner including guarantees and warranties, as-built drawings, lien waivers, operations manuals, and certificates of code compliance. The field office is decommissioned and jobsite equipment removed from the project site. Temporary utilities necessary for field operations are turned off or deactivated, and the site is cleaned up for return to the owner. All final documentation and communications between the project team members is prepared and processed. Final payment is given to the contractor.

## 7.1 PtD in Commissioning and Closeout

In the Commissioning and Closeout phase, a safety review is conducted to compare the design documents with the actual conditions for each of the facility's systems. Any discrepancies are noted and resolved. Residual risks are evaluated with respect to target risks. Industrial monitoring occurs to ensure that hazard control measures have been installed and are operating properly and effectively. Acceptance testing of equipment is conducted along with any retrofits that are necessary. This includes pre-start up safety reviews and the development of standard operation procedures (SOPs). Any changes made during Commissioning and Closeout should themselves undergo a PtD review.

## 7.2 Key PtD Components and Considerations during Commissioning and Closeout

### 7.2.1 Lessons Learned

As with the Project Execution phase, Commissioning and Closeout provides a useful opportunity to collect examples of design practices that worked well in regards to construction worker safety and health. These examples can then be incorporated into a lessons learned database for assistance on future projects.

### 7.2.2 Identifying Maintenance Risks

During Commissioning and Closeout, the facility systems are turned on, tested, and balanced. By doing so, the users learn about operations and maintenance requirements for the systems and possible safety and health issues. This knowledge can be helpful for future work on the systems and should be archived for future reference.

## 7.3 Resources and Tools

### 7.3.1 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on PtD recommendations during the commissioning and closeout phase. Examples of design review checklists are provided in the Appendix.

# 8 OPERATIONS AND MAINTENANCE

## 8.0 What is Operations and Maintenance?

Facilities operations and maintenance embraces all the services required to assure a facility or equipment functions as designed. This includes the day-to-day activities of normal operations. Maintenance includes all activities required to support the facility and keep it operational along with related infrastructure, such as roads, parking lots, utility systems, drainage structures, and grounds. Maintenance activities include preventive, planned, and corrective actions. Preventive maintenance requires planning, scheduling, and executing routine activities such as adjusting, lubricating, cleaning, and replacing components. Planned maintenance includes time intensive activities, such as a bearing/seal replacement, which may be scheduled during periodic shutdown. Corrective maintenance involves repair or modification of equipment and may be undertaken to correct design deficiencies. A post-occupancy inspection may be performed prior to remodeling or repurposing of a facility.

## 8.1 PtD in Operations and Maintenance

During operations and maintenance, workplace operations are monitored to ensure compliance with industry standards and government regulations. Inspections, checks, and tests of equipment are conducted. Productivity is compared against operational targets (quality, yield, costs, optimized, utilization, etc.). Incidents, including injuries, illnesses, exposures, emissions and “near-miss” events are recorded, investigated, and analyzed. All safety incidents are examined to establish the root cause. Design-related incidents provide an opportunity to eliminate hazards through a PtD redesign and retrofit. Training on safety equipment, processes, and policies are conducted to enhance employee awareness and encourage safer behavior. Administrative controls and personal protective equipment are used to complement an overall design for safety risk minimization strategy, which includes the appropriate program development, implementation, employee training, and surveillance.

## 8.2 Key PtD Components and Considerations during Operations and Maintenance

### 8.2.1 Continuous Improvement

The operations and maintenance phase provides an opportunity to realize the impacts of the design and make modifications if needed. While the cost of retrofit may be significant compared to earlier in the facilities lifecycle (e.g., during the design phase), the benefit may still be great given the potential exposure. One component of safety risk is exposure to the hazard. When the exposure is prolonged, and is present for many workers, renovating or revising the design to eliminate the hazard is the best solution. By doing so, continuous improvement in the design can occur.

### 8.2.2 Lessons Learned

Design modifications made during operations and maintenance can provide helpful insights for future facility designs. Collecting these lessons learned in an archival database is an important step in the process. Designers who take time to visit the site, observe the work, and talk with the workers will learn how to create better designs to reduce the risk to worker safety and health. This learning can be incorporated into a database of lessons learned for incorporation on future projects.

### 8.2.3 User Input during Design Reviews

During the operation of a facility, it is often the case that design efforts will take place for an upcoming facility renovation, rehabilitation, or even an additional facility. Including users of the current facility in design reviews for the upcoming projects is a key aspect of PtD. Those with firsthand knowledge of the safety impacts of a design are extremely helpful to implementing PtD. They should be included in all design review meetings and given a chance to review and comment on design options. Their input should not be ignored.

## 8.3 Resources and Tools

### 8.3.1 Risk Mapping

A workplace can be a complicated environment containing many different types of hazards in many different locations. Without an efficient means of identifying and mitigating the hazards, improving the work environment may be difficult. Risk Mapping is one method of assessing and improving workplace safety. The Risk Mapping method incorporates all workplace personnel in a participatory process of locating and assessing safety hazards using a map of the workplace. Maps of the workplace are used in meetings or placed in central locations to prompt workers to identify on the map where hazards exist. The map constitutes a visual tool that all personnel can readily comprehend and utilize to address safety hazards in an efficient manner. Personnel use the map to conduct open-ended, group discussions to brainstorm ideas on how to eliminate hazards. Safety improvement measures are sketched on the map and then implemented through a plan of action. Use of Risk Mapping can facilitate the implementation of the PtD concept.

### 8.3.2 Retro-commissioning

Retro-commissioning entails going back into a facility after start-up and initial use to re-adjust the systems for improved facility performance. This operation provides a valuable opportunity to re-design systems and components to improve safety. Essentially, worker safety is one of the design criteria for improved facility performance. During retro-commissioning, different ways of designing the systems should be considered and incorporated that improve the safety of those who maintain and operate the facility. Importantly, the designs should consider the safety of those who perform the retro-commissioning efforts as well. In many cases the work needs to be done while the current facility is operating, or in a very short period of time during a shutdown or outage. These types of conditions can create significant hazards for workers. PtD provides another chance at designing out the hazards.

### 8.3.3 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on PtD recommendations during the operations and maintenance phase. Examples of design review checklists are provided in the Appendix.

# 9 DECOMMISSIONING

## 9.0 What is Decommissioning?

When an owner decides it will no longer occupy a building, operate a plant/equipment, or utilize a roadway or utility line, it initiates the decommissioning process to decontaminate, dismantle, and/or demolish it. The first activity consists of an assessment, which is intended to document the condition of the facility and to propose several alternatives for disposal. Options may be limited by the historical or current use and operational functions of the facility. Deactivation places the facility in a safe shutdown mode that is economical to monitor and maintain until decommissioning activities begin. The first stage of decommissioning is plant cleanout. This generally begins immediately following shutdown and involves the removal of equipment, materials, supplies, and other consumables. Next, the facility may be sold as is or it may be repurposed (recommissioned). Ultimately, the facility is razed, scrap materials are salvaged, and the land may be sold.

## 9.1 PtD in Decommissioning

Management within the owner firm has an opportunity to reiterate and reinforce the company's commitment to PtD when developing a decommissioning project plan. The plan should include measures to identify and mitigate inherent risks to workers and the public. Elimination of hazards is the first priority in a culture of safety; use of personal protective equipment, harnesses, and guardrails is the second line of protection for workers. The plan may specify removal of hazardous substances like asbestos. Procedures for securing ladders and inspecting scaffolding may be included. To reduce falls from heights, the plan may identify parts of the structure that can be disconnected and disassembled on the ground. The control of dust is frequently needed and should be addressed through a dust control plan. Pre- and post-shutdown safety inspections are required. A readiness review confirms that the organization performing the decommissioning operations is adequately prepared to implement the decommissioning plan and that the workers are properly trained.

## 9.2 Key PtD Components and Considerations during Decommissioning

### 9.2.1 Communication and Planning

In many cases, decommissioning can be more hazardous than actual construction of the facility. As-built drawings may not be available, the actual condition of the structural members may not be known, hazardous materials may be hidden, or work may be required adjacent operational systems that pose high risk. These factors, along with the engineering challenges of deconstructing large structures, can present hazardous situations. Detailed and thorough planning is required which recognizes both the design of the existing structure and the design of the structure during each step of the deconstruction process. Communication is a key component. Those performing the work must regularly communicate amongst themselves about the progress of the work and conditions present. In addition, there must be clear and regular communication between field staff and the engineers and planners designing and coordinating the work. Working together enables designing the deconstruction process such that hazards are minimized during the work.

### 9.2.2 Deactivation

Buildings and industrial facilities are complex structures. They contain many different types of systems used for operation of the facility such as heating, ventilation, and air conditioning (HVAC) systems, electrical systems, fire suppression systems, plumbing systems, and specialized tools and equipment. Prior to dismantling the facilities, these systems must be deactivated. Toxic materials must also be removed. A decommissioning plan should be designed which includes deactivation of these systems. In addition, the plan should include physical, visible assurance that the systems have been deactivated for the personnel conducting subsequent work in the field.

### 9.2.3 New Construction for Deconstruction

Mitigating hazards that will exist during decommissioning may in some cases be best accomplished by designing and constructing new, temporary features in the facility. For example, in order to deconstruct a catwalk system in a mechanical room, structural support for the mechanical equipment may first be needed. The structural support should be designed and installed prior to dismantling the catwalk. Careful review of a facility is needed to identify where and when new support features should be added in order to facilitate safe deconstruction. The design of the new features should both mitigate the safety risk and allow for efficient movement of workers and equipment during the deconstruction activities.

## 9.3 Resources and Tools

### 9.3.1 Design Review Checklists

Checklists provide an efficient and consistent means for project teams to conduct thorough reviews of designs. Checklists are available that focus specifically on PtD recommendations during the decommissioning phase. Examples of design review checklists are provided in the Appendix.

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# APPENDIX

1. Example Organizational PtD Policy
2. Example Project-specific PtD Policy
3. Owner's Guide to Implementing PtD
4. Contract Modifications to Incorporate PtD
5. Professional Liability (PL) Insurance Guidance
6. Organizational Procedure for Integration of OSH into Capital Project Process
7. PtD Programs and Processes
8. Example Rating System PtD Credit
9. PtD Benefit-Cost Model
10. Risk Assessment Pro-forma
11. PtD Design Examples/Checklists
12. PtD Case Studies
13. PtD Bibliography

# A1 Example Organizational PtD Policy

*Source: Renshaw, F.M. (2011). "Model Prevention through Design (PtD) Program," Draft Final Report, prepared for National Institute for Occupational Safety and Health (NIOSH), May 6, 2011. (Modified)*

**XYZ Company**
**Model Environmental, Health, and Safety Policy**

The XYZ Company is a world leader in constructing/manufacturing products. Our environmental, health, and safety values are of the utmost importance to us. They are embodied in the guiding principles set forth in this policy. They reflect our respect and care for the environment, our employees, contractors/subcontractors, customers, and communities. We are committed to incorporating these values into everything we do as we seek to improve the quality of life and the environment through our products and services.

Our Guiding Principles are:

1. We will design our businesses, processes, and products with full consideration for the needs of the present global community and the impact of our design decisions on the ability of future generations to meet their needs.
2. We will include "Prevention through Design" considerations in the design and redesign of all facilities, equipment, processes, work methods, and products, and will incorporate methods of safe design into all phases of hazard and risk mitigation.
3. We will continuously review and improve our worldwide operations, processes, and products, with the goal of making them free of adverse environmental, health, and safety impacts for all of our stakeholders.
4. We will meet or exceed all applicable laws, regulations, and XYZ Company standards.
5. We will provide our employees with a safe and healthy workplace, and ensure that our communities and other stakeholders understand our uncompromising commitment to safe and secure operations and products.
6. We will strive to prevent or reduce pollution from emissions, discharges, and wastes; and will promote resource conservation throughout the lifecycle of our products.
7. We will communicate, listen, and be responsive to our employees, contractors, suppliers, customers, neighbors, governments and other stakeholders; and we will share information concerning potential hazards resulting from our operations and products.
8. We will ensure that standards, procedures, and adequate resources are provided to implement the principles set forth in this policy.

Every employee, contractor, and subcontractor is responsible for compliance with this policy. We will audit our performance and the Board of Directors will monitor our commitments and progress.

President/CEO/Chairman

## A2 Example Project-specific PtD Policy

*Source: Renshaw, F.M. (2011). "Model Prevention through Design (PtD) Program," Draft Final Report, prepared for National Institute for Occupational Safety and Health (NIOSH), May 6, 2011. (Modified)*

**XYZ Project**
**Model Environmental, Health, and Safety Policy**

The XYZ Project entails constructing a building/bridge/roadway/other. As members of the project team, our environmental, health, and safety values are of the utmost importance to us. They are embodied in the guiding principles set forth in this policy. They reflect our respect and care for the environment, our employees, team members, co-workers, customers, and communities. We are committed to incorporating these values into everything we do on this project as we seek to improve the quality of life and the environment through our products and services on this project.

Our Guiding Principles are:

1. We will design our project processes and products with full consideration for the needs of the present global community and the impact of our design decisions on the ability of future generations to meet their needs.
2. We will include "Prevention through Design" considerations in the design and redesign of all facilities, equipment, processes, work methods, and products, and will incorporate methods of safe design into all phases of hazard and risk mitigation.
3. We will continuously review and improve our operations, processes, and products, with the goal of making them free of adverse environmental, health, and safety impacts for all of our project team members and stakeholders.
4. We will meet or exceed all applicable laws, regulations, and XYZ Project standards.
5. We will provide our employees with a safe and healthy workplace, and ensure that our project team members, communities, and other stakeholders understand our uncompromising commitment to safe and secure operations and products.
6. We will strive to prevent or reduce pollution from emissions, discharges, and wastes; and will promote resource conservation throughout the lifecycle of our products.
7. We will communicate, listen, and be responsive to our employees, team members, suppliers, customers, neighbors, governments and other stakeholders; and we will share information concerning potential hazards resulting from our operations and products.
8. We will ensure that standards, procedures, and adequate resources are provided to implement the principles set forth in this policy.

Every team member and subcontractor is responsible for compliance with this policy. We will audit our performance and the project management team will monitor our commitments and progress.

| ______________________ | ______________________ | ______________________ |
|---|---|---|
| President, Company 1 | President, Company 2 | President, Company 3 |

# A3 Owner's Guide to Implementing PtD

*The following guidelines were created by T. Michael Toole/University of Toledo and John Gambatese/Oregon State University, in part based on a CPWR/NIOSH-funded research project conducted 2007-2009. The guidelines are intended to help organizations implement a PtD program on a project for the first time or to audit an existing PtD program. The first section summarizes organizational characteristics and initiatives needed for PtD while the second section summarizes three levels of implementation through which an owner may wish to progress.*

**Owner's Guide to Implementing PtD**

1. <u>Organizational Characteristics and Initiatives</u>

**Strong Leadership and Safety Culture**. It is generally accepted that the culture within an organization significantly influences the behavior of individual employees and that leadership plays a central role in establishing an appropriate organizational culture. Does leadership set a high expectation for worker safety and health to ensure that safety takes priority over other project criteria and to ensure that when multiple options are available to mitigate a hazard, designing out the hazard is desired and chosen whenever practicable?

**Business Value of PtD Recognized Through a Total Project Cost Perspective**. Given that PtD may at least initially increase project planning and design fees, is PtD viewed using a total project, life cycle cost perspective, that is, by identifying all of the costs and benefits associated with PtD over the life cycle of the constructed facility, not just the costs associated with the design, construction planning and construction execution phases? Do managers recognize that while planning and design costs may be higher for projects on which PtD is implemented, total project costs will be lower because the resulting design will yield lower workers compensation insurance costs and fewer delays due to injuries?

**Formal PtD Program**. Does a formal PtD program exist? Does it effectively inform employees of the PtD concept, provide an objective and efficient process for its implementation, ensure that needed collaboration occurs, provide a structured means for monitoring and enforcing the program, and provide processes and documents to ensure PtD is not dominated by competing project and organizational goals?

**PtD Explicitly a Factor in Designer Selection**. Do owners ensure AEs are willing and able to perform PtD through the AE selection process? Ideally, owners should contract with AEs who have a formal PtD program themselves and a demonstrated track record of performing PtD. At the least, AEs should be required to submit documentation that they understand the PtD concept and are willing to have their designers undergo training on how to perform PtD, to use PtD tools, and to collaborate with owner and contractor personnel during design to effectively perform PtD.

**PtD Processes**. Processes to ensure frequent and effective interaction between the owner, designer, and contractor must be established at the start of design. Initial training to ensure that everyone understands the value and principles of the PtD process will likely be required. Informal teambuilding exercises will help establish needed trust. Processes must be established for tracking and fully investigating each PtD suggestion, whether the suggestion is initiated during a formal design-constructor meeting, during an informal conversation, or while one party is reviewing design documents online. After the project is completed, the results of PtD decisions should be analyzed and incorporated into a corporate Lessons Learned database to allow future projects to benefit from the project participants' PtD experiences.

**Project Delivery Method**. Even if designers are knowledgeable about construction safety and PtD, collaboration during design between designers, the lead contractor, construction trades, and construction safety professionals is a key component of an effective PtD program. The traditional design-bid-build method of delivering projects typically does not allow this collaboration because the firms who perform construction are not identified until after design is complete. As such, design-build and integrated project delivery (IPD) are two preferred project delivery methods for enabling effective PtD on a project because they enable the needed collaboration.

**Design Contract Type.** Owners who wish to engage an AE who has not previously performed PtD may wish to agree to have the contract with the AE be a Cost-Plus with a guaranteed maximum price (GMP) contract rather than a traditional fixed fee contract, because such a designer may be hesitant about locking in a price for a process with which they are not familiar.

**Contractual Obligations**. Although it is more difficult to effectively perform PtD on a traditional design-bid-build project, it is not impossible. An owner could choose to require the AE to perform PtD without being able to collaborate with construction personnel during design, or an owner could engage a general contractor and several key trade contractors to act as safety review consultants during the design process (perhaps as part of a Design-Assist contract). With either arrangement, it will be necessary to ensure the contract between the owner and the AE requires or at least recognizes that the AE will perform PtD on the project.

**Constructability Reviews**. The key collaboration with PtD is associated with constructability reviews, that is, when designers and construction personnel meet to discuss aspects of the design that may cause the construction of the design to cost more, take longer, or be of lower quality than is desired. Ideally, such constructability reviews occur at approximately the 10%, 30%, 60% and 90% stages of design, involve individuals representing all relevant engineering disciplines, in-house construction safety, external trades, operational safety, and cost accounting, and include the specific review tasks shown in Figure A3.1.

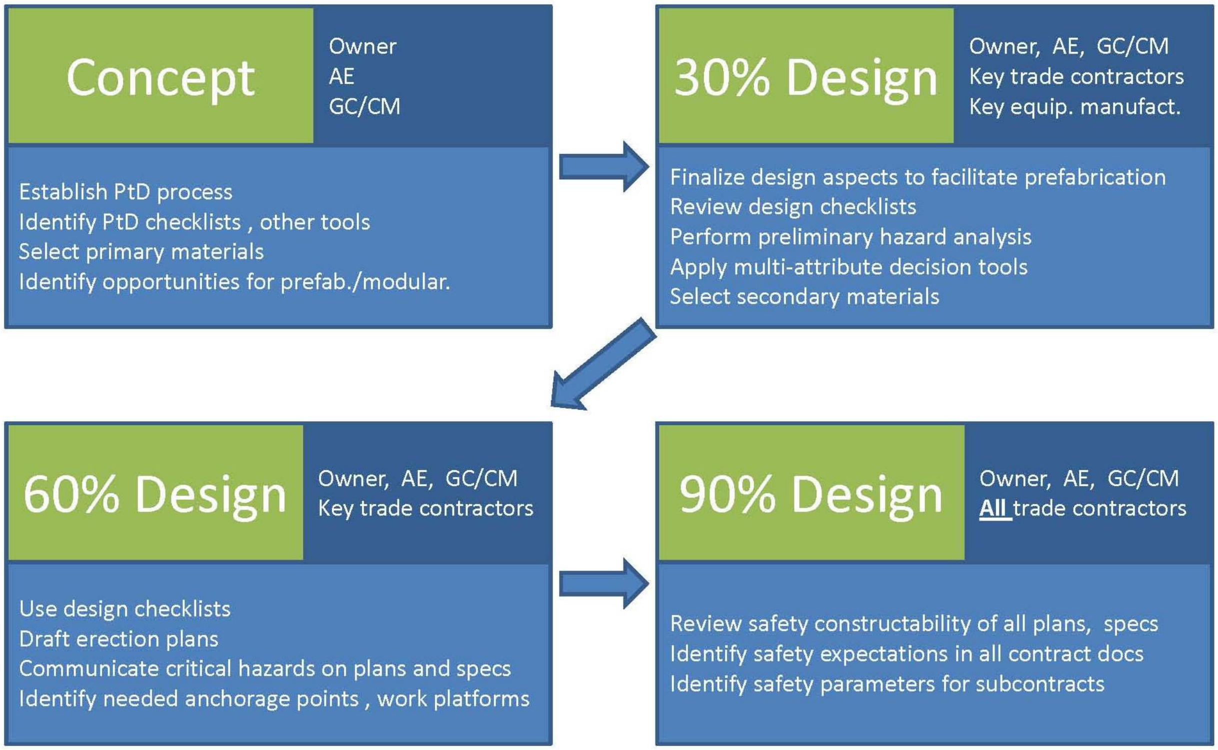




Figure A3.1: PtD Implementation Guide

A mistake that is common on construction projects is not to hold the first constructability review until later in the design process. As suggested in the figure on the next page, opportunities for identifying and facilitating prefabrication and modularization disappear around the 30% design stage. Because prefabrication and modularization can dramatically reduce construction injuries over "stick-built" construction (Toole and Gambatese 2009), constructability reviews that do not start until after the 30% design stage have significantly lower potential for designing a facility that is inherently safer to construct.

Two brief examples from recent construction projects illustrate the importance of early consideration of construction safety. During the concept design of large dam project on the Mississippi River, the project owner stated the desire to have the project completed without putting scuba divers in the water to inspect the construction, which is typical on such dam projects. This safety goal led the program manager to decide to use very large precast concrete modules. A similar principle is associated with a large solar boiler project being constructed in the Mojave Desert. The Program Manager's desire to reduce the amount of construction work performed at height led them to design the 400' tower to be assembled from very large prefabricated modules. Although the use of prefabricated modules on both projects will lead to substantial time, cost, and quality benefits as well, it is less likely that the modules would have been pursued if construction worker safety had not been explicitly considered and valued during the concept design phase.

**Collaboration Enhancing Processes**. Several special process elements are effective at enabling PtD (and constructible and high-quality design in general). First, designers and key construction personnel should be co-located (i.e., have nearby offices) throughout the design. Second, the owner should allocate sufficient time for the design stage, rather than constantly pushing for the design to be completed as soon as possible, which is common in the industry. Third, design and construction personnel must develop trusting relationships through a team-building retreat at the start of the design process. Fourth, the project personnel should use collaborative decision-making tools, such as those associated with lean construction. Fifth, design and construction personnel can share common financial incentives that drive each party to pursue the goals of the project, not just those of their employer. Although IPD is intended to maximize constructability input into a project's design, construction worker safety is not always explicitly included in the constructability review process.

**PtD-Related Knowledge.** Even if collaboration between designers and construction personnel is frequent and cordial, having PtD performed efficiently will be difficult if designers possess insufficient knowledge of construction hazards, construction means and methods, and potential design alternatives to improve safety. Owner firms may wish to hire only AE firms that provide their design employees with training on construction safety. For example, one large EPC firm has provided many of their design engineers with sixteen hours of construction safety training. Owners should also consider giving preference to AE firms that ensure the professional development of engineers (especially young employees) includes a field assignment in order to gain knowledge of construction means and methods. Finally, owners may wish to require AE employees to complete PtD-training before they are allowed to work on the owner's projects, as a large mining company has required for AEs working on a large building program in western Canada.

**PtD Tools**. Given that most design professionals lack sufficient knowledge of construction safety and PtD opportunities, owners should insist that design professionals have access to discipline-specific PtD checklists. Such checklists can be created in-house or secured from external sources. The Construction Industry Institute PtD tool developed by Professors J. Hinze and J. Gambatese provide a database of over 400 individual checklists, organized by construction phase (such as concrete, steel erection, etc.). The www.designforconstructionsafety.org website includes a spreadsheet containing 1,700 PtD examples and checklists that was compiled by Mr. Alan Speegle at the Southern Company. The Australian CHAIR system is another available tool.

Design managers should also consider providing their employees with reference tools and websites for increasing their employees' knowledge of construction safety in general and opportunities for designing for safety. Government agencies within the UK, Australia and Singapore have developed helpful tools that can be identified and accessed through links provided at www.designforconstructionsafety.org.

Many process/industrial construction owners have created lengthy and detailed risk assessment documents and require their use as part of a prescribed risk management process. These documents can serve as a tool to help designers follow a structured process to ensure all potential safety hazards are identified. It should be noted, however, that owners who wish to implement PtD on their projects should not assume their existing capital project risk management documents and processes sufficiently address construction worker safety.

**Information Technology Infrastructure**. Owner, designer, and construction personnel must be able to easily access draft design documents and share PtD-related and other constructability comments. A system must exist that facilitates tracking specific design suggestions from inception to closure. As such, a commercially-available project collaboration software package should be set up at the beginning of the design process, not at the start of construction. An owner seeking to implement PtD on a project should also insist that the designer and key contractor personnel use Building Information Modeling (BIM) software. BIM provides realistic 3D visualization that may allow designers and constructors to identify potential site hazards that are not obvious from viewing 2D plans. Four-dimensional (4D) BIM simulates the construction sequencing over time and allows designers and constructors to identify potential hazards not obvious from viewing static 3D renderings.

2. <u>Levels of PtD Implementation</u>

It is not the case that Prevention through Design is either implemented or not implemented on a project. There is a continuum of implementation levels and it may be appropriate for owners and architects/engineers (AEs) to progress from a low level of implementation to full implementation. Three levels of PtD implementation are summarized below.

**Level 1: Invisible PtD Process**
PtD is not mentioned during the AE proposal and selection process. AE does not ensure its employees and design consultants receive PtD training and does not use PtD design tools, but does consider safety constructability input from owners, CM or GC given during design progress reviews.

**Level 2: Added PtD Process**
PtD is not addressed in the owner's request for proposal (RFP) for design services or in the AE's proposal to the owner, but agrees (during discussions with owner leading to AE selection) to participate in a PtD process if the following text is included in the contract:

> "The AE may attempt to consider the safety of construction and maintenance workers during the design of the Project. It is expressly acknowledged that: a) such consideration shall be only to the extent reasonable possible given that AE may be lacking knowledge of the means, methods, techniques, sequences or procedures of construction that the Contractor will use; b) it is impossible for the design to reduce or eliminate all hazards, c) the Contractor retains sole responsibility for the safety of construction workers even for portions of the project on which the AE may have attempted to reduce site hazards

> through design decisions; d) there will be portions of the Project on which AE has made no effort to reduce hazards through design decisions; and e) that discussions between AE and Contractor or any subcontractor regarding safety or other aspects of the design, shall not be construed to establish a contractual relationship between the AE and Contractor or any subcontractors."

AE sends designers to PtD training given by owner or CM. AE is given PtD design tools by owner or CM and uses them. AE considers safety constructability input from owner, CM, GC, subs during design reviews.

**Level 3: Ideal PtD Process**
AE PtD capability is explicitly included in owner RFP and in the AE proposal and selection by owner. AE has internal PtD training program. AE chooses and uses PtD tools. AE has internal safety design reviews. Owner and constructors provide additional safety constructability input that is incorporated into design. AE actively solicits feedback on the safety of final design and uses lessons learned system to improve safety of future projects.

# A4 Contract Modifications to Incorporate PtD

**Example Modifications to AIA and EJCDC Standard Design Documents to Incorporate Prevention through Design (PtD)**

The objective of this document is to provide examples of how standard design contracts may be modified to require and/or encourage the incorporation of the Prevention through Design (PtD) concept within design services provided on a project. It is desired that, with its dissemination, the document will assist owners/clients with PtD implementation and provide designers with contractual direction on implementing PtD.

The document is designed to be an example of how design documents promulgated by the American Institute of Architects (AIA) and the Engineers Joint Contract Documents Committee (EJCDC) may be modified. It is intended for all types of design activities on all types of projects in the architecture/engineering/construction (AEC) industry.

The example modifications are not intended to be comprehensive of all changes that may be put in place. The modifications may not be appropriate for some projects and contractual relationships. *Prior to implementing the modifications, those utilizing the document should consult with their legal counsel to ensure that any changes made are appropriate.*

Added text is <u>underlined</u>. Strikethrough is used to show deleted text.

For more information about Prevention through Design, please see the following website: www.cdc.gov/niosh/topics/ptd/.

For more information about this document, please contact the National Institute for Occupational Safety and Health (NIOSH) at www.cdc.gov/dcs/ContactUs/Form.

**AIA Document A141 – 2014 Standard Form of Agreement Between Owner and Design-Builder**

Article 1 – General Provisions

“Section 1.1.4 The Owner’s anticipated Sustainable Objective for the Project, if any: *(Identify the Owner’s Sustainable Objective for the Project such as Sustainability Certification, benefit to the environment, enhancement to the safety, health and well-being of building occupants, construction workers, and building maintenance workers, or improvement of energy efficiency. If the Owner identifies a Sustainable Objective, incorporate AIA Document A141TM-2014, Exhibit C, Sustainable Projects, into this Agreement to define the terms, conditions and Work related to the Owner’s Sustainable Objective.)”*

“Section 1.1.9 Additional Owner’s Criteria upon which the Agreement is based: *(Identify special characteristics or needs of the Project not identified elsewhere, such as historic preservation requirements and safety requirements.)”*

Article 4 – Work prior to Execution of the Design-Build Amendment

Section 4.1 General:
“4.1.2 The Design-builder shall advise the Owner on proposed site use and improvements, selection of materials, and building systems and equipment. The Design-Builder shall also provide the Owner with recommendations, consistent with the Owner’s Criteria, on constructability; availability of materials and labor; time requirements for procurement, installation and construction; opportunities for enhancing construction and maintenance worker safety and health through the design phase of the Project; and factors related to construction cost including, but not limited to, costs of alternative designs or materials, preliminary budgets, life-cycle data, and possible cost reductions.”

Section 4.2 Evaluation of the Owner’s Criteria:
“4.2.1 The Design-Builder shall schedule and conduct meetings with the Owner and any other necessary individuals or entities to discuss and review the Owner’s Criteria as set forth in Section 1.1. The Design-Builder shall thereafter again meet with the Owner to discuss a preliminary evaluation of the Owner’s Criteria. The preliminary evaluation shall address possible alternative approaches to design and construction of the Project and include the Design-Builder’s recommendations, if any, with regard to accelerated or fast-track scheduling, procurement, or phased construction. The preliminary evaluation shall consider cost information, constructability, construction worker safety, maintenance worker safety, and procurement and construction scheduling issues.”

Section 4.3 Preliminary Design:
“4.3.1 Upon the Owner’s issuance of a written ~~consent~~ direction to proceed under Section 4.2.3, the Design-Builder shall prepare and submit a Preliminary Design to the

Owner. The Preliminary Design shall include a report identifying any deviations from the Owner's Criteria, and shall include the following:

.1 Confirmation of the allocations of program functions;
.2 Site plan;
.3 Building plans, sections and elevations;
.4 Structural system;
.5 Selections of major building systems, including but not limited to mechanical, electrical and plumbing systems; and
.6 Outline specifications or sufficient drawing notes describing construction materials <u>and Project features designed for construction and maintenance worker safety and health</u>."

Article 10 – Protection of Persons and Property

Section 10.2 Safety of Persons and Property:

Add the following subsection after Subsection 10.2.2:
<u>"The Design-Builder shall consider the safety and health of construction and maintenance workers during the design phase of the Project by: identifying significant safety and health hazards likely to be associated with constructing and maintaining the design; altering the design to mitigate the safety risk associated with the hazards; and, if the design cannot be reasonably altered, communicate the identified hazards and associated risk to those who will construct and maintain the design."</u>

Add the following subsection after Subsection 10.2.5:
<u>"The Design-Builder shall designate a responsible member of the Design-Builder's organization whose duty shall be to ensure that the safety and health of construction and maintenance workers have been taken into consideration for the project's service life and life-cycle cost during the design of the Project."</u>

**AIA Document A201 – 2007 General Conditions of the Contract for Construction**

Article 3 – Contractor

Section 3.3 Supervision and Construction Procedures:
"3.3.1 The Contractor shall supervise and direct the Work, using the Contractor's best skill and attention. The Contractor shall be solely responsible for, and have control over, construction means, methods, techniques, sequences and procedures and for coordinating all portions of the Work under the Contract, unless the Contract Documents give other specific instructions concerning these matters. If the Contract Documents give specific instructions concerning construction means, methods, techniques, sequences or procedures, the Contractor shall evaluate the jobsite safety thereof and, except as stated below, shall be fully and solely responsible for the jobsite safety of such means, methods, techniques, sequences or procedures. If the Contractor determines that such means, methods, techniques, sequences or procedures may not be safe, the Contractor shall give timely written notice to the Owner and Architect, <u>recommend changes to the Project design that may mitigate the safety hazards,</u> and shall not proceed with that portion of the Work without further written instructions from the Architect. If the Contractor is then instructed to proceed with the required means, methods, techniques, sequences or procedures without acceptance of changes proposed by the Contractor, the Owner shall be solely responsible for any loss or damage arising solely from those Owner-required means, methods, techniques, sequences or procedures.

Article 10 – Protection of Persons and Property

Section 10.2 Safety of Persons and Property:

Add the following subsection after Subsection 10.2.2:
<u>"When providing input on the design to the Owner or Architect, the Contractor shall consider the safety and health of construction workers by: identifying significant safety and health hazards likely to be associated with constructing the design; suggesting design alternatives to mitigate the safety risk associated with the hazards; and, if the design cannot be reasonably altered, mitigating the risk through other safety measures. The Contractor shall solicit, from specialty subcontractors on the project, input regarding the impacts of the design on the safety and health of the construction, operations, and maintenance workers."</u>

**AIA Document B101 – 2007 Standard Form of Agreement Between Owner and Architect**

Article 3 – Scope of Architect's Basic Services

Section 3.2 Schematic Design Phase Services:
"3.2.2 The Architect shall prepare a preliminary evaluation of the Owner's program, schedule, budget for the Cost of the Work, Project site, and Owner's project requirements (OPR), inclusive of a plan for ensuring the safety and health of the occupants, construction workers, and maintenance workers, and the proposed procurement or delivery method and other Initial Information, each in terms of the other, to ascertain the requirements of the Project. The Architect shall notify the Owner of (1) any inconsistencies discovered in the information, and (2) other information or consulting services that may be reasonably needed for the Project."

Section 3.2 Schematic Design Phase Services:
"3.2.3 The Architect shall present its preliminary evaluation to the Owner and shall discuss with the Owner alternative approaches to design and construction of the Project, including the feasibility of incorporating environmentally responsible and safe design approaches. The Architect shall reach an understanding with the Owner regarding the requirements of the Project."

Section 3.2 Schematic Design Phase Services:
"3.2.5.2 The Architect shall consider the value of alternative materials, building systems and equipment, together with other considerations based on program, safety, and aesthetics, in developing a design for the Project that is consistent with the Owner's program, schedule and budget for the Cost of the Work."

Section 3.2 Schematic Design Phase Services:

Add the following subsection following Subsection 3.2.5.2:
"The Architect shall consider the value of safe design alternatives together with other considerations based on program and aesthetics, in developing a design for the Project that is consistent with the Owner's program, schedule and budget for the Cost of the Work, with a separate review of the design for the service life and demolition of the facility."

Article 4 – Additional Services

Section 4.1:
Add the following additional services item to the list provided in the table:

"Design for construction safety review"

Section 4.3.1:

Add the following additional item to the list of services provided after item 4.3.1.2:

“Services necessitated by the Owner’s request for design alternatives that enhance the safety and health of construction and maintenance workers.”

**EJCDC E-500 (2014) Agreement between Owner and Designer for Professional Services**

Exhibit A – Engineer's Services

Section A1.01 – Study and Report Phase, Subsection A:

10. "When mutually agreed, assist Owner in evaluating the possible use of building information modeling; civil integrated management; geotechnical baselining of subsurface site conditions; safety prevention through design phases; innovative design, contracting, or procurement strategies; or other strategies, technologies, or techniques for assisting in the design, construction, and operation of Owner's facilities. The subject matter of this paragraph shall be referred to in Exhibit A and B as "Project Strategies, Technologies, and Techniques."

Section A1.01 – Study and Report Phase, Subsection A:

After Subsection A.11, add a new clause similar to A.11 that reads as follows:
"If requested to do so by Owner, assist Owner in identifying opportunities for enhancing construction and maintenance safety through the design phases of the Project, and pursuant to Owner's instructions, plan for the inclusion of features in the design that enhance worker safety and health during construction and maintenance."

Section A1.02 – Preliminary Design Phase:

A. "After acceptance by Owner of the Report and any other Study and Report Phase deliverables; selection by Owner of a recommended solution; issuance by Owner of any instructions of for use of Project Strategies, Technologies, and Techniques, or for inclusion of sustainable or construction and maintenance safety-related features in the design; and indication by Owner of any specific modifications or changes in the scope, extent, character, or design requirements of the Project desired by Owner, (1) Engineer and Owner shall discuss and resolve any necessary revisions to Engineer's compensation (through application of the provisions regarding Additional Services, or otherwise), or the time for completion of Engineer's services, resulting from the selected solution, related Project Strategies, Technologies, or Techniques, sustainable design instructions, or specific modifications to the Project, and (2) upon written authorization from Owner, Engineer shall:"

Section A1.02 – Preliminary Design Phase, Subsection A:

2. "In preparing the Preliminary Design Phase documents, use any specific applicable Project Strategies, Technologies, and Techniques authorized by Owner during or following the Study and Report Phase, and include sustainable and safety-related features, as appropriate, pursuant to Owner's instructions."

Section A2.02 – Additional Services Not Requiring Owner's Written Authorization, Subsection A:

4. "Additional or extended services arising from (a) the presence at the Site of any Constituent of Concern or items of historical or cultural significance, (b) emergencies or

acts of God endangering the Work, (c) damage to the Work by fire or other causes during construction, (d) a significant amount of defective, neglected, or delayed Work, (e) acceleration of the progress schedule involving services beyond normal working hours, (f) recognized site-specific construction safety hazards, or (g) default by Contractor."

Exhibit B – Owner's Responsibilities

Section B2.01:

L. "Inform Engineer in writing of any specific requirements of safety or security programs that are applicable to the Designer of Record / Engineer, as a visitor to the Site or as part of the design of the Project to enhance the safety and health of construction and maintenance workers."

Section B2.01:

After Subsection O, add a new clause similar to Subsection O that reads as follows: "Advise Engineer as to whether Engineer's assistance is requested in identifying opportunities for enhancing construction and maintenance worker safety and health on the Project through the design phases of the Project."

**EJCDC D-700 (2009) Standard General Conditions of the Contract Between Owner and Design/Builder**

Section 6.01 – Design Professional Services, Subsection B – Preliminary Design Phase:

Add the following new clause to the list of clauses:

[After the Contract Times commence to run, Design/Builder shall:]

8. "Assist Owner in identifying opportunities for enhancing construction and maintenance safety of the Project, and pursuant to Owner's instructions, plan for the inclusion of features in the design that enhance worker safety and health during construction, operation, maintenance, and demolition."

Section 6.01 – Design Professional Services, Subsection C – Final Design Phase:

Add the following new clause to the list of clauses:

[After written acceptance by Owner of the preliminary design phase documents, Design/Builder shall:]

5. "During preparation of the final design documents, include a formal, documented review and consideration of construction and maintenance worker safety and health in the final design of the Project."

Section 6.13 – Safety and Protection:

Add the following new clause to the list of clauses:

G. "Design/Builder shall consider the safety and health of construction and maintenance workers during the design phases of the Project. Design/Builder shall identify safety and health hazards associated with the design, and design the Project to eliminate or reduce the hazards and mitigate the safety and health risks. If the design cannot be reasonably altered, Design/Builder shall communicate the identified hazards and associated risks to those who will construct, operate, maintain, and demolish the facility."

Section 6.14 – Safety Representative:

A. "Design/Builder shall designate a qualified and experienced safety representative ~~at the Site~~ for the Project whose duties and responsibilities shall be the prevention of accidents and the maintaining and supervising of safety precautions and programs, and provide input into the design of the Project to benefit the safety and health of those who construct and maintain the Project."

B. Coordinate with the Design/Builder, or Owner provided insurance program and insurance provider, to provide a review of design documents evaluating risks posed to the construction, operations, maintenance, and demolition personnel.

**EJCDC C-700, Rev 1 (2013) Standard General Conditions of the Construction Contract**

Section 7.12 – Safety and Protection:

Add a new clause to the list that reads as follows:

H. "If requested to do so by Owner, assist Owner and/or Designer of Record / Engineer in identifying opportunities in the design phases of the Project for enhancing construction, operation, and maintenance safety of the Project, and pursuant to Owner's instructions, plan for the inclusion of features in the design that enhance worker safety and health during construction, operation, and maintenance."

Section 7.13 – Safety Representative:

A. "Contractor shall designate a qualified and experienced safety representative ~~at the Site~~ for the Project whose duties and responsibilities shall be the prevention of accidents and the maintaining and supervising of safety precautions and programs, and if requested to do so by Owner, provide input into the design of the Project to benefit the safety and health of those who construct and maintain the Project."

B. The Owner shall designate a qualified and experienced safety representative for the design and construction phases of the Project whose duties and responsibilities shall be the prevention of worker injuries and the maintaining and supervising of safety precautions and programs, and if requested to do so by the Owner, the Contractor shall provide input in the design phases of the Project to benefit the safety and health of those who construct, operate, and maintain the Project.

## Example PtD Clauses for Inclusion in Design Consultant Contracts

*The following example clauses were prepared by T. Michael Toole/University of Toledo and John Gambatese/Oregon State University, in part based on a CPWR/NIOSH-funded research project conducted 2007-2009. The clauses are intended to assist owner organizations implement a PtD program on a project, ensure that PtD activities are undertaken, and monitor the success of the PtD program. When standard contract documents are utilized (e.g., EJCDC E-500 and AIA B101), care should be taken to integrate the selected clauses with the other portions of the contract. Consultation with and assistance from legal counsel is recommended.*

### Example PtD Clauses

Engineer shall attempt to consider the safety of construction and maintenance workers during the design of the Project. It is expressly acknowledged that: a) such consideration shall be only to the extent reasonably possible given that Engineer may be lacking knowledge of the means, methods, techniques, sequences or procedures of construction that the Contractor will use; b) it is impossible for the design to reduce or eliminate all hazards, c) the Contractor retains sole responsibility for the safety of construction workers even for portions of the project on which Engineer has attempted to reduce site hazards through design decisions; d) there will be portions of the Project on which Engineer has made no effort to reduce hazards through design decisions; and e) that discussions between Engineer and Contractor or any subcontractor regarding safety or other aspects of the design, shall not be construed to establish a contractual relationship between the Engineer and Contractor or any subcontractors.

The Architect may attempt to consider the safety of construction and maintenance workers during the design of the Project. It is expressly acknowledged that: a) such consideration shall be only to the extent reasonably possible given that Architect may be lacking knowledge of the means, methods, techniques, sequences or procedures of construction that the Contractor will use; b) it is impossible for the design to reduce or eliminate all hazards, c) the Contractor retains sole responsibility for the safety of construction workers even for portions of the project on which the Architect may have attempted to reduce site hazards through design decisions; d) there will be portions of the Project on which Architect has made no effort to reduce hazards through design decisions; and e) that discussions between Architect and Contractor or any subcontractor regarding safety or other aspects of the design, shall not be construed to establish a contractual relationship between the Architect and Contractor or any subcontractors.

Engineer shall:

- Consult with Owner and/or Contractor regarding the constructability of the design, including whether aspects of the design can be made less hazardous through changes that will not significantly affect other project criteria.
- Consider revising Preliminary Design Phase documents in response to Contractor’s comments regarding constructability, as appropriate and as approved by Owner.

## Appendix 23: Recommended Changes to the IPD Agreement to Facilitate DfCS

Excerpts from Integrated Agreement for Lean Project Delivery Between Owner, Architect & CM/GC

*This document includes excerpts from the IPD agreement used on a hospital construction project that are related to construction safety. The italicized text are suggested changes to the agreement if design for construction safety was to be explicitly implemented on the project.*

11.3. Constructability. The IPD Team shall continually review the Design Documents for clarity, consistency, constructability and coordination among the construction trades and collaborate with the IPD Team in developing solutions to any identified issues. The purpose of the Constructability Reviews is to determine that the design is progressing in a manner that will result in complete, accurate and coordinated drawings which are sufficiently complete and coordinated for construction, and thereby reduce the risk of disruption, delay, *injuries*, change orders and potential claims. CM/GC and the Subcontractors will focus on accuracy, completeness, sequencing and coordination. These reviews will also seek out alternative construction materials, sequences, details, pre-fabrication opportunities, and systems that may result in a cost or time savings to Owner, or increased quality *and safety and health*. Nothing in this section shall relieve Architect, CM/GC or any Subcontractor, Supplier or Architect's Consultant from its obligation to perform its services or work in accordance with the terms of its contract and the applicable standard of care.

16.5. Means and Methods. Architect will neither have control over or charge of, nor be responsible for, the construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the Work, since these are solely CM/GC's and Subcontractor's rights and responsibilities under the Contract Documents, except as expressly provided elsewhere. *Notwithstanding the previous sentence, it is acknowledged that the Architect is expected to participate in discussions relating to constructability while design is occurring.* Architect will not be responsible for CM/GC's failure to perform the Work in accordance with the requirements of the Contract Documents. Architect will neither have control over or charge of, nor be responsible for, acts or omissions of CM/GC, Subcontractors, or their agents or employees, or of any other persons performing portions of the Work.

20. SAFETY PRECAUTIONS AND PROGRAMS

20.10. Architect's Role. *Notwithstanding the previous paragraphs, Architect is expected to participate in discussions relating to constructability, including aspects relating to safety, while design is occurring.* Architect's review of CM/GC's performance does not include review of adequacy of CM/GC's safety measures.

*(The paragraph below is a new paragraph that is modeled on paragraph 25 "**QUALITY OF THE WORK AND SERVICES"** in the agreement.**)***

***25B. PROJECT SAFETY AND HEALTH***

*25B.1. Safety Initiative. The goal of Lean Project Delivery is production of defect-free work at the least cost, in the least time possible and without posing unnecessary risk to project personnel. Recognizing and avoiding risks that could have been designed out in the first place is costly both in time and dollars and is not a value-adding activity. While it is recognized that construction is an inherently dangerous process, safety and health should be considered during the design phase and the resulting design should be as safe to implement as reasonably possible.*

*25B.2. Design for Safety Plan. Architect and CM/GC, in collaboration with other IPD Team Members, shall participate and develop a design for safety plan that, at a minimum, addresses the following issues:*

> *25B.2.1. Confirming that the Contract Documents adequately communicate that design for safety will be part of the Project'*
>
> *25B.2.2. Training project personnel on design for safety concept and the potential consequences of design processes that fail to consider the safety of construction workers;*
>
> *25B.2.3. Providing design and construction personnel with relevant design for safety checklists and other available tools;*
>
> *25B.2.4. Design of feed-back mechanisms for on-site managers and corporate safety managers to review early work product and assure completion according to conditions of satisfaction;*
>
> *25B.2.5. Integration of safety review and management with hand-off criteria and the Six Week Look Ahead Plan;*
>
> *25B.2.6. Protocols for trades to discuss and assure a safe working environment;*
>
> *25B.2.7. Procedures for immediately discussing injuries and other safety-related incidents*
>
> *25B.2.8. Procedures for recognizing outstanding performance and safety according to the conditions of satisfaction;*

# A5 Professional Liability (PL) Insurance Guidance

**Professional Liability Insurance Guidance for Design Professionals with respect to Prevention through Design (PtD) Activities**

The objective of the attached document is to provide designers and design firms with general guidance regarding Professional Liability (PL) insurance coverage as it relates to Prevention through Design (PtD). It is desired that, with its dissemination, the document will help clarify and inform designers about how PL insurance coverage may or may not provide liability protection associated with PtD implementation, and provide designers with recommended actions to take in order to maintain professional liability protection when implementing PtD.

The document is designed to be brief and generic. It is intended for all types of design firms performing any type of design activities in the architecture/engineering/construction (AEC) industry. The descriptions of PL insurance policies and coverage are intended to be general in nature and do not provide a comprehensive description of all types of PL insurance policies and coverage. *Prior to implementing PtD,* d*esigners should consult with their PL insurance provider with respect to the specific coverage provided by their PL insurance policy.*

PL insurance providers may elect to distribute the document directly to their policy holders. If so, the PL insurance provider may choose to modify the document prior to distributing the document to their clients to more accurately reflect the specific PL insurance policies and coverage that it provides.

For more information about Prevention through Design, please see the following website: www.cdc.gov/niosh/topics/ptd/.

For more information about this document, please contact the National Institute for Occupational Safety and Health (NIOSH) at www.cdc.gov/dcs/ContactUs/Form.

**What is Prevention through Design?**

Prevention through Design (PtD) is a safety and health management principle that supports eliminating or reducing hazards through the design of a product or process (i.e., "designing out" the hazards). PtD promotes preparing designs that eliminate or reduce foreseeable safety and health hazards rather than exposing downstream stakeholders, i.e., those who use, construct, operate, maintain, and recommission/decommission the product, to the hazards.

For the architecture/engineering/construction industry (AEC), PtD encompasses all of the following attributes:

- Implemented when any design activities are performed during any phase of a facility's lifecycle;
- Implemented by any architect, engineer, or other design professional or any person providing design services;
- Applied to any design element/feature of a facility, both permanent and temporary; and
- Addresses the safety and health of all parties affected by the design, including the end-users, constructors, operators, maintainers, and any others affected by the design during the facility's lifecycle.

PtD is a design principle; it is implemented, either formally or informally, as part of design services.  Importantly, PtD does not include a designer directing, controlling, or supervising the means, methods, techniques, sequences, or procedures implemented to use, construct, operate, maintain, or recommission/decommission the facility. In addition, PtD does not include a designer assuming responsibility for safety during the construction phase. PtD does not extend a designer's scope of work to include active designer participation in or oversight of the construction operations of a project in any way.

**PtD in AEC Industry Design Practice**

For the AEC industry, PtD is consistent with current design practice which promotes creating safe designs. PtD is just one of many different safety and health interventions that may be implemented by a project team to enhance the safety and health of those who interact with a design. Additionally, PtD may be implemented at any point in a facility's lifecycle when design takes place, and target the safety and health of any downstream stakeholders affected by the design in any of its forms.

Current design practice includes formal consideration of PtD for the safety and health of the end-users of a design after it is constructed. Design contracts, governing regulations, building codes, and standard practice typically address the safety and health of the public and those who use the facility or design feature in its final form after it has been constructed.

Formal inclusion of PtD with respect to *construction* worker safety and health, however, is typically not included in design scopes of work by contract, regulation, code, or standard practice. However, PtD may be utilized as an intervention for construction worker safety and health. For construction workers, PtD poses the question, "How can this element be designed to reduce the safety risk to those who will construct the element?" That is, when designing a permanent or temporary element of a facility, a designer may elect to create a design that enhances the safety and health of construction workers. By doing so, the hazard is eliminated or reduced through the design, rather than transferring the safety risk to others downstream who are typically only able to use less reliable and less effective safety controls.

Those designers who choose to implement PtD with respect to the safety and health of construction workers, whether via contract or voluntarily, may be concerned with potential liability associated with incorporating it into their professional services. Mitigating the liability exposure to third party claims related to professional services is a key step to accepting and including PtD in professional services. Therefore, it is important for designers to understand how PtD fits within standard professional liability insurance coverage and what actions to take when planning to implement PtD with respect to construction worker safety and health.

**What does Professional Liability Insurance Cover?**

Professional liability (PL) insurance provides, to the insured party, protection from third-party claims that result from alleged wrongful acts by the insured. A PL insurance policy commonly pays on behalf of the insured AEC firm all sums which the insured becomes legally obligated to pay as a result of a wrongful act occurring during the policy period anywhere in the world. A wrongful act refers to any negligent act, error or omission, by the insured or any entity for which the insured is legally liable, arising out of the performance of or failure to perform professional services. The following general definitions apply to PL insurance:

- Bodily injury claims are those claims in which there is physical injury, sickness, disease, or death sustained by a person, which directly results from the insured's performance of professional services including supervision of the work, and any resulting humiliation, mental injury, mental anguish, emotional distress, suffering, or shock.
- A wrongful act is an error, omission, or other act that causes liability in the performance of professional services for others by the insured or by any person or entity for whom the insured is liable. A wrongful act cannot arise from dishonest, fraudulent, malicious, or criminal conduct committed by the insured or at the insured's direction or with the insured's prior knowledge.
- A design defect is a type of wrongful act in which the design does not meet the established standard of care. Design defects commonly do not include any actual or alleged negligence in the review of shop drawings and submittals, issuance of change orders, observation of construction or review of any contractors' requests for payment.
- Professional services are commonly those services that the insured performs for others on behalf of a named insured in the insured's practice as an architect, engineer, interior designer, land surveyor, LEED® green building program consultant, landscape architect, construction manager, scientist, expert or forensic witness, land/space planner, or technical consultant.

When implementing PtD as part of professional services, PL insurance covers third-party claims for negligent acts, errors, or omissions associated with implementing PtD unless such services and resulting damages are specifically excluded. It is important to note that AEC professional liability policies are not standardized across the industry; the coverage discussions in this document are based on commonly available policy forms. Designers should consult with their insurance provider regarding the specific coverage provided in their PL insurance policy.

**What does Professional Liability Insurance not Cover?**

While professional liability policies can differ in many ways, and designers should consult their insurance provider to understand the specific coverage provided in their policy, PL insurance policies typically identify exclusions for which coverage is not provided. For example, PL insurance coverage may exclude claims resulting from bodily injury to an employee of the insured, since that is covered by workers' compensation insurance. Claims arising from providing construction services may also by excluded, where "construction" is typically defined as the assembly, erection, excavation, fabrication, installation, demolition, or other similar or related work or services on any building, structure, or facility, including on any element or component of such. Faulty workmanship, liquidated damages, and contractual liability are examples of exclusions among others that are commonly included in PL insurance policies.

As a design activity, when implemented as part of the designer's identified professional services, PtD does not fall within a type of exclusion that is commonly included within PL insurance policies. However, PL policies may exclude "the preparation or failure to prepare any safety precautions or procedures in connection with any project" or more broadly "supervision of the safety obligation of others." This type of exclusion should be removed via endorsement if PtD services are being provided. Designers should consult with their insurance provider regarding this exclusion.

**Recommended Actions for Design Professionals in the AEC Industry**

Incorporating PtD into an organization's professional services can enhance the safety and health of those who use, construct, operate, maintain, and recommission/decommission a facility. Focusing PtD on the safety and health of those who construct a design element/feature, whether permanent or temporary, requires additional consideration and planning to ensure that potential wrongful acts are covered by PL insurance. Any project or design service that is new and/or unusual from the designer's perspective should involve careful consideration of appropriate security and risk transfer options with respect to the design. Recommended actions by design professionals to ensure appropriate planning and liability coverage when implementing PtD with respect to construction worker safety and health include the following eight steps:

1. Prepare and document a formal process to be followed when implementing PtD as part of professional design services;

2. Identify and, if possible quantify, the foreseeable risks to the AEC firm that are associated with implementing PtD according to the PtD process developed;
3. For the identified risks, identify planned controls to mitigate the risk and how the controls will be implemented;
4. Educate those implementing the PtD process while performing design services about PtD and train them on how to implement the PtD process developed;
5. Provide a description of the PtD process to your PL insurance provider for its reference and comment;
6. Together with consultation from your PL insurance provider, review your PL insurance policy and ensure that it provides the level of protection you desire with respect to PtD;
7. Carefully review professional liability policies provided by other AEC project participants to assure there are no exclusions that would remove coverage for PtD services provided;
8. Document when and how the PtD process is implemented during design and the outcomes of its implementation; and
9. Regularly monitor the implementation of the PtD process and modify it when needed.

# A6 Organizational Procedure for Integrating OSH & PtD

*Source: Renshaw, F.M., Model Prevention through Design (PtD) Program, Draft Final Report to National Institute for Occupational Safety and Health (NIOSH), May 6, 2011.*

| [Organization Name] | **OCCUPATIONAL SAFETY AND HEALTH PROCEDURE** |
|---|---|
| **TITLE: INTEGRATION OF OSH INTO THE CAPITAL PROJECT PROCESS** | **Document Number:**<br><br>**Issue Date:** |

## 1.0 PURPOSE

1.1 The purpose of this procedure is to clarify and reinforce the requirement to address occupational health and safety (OHS) considerations in capital projects at the design and redesign stage before changes occur. This is to be accomplished by integrating OHS methods and procedures, such as OHS Design Reviews, Hazard Analysis and Risk Assessment studies, and hazard control measures into the Capital Project Process (Appendix 1 – Integration of OHS Deliverables into the Capital Project Process). Optimum results are achieved when the output from these methods and procedures is delivered at the appropriate stage in the process.

1.2 The integration of OHS into the Capital Project Process has its origin in the XYZ Company's Environmental, Health, and Safety Policy (7.1) and OHS Management System, Operational Element 5.1.2: Design Review and Management of Change (7.2). This integration process directly supports the Company's commitment to include Prevention through Design considerations in the design and redesign of all facilities, equipment, processes, work methods and products, and to incorporate methods of safe design into all phases of hazard and risk mitigation.

1.3 This procedure extends and applies requirements of the XYZ Company's Management of Change Standard (7.3) to the Capital Project Process. A thorough understanding of XYZ Company's Management of Change process as set forth in the standard is essential for successful use of this procedure.

## 2.0 SCOPE

2.1 This procedure applies to all manufacturing, technology, warehouse and office sites within the [organization name]. It covers all projects valued at $50,000 or more which are managed in accordance with the [organization name] Capital Project Process. Projects involving engineering design and new construction, major redesign of existing facilities, processes and operations, and transfers of technology into existing operations are covered by this procedure.

2.2 Direct-purchase items which are capitalized, such as computer software, office equipment, and laboratory apparatus, are not covered by this procedure. OHS issues associated with direct-purchase items and capital projects valued at less than $50,000 are expected to be addressed through the local management of change process of the receiving organization.

## 3.0 RESPONSIBILITIES

3.1 Capital project managers are responsible for ensuring that OHS Design Reviews, Hazard Analysis and Risk Assessment studies, and other required OHS methods and procedures are scheduled, conducted, followed up, and documented for their projects. This includes the submission of a Project OHS Deliverables Plan (Appendix 2 – OHS Deliverables Planning Template) with each project authorization request and completion of the Planning Template form as part of the project closeout.

3.2 Manufacturing/operations managers are responsible for approving the OHS Deliverables Plan for each project authorization request involving their facilities.

3.3 Engineering functional managers are responsible for monitoring the quality and completeness of OHS methods and procedures and their integration into the Capital Project Process.

3.4 OHS managers assigned to manufacturing/operations groups are responsible for reviewing the OHS Deliverables Plan for their group's capital projects. They are also responsible for advising capital project managers in the selection of qualified OHS resources, Hazard Analysis and Risk Assessment studies, and application of other OHS methods and procedures.

3.5 OHS technical staff assigned to capital project teams are responsible for the correct application and use of specified OHS methods and procedures and assisting other project team members in the use of these methods and procedures.

3.6 Engineering technical staff assigned to capital project teams are responsible for the correct application and use of the specified OHS methods and procedures.

3.7 Facility managers, as lead representatives of the receiving organizations for capital projects, are responsible for maintaining the overall safety of their facilities for site personnel, contractors, visitors and the surrounding community during all stages of the project. They are also responsible for providing input and arranging local site participation in the OHS methods and procedures for the project, and for ultimately accepting the new installation upon completion.

3.8 Employees of the receiving organization are responsible for providing input and participating in OHS methods and procedures for capital projects as requested by their site management and capital project team management.

3.9 Contractors are responsible for following site and project safety rules and procedures, and participating in OHS methods and procedures for capital projects as requested by contractor management and project team management.

3.10 Suppliers of equipment, materials and services are responsible for meeting specifications provided by the project team including all certifications and approvals prescribed by regulatory authorities. Suppliers are also responsible for cooperating with project team members in conducting tests, checks, field trials and final installation in connection with acceptance of their products.

## 4.0 REQUIREMENTS

4.1 OHS Design Reviews as well as Hazard Analysis and Risk Assessment studies must be scheduled, conducted, followed-up and documented by the project or technology transfer manager for each qualifying capital project.

4.2 Prevention through Design considerations must be included in the design and redesign of all facilities, equipment, processes, work methods and products, and safe design methods incorporated into all phases of risk mitigation.

4.3 All projects within the scope of this procedure are expected to meet or exceed the “Basic Change” category as defined in the [organization name] Management of Change Standard [7.3]. An OHS Design Review is required as a minimum. The need for additional OHS methods and procedures, including Hazard Analysis and Risk Assessment studies, are to be determined on the basis of the project features, complexity, and OHS requirements. Major facility, process or equipment changes require a Hazard Analysis and Risk Assessment study in addition to an OHS Design Review [7.3]. Recommendations as to which methods and procedures are needed and when in the various stages of the Capital Project Process, are provided in Appendix 1. It is not intended that every project will be subjected to every OHS method and procedure. The objective is to ensure that a conscious decision is made as to the appropriateness of each OHS deliverable by the project team manager in consultation with the manufacturing/operations OHS manager where necessary.

4.4 Capital project managers are required to complete and forward an OHS Deliverables Plan (Appendix 2) to the appropriate manufacturing/ operations manager and OHS manager with each project authorization request.

4.5 The project OHS Deliverables Plan must be approved by the manufacturing/operations manager and OHS manager as part of the approval process for the project authorization request.

4.6 All OHS Design Reviews and all Hazard Analysis and Risk Assessment studies included in the project OHS Deliverables Plan must be conducted by qualified resources using approved analysis/assessment methods. Qualified resources and approved methods are those specified in the [organization name] standard on Management of Change, in applicable government standards, and as recommended by the manufacturing/ operations OHS manager.

4.7 The manufacturing/operations OHS manager is to be included by information copy on all meeting notices for capital project OHS Design Reviews and all Hazard Analysis and Risk Assessment studies as well as the results of such reviews and studies.

4.8 Documentation of all capital project OHS Design Reviews and all Hazard Analysis and Risk Assessment studies is required. Action items generated from these reviews and studies must include an assigned owner, target completion date, and must be tracked to closure by the Capital Project Team manager.

## 5.0 DEFINITIONS

5.1 Basic Change – A deliberate, permanent or interim change in equipment, material, process, operating procedure, organization, packaging or any non-routine operation.

5.2 Capital Project Process – The management systems-based process whereby all stages of development and construction of new facilities, processes, products and equipment, as well as modifications to existing units are managed to achieve the desired results.

5.3 Hazard Analysis and Risk Assessment Studies – An organized, systematic evaluation of equipment, processes or operations that identifies and analyzes hazards, assesses risks associated with those hazards, and recommends safeguards to reduce risks to acceptable levels. A Hazard Analysis and Risk Assessment study may be required for a Basic Change and will be required for Major Facility or Process changes. Refer to [organization name] Management of

Change Standard (Reference 7.3) for brief descriptions of selected Hazard Analysis and Risk Assessment studies.

5.4 Major Facility, Process or Equipment Change – A major new installation or fundamental process change involving hazardous materials or equipment that may invalidate a previous Hazard Analysis and Risk Assessment.

5.5 Management of Change – A procedure to manage changes to facilities, processes, materials, equipment, and work methods such that the impact of those changes is not detrimental to the occupational health and safety of personnel or the community.

5.6 OHS Deliverables – OHS methods and procedures which are expected to be conducted and results generated at specified stages in the Capital Project Process. Deliverables include, but are not limited to: early identification of significant and unique OHS hazards and risks, early identification of Prevention through Design opportunities, OHS Design Reviews, Hazard Analysis and Risk Assessment studies, insurance assessments for fire protection and security, preparation and submission of permit applications for regulatory approval, review and approval of detailed drawings, pre-construction safety plans, construction permits, pre-start-up OHS reviews, acceptance testing of equipment and OHS devices, preliminary industrial hygiene exposure monitoring, incident investigations, residual risk assessment, and OHS standards modification.

5.7 OHS Design Review – A systematic process for carefully reviewing design attributes, applications, misapplications, energy control systems, human interactions and compliance with codes, permits and standards. OHS Design Reviews attempt to identify hazards and hazardous conditions that are foreseeable throughout the life cycle of a product or process, and to develop mitigation strategies. In most cases a Design Review is conducted through a meeting including the appropriate functions to specifically address occupational health and safety implications of planned changes. An OHS Design Review is appropriate for basic changes as well as major facility or process changes.

5.8 Prevention through Design – A comprehensive national initiative of NIOSH (National Institute for Occupational Safety and Health) for saving lives and preventing work-related injuries and illnesses. The initiative is grounded in three key concepts:

- Eliminating hazards and controlling risks to workers to an acceptable level “at the source” or as early as possible in the life cycle of processes, facilities, equipment, and products.

- Including design, redesign and retrofit of new and existing work premises, structures, tools, facilities, equipment, machinery, products, substances, work processes and the organization of work.
- Utilizing the traditional hierarchy of controls by focusing on hazard elimination and substitution followed by risk minimization through the application of engineering controls and warning systems. Prevention through Design also supports the application of administrative controls and personal protective equipment when they supplement or complement an overall risk minimization strategy and include the appropriate program development, implementation, employee training and surveillance.

## 6.0 RECORDS GENERATED

6.1 An OHS Deliverable Plan must be completed for each project, including a description of the applicable stage in the capital project process, the type of review or study, date completed, verification that minutes were generated and an action item list developed and documented.

6.2 Documentation must be provided for each OHS Design Review, Hazard Analysis and Risk Assessment study, including a list of action items, assigned owner, target completion date and a notation indicating the status and date each action was completed.

## 7.0 REFERENCES

7.1 XYZ Company Environmental, Health, and Safety Policy, MMDDYY 2011.

7.2 XYZ Company Standard for Occupational Health and Safety Management Systems, OHSMS Operational Element 5.1.2: Design Review and Management of Change, MMDDYY 2011.

7.3 XYZ Company Management of Change Standard, MMDDYY 2011.

## 8.0 APPENDICES

8.1 Appendix 1
- Worksheet 1 - Stages in the Capital Project Process
- Worksheet 2 - Integration of OHS Deliverables into the Capital Project Process

8.2 Appendix 2 - OHS Deliverables Planning Template

# A7 PtD Programs and Processes

PtD programs and processes have been developed and implemented by a variety of organizations in the construction industry. Each program/process is tailored to the unique needs and desires of the organization. Provided below are examples of PtD programs and processes from different organizations. The examples are intended to illustrate the wide variety of PtD programs and processes that have been developed. It is recommended that an organization create its own program/process that fits within its organizational structure, culture, and goals.

## BHP Billiton Prevention through Design (PtD) Program

BHP Billiton's Jansen Potash project in Saskatchewan, Canada, created its Prevention through Design (PtD) Program to incorporate construction, operations, and maintenance expertise into the design phase of projects. The PtD program aims to mitigate hazards in the design by "bridging the gap" between designers and end-users. The objectives of the program are twofold:

1. Provide a structured and documented approach for implementing HSE requirements early in a project's lifecycle; and
2. Apply sound engineering principles to mitigate health, safety, and environment (HSE) risks during project design by leveraging the knowledge and experience of the design team.

The overall goal of the program is to produce an inherently safer facility design that is less reliant on administrative and procedural controls, minimizes environmental footprint, and does not expose workers to long term health hazards. By utilizing a team of experts from engineering, operations, maintenance, construction, and HSE, these considerations are brought into early stages of the design process.

Initiatives or ideas are also generated in a variety of risk workshops, design reviews, HAZOPS, and event analyses from industry. The ideas are then evaluated for suitability and applicability, and captured in a database for tracking and verification (see Figure A7.1).

Transmit Tools Reports

1 - 100 of 303 documents (0 selected) <<previous 1 2 3 4 next>>

| Document No | Title | Description | Impact Type | Hazard Type | Control Measure | Project (s)/Area (s) | Supplier | Status | Risk Reduction | Source | Severity Before | Likelihood Before | Severity After | Likelihood After | Responsible Discipline |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BHPB-PTD-00100 | Odourized CO2 Fire Suppression Gas | To help prevent potentially lethal ... as the CO2 system discharges into the risk." | S - Safety | Chemical | 3 – Redesign | Jansen Surface | SNCL | Closed | | Internal | | | | | Building Services |
| SNC-PTD-00001 | Guide Rail System Submersible Pumps | To reduce confined space entry and to minimize ... be used to connect and disconnect the pumps. | S - Safety | Hygiene: Airborne Contaminants | 1 – Eliminate | Jansen Surface | SNCL | Verified | 2 - Significant | Internal | 4 | 0.3 | 1 | 1 | |
| SNC-PTD-00002 | Lifting Davits Submersible Pumps | To reduce potential over-exertion when ... boom and manually or electrically operated. | S - Safety | Ergonomics | 1 – Eliminate | Jansen Surface | SNCL | Verified | 1 - Minor | Internal | 2 | 1 | 1 | 0.3 | |
| SNC-PTD-00003 | Man access hatches 950 mm diameter minimum | To minimize the associated risk associated ... with lock, safety chain and inspection window. | S - Safety | Ergonomics | 3 – Redesign | Jansen Surface | SNCL | Verified | 1 - Minor | Internal | 1 | 1 | 1 | 1 | |
| SNC-PTD-00004 | Wireless Transmitters | Utilize wireless transmitters to minimize ... temperature & humidity, dusty conditions, etc. | S - Safety | Hygiene: Airborne Contaminants | 4 – Separate | Jansen Surface | SNCL | Closed | | Internal | 0.0 | 0.0 | 0.0 | 0.0 | |

Figure A7.1: PtD Database

Design reviews focus on specific issues including: design safety, operability and maintainability, construction sequence of events, equipment location and setting requirements, and site spatial relationships between permanent facilities, construction equipment/facilities, and the workforce. Design discipline reviews include drawing reviews of discipline deliverables such as: earthworks, foundations, structural steel, architectural, piping, rotating equipment, vessels and exchangers, electrical, instruments, paint, insulation and fireproofing, specialty technology packages, vendor packages, and modularization packages. 3D models of the design are utilized to facilitate design reviews. Where appropriate, PtD requirements are included in the technical specifications for a project.

In addition, a special focus is given to human factors design. The basic framework developed for the assessment of human factors in the design follows the hierarchy of controls used to mitigate safety and health hazards, as shown in Figure A7.2.

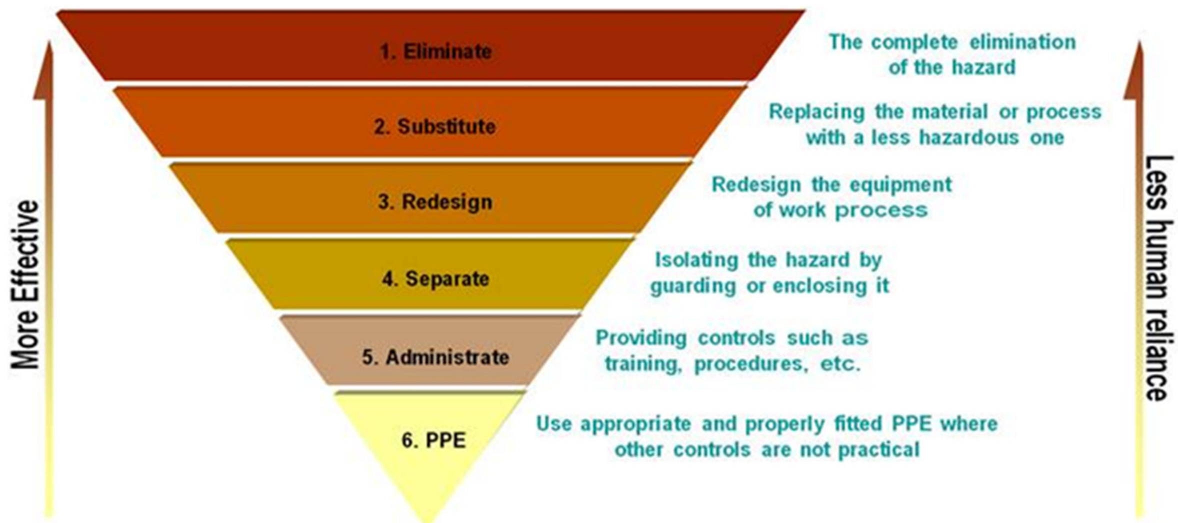


Figure A7.2: Hierarchy of Controls

**PtD Training:**
Orientation and training regarding the PtD program for all engineering firms and suppliers involved in the project are provided to give them sufficient foundational knowledge about the philosophy and how to apply the process.

**PtD Process:**
The PtD process consists of the following six steps, and is illustrated in Figure A7.3:

STEP 1 – GENERATE IDEA
The first step in the process is the identification of a PtD idea. Common sources for PtD ideas include, but are not limited to:

- Design Development: Engineers are accountable for the inherent safety of their designs. Coordination with other disciplines and specialist groups (i.e., HSEC, Construction, Maintenance, and Operations) is essential to ensure that PtD has been incorporated prior to the design.

- Document Reviews: A PtD idea may be added to a drawing or vendor document as a comment during the document review cycle or may be developed during discussions related to engineering drawings.
- Risk: Risk assessments and Hazard and Operability (HAZOP) studies are a structured and systematic examination of a process or operation identifying risks to personnel or equipment.
- 3D Model Reviews: During 3D model review meetings maintainability and constructability tags are generated with corresponding action items. The reviews take place at approximately the 30%, 60%, and 90% points in the completion of the design.
- PtD idea log: All ideas are catalogued in the Aconex database.

STEP 2 – TECHNICAL VALIDATION
This step is coordinated by the PtD Team within the project structure and the idea is presented for technical validation prior to implementation.

STEP 3 – CHANGE MANAGEMENT QUALIFICATION
Before an idea is incorporated into design, the potential impact will be assessed through the change management process used to approve or reject scope changes, thereby closing the project control cycle loop.

STEP 4 – CHANGE MANAGEMENT
The PtD Team will ensure that all necessary information related to the PtD idea is included in the change request (i.e., Idea description, risk reduction, technical validation notes).

STEP 5 – DESIGN IMPLEMENTATION
Once all necessary approvals are in place, the Engineering team can implement the PtD idea into the design and deliverables such as technical specifications, design criteria, scopes of work, and other design documents or drawings.

STEP 6 – VERIFICATION
Ideas will be verified on the final issue drawings and work (i.e., issued for construction/design).

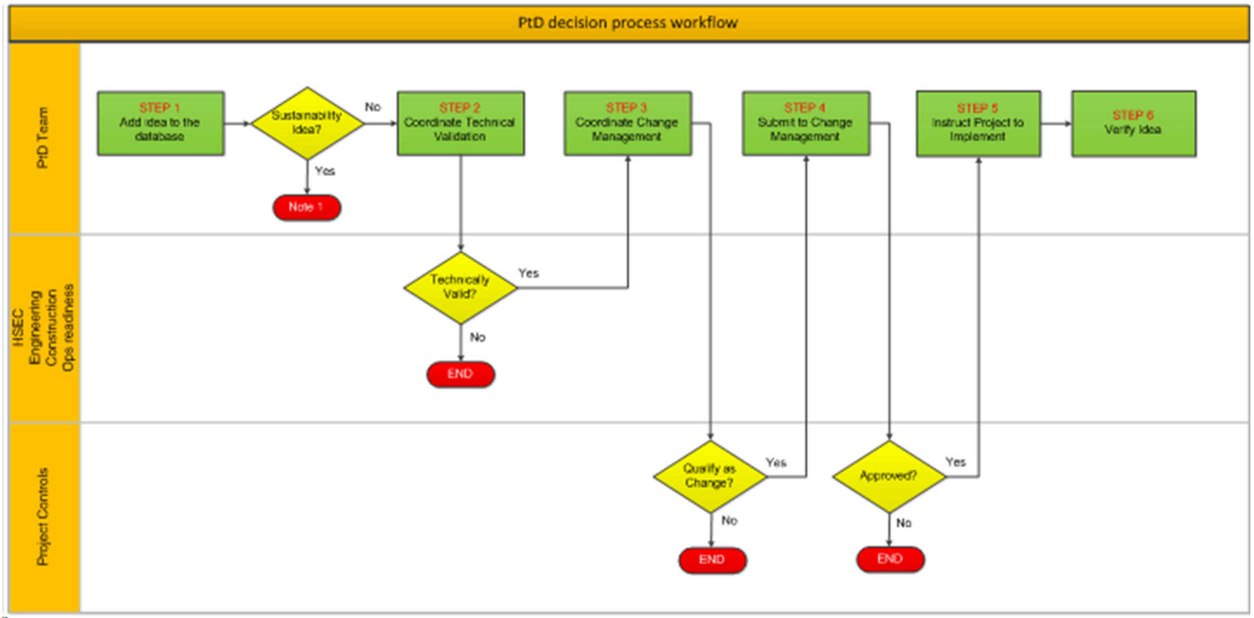


Figure A7.3: PtD decision process workflow

**PtD Recognition:**
A PtD recognition process is included to promote and reward the generation of valuable input from project participants.

**PtD Program Evaluation:**
BHP Billiton conducts periodic evaluation of its PtD program. Key program performance indicators are used to assess the program's level of effectiveness. As an example, the ideas by control method, shown in Figure A7.4, illustrates that controls relying on human behavior (e.g., administrative procedures, and PPE) are weak compared to risk elimination and substitution which contribute to an inherently safer design.

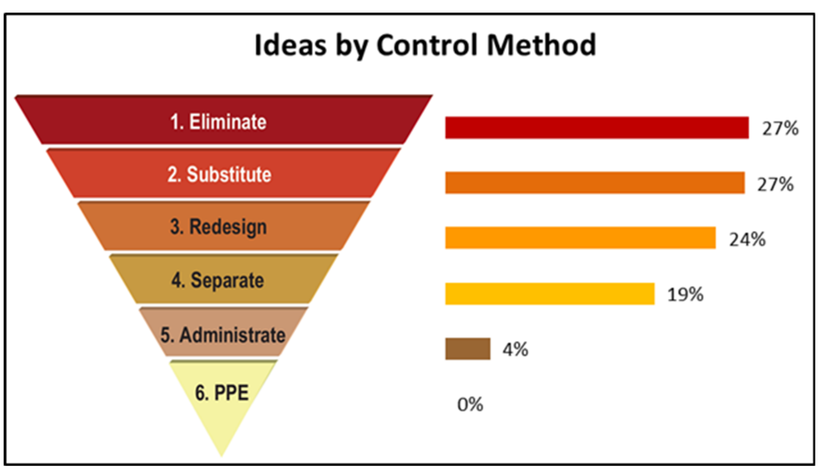


Figure A7.4: Ideas by Control Method

The PtD initiatives have had a significant impact on the risk management process.  Four examples of implemented PtD initiatives are shown in Figure A7.5 along side the hazard risk reduction chart.

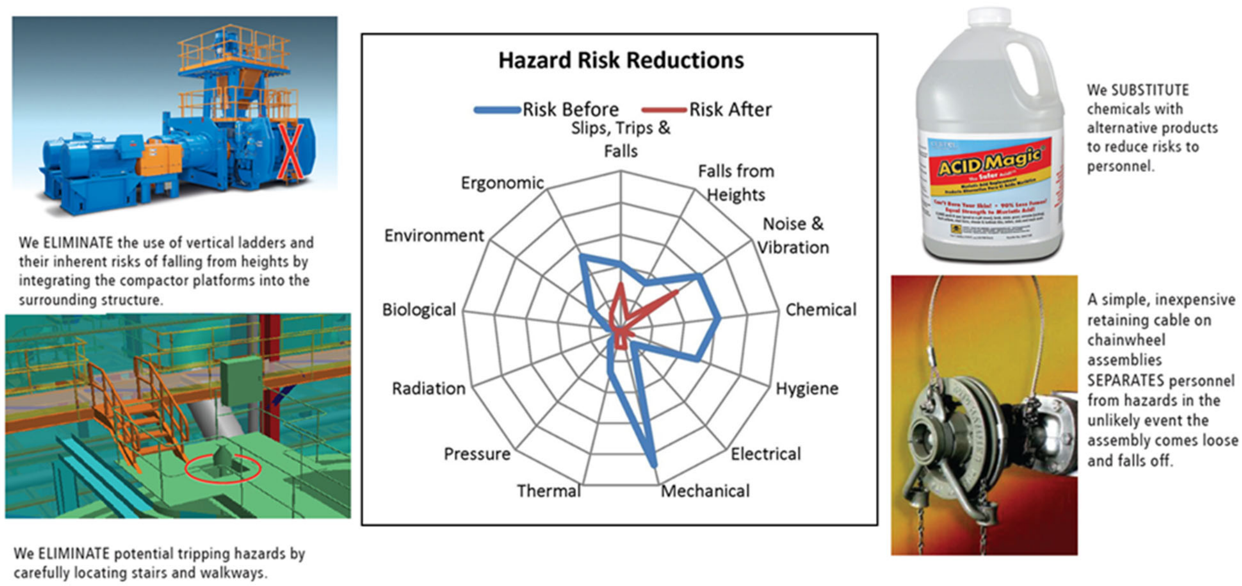


Figure A7.5: Hazard Risk Reduction

The strong PtD presence during the design will reduce injuries during operations and expensive changes, resulting in a cost-efficient and inherently safer design. The direct and indirect results of culture shift fostered by the PtD program will have a lasting legacy.

**Bovis Lend Lease (BLL) *Risk and Opportunity at Design* (ROAD) Program**

Bovis Lend Lease (BLL), an international design and construction company, has established and implemented a program that it calls ROAD – *Risk and Opportunity at Design* (Zou et al. 2008). ROAD aims to eliminate or minimize the risks of injury throughout the life of the product being designed by involving all decision makers that will be involved in the lifecycle of the product (ASCC 2006). ROAD incorporates the following key principal elements and considerations: person with control, product lifecycle, systematic risk management, safe design knowledge and capability, and information transfer. BLL implements the ROAD process through the following nine steps (BLL 2004, Zou et al. 2008):

- Building element assessment at pre-construction phase
- Trade package assessment at construction stage
- Recording ROAD document and uploading into the project management plan
- Including a ROAD agenda item on design program meetings
- Establish action and status lists
- Update and report status at each design review
- Actions from ROAD issues considered prior to approval for construction
- Environment, health, safety, and quality monthly management meetings review the reporting of projects including the ROAD status
- Monthly update of the ROAD document as part of the project review

In their research of the effectiveness and impacts of ROAD at BLL on case study projects, Zou et al. (2008) indicate that architects and clients can gain from many beneficial qualities that come with implementing ROAD in the earlier phases of the project lifecycle. These benefits include improved worker safety and health plus improvements in productivity, usability, cost savings, and the management and prediction of costs. The researchers also found that implementing the ROAD process made the assessment and minimization of safety risks at the design stage a key priority. In addition, BLL took advantage of additional factors resulting from ROAD such as greater teamwork, communal accountability and responsibility for safety, and stronger control and management of safety risks that could disrupt strict timetables and budgets.

**Sources:**

ASCC (2006). "Guidance on the Principles of Safe Design for Work," Australia Safety and Compensation Council (ASCC), Canberra, May 2006.

BLL (2004). "Safety in Design Guidelines," Bovis Lend Lease (BLL) internal company publication.

Zou, P.X.W., Redman, S., and Windon, S. (2008). "Case Studies on Risk and Opportunity at Design Stage of Building Projects in Australia: Focus on Safety." *Architectural Engineering and Design Management*, Earthscan, www.earthscanjournals.com, Vol. 4, pp. 221-238.

## Foster and Partners Safety in Design Program

Foster and Partners, an international architecture and design firm based in London, has responded to the UK's CDM regulations to incorporate safety and health in its programming and design activities (Istephan, 2004). The firm has developed a program that includes the following components:

- Training to increase the competence of its employees
- Design reviews
- Integration of health and safety with existing quality assurance systems
- Integration of safety into other systems, e.g. specifications
- Production and transfer of information
- Management of knowledge through feedback, adjustments, and lessons learned

A critical part of Foster and Partners' program is the early start and planned timing of the design reviews (Istephan, 2004).

**Source:**

Istephan, T. (2004). "Collaboration, total design, and integration of safety and health in design – Project case studies." In: Hecker, S., Gambatese, J., and Weinstein, M. (Eds.), Designing for Safety and Health in Construction: Proceedings from a Research and Practice Symposium, September 15–16, Portland, Oregon, USA. Eugene, OR: UO Press, 264-279.

**The Haskell Company "Designing for Safety" Program**

As a design-build firm that targets the industrial, commercial, government, and civil infrastructure markets, the Haskell Company is in a good position to implement PtD on its projects. PtD is facilitated with open and timely communication between constructors and designers. The design-build method of project delivery, especially when it involves a single design-build firm, enables this communication and collaboration to occur.

The Haskell Company's "Designing for Safety" Program begins with a policy about safety and designing for safety. The policy states:

> "Design-build is a process wherein all team members participate in and are responsible for all aspects of the project. We are all responsible for creating safe environments, preventing injury and saving lives. State licensing boards charge licensed professionals with responsibility for health, *safety* and welfare of the public. Our responsibilities include facility constructors, users and maintenance personnel.
>
> Safety is promoted in project design through the following company policies:
>
> - Safety education/training/awareness:
>     - All A/E professional and management staff shall attend safety educational training courses.
>     - All A/E staff shall receive training on designing inherently safe buildings, including use of Safety Design Checklists.
> - Promoting safety during construction:
>     - The Safety Alert System shall be incorporated in design documents on all projects."

In support of its PtD program efforts, Haskell recognized that it needed to train its employees. Therefore, the company created training modules which it uses to train its employees about safety and its PtD program. The training modules are as follows:

- Module 1 – Introduction to Safety
- Module 2 – Jobsite Safety
- Module 3 – Safety Design

The modules target the design aspects of safety and include material necessary to receive OSHA 10-hour certification. The modules also provide the opportunity for design professionals to receive continuing education credits. All in-house design professionals attend the training course. In addition, a 1.5 hour short course is provided to orient technical staff to the PtD program and provide training on application of how to insert safety awareness symbols in construction drawings.

A unique aspect of Haskell’s PtD program is its Safety Alert System (SAS). The SAS includes three components:

- Periodic progress reviews of the design and design documents. This includes use of a Safety Design Checklist.
- Final safety review conducted near the completion of the design. The review is conducted by the Manager of Safety for the project.
- Insertion of safety hazard symbols in the design documents, and corresponding OSHA reference, to alert construction staff and other downstream stakeholders of the hazards present in the design. Symbols related to the following hazards are provided:
    - Slips/falls
    - Electrocution
    - Cave-ins
    - Falls from elevation
    - Struck by/against/caught
    - Asphyxiation – confined spaces
    - Demolition hazard
    - Struck by – steel erection

**Sources:**

The Haskell Company, “Design for Safety” Program, October 13, 2004.

Simons, L.G. and Engdahl, D.L. (2005). “Designing for Safety – We’re All Responsible.” *Design-Build Dateline*, Design-Build Institute of America (DBIA), Vol. 12, No. 2, pg. 20, Feb. 2005.

**Intel *Life Cycle Safety* (LCS) Process**

Hecker et al. (2005) describe the *Life Cycle Safety* (LCS) process developed by the Intel Corporation. In the LCS process, construction worker safety is considered along with safety in operability, maintainability, and re-tooling in the conceptual and design phases of a newly constructed manufacturing facility. Trade contractors familiar with similar facilities are hired during design to provide construction safety input during the conceptual and design phases of a project. Ad-hoc meetings with trade contractors are held to focus on specific options for evaluating implications for constructability, value engineering, and safety. A Safety in Design checklist, which evolved from previous projects, is used and provides a foundation for the LCS group. LCS reviews are conducted of every design package prepared by the design team. Figure A7.6 illustrates the design review process and targeted reviews for each design package along with the timing of the reviews for fast-track projects.

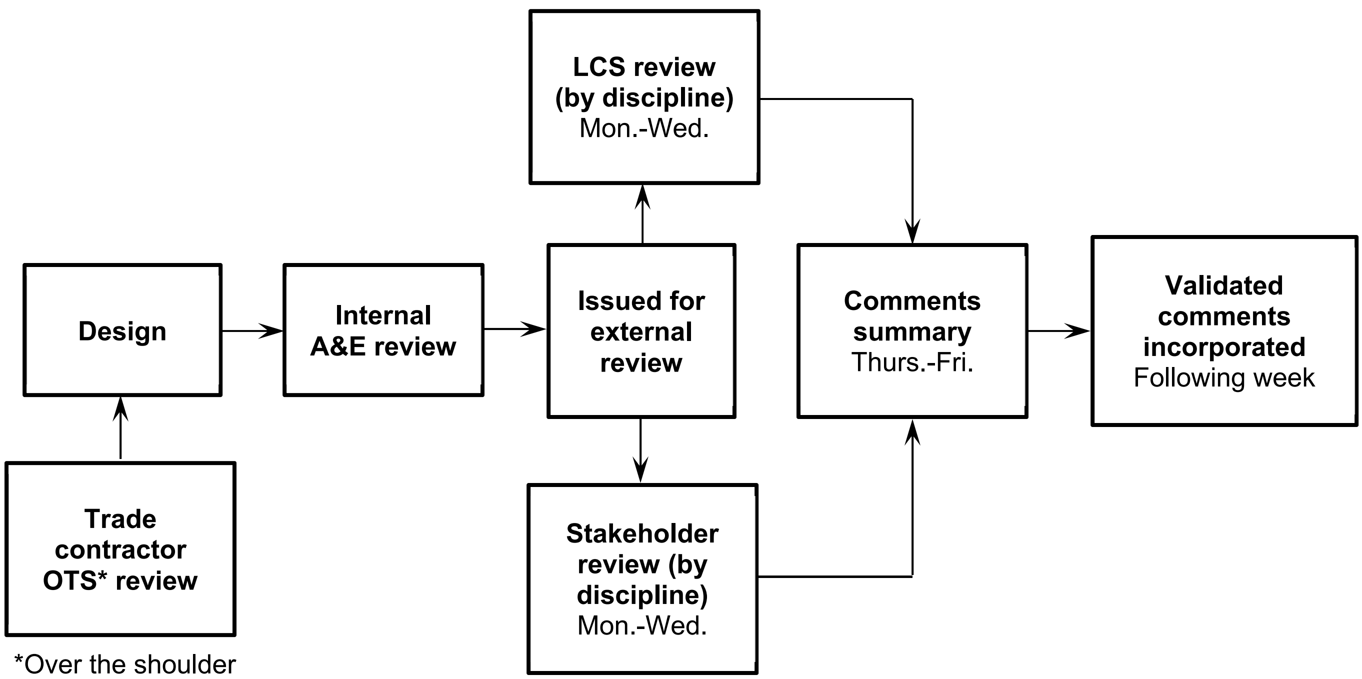


Figure A7.6: LCS Detailed Design Review Process (Hecker et al. 2005, modified)

Several tools are used as part of a total evaluation plan to assist workgroups in systematically addressing each project goal and provide a graphical representation of their findings. Each tool was developed to address a specific part of the evaluation. The Change Evaluation Checklist and supporting Project Goal Evaluation Worksheet provide a comprehensive view of each work group's assessment against each of the project goals. The Option Evaluation Sheet and Option Summary provide each workgroup with a way to quantify the pros and cons of each option against the project goals. This tool also allows multiple options to be compared against each other. The Risk Comparison and a Mitigation Plan was developed to assist in specifically evaluating hazards for options under consideration and proposing mitigation strategies for phases of the building lifecycle. These phases are Construction, Tool Install/Retrofit, and Facilities and Manufacturing Operations & Maintenance. A report on the evaluations is included in the weekly Project Team Review.

Research to study the LCS process revealed that it was successful in minimizing construction safety and health hazards when a dedicated evaluation of construction safety was considered early in the life of a project (Hecker et al. 2005).

**Source:**

Hecker, S., Gambatese, J., and Weinstein, M. (2005). "Designing for Worker Safety: Moving the Construction Safety Process Upstream." *Professional Safety*, Journal of the American Society of Safety Engineers (ASSE), 50(9), 32-44.

## Port of Portland Prevention through Design (PtD) Program

The Port of Portland initiated its formal Prevention through Design (PtD) program to eliminate hazards and minimize risks associated with Port facilities, work methods, processes, equipment, and products. The Port's PtD initiative is designed to help ensure that hazard assessments for construction, operations, and maintenance are conducted so that worker safety is considered during a building's design. The Port describes the process as simply a formal, common process that can be used to consistently implement PtD on its projects.

To develop its PtD program and procedures, the Port looked to existing national safety and engineering standards, such as the ANSI/ASSE Z590.3-2011 standard titled "Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes." Basing the program on this standard ensures that risk assessments take place regularly during both the design and construction phases. In addition, the process accounts for the cases where hazards cannot be eliminated through the design. In such cases, the residual risk is mitigated by implementing engineering controls, warning systems, administrative controls, and personal protective equipment (PPE).

A key aspect of the Port's PtD program is the timely inclusion of staff and stakeholders. Those involved and affected by the design participate in scheduled review sessions that focus on constructability, operability, and maintainability. The Port views its PtD program as one element in an overall worker safety and health program, and hopes that the PtD program will help the Port qualify for and participate in the OSHA Safety and Health Achievement Recognition Program (SHARP).

In conjunction with its PtD program, the Port has implemented parapet design standards that prescribe parapet heights to be at least 39 inches tall. Parapets of such height meet the OSHA guardrail height requirements. A review of past work activities on its roofs revealed that employees worked very close to roof edges, exposing them to fall hazards. The parapet standard eliminates the need for installation of roof anchors and use of worker fall protection, and minimizes the chance of the workers falling.

In addition to reducing hazards around its facilities, one outcome from the PtD program realized by the Port is an increase in communication. The process promotes discussion between designers and constructors as to how a building element can/should be designed to make it safer to construct and maintain. The Port has found that the PtD procedures and processes help ensure that these types of conversations occur regularly.

**PtD Process:**

The Port developed several documents to support the implementation of its PtD program. A description of the PtD process is provided in a flowchart that depicts the steps that are to be undertaken during a project. The flowchart begins with the Project Manager/Project Engineer having an initial discussion to identify stakeholders who may have a stake in PtD on the project. The process continues with the development and use of a PtD log, a PtD charrette that includes all project team members and stakeholders, periodic design reviews, cost estimates of PtD suggestions, and incorporation of PtD items in the project file. A form is also available on which concerns about maintenance issues associated with the proposed design can be recorded and communicated to the project team. Copies of the flowchart, PtD log, and maintenance input for are shown below.

**Source:**

Martinec, F. (2014). "OP-ED: Port working to ensure safety through design." Daily Journal of Commerce, Portland, OR, www.djcoregon.com/news/2014/03/12/op-ed-port-working-to-ensure-safety-through-design/, March 12, 2014.

## Southern Company Design for Safety (DfS) Program

The Southern Company, a power provider within the southeastern part of the US, has developed a Design for Safety (DfS) program to alert design personnel of construction worker safety, operations safety, constructability, lessons-learned, and code requirements (Toole et al. 2012). The DfS program is a design engineering effort that supports Southern's "Target Zero" company-wide safety program.

Southern's DfS program begins with a meeting between the key design personnel and construction personnel on the project. A flowchart depicting the process is provided in Figure A7.7. The meeting is scheduled for no later than 25% completion of the design. Prior to the meeting the design leads review a design for safety checklist that Southern created which contains prompts to query the designers regarding aspects of their design. An excerpt from the design safety checklist for civil works design is shown in Figure A7.8. The designers also are instructed to search a DfS/lessons-learned database for applicable suggested designs.

Constructability issues and site specific hazards are identified and added during the conceptual and detailed design phases of the projects. Specifications are reviewed for safety, and the applicable checklist and database items are discussed and updated. Modifications to the design are made accordingly following the meetings.

A web page describing the DfS program was set up on the firm's intranet which describes the program and provides assistance to those involved. In addition, an internal DfS team was established to implement and monitor the DfS program, maintain and update the checklist and database, and provide assistance to project personnel. Training on the DfS program was provided for all design and construction personnel as Southern began the program.

**Source:**

Toole, T.M., Gambatese, J.A., and Abowitz, D.A. (2012). "Owners' Role in Facilitating Designing for Construction Safety," Final Research Report. The Center for Construction Research and Training, January 2012.

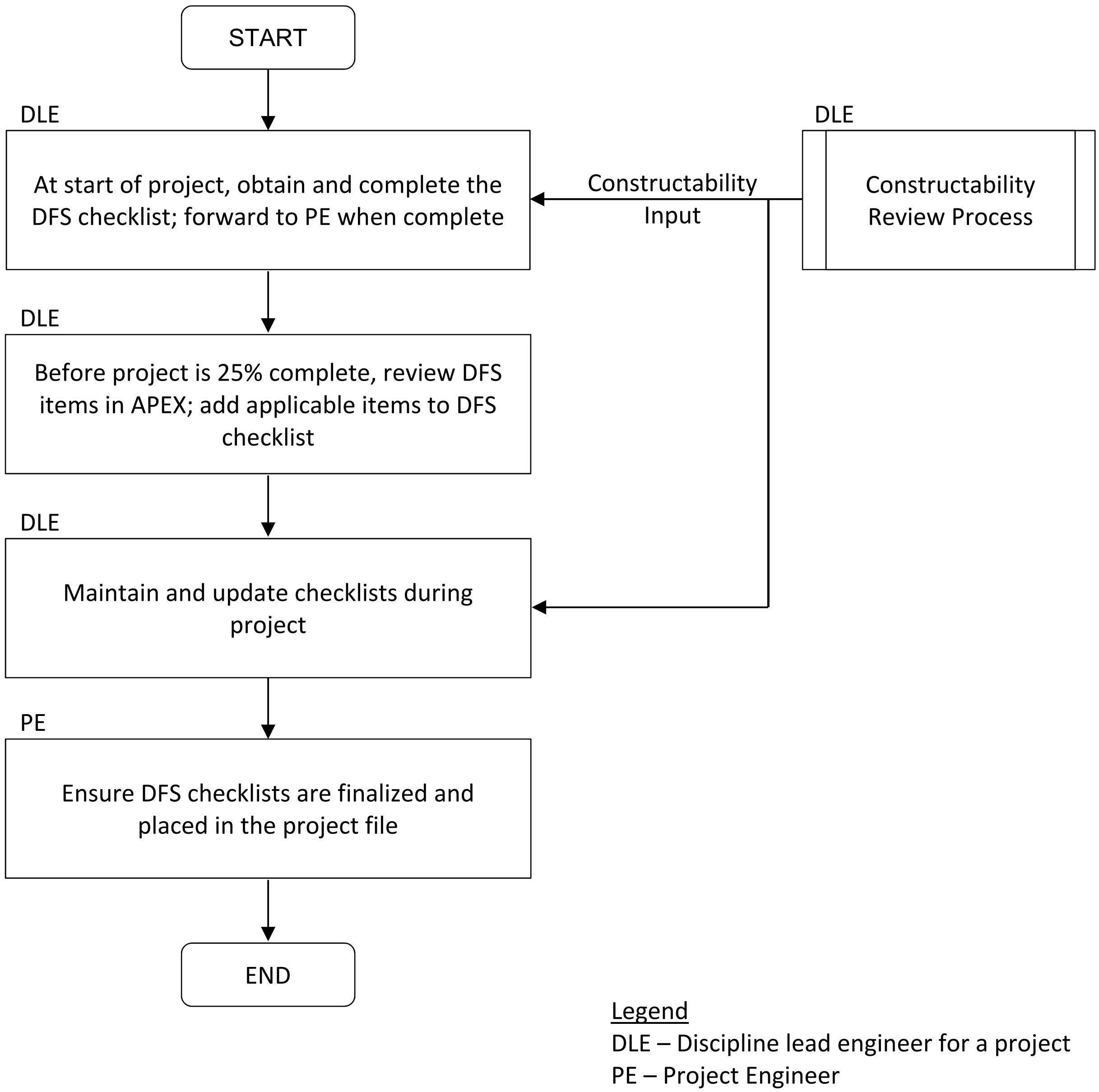


Figure A7.7: Design for Safety Process Flowchart

## 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 proper disposition for structural specified **materials**. (Examples: high strength bolts, U-drain grates, concrete cylinder breaks.) |

Figure A7.8: Excerpt from Design Safety Checklist for Civil Works Design

## A8 Example Rating System PtD Credit

*The following is an example of a credit related to construction worker safety and health that could be included in a sustainability rating system for new construction. (Source: Paul Muller/Muller Architects, Inc., modified by John Gambatese/Oregon State University and Nicholas Tymvios/Bucknell University)*

**Example Credit for Including PtD in a Sustainability Rating System**

**INTENT**

The intent of the credit is to maximize the health and safety of people on the construction site. This aim is achieved through utilizing innovative approaches and techniques that increase safety throughout the entire process of design and construction, and by encouraging the use of safe practices and participation in safety thinking by all project participants.

**PREREQUISITES**

To be considered for this credit, projects must satisfy the other credits related to occupational safety and health that are contained within the rating system. Exception will only be given when the other credits are not applicable to the project.

**REQUIREMENTS**

In addition to the Prerequisites indicated above, at a minimum, ensure the project employs cross-discipline design and decision making, beginning in the programming and pre-design phase, and includes the following activities:

- **Preliminary Safety Goals.** Before Schematic Design, conduct a Preliminary Safety meeting of at least the four key project team members as described below, including the Owner or Owner's representative. During the meeting the following should be decided:
    - The creation of a Safety and Health Action Plan that, at a minimum, includes the following:
        - The Safety Targets (desired outcomes) for the project.
        - The creation of a Safety and Health Action Team that will monitor all safety and health aspects for the project. The Action Team should include representatives from major parties involved, such as the Owner, Designer, Contractor, and major Subcontractors. Since contractors are not always known during Schematic Design, population of the Action Team can take place as the major parties become known and involved in the project.

- **Design for Safety Plan.** Prepare a Design for Safety Plan that addresses how the project team will review and design the project for the safety of the construction workers, maintenance staff, and facility operators. The design team must incorporate safety aspects into its design and consult with contractors whenever possible. Design elements in the proposed construction must be designed for health and safety for everyone involved during construction, operation, and maintenance. Priority shall be given to designing out safety and health hazards wherever practicable.

- **Construction Safety Plan.** Prepare a Construction Safety Plan that significantly exceeds OSHA "Safety and Health Standards for Construction" (29 CFR 1926). Exceed "OSHA 30" training and certification by a verifiable amount. Review Federal guidelines such as EM-385.1.1 for additional safety strategies. The Safety Plan should also include sections, where applicable, for the following construction activities:
  - If construction involves brownfield redevelopment, potential risks to worker safety and health must be outlined in the Safety Plan along with the necessary actions needed to handle any brownfield redevelopment risks.
  - If construction involves the reuse of existing walls, floors, roofs, and interior nonstructural elements, the Safety Plan must address any potential risks that might be present to worker safety and health and list the actions that need to be taken in order to counteract the risks.
  - The Safety Plan must include instructions for the safe handling of construction waste material.
  - The Safety Plan must include instructions for the safe reuse of materials salvaged from the construction site.
  - The Safety Plan must prescribe a "smoke-free" construction site.

- **Training.** Conduct the *OSHA 10-hour* construction outreach training course, and make it compulsory for all workers and managers involved in the project as well as members of the design team.

- **Monitoring.** The Safety and Health Action Team shall monitor the implementation of both the Design for Safety Plan and the Construction Safety Plan, and report status to all participants of the project on a regular basis. Modifications to the Plans shall be made to mitigate any identified deficiencies and improve safety and health performance.

- **Safety Meetings.** Conduct safety meetings on a regular schedule during all phases of design and construction to review current and upcoming safety issues.

- **Final Report.** At the conclusion of construction, prepare a final report that presents the actions taken to improve safety and health and the level of performance attained on the project.

**POINT ALLOCATION**

**1 point**

For a New Construction project to be eligible for one point for this Credit, it must at a minimum:

- Satisfy all of the Prerequisites and Requirements; and

- Improve by 25% the safety performance on the project in terms of "Incidence Rates" for fatal and non-fatal accidents compared to projects of the same type as published by the Bureau of Labor Statistics (BLS) (25% lower than BLS value).

**2 points**
For a New Construction project to be eligible for two points for this Credit, it must at a minimum:

- Meet all requirements necessary to attain the first point;
- Improve by 50% the safety performance on the project in terms of "Incidence Rates" for fatal and non-fatal accidents compared to projects of the same type as published by BLS (50% lower than BLS value);
- Set up a plan for monitoring and evaluating potable water quality for construction crews and the completed project that meets and exceeds acceptable local environmental standards (Wargo 2010); and
- Provide significant reduction in the amounts of Formaldehyde, Particulates, Pesticides, Bisphenol-A (BPA), Phthalates, Perfluorooctanoic Acid (PFOA), and Volatile Organic Compounds (VOC's) used in the construction materials for the proposed construction.

**3 points**
For a New Construction project to be eligible for three points for this Credit, it must at a minimum:

- Meet all requirements necessary to attain the first and second points;
- Improve by 75% the safety performance on the project in terms of "Incidence Rates" for fatal and non-fatal accidents compared to projects of the same type as published by the BLS (75% lower than BLS value); and
- Provide temporary housing for workers having to commute a distance further than 90 miles from the construction site.

**POTENTIAL TECHNOLOGIES AND STRATEGIES**

- Reinforce corporate/institutional commitments to occupational health and safety.
- Use cross-discipline design, decision-making, and charrettes. Use goal-setting workshops and build a team approach to project safety.
- Prepare checklists for strategies prior to beginning the design process; refer to the checklist at milestones during the design process.
- Engage owner, staff, designers, contractors, user groups, and community groups, educating them on the benefits of Safety by Design and bringing them into the safety planning process at key points.
- Participate in peer-to-peer information exchange and problem solving.
- Consider performance-based incentives in professional contracts that reward achievement of a safe design and a safe work environment. Incentives may be based on comparisons to benchmarks of existing facility design and facility construction.

# A9 PtD Benefit-Cost Model

*The following is an example of a benefit-cost model that can be used to evaluate alternative design options with regard to their expected value to a project. The model was developed by Nicholas Tymvios at Bucknell University, and is designed for use by owners to assist in deciding whether to implement a PtD solution on a project. Source: Tymvios, N. (2013). "Direction, Method, and Model for Implementing Design for Construction Worker Safety in the US," PhD Dissertation, Oregon State University.*

The PtD benefit-cost model compares a PtD option against a traditional construction/design solution using a decision spreadsheet. The model allows the user to rate ("score") the costs and benefits of various items related to design effort, construction personnel, time commitments, etc. The scores given to each item are then combined to determine an overall score for the PtD option compared to the traditional construction/design solution.

The spreadsheet used for the model is shown in Figure A9.1, followed by instructions for implementing the model. The spreadsheet cells that need user input are highlighted in green. These include the values for the monetary cost for design and construction, the impact factors, and the importance factors. The overall scores for the two options are then calculated automatically by the computer software as the user enters these values. The design with the higher score has a higher benefit-cost ratio, and is the more desirable option.

| This is a Benefit/Cost analysis for the Owner to decide whether to proceed with a DCWS solution | | | |
|---|---|---|---|
| Option A: | | | |
| Option B: | | | |
| | **Option A** DCWS solution A Impact Factor | **Option B** Traditional Solution Impact Factor | **Importance Factor** |
| **Design& Construction Costs** | | | |
| Design Costs | $ 1.00 | $ 1.00 | 1 |
| Construction Costs | $ - | $ - | |
| | $ 1.00 | $ 1.00 | |
| | % Difference | % Difference | |
| | 0% | 0% | |
| **Personnel** | | | |
| Need for Owner Personnel Training | 0 | 0 | 1 |
| Need of hiring additional personnel | 0 | 0 | 1 |
| Quality of recruited workforce | 0 | 0 | 1 |
| Staff Retention | 0 | 0 | 1 |
| **Owner Time Commitments** | | | |
| Owner commitment for meetings & coord. (Increase/Decrease) | 0 | 0 | 1 |
| Owner commitment for site visits (Increase/Decrease) | 0 | 0 | 1 |
| Owner time for drawing/specs reviews (Increase/Decrease) | 0 | 0 | 1 |
| **Construction/Design Time** | | | |
| Design Time (Increase/Decrease) | 0 | 0 | 1 |
| Construction Time (Increase/Decrease) | 0 | 0 | 1 |
| **Project Issues** | | | |
| Number of RFI requests (Increase/Decrease) | 0 | 0 | 1 |
| Complexity of Bidding contract (Increase/Decrease) | 0 | 0 | 1 |
| Complexity of awarding contract (Increase/Decrease) | 0 | 0 | 1 |
| Complex. of manag. Constr. contract (Increase/Decrease) | 0 | 0 | 1 |
| Maturity of contractors & workers | 0 | 0 | 1 |
| Worksite productivity | 0 | 0 | 1 |
| Relationships between Designers and Contractors | 0 | 0 | 1 |
| Worksite Organization | 0 | 0 | 1 |
| **Safety** | | | |
| Overall Construction Safety | 0 | 0 | 1 |
| Number of workers on site | 0 | 0 | 1 |
| Costs/Savings from safety concerns | 0 | 0 | 1 |
| **Litigation/Insurance** | | | |
| Potential for litigation | 0 | 0 | 1 |
| Potential for workers' compensation | 0 | 0 | 1 |
| Owner furnished insurance costs | 0 | 0 | 1 |
| Owner inherent liability via designers (Increase/Decrease) | 0 | 0 | 1 |
| Blurs of lines between "Design" and "Build" | 0 | 0 | 1 |
| **Post Construction** | | | |
| Sustainability of final capital assets (Improved/Worsened) | 0 | 0 | 1 |
| Overall potential of project quality (Better/Worse) | 0 | 0 | 1 |
| Life cycle of capital assets (Increase/Decrease) | 0 | 0 | 1 |
| Maintenance/operation costs | 0 | 0 | 1 |
| Ease of facility operations with safety in mind | 0 | 0 | 1 |
| **Marketability** | | | |
| Morale for construction crews | 0 | 0 | 1 |
| Owner image to the general public | 0 | 0 | 1 |
| Number of bidding contractors (Increase/Decrease) | 0 | 0 | 1 |

| | **Option A** | **Option B** |
|---|---|---|
| **Total =** | **0** | **0** |

Figure A9.1: Benefit-Cost Model Spreadsheet

**PtD BENEFIT-COST MODEL INSTRUCTIONS**

This benefit/cost analysis tool helps construction facility owners make a decision regarding the implementation of a PtD solution in a proposed project. Owners can compare a PtD option against a traditional construction/design solution. In the model, the proposed PtD option is labeled “Option A”, and the traditional solution is labeled “Option B”. Owners can also compare two different PtD solutions by changing the second option to "PtD solution B".

The spreadsheet allows owners to consider costs/benefits using a decision score card. Items considered in the scorecard include cost of design and construction, as well as issues regarding personnel, owner time commitments, various project issues, safety, litigation/insurance, post construction and marketability.

- Owners are asked to input values in cells shaded green only.
- In the Design & Construction costs cells, owners are asked to enter the values of the cost estimates for the two solutions.
- In the other categories, owners are asked to rate each line item according to its impact and importance for each particular solution. The impact score is on a scale of -3 to 3. If the line item is not affected by the option, owners are asked to leave the impact value as neutral ("0").
- The "Importance Factor" is a rating of how significant the group of line items is in terms of making a decision for each particular option. The Importance Factor is based on a 1-5 scale, where a value of 1 has the least amount of importance and a value of 5 has the highest value of importance.

After the user enters the values, an option score is calculated. The owner should choose the option with the highest score.

**LINE ITEM DEFINITIONS**

**1. Personnel**

- *Need for owner personnel training*
  If the option requires training investment, then the impact is below zero. If the option requires less training than the baseline model, then the impact value is greater than zero.
- *Need for hiring additional personnel*
  If the option requires the hiring of additional personnel, then the impact is below zero. If the option requires fewer personnel than the baseline model, then the impact value is greater than zero.
- *Quality of recruited workforce*
  If the option attracts a better quality workforce, then the impact score is greater than zero. If the workforce attracted is of lower quality, then the impact value is less than zero.

- *Staff retention*

  If the option encourages staff retention during the time of the project, then the impact value is greater than zero. If the option does not encourage staff retention, then the impact value is less than zero.

**2. Owner Time Commitment**

- *Owner commitments for meetings and coordination*

  If the owner's time commitments are increased, then the value is less than zero. If the commitments are reduced, then the value is greater than zero.
- *Owner commitments for site visits*

  If the owner commitments for site visits are increased, then the value is less than zero. If the commitments are reduced, then the value is greater than zero.
- *Owner time for drawing and specs reviews*

  If the owner commitments for reviews are increased, then the value is below zero; otherwise it is greater than zero.

**3. Construction/Design Time**

- *Design time*

  If the design time required to implement the option is increased, then the impact value is less than zero; otherwise it is greater than zero.
- *Construction time*

  If the construction time required to implement the option is increased, then the impact value is less than zero; otherwise it is greater than zero.

**4. Project Issues**

- *Number of RFI requests*

  If the number of Requests for Information (RFI) is expected to be more, then the impact value is less than zero. If the number of RFI requests is expected to be fewer, then the impact value is greater than zero.
- *Complexity of bidding contract*

  If the complexity of bidding a contract is increased, then the impact value is less than zero. If the complexity is decreased, then the impact value is greater than zero.
- *Complexity of awarding contract*

  If the complexity of awarding a contract is increased, then the impact value is less than zero. If the complexity is decreased, then the impact value is greater than zero.
- *Complexity of managing construction contract*

  If the complexity of managing the contract is increased, then the impact value is less than zero. If the complexity is decreased, then the impact value is greater than zero.
- *Maturity of contractors and workers*

If the contractors and workers who will be working on the project are expected to be more mature, then the impact value is greater than zero; otherwise it is less than zero.

- *Worksite productivity*
  If the productivity of the workers is expected to be increased, then the value is greater than zero; otherwise it is less than zero.
- *Relationships between designers and contractors*
  If the relationships between the contractors and designers are expected to be improved, then the impact value is greater than zero; otherwise it is less than zero.
- *Worksite organization*
  If the organization of the worksite is expected to be improved, then the impact value is greater than zero; otherwise it is less than zero.

5. **Safety**
- *Overall construction safety*
  If safety due to the presence of the PtD solution is improved compared to the baseline safety performance, then the impact score should be greater than zero; otherwise it is less than zero.
- *Number of workers on site*
  If the number of workers needed onsite is increased, then the impact vale is less than zero. Otherwise the value is greater than zero.
- *Costs/savings from safety concerns*
  If there are expected to be savings from eliminating safety concerns, then the impact value is greater than zero. Otherwise, if safety concerns are increased, then the impact value is less than zero.

6. **Litigation/Insurance**
- *Potential for litigation*
  If there is an increased potential for litigation, then the impact value is less than zero; otherwise the impact value is greater than zero.
- *Potential for workers' compensation claims*
  If there is an increased potential for workers' compensation claims, then the impact value is less than zero; otherwise the impact value is greater than zero.
- *Owner furnished insurance costs*
  If there is a potential for increased rates for owner-furnished insurance costs, then the impact value is less than zero; otherwise the impact value is greater than zero.
- *Owner inherent liability via designers (increase/decrease)*
  If there is a potential for increased inherent liability from designers, then the impact value is less than zero; otherwise the impact value is greater than zero.
- *Blur of line between "design" and "build"*

If the option would blur the line between design and build, then the impact value is less than zero; otherwise the value is greater than zero.

**7. Post-Construction**

- *Sustainability of final capital assets (improved/worsened)*
  If there is an increased sense of sustainability of the capital assets, then the impact value is greater than zero; otherwise the value is less than zero.
- *Overall potential of project quality (better/worse)*
  If there is an increased potential for improvements in project quality, then the impact value is greater than zero; otherwise the value is less than zero.
- *Lifecycle of capital assets (increase/decrease)*
  If the lifecycle of the capital assets is improved, then the impact value is greater than zero; otherwise the value is less than zero.
- *Maintenance/operation costs*
  If future maintenance/operation costs are expected to be reduced, then the impact value is greater than zero; otherwise the value is less than zero.
- *Ease of facility operations with safety in mind*
  If facility operations are expected to be operated safely, then the impact score is greater than zero; otherwise the score is less than zero.

**8. Marketability**

- *Morale of construction crews*
  If the morale of the construction crews is expected to be improved, then the impact score is greater than zero; otherwise it is less than zero.
- *Owner image to general public*
  If the owner's image to the general public is expected to be favorable, then the impact value is greater than zero; otherwise the value is less than zero.
- *Number of bidding contractors (increase/decrease)*
  If the number of contractors bidding on the project is expected to increase, then the impact value is greater than zero; otherwise the impact value is less than zero.

## A10 Risk Assessment Pro-Forma

Provided below are examples of documents that have been created to support conducting design reviews. The documents enable identifying hazards present in designs, quantifying the associated risk, selecting an alternative to mitigate the risk, and taking action to implement the selected alternative.

## Risk Evaluation Form

| **Project Title:** | **Project No.:** | **Assessment by:** | **Date:** |
|---|---|---|---|

**Instructions:** This form is used to evaluate a project feature based on the safety and health risks due to the hazards associated with the feature. The project feature can be associated with any part of the planning, design, construction, operations, maintenance, and/or decommissioning/recommissioning of the project.

1. Enter the worker safety and health hazard(s) associated with the project feature.
2. For each hazard:
   a. Enter the probability (1 = low, 3 = medium, 5 = high) of an injury occurring as a result of the hazard.
   b. Enter the likely severity (1 = low, 3 = medium, 5 = high) of an injury that occurs.
   c. Enter the extent of exposure (1 = low, 3 = medium, 5 = high) of the workers to the hazard.
   d. Calculate the risk associated with the hazard: Risk = (Probability)*(Severity)*(Exposure)
   e. Based on the magnitude of risk, identify the type(s) of control(s) selected to mitigate the risk.

| **Description of Project Feature:** |
|---|
| |

| **Hazard(s)** | **Probability (A)** | | | **Severity (B)** | | | **Exposure (C)** | | | **Risk (A)*(B)*(C)** | **Recommended Control(s)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Low (1) | Medium (3) | High (5) | Low (1) | Medium (3) | High (5) | Low (1) | Medium (3) | High (5) | | Eliminate | Reduce | Inform | Protect |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

## Safety in Design Review Form

| **Project Title:** | **Project No.:** | **Assessment by:** | **Date:** |
|---|---|---|---|

**Instructions:** This form is used to evaluate a project feature based on the safety risks due to the hazards associated with the feature. The project feature can be associated with any part of the planning, design, construction, operations, maintenance, and/or decommissioning/recommissioning of the project.

1. Enter the safety hazard(s) associated with the project feature.
2. For each hazard:
    a. Enter the probability of an injury occurring as a result of the hazard (1 = low, 3 = medium, 5 = high).
    b. Enter the likely severity of an injury that occurs as a result of the hazard (1 = low, 3 = medium, 5 = high).
    c. Enter the extent of exposure of the workers to the hazard (1 = low, 3 = medium, 5 = high).
    d. Calculate the risk associated with the hazard: Risk = (Probability)*(Severity)*(Exposure)
    e. Indicate the type(s) of control to mitigate the risk (place an "X" in the appropriate column). One or more types of controls may be needed or desired.
    f. Identify recommended actions for how for each type of control to mitigate the risk.

| **Description of Project Feature:** |
|---|

| **Hazard(s)** | **Probability (A)** | **Severity (B)** | **Exposure (C)** | **Risk (A)*(B)*(C)** | **Applicable Control(s)** | | | | **Recommended Action(s)** |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Eliminate | Reduce | Inform | Protect | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

*Source: Skanska USA Commercial Development, PtD Workshop, 2018.*

## Design Alternative Evaluation Sheet

| **Project Title:** | **Project No.:** |
|---|---|
| **Assessment by:** | **Date:** |

**Instructions:** This form is used to evaluate the impacts of a design option with respect to project goals.

3. Enter the performance goals established for the project.
4. For each project goal, enter a weighting factor that signifies the importance of meeting the goal to overall project success. Use a common weighting scale for all goals (e.g., 1 = low; 10 = high).
5. For each goal, rate the impact of the design option on the goal. Use a rating from -5 (negative impact) to +5 (positive impact). Shade in the appropriate cell to indicate the level of impact.
6. Calculate the total weighted impact for each goal by multiplying the weighting factor by the impact rating.
7. Calculate the total weighted impact for the design option by summing the impacts to each goal.
8. Provide comments regarding the selected weighting factors and ratings, if desired.

| **Design Option Title and Description:** |
|---|
| **Description of Occupational Safety and Health Issue(s) of Concern:** |

| **No.** | **Project Goals** | **Weighting Factor (A)** | **Impact Rating (B)** -5 0 +5 | **Weighted Impact (A) x (B)** | **Comments** |
|---|---|---|---|---|---|
| | | | □□□□□ □□□□□ | | |
| | | | □□□□□ □□□□□ | | |
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| | | | □□□□□ □□□□□ | | |
| | | | **Total** | | |

*Source: Hecker, S., Gambatese, J., and Weinstein, M., Editors (2004). Designing for Safety and Health in Construction, Eugene, OR: University of Oregon Press. Proceedings of the Designing for Safety and Health in Construction Research and Practice Symposium, Portland, OR, Sept. 15-16, 2003. (Modified)*

## Design Alternative Risk Comparison Form

| **Project Title:** | **Project No.:** |
|---|---|
| **Assessment by:** | **Date:** |

**Instructions:** This form is used to compare suggested options for a design element to a base option or Plan of Record (POR) based on the safety and health risk associated with each design option.

1. For each lifecycle phase, enter the risks associated with the design element that occur within the phase.
2. Enter the names of the different design options at the top of the right-hand columns.
3. For each risk and for each design option, including the base option/POR, assign a relative value from -5 (high risk relative to base option/POR) to +5 (low risk relative to base option/POR). Values of 0 should be entered when the risk is equal to that of the base option/POR.
4. Subtotal the values for each phase.
5. Sum the subtotal values to get the total risk associated with each design option.

| **No.** | **Safety and Health Risks Present** | **Design Options** | | | | |
|---|---|---|---|---|---|---|
| | | Base/POR | | | | |
| **Construction** | | | | | | |
| | | | | | | |
| | | | | | | |
| | **Subtotal** | | | | | |
| **Tool Install** | | | | | | |
| | | | | | | |
| | | | | | | |
| | **Subtotal** | | | | | |
| **Commissioning** | | | | | | |
| | | | | | | |
| | | | | | | |
| | **Subtotal** | | | | | |
| **Operations/Maintenance** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | **Subtotal** | | | | | |
| **Decommissioning** | | | | | | |
| | | | | | | |
| | | | | | | |
| | **Subtotal** | | | | | |
| | **Total** | | | | | |

## Design Option Risk Assessment and Mitigation Form

| Project Title: | Project No.: |
|---|---|
| Assessment by: | Date: |

| |
|---|
| Design Element: |
| Tasks Required to Construct the Design Element: |
| Nature of Hazard(s): |
| Nature and Magnitude of Worker Safety and Health Risks: |
| Workers Exposed: |

| Alternatives for Mitigating Identified Risks | Project Impacts (cost, schedule, quality, safety, etc.) |
|---|---|
| | |
| | |
| | |

| |
|---|
| Preferred Measure(s), if any: |

| |
|---|
| Residual Risks that will Remain, if any: |
| Recommendations for Mitigating Residual Risks: |

| |
|---|
| Actions Required (what, when, and by whom): |

| Signed: | Date: |
|---|---|

# A11 PtD Design Examples/Checklists

Many examples of designs that enhance construction worker safety have been developed and implemented. Checklists have also been developed that prompt designers to consider specific design options. In many cases, the design suggestions are project-specific. However, there are many PtD design examples that are good design practices and can be implemented on all projects. Provided below are lists of PtD design examples/checklists that have been identified and developed. The lists are organized according to the different types of design element/systems in a facility and the elements within the typical scope of work of designers of the permanent facility. The lists are not all-encompassing; many other PtD design examples likely exist and can be developed. Project team members are encouraged to innovate and develop new designs that further benefit safety on projects.

## PtD Design Suggestions

*Source: Hinze, J.W. and Gambatese, J.A. (1996). Addressing Construction Worker Safety in the Project Design, Research Report 101-11. Austin, TX: Construction Industry Institute (CII).*

### 1. Project Component: General Conditions and Special Provisions

**Schedule/Sequence**

A. The work schedule and construction sequence can lead to safety hazards if they do not allow for adequate lighting, rest, or safety and health requirements.
    1. To prevent accidents resulting from tired construction workers, do not allow schedules which contain sustained overtime.
    2. Minimize the amount of night work.
    3. Do not allow work to be performed on Friday or Saturday nights.
    4. Design and schedule different projects that occur at the same location to be performed simultaneously.
    5. When estimating the length of time for completion of individual work stages and the overall project, take into account the safety and health requirements of the construction workers.

B. Road construction, maintenance, and excavation operations can be hazardous for construction workers when working around existing utilities and ongoing public traffic.
    1. Require hand excavation around existing underground utilities.
    2. Design new utilities under roadways and sidewalks to be placed using trenchless technologies or tunneling instead of trenching.
    3. Require public traffic to be detoured around the project site.
    4. Require ongoing public traffic to be slowed down as much as possible by using flagcars, flagpeople, or by closing adjacent traffic lanes.
    5. Impose a ceiling on the number of workers on site or in a particular area.

C. Complicated or unique designs and improper materials handling can lead to safety hazards for construction workers.
    1. Provide or require the constructor to submit a construction sequence for complicated or unique designs.
    2. Require regularly scheduled site housekeeping.
    3. Require unused or unsecured materials to be stored in designated areas only, and not in areas of construction activity.
    4. Prohibit metal decking or forming work by hand if wind speed exceeds 30 mph.
    5. Require the constructor to locate and mark existing reinforcing steel prior to cutting into existing reinforced concrete structures.

**Site Hazards**

A. Working with existing utilities and toxic substances, and renovating an existing structure, create potential safety hazards for construction workers.
    1. Require the constructor to "pothole" for underground utilities before excavation operations.
    2. Do not locate constructor material storage areas next to, over, or under electrical power lines.
    3. Provide the constructor with a list and the location of toxic substances and other hazardous materials which may be located on the site.
    4. Confirm that the constructor knows of the potential hazards of all construction materials, and their proper storage and disposal.
    5. Provide the constructor with original erection drawings of the existing structure on renovation projects.

**Safety Plans**

A. An absence of safety plans during construction can compromise the safety of construction workers in emergency situations.
    1. Require the submittal of a fire control plan, or that the fire department be contacted to discuss plans for fire protection services during construction. Consider a fire watch system.
    2. Require the submittal of a job-site safety survey and plan, and an emergency action plan.
    3. Require the submittal of an erosion control plan.
    4. Require a pre-construction meeting between the general contractor and all subcontractors to discuss safety issues.
    5. Consider involving OSHA in planning safety measures prior to starting construction, or prior to performing complicated or unique construction efforts.

**Public Interaction**

A. Public access on or adjacent to the project site can distract the construction workers and create safety hazards for the workers and the public.
    1. Minimize construction visitation and public access through or adjacent to the project site.
    2. Contact the local police department to set up police officer patrols during road construction and maintenance work.
    3. Provide for evacuation drills, egress routes, and expedite installation, testing, and turnover of fire systems.

## 2. Project Component: Technical Specifications

### Materials

A. Construction materials can be hazardous to construction workers if the materials are flammable, contain toxic substances, or do not meet their specified use requirements.
    1. Ensure that specified materials of construction are appropriate for the flammability hazards which may be encountered on the work site.
    2. Do not specify materials which contain asbestos or other known hazardous substances.
    3. Ensure that all materials meet the expected environmental and work site conditions.

### Concrete

A. Concrete placement and post-tensioning operations can be hazardous for construction workers if adequate design-related safety plans are not developed and followed.
B. A lack of knowledge of the contents of underground concrete structures can lead to safety hazards for construction workers during excavation operations.
    1. Limit the lift height of concrete pours to minimize the load on formwork and the risk of collapse of fresh concrete during pouring operations.
    2. Provide a procedure for placing and holding initial loads on post-tensioned concrete members.
    3. Use red concrete to encase underground utility lines.

### Masonry

A. Construction worker safety and health can be affected by continual exposure to masonry materials and cleaning agents which contain toxic substances.
    1. Do not specify the use of masonry materials or liquids which contain toxic substances.
    2. Investigate the hazards associated with the specified construction materials and alert the constructor of the necessary safety precautions.

### Steel

A. Tall steel structures can easily collapse during the erection process if the steel is not adequately supported before it is permanently bolted or welded into place.
    1. Limit the lift heights of steel erection.

### Wood

A. Construction worker safety and health can be affected by continual exposure to wood treated with chemicals containing toxic substances.

1. Avoid using creosote to treat timber piles, railroad ties, or other ground contact members.

**Roadways**

A. Repeated work on or adjacent to automobile traffic facilities increases the safety hazard risks for construction and maintenance workers.
    1. Increase the project maintenance life cycle by increasing or upgrading the project specification standards.

**Testing**

A. Timely testing of materials, structural members, and project systems is essential to prevent collapse of the structure or injury during construction.
    1. Require concrete test results to be verified before form stripping and removal of shoring.
    2. Specify the use of testing devices which are embedded in concrete members in order to test the strength of the concrete before form removal.
    3. Specify testing procedures for complicated designs or specialized mechanical, electrical, or piping systems.

**3. Project Component: Contract Drawings**

**Utilities**

A. A lack of access to or knowledge of existing utilities can affect the safety of construction workers in emergency situations and during excavation operations.
    1. Indicate on the contract drawings the locations of shut-off valves and switches for existing utilities. Provide the constructor with access to these locations.
    2. Indicate on the contract drawings the locations of existing underground utilities and mark a clear zone around the utilities.
    3. Include the name, address, and telephone number of local utility companies on the drawings.
    4. Note on the drawings the source of information and level of certainty on the location of underground utilities.

**Existing Structure**

A. Working with an existing structure can lead to collapse hazards if the constructor lacks knowledge of the existing structure's loading conditions and structural integrity.
    1. Note on the contract drawings the locations of existing vertical load bearing walls.
    2. Indicate on the contract drawings the locations where shoring of the existing structure is required during construction.
    3. Review the condition and integrity of the existing structure and indicate any known hazards or deficiencies on the contract drawings.

**Design Loads**

A. Adequate support for construction workers, equipment, and materials is essential for preventing collapse of the existing or new structure.
    1. Provide the constructor with floor and roof design loads for use in determining material stockpile locations and heavy equipment maneuverability.

**Hazardous Substances**

A. Hazardous and toxic substances existing on the project site can create safety and health hazards during construction.
    1. Research the history of the project site and alert the constructor of the type and location of any hazardous and toxic substances existing on the site.

**4. Project Component: Work Schedule and Sequence**

**Stairways**

A. Timely erection of permanent stairways and handrails can help eliminate falls and other hazards associated with temporary stairs and scaffolding.
    1. Schedule a permanent stairway to be constructed at the beginning, or as close as possible to the start, of construction.
    2. Schedule permanent handrails to be erected along with the structural steel as one assembly.

**Fire Hazards**

A. The scheduled construction or demolition of fire prevention devices can lead to fire hazards for construction workers.
    1. Schedule an underground firewater system to be constructed at the beginning of the project.
    2. For multi-story buildings, schedule a firewater protection system to be installed and in use as early as possible during construction.
    3. Schedule permanent emergency exit and egress signs to be erected early in construction.
    4. Schedule fire walls and fire doors to be constructed or placed early in the construction phase.
    5. During demolition operations, schedule fire walls and fire doors to be kept in place as long as possible.

**Electrical**

A. The scheduled construction of electrical lines and equipment can lead to safety hazards for construction workers.
    1. Schedule permanent telephone lines to be installed early in the construction phase. Locate the lines in remote buildings, process areas, and on the site perimeter.
    2. Schedule the permanent electrical system to be installed early in the construction phase and available for the constructor's use.
    3. Schedule permanent lighting systems to be installed early in the construction phase and available for the constructor's use.
    4. If possible, where existing electrical lines need to be in service during construction, consider scheduling the voltage or current to be decreased before construction begins.

**Mechanical/HVAC**

A. The scheduled construction of mechanical and HVAC equipment can lead to safety hazards for construction workers.

1. Schedule air conditioning, heating, and ventilating systems to be available for use by the constructor at close-in.
2. Design and schedule ventilating systems to be in place in areas where coatings will be applied prior to applying the coatings.

**Materials**

A. Construction materials and debris scattered around the project site can lead to obstructions, tripping hazards, and fire hazards for construction workers.
B. Painting, insulating, or other similar work on materials, piping, or equipment in place can lead to falls if the work is performed at elevated levels.
    1. Require regularly scheduled site housekeeping to ensure a neat, clean work area.
    2. Schedule materials, piping, and equipment to be painted and/or insulated prior to erection or installation.

**Workers**

A. Construction schedules can affect worker safety and health if the schedules do not allow for sufficient safety planning and recognize worker health requirements.
    1. In order to prevent hazards due to fatigue, do not allow schedules with sustained overtime.
    2. To minimize a work crew's exposure to hazards, design and schedule projects which occur at the same location to be completed simultaneously.
    3. Account for incompatible activities in the schedule, e.g. no welding during painting operations.
    4. Schedule the release of engineering drawings such that sufficient time is allowed for materials to be purchased, delivered, and installed.
    5. Require a pre-construction safety meeting between all workers on the site, and require a jobsite safety survey and plan to be submitted before construction begins.

**Designs**

A. Without adequate knowledge of the project design concept, complicated or unique designs can lead to construction site hazards.
    1. Provide, or require the constructor to submit, directions for a construction sequence in complicated or unique designs.
    2. Conduct constructability reviews early in the design phase. Include the constructor and maintenance personnel in the reviews.
    3. In estimating the periods for completion of work stages and the overall project, take into account worker safety and health requirements.

**Elevated Work**

A. The work schedule and construction sequence for work performed at elevated levels can affect the safety of construction workers.
    1. Limit the lift heights of steel erection and concrete pours.
    2. Pre-fabricate building components in the shop or on the ground and erect them as one assembly.
    3. Erect permanent lighting systems along with the structural framing as one assembly.
    4. Schedule sidewalks, slabs, and roadways around elevated work areas to be constructed as early as possible to provide a stable base for scaffolding and ladders.
    5. In multi-story buildings, schedule the exterior wall structure and/or finish to go up with the framework or soon thereafter.

**<u>Testing</u>**

A. Timely testing of new construction materials and work in place can eliminate safety hazards for construction workers.
    1. Require concrete test results to be verified before removal of the forms and shoring.
    2. Provide a schedule for removing concrete forms and shores.
    3. Provide a procedure for placing and holding initial loads on post-tensioned concrete.

**<u>Roadways</u>**

A. The work schedule and construction sequence for road construction and maintenance can affect the safety of construction workers.
    1. Do not perform road work on Friday or Saturday nights.
    2. Avoid road work during peak traffic volume times of the day.
    3. Minimize the amount of night work.
    4. Prior to the start of the project, erect informational signs near the project site and announce to the media about the construction work and schedule.
    5. Schedule the project to minimize the amount of time that excavations are open.

**<u>Existing Structure</u>**

A. The work schedule and sequence for projects which require work with an existing structure or utilities can lead to safety hazards for construction workers.
    1. Maintain existing automatic sprinkler systems in operation as long as possible in the construction phase.
    2. Provide a work sequence for safe tie-ins to existing utilities.

**5. Project Component: Project Layout**

**Power Lines**

A. Power lines which are in service during construction present an electrical shock hazard. Below-grade lines present a hazard when operating excavation, pile driving, and drilling equipment. Overhead lines are hazardous when operating cranes and other tall equipment.
   1. Maintain a minimum clearance between the project and overhead power lines as outlined in Section 1926.950 of the Code of Federal Regulations.
   2. Disconnect the power lines before construction begins.
   3. Bury overhead power lines below grade before construction begins.
   4. Re-route the power lines around the project site before construction begins.
   5. Clearly mark the power lines with warning flags, tape, paint, chalk, etc., and note their location on the contract drawings.

**Emergency Access**

A. Emergency access to all parts of the project site is essential to provide prompt and adequate response to accidents and injuries.
   1. Allow for at least two formal, controlled intersections at access points to the site.
   2. Orient the project to allow for the construction of temporary roads, fire lanes, and approach roads during construction.

**Excavations**

A. Inadequate clearance or congestion during excavation work can create cave-in and obstruction hazards for construction workers.
   1. Allow adequate clearance for shoring, forms, equipment, and workers to perform below-grade work.
   2. Locate underground utilities and other below-grade features in areas easily accessible for excavation. Allow sufficient area around excavations for stockpiling the soil.
   3. Avoid locating utilities which cross under other pipelines, run directly adjacent to existing pipelines, intersect previously backfilled, disturbed, or fissured soil, intersect manhole excavations, or cross different types or conditions of soil.
   4. Consider area drainage of excavations during construction when developing the plot plan.

**Masonry**

A. Crowded and confined areas below elevated masonry work increases the risk of workers being struck by falling bricks, masonry tools, and other materials.

1. Allow for a large, unobstructed, open area (limited access zone) below elevated masonry work to minimize the risk of workers being struck by falling objects. See Section 1926.750 of the Code of Federal Regulations.

**Vehicular Traffic**

A. Confined, congested, or sloped areas for contractor parking, material storage, and pedestrian access can lead to safety hazards for construction workers.
    1. Do not locate constructor material lay-down areas next to or under electrical power lines.
    2. Allow adequate room for constructor parking, temporary buildings, shops, material storage areas, and unobstructed access to and from the project site.
    3. On sloped sites, orient the project layout or grade the site accordingly to minimize the amount of work on steep slopes.
    4. Allow for pedestrian traffic to be isolated from construction vehicular traffic.

**6. Project Component: Structure Plan and Elevation**

**Floor Plan**

A. A building's floor plan can lead to fall hazards if there are numerous offsets of varying size, floor levels varying in size or shape, or if the size and layout does not meet local building codes.
   1. To minimize the risk of falling, minimize the number of offsets, and make the offsets a consistent size and as large as possible.
   2. In multi-story buildings, design each floor plan to have a smaller area than the story below to prevent objects and workers from falling more than one story.
   3. Ensure that the building height and area per floor meet all local building code requirements for the type of construction used.

**Space Layout**

A. Rooms, walkways, platforms, etc. within a building which do not allow adequate egress or provide protection against hazardous materials can create safety hazards for construction workers.
   1. Isolate from adjoining areas the storage areas for combustible and toxic materials, such as paper, explosives, tires, celluloid, excelsior, petroleum, plastics, etc.
   2. Provide at least two means of egress on large maintenance platforms or walkways.
   3. Minimize the number of confined spaces. Design access points to confined spaces as large as possible. Provide at least two access points to confined spaces.
   4. Provide access by means of a ladder or stairway when there is a change in elevation of greater than 19 inches.

**Mechanical**

A. The location and layout of mechanical rooms, and the positioning of control valves and panels, can create obstruction and other safety hazards for construction workers.
   1. Provide a clear, unobstructed, spacious work area around all permanent mechanical equipment. See Section 1926.403 of the Code of Federal Regulations.
   2. Do not locate permanent mechanical equipment in or directly adjacent to passageways.
   3. Position control valves and panels away from passageways and work areas.
   4. Prevent access near hoist or crane electrification points and travel clearances.

**Electrical**

A. The location and layout of electrical rooms, and the positioning of electrical controls, can create electrical shock and other safety hazards for construction workers.
   1. Provide adequate passageways and access areas around all equipment in control, electrical, and electronic rooms.

2. Locate electrical circuit breaker boxes in sight of the equipment it affects.
3. Do not locate electrical rooms under pipes carrying liquids.

**Windows**

A. Prior to installation of upper story windows, low sill heights add to the chance of falling through the window openings.
    1. Design window sills to be 42 inches minimum above the floor level. Window sills at this height will act as guardrails during construction.
    2. Keep dimensions similar from story to story to facilitate the reuse of concrete forms.

**Stairways, Ramps**

A. Stairways and ramps which are exposed to the weather and isolated can lead to fall hazards for construction workers.
    1. Locate exterior stairways and ramps on the sheltered side of the structure to protect them from rain, snow, and ice.
    2. Locate exterior stairways and ramps away from the north side of the structure to minimize the buildup of moss and ice.
    3. Design stairways and ramps to run parallel and immediately adjacent to the structure, rather than perpendicular to the structure.

**7. Project Component: Foundation**

**Excavations**

A. Foundation excavations which are congested, excessively deep, of varying depth within the work site, or which are required to be open for long periods of time can be cave-in hazards.
    1. Consider using a pile or caisson foundation system which does not require excessively deep excavations and allows construction work to be performed above grade.
    2. Minimize the amount of excavation work and maintain a constant foundation depth throughout the project.
    3. Design and schedule the project to minimize the amount of time excavations are open.
    4. Keep detailed work above grade; simplify all below grade work.
    5. Allow adequate clearance for shoring, forms, and workers within the excavation.

**Footings**

A. Footing location and reinforcing steel can create collapse, tripping, and fall hazards for construction workers during the construction of the foundation.
    1. On spread and continuous footings, and mat foundations, design the top layer of reinforcing steel to be spaced at no more than 6 inches on center, each way, to provide a continuous, stable walking surface before the concrete is poured.
    2. When developing a plot plan, group footings in a way that permits proper drainage of mass excavations.
    3. Locate new footings away from existing foundations.

**Piles**

A. Pile foundation systems which are not designed with consideration of the soil conditions and pile driving equipment can lead to cave-in and other hazards for construction workers.
    1. To prevent cave-ins due to vibration of loose soil, do not use driven piles in deep excavations in areas of loose or backfilled soil.
    2. Avoid designing piles at angles flatter than 4:12 (horizontal:vertical).
    3. Design wood piles such that they are below the water table, and do not specify creosote for protection of the piles from environmental deterioration.
    4. Design the foundation for the soil variations within the site. Consider the soil classifications outlined in Section 1926.650 of the Code of Federal Regulations.
    5. Take heave into account when locating piles.

**Landings**

A. Stairway and ladder landings should be designed to prevent falls and obstructions during ascent and descent.

1. Design and schedule the layout of stairway and ladder landings to be constructed as part of the structure's foundation system.

**8. Project Component: Structural Framing**

**Structural Members**

A. All structural members should be designed to withstand construction loading, and to minimize the safety hazards associated with erecting and working around the members.
    1. Design the structural members to withstand all anticipated construction loading during fabrication, storage, erection, and final connection.
    2. Design member depths to allow adequate head room clearance around stairs, platforms, valves, and all areas of egress.
    3. Minimize the amount of overhead work.
    4. Design members which are of consistent size, light weight, and easy to handle.

**Column**

A. Connection points for lifeline and guardrail attachment which are welded or connected to columns by the Constructor can break off, and also protrude into working areas.
B. Column splice connections which are located at or just below the floor level can present safety hazards for construction workers.
    1. Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.
    2. Locate column splices between 2 and 3 feet above the finished floor level, and at two-story intervals.

**Beam**

A. Traditional beam-to-column horizontal framing requires manipulating numerous components that can easily be dropped, provide minimal support for workers, or collapse.
    1. In order to allow sufficient walking surface, use a minimum beam width of 6 inches.
    2. Consider alternative steel framing systems which reduce the number of elements and where beams are landed on supports rather than suspended between them.
    3. Minimize the use of cantilevers.
    4. Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 lbs.). Design connection points along the beams for the lifelines. Note on the contract drawings which beams are designed to support lifelines, how many lifelines, and at what locations along the beams.

**Wall**

A. Walls surrounding elevated automobile traffic surfaces which only rise to the height of the traffic surface can be hazardous for construction workers operating motor vehicles.
B. Confined and congested work areas below masonry walls can lead to workers being struck by falling bricks or masonry tools.

1. Design perimeter walls to rise above the automobile traffic surface in order to provide a curb before permanent wheelstops and guardrails are placed.
2. Allow for a large, unobstructed, open area (limited access zone) below masonry walls to minimize the risk of workers being struck by falling objects. See Section 1926.750 of the Code of Federal Regulations.

**Connection**

A. The design of structural steel framing connections can greatly affect the fall hazards associated with constructing the connections.
    1. Consider the erection process when designing and locating member connections.
    2. Design beam-to-column double-connections to have full support for the beams during the connection process.
    3. Avoid steel beams of common depth connecting into the column web at the same location.
    4. Provide pin-hole or bolted connections on beams and columns to create proper alignment and stability immediately after placement of the members.
    5. For bolted beam connections, provide an extra, "dummy" hole in which a spud wrench or other object can be inserted to provide continual support for the beam during installation of the bolts.

B. Complicated or non-standard connections can lead to confusion and mis-installation of bolts, screws, or nails, and collapse of the structural members.
    1. Use a single size, or a minimum number of sizes possible, of bolts, nails, and screws. If more than one size is required, specify sizes which vary greatly and are easily distinguishable.
    2. Use a minimum of two bolts, nails, or screws per connection.

**Concrete**

A. The manipulation and erection of reinforcing steel and formwork for reinforced concrete structural members can be hazardous to construction workers.
    1. Prohibit forming work by hand if wind speed exceeds 30 mph.
    2. Design concrete members to be of similar size and regularly spaced to facilitate the use, and re-use, of pre-fabricated forms. Consider using shotcrete instead of poured concrete.
    3. Use a metal deck and concrete fill rather than a slab that requires temporary formwork.
    4. Use small sized rebar for framing members at elevated floor levels. Design the rebar such that it can be assembled on the ground and erected in large sections.
    5. Use a single, or multiple, curtain(s) of welded wire mesh for reinforced concrete walls and columns to allow placement of the reinforcing in large sections rather than many small pieces.

**Masonry**

A. Construction workers can sustain injuries due to repeated lifting of masonry blocks which are heavy, odd-sized, or irregularly shaped.
    1. Minimize the size and weight of masonry blocks.
    2. Use masonry blocks of consistent size and shape.
    3. On larger masonry blocks, provide cast-in handles or handholds for easy lifting.
    4. Consider other materials such as precast concrete or lighter weight, stick or modular components.

**Steel**

A. Structural steel erection operations can lead to collapse if adequate support is not provided for the members before permanent connection.
B. Welding operations can create fire hazards due to excessive slag or sparks, and also expose construction workers to toxic fumes.
    1. Limit lift heights of steel erection.
    2. Design connections to be welded in the shop rather than in the field.
    3. Eliminate field welding of steel with a galvanized coating.
    4. Ensure that the welding procedures specified are compatible with the materials being welded.
    5. Consider alternative steel framing systems which reduce the number of elements and where beams are landed on supports rather than suspended between them.

**Wood**

A. Complicated or non-standard wood connections can lead to confusion and mis-installation of member bolts, screws, or nails, and collapse of the structural members.
    1. Consider using pre-fabricated metal timber fasteners for wood connections instead of end nailing or toe nailing.

**Post-tensioning**

A. Concrete post-tensioning operations can be hazardous to construction workers if a jack, cable, or fitting fails during tensioning.
    1. Align or locate post-tensioning cables such that if failure of a jack, cable, or fitting occurs during tensioning, the cable is not directed towards an active work area.

**Pre-fabricated**

A. Pre-fabricated members which are similar in size and shape can be easily mixed up and incorrectly placed, leading to collapse hazards.
B. Without adequate connection locations for lifelines, construction workers are at risk of falling during elevated work.

1. Design pre-fabricated members to be of one size and shape, or easily distinguishable different sizes.
2. For precast concrete members, provide inserts or other devices to attach fall protection lines.

**Elevated Work**

A. Work at elevated levels or on the exterior of a structure puts construction workers at risk of falling and being struck by falling objects.
    1. Design special attachments or holes in members at elevated work areas to provide permanent, stable connections for supports, lifelines, guardrails, and scaffolding.
    2. Design holes in the webs of beams above piping for attachment of supports and lifelines.
    3. Use light, precast materials and attachments for elevated, exterior work areas.
    4. Use pre-fabricated members for work over water, railways, roads, etc.

**Existing Structure**

A. When welding near or cutting into existing structures, construction workers are at risk of injury due to fire or collapse of the existing structure.
    1. When working on or near existing structures, consider using bolted, rather than welded, connections to minimize the fire hazard.
    2. Require the constructor to locate and mark the existing reinforcing steel prior to cutting into existing reinforced concrete members.

**Fire Hazards**

A. Structures which contain or are constructed of combustible materials can be fire hazards during the construction phase.
    1. Provide adequate fire protection on all structural framing.
    2. Limit the spread of fire by the use of fire walls, parapets, fire stops, deluge systems, etc.

**9. Project Component: Slab-on-grade, Floor, and Roof**

**Slab-on-Grade**

A. A stable base around the structure must be provided to prevent overturning or collapse of temporary scaffolding and ladders.
   1. Design and schedule slabs-on-grade, sidewalks, roadways, and other flatwork around elevated structures to be constructed as early as possible and available for use by construction workers.

**Floors**

A. Many floor features can present tripping and obstruction hazards for construction workers during the construction phase.
   1. Design the finished floor around mechanical equipment to be at one level (no steps, blockouts, slab depressions, etc.).
   2. Keep steps, curbs, blockouts, slab depressions, and other tripping hazards away from window openings, exterior edges, and floor openings.
   3. Design the covers over sumps, outlet boxes, drains, etc. to be flush with the finished floor.
   4. Route pipes at least 30 inches above the finished floor level.
   5. Keep all equipment and related hardware on a pad above the finished floor.

B. Inadequate floor finishes, coverings, or drainage can put construction workers at risk of slipping.
   1. Provide non-slip walking surfaces on floors adjacent to open water or exposed to the weather.
   2. Route piping drains and overflow outlets to trench drains.
   3. Route pump seal water in a manner to avoid wet surfaces around the equipment.
   4. Locate drains away from walkways, work areas, and the structure perimeter.
   5. Provide drainage for all floor areas, especially around elevated equipment pads.

C. Floor openings can be hazardous to construction workers if they are numerous, in or adjacent to passageways, or not adequately guarded.
   1. Group floor openings together to create one larger opening rather than many smaller openings.
   2. For access doors through floors, use doors which immediately provide guarded entry around the hole perimeter when the door is opened.
   3. Locate floor openings away from passageways, work areas, and the structure perimeter.
   4. Provide permanent guardrails around floor openings.
   5. Eliminate tripping hazards around floor openings.

D. Construction materials, equipment, and formwork can overload existing and new floors, and lead to collapse of the structure or fall hazards during their manipulation and installation.
   1. Prohibit metal decking or formwork by hand if wind speed exceeds 30 mph.
   2. Note on the contract drawings the existing and new floor design loads to aid the constructor in determining material stockpile locations and heavy equipment maneuverability.
   3. For elevated floors, use permanent metal formed deck with concrete fill rather than a concrete slab which requires temporary formwork.
   4. Do not design split-level floors.

E. The design of post-tensioned and conventional steel reinforcement for floor slabs can create safety hazards for construction workers.
   1. Align post-tensioning cables such that if failure of a jack, cable, or fitting occurs during tensioning, the cable is not directed towards an active work area.
   2. Use welded wire mesh for slab reinforcing to allow placement of the steel in large sections rather than many small pieces.
   3. Design the top layer of floor slab reinforcing to be spaced at no more than 6 inches on center each way to provide a stable, continuous walking surface before placement of the concrete.

**<u>Roof</u>**

A. Roof openings can create fall hazards for construction workers if they are numerous or not adequately guarded.
   1. Locate roof openings away from the edge of the structure.
   2. Group roof openings together to create one larger opening rather than many smaller openings.
   3. Provide permanent guardrails around roof openings.
   4. Eliminate tripping hazards around roof openings.
   5. Locate rooftop mechanical/HVAC equipment away from roof openings.

B. Short parapets and steep roofs increase the chance of a construction worker falling off of the roof during construction and future roof maintenance.
   1. Design the parapet to be 42 inches tall. A parapet of this height will provide immediate guardrail protection and eliminate the need to construct a guardrail during construction or future roof maintenance.
   2. Minimize the roof pitch to reduce the chance of workers slipping off the roof.
   3. Provide a guardrail around roof accesses and roof work areas.

C. Inadequate or no connection points for fall restraint systems on the roof increases the chance of construction workers falling off of the roof.

D. Stairways, ramps, and walkways which are uncovered and exposed to the weather can create fall hazards due to the buildup of moss or ice.

1. Install belaying bolts on pitched roofs for workers to connect fall restraint systems.
2. Design in a means of attaching a railing and safety lines for roofing operations.
3. Design and schedule eye-bolts or other connections used for window maintenance so that they can be constructed as early as possible and used during construction.
4. Provide a covering, or extend the roof line over exterior stairs, ramps, and walkways.

**Skylights**

A. Unprotected or poorly located skylights can present fall hazards for workers during construction and during future roof maintenance.
    1. Provide permanent guardrails around skylights.
    2. Design domed, rather than flat, skylights with shatterproof glass or add strengthening wires.
    3. Locate skylights on flat areas of the roof and away from the roof edges.
    4. Locate rooftop mechanical/HVAC equipment away from skylights.
    5. Place skylights on a raised curb.

**10. Project Component: Mechanical / HVAC**

**Controls**

A. Mechanical/HVAC controls can create safety hazards for construction workers if they protrude into passageways, or are hard to operate, hidden, or inaccessible.
   1. Position equipment controls and control panels away from passageways and work areas.
   2. Indicate on the contract drawings the location of equipment shut-off valves and switches for existing utilities. Allow the constructor access to these locations for emergency situations.
   3. Place electrical circuit breaker boxes in sight of the equipment which they affect.
   4. Provide clearly marked and identified emergency controls and displays.
   5. Allow adequate access to equipment controls for ease of operation.

**Valves**

A. Valve location and operation can lead to safety hazards for construction workers during the construction and initial startup phases.
   1. Locate valves such that they can be operated easily, or so that a standard type of operating device can be installed. Consider using remote valve operators.
   2. Provide remotely operated valves or valves with extension handles when valves are located near hazardous materials or in confined spaces.
   3. Provide a safety valve on the discharge of positive displacement type air compressors and multi-stage centrifugal compressors to avoid over-pressurization in case the discharge valve is closed.
   4. Provide relief valves for heat exchangers and chiller refrigerant.

**Piping**

A. Piping elements which are not designed with consideration of the connecting mechanical and HVAC units can lead to safety hazards during construction and initial startup phases.
   1. Provide purging cycles and special interlocks for all gas- and oil-fired equipment.
   2. Ensure that the shut-off head on all pumps is compatible with the associated piping.
   3. Design piping systems which feed tanks, chests, and large walk-in type equipment to prevent inadvertent system activation. (LO/TO procedures)
   4. Ensure that safety relief valves exhaust and drain away from passageways and work areas.

**Equipment Cooling**

A. Inadequate cooling and ventilation of electrical equipment can lead to fire hazards during the construction phase.
   1. Ensure that all electrical equipment is adequately cooled and ventilated.

**Electrical/Grounding**

A. Adequate electrical protection and grounding of equipment is essential to prevent electrical shock hazards.
   1. Ensure that all equipment is grounded and protected against lightning.
   2. Isolate all live conductors and equipment from accidental contact.
   3. Ensure an adequate interrupting rating to protect all equipment.

**Equipment Supports**

A. Mechanical and HVAC systems and their supports which are not designed to withstand all anticipated construction loading present collapse and fall hazards to construction workers.
   1. Design overhead equipment and their supports to hold up the weight of a construction worker.
   2. Specify the material hoist or crane loading capacity to be clearly stenciled onto the hoist or crane beams or rails.

**Equipment Location**

A. The location of mechanical and HVAC systems within a project can lead to fall, ergonomic, and other safety hazards for construction workers.
   1. Minimize the amount of overhead work.
   2. Locate underground equipment in an area easily accessible for excavation. Allow sufficient area around the excavation for stockpiling the soil.
   3. Locate rooftop mechanical/HVAC equipment away from the structure's edge and skylights.
   4. Ensure that equipment located in a hazardous area meets the requirements for the area's hazard classification.

**Work Area**

A. An enclosed or congested work area surrounding mechanical and HVAC equipment can affect the safety of workers during installation and maintenance of the equipment.
   1. Do not locate mechanical equipment in or directly adjacent to passageways.
   2. Provide a clear, unobstructed, spacious area around all permanent equipment. See Section 1926.403 of the Code of Federal Regulations for working clearances.
   3. Ensure that all equipment enclosures meet hazardous location classification requirements.
   4. Do not place machinery breathing equipment, oxygen sensor, refrigerant sensor, or refrigerant/fuel burning equipment in the same space unless a clean air source is provided.

B. The floor area and support structure surrounding mechanical and HVAC systems can create safety hazards during placement of the equipment and work around the equipment.
    1. Keep the finished floor around mechanical and HVAC equipment free of steps, blockouts, etc.
    2. Place all equipment and related hardware on an elevated housekeeping pad above the finished floor level.
    3. Locate lifting eyes, hoist, or crane above equipment to aid in the installation and maintenance of the equipment.
    4. Minimize the number of wires, cables, and hoses laid on walking surfaces. Use elevated cable trays or hose supports.

C. Work areas without adequate protection from equipment noise, electrical shock, or moving parts are hazardous for construction workers.
    1. Specify mechanical and HVAC equipment which does not produce high noise levels while operating. See Section 1926.52 of the Code of Federal Regulations for acceptable noise levels.
    2. Provide guards around equipment to protect workers from moving parts.
    3. Provide guards around fan inlets/outlets and exhaust ports.
    4. Provide signs, lights, alarms, etc. as necessary to ensure safety near exposed equipment.
    5. Provide smoke detectors or insulation around equipment susceptible to fire.

**Equipment Materials**

A. Mechanical and HVAC systems which are not constructed of materials adequate for the expected construction environment and loading create safety hazards for construction workers.
    1. Design all mechanical equipment and HVAC components to meet the anticipated material, corrosion, and loading requirements of the construction site.

**Ventilating Equipment**

A. Adequate ventilation for construction workers during the construction phase is essential for a safe work environment.
    1. Design ventilating and lighting fixtures in a mechanical room and confined space to be operated by the same switch.
    2. Provide ventilation systems in mechanical rooms and confined spaces which are temperature, oxygen depletion, or refrigerant controlled.
    3. Design and schedule ventilation and illumination in stair shafts to be operable during construction.
    4. Provide ventilation systems around fueled equipment operating indoors.

**Erection**

A. The erection or placement operations required for mechanical and HVAC systems can create safety hazards for construction workers.
    1. Design and schedule new air conditioning and ventilating systems to be in use as early as possible in the construction phase.
    2. Minimize the need for special or complicated equipment installation operations.
    3. Design and schedule equipment to be painted and/or insulated prior to erection or installation.
    4. Schedule new ventilating systems to be in use in areas in which painting or other coatings will be applied, prior to their application.

**Testing**

A. Sufficient testing of mechanical and HVAC systems is essential to eliminate safety hazards due to failure of the systems.
    1. Require systems, components, and welds to be tested to ensure they meet minimum requirements. Types of testing to consider: hydrostatic, radiographic, ultrasonic, magnaflux, weld sectioning, dye penetrant, halogen mass spectrometer, etc.
    2. Design for safety against possible equipment failures, such as desuperheated, control valve, or component failure.

**Existing Structure**

A. Working with and connecting to existing mechanical and HVAC systems presents safety hazards for construction workers.
    1. Design and schedule safe tie-ins to existing utilities.

**11. Project Component: Electrical / Instrumentation**

**Controls**

A. Electrical/instrumentation controls can create safety hazards for construction workers if they protrude into passageways, or are hard to operate, hidden, or inaccessible.
   1. Position controls and control panels away from passageways and work areas.
   2. Indicate on the contract drawings the location of existing equipment and electrical shut-off switches. Allow the constructor access to these locations for emergency situations.
   3. Include the name, address, and telephone number of the local electrical power supply company on the contract drawings for quick reference in emergency situations.

B. A lack of safety alarms, switches, and component identification can lead to safety hazards for construction workers in emergency situations.
   1. Provide safety switches, pull cords, alarms, etc. which are clearly displayed, standardized, and easily identifiable.
   2. Provide disconnection switches which are readily accessible.
   3. Review from a safety aspect the possible misuse of the electrical/instrumentation control systems.
   4. Ensure that all electrical circuits are sufficiently identified throughout their length.

**Grounding**

A. Electrical systems must be adequately grounded to prevent electrical shock of construction workers.
   1. Ensure that all equipment is adequately grounded and protected against lightning.
   2. Provide grounding circuits to all 480 volt lighting fixtures.
   3. Ensure that the withstand rating is adequate for the available fault current.
   4. Ensure that the interrupting rating is adequate to protect all equipment.

**Location**

A. Locating electrical/instrumentation systems overhead can create fall, electrical shock, and other safety hazards for construction workers.
   1. Route cable trays above pipelines to minimize the chance of electrical shock due to leaking pipes.
   2. Minimize the amount of overhead work.
   3. Do not place overhead wiring close to windows or equipment. Locate overhead lines to minimize contact.

B. Electrical and instrumentation system enclosures and surroundings can affect the safety of construction workers.

1. Provide electrical/instrumentation system enclosures which are adequate for the expected environmental/climate conditions.
2. Ensure that electrical/instrumentation systems located in hazardous areas meet the hazard classification requirements.
3. Isolate live conductors from accidental contact.
4. Prohibit access near hoist and crane electrification components.

C. Inadequate design of electrical and instrumentation system cooling and fire protection can affect the safety of construction workers.
    1. Ensure that electrical/instrumentation components are adequately cooled.
    2. Design electronic, electrical, and control rooms which are designated to be fire protected by Halon systems to be interlocked with their respective HVAC system.
    3. Route main cable runs to avoid potential fire hazard areas.

D. The location of electrical/instrumentation components throughout a project can affect the safety of construction workers.
    1. Design and schedule lighting systems to be provided in enclosed stair shafts as early as possible in the construction phase.
    2. Provide adequate access to all electrical/instrumentation components in control, electrical, and electronic rooms.
    3. Do not locate electrical/instrumentation components under pipes carrying liquids or in other areas where water is present.
    4. Minimize the number of wires, cables, and hoses laid on walking surfaces.  Use elevated cable trays or hose supports.

**Electrical Materials**

A. Without knowledge of the nature of each existing electrical wire, construction workers are at risk of electrical shock.
    1. Specify that all electrical and instrumentation wiring is to be color coded to comply with N.E.C. design requirements.

**Erection**

A. The erection schedule and sequence can affect the safety of construction workers.
    1. In structures with tall stories, design and schedule the lighting systems to be erected with the structural steel.
    2. Schedule telephone lines to be installed and in-use early in the construction phase. Locate telephones in remote buildings, process areas, and on the site perimeter.
    3. Design and schedule the electrical system to be constructed early and allow the constructor to tie into it for use during construction.
    4. Provide permanent electrical outlets on the roof to allow for easy tie-in during construction and future roof maintenance.

## Underground Lines

A. New and existing below-grade power lines present hazards for excavation, pile driving, and drilling operations.
   1. Locate underground lines in areas easily accessible for excavation. Allow sufficient area around the excavations for stockpiling the soil.
   2. When new electrical lines are to be placed below existing concrete surfaces, roads, or other traffic areas, design the lines to be placed using trenchless technologies.
   3. Note on the contract drawings the level of certainty and source of information on the location of existing underground power lines.
   4. Mark on the contract drawings a clear zone around existing underground power lines.

B. Underground power lines which are in service during construction present an electrical shock hazard to construction workers.
   1. Require the constructor to locate, or "pothole", for underground lines before work begins.
   2. Specify hand excavation when near existing underground lines.
   3. Encase new underground lines in concrete which is colored red.
   4. Require a brightly colored warning tape to be placed along underground lines approximately 12 inches above the lines.
   5. Disconnect the power lines before construction begins.

## Overhead Power Lines

A. Overhead power lines which are in service during construction are hazardous when operating cranes and other tall equipment.
   1. Disconnect the power lines, or decrease the voltage, before construction begins.
   2. Bury the power lines below grade, or re-route the lines around the project site, before construction begins.
   3. Clearly mark the power lines with warning flags, and note their location on the drawings.
   4. Allow adequate clearance between the power lines and the structure. See Section 1926.950 of the Code of Federal Regulations for minimum clearances.
   5. Do not locate power lines adjacent to constructor material storage areas.

## Equipment

A. The design of electrical systems for mechanical rooms and equipment can lead to safety hazards for construction workers.
   1. Design the ventilation system and lighting fixtures in a mechanical room to be operated by the same switch.
   2. Place electrical circuit breaker boxes in sight of the mechanical equipment they affect.

3. Provide fire stops where cable trays penetrate floors and walls.

**Testing**

A. Sufficient testing of electrical and instrumentation systems is essential to eliminate safety hazards due to failure of the systems.
   1. Require systems, components, and welds to be tested to ensure they meet minimum requirements. Types of testing to consider: hydrostatic, radiographic, ultrasonic, magnaflux, weld sectioning, dye penetrant, halogen mass spectrometer, etc.
   2. Design for safety against possible equipment failures, such as desuperheated, control valve, or component failure.
   3. Design all system components to prevent inadvertent system activation.
   4. Ensure that the electrical system design meets all N.E.C. requirements and the requirements of N.F.P.A. for the protection of electronic computer/data processing equipment.

**Existing Structure**

A. Working with and connecting to existing electrical and instrumentation systems presents safety hazards for construction workers.
   1. Design and schedule safe tie-ins to existing utilities.

**12. Project Component: Piping**

**Pipes**

A. The design of piping materials and welds, and the identification of piping contents, can affect the safety of construction workers.
    1. Check that foreign piping components are compatible with other piping system components.
    2. Color code the pipes to easily identify their contents.
    3. Show the pipe content flow direction on the contract drawings so that the first valve upstream of an emergency can be easily located.
    4. Avoid interior welds in large pipes and tanks, and ensure that welding conditions are appropriate for the type of pipe material, e.g. alloy piping systems requiring PWHT/preheat.
    5. Specify the use of hose racks for all areas requiring hoses.

B. Piping systems which do not meet design code regulations and which are not designed for the appropriate construction conditions create safety hazards for construction workers.
    1. Design piping system components to meet all national, state, and local building code requirements.
    2. Do not make direct cross connections between drinking water or utility systems and plant or process streams.
    3. Design trap discharge piping for the pressure of the piping system being trapped unless protected by vents or relief valves.
    4. Minimize pockets in piping systems. Trap all pockets.
    5. Minimize flanges in piping under high pressure, or which contains explosive or lethal gases.

C. Inadequate consideration of the entire piping system design can lead to safety hazards for construction workers.
    1. Provide adequate safety measures in the event of possible equipment failure.
    2. Design adequate protection against over-pressure for all piping components.
    3. Locate explosive or lethal gas lines outside of buildings, or in areas properly ventilated. Use all-welded construction to reduce chances of a leak.
    4. Design all impoundments for liquids to provide a means or facility to accommodate emergency bypass conditions.
    5. Design pipe materials to be chemically resistant to the fluids the system is designed to carry.

**Controls/Valves**

A. The design of piping controls and valves can lead to safety hazards for construction workers.

1. A bypass around a reducing valve should not have greater capacity than the reducing valve unless the piping is adequately protected by relief valves or meets the requirements of the higher pressure system.
2. Provide proper protection to prevent injury or damage caused by escaping fluid from relief or safety valves if vented to the atmosphere.
3. Prevent "water hammer" by providing air vents, surge valves, surge chambers, or delayed or timed valve operation.
4. Position controls away from passageways and work areas.

B. The design of piping controls and valves can lead to safety hazards for construction workers.
   1. Locate valve controls so that handles can be reached easily, or so that a standard type operating device can be installed.
   2. Indicate on the contract drawings the location of shut-off valves and switches for existing systems. Allow and provide access by the constructor to the locations.
   3. Ensure that control valve specifications meet the piping specifications for body rating, body material (corrosion and hazardous services), and flange type.
   4. Size control valves with consideration of noise level.
   5. Provide a tag or other positive ID of the appropriate pressure, temperature, etc. on all valves.

C. The design of piping controls and valves can lead to safety hazards for construction workers.
   1. Direct safety relief valve exhausts away from passageways and work areas.
   2. Consider rupture disks as a safety device either in conjunction with or as a substitute for safety valves, or to act as an explosion door on vessels and piping subject to explosions.
   3. Check safety relief valves against the piping process to determine if the valves are required to be A.S.M.E. code stamped.
   4. Provide relief valves between each pair of sectionalizing valves on lines containing liquids and subject to being both isolated and heated, such as heat exchangers, liquefied gas piping, etc.
   5. Use a globe or throttle valve on a bypass.

**Piping Location**

A. The location of piping components throughout a project can affect the safety of construction workers.
   1. Route piping lines below electrical/instrumentation cable trays to prevent the chance of electrical shock due to leaking pipes.
   2. Minimize the amount of overhead work.
   3. Locate piping lines which are under very high pressure or contain explosive or lethal gases on the outside of buildings or in areas properly ventilated and guarded.
   4. Do not locate piping in rooms containing high voltage equipment, bare wires, or bus bars.
   5. Route piping to avoid "head knockers" (6'-6" min. above grade) and tripping hazards.

**Piping Supports**

A. A lack of sufficient support for piping systems can create collapse and fall hazards for construction workers.
   1. Provide fall restraint cables along the length of overhead piping runs.
   2. Design overhead piping and supports to hold up a worker.
   3. Provide for thermal expansion of the piping by adding pipe bends, offsets, etc.
   4. Design steam lines with drips or freeblows to prevent "steam hammer" or "slugging".
   5. Design cross connections between low and high pressure systems with one or more of the following valves: double valves (both to have high pressure rating), high pressure check valve, normally open vent valve between double valves, or a relief valve on low pressure system.

**Drains**

A. Drains can create tripping and slipping hazards for construction workers.
   1. Design covers over sumps and drains to be flush with the floor level.
   2. Design area drains to be trapped or valved shut to avoid the spread of fire in case of a ruptured pipe.
   3. Route piping drains and overflows to trench drains so that floors remain dry.
   4. Pipe pump seal water in a manner to avoid slipping, e.g. case drains/base plates to hubs.

**Underground Lines**

A. New and existing below-grade piping lines present hazards during excavation, pile driving, and drilling operations.
   1. Locate underground lines in areas easily accessible for excavation. Allow sufficient area around the excavations for stockpiling and transporting the soil.
   2. When new piping lines are to be placed below existing concrete surfaces, roads, or other traffic areas, design the lines so that they may be placed using trenchless technologies.
   3. Note on the contract drawings the level of certainty and source of information on the location and size of existing underground lines.
   4. On the contract drawings, mark a clear zone around existing underground lines.
   5. Require hand excavation when near existing underground utilities.

B. Existing underground lines which are in service during construction present safety hazards for construction workers.
   1. Protect underground lines from crushing by use of sleeves or slabs, or by providing guard posts to prevent travel over them.

2. Provide over-sized pipe sleeves around lines under railroad tracks and highways to avoid damage to the tracks or roadbed in case of a leak.
3. Encase new underground lines in red concrete.
4. Require a brightly colored warning tape to be placed along underground lines approximately 12 inches above the lines.
5. Provide anchors or tie-downs for piping with push-type joints or other mechanical joints.

**Fire Hazards**

A. The scheduled construction of new fire water systems, or demolition of existing systems, can lead to fire hazards on the construction project.
    1. For taller buildings, design and schedule the fire water system to be installed early in the construction phase.
    2. Design and schedule an underground fire water system to be constructed throughout the project site before construction begins.
    3. Minimize downtime periods of existing automatic sprinkler systems.

**Hazardous Fluids**

A. Piping systems which contain hazardous fluids can present safety hazards for construction workers.
    1. Design piping which carries hazardous fluids to have a double lock-nut capability. Allow for a pressure bleed on trapped hazardous fluids, especially steam and condensate bypasses.
    2. Eliminate drainage of slippery and dangerous chemicals into passageways and work areas.
    3. Avoid routing dangerous fluids over equipment, control boards, aisles, and operator areas to avoid injury in case of a pipe leak.

**Erection**

A. Applying paint or insulation to elevated piping systems can lead to fall hazards for construction workers.
B. Large pipe sections which lack adequate connection points for lifting, and lack restraint from rolling, can create safety hazards for workers during lifting and placing operations.
    1. Design and schedule piping materials to be painted and/or insulated prior to erection or installation.
    2. Design large pipe sections to be oval or have one flatten portion to prevent rolling.
    3. Design in connection points on piping sections for lifting operations. Consider designing the connection points such that after pipe installation they can be used to connect the pipe sections.

**Testing**

A. Piping material and system performance testing is essential to eliminate construction site safety hazards.
    1. Require performance testing of the piping system, components, and welds using such tests as hydrostatic, radiographic, ultrasonic, magnaflux, weld sectioning, dye penetrant, etc.
    2. Require a stress analysis to be performed on applicable systems.
    3. Ensure that the shut-off head on all pumps is consistent with the associated piping.
    4. Design piping systems which feed tanks, chests, and large walk-in type equipment to prevent inadvertent system activation.

**Existing Structure**

A. Working with and connecting to existing piping systems presents safety hazards for construction workers.
    1. Design and schedule safe tie-ins to existing utilities. Ensure that the tie-in is appropriate for the piping contents and system. (stopple/hot top/cold cut, rubber plug and weld flange/unbolt)
    2. Use bolted rather than welded connections when working around existing flammable structures.
    3. Minimize the need for "hot work" permits by providing adequate buffer from existing piping systems.

## 13. Project Component: Tanks and Vessels

**Hazardous Conditions**

A. Tanks can present confined space, toxic substance, fire, and explosion hazards for construction workers.
    1. Avoid interior welds in tanks. Provide ventilation in the tank if interior welds are required.
    2. Provide vents and overflow or relief devices to avoid over-pressurization, and to avoid creating sufficient vacuum to cause the tank to collapse.
    3. Provide dikes around storage tanks which contain hazardous substances. Use a slab rather than an HDPE liner for the leak detection (LD) system on the bottom of large storage tanks.
    4. Provide traps or valves on process sewers and area drains to avoid the spread of fire in case of a ruptured tank.
    5. Ensure that tanks and vessels meet all local, state, and federal design code requirements.

**Tank Stairs**

A. The design of stairs for large tanks and vessels can lead to fall hazards for construction workers.
    1. Coordinate the layout of tank stair landings with the tank foundation design to prevent tripping hazards.
    2. Design circumferential stairs around tanks to ascend clockwise.

**Tank Entrances**

A. Without adequate entrances and ventilation, tanks and vessels can create confined space hazards.
    1. Locate permanent atmosphere testing devices and forced air ventilation equipment at entrances to tanks and vessels.
    2. Provide connection points adjacent tank and vessel entrances for attachment of a lifeline or safety harness.
    3. Provide at least two access ports for tanks and vessels to aid in access/egress and ventilation.
    4. Provide for a door to be installed in floating roofs for large vessels. Design and schedule the door to be installed prior to erection of the roof.

**Underground Tanks**

A. Underground tanks and vessels which are not adequately protected can be safety hazards for construction workers.

1. Protect underground tanks and vessels against crushing by use of sleeves, concrete slabs, or by providing guard posts to prevent travel over them.

**Tank Erection**

A. The erection and/or placement process used for tanks and vessels can lead to safety hazards for construction workers.
    1. Fabricate tank roofs at grade and lift them into place as one assembly.
    2. Complete interior welds on tank walls before erecting the roof.
    3. Provide a guardrail along the perimeter of the tank roof.
    4. Provide connection points for lifelines at the center of the tank roof.

**14. Project Component: Doors and Windows**

**Doors**

A. Doors which open into passageways and work areas can strike other workers, and also limit the width of the passage or work area when open.
   1. Design doors to swing away from passageways and platforms when opened.
   2. Design doors to swing open in the direction of exit travel.
   3. Instead of regular swinging doors, use sliding or bi-fold doors, or doors with window panels.
   4. Clearly mark interior glass doors to prevent workers from mistakenly trying to walk through the doors when closed.
   5. Design and schedule doors to be installed late in the construction phase.

B. The design of door hardware and the structure surrounding doors can lead to safety hazards for construction workers.
   1. Select door hardware that can keep doors in an open position without props or blocking.
   2. Eliminate tripping hazards around doors.
   3. Design and schedule new fire doors to be hung as early as possible in the construction phase. In demolition projects, keep existing fire doors in place as long as possible.
   4. Provide door protection such that natural elements (snow, wind, and lightning) will not cause unsafe conditions.

**Windows**

A. Prior to installation of upper story windows, low sill heights add to the chance of falling through the window openings.
   1. Design window sills to be 42 inches minimum above the floor level. Window sills at this height will act as guardrails during construction.
   2. Design window sills at a consistent level throughout the project.
   3. Provide inserts in window jambs for guardrail attachment.
   4. Clearly mark interior glass windows to prevent workers from mistakenly trying to walk through the windows.

**Skylights**

A. Skylights present falling hazards during roof construction and future maintenance operations.
   1. Design a permanent guardrail that surrounds each skylight.
   2. Design domed, rather than flat, skylights with shatterproof glass or add strengthening wire.
   3. Locate skylights on flat areas of the roof.

4. Locate skylights away from rooftop mechanical/HVAC equipment.
5. Place skylights on a raised curb.

**Access Doors**

A. Access doors in floors and roofs present fall hazards when no guardrails are used around the doors when they are opened.
    1. Use access doors which automatically provide a guarded opening when the doors are opened.

**15. Project Component: Walkways and Platforms**

**Environment/Climate**

A. Environmental/climate conditions can create slipping hazards for construction workers walking or working on exterior walkways and platforms.
   1. Protect exterior walkways and platforms from the weather by providing a covering, extending the roof line, or locating them on the sheltered side of the structure.
   2. Locate exterior walkways and platforms away from the north side of the structure to prevent the buildup of moss and ice due to lack of sun.
   3. Provide a minimum amount of slope on exterior walkways and platforms to prevent puddling.
   4. Provide a non-slip walking surface on walkways and platforms adjacent open water or exposed to the weather.

**Access**

A. Limited access to elevated walkways and platforms can prohibit timely response and efficient maneuverability into and out of the areas in emergency situations.
   1. Provide multiple means of access to elevated walkways and platforms which can be used during emergency situations.

**Materials**

A. Walkways and platforms of steel construction can lead to electrical shock hazards and slipping hazards for construction workers.
   1. Design walkways and platforms to be constructed of non-conductive materials, such as concrete, wood, or plastic.
   2. Use serrated grating, instead of checkered steel plate, for walking surfaces to prevent slipping hazards.

**16. Project Component: Stairs, Ladders, and Ramps**

**Stairs**

A. A lack of consistent stairway slopes and stair dimensions throughout a project can lead to construction workers tripping or falling due to unanticipated stairway layouts.
   1. Maintain a uniform stair slope throughout the project.
   2. Use consistent tread and riser dimensions throughout the stairway run and the project.

B. Inadequate, misplaced, or obstructed stairway landings can lead to falls when stepping onto or off of a stairway.
   1. Coordinate the layout of exterior stair landings with the foundation design to provide a smooth, clear landing area free of tripping hazards.
   2. Avoid stair landings constructed separate from the stairs.
   3. Provide a minimum 2'-6" x 2'-6" landing area.
   4. Build stair landings up above an uneven grade.

C. Stairway materials should be selected with consideration of the anticipated construction work area and surrounding environmental conditions to minimize deterioration of the stairways and the possibility of falling.
   1. Use perforated steel or steel grating for stair treads on exterior stairways to prevent slipping, or when there is a need to "see through" the stairs in tight, congested work areas.
   2. Consider using prefabricated stairways which can be erected as one assembly.
   3. Use steel or concrete instead of wood for stairways in areas where welding or other potential fire sources are present.
   4. Use wood, concrete, or other nonconductive materials instead of steel for stairways in areas where electrical work will be performed.

D. Exposed or tightly compacted stairways can create climbing problems for construction workers carrying materials or equipment and lead to falls.
   1. Design exterior stairs to be directly adjacent and parallel, rather than perpendicular, to the structure.
   2. Design circumferential stairways to ascend clockwise.
   3. In areas which receive snow, place exterior stairways on the sheltered side of the structure, or under a covering, overhang, or extended roof line.
   4. Place exterior stairs on the sunny side of the structure to prevent the buildup of moss or ice.
   5. Avoid using spiral stairways. If spiral stairways are used, provide a handrail to prevent stepping on areas where the tread width is less than 6 inches.

E. Stairways with inadequate or non-existent handrails or stairrails can create fall hazards for construction workers.

1. Provide a handrail or stairrail along each unprotected stairway edge, and when the gap between the stairway and the structure is greater than 6 inches.
2. Provide at least one handrail or stairrail along stairways with 4 or more risers, or which rise more than 30 inches in height, whichever is less.

F. To get to elevated work areas prior to erection of permanent stairways, construction workers must use temporary stairways, ladders, or manlifts which are often unstable, inadequately designed, or damaged.
   1. Design and schedule permanent stairways to be built as soon as possible in the construction phase and used by the construction workers.

**Ladders**

A. The orientation and design of ladders with respect to the structure can create fall hazards for construction workers.
   1. Design ladders to be vertical, or not exceeding 15 degrees forward, and straight throughout their length.
   2. Orient ladders such that the person faces the structure while climbing.
   3. Provide safety gates at the top of walk through and side access ladders.
   4. Provide a ladder cage or barrier on the back side of ladders that can be inadvertently climbed on the back side.

B. Inadequate landings and ladder design at the top and bottom of ladders can create fall hazards.
   1. Provide a minimum 2'-6" x 2'-6" landing area at the top and bottom of ladders. Coordinate the layout of the landings with the structure design to eliminate tripping hazards.
   2. Design the step-across distance between the center of the step/rung and the nearest edge of a landing to be between 7 and 12 inches. Provide a landing platform if more than 12 inches.
   3. For through-ladder extensions, omit steps/rungs within the extension. Flare the extension side rails to provide between 24 and 30 inches clearance between the side rails.
   4. Design the side rails of through or side-step ladders to extend at least 42 inches above the top level or landing platform.

C. Ladder step or rung size, spacing, and materials can make ladders awkward to climb or slippery and create fall hazards for construction workers.
   1. Design ladder steps/rungs to be spaced between 10 and 12 inches apart, parallel, level, and uniformly spaced throughout the ladder.
   2. Locate the first step/rung between 6 and 12 inches above the bottom landing, and the top step/rung at the level of the top landing.

3. Design ladder steps/rungs to be corrugated, knurled, dimpled, coated with a skid-resistant material, or treated to minimize slipping. Do not coat wood ladders with an opaque material.
4. Design the ladder steps/rungs of individual step/rung ladders to be shaped to prevent slipping off the end of the steps/rungs.

D. Inadequately designed ladder cages can create obstructions or snag construction worker clothing or equipment while climbing, and lead to construction workers falling.
    1. Design horizontal bands to be fastened to the side rails of rail ladders, or directly to the structure for individual-rung ladders.
    2. Design vertical bars to be on the inside of the horizontal bands and fastened to them.
    3. Design horizontal bands to be spaced at intervals not more than 4 ft. apart between centerlines.
    4. Design vertical bars to be spaced at intervals not more than 9.5 in. apart between centerlines.
    5. Keep the inside of the cage clear of projections.

E. Ladder cages can create fall hazards for construction workers if they are too small, too large, or do not provide protection along the entire length of the ladder.
    1. Design cages to extend at least 27 inches, but not more than 30 inches, from the centerline of the step or rung, and not less than 27 inches wide.
    2. Design the bottom of the cage to be between 7 and 8 feet above the point of access to the bottom of the ladder. Flare the bottom of the cage not less than 4 inches between the bottom horizontal band and the next higher band.
    3. Design the top edge of the cage to be a minimum of 42 inches above the top of the platform, or the point of access at the top of the ladder.

F. Ladder lengths can affect a construction worker's risk of falling if the ladders are long and do not provide a rest area, or if they do not extend above the top landing.
    1. Provide ladder cages, wells, or other safety devices where the length of climb is less than 24 feet but the top of the ladder is at a distance greater than 24 feet above lower levels.
    2. If the total length of a climb equals or exceeds 24 feet, provide a cage or well, and multiple ladder sections, each section not to exceed 50 feet. Offset each ladder section from adjacent sections, and provide landing platforms at intervals of 50 feet maximum.
    3. Design individual step/rung ladders to extend at least 42 in. above an access level or landing platform either by the continuation of the rung spacing as horizontal grab bars or by providing vertical grab bars that have the same lateral spacing as the vertical legs of the ladder rails.

G. Ladders which have attachments or other objects adjacent to the climbing area can obstruct workers during climbing and create a fall hazard.

1. Design ladders to prevent injury from punctures or lacerations, and prevent snagging of clothing.
2. Provide a minimum perpendicular clearance of 7 inches between ladder rungs, cleats, or steps, and any obstruction behind the ladder, except that the clearance for elevator pit ladders may be no less than 4.5 inches.
3. Provide a minimum perpendicular clearance of 30 inches between the centerline of ladder rungs, cleats, or steps, and any obstruction on the climbing side of the ladder. If obstructions are unavoidable, clearance may be reduced to 24 inches provided a deflection device is installed to guide workers around the obstruction.

H. Ladders which are not designed to withstand construction loading can collapse and lead to construction workers falling.
   1. Design ladders to be capable of supporting at least two loads of 250 lbs. each concentrated between any two consecutive attachments.
   2. Design each step or rung to be capable of supporting a load of at least 250 lbs. applied in the middle of the step or rung.
   3. Design ladders for any anticipated loads caused by ice buildup, wind, rigging, and impact loads resulting from the use of ladder safety devices.

I. Inadequate spacing of ladders with respect to other ladders and objects can limit the climbing area and create fall hazards for construction workers.
   1. Provide a minimum clear distance of 16 inches between the sides of individual step/rung ladders, and between the side rails of adjacent ladders.
   2. Provide ladder cages or wells around ladders which have greater than 15 inches clear width to the nearest permanent object on each side of the centerline of the ladder.
   3. Avoid designing manhole covers, doors, or other objects which swing into the climber's access space at the foot or head of the ladder.

J. Ladder wells can create fall hazards for construction workers if the wells are too small, too large, or do not provide unobstructed protection along the entire length of the ladder.
   1. Design the well to completely encircle the ladder.
   2. Design the inside face of the well on the climbing side of the ladder to extend between 27 and 30 inches from the centerline of the step/rung.
   3. Design the inside width of the well to be at least 30 inches.
   4. Design the bottom of the well above the point of access to the bottom of the ladder to be between 7 and 8 feet.
   5. Keep the inside of the well clear of projections.

K. Frequent use of ladders by construction and maintenance workers to move material and equipment increases the possibility of falling from the ladders.
   1. Consider stairs in lieu of a ladder when the ladder will be used frequently to move material and equipment.

**Ramps**

A. Ramps which do not contain any slip resistance measures or are subject to water, snow, or ice can be falling hazards for construction workers.
    1. Provide a non-slip surface treatment on ramps to help prevent slipping.
    2. Provide cleats on steel or wood ramps, or create grooves on concrete ramps, to help prevent slipping.
    3. In areas which receive snow, provide a covering, overhang, or extend the roof line over exterior ramps.
    4. Use a maximum ramp slope of 7 degrees.

## 17. Project Component: Handrails and Guardrails

**Railing Dimensions**

A. Handrail, guardrail, and stairrail dimensions can affect the safety of construction workers.
   1. When the top edge of a stairrail system also serves as a handrail, the height of the top edge should be between 36 and 37 in. from the upper surface of the stairrail to the surface of the stair.
   2. Design the height of handrails to be between 30 and 37 inches from the upper surface of the handrail to the surface of the tread.
   3. Design intermediate vertical members on stairrails and guardrails to be at most 19 inches apart.

**Railing Design**

A. Inadequately designed handrails, guardrails, and stairrails can lead to obstruction and fall hazards for a construction worker.
   1. Mount the toprails on top of the posts, rather than on the side of the posts.
   2. Provide a minimum clearance of 1-1/2 inches along the top and sides of the toprail.
   3. Do not attach equipment or other objects to the toprails.
   4. Connect railing members by welding rather than bolts.
   5. Design joints and railing ends to be rounded and smooth.

B. Handrails, guardrails, and stairrails which are not designed for construction loading and work site conditions can create safety hazards for construction workers.
   1. Design handrails and the top rails of a stairrail system to withstand at least 200 lbs. applied within 2 in. of the top edge in any downward or outward direction, at any point along the top edge.
   2. Provide continuous toeboards along the length of guardrails.
   3. Use a uniform railing height throughout the project.

**Materials**

A. The selection of handrail, guardrail, and stairrail materials can affect the safety of construction workers.
   1. Use steel instead of wood for railings in areas where welding or other potential fire sources are present.
   2. Use wood, concrete, or other non-conductive materials instead of steel for railings in areas where electrical work will be performed.

**Erection**

A. Stairs and elevated walkways and platforms can lead to falls during construction before handrails, guardrails, and stairrails are erected.

1. Design and schedule handrails, guardrails, and stairrails to be erected as part of the structural steel erection.

**18. Project Component: Furnishings and Finishes**

**Cabinets**

A. Cabinet, cupboard, and locker handles which project into work areas and passageways create obstruction hazards for construction workers.
   1. Provide recessed handles and other cabinet, cupboard, and locker hardware which do not project into work areas and passageways.

**Lighting**

A. The design and erection sequence of lighting systems can affect the safety of construction workers.
   1. Design and schedule lighting systems to be erected with the structural framing.

**Ceilings**

A. Inadequate design of ceiling systems and their supports can lead to safety hazards for construction workers.
   1. Design ceiling hangers and connections to support anticipated construction live loads including the weight of a worker.
   2. Minimize the complexity of construction of ceiling systems.
   3. Provide permanent catwalks or work platforms for ceiling installation and maintenance on tall, long span structures.

**Signs**

A. The design and erection sequence of permanent signs can create obstruction and other safety hazards for construction workers.
   1. Design signs with rounded or blunt corners, free of sharp edges, burrs, splinters, and other sharp projections. Orient fasteners so that they do not constitute a safety hazard.
   2. Design and schedule traffic and emergency signs for erection early in the construction phase.
   3. Design signs to be integral parts of walls and floors using color, tiles, or floor coverings.
   4. Ensure proper position and location of warning signs to clearly alert workers of hazards.

**Warning Devices**

A. Inadequate safety warning devices and signs can lead to safety hazards for construction workers.

1. Ensure that warning signs, controls, and alarms are standardized throughout the project.
2. Ensure that hazardous areas are identified, classified, and provided with adequate boundaries.
3. Provide signs, lights, alarms, etc. to ensure safety near dangerous equipment or areas.
4. Provide warning signs which describe the allowable floor loading.
5. Provide emergency showers and eye-wash basins in areas where personnel might come in contact with highly toxic or poisonous materials.

**Coatings**

A. The selection of coating materials can affect the safety and health of construction workers.
    1. Specify high solids, and no or low VOC (volatile organic compound) coating systems.

**Elevated Work**

A. Work performed overhead and at elevated levels presents fall, ergonomic, and other safety hazards for construction workers.
    1. Minimize the amount of overhead work.
    2. Use smaller, light weight, materials and equipment for elevated work.

**Erection**

A. The erection sequence or placement procedures for furnishings and finishes can affect the safety of construction workers.
    1. Design and schedule materials and equipment to be painted and/or insulated prior to erection or placement.

**19. Project Component: Roads, Paving, and Flatwork**

**Road Design**

A. Inadequate or congested traffic areas, and unstable road edges and shoulders, can lead to safety hazards for construction workers.
    1. In embankments directly adjacent to the road edge, provide an initial bench at the road grade to provide room for crews to work.
    2. Provide structural support at the edge of roadways to keep heavy construction equipment from crushing the edge and overturning.
    3. Provide a smooth transition between the road and shoulder.
    4. Design the slope, width, height, turning radius, and surface treatment of traffic surfaces with consideration of the anticipated size, weight, and maneuverability of the construction equipment.

B. The design of traffic facility components can affect the safety of construction workers.
    1. Around parking areas, ramps, and other elevated traffic surfaces, increase the height of the perimeter wall above the traffic surface to prevent driving off the traffic surface prior to placement of permanent wheelstops, curbs, and guardrails.
    2. Increase the specification standards to lengthen the project maintenance life cycle.
    3. Design traffic barriers and guardrails so that there is no need to temporarily or permanently replace or re-design them when new pavement overlays are put down.
    4. Use thermoplastic markings or buttons rather than paint for pavement markings.

**Project Layout**

A. The layout of a project can lead to safety hazards for construction workers by creating congestion and limiting access to the site.
    1. Locate project control points away from areas of high construction and public traffic.
    2. Allow room for temporary roadways to be constructed for use by emergency vehicles.
    3. Require at least two formal, controlled intersections at access points to the site.
    4. Provide road access into large, deep excavations such as wastewater treatment ponds and underground garages.

**Slopes**

A. Project sites which contain steep slopes and limited sight distances can lead to safety hazards for construction workers.
    1. Orient the project layout or grade the site accordingly to minimize the amount of work on steep slopes.
    2. Maintain site distances on the project site and haul roads.
    3. Limit long hauls on steep grades.

**Schedule/Sequence**

A. The project schedule and work sequence can lead to safety hazards for construction workers.
   1. During road work, slow down the ongoing traffic as much as possible by closing down adjacent lanes, posting flagpeople to control traffic, or running lead cars to guide the adjacent traffic.
   2. Design and schedule traffic and emergency signs for early erection.
   3. Detour public traffic around the project site.
   4. Design and schedule new parking areas to be constructed as early as possible to provide a formal, safe location for workers to store materials and equipment.
   5. Prior to the start of the project, erect informational signs near the project and announce to the media about the construction project.

B. Work performed at night and during peak traffic volume periods can be hazardous to construction workers.
   1. Avoid performing road work on Friday and Saturday nights.
   2. Minimize the amount of night work.
   3. Avoid road work and maintenance during peak traffic volume periods of the day.

**Safety Plans**

A. A lack of safety planning for the construction phase can lead to safety hazards for construction workers.
   1. Prepare, or require submittal of, an erosion control plan.
   2. Minimize construction visitation and public access through and adjacent to the construction site.
   3. Employ police officers to patrol around the project site to help with traffic control.
   4. Provide adequate illumination on projects during work at night.
   5. For projects adjacent open rock slopes, require rock fences to be erected, or regularly spaced benches to be cut into the slopes, early in the construction phase.

**Walkways**

A. Exterior walkways and other flatwork can lead to tripping and slipping hazards for construction workers.
   1. Do not have unanticipated, random steps along walkways.
   2. Consider providing a covering over walkways to protect them from snow and ice.
   3. Design a minimum amount of slope into walkways to prevent puddling.

**20. Project Component: Earthwork and Utilities**

**Embankments**

A. Embankments which are unstable or very close to the work area can lead to congestion and falling object hazards for construction workers.
    1. Require rock fences to be erected on embankments early in the construction phase to smother any falling rocks.
    2. Provide an initial earthwork bench at the level of the work area to allow sufficient room for construction equipment and materials.
    3. Design in regularly spaced benches on embankments to stop loose rock from falling down to the work site.

**Excavations**

A. Excavations can present cave-in hazards for construction workers.
    1. Design the project such that the cut and cover method can be used for excavation rather than tunneling.
    2. Minimize the amount of excavations required in backfilled or other loose soil, and where there are vibrations from railroads, highway traffic, or large machines.
    3. Provide road access into large, deep excavations such as wastewater treatment ponds or underground garages.
    4. Provide a seal slab or walls in excavations where the soil is saturated or likely to flood the excavation before backfilling.

B. Trench excavation for underground utilities can lead to cave-in hazards for construction workers.
    1. Allow for the placement of underground utilities using trenchless technologies rather than the cut and cover method.
    2. Avoid requiring trenches in previously backfilled or disturbed soil, or which cross between different types or conditions of soil.
    3. Avoid designing utilities which cross under existing pipelines, run parallel to immediately adjacent existing pipelines, or intersect manhole excavations.

**Sewers**

A. Inadequate sewer coverings and bypasses can create safety hazards for construction workers.
    1. Design open drainage pipes for storm sewers to allow for easy access to and removal of debris.
    2. Design sewer gratings such that the openings are not easily plugged by debris, but not too large that a worker's foot will go through.
    3. Cover open drainage routes in high foot traffic areas to prevent tripping hazards.
    4. Design all impoundments or holding ponds with emergency bypass capabilities.

5. Ensure that all accessways and manholes are provided with venting or non-venting lids appropriate to the service and traffic location.

B. Sewer systems which are not designed for the surrounding conditions and the liquids they will carry can be safety hazards for construction workers.
   1. Ensure that all open sewer embankments are designed for adequate stability under anticipated worksite conditions.
   2. Provide sewers with adequate accessways to allow for inspection and maintenance operations.
   3. Ensure that sewer lines are suitable for the maximum temperature service conditions.
   4. Provide adequate clearance between process/sanitary sewers and any adjacent or crossing potable water lines.
   5. Design process/effluent sewer systems to vent any gases to the outside of all buildings or other project work areas.

**Underground Utilities**

A. Existing underground utilities create safety hazards for construction workers during excavation and pile driving operations.
   1. Require the constructor to locate, or "pothole", existing underground utilities before excavation operations begin.
   2. Require hand excavation when near existing underground utilities.

**Slopes**

A. Earthwork performed on sites which are steeply sloped can be hazardous for construction workers operating heavy equipment.
   1. Orient the project layout or grade the site accordingly to minimize the amount of work on steep slopes.

**Safety Plans**

A. A lack of safety planning for the construction phase can lead to increased risk for construction workers.
   1. Prepare, or require submittal of, an erosion control plan.

## PtD Design Review Checklist

*Source: Hollingsworth, J.C. (2011). "Design for Construction Worker Safety." Field Research Project, MS Occupational Safety Management, Department of the Built Environment, Indiana State University, Terre Haute, IN, May 2011.*

### 1. Contract Drawings

A. Indicate material storage area that is at least fifty feet from any power-lines. Require unused or unsecured materials to be stored in designated areas only, and not in areas of construction activity. Reference CFR 1926.600, 1926.1407-1411.
B. Indicate the locations of shut-off valves and switches for existing utilities.
C. Indicate on the contract drawings the locations of existing underground utilities and mark a clear zone around the utilities. Include the source of information and the level of certainty on the location of the utilities.
D. Include the name, address, and telephone number of local utility companies on the drawings.
E. Indicate the locations of existing vertical load bearing walls.
F. Indicate the locations where shoring of the existing structure is required during construction.
G. Indicate floor and roof design loads for use in determining material stockpile locations and heavy equipment maneuverability.
H. Indicate which beams are designed to support lifelines, how may lifelines, and at what locations along the beams. Anchorages used for attachment of personal fall arrest equipment shall be independent of any anchorage being used to support or suspend platforms and capable of supporting at least 5,000 pounds (22.2 kN) per employee attached. Reference CFR 1926.502(d)(15)
I. Noise exposures identified and controlled, necessary signage indicated.
J. Indicate locations for Emergency Call Boxes in parking lots.

### 2. Schedule

A. Schedule the permanent electrical system to be installed early in the construction phase and available for use by the contractor.
B. Schedule permanent lighting systems to be installed early in the construction phase and available for use by the contractor. Refer to the American National Standard A11.1-1965 and CFR 1926.56(a).
C. Maintain existing automatic sprinkler systems in operations as long as possible during the construction phase. Refer to NFPA 101-2000, the Life Safety Code, CFR 1910.159, & CFR 1926.150.
D. Maintain existing fire walls and fire doors as long as possible during construction phase. Refer to NFPA 101-2000, the Life Safety Code.
E. Schedule sidewalks, slabs, and roadways around elevated work areas to be constructed as early as possible to provide a stable base for scaffolding and ladders.

F. For multi-story buildings, schedule a firewater protection system to be installed and in use as early as possible during construction. Refer to NFPA 101-2000, the Life Safety Code, CFR 1910.159, & CFR 1926.150.
G. Schedule ventilating systems to be in place in areas where coatings will be applied prior to applying the coatings. Refer to the American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2-1960, and ANSI Z33.1-1961, CFR 1910.94, & CFR 1926.57. NFPA No. 91-1961
H. Schedule a permanent stairway to be constructed at the beginning, or as close as possible to the start, of construction.
I. Schedule air conditioning, heating, and ventilating systems to be available for use by the contractor at close-in.
J. Schedule fire walls and fire doors to be constructed or placed early in the construction phase. Refer to NFPA 101-2000, the Life Safety Code.
K. Schedule materials, piping, and equipment to be painted and/or insulated prior to erection or installation. Painting and/or insulating prior to erection or installation will eliminate access and fall protection issues.
L. Schedule permanent emergency exit and egress signs to be erected early in construction. Installing permanent emergency exit and egress signs early in construction will eliminate relying on the contractor to maintain temporary paper signage will provide the best form of warning.
M. Schedule permanent handrails to be erected along with the structural steel as one assembly. Installing permanent handrails prior to erection will eliminate multiple fall protection issues.
N. Schedule projects which occur at the same location to be completed simultaneously.
O. Sequence permanent lighting systems along with the structural framing as one assembly. Refer to the American National Standard A11.1-1965 and CFR 1926.56(a).
P. Schedule the installation of permanent guardrails, anchor points, or other fall protection mechanisms early into the schedule. Installing fall prevention/protection systems early into the construction phase will eliminate numerous fall protection hazards with construction personnel.
Q. Schedule traffic and emergency signs for early erection. Installing permanent signage early in construction will eliminate relying on the contractor to maintain temporary signage and will provide the best form of warning.
R. Schedule doors to be installed late in the construction phase. Select door hardware that can keep doors in an open position without props or blocking.
S. Maintain existing toilet facilities in operations as long as possible. Schedule temporary toilet facilities to be installed as early as possible. Toilets and washing facilities shall be provided in accordance to CFR 1926.51.

**3. Roof Access and Design**

A. Building Information Modeling (BIM) coordination is complete. Worker access has been reviewed.

B. If the parapet can be designed at 39-45" it eliminates fall protection for roof maintenance and construction personnel. Reference CFR 1926.502.
C. Design the roof with minimum pitch to reduce the chance of workers slipping off the roof.
D. Roof Davits or other means installed for window washers. Window washing companies should be consulted for locations.
E. Installing anchorage points fifteen feet back from the edge of the building will eliminate falling hazards for construction and maintenance personnel. Reference CFR 1926.501-503.
F. Design permanent guardrails to be installed around roof access, work areas, hatches, and openings. Reference CFR 1926.501-503, & CFR 1910.23.
G. Fall protection has been planned for awning maintenance and construction. Consider permanent anchorage points and/or lifeline attachments. Reference CFR 1926.501-503, & CFR 1910.23.
H. Design permanent electrical outlets on the roof to allow for easy tie-in during construction and future roof maintenance. Provide enough outlets for portable lights on the roof during construction.
I. Design fixed ladders or steps stairways when there is a change in elevation so portable ladders and steps do not have to be used.
J. Design permanent guardrails to prevent personnel from falling in an open roof hatches or openings during construction and after occupancy.
K. Avoid trip hazards around openings and sharp objects, such as lightning protection.
L. Design fall protection anchorage points into the frame of roof hatches to provide means of fall protection for personnel carrying objects up and down the access ladder.
M. Design roof equipment (e.g. air handlers) to be installed away from openings and edges.
N. Design water, snow, & ice control measures.
O. Design skylights on flat areas of the roof and away from the roof edges.
P. Design skylights on a raised curb (10-12 inches).
Q. Design permanent guardrails around skylights. Reference CFR 1910.23.
R. Design domed, rather than flat, skylights with shatterproof glass or add strengthening wires.

**4. Walking & Working Surfaces**

A. Building Information Modeling (BIM) coordination is complete. Worker access has been reviewed.
B. In multi-story buildings, design each floor plan to have a smaller area than the story below to prevent objects and workers from falling more than one story.
C. Design perimeter beams and beams above floor openings to support lifelines. Design connection points along the beams to support lifelines.
D. Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.
E. Design scaffolding tie-off points into exterior walls of buildings for construction purposes.

F. Design ceiling hangers and connections to support anticipated construction live loads including the weight of a worker.
G. Design fixed ladders to meet and exceed OSHA Standards.
H. Design access by means of a ladder or stairway when there is a change in elevation greater than 19 inches.
I. Design floor holes greater than 1”x1” with bevel-edged covers. Bevel-edged covers minimize the tripping hazard in those areas. Reference CFR 1910.21(a)(1).
J. Design toeboards wherever tools, machine parts, or materials are likely to be used and have the possibility of falling to a lower level. Reference CFR 1910.23.
K. Design non-slip walking surfaces on floors adjacent to open water or exposed to the weather.
L. Design exterior stairways and ramps on the sheltered side of the structure, away from the north side, to protect from rain, snow, ice, and to minimize the buildup of moss.
M. Design stairways and ramps to run parallel and immediately adjacent to the structure, rather than perpendicular to the structure.
N. Design walkways and platforms to be constructed of non-conductive materials such as concrete, wood, or plastic. Non-conductive walkways minimize the risks of electrocution hazards.
O. Design a non-slip surface treatment on ramps to help prevent slipping.
P. Design ramps with a maximum slope of seven degrees.
Q. Design window sills to be 42 inches minimum above the floor level. Window sills at this height will act as guardrails during construction. Reference CFR 1926.501-502.
R. Design multiple means of access to elevated walkways and platforms which can be used during emergency situations.
S. Design steps, curbs, block-outs, slab depressions, and other tripping hazards away from window openings, exterior edges, and floor openings.
T. Design the covers over sumps, outlet boxes drains, and etcetera to be flush with the finished floor. Flush covers will minimize the tripping hazard in these areas.
U. Design equipment location for safe working access. If the equipment is elevated, provide access via fixed ladder, stair, and/or work platform. If elevation is greater than four feet, provide permanent guardrails or appropriate fall protection anchorage points.
V. Design light fixture locations for easy access, so lamps can be changed and serviced safely and cost effective.
W. Design permanent guardrails where elevations of four feet or greater exist. Schedule permanent guardrails to be installed early during the construction phase. If permanent guardrails are not feasible, provide appropriate fall protection anchorage points.
X. Design doors to swing away from passageways ad platforms when opened.
Y. Design doors to swing open in the direction of exit travel.
Z. Design lifeline system along the length of overhead piping runs to ensure that workers do not tie off to inappropriate elements. (E.g. sprinkler pipes, conduit, all-thread, etc.)

**5. Electrical**

A. Building Information Modeling (BIM) coordination is complete. Worker access has been reviewed.
B. Provide a work sequence for safe tie-ins to existing utilities. If feasible, all tie-ins will be de-energized.
C. Specify red concrete to encase underground utility lines. Red is the universal color code for electric utility locations. Reference www.iupps.org.
D. Design installations to meet or exceed NFPA 70E requirements. Reference NFPA 70E, Standard for Electrical Safety in the Workplace (www.nfpa.org):
    1. Panel schedules professionally typed and updated. When updating panel remove existing and replace with new.
    2. When fuses are needed provide current limiting fuses for over current protection.
    3. Avoid when possible the creation of work in environments above 40 cal/cm2 because of the blast hazards caused by arc flash.
    4. Flash Hazard Analysis:
        a. Flash protection boundaries
        b. Incident energy exposure level
        c. Protective clothing and Personal Protection Equipment
    5. Shock Hazard Analysis should be completed:
        a. Operating voltage of the system
        b. Shock protection boundaries
        c. Personal Protection Equipment
E. All electrical panels are installed with a minimum 36" 'safe zone' from equipment and materials. Reference CFR 1910.303.
F. Provide lock out availability on all equipment.
G. All outlets that have the potential to get wet install GFCI and install the waterproof covers that allow for the lid to close over the plug.
H. Provide emergency stop buttons or equivalent on energized equipment.
I. Specify permanent fixtures with guards that will protect the light bulbs. Moving material (ladders, pipes etc.) in and out of maintenance spaces creates hazards for breaking bulbs.
J. Provide adequate emergency power, so there is not a net gain on normal or emergency power.
K. For any equipment exposed to outdoor elements provide overhang, extend the roof line or other means to keep employees and equipment out of the rain and snow.
L. Design rubberized flooring around electrical components (such as breakers) with holes that allow for water drainage. Antistatic material will reduce the hazard of electrical shock.

## 6. Machine Guarding

A. All open motors, fans or moving parts are shielded.
B. Fences around elevator pulleys or equivalent.

C. Any place personnel can come into contact with moving parts and can get trapped between must be guarded.
D. Any place personnel can become trapped, fall in or caught must be guarded.

**7. Confined Space Entry**

A. If a space can be designed to eliminate a confined space it should be evaluated.
B. If a confined space cannot be eliminated, access points are to be designed as large as possible. Large access points will make it easier for retrieval during an emergency situation. Reference CFR 1910.146.
C. If a confined space cannot be eliminated, design the confined space with two access points.
D. Design ventilating and lighting fixtures in confined spaces to be operated by the same switch.

**8. Mechanical**

A. Building Information Modeling (BIM) coordination is complete. Worker access has been reviewed.
B. Provide a clear, unobstructed, spacious work area around all permanent mechanical equipment. Reference CFR 1926.403.
C. Labeling all equipment and pipes consistently.
D. When necessary, facilities for drenching or flushing the eyes ***"shall be provided within the work area for immediate emergency use."*** In applying these general terms, OSHA would consider the guidelines set by such sources as American National Standards Institute (ANSI) Z358.1-1998, ***Emergency Eyewash and Shower Equipment***, which states, at section 7.4.4, that eyewash facilities are to be located to require no more than 10 seconds to reach but that where a strong acid or caustic is used, the unit should be immediately adjacent to the hazard. Reference CFR 1910.151.
E. Floor drains are necessary in applicable areas to prevent the buildup of slippery/wet conditions.
F. Specify filters on equipment easily accessible and not located in an office. Consideration for employee access reviewed.
G. Specify equipment controls away from passageways and work areas. This will prevent accidental touch.
H. Design walkways or other means for easy access to service equipment. Consideration for employee access reviewed.
I. Air intake not close to trucks, generators or other equipment that is letting out exhaust.
J. Reference CFR 1910.104, 'Oxygen' prior to design.
K. Reference CFR 1910.101, 'Compressed gases' prior to design.
L. Specify housekeeping pads to be included for cleanliness and water accumulation.
M. Design ventilating and lighting fixtures in mechanical rooms to be operated by the same switch.

N. Design connection points adjacent to tank and vessel entrances for attachment of a lifeline or safety harness. Reference CFR 1926.501-503.
O. Design connection points for lifelines at the center of tank roofs. Reference CFR 1926.501-503.

**9. Egress**

A. For open areas such as crawlspaces specify signs showing exit routes or arrows. Design traffic and emergency signs for early erection. Refer to NFPA 101-2000, the Life Safety Code.
B. Provide adequate lighting for sidewalks and parking lots.
C. Maintain the existing Emergency Alarm system for renovation if all possible.
D. Design a minimum of two means of egress on large maintenance platforms (catwalks) or walkways.
E. Locate exterior stairways and ramps on under shelter side of structure to protect from rain, snow and ice.

**10. Other**

A. Require designers and construction managers to complete the OSHA 30 hour construction training course. The OSHA 30 hour for Construction is a comprehensive course that covers a wide variety of topics.
B. Consider the use of light, precast materials and attachments for elevated, exterior work areas.
C. Consider the use of prefabricated panels for work over waters, roads, and other environmental hazards.
D. Consider minimizing the size and weight of masonry blocks. On larger masonry blocks, provide cast-in handles or handholds for easy lifting.
E. Consider using prefabricated stairways which can be erected as one assembly.

## Design for Safety Checklist

*Source: "Safe Design of Structures: Code of Practice." Safe Work Australia, www.safeworkaustralia.gov.au, July 2012.*

### Design for Safe Construction

- Providing adequate clearance between the structure and overhead electric lines by burying, disconnecting or re-routing cables before construction begins, to avoid 'contact' when operating cranes and other tall equipment.
- Designing components that can be pre-fabricated off-site or on the ground to avoid assembling or erecting at heights and to reduce worker exposure to falls from heights or being struck by falling objects, for example fixing windows in place at ground level prior to erection of panels.
- Designing parapets to a height that complies with guardrail requirements, eliminating the need to construct guardrails during construction and future roof maintenance.
- Using continual support beams for beam-to-column double connections, be it adding a beam seat, extra bolt hole, or other redundant connection points during the connection process. This will provide continual support for beams during erection – to eliminate falls due to unexpected vibrations, misalignment and unexpected construction loads.
- Designing and constructing permanent stairways to help prevent falls and other hazards associated with temporary stairs and scaffolding, and schedule these at the beginning of construction.
- Reducing the space between roof trusses and battens to reduce the risk of internal falls during roof construction.
- Choosing construction materials that are safe to handle.
- Limiting the size of pre-fabricated wall panels where site access is restricted.
- Selecting paints or other finishes that emit low volatile organic compound emissions.
- Indicating, where practicable, the position and height of all electric lines to assist with site safety procedures.

### Design to Facilitate Safe Use

- Designing traffic areas to separate vehicles and pedestrians.
- Using non-slip materials on floor surfaces in areas exposed to the weather or dedicated wet areas.
- Providing sufficient space to safely install, operate and maintain plant and machinery.
- Providing adequate lighting for intended tasks in the structure.
- Designing spaces which accommodate or incorporate mechanical devices to reduce manual task risks.
- Designing adequate access, for example, allowing wide enough corridors in hospitals and nursing homes for the movement of wheelchairs and beds.
- Designing effective noise barriers and acoustical treatments to walls and ceilings.

- Specifying plant with low noise emissions or designing the structure to isolate noisy plant.
- Designing floor loadings to accommodate heavy machinery that may be used in the building and clearly indicating on documents design loads for the different parts of the structure.

**Design for Safe Maintenance**

- Designing the structure so that maintenance can be performed at ground level or safely from the structure, for example, positioning air-conditioning units and lift plant at ground level, designing inward opening windows, integrating window cleaning bays or gangways into the structural frame.
- Designing features to avoid dirt traps.
- Designing and positioning permanent anchorage and hoisting points into structures where maintenance needs to be undertaken at height.
- Designing safe access, such as fixed ladders, and sufficient space to undertake structure maintenance activities.
- Eliminating or minimizing the need for entry into confined spaces (refer to the *Code of Practice: Confined Spaces* for further guidance)
- Using durable materials that do not need to be re-coated or treated.

# A12 PtD Case Studies

The following case studies provide detailed descriptions of PtD when applied to actual projects. The case studies are intended to describe the hazards present on the projects and how the designs were modified to enhance the safety of those constructing the facility. Information about the impacts of the PtD efforts is provided for some of the cases.

## Case Study – Concrete Imbeds for Guardrail Support

The risk of falling is ever present on any high-rise construction project, to a great extent due to the absence of a complete building envelope. The lack of an enclosed perimeter leaves the edges of all floors exposed. There is a need for a barrier to protect construction personnel from this hazard. Temporary guardrails need to be installed at the edges of all floors to prevent falling. Installing the guardrails can be achieved by using the concrete imbeds (fabricated steel plates) located along the edge of the concrete slabs that are designed for the permanent attachment of the brick facade. Once the imbeds are placed, temporary guardrail posts can be attached to the imbeds as shown in Figure A12.1.

Figure A12.1: Guardrail attached to concrete imbeds at the edge of the concrete slab

The steel imbeds with the installed temporary guardrail posts, shown in Figure A12.1, were originally placed along the slab edge for the support of the brick veneer and the curtain wall system. After discussions between the contractor and the designer of the building during constructability meetings, it was agreed that these imbeds could also be used for the support of the temporary guardrails during its construction phase.

The architectural detail for the concrete imbed is shown in Figure A12.2. As observed in the figure, at the end of the concrete slab, a plate is embedded with anchor bolts. The plate has an additional plate welded to it that is used to bolt the supports for the brick veneer wall. Since the brick veneer wall is not installed until later in the construction process, the contractor used the plate with the bolt holes to attach the posts for the temporary guardrails that are shown in Figure A12.1.

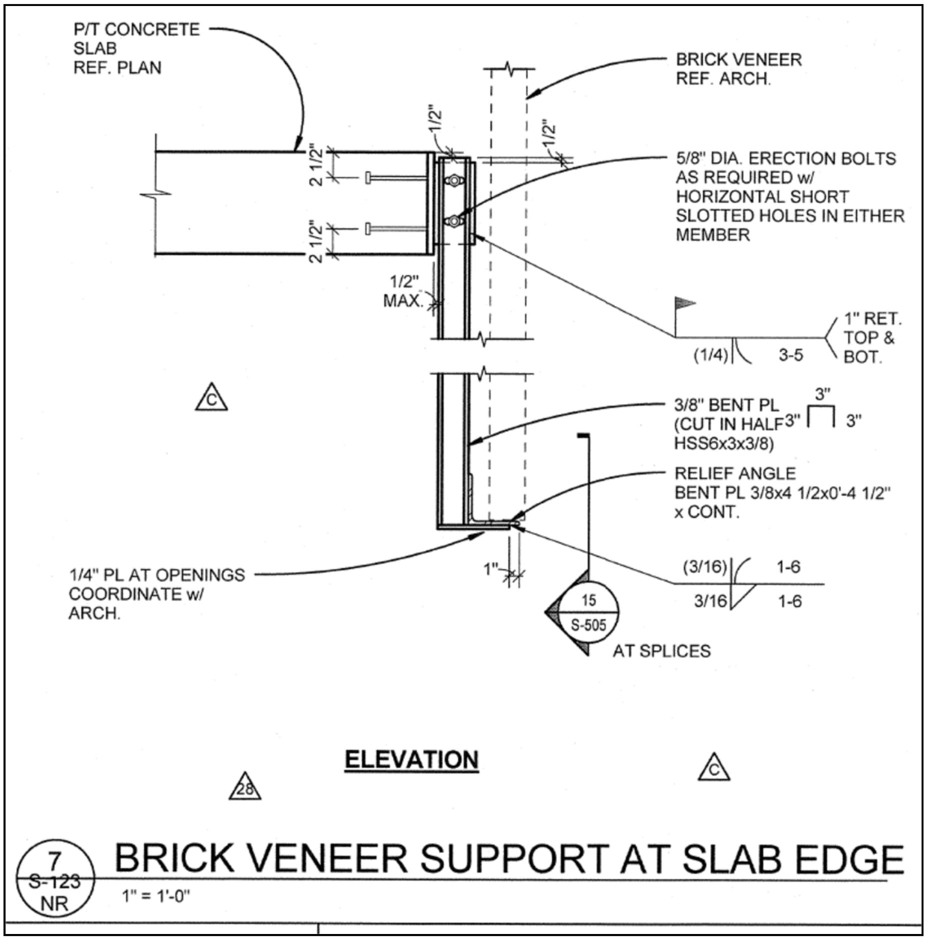


Figure A12.2: Design detail for the support of the brick veneer

This design solution can be used without additional cost at places where the concrete imbeds are specified in the design of the building. In places where the imbeds are not required for the completion of the building, the imbeds would be installed at additional cost. The additional cost is most likely offset by the reduced cost associated with installing a temporary guardrail by other means and by the reduced risk of worker injury while installing the other temporary guardrail support attachment.

This method of providing elevated slab edge protection from falls is very quick to install. In addition, only a minimal amount of re-design is needed, if any, since it utilizes the permanent structural elements in a building.

The installation of a temporary guardrail system on the permanent structural systems required in buildings provides the contractor and the designer with a safety solution that does not require an extensive amount of design. The guardrails used in this example were quickly installed and can be removed just as fast when they are no longer needed.

**Sources:**

Gambatese, J.A. and Tymvios, N. (2010). Final Report – Task 1 of "Identifying and Documenting Successful Construction Hazard PtD Solutions" research study, funded by National Institute for Occupational Safety and Health (NIOSH).

NIOSH (2014). "Preventing Falls from Heights through the Design of Embedded Safety Features," *Workplace Design Solutions*, NIOSH, Publication No. 2014-124, May 2014.

**Case Study: Concrete Straps for Fall Arrest**

During most of the construction phase of any building, the building envelope is not complete and workers are exposed to potential fall hazards. For this reason, temporary support for fall protection is necessary for craft workers who work in building construction.

“Concrete straps” are fall arrest straps made from polyester and are currently produced by several manufacturers. They are relatively inexpensive, single-use straps. Their installation is recommended to take place prior to casting of the concrete by attaching them to the concrete reinforcement as shown in Figure A12.3. The strap is wrapped around the reinforcement either by inserting the rebar through the short loop of the strap or by choking the loop around the reinforcement (3M, 2010).

Figure A12.3: Concrete strap attached to column reinforcement (left), and floor reinforcement (right)

The other end of the strap and its connecting D-ring is left hanging, as is shown in Figure A12.4, allowing workers to attach their personal fall protection harnesses or other personal safety equipment to it. According to the strap manufacturers, the straps provide a “5,000-lb fall arrest rated anchorage point”, and they are designed to be used by only one person at a time. The strap requires a 4-inch minimum embedment in the concrete (3M 2010).

Figure A12.4: Concrete strap hanging below formwork from column reinforcement

The literature provided by the manufacturers of the straps gives guidelines regarding installation, limitations, and inspection requirements of the strap, as well as technical characteristics and the standards to which the strap is designed. According to one manufacturer, these straps meet ANSI Standard Z359.1 2007, which covers "Safety Requirements for Personal Fall Arrest Systems, Subsystems and Components" (ANSI 2007). To accommodate the straps in the structure's design, the permanent rebar and supporting column to which the strap is attached must be designed to support the 5,000-lb load. This requires pre-planning and design effort by the structural engineer during the design of the project.

Once the strap is no longer necessary at the construction site or the risks of falls are eliminated, the strap can be removed by cutting the strap flush with the surface of the concrete. Since the straps are for single use only, after a strap is used to prevent a fall, the cut strap must not be used again.

This safety feature is currently implemented by contractors and subcontractors, and it is primarily a contractor-led safety design idea. The designer of the structure typically does not specify the use of the straps in the project documents. However, as mentioned above, involvement of the structural engineer is required to ensure that the permanent structure is sufficiently designed to support the fall arrest load. Inclusion of the straps may require larger-sized rebar to which the strap is attached.

Because of liability concerns, all subcontractors working on a project will commonly install their own straps. This can be seen in Figure A12.5 where several straps are placed side by side. If designers specify the locations of these straps, then multiple straps at any particular point may not be necessary.

Figure A12.5: Concrete straps attached to slab reinforcement above

Since the straps are temporary fixtures in the building, permanent fall arrest systems must also be installed where needed for the on-going operations and maintenance of the building. Examples of such systems are fall protection anchorage points permanently installed in the soffit of floor slabs, and roof anchors around the perimeter of the building. These anchorage points can be used during construction as well as after the construction phase is complete.

Using concrete straps is a very inexpensive method that is designed into the structure to provide fall restraint anchor points for all trades. By including concrete straps, additional work is not necessary during construction to provide anchorage points for fall arrest systems.

Concrete straps are a quick and effective method of providing anchor points for fall arrest systems. Design of these straps is currently initiated by the contractors, and requires verification of the location of their use by the structural engineer, and possible re-design of the permanent structure to accommodate the straps.

**Sources:**

3M, O.H.E.S.D. (2010). Concrete Anchor Strap User Instructions. 3M Company, Concord, NC.

ANSI (2007). ANSI Z359.1 - Safety Requirements for Personal Fall Arrest Systems, Subsystems and Components. Des Plaines, Illinois: American Society of Safety Engineers (ASSE).

Gambatese, J.A. and Tymvios, N. (2010). Final Report – Task 1 of “Identifying and Documenting Successful Construction Hazard PtD Solutions” research study, funded by National Institute for Occupational Safety and Health (NIOSH).

NIOSH (2014). “Preventing Falls from Heights through the Design of Embedded Safety Features,” *Workplace Design Solutions*, NIOSH, Publication No. 2014-124, May 2014.

**Case Study – Electrical Wiring in Slabs and Underground**

Electrical wiring in commercial buildings is often placed in conduit located within the ceiling space of every floor as shown in Figure A12.6. This placement exposes workers to risks associated with working overhead and working at elevation. These risks include: falls from heights, awkward postures, working in congested spaces, and lifting equipment. The risks can be eliminated by placing the cables within the floor slab or underground for slabs-on-grade.

Figure A12.6: Electrical cables running in conduit and on cable trays

By placing cables at a lower elevation, several of the risks are eliminated. Primarily, the risk of falling from a height, which is the main cause of accidents in construction, is eliminated since workers are working at ground level. The other risks of working in an awkward posture and a congested space are also greatly reduced. In addition, workers do not have to lift materials and equipment to the level of their work, reducing injuries associated with lifting materials and heavy equipment.

Examples of designs in which the electrical cables are placed in conduits at the floor level and underground are shown in Figure A12.7. The picture on the left shows electrical conduit placed along with the reinforcement in a floor slab of a multi-story, steel-framed building. The conduit is then cast in the concrete, and the electrical wiring is pulled through the conduit at a later time. The right-hand picture shows a similar arrangement where conduit for electrical wiring is placed at the foundation level before any concrete is cast. The conduit for the HVAC mechanical system is also placed in the same way.

Figure A12.7: Electrical wiring placed in the floor before casting (left), and at foundation level (right)

One design issue that needs to be addressed when considering the placement of the conduit in the slabs is to ensure that the slab depth is adequate to cover the required conduit thickness. Another concern is to ensure that the structural capacity of the slab is not compromised by the addition of the various conduit runs.

One limitation that is observed with placing the electrical conduit at ground level is that workers are now forced to work in a bent-over or kneeling position. This requires that they use knee protection and possibly personal protective equipment (PPE) to support their back. Also an additional risk of tripping arises when the conduits are placed over corrugated steel deck.

There have not been any studies performed on the economic feasibility of this solution, and therefore no cost analysis conclusions can be made. Also, in order to implement this solution, design alternatives need to be considered prior to construction. Since the conduit is cast in the concrete, any subsequent changes to their location will lead to significant additional costs.

It is suggested that the conduit be placed before the placement of any reinforcement in the slabs. This will allow for easier installation of both the conduit and rebar. Once the rebar is placed and the concrete is poured and cured, the electrical subcontractor can return to the site to place the electrical wires through the conduit. There should be no additional exposure to risks for the workers after the concrete is poured since any possible tripping hazards are eliminated by the flat, smooth surface of the concrete.

Some additional monetary cost might accrue from having the electrical subcontractor workers come to the site twice, once to place the conduit and then again to place the wires. However, with effective phasing of the work and proper coordination between the trades, the electrical subcontractor should not have to leave the site.

The introduction of conduit in elevated floor slabs may affect the fire rating of the slabs. The design engineer must ensure that the introduction of the conduit does not reduce the fire rating.

The major benefit of placing the electrical conduit within the floor slab or underground is the elimination of the risk of falling. Also, from an ergonomics viewpoint, workers do not have to work overhead in awkward postures.

By placing electrical cables at the floor slab or ground level, a major cause of accidents and injuries is eliminated. This method is a practical solution for the prevention of future accidents through the design of the structure.

**Source:**

Gambatese, J.A. and Tymvios, N. (2010). Final Report – Task 1 of "Identifying and Documenting Successful Construction Hazard PtD Solutions" research study, funded by National Institute for Occupational Safety and Health (NIOSH).

## Case Study: Increased Height of Roof Parapets

Roof access is necessary for a multitude of work tasks during the construction phase and maintenance of all buildings. Adequate protection should be provided around roof edges to protect workers and maintenance crews from potential fall hazards without the presence of additional fall arrest roof anchors, temporary barricades, or signage. One method to provide this protection is by constructing parapets that meet the minimum OSHA requirement for guardrails (OSHA 2010).

Increasing the height of the parapets around a building's perimeter involves several design changes that need to be implemented during the design phase. These changes require considerations regarding, but not limited to, drainage, roof access, and roof insulation.

In order to satisfy OSHA guardrail requirements, the parapet must have a height of 42 inches. The requirement allows a tolerance of 3 inches, so the absolute minimum height that the parapet needs to meet is 39 inches (OSHA). An example of such a parapet is shown in Figure A12.8. For buildings that do not have a parapet of at least this height, a temporary guardrail needs to be installed on the roof when personnel are present there. One example of such a situation is also shown in Figure A12.8.

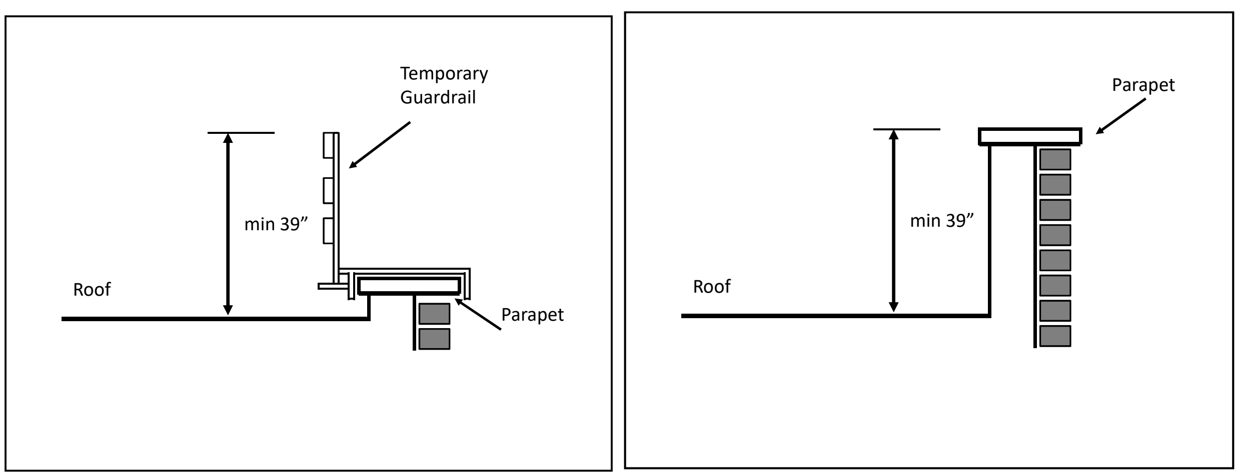


Figure A12.8: Roof parapet with temporary guardrail (left), and parapet with increased height (right)

Increasing the height of the parapet significantly reduces the risk of falls from the roof edge during the construction process. This added protection is present even after the construction of the building is complete, allowing maintenance crews to benefit from it as well.

The inclusion of the taller parapet on a building eliminates the need for a fall restraint system to be installed such as roof davits. In addition, a taller parapet eliminates the need for all equipment and access points placed on the roof to be 15 feet back from the roof edge, thus allowing use of a larger portion of the roof.

Maintenance and inspection of a parapet is no different than that of the rest of the building. On the other hand, alternatives such as roof davits need to be inspected by a structural engineer after every incidence in which they are utilized.

Raising the height of the parapet to the OSHA-required guardrail height provides increased protection for work that needs to be performed on roofs without the need for additional protective equipment. The only limitation to this design solution is its additional up-front monetary cost. However, this cost is offset by eliminating the need for installing additional permanent fall arrest anchors, and/or temporary protective equipment every time work needs to be conducted on the roof in the future.

**Costs of Fall Protection – Case Study Example**

One factor that may inhibit the use of this method for fall protection on all buildings is the additional initial monetary cost that is required to construct the taller parapet. This cost increase is significant in buildings with a large roof perimeter. However, this initial cost is typically offset by the long-term savings in the cost of needed temporary fall protection, increased maintenance worker productivity, and lower risk to worker safety.

A comparison of the costs associated with rooftop fall protection and parapet heights was prepared for two different parapet heights along the edge of a roof of a building being constructed (Rajendran and Gambatese 2013). The project, located in the Portland, Oregon area, involved the construction of a physical plant building. The building was part of a medical facility that housed an emergency power room, a normal power room, a chiller room, a boiler room, and a control room. The building being constructed was free-standing with a roof area of 929 $m^2$ (10,000 $ft^2$). The two parapets had a height of 30.5 cm (12 inches) and 99 cm (39 inches), respectively. The 12-inch tall parapet was designed for and constructed on the building, while the possibility for the 39-inch tall parapet was only considered after the fact. In this case, the 39-inch tall parapet is considered the PtD solution, while the 12-inch tall parapet is the traditional solution. A height of 39 inches is the minimum OSHA requirement for any work to be performed without the use of a temporary protection barrier. Therefore, a guardrail was required atop the 12-inch parapet during construction. A picture of the roof with the 12-inch tall parapet and attached guardrail is shown in Figure A12.9.

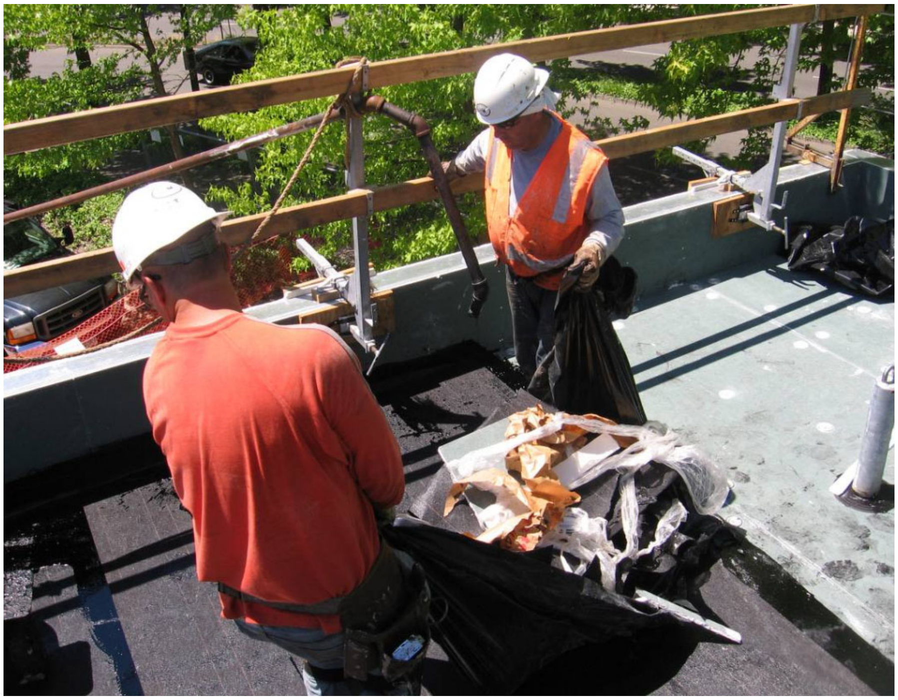

Figure A12.9: Construction workers placing insulation on the roof (Rajendran and Gambatese 2013)

Information about the two options was gathered from the subcontractors involved in the project through Requests for Information (RFI). The three subcontractors were the: walls and ceilings contractor, roofing contractor, and exterior skin contractor. Because a shorter parapet requires the installation of permanent roof anchors on the roof, information about the cost of the anchors was also collected from the firm that produces the anchors and the contractor that installs them.

Construction personnel were interviewed to determine time and effort requirements for the installation of the temporary fall protection equipment. The material cost for these fall protection measures was obtained through vendors that rent them. The labor cost for the workers necessary to install the equipment was obtained from the specific contractors involved. The case study also accounted for delivery costs, hoisting, and any necessary training needed for the protective measures on site.

As part of the case study, the facility's designers were asked whether there would be additional cost for the design of a taller parapet. The designers indicated that there would be no difference in design costs between the two parapet heights.

The PtD solution had a considerably higher cost at $44,028, while the traditional (shorter) parapet solution only cost $5,025 (without the roof anchors) to design and construct. Tables A12.1 and A12.2 provide summaries of the costs associated with each parapet design option, plus the cost of installing roof anchors.

Table A12.1: Costs associated with 39-inch Tall Parapet System (Rajendran and Gambatese, 2013)

| Item No. | Work and/or Design Feature Description | Cost |
|---|---|---|
| 1 | Walls and ceiling | $19,533 |
| 2 | Roofing | $4,475 |
| 3 | Exterior wall panel | $20,020 |
| | Total | $44,028 |

Table A12.2: Costs associated with 12-inch Tall Parapet with Roof Anchor System (Rajendran and Gambatese, 2013)

| Item No. | Work and/or Design Feature Description | Cost |
|---|---|---|
| 1 | Temporary guardrail installation/removal (18 work hours) | $904 |
| 2 | Temporary guardrail material cost | $687 |
| 3 | Safety warning line system installation/removal (6 work hours) | $301 |
| 4 | Safety warning line system material cost | $486 |
| 5 | Delivery cost (supplier to jobsite) | $300 |
| 6 | Delivery cost (jobsite to roof – crane and forklift) | $100 |
| 7 | Construction worker fall protection equipment | $1,883 |
| 8 | Construction worker fall protection training | $165 |
| 9 | Tools | $200 |
| | Subtotal | $5,025 |
| 10 | Engineered roof anchors | $2,638 |
| 11 | Roof anchor installation | $1,709 |
| 12 | Supply and installation of base plates | $1,082 |
| 13 | Engineering, upsizing, and supplemental steel for roof joists | $6,756 |
| | Subtotal | $12,185 |
| | Total | $17,210 |

The taller parapet system was found be an expensive, but safer, alternative compared to the shorter parapet with roof anchor system. Because the shorter parapet with roof anchor system requires an extensive amount of temporary fall protection measures during construction, it creates more risk to worker safety. This requirement puts more workers at risk of injury while installing temporary guardrails during construction and while working near the leading edge during facility operations and maintenance. The shorter parapet with roof anchor system is the least expensive option compared to the taller parapet but the fall hazard is not eliminated when using a personal fall arrest system. A fall restraint system should be used with a roof anchor that prevents the fall; however, a restraint system is not feasible on all roofs. In addition, those involved in the project felt that the roof anchor system indirectly decreases worker productivity by at least 15% compared to a taller parapet system.

**Sources:**

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**Case Study: Pre-assembled Cable Trays**

This case study focuses on cable tray assemblies designed and installed for a power plant project. The assemblies were part of work to retrofit the aging plant. The work involved the replacement of the flue gas desulfurization (FGD) system to provide increased reliability and sulfur removal efficiency. The cable trays were necessary to support the system and carry all the ductwork that was necessary for its operation (URS Corp. 2011; B&W 2012). A picture of a cable tray being lifted into place is shown in Figure A12.10.


Figure A12.10: Cable tray being lifted into place (Picture provided by URS Corp.)

The construction firm for the project designed and constructed the cable trays. During the design process, the design personnel considered alternatives to the traditional (stick built) on-site cable trays. The personnel came up with the solution of pre-assembled cable trays that were transported to the site and lifted into place. The aim of the design solution was to conduct the work on the ground rather than at a high elevation in order to minimize the safety risk associated with the construction of the cable trays.

The construction firm developed a detailed estimate for the stick built solution, and tracked the engineering and construction costs for the pre-assembled solution (URS Corp. 2012). Table A12.3 provides a summary and comparison of the direct costs of the two solutions. The workforce required for the preassembly included electricians and ironworkers. The engineering cost involved the design and layout of the trays; however no additional design cost was included for the stick-built solution since the designs were replicated from other similar buildings in the facility. The material costs were approximately the same for each solution, with the pre-assembled trays needing some additional material for fastening the trays to the overhead beams.

Table A12.3: Cost Comparison for Alternative Design Solutions (URS Corp. 2012)

| Cost Category | Design Solution | | Difference (B) – (A) |
|---|---|---|---|
| | Pre-assembled (A) | Stick Built (B) | |
| **Time** | | | |
| Craft hours | 1,300 hours | 7,910 hours | 6,610 hours |
| Engineering hours | 743 hours (to develop design of trays) | 0 hours (original design based on typical details) | ($743) |
| Total | 2,043 hours | 7,910 hours | 5,867 hours |
| **Cost** | | | |
| Craft-related costs | $79,812 | $477,391 | $397,579 |
| Material and assembly costs | $142,408 | $132,389 | ($10,019) |
| Engineering costs | $92,292 | $0 | ($92,292) |
| Total | $314,512 | $609,780 | $295,268 |

In addition to the positive impacts in terms of cost and time, the pre-assembled solution led to less risk to worker safety on the jobsite. Being able to pre-assemble the cable trays on the ground eliminated the risk associated with workers building the trays at high elevation. In addition, the amount of time required for workers at high elevation to install the pre-assembled units was much less than that required to fully build the trays at high elevation. The alternative design resulted in not only lower risk of worker injuries, but also lower cost and a faster schedule.

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**Case Study: Soil Retention with Railing**

Risks associated with excavations include cave-ins and falls. The risk of cave-ins can be eliminated to a significant extent by the use of trench boxes or other earth-retaining systems. The risk of falling into the trench from the surface requires additional protective measures. Work activities related to trenching require construction personnel to work inside the trench, as well as at grade level close to the edge of the excavation for supervision, supply of materials, and inspection. The personnel who are posted at grade level encounter the risk of falling inside the trench since there are generally minimum protective measures installed that guard against falling into the trench. Figure A12.11 shows a worker looking into a trench from above.

Figure A12.11: Trench box supporting excavation (Source: United Rentals, www.ur.com)

To protect workers from falling into a trench from the surface of the excavation, contractors typically "step" the excavation to reduce the height of a potential fall from the edge. However, this method may make it difficult to see the full depth of the trench from above, and may not be practical given the confines of the site. Another method to eliminate that risk is to design a guardrail that is permanently attached at the top of the trench box. Having a guardrail attached to the top edge of the trench box provides immediate protection from falling into the trench wherever and whenever the trench box is placed. A new guardrail does not have to be constructed each time the trench box is relocated.

As shown in Figure A12.12, the guardrail must be designed to meet the 42-inch tall guardrail (minimum 39 inch) height requirement that is prescribed by OSHA. At the same time, the guardrail must be modular and be able to be installed or removed according to the job requirements.

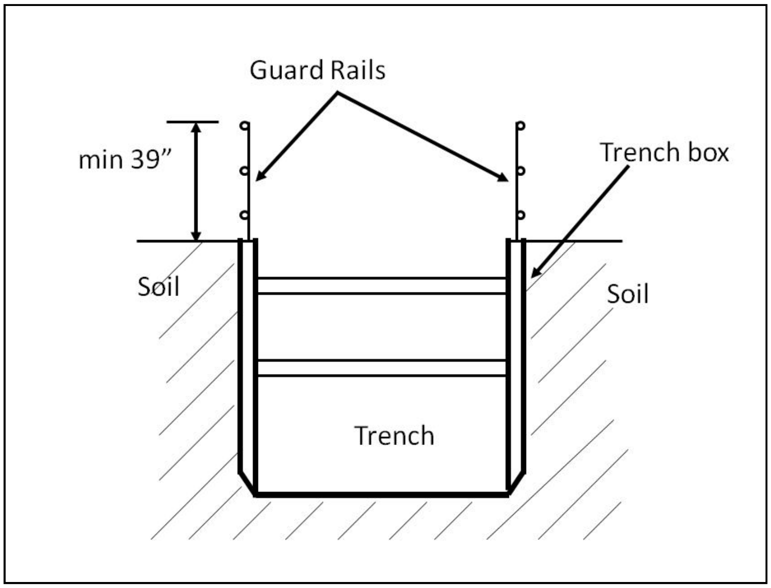


Figure A12.12: Trench box with attached guardrail

During an online search of trench box manufacturers, it was observed that there are no trench boxes with attached guardrails currently available on the market. The design of the trench box to include guardrails would need to be performed by the manufacturers of these products or other qualified professional engineer. Contractors should not install them without manufacturer and professional engineering input.

The proposed trench box with guardrail can significantly reduce the risk of falls into trenches and make the work accessible and safe for all personnel involved in excavation work. This design solution also enables installation of the guardrails immediately, without requiring workers to be exposed to the hazard while installing temporary guardrails.

**Source:**

Gambatese, J.A. and Tymvios, N. (2010). Final Report – Task 1 of “Identifying and Documenting Successful Construction Hazard PtD Solutions” research study, funded by National Institute for Occupational Safety and Health (NIOSH).

## Case Study: Stairwell Handrails

Movement of workers through a building is critical to complete the construction work. Workers must be able to get from one floor to another floor and move between locations on each floor. A variety of options are available to allow workers to go from one floor to another floor, such as a temporary manlift, ladder, and stairs. However, utilizing the permanent stairs for the building is often a preferred option because permanent stairs provide safe access for users of the building. Making the permanent stairs available for use by construction workers may require altering the design of the permanent stairwell.

This case study focuses on a high-rise construction building project in which the stairs, walls, and handrails in the permanent stairwells were re-designed to facilitate safe use by the construction workers. The project, a 95,000 sq. meters, mixed use development, included the construction of 35 stairwells. The material of construction for the stairwells was reinforced concrete.

The original stairwell design included cast-in-place concrete for the walls and stairs. The handrails in the stairwell between flights were to be metal. However, the construction project manager suggested a different design in which both the walls, including new solid spine walls between flights, and stairs were precast. A picture of one of the stairwells during construction is provided in Figure A12.13. This design change also required redesigning the handrails.

Revising the design to precast concrete resulted in the following safety benefits:

- The precast elements could be placed earlier in the project, giving the worker earlier access to the permanent stairs
- The need for temporary fall protection around the stairwells, and in particular between flights, was eliminated

The project also realized the following secondary benefits:

- With the large number of stairwells to construct throughout the development, the total cost of construction decreased when no temporary protection was needed during construction
- Less time was required to detail the handrail types. The handrail detail was much simpler and there were not as many different types of details required.

There were also no architectural impacts of using precast concrete. For those stairs located in more public areas, the stairwell walls were clad in stone; therefore the concrete was covered up and not visible. For “back of house” and emergency exit stairwells, the walls were painted, which hid the fact that the walls were precast rather than cast-in-place.

Figure A12.13: Precast spine walls and stairs under construction

**Source:**
Keyes, M., Project Supervisor Design Process, Aegis Safety Management, Ireland

**Case Study: Telescoping Column Canopy**

Sinclair Knight Merz (SKM), a large engineering and construction company headquartered in Australia, participated in the design and construction of a fuel retail facility network development program in Asia for a petrochemical company. The program included the construction of retail fuel stations at multiple locations. The sites typically include a structurally-supported canopy covering the refueling pumps.

One of the hazards associated with the construction of the fuel stations is working at heights. During the typical process used to construct the fuel station canopies, workers typically have to work at an elevated level, i.e., the height of the canopy. For this particular project, the owner/client was interested in finding a solution to reduce the risk of falls. Working with SKM, the owner/client developed a new canopy design and installation method.

The design selected for use included telescoping canopy support columns. A picture of the columns is provided in Figure A12.14. The telescoping columns enable the entire canopy to be assembled at less than 1.5 meters above the ground and then raised up to its final height as one assembly. The columns extend, like a telescope, using a synchronized hydraulic system to raise the assembly to its final height of 5 meters above ground. Once at its final elevation, the canopy is bolted in place, and the hydraulic jacks removed.

The telescopic column design allowed for most of the canopy work to be conducted at a lower level. This included installation of the roofing, gutter system, fascia stickers, and the false ceiling with lights.

The impact on construction worker safety was significant. As a result of the design change, the total worker-hours required to work at height on canopy installations was reduced by 95% (from 3,250 hours to 50 hours). Thus, the re-design almost eliminated all work at height. In addition to improving worker safety, the revised design resulted in other project benefits. For example, the time required to construct the canopy reduced from 25-30 days to 6-8 days on average.

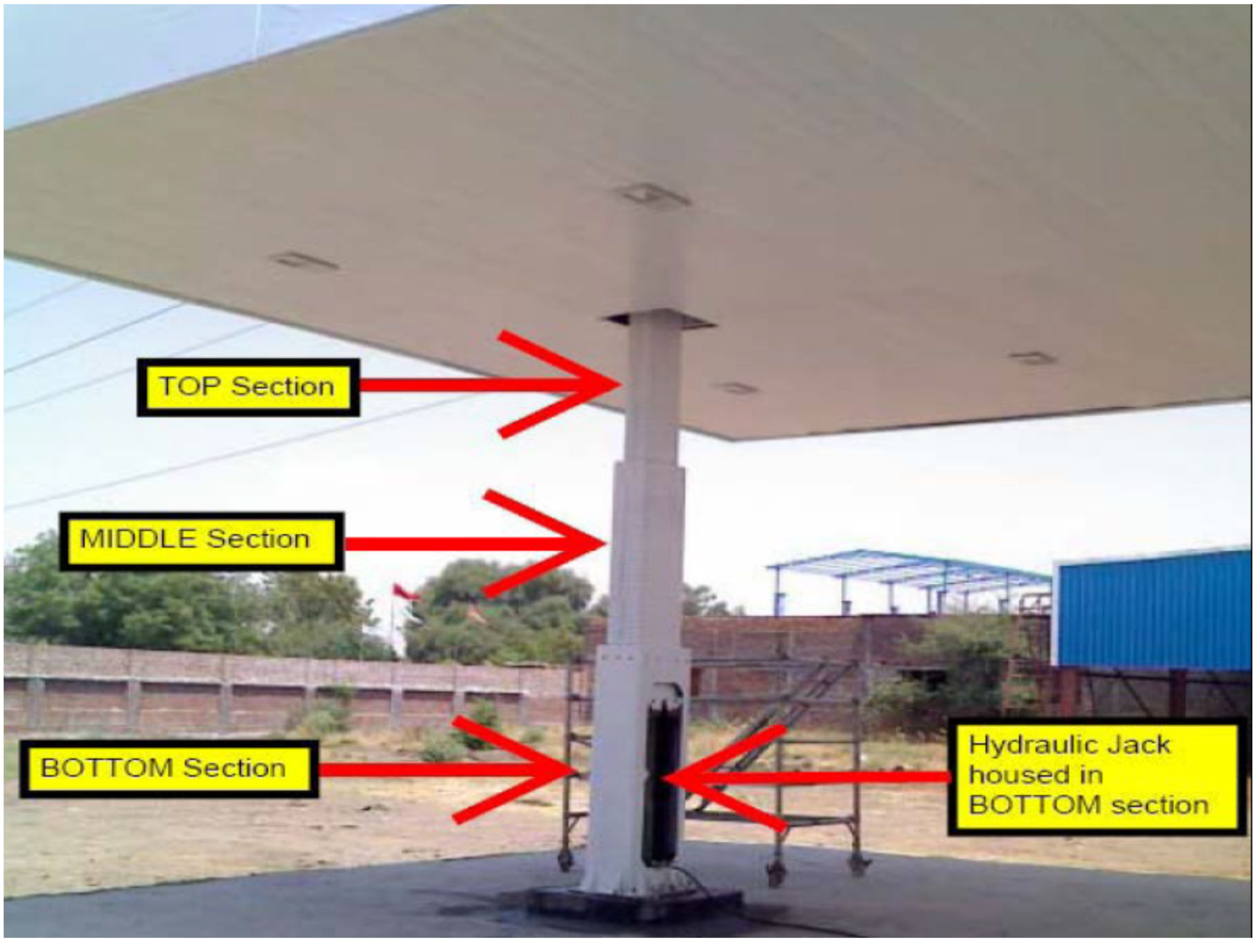


Figure A12.14: Telescoping Column and Canopy

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*Source: Prepared by Nicholas Tymvios at Bucknell University as of June 12, 2016, www.designforconstructionsafety.org/. He would appreciate receiving an email (nicholas.tymvios@bucknell.edu) regarding publications not on this list.*

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