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Technical Report: Prevention through Design – A Life Cycle Approach to Safety and Health in the Construction Industry

A Technical Report prepared by ASSP and registered with ANSI



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ASSP Technical Report

**Prevention through Design -
A Life Cycle Approach to Safety and Health
in the Construction Industry**

A Technical Report prepared by the American Society of Safety Professionals

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Secretariat and Standards Developing Organization:

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FOREWORD

This Prevention through Design (PtD) report was developed to provide information and guidance to the construction industry on a “life cycle design” approach to building construction with the goal of reducing or eliminating injuries, illnesses, and fatalities throughout the entire process of building construction, operation, maintenance, retrofit, and demolition. This technical report reviews and organizes recent research, constructive examples, and educational resources on PtD and is intended to be a resource for the design community. The design community includes those organizations and individuals who are in position to understand, accept, and apply PtD principles early enough to make a difference throughout the “life” of the building.

Prevention through Design in construction, and the focus of this technical report, addresses the building life cycle which includes the design and construction phases of a building, its use, and its eventual decommissioning. Although construction includes many types of projects, such as bridges, highways, and dams, the scope of this document is limited to the construction of *buildings*. The application of PtD principles during the building life cycle differs from other construction efforts. However, the process of PtD can be applied to all construction processes.

Construction work has been described as dangerous. However, the preferable terminology that allows for early identification and correction is “hazardous”. There are hazards inherent to the construction of a building as well as subsequent phases of operations and maintenance (O&M), retrofit, and demolition activities. But the life cycle of a building is only as hazardous as the systems (i.e., design, environment, people, etc.) through which it is created. With PtD, hazards and associated risks can be identified, and eliminated or reduced. With growing evidence that early intervention can result in significant reduction and elimination of hazards in all phases of the building life cycle, it is incumbent on building owners and construction design professionals to engage in the PtD process.

The reader will see the PtD process referred to as “techniques”, “components”, “practices”, and “principles”. The use of these terms, as they fit to the issue being addressed, is an indication of the multifaceted discipline that PtD represents and the need to ensure that all aspects of safety and health hazard prevention are addressed early in the construction process.

Revisions: The A10 Committee welcomes proposals for revisions to this Technical Report. Revisions are made periodically to incorporate changes that appear necessary or desirable, as demonstrated by experience gained from the application of the information contained herein.

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**ASSP TECHNICAL REPORT TR-A10.100
PREVENTION THROUGH DESIGN –
A LIFE CYCLE APPROACH TO SAFETY AND HEALTH
IN THE CONSTRUCTION INDUSTRY**

1. SCOPE, PURPOSE AND APPLICATION

Scope

This technical report provides guidance on including prevention through design concepts regarding the application of occupational safety and health principles in the construction industry. Through the application of these concepts, occupational hazards and risks can be identified, avoided, reduced, and/ or eliminated before, during and after a building or structure is constructed, renovated, and/or demolished.

This technical report complements but is not intended to replace existing specific standards and procedures, but rather to support those that meet related performance objectives.

The goals of applying prevention through design concepts in an occupational setting are:

- A. Achieve that state in which the hazards are identified early, and the exposures to those hazards are reduced to the lowest extent possible to minimize risks.
- B. Reduce the occurrence of occupational injuries, illnesses, and fatalities.
- C. Reduce the cost of retrofitting necessary to mitigate hazards and risks that were not addressed in the design or redesign processes.
- D. To develop a proactive and collaborative team approach between owners/operators, designers and contractors to develop a safe functioning building and work environment throughout the life of the facility.

Purpose

The purpose of this technical report is to reduce injuries, illnesses and fatalities in the construction industry by incorporating methods and features in the design stage and /or construction planning phase of a new construction project and/or renovation or retrofit of an existing building or facility to make a building or structure safer and healthier to build, maintain, and decontaminate, decommission, deconstruct and ultimately demolish. This document is intended to provide guidance for designers, architects, engineers, constructors and owners/ developers on these methods and features.

Application

The concepts discussed in this technical report may be applied in any occupational setting but concentrate on the construction industry.

2. TEAMING FOR PTD LIFE CYCLE - OVERVIEW

Prevention through Design (PtD) is a risk reduction strategy implemented in the design and planning stages of new construction that provides a unique opportunity to identify hazards and reduce exposures to those hazards. By integrating safety, health, and environmental considerations in these early stages, PtD provides an opportunity to control and reduce hazardous exposures throughout the life of the building by refocusing efforts from Risk Management (reactive) towards Hazard Elimination (proactive). Applying PtD therefore has the potential to reduce or eliminate hazards to everyone involved in the construction, management, operation, maintenance, renovations and deconstruction/decommissioning phases of the building.

Looking at a project from beginning through decommissioning is called the “life cycle approach” (Figure 1). This approach is important to ensure consideration of the safety and health of all who eventually interact with the facility or building. Construction represents only a small portion of the building life cycle. Therefore, latent hazards in the building after construction will remain for many years to come.

To consider PtD and incorporate the life cycle approach it is critical for those who drive this process to build a collaborative environment for all parties involved including end users and other stakeholders. Per a 2017 Dodge Data and Analytics “SmartMarket” report entitled *Managing Risk in the Construction Industry (Dodge 2017)*, 91% of owners, construction managers (CMs), general contractors (GCs) and trade contractors involved in the report study agree that a cooperative approach can reduce risk on construction projects. The study gathered input from 507 respondents in the construction industry including 111 owners.

Many of the findings throughout the study point to the same conclusion: that increased collaboration is a fundamental strategy for reducing risk.¹

At the forefront and leading these efforts is the “owner,” who can dramatically influence the depth of involvement of PtD and incorporate it into the life cycle of the project. *An owner who is fully engaged may critically impact the success of PtD efforts.* Architects and engineers are the backbone of the initial design team as they move the owners’ expectations to reality through their professional practices.

Other important members of the PtD project team that should be involved in the design phase are constructors (construction manager, general contractor, and key trade contractors), equipment vendors/suppliers, safety and security professionals, and specialists such as industrial hygienists, ergonomists, human factor/systems engineers, and disaster specialists.

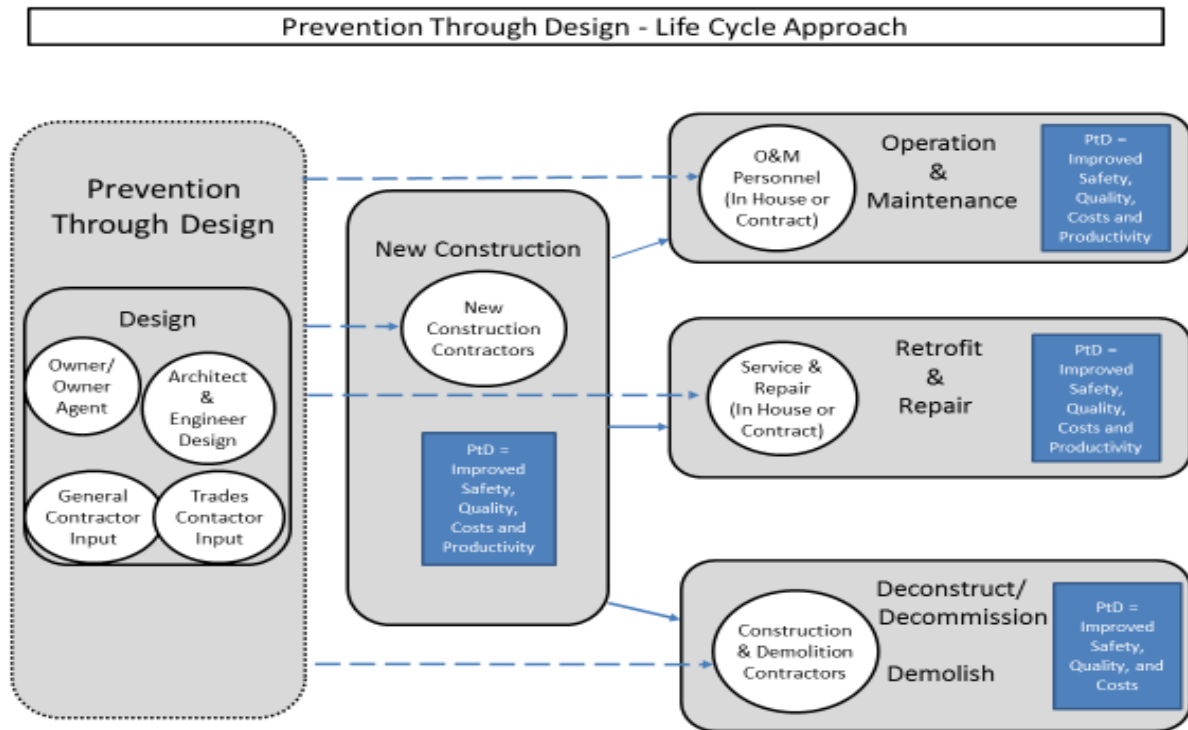


Figure 1. PtD Life Cycle Approach

The life cycle approach to design must include all known or anticipated uses for the facility or building to adequately consider the health and safety of all stakeholders, including:

- Workers who construct the project,
- End users who will work in the building or facility (includes owners, operators, maintenance personnel, repair and retrofit contractors, and vendors),
- The public (during and after construction),
- Workers involved in the deconstruction/decommissioning/demolition of the project.

Consideration must also be given to unforeseen conditions or circumstances such as natural disasters (flood, fire, earthquake, etc.), terrorism, future unintended uses of the building (re-purposing), changes in technology, or other potentially unanticipated yet impactful conditions.

Per Szymberski (1997)², the potential to influence site safety and health conditions decreases significantly as the project progresses (See Figure 2).

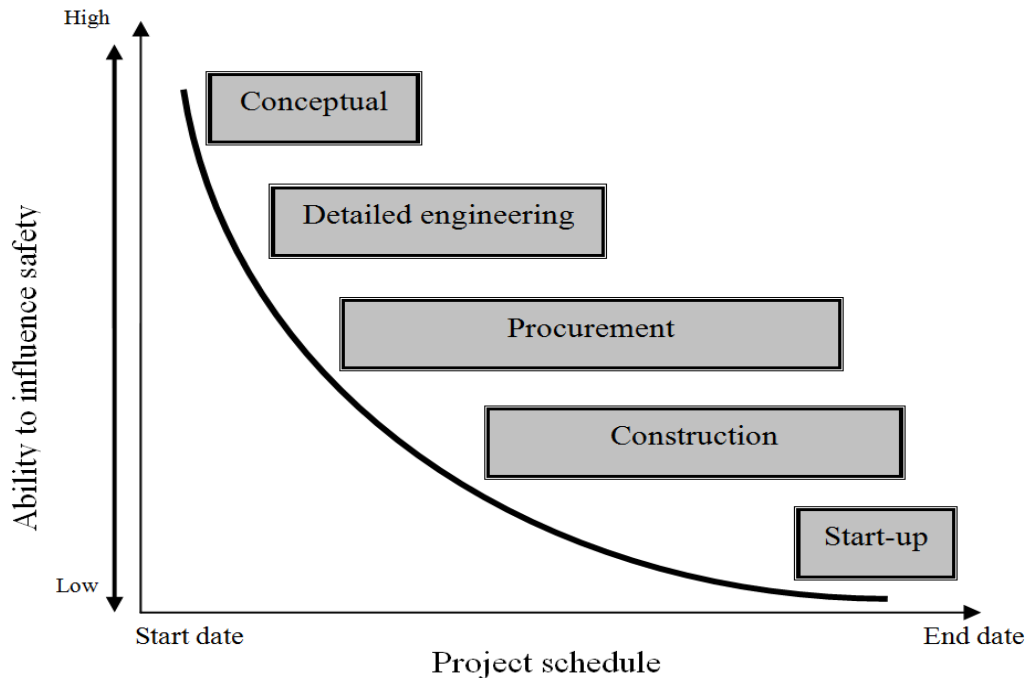


Figure 2. The potential to influence site safety and health conditions during a project
(Adopted from Szymberski 1997)

Recent research indicates that the many effective safety program elements occur during the design and preconstruction phases.^{3,4,5} Unfortunately, in the building construction industry in the U.S., typical methods for considering safety and health in these early phases are highly variable, or nonexistent. Thus, there is a clear need to enhance preconstruction risk management strategies toward hazard elimination / control strategies.

Examples of successful application of PtD and resources on PtD available to educators and practitioners are growing. Success stories and PtD-dedicated resources such as websites in the United States and Internationally are discussed further in Sections 2 and 4.

As Szymberski pointed out in 1997, the traditional roles and responsibilities in building design need to change and design professionals must accept these new concepts to improve and maximize the benefits of current building design processes. Hazards can be identified during the design phase and effectively eliminated without substantially affecting the cost, aesthetics, or function of the building. Stakeholders need to weigh the relative advantages of the design feature and eliminate the hazards when appropriate.

Historically, architects and engineers worked independently, often with only informal input from other construction professionals. The new approach to designing buildings includes a group effort, taking time to “look ahead” with organized interaction from all stakeholders.

One example of a safe design process is in Figure 3. Note the need for safety design at the initial design kickoff and the early involvement of trade contractors. Construction managers and general contractors should also be included in the early design phase. This makes the contracts and associated project delivery methods significant starting points for the PtD process.

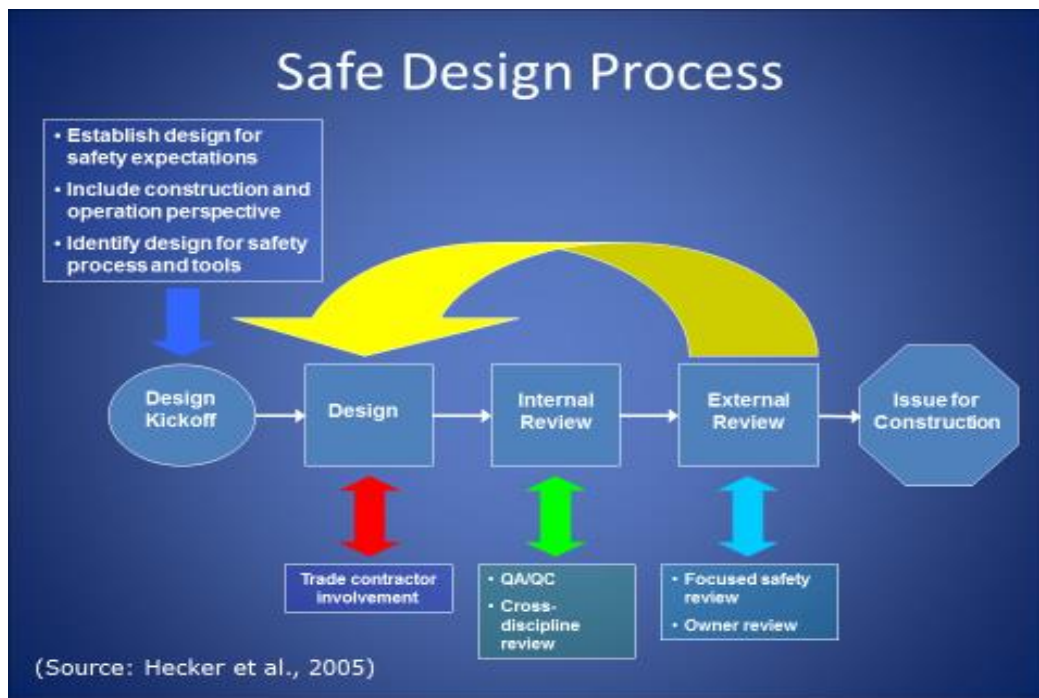


Figure 3. Strategy for a Safe Design Process ^{6,7}

Elimination of hazards and risks throughout the life cycle should be the goal in the design process. However, some construction environments make eliminating risk through design and planning a significant challenge. Building design processes may differ based on several factors including owner needs, architectural creativeness, and engineering requirements. When the ability to fully implement a PtD process is affected by site-specific constraints, efforts should be made to implement PtD methods to the greatest extent possible.

Where it is not practical to eliminate risk identified in the design and planning stages, the risks should be minimized with the application of prevention measures consistent with the hierarchy of risk controls.

The Hierarchy of Controls for Safety and Health Hazards

Work-related injuries and fatalities are undesirable consequences of accidents that occur during the project life cycle. Heinrich (1959)⁸ defined an accident as “an unplanned and uncontrolled event in which the action or reaction of an object, substance, or person results in personal injury or the probability thereof.” Many accident causation theories incorrectly emphasize human subject (worker) as the fundamental cause of accidents when ultimately there are a variety of causes within the system and culture in which they work.

Protecting workers from hazardous work environments requires consideration of the hierarchy of controls. One representation of this hierarchy is shown in Figure 4. The control methods at the top of the list are potentially more effective, protective, and economical (in the long run) than

those at the bottom. Following the hierarchy normally leads to the implementation of inherently safer systems, ones where the risk of illness or injuries has been substantially reduced.

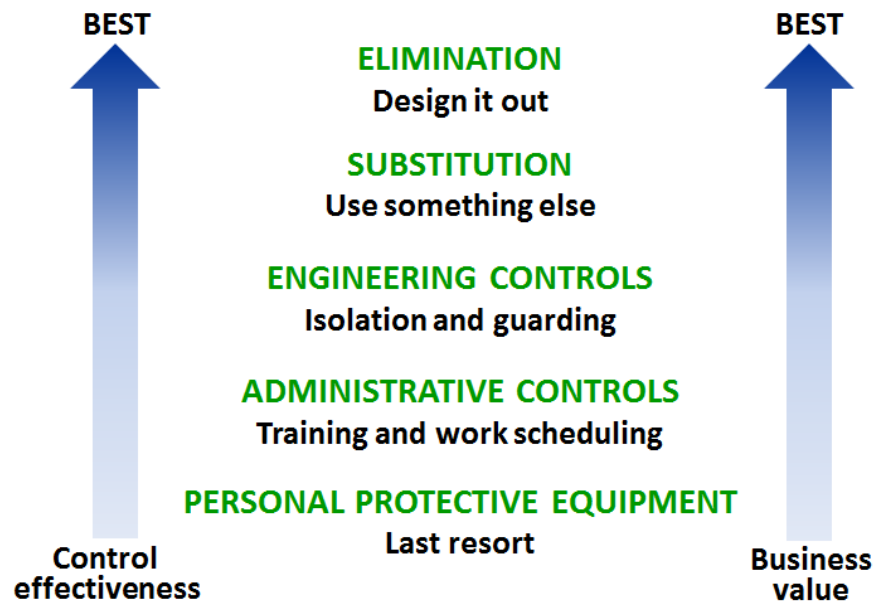


Figure 4. Hierarchy of Hazard Controls^{9,10}

In line with the hierarchy of controls concept and "physical elimination of hazards" at the top, the primary objective is to design out potential hazards. Designing out hazards eliminates risk. Risk mitigation often depends on administrative and procedural controls such as training and personal protective equipment. These procedural controls often default to the trade contractors and building maintenance personnel who must now manage these hazards and risks.

Owners, architects and engineers are in a unique position to identify and eliminate potential hazards during the design phase through collaborative efforts with all stakeholders' representatives. Some construction professionals have stated that safety hazards are often unknowingly designed into building projects.¹¹ Nevertheless, it is a common belief that the safety of the worker must be considered upstream during the design and planning process.

Motivations for PtD

There are many reasons to implement safety and health prevention measures in the construction industry, especially risk reduction measures during the design phase of projects as identified in this technical report. This section will discuss three important motivations the design community should consider for safe and healthy building design:

- Ethics and Sustainability - "the right thing to do" and the long-term use, maintenance and decommissioning of the building.
- The Business Case - safety in design can reduce life cycle costs and demonstrates active caring and value added to the client (building owner).
- Proven Success of Implementing PtD Principles.

Ethical Obligations and Sustainability – A Culture of PtD

Ethical obligations are often an important point in considering a prevention through design life cycle approach. This technical report suggests that the design community is in the best position to implement PtD as the “right thing to do” including the obligation to inform the owner of safer design opportunities. Design professionals are aware of the ethical obligations that they have, as discussed in the National Society of Professional Engineers (NSPE) code of ethics.

*Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and **must be dedicated to the protection of the public health, safety, and welfare.** Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.*
(emphasis added)¹²

The opportunity to eliminate hazards from a structure must start at the conceptual phase when architects have the unique ability and social responsibility to incorporate design elements that reduce or eliminate risk. Architects traditionally have been trained not to deal with the "means and methods" of constructability, so there is a historical reluctance for them to offer design ideas based on safety and risk prevention. However, not considering or incorporating reasonably safe design elements as features of the construction could be considered careless, and in the future, perhaps negligent. In fact, the National Council of Architectural Registration Boards (NCARB) recognizes the importance of protecting the public with its first rule of conduct pertaining to competence.

*In practicing architecture, **an architect's primary duty is to protect the public's health, safety, and welfare.** In discharging this duty, an architect shall act with reasonable care and competence, and shall apply the knowledge and skill which is ordinarily applied by architects of good standing, practicing in the same locality.*
(emphasis added)¹³

The level of care architects and engineers provide while designing for the protection of “the public” should include construction workers, maintenance personnel, vendors and others during and after initial construction (the life cycle of the building). For decades, architects have made design decisions based on related codes and standards which have provided safety and health hazard prevention measures for earthquakes, fire protection, etc.

For example, the National Fire Protection Association (NFPA) *Life Safety Code* includes exit requirements that architects incorporate into building design. Prevention through Design provides additional opportunities for architects and engineers to not only save lives but improve the lives of those interacting with the structure.