NIOSH
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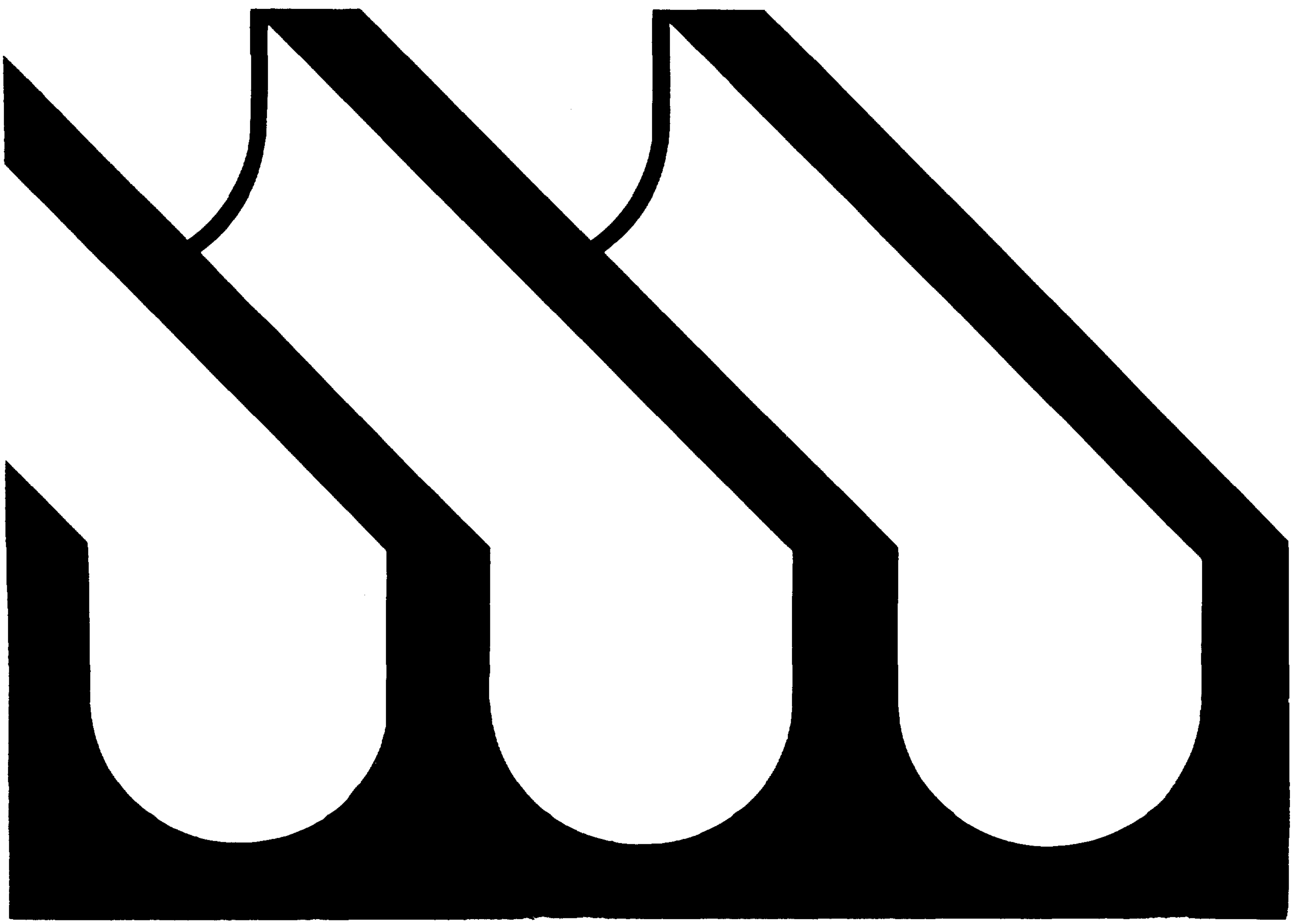
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

Comprehensive Safety Recommendations for the Precast Concrete Products Industry



COMPREHENSIVE SAFETY RECOMMENDATIONS FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

Contract No. 210-80-0040

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health
Division of Safety Research
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PREFACE

The Occupational Safety and Health Act of 1970 (Public Law 91-596), states that the purpose of Congress expressed in the Act is "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources...by," among other things, "providing for research in the field of occupational safety and health...and by developing innovative methods, techniques, and approaches for dealing with occupational safety and health problems." Later in the Act, the National Institute for Occupational Safety and Health (NIOSH) is charged with carrying out this policy. One method by which NIOSH responds to this charge is to publish Technical Guidelines.

Technical Guidelines present the results of comprehensive systematic analyses of occupational hazards, and suggestions for preventing injury and disease among workers. They are intended to supplement existing Federal safety and health standards and may provide background useful in formulating new standards for development. In the interest of wide dissemination of this information, NIOSH distributes Technical Guidelines to other appropriate governmental agencies, organized labor, industry, and public interest groups. We welcome suggestions concerning the content, style, and distribution.

This document provides guidance for protecting workers in the precast concrete products industry. It was prepared by the staff of the Division of Safety Research in conjunction with the Division of Standards Development and Technology Transfer, NIOSH. I am pleased to acknowledge the many contributions made by reviewers selected by the Prestressed Concrete Institute (PCI), the American Concrete Pipe Association (ACPA), and the National Precast Concrete Association (NPCA); other reviewers and consultants; representatives of other Federal agencies; and the staff of the Institute. However, responsibility for the conclusions and recommendations belongs solely to the Institute. All comments by reviewers, whether or not incorporated into the final version, are being sent with this document to the Occupational Safety and Health Administration (OSHA) for consideration in standard setting.

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ABSTRACT

Concerned by reports that the precast concrete products industry (SIC 3272) has an injury incidence rate which is consistently at least twice that of the national average, the National Institute for Occupational Safety and Health (NIOSH) began developing this document with the intent of providing recommendations aimed at reducing worker exposure to hazards.

The document characterizes the industry and describes the operations, tasks and processes required to manufacture precast concrete products. The magnitude of the occupational safety problem in the precast concrete products industry is defined through presentation of injury and illness incidence rates. In support of the document's systematic approach to the identification of industry hazards, a detailed analysis of 1,319 accident case histories was performed. This analysis identifies the tasks, tools, and equipment that are the most hazardous to the worker.

For example, materials handling tasks, both manual and mechanical, accounted for 28.0% of the total injuries studied. Tasks associated with welding, burning and cutting accounted for 4.6% of the total injuries. Some of the specific tools found to be particularly hazardous to precast concrete workers include: hoists and cranes, which accounted for 4.4% of the total injuries and 40% of the fatalities; unpowered handtools, which accounted for 5.7% of the total injuries; and powered handtools, which accounted for 5.8% of total injuries.

The determination of how workers are injured during precasting operations led to the formulation of comprehensive safety recommendations. The recommended engineering controls and/or operational safe work practices offered are applicable to product manufacture and delivery to a construction site only, and do not address erection or installation procedures.

To further enhance the document's usability for small to middle-sized precasting plants, a chapter addressing safety management principles is presented.

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CHAPTER I
INTRODUCTION

A. Historical Background

Various forms of cement or cement-lime have been used since ancient times. The Romans used the product in ashlar work (stone and brick) and as concrete in building harbors, piers, canals, and water supply and sewerage systems. The remains of ancient structures reveal that building materials progressed from relatively simple applications of natural materials to cast concrete, one of the earliest substitutes for natural stone. Despite the ravages of time, weather, and warfare, many ancient concrete structures remain to give testimony to their durability.

Following the Roman period, the use of cement and concrete had a long period of dormancy until the emergence of studies by the early British civil engineers in the late 18th century. During the 19th century, after the successful development of the Erie Canal under Governor DeWitt Clinton of New York, engineering projects increased the need for cement and concrete. New sources and techniques were developed, transportation improved, industrial growth expanded, and concern for public health emerged. Transportation requirements created a demand for railways, highways, storm drainage, and bridges; buildings required structural and architectural elements; and improvements in public health called for sewerage, water storage, and water distribution systems.

Technological advances, beginning with reinforced concrete and culminating in contemporary prestressing methods, have made longer, stronger concrete members possible. Thus, concrete has grown out of a mere supplemental relationship with steel into direct competition with it in construction of varying projects.

The widespread use of standardized precast/prestressed concrete products, such as architectural panels, pipe, etc., has brought about the prevalence of fixed, permanent plants for manufacturing concrete products. The improvement of transportational methods and systems has contributed to the evolution of the precast concrete plant, in that it has become cost efficient to mass produce concrete products and transport them to the various construction sites rather than cast members on-site. Such plants capably produce job-specific, one-of-a-kind product as well, offering an alternative to poured-in-place operations, or casting operations adjacent to actual construction sites.

B. Scope

This document concerns occupational exposure in the manufacturing of precast

concrete products (SIC 3272). Examples of products manufactured within SIC 3272 are contained in Appendix A. Contractors engaged in concrete construction work including on-site precasting of concrete products are classified in the construction industries and are not considered in this document. Other industries concerned with manufacture of concrete products which are excluded from the scope of this document are:

- Concrete Block and Brick (SIC 3271)
- Ready-Mixed Concrete (SIC 3273)
- Lime (SIC 3274)
- Gypsum Products (SIC 3275).

CHAPTER II
DESCRIPTION OF THE PRECAST CONCRETE PRODUCTS INDUSTRY

In this chapter the precast concrete products industry is described, its structure is examined, the number of plants and the size of the work force are defined, and the labor and trade organizations associated with the industry are identified. An operations approach that follows the production flow is used to give a description of specific manufacturing techniques or processes, the tasks performed by workers within each operation, and the tools and equipment associated with such operations.

Concrete is a building material made by thoroughly mixing cement; sand; aggregate, such as gravel or crushed stone; and water in desired proportions. The cementitious material usually is a hydraulic cement that sets and hardens in water. Initially, the concrete mix is a plastic material that assumes the shape of the mold into which it is cast. The mixture is poured into a cavity, an excavation in the ground, or a form designed for a specific purpose. After hardening, concrete has the appearance and structure of stone. In fact, it may be thought of as "moldable stone." When the mixture is deposited in its final position, it is known as cast-in-place concrete. When a concrete product or element is cast elsewhere (whether in a plant or on a field site) and then brought to its final position, it is termed precast concrete.

Precasting is a manufacturing procedure, whereas casting-in-place is a construction procedure. Being a manufacturing operation, precasting can have certain advantages:

- Work can be performed at a fixed site with accelerated curing facilities.
- A single location for batching and mixing concrete can be provided.
- A convenient source of water and other raw materials can be used.
- A location convenient to transportation facilities can be selected.
- Mass production techniques can be employed.
- Opportunities for storing product and working under shelter reduce the impacts of cyclical demand and weather conditions.

A. Plant Census and Worker Population

The precast concrete products industry is entrepreneurial, highly diversified, and geographically dispersed, with nearly 4,000 disparate plants manufacturing more than 600 different products. The NIOSH Industrial Profile data for 1980 (Table II-1) show that 3,930 precast concrete manufacturing plants employ about 82,049 workers [1]. These figures compare well with information derived from the 1979 Pennsylvania Industrial Directory [2], and the U.S. Department of Commerce 1977 Census of Manufacturers [3](Table II-2).

TABLE II-1
NUMBER OF PLANTS AND EMPLOYEES PRODUCING
PRECAST CONCRETE PRODUCTS, 1980
(SIC 3272)

	Range by Number of Employees							
	1-7	8-19	20-49	50-99	100-249	250-499	500+	Total
Number of Plants	2,004	951	610	236	106	17	6	3,930*
% of Plants	51.0	24.2	15.5	6.0	2.7	0.4	0.2	100.0
Number of Employees	7,548	11,113	17,924	14,910	14,341	5,088	11,125	82,049
% of Employees	9.2	13.5	21.8	18.2	17.5	6.2	13.6	100.0

*Thirty-three additional plants did not report the number of their employees; the actual total number of plants, therefore, is 3,963.
Compiled from Summary of Dun & Bradstreet Data in NIOSH Industrial Profile, 1980 [1].

TABLE II-2
SUMMARY OF PLANT CENSUSES (SIC 3272)

	Dept. of Commerce Census of Mfg., 1977	NIOSH Industrial Profile, 1980	Pa. Industrial Directory, 1979
Total Number of Plants	3,916	3,963	--
Number of Plants with 20 or More Employees	862	975	--
Number of Plants in State of Pa.	--	163	165
Number of Employees in State of Pa.	--	2,400	2,553

Compiled from the Summary of Dun & Bradstreet Data in NIOSH Industrial Profile, 1980 [1], 1979 Pennsylvania Industrial Directory [2], and 1977 Census of Manufacturers [3].

Information supplied by trade associations also verifies the plant census figures in the NIOSH profile. The American Concrete Pipe Association (ACPA) [4], the Prestressed Concrete Institute (PCI) [5] and the National Precast Concrete Association (NPCA) [6] estimations of worker population corroborate the NIOSH profile figures. Further, the trade associations estimate that the precast concrete industry is comprised of approximately 62,500 production workers. This equates well with the aforementioned NIOSH profile total population of 82,049 workers, and the Department of Commerce Census estimation that approximately 77% (or 63,178) of the total worker population in the industry are production workers. Table II-3 presents these trade association estimates.

For the purposes of this study, the NIOSH Industrial Profile data was used since it was the latest compilation of data on the industry.

TABLE II-3
TRADE ASSOCIATION ESTIMATES OF NUMBER OF PLANTS AND PRODUCTION EMPLOYEES, 1980
(SIC 3272)

Industry Product Sector	Number of Plants	Production Employees
Precast Concrete Pipe*	425	18,000
Architectural and Structural Products**	400	18,500
Miscellaneous Precast Concrete Products***	3,100	26,000
Total	3,925	62,500

*From Duffy J. J. American Concrete Pipe Association [4].
**From Freedman S. Prestressed Concrete Institute [5].
***From Tilford J. E. National Precast Concrete Association [6].

B. Process and Task Descriptions

This section describes the operations, tasks, and equipment required to manufacture precast concrete products. These descriptions are presented in organizational groupings that follow the primary production steps necessary in the precasting process. In many instances, the operations, tasks, and equipment described under a particular process heading are not unique only to that specific process; however, it is convenient to present the task descriptions in the sequence of the production flow. An additional section on materials handling is presented following the production task descriptions.

1. Forming

Forms or molds used for the casting of precast concrete products usually are made of steel or wood. However, they may be constructed of any material that remains stable during casting and is able to withstand the abuse of preparation, installation of steel reinforcement, oiling, curing, stripping, and reuse. Wood is commonly used for the construction of forms expected to have a limited use; that is, forms built for the casting of fairly unique concrete products. Concrete is sometimes used as a form because it can be cast into intricate shapes. With a dense, smooth surface finish and the application of form release agents, concrete is an excellent form material for products requiring smooth or curvilinear surfaces. Styrofoam, fiber glass, rubber matting, and various paperboards are also occasionally used to make forms or form liners for special surface effects. Because many of the products manufactured in the industry are produced repetitively, steel forms are common. Such forms are usually made to design specification by other departments or are purchased as standard equipment from other form manufacturers. Occasionally, it is necessary to modify or customize steel forms; that is, holes, notches, and sections may be burned out or fillets, boxouts, and seats may be welded in place as needed. Large forms may be equipped with access ladders, stairways, work platforms, conveyor connections for receiving concrete, and external vibrators for consolidation.

Steel forms are hammered, vibrated, modified, and moved, creating dents, holes, and misalignments that require periodic repair and maintenance. In addition to welding shops, many plants have portable welding equipment for repair and modification of forms too large and unwieldy to move. Welds and patches are occasionally required to fill in depressed spots; chipping and grinding operations are used to smooth rough areas.

The form surface against which the concrete will be cast must be clean and smooth (unless specifically designed otherwise). Forms are cleaned for reuse by chipping, wire brushing, scraping, scrubbing with water, sanding, and/or air blowing.

Form assembly follows repair and cleaning. Large forms are moved to the casting station by overhead hoists or cranes, or by lift truck. Many products have interior and exterior forms. Often, the interior form is placed and fixed to a cleaned steel plate, or pallet ring that forms the bottom of the product. Exterior forms are then locked into place with various fittings (makeup bolts, tack welding) that both fix its position and maintain the required dimension between the interior and exterior form.

Forms for long or flat products require minimum assembly, except to position the edges, bulkheads, and boxouts at the desired locations. Edges and bulkheads usually require appropriate spacers, spreaders, braces, and stiffeners. These pieces are usually cut from wood to the proper length, hammered into place, and held by nails. Hammers are used

for driving nails and tacking chamfer strips in wood forms. Sledge hammers, crowbars, and prybars are used in the alignment of forms as well as during the placement and removal of bulkheads.

The tasks and equipment used during the construction of the forms are typical to wood, Styrofoam, or fiber glass assembly/manufacturing processes. Most companies have carpenters' shops or areas equipped with hand and power tools for form construction. Larger companies usually have full-time personnel to use this equipment while smaller companies usually assign workers the task of making the form as part of their other routine responsibilities (casting, oiling, mixing, etc.).

2. Oiling

The form surface is coated with a release agent to keep the fresh concrete from bonding to the form. Form release agents usually have a kerosene or paraffin base and are applied to the form by swabbing or spraying before the reinforcing steel is placed.

Swabbing is the hand application and spreading of the agent on the interior surface of the form with the use of brooms, mops, rags, or brushes. Swabbing operations require a worker to fill a container (bucket) with form oil from a drum, transfer it to the form, and physically apply it to the form walls. Usually the worker will swab while standing and walking in the form. Some forms (vertical walls) may require the worker to stand on the form structure and mop the walls.

Most spray application of form oil is by hand-pumped, hand-carried sprayers similar to garden insecticide sprayers. The pump is filled from a central drum and carried by the worker to the form. Typically, the worker will walk along the edge of the form and spray the required surfaces. Some precast plants use a central pressurized air venturi system instead of hand pumps to spread the form oil.

3. Reinforcing

The reinforcing operation includes the fabrication and placement of steel reinforcement into the product forms. The tasks associated with this operation are cutting, bending, tying and welding of rebar, wire and wire mesh; and stringing and stressing of steel strand. The reinforcement, once sized and shaped, may be assembled in the form or fabricated outside of the form in a separate area or shop. The movement or placement of the steel may be done mechanically or by manual means.

There are four basic types of steel reinforcement:

- o Plant fabricated cages and mats
- o Prefabricated wire, loops, bars, rods, and welded wire mats
- o Steel plates and rolled sections
- o Prestressing steel strand.

a. Plant Fabricated Steel

Manual fabrication of reinforcing assemblies is common. Sometimes reinforcing bars or welded wire fabric are placed and tied in the form. For more complex assemblies, a jig is built to position bars. Transverse and shear steel is manually tied to the longitudinal steel with wire and pliers or with looped-end wire ties and a special "pigtail" tool that twists the two ends of the wire tie together when pulled. To produce reinforcing bars with the bends, loops, angles, and hooks specified by the design, a rebar bender is used. A cage or mat can be made to any desired size or shape. The completed plant fabricated reinforcing steel assembly is then lifted and placed in the form by manual or mechanical means. With prestressed concrete products, individual stirrups or welded wire fabric used for shear reinforcement are hand placed and may be tied to the prestressing steel.

Circular or elliptical reinforcing cages for concrete pipe are usually made of welded wire fabric (2- to 4-inch mesh made from 1/8- to 3/8-inch wire) or cold-drawn steel wire. A wire roller forms rolls or flat mats of welded wire fabric into the desired circular shape, which is then cut and spot welded to make the cage. Both cage machines or mandrels can be used to form steel wire into cages. In a cage machine, the operation is continuous and the endless cage produced is cut to the required length; in a mandrel operation, each cage is made individually to the desired diameter and length. Both techniques require that the wire mesh be shaped into a cylinder (by rolling or bending), the ends joined (by welding or using tie wires), and the finished reinforcing cage placed into the annular space of the pipe form.

b. Prefabricated Steel

Many small precast concrete products are reinforced by prefabricated steel manufactured to specification by others. This prefabricated steel is placed, tied, or secured into the form or pressed into the freshly cast concrete at the desired locations.

c. Steel Plates and Rolled Sections

For connecting some structural and architectural precast concrete products, small, rolled, sectioned steel plates with reinforcing bars or studs welded to them are tied to the cages inserted in the freshly placed concrete. Wire loops of prestressing strand or reinforcing bars are tied in place or inserted manually for lifting and handling the finished product. Connection and handling steel is called "hardware," and should be designed by the plant engineering staff or the project engineer. The tasks necessary when using steel plates are similar to those described in the preceding sections.

d. Prestressing Steel Strand

Prestressing steel is usually seven-wire strand that is manually or mechanically strung in the form before concrete is cast. Manual strand stringing is performed by a worker physically pulling the length of strand down the bed from a reel stationed at one end of the bed. The strand is then cut by torch or strand saw, and the process is repeated. Mechanical stringers pull multiple lengths of strand from separate reels at the same time. Single or multiple strands may be threaded through cages of reinforcing steel and through bulkheads used to separate adjacent members.

The steel wire strands are laid in the stressing bed (a long form up to several hundred feet in length with the cross section of the desired shape) and fixed at the ends (abutments). The stressing bed is the mold for several precast units along its length. For example, if 50-foot-long "double tees" are desired and a 610-foot-long stressing bed is used, 12 such units can be produced in one bed, each separated by a bulkhead. Some beds are designed as selfstressing forms, eliminating the need for end abutments.

Once the strands are in place they are then stressed. This operation is the tensioning (stretching) of wire strands previously positioned in the form. Stressing includes strand vise placement, jacking, tensioning, harping, and detensioning. The stressing operation can be done by single strand jacking or multiple strand jacking where all the strands are tensioned at the same time. The strands to be stressed (usually 1/2-inch, seven-wire strand [7], tensioned to approximately 200,000 pounds per square inch (psi) or a 30,000 pound load) are anchored at one end of the bed with a strand vise.

The strand vise barrel has a truncated conical hole along its longitudinal axis that holds the three jaws of a chuck. The chuck is serrated on the inside surface and conical in shape outside. The jaws permit free movement of the strand in one direction. In the other direction, they grip the strand and wedge themselves into the conical hole in the barrel of the strand vise. A strand vise is placed over each length of strand at the anchor end abutment, which fixes it in place. At the jacking abutment, two strand vises are placed on the strand in opposing directions. One is seated against the end abutment and allows the strand to be pulled through as the jack tensions the strand. This strand vise also holds and anchors the tensioned steel to the abutment. The other strand vise provides a grip for the jack. Figure II-1 shows a rectangular prestressed beam form with strands stressed and reinforcement in place.

The steel strand may run straight through the bed and may be stressed in this position. Alternatively, the strands may be depressed within the form for each member along the bed to create

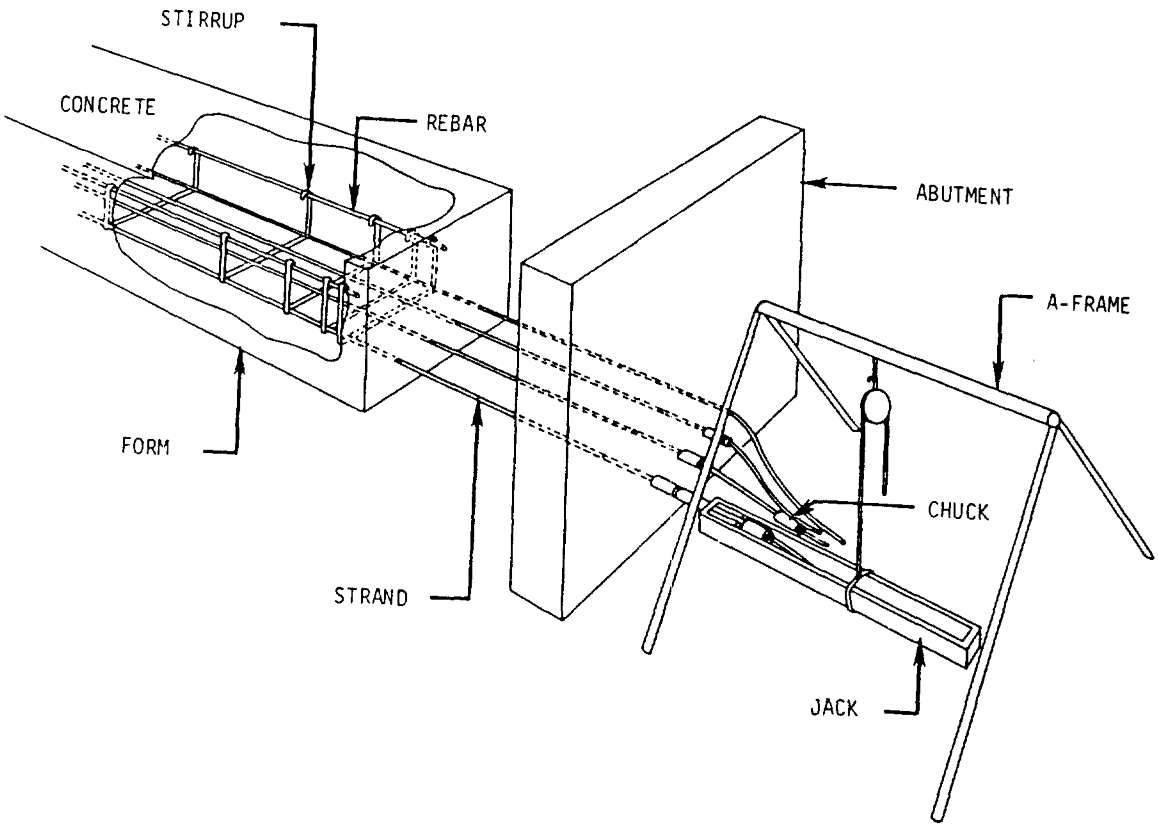

FIGURE II-1. PRESTRESSED AND REINFORCED BEAM FORM

an upward force that improves structural efficiency [7]. This technique is called draping or harping.

The term "draping" describes the profile of the steel strand, which is "draped" from its high point near the ends of each precast member to the low point at the midspan of each member. Strands can either be depressed or pulled up. The strands are passed through and over pin and roller fixtures that minimize friction at the points of change in the steel strand profile. Figure II-2 shows the strands depressed at the midpoint of a member, thus creating the appearance of strings on a harp. Some designs may require other holddown locations for each member.

After the concrete is cast and has gained the specified strength (usually 3,500 psi or more [7]), the strand tension is released, or detensioned. In some cases, strands are individually cut by torch; however, with hydraulic jacks, the tension is gradually released from the header.

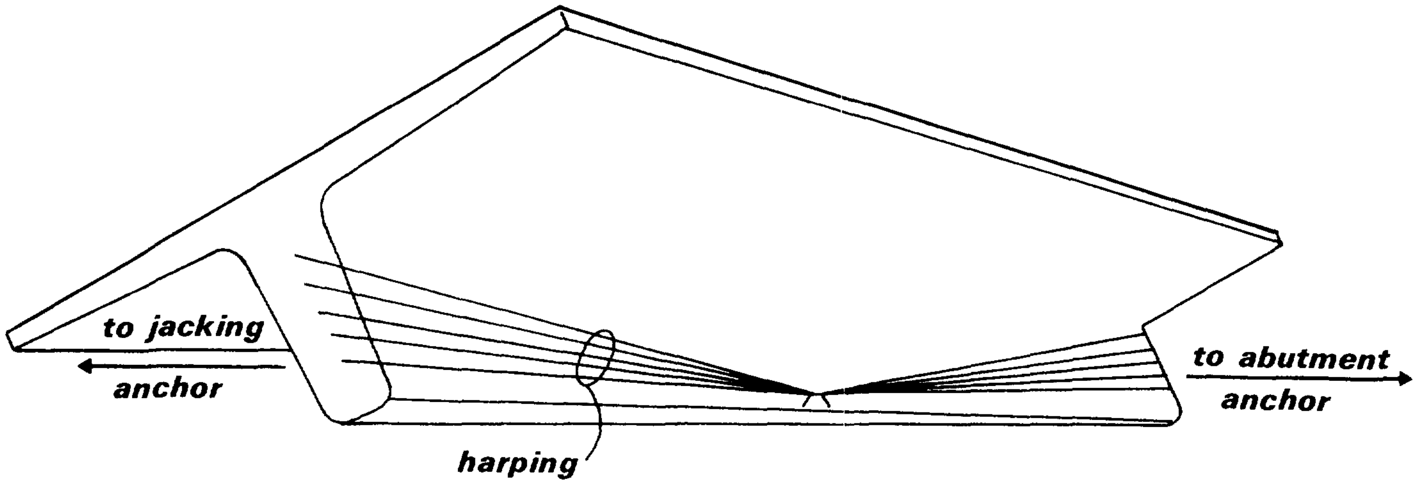

FIGURE II-2. A "SINGLE TEE" SLAB WITH THE STRANDS HELD DOWN AT THE MIDPOINT TO "HARP" THE PRETENSIONED STEEL

Adapted from Bennett W. B. Jr. [7].

Detensioning transfers the stress from the steel to the concrete to which it has bonded, precompressing the concrete.

4. Concrete Mixing

Concrete may be batched and mixed at the products plant or purchased from a ready-mix concrete producer. The correctly weighed proportions of cement, aggregates, and water are charged into a drum mixer, pan mixer, or a transit mix truck. Small mixers that are used in many miscellaneous products plants are gas, diesel, or electrically powered.

Cement may be delivered to the plant in bulk cement trucks or railroad cars and unloaded by a totally enclosed, screw auger pneumatic system that carries the cement to an elevated hopper or silo. Aggregates for larger plants are unloaded in much the same way as cement, except that open conveyors may be used. The material stored at a higher elevation is weighed and chuted by gravity (charged) into the mixer. The proper weight of water is added, and the mixer blends the components into a homogeneous mixture by rotating paddles inside an enclosed vessel at speeds of 2-15 revolutions per minute (rpm), or approximately 2 linear feet per second.

The two most common types of mixers used in the industry are drum mixers and pan mixers. A drum mixer is a rotating cylinder in which stationary paddles, mounted along the cylinder, mix the concrete (truck

mixers are of the drum type, inclined from the horizontal). The pan mixer consists of a shorter cylinder than the drum mixer and is vertically oriented; paddles are mounted vertically and rotate to mix the concrete in the stationary cylinder. The mixer is usually positioned 10-15 feet above the adjacent working surface to allow gravity discharge of the mixed concrete into buckets, trucks, or other means of conveyance to the casting area. Access for cleaning, maintenance, or concrete quality control is provided by ladder or steps to a working platform that will partially or totally encircle the mixer. Figure II-3 depicts a concrete batching, mixing, discharge, and transport system.

At the end of each shift or after mixing is completed for the day, the mixers are cleaned. In addition to daily cleaning and flushing of concrete mixers, it may be necessary to hammer or chip away built-up encrustations of concrete on a periodic basis. Mixers also require maintenance, paddle replacement, and repair. All of these tasks may require workers to enter the mixers.

5. Concrete Delivery and Casting

Casting of small products can be a manual operation; a quantity of mix is made available to the operator, who trowels or shovels it into a prepared mold around the reinforcement. The material may be hand tamped or vibrated to consolidate the mix. Many small products are made with high production, automated equipment.

For casting larger pieces, the concrete is delivered from a truck, a concrete bucket, or a concrete buggy moved to the location where the concrete is to be used. For very large pieces or for long-line prestressing beds, the concrete may be delivered by a monorail bucket system, overhead bridge crane, or other mechanical means and deposited directly in the form, where it is vibrated and consolidated by machinery or by manually inserted spud vibrators. Usually two to five employees will be directly involved in these tasks. In addition, concrete may be extruded through a die to form products such as hollow-core slabs.

Systems used to deliver the mixed concrete to the placement location vary from simple manual handling to totally automated, enclosed conveyances. Concrete mixed in small power mixers is delivered by direct deposit (when the mixer or form is portable), by front-end loader (which carries concrete from mixer to form), or by wheelbarrow. Ready-mix trucks frequently are used to deliver concrete because they can carry, and continuously mix, large volumes (up to 12 cubic yards) directly to or near the forms for placement. A chute, attached to a lip below the discharge opening of the truck's drum mixer, is directed by a worker to deposit the concrete. The chute is moved around during the casting process to spread the concrete and reduce shoveling or raking.

As parts of the form are filled with concrete, the truck moves along the form, placing concrete to the desired level. The process continues,

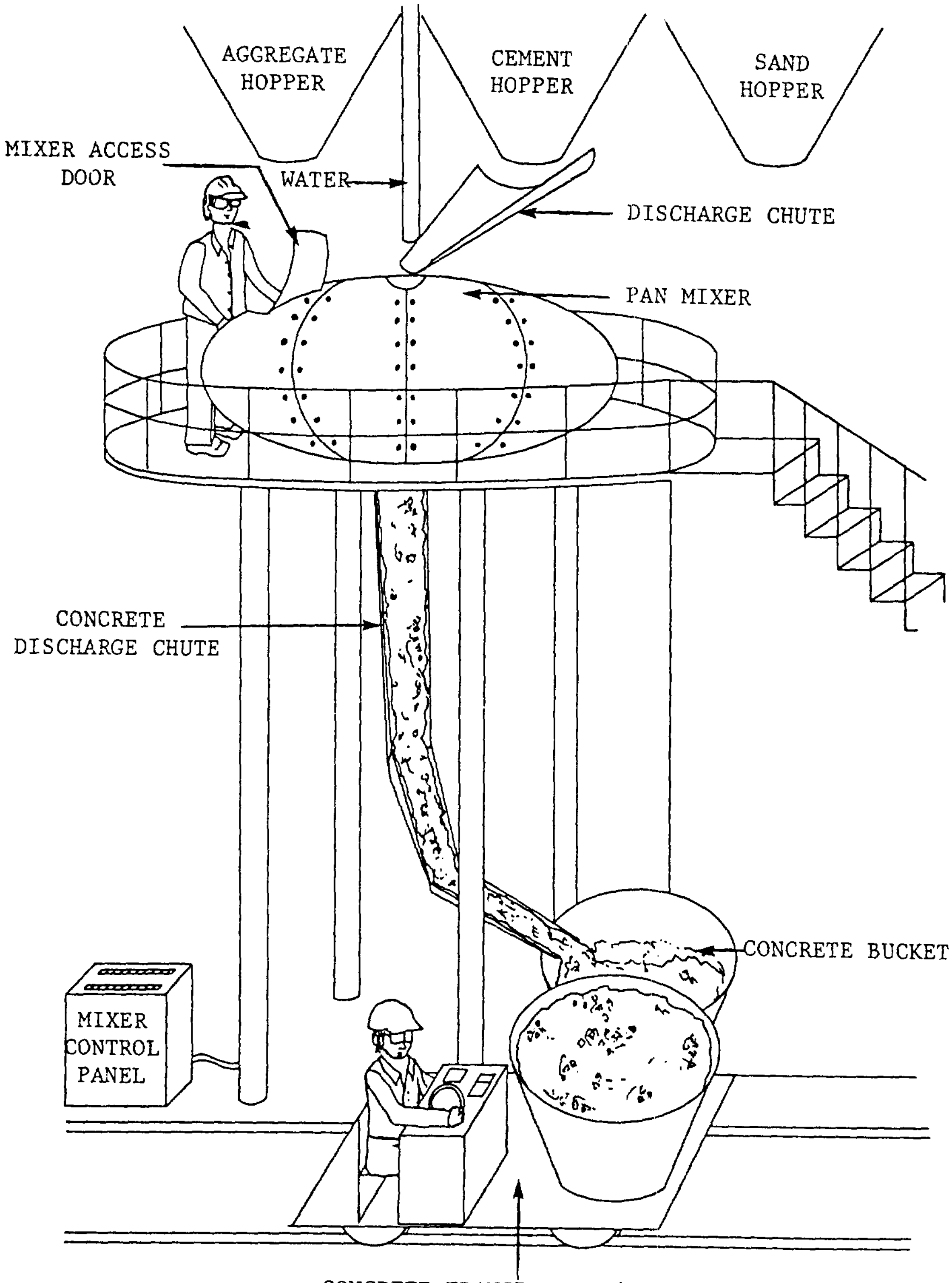

FIGURE II-3. CONCRETE BATCHING, MIXING, DISCHARGE, AND TRANSPORT SYSTEM

using additional ready-mix trucks with loads of concrete, to completely cast the products being made. During casting, workers will be engaged in a series of continuous tasks directed at filling the form with concrete. When a ready-mix truck is used, workers will be working adjacent to and along with the movement of the delivery truck. Access (steps or ramps) to low forms (1-3 feet high) is usually limited or nonexistent. Employees will frequently be working and moving among multiple form tiedowns, spacers, and spreaders as well as walking on the reinforcing mats while filling and vibrating the forms. When it is not possible for a truck to deposit concrete directly into the form, wheelbarrows, hoisted concrete buckets, or concrete delivery vehicles are used. Workers may push wheelbarrows along walkways, planks, or ramps to fill the form with concrete.

Another method of delivering concrete is by transporter, which takes mixed concrete from a central mixer and carries it directly to the forms. Enclosed transporters have a smaller capacity (up to 6 cubic yards) and are usually lighter, smaller, and more maneuverable than ready-mix trucks. This method of depositing concrete is similar to that for ready-mix trucks except that the chute is tubular in shape, with an enclosed auger or conveyor belt, allowing concrete to be pushed to higher elevations instead of depending on gravity. Some transporters consist of wheeled or tracked carriers that take large buckets or hoppers of mixed concrete (up to 4 cubic yards) to placing or casting machines. Transporters may travel on aisleways, rails, or roadways at speeds of up to 500 feet per minute. Transfer, turnaround, or backing areas may be provided at the end of the travelways for moving the transporters laterally relative to the casting areas or for access to the concrete mixers. Visibility may be limited because of walls, corners, other equipment, storage, or layout. Once the concrete buckets have been delivered to the casting area, an overhead hoist, which may be an integral part of a casting machine, will be used to hoist and position the bucket over the form or casting hopper.

Conveyors are frequently used to deliver concrete to the point of placement, especially in the miscellaneous and pipe sectors of the industry. The forms can be set up under the discharge end of the conveyor, or a portable conveyor can be set up with its discharge over the forms (depending on form mobility). Concrete is deposited onto the conveyor and moved along the conveyor system (which can be arranged to move the concrete around corners, to different elevations, or to remote plant locations) to the point of discharge.

Access to elevated forms during casting is usually provided by platforms, stairs, movable scaffolds, or ramps. Large pipe forms and miscellaneous products forms will sometimes have walkway platforms built around the forms or attached for the casting operations. Ramps are a convenient means of access to forms at elevations different from the surrounding working surface; otherwise, stairs are used. Access to lower beds up to 3 feet above the plant or yard surface usually is by

stepping up and jumping down; it is uncommon for steps or ramps to be provided.

In mechanized plants, placement of concrete into longbed forms is accomplished by placing or casting machines, similar to pavers or extruders. The concrete is spread, vibrated, compacted, screeded, and finished as the machine passes over the form, or is extruded as it moves along the bed. Drive controls are located in a cab on the machine or on a panel reached by workers from the side of the machine.

One method of casting utilized in the manufacture of pipe and many miscellaneous circular products requires a concrete mix that is wet compared to the mixes used in dry mix processes. Using both inner and outer forms, a cone is placed on the inner form to direct concrete down into the annular space between the forms. The concrete is then consolidated by stick vibrators or external vibrators, and the exposed top surface shaped and finished as required by hand, using edgers, trowels, and brushes.

Figure II-4 depicts an automated vertical pipe casting operation. Employees work from scaffolds that are rolled into place around the perim eter of the external pipe form. As the concrete discharge chute rotates around the form, workers using shovels, boards, tampers, and/or vibrators ensure the proper placement and consolidation of the concrete.

Most concrete pipe is cast with a relatively dry, low-slump mix that is mechanically placed and consolidated in the form. Two of the four mechanical methods use both inner and outer forms, which vibrate with either tampers or vibrators while the dry-mixed concrete is cast into the annular space between them. In the tamping method, compaction is performed directly by vertically operated tampers. In the dry cast method, consolidation is done by external vibration of the inner or outer form. The other two mechanical methods use only the outer form and either spin the pipe horizontally while centrifugal forces distribute the concrete delivered by conveyor, or spin a mandrel-like packerhead that is drawn up inside the pipe as concrete is cast from above, compacting as it goes. These four mechanical, dry-type mix methods of casting pipe are shown in Figure II-5.

Figure II-6 shows one type of vertical packerhead operation used in the manufacture of pipe. Metal pipe forms are placed by forklift or manual or automated cranes onto openings in a circular casting floor. The floor rotates (at slow speeds) to position the form in the operational packerhead area. An employee on an elevated platform controls the packerhead spinning speeds, the up-and-down motion of the packerhead, and the flow of concrete into the form. When the casting is complete, the floor rotates an empty form into place and the forklift removes the cast pipe and mold to a curing area.

Pipes manufactured by spin-casting methods have an inside diameter of 12-60 inches or larger. The form is spun at speeds of 2-4 revolutions

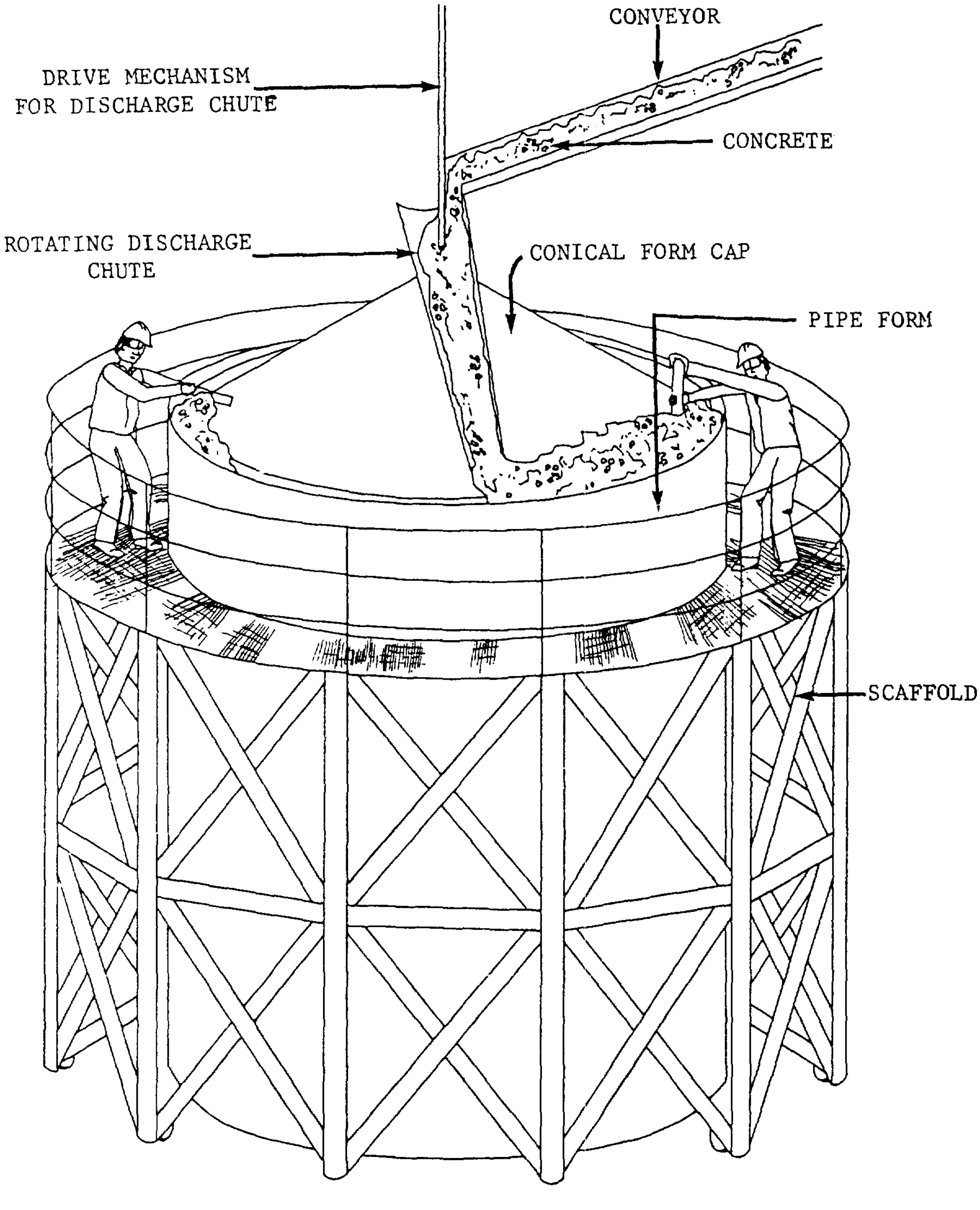

FIGURE II-4. VERTICAL PIPE CASTING

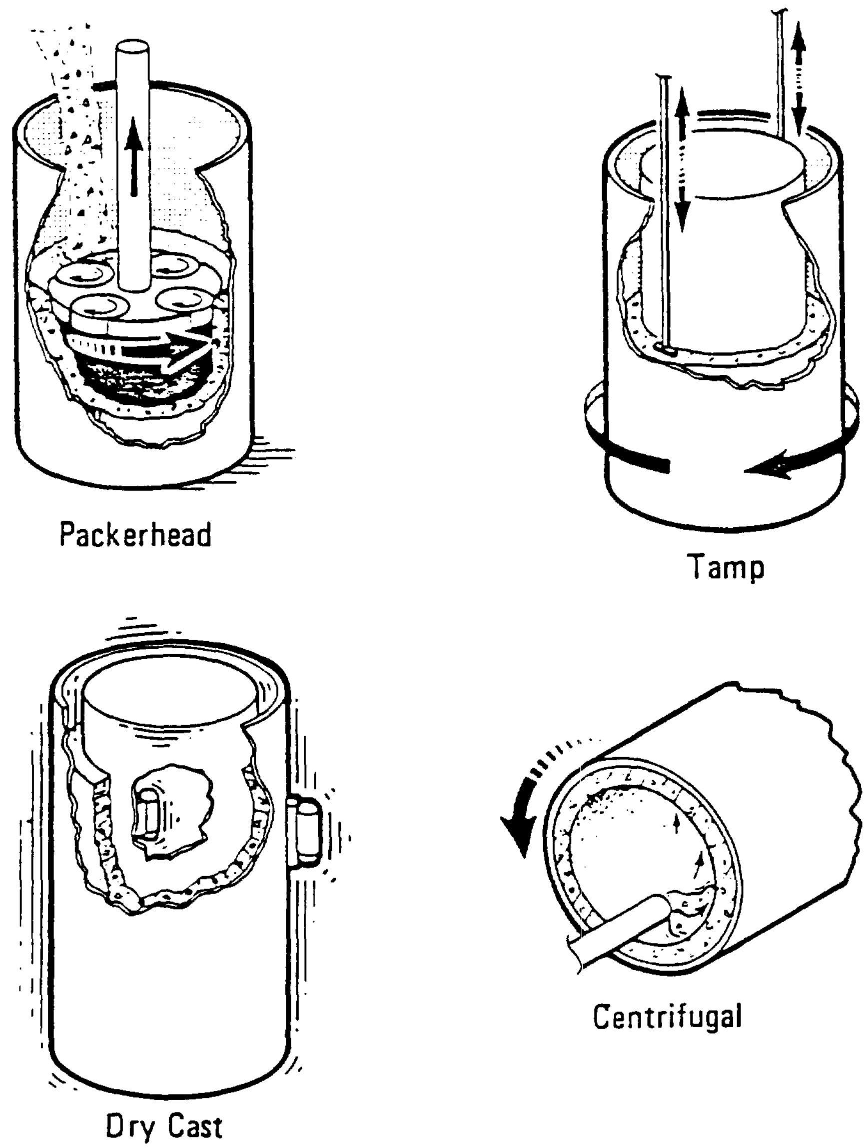

FIGURE II-5. FOUR MECHANICAL METHODS OF CASTING CONCRETE PIPE [8]
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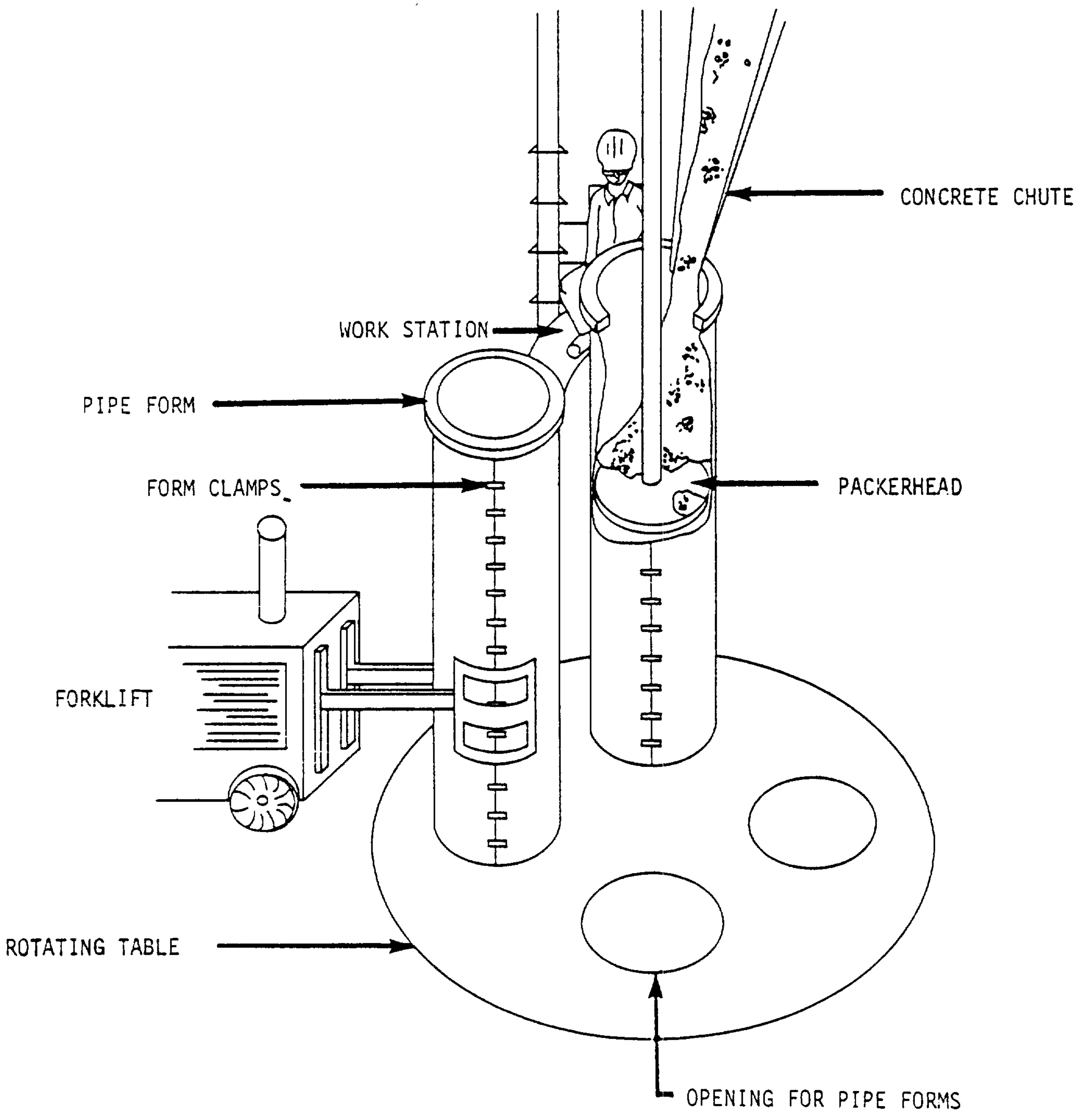

FIGURE II-6. SEMIAUTOMATIC VERTICAL PACKERHEAD PIPE CASTING SYSTEM

per second (rps) while vibrating and depositing concrete, and at speeds up to 10-12 rps while "throwing" the concrete and compressing it against the rotating form. In the centrifugal process, excess water is removed, further lowering the water/cement ratio of the concrete.

Figure II-7 depicts one method of pipe spin-casting. In this method, the pipe form is assembled by bolting or clamping the halves together. The form is placed by hoist onto a rotating pipe machine. Horizontal pipe machines are usually constructed from groupings of auto/truck tires that serve to cradle and spin the form. In this figure, the rotating force is applied by overhead tires that spin the pipe form at the required speeds. Concrete is added by a movable extruder, operated by a worker who is positioned to visually inspect the centrifugal consolidation during the placement process. Internal finish work is usually performed by a hand-held, dowel-mounted trowel. A worker runs it in and out of the pipe orifice while the form is spinning.

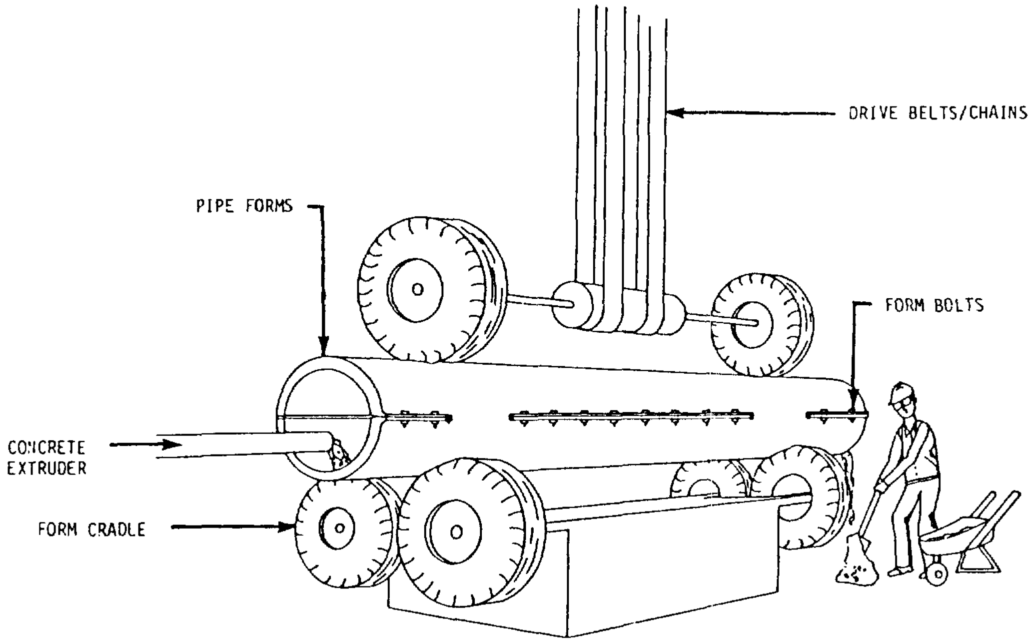

FIGURE II-7. HORIZONTAL PIPE SPIN CASTING

Casting large miscellaneous products is similar to the tamping, dry cast, or wet cast methods used for pipe manufacture; however, the form may be square or rectangular as for burial vaults or septic tanks.

6. Finishing

Wet finishing includes tasks such as screeding, floating, troweling, patching, rubbing, and cleaning surfaces not in contact with the form. Screeding is the back-and-forth motion of a strike off (a wood 2 by 4 or steel channel) resting on a screed guide to form the surface of the concrete to be finished. Workers may have to reach, bend over, and pull to perform this task. Floating, the smoothing of the surface with a wood, aluminum, or magnesium float, is manual work requiring bending, kneeling, and reaching. Troweling smooths and compacts the floated surface when the surface is hard enough to walk on without leaving indentations.

Additional treatment of the formed surface may take place after the form has been removed and the product has cured. This is particularly true for architectural panels, when the surface texture is important. Techniques such as grinding, bush hammering, sand blasting, water washing of retarded surfaces, or acid etching are used to produce a variety of desired architectural effects. Bush hammering is the roughening of the hardened concrete surface with a vibrating hammer, the head of which is serrated with a series of pointed teeth. Sand blasting is the high-pressure spraying of sand onto the exterior concrete surface to clean or smooth it. Water washing (up to 300 psi) is the flushing of cement paste that purposely has been retarded in setting to expose the surface of the aggregate. Acid etching serves a similar purpose, but does not expose as much of the aggregate. This procedure involves the mixing, dilution, and application of muriatic acid, an industrial grade of hydrochloric acid.

In some instances, precast concrete products are cut to length or have portions removed by sawing them with a concrete saw. This type of saw is similar to that of a carpenter's circular skill saw except that the blade size ranges from 1-3 feet (or more) in diameter. During repetitive operations, or when using larger blades, saws may be semiautomated and suspended overhead. The power source for the concrete saws may be electricity or pressurized air, although some of the smaller, portable models may be powered by gasoline engines. Most saws are not provided with a lower (exposed) blade guard.

7. Curing

Three fundamental factors in all methods of curing concrete are time, temperature, and moisture. Within limits, an increase in temperature shortens the curing period by accelerating strength gain. The time/-temperature relationship is not the same for all mixtures, materials, and conditions and is determined empirically.

The curing of many larger precast products is accelerated by radiant heat, steam, hot water, or hot oil. In some instances, the cast product is exposed to live, low-pressure steam within an insulated kiln or steam shed. Pipe or other products to be steam or heat cured will usually be transferred from the casting area to the heated shed by conveyor, fork-lift, hoist, or, in some instances, by rolling. The products remain in the steam shed for 2-8 hours (frequently overnight) before being removed and the form stripped. In some instances, the form is stripped before the product is steam cured. Large pipe is frequently enclosed (in the place where it was cast) by canvas, plastic, or other material into which steam or warm, moist air is introduced. Steam and hot water for accelerated curing procedures are usually generated at the plant by a low-pressure boiler and piped to designated locations prior to release into the curing shed. Occasionally, a chemical curing compound is sprayed on the finished surface of the concrete.

8. Form Stripping

Once a concrete product has cured sufficiently to be handled, it is necessary to remove it from the forms it was cast in or, conversely, to remove the forms from the product. The tasks and equipment used in form stripping operations vary considerably with the nature of the product. Reusable metal forms, such as those used during the manufacture of pipe, are usually handled by overhead hoist. The inner form is rigged to the crane and removed--a task made more difficult because the product frequently adheres to the form surface. In some instances, striking the form with a hard rubber mallet is sufficient to jar the concrete loose. In others, a hoist is used to shake the form and/or to pull the form free. Large pipe forms are frequently equipped with a means to collapse the internal form within the pipe bore. Workers enter the pipe bore to release retaining clamps. Rigging of the hoist to large form members requires that employees gain access to elevated areas. This may be done by ladder, rolling scaffolding, or climbing the form structure itself if it provides safe access. With low-slump, consolidated pipe, the mold is removed at the kiln prior to accelerated curing.

Flat products are removed from the mold by means of a vacuum lifter, or by lifting the product from the mold utilizing "lifting eyes" previously inserted in the product. Girders, beams, or other large, vertical products may have side forms to be removed before the product is freed from the forms. Bolts and other connectors are removed, and the side form panels pulled away or dropped to the ground.

Some concrete products may require dismantling of the forms for removal either because the form material will not be used again or because this is the only practical means of removing the completed product. Depending on the size and shape of the form, workers may perform the dismantling from the plant floor, from the elevated casting beds, from rolling ladder/scaffolds, or from the form itself. Workers will usually be performing their tasks on and among the equipment and material used during the form stripping process. Prybars, crowbars, sledge hammers,

and wrenches will be used to pull nails and remove the spreaders, stiffeners, and bulkhead-retaining tie rods. Sledges and prybars will be used to force the separation of bulkheads from the product and/or other form structures. This frequently involves workers pushing or pulling on the bar until the adherence forces release, sometimes suddenly.

9. Material/Product Storage

Material storage in the precast concrete products industry follows a usage pattern typical to most manufacturing processes. Raw materials necessary to produce the product will be shipped and temporarily stored in a yard. Usually raw materials will consist of the basic ingredients of the concrete (cement, sand, aggregate), the reinforcing materials (reinforcing steel, strand, wire mesh, hardware), and a variety of ancillary materials (blasting sand, equipment maintenance materials, etching acids, etc.) necessary for the production of a finished concrete product.

The bulk ingredients for the production of concrete may be hauled in by truck and dumped in covered bays or, in smaller plants, a convenient place on the premises. Larger, more automated plants may yard considerable volumes of various sized aggregates and cement prior to transfer to mixers. Cement may be bagged, palletized, and stored in weatherproof areas or it may be delivered by bulk tankers and stored in silos. These 94-pound bags of cement may be stacked higher than a worker's head, requiring access to the upper levels. Reinforcing steel bars are usually received in banded lots of various lengths, ranging up to 40 feet or more. Prior to cutting to required lengths, the rebars will usually be stored on the ground on cribbing material. Spooled or reeled material (e.g., wire mesh) is frequently stored in stacked rows. The end spools are chocked to prevent rolling or shifting; second level spools are nestled in the spool interface. Since forklifts or mobile cranes will be used to move these heavy rolls, adequate access space between rows of stored materials should be considered.

Product storage methods vary considerably with the size and shape of the product. Small miscellaneous products are frequently produced in a variety of shapes at the same plant. Yard areas are usually limited, necessitating multilayered stacking of the pieces. Layers may be separated by cribbing and/or pallets to both protect the finished surface and to increase the load-bearing surface stability. Larger and heavier shapes, such as vaults and manholes, are frequently stacked with cribbing layers between them to provide access for forklifts or rigging material. Pipes and cylindrical products are stored in the manner described for rolls and reels. Pipes of the same size are stored in the same stack. Again, care must be taken to allow adequate access for materials handling equipment and to prevent stack shifting. Large pipes are usually stored vertically.

Discarded products, broken pieces, metal scrap from forms, reinforcement,

tie-wire, wood scrap, nails, chamfer strip, rejected hardware, concrete, forms, and the remainder of unused raw materials can be found in plants in this industry. Many plants have a "bone yard" in which such discarded material is kept, pending burial or removal.

10. Materials Handling

Materials handling operations are performed throughout all phases of the production of precast concrete products. At the simplest (and frequently overlooked) level, employees lift, carry, push, or pull everything from concrete debris to wood form material to smaller, finished products. In fact, throughout the industry, manual handling is necessary to perform many of the tasks required in the production process, including:

- o Building and locating form and form material
- o Placing and tying reinforcing steel
- o Hand batching concrete
- o Casting (shoveling concrete)
- o Transporting moist concrete by wheelbarrow
- o Form stripping
- o Housekeeping and general cleanup
- o Handling and moving products.

Individual, small miscellaneous products may be loaded or unloaded by hand. When several small items of the same variety are to be handled, they usually are strapped and palletized. Larger products and concrete pipe require the use of lifting and unloading equipment. Architectural and structural products usually are large, bulky, and heavy, requiring the use of cranes and special loading and handling techniques such as "A" frame holders and wood and metal chocking for security, for bolting to the trailer bed, and for single-product loads.

Since precast concrete products and their components are heavy by their nature, the industry makes use of a variety of mechanical devices to assist in handling and movement operations.

a. Hoists and Cranes

For the most part, the types and varieties of hoists and cranes that are used in precasting operations do not differ significantly from those used in other industries. However, because of the weight of the material and products being moved, crane and hoist usage may be more prevalent.

Smaller plants may use rubber-tired cranes with hydraulic booms to move material and products around the yard, onto trucks for transport, and from the casting bed to the storage yard. These mobile cranes are prevalent throughout the industry for movement of yarded material and products. In most instances, the crane operator will work in tandem with other employees charged with the material

rigging responsibilities. Products may be manufactured with integral picking eyes that facilitate proper rigging and load balance. In other instances, the rigging and hoisting will be performed on material necessitating new or single instance handling procedures. Load weights and balance points must be identified by the workers as part of the rigging operation.

Larger, more automated plants are likely to have semipermanent work stations and fairly repetitive product design. These plants are likely to use a number of overhead hoists. Overhead hoists may run on tracks and be located to service multiple operations in the manufacturing process. Larger overhead cranes are controlled by an operator located in the crane cab. Work stations may be serviced by smaller, 2- to 10-ton jib cranes. Although a jib crane may be mounted on an independent vertical column, the horizontal "jib" is most frequently affixed to a vertical column integral to the plant's structure. Employees at the work station operate the jib crane by using a wire-attached pendant control, which allows the worker to control the up/down and back/forth movements, or other functions of the crane, from the floor of the plant. In these instances, the hoist operator is usually the same worker that performs the rigging. He is also likely to accompany, with hands on, the load being transported to its destination.

Straddle carriers are large, four-wheeled, wide-spaced, high-legged movers that straddle large products (such as girders, planks, or other structural elements) pick them out of forms and move them. This open-framed machine, basically square in configuration, hoists and carries the load within a large open bay between the four wheels on which it travels. The operator's cab is located on the extreme left-hand side between the front and rear wheels. Loads suspended in the bay often obscure the driver's view of the right side wheels. The machine ordinarily moves at about 2 miles per hour (mph) and has a maximum speed of about 10 mph.

b. Forklifts

Many of the palletized raw materials and finished products used in precast plants are moved by forklifts. Fork extenders may be used to increase the bearing surface of the forklift. In some instances, a jib may be added to the forklift to convert it to a small, movable crane. Pipe and other circular products are moved by forklifts with specially designed long forks or fitted forks with curved surfaces to cradle the product. Some forklifts are equipped with clamping forks used for attaching to and moving forms or other compatible shapes. The power source on forklifts is most frequently propane or diesel fuel.

CHAPTER III
IDENTIFICATION OF THE SAFETY HAZARDS AND DEFINITION OF THE PROBLEMS

This chapter is divided into two major areas of emphasis: the development and presentation of data pertaining to injury incidence rates for the precast concrete products industry (SIC 3272), and the identification of those tasks performed that are hazardous to the worker. Additionally, an estimation of the cost of injuries sustained by workers in the precast concrete products industry is presented.

A. Injury and Illness Incidence Rates

The yearly compilations of occupational injury and illness data, prepared by the BLS, show that between 1976 and 1980, the precast concrete products industry had an average incidence rate of about 23 cases per 100 employees (Table III-1) [9-12]. In comparison, the incidence rate for all private sector industries averaged about 9.2 during the same interval. Workers in the precast concrete products industry have been consistently injured at a rate nearly 2.5 times the national average. Also, between 1976 and 1980 the average incidence rate for all durable goods manufacturing industries (which include SIC 3272) was about 14, which is substantially less than the rate for manufacturers of precast concrete products (Tables III-1 and III-2).

TABLE III-1
OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (SIC 3272)

Year	Average Annual Employment	Total Case Incidence Rate*	No. of Cases**	Lost Workday Cases*	Nonfatal Cases Without Lost Workdays*	Lost Workday Rate***	Actual Lost Workdays****
1976	63,100	21.4	13,503	9.1	12.3	144.7	91,306
1977	67,300	24.5	16,488	10.3	14.1	159.5	107,344
1978	72,200	24.2	17,472	11.7	12.5	165.8	119,708
1979	71,900	24.7	17,759	12.1	12.6	180.6	129,851
1980	67,200	22.3	14,986	10.4	11.9	158.3	106,378

*Number of recordable cases/100 employees.
**Calculated by multiplying the reported employment figures by the total case incidence rate and dividing by 100.
***Number of lost workdays/100 employees.
****Calculated by multiplying the average annual employment figure by the reported lost workday rate; i.e., for 1976, (63,100) x (144.7 divided by 100) = 91,305.7.
Compiled from Bureau of Labor Statistics [9 - 12].

TABLE III-2
OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES FOR
ALL DURABLE GOODS MANUFACTURING INDUSTRIES

Year	Average Annual Employment (1,000)	Total Case Incidence Rate*	No. of Cases**	Lost Workday Cases*	Nonfatal Cases Without Lost Workdays*	Lost Workday Rate***	Actual Lost Workdays****
1976	11,016	14.1	1,553,256	5.1	9.0	84.1	9,264,456
1977	11,573	14.0	1,620,220	5.4	8.6	86.4	9,999,072
1978	12,246	14.2	1,738,932	5.9	8.3	89.1	10,911,186
1979	12,772	14.2	1,813,624	6.3	7.9	95.1	12,146,172
1980	12,181	12.9	1,571,349	5.6	7.3	90.9	11,072,529

*Number of recordable cases/100 employees.
**Calculated by multiplying the reported employment figures by the total case incidence rate and dividing by 100.
***Number of lost workdays/100 employees.
****Calculated by multiplying the average annual employment figure by the reported lost workday rate; i.e., for 1976, (11,016,000) x (84.1 divided by 100) = 9,264,456.
Compiled from Bureau of Labor Statistics [9 - 12].

The incidence rates for precast concrete products are among the highest rates within the manufacturing sector (top 3%). A representative selection of the manufacturing industries is shown in Table III-3.

Table III-3 demonstrates that the occupational incidence rate per 100 employees in the precast concrete products industry was higher than those for concrete block and brick manufacturers and ready-mixed concrete, which exhibited incidence rates of 15.8 and 13.7, respectively. The incidence rate for concrete products was also substantially higher than for blast furnaces and steel mills (9.5), which is a heavy industry involving additional injury potentials attendant to the handling of molten metal.

The severity of injuries sustained by employees of the precast concrete products industry was also shown to be high. The lost workday <u>cases</u> and lost <u>workdays</u> incidence rates, represent a general measurement of the seriousness of occupational injuries and illnesses. The lost workday cases incidence rate for the precast concrete products industry (SIC 3272) in 1980 was reported by the BLS as 10.4 (Table III-1). This figure ranged from a reported high of 12.1 in 1979 to a low of 9.1 in 1976, with an average of about 10.7 for the years between 1976 and 1980 (Table III-1). The lost workday cases incidence rate for all private sector industries in 1980 was reported by the BLS as 4.0 [12] and for the durable goods manufacturing industries as 5.6 (Table III-2). Furthermore, for every 100 employees in the precast concrete products industry in 1980, a total of about 158 days were lost due to disabling injuries and illnesses (Table III-1). The

TABLE III-3
EXAMPLES OF OCCUPATIONAL INJURY AND ILLNESS INCIDENCE RATES
FOR SELECTED MANUFACTURING INDUSTRIES, 1980

Manufacturing Industry	Average Annual Employment (1,000)	Total Case Incidence Rate*	Lost Workday Cases*	Lost Workdays**
Mobile Homes	45.9	27.5	11.4	173.1
Truck & Bus Bodies	38.6	24.8	10.4	129.9
Cold Finishing of Steel Shapes	N.A.	23.7	10.9	192.3
Gray Iron Foundries	125.9	23.2	11.0	171.4
Precast Concrete Products	67.2	22.3	10.4	158.3
Steel Wire	N.A.	21.4	10.1	169.6
Architectural Metal Work	31.6	19.4	8.9	113.1
Machine Tools, Metal Forming	26.8	17.2	6.8	113.7
Concrete Block & Brick	21.2	15.8	7.6	148.0
Glass Containers	69.6	15.7	9.4	180.7
Screw Machine Products	50.7	15.0	5.6	69.5
Ready-Mixed Concrete	94.7	13.7	6.2	124.0
Upholstered Household Furniture	94.7	13.4	5.1	78.8
Blast Furnaces & Steel Mills	429.3	9.5	3.4	81.6
Small Arms Ammunition	N.A.	6.3	2.9	43.4

* Number of recordable cases/100 employees.
** Number of lost workdays/100 employees.
Compiled from Bureau of Labor Statistics [12].

industries comprising the manufacturers of durable goods reported a substantially lower rate of about 91 days lost per 100 employees (Table III-2).

About 46%[1] of the workers injured in reported accidents in the precast concrete products industry between 1976 and 1980 lost time from their jobs, an average of about 15 days per case in 1980.[2]

B. Costs of Injuries

The total cost of work injuries is difficult to develop due to incomplete recording and lack of data on both direct and indirect costs. Estimates can

[1]Average percentage of total recordable cases reported as lost-time cases by the BLS (Table III-1).

[2]Lost workdays/lost workday cases = lost workdays rate divided by lost workday cases; i.e., for 1980 (Table III-1),

$$\frac{158.3}{10.4} = 15.2 \text{ lost workdays/lost workday case.}$$

be made, however, which reveal the magnitude of the problem. Best available workers' compensation data from 46 States [13-21] reported a total of 9,335 medical and indemnity compensation cases during 1977 (the most current year reporting reasonably complete data) with actual paid claims totaling $30,855,454 or an average of about $3,305 per case. This averages about $595[1] per production worker in 1977 dollars. Although the estimates of direct costs of worker injuries are not precise, they do reflect the magnitude of the problem.

Estimates derived from National Safety Council [22] data indicate that full costs of work-related accidents are more than 3.4 times the direct wage loss and medical expense costs. Since the indemnity payments are normally less than wage loss, the real accident costs for the precast concrete products industry are estimated to exceed $105 million per year (3.4 x $30.9 million). In addition to medical and indemnity expenses, estimates of the real cost of accidents include:

- Cost of wages for lost worktime by injured employee(s), other than workers' compensation payments
- Cost of wages for supervisor's time required for activities necessitated by the injury
- Cost of wages for decreased output of injured employee(s) after return to work
- Cost of learning period for new employee(s)
- Cost of time spent by higher supervisory and clerical employees on investigations or in processing compensation application forms
- Net cost to repair, replace, or straighten up material or equipment damaged in an accident
- Extra cost for overtime work necessitated by an accident
- Cost of wages for lost worktime by employee(s) not injured
- Cost of litigation resulting from OSHA investigations
- Uninsured medical cost borne by company.

C. Identification of the Hazards

The preceding section of this chapter defined the magnitude of the safety problem in the precast concrete products industry. The next step in a systematic approach to effectively lowering worker accident/injury exposure is the identification of how workers are injured while performing the tasks required to produce precast concrete products.

1. The Supplementary Data System (SDS)

Currently, occupational accident and injury information from participating states, which is taken from employers' first report of injury forms,

[1] Production workers comprise about 77% of the total work force for this industry [3]. Seventy-seven percent of the reported 1977 employment figure of 67,300 (Table III-1) is 51,821 production workers. Compensation losses of $30,855,454 divided by 51,821 production workers yields about $595 per production worker.

is compiled and reported by the BLS Supplementary Data System (SDS) [23, 24]. The SDS is intended to alert users to patterns and relationships of injury causal factors. The information is entered into each of four major groupings:

- o Source of injury
- o Type of accident
- o Nature of injury
- o Part of body affected.

The frequency and percentage distribution of the injuries reported to SDS by the precast concrete products industry for the years 1976 - 1979 are presented in Table III-4 for each of the groupings mentioned above. The percentages do not indicate that one category represents a greater hazard than another, since data clarifying worker exposure are not available.

2. Accident/Injury Analysis

The SDS data are limited when used in the analysis of a specific industry because the "source of injury" category contains subcategories which do not apply to the industry under study, and does <u>not</u> contain subcategories which are related to industry-specific tools and equipment. Further, the "source of injury" reported is the object most responsible for causing the injury. Thus, if a worker falls from a ladder and fractures his leg on the plant floor, the "source of injury" is the floor, which probably contributed little to the actual cause of the accident.

Despite the constraints, the SDS data reported by the precast concrete industry for 1976 - 1979, which included 15,208 injuries, were analyzed to identify specific industry hazards. The analysis included 37 categories that identified injury sources within precasting operations.

The results of the cross-analysis of the SDS data are summarized in Table III-5. The total number of accidents/injuries appears in the "Source of Injury" column. The numbers associated with "Type of Accident," "Nature of Injury" and "Body Part" do not agree with the "Source of Injury" totals since the figures given are merely the most frequent subcategories.

3. Analysis of Accident Case Histories

For a more complete understanding of accident/injury causal factors, full text copies of employers' first report of injury forms filed by SIC 3272 industries were requested from all 50 States. In most instances, the state agencies were not able to provide information. However, 10 States [1] did provide copies of 2,250 first report of injury forms from

[1] California, Hawaii, Iowa, Kentucky, Michigan, Montana, Maryland, Washington, Wyoming, and Vermont.

TABLE III-4

SUMMARY OF SUPPLEMENTARY DATA SYSTEM ACCIDENT/INJURY PROFILE, 1976-79, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

	No. of Accidents	(%)		No. of Accidents	(%)
TYPE OF ACCIDENT			NATURE OF INJURY		
Struck By or Against	5,187	(34.1)	Amputation	115	(0.8)
Falls	2,210	(14.5)	Burns (Heat)	297	(1.9)
Caught In or Between	1,523	(10.0)	Burns (Chemical)	175	(1.1)
Rubbed/Abraded Against	767	(5.0)	Contusions, Bruises	2,403	(15.8)
Bodily Reaction	762	(5.0)	Cuts, Lacerations	2,133	(14.0)
Overexertion	3,220	(21.2)	Fractures	1,647	(10.9)
Contact w/Temp. Extremes	295	(1.9)	Scratches, Abrasions	893	(5.9)
Contact w/Caustics	599	(4.0)	Sprains, Strains	4,724	(31.1)
Motor Vehicle Accident	162	(1.1)	All Other Occ. Diseases	1,376	(9.0)
All Other Classifiable	118	(0.8)	All Other Classifiable	212	(1.4)
Nonclassifiable	365	(2.4)	Nonclassifiable	1,233	(8.1)
Total	15,208	(100)	Total	15,208	(100)
PART OF BODY INJURED			SOURCE OF INJURY		
Eyes	1,275	(8.4)	Boxes, Barrels, Containers	793	(5.2)
Head, Neck	836	(5.5)	Chemicals	307	(2.0)
Fingers	2,083	(13.7)	Handtools	1,247	(8.2)
Upper Ext., Not Fingers	2,135	(14.0)	Machines	845	(5.6)
Back	2,961	(19.5)	Metal Items	3,212	(21.1)
Trunk, Not Back	1,478	(9.7)	Vehicles	953	(6.3)
Lower Extremities	3,483	(23.0)	Wood Items	589	(3.9)
Multiple Body Parts	670	(4.4)	Working Surfaces	1,797	(11.8)
Body System	161	(1.0)	All Other Classifiable	4,977	(32.7)
Nonclassifiable	126	(0.8)	Nonclassifiable	488	(3.2)
Total	15,208	(100)	Total	15,208	(100)

Compiled from Bureau of Labor Statistics [24].

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Bodily Motion (no lifting, pushing, pulling)	726	Bodily reaction (slips, loss of balance, reaching, bending)	689	Sprain, strain	601	Back	283
						Ankle	157
						Knee	99
Chemicals (acids, alkalis, moist concrete)	307	Contact with caustics	246	Chemical burns	127	Eye	88
				Dermatitis	56	Multiple parts	52
				Systemic poisoning	38	Body System	41
						Hand	31
Coal/oil products (form release agents, lube cutting oil, safety solvents)	89	Contact with caustics	53	Dermatitis	33	Hand	27
		Contact temperature extremes	27	Burns	26	Eye	12
				Chemical burns	14	Multiple parts	9
Concrete aggregate (sand, cement, gravel)	842	Overexertion	203	Sprain, strain	225	Eye	178
		Struck by falling obj.	152	Abrasion	136	Back	151
		Rubbed or abraded by foreign material	115	Contusion	131		
Concrete Items	349	Overexertion	129	Sprain, strain	122	Back	83
		Struck by falling obj.	68	Contusion	71	Finger	63
		Caught in, under, or between	61	Fracture	52	Trunk	41
Concrete Mixers	125	Caught in, under, or between	60	Cut, laceration	28	Finger	44
				Sprain, strain	25	Hand	18
		Struck against stationary object	16	Fracture	24	Back	13
				Contusion	21		
		Overexertion	15				
		Struck by	13				

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Concrete pipe	137	Overexertion	73	Sprain, strain	71	Back	49
		Caught in, under, or between	19	Contusion	19	Trunk	21
				Fracture	14	Finger	21
Containers (bags, boxes, bundles, reels, rolls)	714	Overexertion	444	Sprain, strain	410	Back	310
				Contusion	93	Trunk	102
						Finger	72
Conveyors (gravity, powered)	115	Caught in, under, or between	70	Contusion	23	Finger	34
				Fracture	22	Hand	14
		Overexertion	13	Sprain, strain	19	Back	12
				Cut, laceration	17	Foot(not toes)	12
Cranes	99	Struck by	30	Contusion	29	Finger	17
		Caught in, under, or between	18	Fracture	18	Trunk	16
				Sprain, strain	15	Back	12
		Overexertion	12	Cut, laceration	10	Head	11
		Struck against stationary object	10				
Crowbars	85	Struck by	30	Contusion	25	Back	24
		Overexertion	26	Sprain, strain	24	Finger	12
		Struck by falling object	10	Cut, laceration	15	Trunk	9
				Fracture	12		
Doors, gates	90	Overexertion	27	Sprain, strain	27	Finger	18
		Struck by falling obj.	18	Contusion	20	Trunk	16
		Caught in, under, or between	17	Fracture	16	Back	14
				Cut, laceration	13		
		Struck by	12				
		Struck against stationary object	10				

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Flame/fire	81	Contact temperature extremes	76	Burn	76	Multiple parts	20
						Hand	10
Forklifts	296	Caught in, under, or between	91	Contusion	80	Finger	59
				Fracture	72	Foot(not toes)	42
		Struck by	71	Sprain/strain	51	Back	33
		Overexertion	30	Cut/laceration	34		
		Struck against stationary object	30				
Forms	110	Overexertion	35	Sprain, strain	38	Finger	28
		Struck by falling object	27	Contusion	30	Back	27
				Cut, laceration	14		
		Caught in, under, or between	20				
Hammers, powered	81	Overexertion	29	Sprain, strain	27	Back	18
		Struck by	20	Contusion	16	Finger	18
		Struck by falling object	10	Fracture	13		
				Cut, laceration	11		
Hammers	299	Struck by	184	Contusion	133	Finger	95
		Overexertion	47	Sprain/strain	44	Hand	48
				Fracture	42		
Hand Tools, powered (drills, grinders, saws and welding tools)	228	Struck by	77	Cut, laceration	86	Finger	66
		Overexertion	42	Sprain, strain	44	Hand	25
		Caught in, under, or between	24	Fracture	25		
				Contusion	23		

TABLE III-5

SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Hand tools, non-powered (blow torches, chisels, ropes and chains, saws, screwdrivers)	345	Struck by	126	Cut, laceration	113	Finger	87
		Overexertion	87	Sprain, strain	91	Back	41
				Contusion	57	Hand	40
Hoisting apparatus (air hoists, chain hoists, electric hoists, jacks)	154	Caught in, under, or between	42	Contusion	41	Finger	50
		Struck by falling object	34	Fracture	32	Back	18
		Struck by	29	Sprain, strain	27		
		Overexertion	23	Cut, laceration	26		
Lumber and other wood items	589	Overexertion	221	Sprain, strain	219	Back	154
		Struck by falling object	125	Contusion	114	Finger	87
		Struck by	75	Fracture	92	Trunk	85
Machinery (cage roller, concrete extruding, concrete saw, pipe spinning, press brake, rebar bending, rebar cutting)	720	Caught in, under, or between	302	Cut, laceration	197	Finger	287
		Overexertion	90	Contusion	131	Hand	97
		Struck against moving object	75	Fracture	117		
				Sprain, strain	100		
Mechanical power transmission apparatus (chains, ropes, cables; drums, pulleys)	135	Caught in, under, or between	51	Cut, laceration	41	Finger	46
		Struck by	30	Sprain, strain	26		
		Overexertion	26	Contusion	21		
				Fracture	15		

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Nails	146	Struck against stationary object	113	Puncture	137	Foot(not toes)	106
						Hand	15
Particles (unidentified)	323	Rubbed or abraded by foreign material	256	Abrasion	271	Eye	314
Reinforcement bars	268	Overexertion	68	Sprain, strain	81	Back	52
		Struck by falling object	60	Cut, laceration	53	Finger	48
				Contusion	51	Trunk	36
		Struck by	44	Fracture	37		
		Struck against stationary object	38				
Reinforcement other than bars and steel forming (bolts, nuts, plates, rods, shapes, wire strand)	2,284	Overexertion	465	Cut, laceration	645	Finger	360
		Struck by falling object	440	Sprain, strain	461	Back	336
				Contusion	363	Eye	310
		Struck by	332	Fracture	266		
		Struck against stationary object	281	Abrasion	230		
Shovel	109	Overexertion	91	Sprain, strain	90	Back	78
						Trunk	11
Steel pipe	404	Overexertion	134	Sprain, strain	145		
		Struck by	71	Contusion	97	Back	105
		Caught in, under, or between	63	Fracture	45	Finger	74
				Cut laceration	43		
		Struck by falling object	56				

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Continued)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Structures (not floors, working surfaces, or walkways)	129	Overexertion	27	Contusion	35	Back	28
		Caught in, under, or between	26	Sprain, strain	33	Finger	22
		Fall on same level against object	23	Cut, laceration	21	Trunk	13
		Struck against stationary object	17	Fracture	18		
		Struck by falling object	16				
Tank bins	79	Overexertion	21	Sprain, strain	25	Finger	15
		Caught in, under, or between	21	Contusion	15	Back	15
		Struck by falling object	9	Cut, laceration	14	Trunk	9
		Struck against stationary object	8	Fracture	9		
Vehicles (industrial, tractors and other powered vehicles)	110	Caught in, under, or between	33	Sprain, strain	29	Trunk	23
		Overexertion	15	Contusion	24	Finger	14
		Occupant in motor vehicle accident	14	Fracture	18	Back	12
		Struck by	13				
Vehicles (highway)	377	Occupant in motor vehicle accident	140	Sprain, strain	97	Trunk	74
		Struck against stationary object	52	Contusion	95	Multiple parts	53
		Caught in, under, or between	39	Cut, laceration	55	Back	52
				Fracture	47	Finger	40

TABLE III-5
SUMMARY OF CROSS-ANALYSIS TABULATION OF SDS ACCIDENT/INJURY PROFILE, 1976-1979, FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY (Concluded)

Source of Injury	Number	Type of Accident	Number	Nature of Injury	Number	Body Part	Number
Welding machines (electric)	167	Contact with radiation	127	Welder flash	110	Eye	156
				Radiation effects	37		
Wheelbarrows and handtrucks	170	Overexertion	84	Sprain, strain	90	Back	54
		Caught in, under, or between	29	Contusion	34	Trunk	23
				Fracture	18	Finger	20
		Struck by	19				
Working/walking surfaces	1,797	Fall to work surface	540	Sprain, strain	776	Back	329
		Fall to level below	307	Contusion	307	Ankle	284
		Fall from vehicles	299	Fracture	273	Trunk	230
						Knee	185
Wrench	100	Overexertion	43	Sprain, strain	40	Finger	23
		Struck by	36	Contusion	21	Trunk	22
		Struck by falling obj.	10	Cut, laceration	13	Back	15
				Fracture	12		
Miscellaneous classifiable	1,541	Overexertion	514	Sprain, strain	492	Back	378
		Struck by falling object	198	Contusion	222	Finger	174
				Cut, laceration	171		
Nonclassifiable	488	Overexertion	96	Sprain, strain	145	Back	145
						Trunk	67
Total incidents	15,208		10,123		11,272		7,987
(%)	100%		67%		74%		53%

Compiled from U.S. Department of Labor Supplementary Data System (SDS) unpublished accident and injury data for 1976 - 1979 [24].

recent years (1977 to 1981). Of the 2,250 accident/injury reports, 1,319 (about 59%) were included in the analysis. Of these 1,319 injuries, 34 resulted in a fatality. Those reports not included in the analysis primarily contained injury information, and were found to contain insufficient data to determine accident causal factors.

A preliminary analysis of these accident case histories was performed to determine whether the accident data base was indicative of accidents occurring to workers in precasting operations nationwide. Each report was categorized by type of accident ("struck by," "caught between," "fall"). Numerical and percentage values of the "type of accident" categories were compared to the national SDS figures (Table III-4). The comparison (Table III-6) shows markedly similar ratios; e.g., the percentage of "struck by" and/or "caught between" accident types are reasonably consistent in both data bases. Because of the similarities between data from the sources considered, it was concluded that the accident/injury case histories used in this report are representative of accidents that occur to workers in the precast concrete products industry.

The first step in the analysis was the identification of the specific task, tool, type of material, piece of equipment, or plant area most closely associated with the accident in each case. This procedure made possible more precise and industry-specific classification than the SDS "Source of Injury" category could provide. Then, a causal factor was identified in each case (e.g. improper tool use, lack of personal protective equipment, lack of adequate guarding, improper materials handling procedures). The task/tool/equipment factors and accident causal factors were then cross-indexed to allow the identification of problem areas.

The following narrative descriptions of how workers are injured in the precast concrete products industry are based on analysis of SDS data (Table III-5) and the accident case histories. The percentage that follows each category or factor is the percentage of the total number of accidents (1,319) from the case history analysis.

Section a covers general accident factors; i.e., tasks, tools and items of equipment that are not specific to the precast industry. Section b presents factors that are specific to precasting processes. Section c describes accident causal factor patterns, groups of factors which may encompass several task/tool/equipment categories. Essentially, the organization of sections a, b, and c is followed in the presentation of the recommendations in Chapter IV.

a. General Accident Factors

The following narrative paragraphs describe the ways workers are injured due to task/tool/equipment factors which are not necessarily specific to the precast concrete products industry.

TABLE III-6
COMPARISON OF SDS ACCIDENT/INJURY CLASSIFICATION WITH THE ANALYSIS OF ACCIDENT CAUSAL FACTORS FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

Type of Accident	No. of Accidents	(%)*	No. of Accidents	(%)**
Struck By or Against	5,187	(34.1)	508	(38.5)
Falls	2,210	(14.5)	268	(20.3)
Caught In or Between	1,523	(10.0)	152	(11.5)
Rubbed/Abraded Against	767	(5.0)	11	(0.8)
Overexertion	3,220	(21.2)	258	(19.6)
Contact w/Temp. Extremes	295	(1.9)	22	(1.7)
Contact w/Caustics	599	(4.0)	67	(5.1)
Motor Vehicle Accidents	162	(1.1)	16	(1.2)
All Other Classifications (including nonclassifiable)	1,245	(8.2)	17	(1.3)
Total	15,208	(100.0)	1,319	(100.0)

*Taken from Table III-4 [Note: The SDS classifications "Bodily Reaction" and "Nonclassifiable" were not used in the analysis; however, their totals are included under "All Other Classifications."]

**Analysis of 1,319 accident case histories from OSHA accident investigations and employers' first report of injury forms.

Although these general factors are arranged in order from highest to lowest percentage of occurrence, this grouping does not suggest that one factor represents a more significant hazard than another, since no data clarifying worker exposure are available.

(1) Materials Handling (28.0%)

(a) Manual (19.9%)

(i) Lifting (9.6%)

The act of lifting items resulted in nearly 10% of the injuries in the industry. Approximately 81% of these incidents involved overexertion to the back while manually handling materials. Loss of grip accounted for 9% of the lifting accidents. These usually resulted in injuries either to the lower extremities when the load was dropped or to the

fingers when the load was set down with inadequate clearance.

(ii) Mechanical Materials Transport (7.1%)

This category presents a variety of tasks associated with materials handling as well as a variety of other accident causal factors. Included in this activity are interface of manual and mechanical load handling procedures performed on flatbed trucks and the manual transfer of materials to forklifts. Manual materials handling and gripping of materials accounted for 27% of the injuries in approximately the same causal/injury breakdown as cited in the discussion of the lifting category. Improper stacking and binding of materials was reported to be the cause of about 27% of these accidents, usually from the material falling onto the worker. An additional 12% of the accidents occurred to workers attempting to climb onto the transport vehicle or the material itself when access was not provided.

(iii) Carrying and Holding (1.8%)

This category of activity includes the manual tasks, by one or more workers, of carrying or handling materials. Many of the injuries were sprains and strains that usually occurred from overexertion during the procedure. About 29% of the injuries were attributed to falls from working/walking surfaces which were wet and/or slippery and cluttered with tripping hazards. Inadequate interworker coordination on multiperson tasks accounted for 25% of the accidents. These incidents frequently occurred when a worker would prematurely drop his portion of the load (See Table III-5, "Concrete aggregate" and "Containers").

(iv) Wheelbarrows and Handtrucks (1.4%)

About one-third of the accidents that occurred with hand transport systems were attributed to working/walking surfaces which were either cluttered with tripping hazards or were wet and/or slippery. Wet, slippery surfaces increase the potential hazard when pushing or pulling items. Most of the remaining accidents were attributable to manual materials handling problems, including improper worker position and improper lifting techniques.

(b) Mechanical (8.1%)

(i) Hoists and Cranes, Including Pendant-Operated (4.4%)

The injury analysis indicated the most serious accidents and injuries occurred during tasks involving the use of cranes and hoists. Fourteen (41%) of the reported fatalities happened during craning activities. The fatal accidents were most frequently related to rigging practices and/or overloading. Workers were struck by dropped loads, material falling off the loads, as well as falling hoist components during crane failures. Two fatalities occurred when workers were struck by cranes moving a suspended load. Another worker was fatally injured when struck by a load suspended by a straddle carrier.

The nonfatal injuries followed a similar pattern of accident causal factors. Although a number of incidents involved fingers being caught between suspended loads and stationary objects or in the rigging material (Table III-5, "Cranes" and "Hoisting apparatus"), most of these accidents were caused either by inadequate rigging and/or crane overload or by the movement of the crane or load. In these instances, although the injuries were less severe, the potential for fatal accidents was evident.

(ii) Forklifts (1.9%)

Forklifts are used throughout the industry to move material as well as finished products. Forklift operations accounted for about 12% of the fatalities. These accidents usually occurred to coworkers that were not seen by the forklift operator. One fatality resulted from overloading of the lift's capacity, causing the forklift to tip and crush the operator. Accidents that occurred during lift operations that were attributable to improper stacking, storage, or binding techniques are listed in other categories (e.g., Mechanical Materials Transport and Material Storage).

Operating errors (running into or over objects, tripping, and speeding) were the causal factors cited in many of the accident reports. Inadequate visibility in the work area and inadequate audibleness of the forklift in motion contributed to

the accidents occurring to coworkers. Table III-5 indicates that workers suffered injuries to the fingers and feet by being caught in or struck by the forklift.

(iii) Hoists, Chain (0.8%)

Rigging practices were again found to be commonly at fault in accidents involving mechanical chain hoists. Hand operation of the hoists necessitated close proximity to the hoisted loads and contributed to employee exposure to hoist or rig failure.

(iv) Conveyors (0.6%)

Although only 0.6% of the accidents involved conveyors, they accounted for nearly 9% of the fatal injuries. These accidents occurred when the conveyor jammed and the operator/worker attempted to free the jam without deenergizing and locking out the system. Workers were caught by or in exposed moving portions of the conveyors. Lack of guarding of exposed moving parts and/ or nonlimiting access to the area were cited as contributing factors to the accidents. Similarly, the nonfatal incidents usually involved the upper extremities being caught in or between the conveyor mechanisms as shown in Table III-5.

(v) Front-End Loaders (0.4%)

Front-end loaders are normally used in the movement of bulk materials (aggregate, sand) from the stockpile to the mixing area. There were two types of accidents involved: those that occurred to the operator during the process of getting off the loader (access), and those that resulted in coworkers being injured. In the latter accidents, the injured workers were in the path of travel of the loaders and were either caught between it and another object or they were run over by the moving equipment. Inaudible or nonfunctioning backup alarms as well as operator inability to see coworkers were cited as contributing factors.

(2) Handtools (11.5%)

(a) Handtools, Powered (5.8%)

Nearly all of the injuries attributable to the use of powered handtools resulted from deficiencies in three

areas: guarding, tool usage, and lack of eye protection.

The injury analysis revealed that most eye injuries occur during use of grinders. The remaining grinder-related accidents were the result of inadequate or non-existent guards that failed to prevent finger contact or protect against stone disintegration. In some instances, while using the grinder, part of an employee's body, usually the thigh, came into contact with the abrasive stone. In the SDS accident/injury analysis (Table III-5), eye injuries occurring during grinding activities were not listed with grinders; rather, they were tabulated in the "Particles" category.

Although lack of eye protection contributed to 20% of the powersaw injuries, the single, consistent accident causal factor was inadequate or nonexistent saw blade guards (58%). Included in this category were instances when anti-kickback devices were not used during ripping operations. The majority of injuries resulting from lack of saw guards were lacerations and amputations of fingers. Two eye injury accidents also occurred while using concrete saws.

The accident analysis shows that most accidents during drilling tasks occurred when large-diameter (1-inch or larger) holes were drilled through forms. The drill bit would bind and the drill motor would continue to turn, catching the workers' hands between the motor and adjacent items, usually the form. This may be interpreted as improper tool use or as improper worker position relative to the task.

Lack of eye protection accounted for one-third of the reported injuries that occurred while using airhammers. In some instances, airhammers were used in awkward positions, resulting in strains and sprains of the back and/or arms. In three instances, the airhammer was positioned for use too close to the edge of either a form or product, and the worker's hands or fingers were caught. Table III-5 indicates that powered hammers as a source of injury resulted in injuries to the back because of worker overexertion and to fingers that were struck by the hammer.

(b) Handtools, Unpowered (5.7%)

Strains of the back are the most prevalent injury associated with shoveling activities. The injury reports indicated that many injuries were associated with overloading the shovel, twisting the body, and handling the

load from too great a distance (see Table III-5, "Shovel" and "Concrete aggregate").

The activity of "prying" is frequently performed by workers dismantling forms and separating the product from the form. Referring back to Table III-5, 47% of the accidents involving crowbars, a tool routinely used for prying, were classified by the SDS as "struck by" accident types resulting in contusions and sprains and strains. The most frequent areas of the body injured were the back and finger. The analysis of the accident cases showed that 65% of the prying accidents were reported to be caused by improper worker position relative to the task. When the prying implement slipped, the tool usually either struck the worker or the worker slipped and fell. Most of the remaining accidents involving prying activities resulted from improper tool use. Shovels were commonly misused by workers attempting to pry forms loose from cured concrete.

The most common type of accident that occurs during the use of handtools is the "struck by" variety (Table III-5), most frequently caused by improper position of the worker relative to the task. The analysis indicated that glancing blows are commonly cited as the cause of the accident. Fingers and hands were struck by hammers and sledge hammers when part of a worker's body was in the path of the deflected hammer movement. Use of improper tools contributed to 25% of the hammering accidents. Typical cases involved shovels, wrenches, and boards used to hammer forms, nails, or other materials.

The analysis indicated that fingers were the most frequent part of the body injured while using a wrench; usually, the wrench slipped off a nut or bolt. The injury reports indicated that many accidents associated with tool slippage were caused by improper tool usage (size and/or adjustment). The accident probability was compounded by improper worker position relative to the task. The information in Table III-5 indicates that workers suffered sprains and strains from excessive physical effort while using wrenches. This could possibly be a result of using wrenches of improper size for the job.

(3) Worker Proximity to Operations (7.4%)

(a) Walking Through Work Areas (6.3%)

In a number of instances a specific task or activity description was not included in the accident report. The

worker was "walking" in an unspecified section of the plant. Almost 29% of these injuries were nail punctures of the foot. More than 45% were falls to the working/walking surface caused by slipping on wet, slippery surfaces or tripping on material, usually pieces of concrete debris, rebar, welding stubs, or leads.

(b) Working Near Operations (1.1%)

This category includes workers injured by tasks or operations that were independent from their assigned tasks. The most prevalent accident/injury in this grouping was flash burns from nearby welding operations. In fact, 45% of the reported flash burns occurred to workers who were not involved in the actual welding process. Two workers were also injured by particles from nearby metal grinding operations.

(4) Welding, Cutting, Burning (4.6%)

The data indicated most of the injuries (54%) that occurred in welding, cutting, and burning activities were typified by foreign bodies in the eye that were caused by slag or weld "pop." In these instances, the workers were not wearing eye protection. An additional 20% of the injuries were flash burns to the workers performing the welding operations. In these cases, the worker was usually inadequately protected because cutting goggles were being used instead of approved welding hoods during short welding operations. The SDS data (Table III-5) indicate that welders flash burns account for 1% of the industry's injuries.

(5) Chemical Handling (4.6%)

More than 44% of the incidents in this category involved chemical dermatitis caused by direct skin contact with moist concrete. Concrete burns, most commonly to hands and forearms, were usually sustained during casting or cleanup operations. In a few instances, concrete dermatitis developed during the dry mixing of the concrete. Lack of respiratory protection accounted for four of the incidents involving cement dust.

Lack of personal protective equipment, mostly eye protection, was a contributing factor in 30% of the chemical handling injuries. Workers received eye injuries during mixing, casting, and cleanup operations. Lack of eye protection was also a causal factor in four eye injuries that occurred during spray application of form release agents. Sprayers were overpressurized by misapplication of unregulated systems, resulting in explosions of the canisters in two instances.

(6) Materials Storage (4.5%)

Analysis of the accident data indicates that 46% of the materials storage accidents were the direct result of improper stacking and/or binding procedures. Product storage (multi-level) stacks were not stable enough to support their height and weight. Most of the injuries occurred while workers were in the process of adding additional material to the stack. The second most frequent cause of injury in materials storage activities was related to manual materials handling and improper gripping of the load. Fingers and toes were most at risk during these activities.

(7) Ladders and Scaffolds (3.9%)

One-fourth (25%) of the ladder/scaffold accidents were directly attributable to working from makeshift platforms (improper tools). The accidents that occurred on makeshift scaffolds were usually falls to the level below. Two scaffold accidents (one fatal) involved scaffolds with inadequate or nonexistent guardrails. Slippery (wet, icy) conditions on the ladders/scaffolds were cited in more than 22% of the accidents, mostly resulting in falls to the working surface of the scaffold. Inadequate securing of ladders against slipping (chocking, blocking, or tying) caused six of the accidents that were falls to levels below. In two instances, ladders were placed in the paths of moving vehicles (forklift, crane), resulting in collisions and serious injuries.

(8) Chipping/Cleaning (2.9%)

The majority of injuries that occurred to workers cleaning forms, products, or mixers probably would have been prevented by eye protection. The second largest accident causal factor in chipping/cleaning tasks was inadequate or nonexistent access to the area; makeshift worker platforms were common.

b. Process-specific Accident Factors

The following narrative paragraphs describe the ways workers are injured due to task/tool/equipment factors specific to the precasting processes. In the absence of data clarifying worker exposure, the percentage ranking is not intended to imply that any one factor represents a more significant hazard than another.

(1) Form Work (7.2%)

(a) Form Assembly/Disassembly (4.9%)

Form assembly and dismantling are frequently manual procedures that involve physical manipulation of form

components. Consequently, the accident/causal factors associated with form assembly primarily fall into the categories that typify physical procedures; e.g., the worker's position relative to the task, and gripping and handling form components. Many of the injuries that occurred in form assembly tasks were sprains and strains of the back, and injuries to the fingers. In two instances, workers were struck by form sections being turned by overhead hoists. Inadequate chocking and bracing of form sections during assembly or stripping contributed to many of the more serious injuries. In the instances when the form component adhered to the cured concrete, workers were struck by or caught beneath a portion of the form that was suddenly released and fell. Additional information concerning injuries resulting from form work can be found in Table III-5, "Forms" and "Lumber".

(b) Form Closing (1.1%)

Included in this activity are the tasks associated with closing (assembly) of prefabricated multiuse form components. Binding and unexpected release of the inner cores or outer forms of pipe molds typified most of the accidents in this group. "Caught between" accidents resulting in injuries to the fingers were the most common.

(c) Form Stripping (1.2%)

The most common cause of accidents in form stripping activities involved improper tool usage. Most frequently, these accidents resulted from using shovels as levers to pry form walls loose from the cured concrete.

The most serious accidents, one of which was fatal, involved inadequate or nonexistent cribbing or blocking of form walls. The fatality resulted when a worker crawled under a portion of form wall no longer integral to the remainder of the form or the product to determine where the form was still "hung up." The form wall fell while the worker was under it.

(2) Reinforcing (4.3%)

(a) Tying Resteel (1.5%)

With the exception of hands and fingers that were lacerated during the handling of the resteel, most workers (40%) were injured in accidents involving access to the forms and/or slippery working surfaces. The actual placing of strand differed little in accident

causal patterns from other forming and casting operations. Additional injury information is contained in Table III-5, "Reinforcement".

(b) Stressing (1.5%)

The accidents that most frequently occurred during stressing operations were similar to accidents which occurred during other forming and casting operations. Lack of eye protection accounted for more than 32% of the incidents--most of these caused by metal particles (scale) flicking off during the handling of the strand. The more serious accidents occurred during the actual stressing procedure and involved inadequate or nonexistent means for controlling employee access to the stressing area.

The high tension stretching of the steel strand poses a somewhat unique hazard to the industry. Since stressing is used in only about 10% of the precasting plants, the relatively small number of accident cases (19) may not reflect the frequency of accidents occurring in the actual stressing operation. The static forces contained in stressed strand are potentially hazardous. When these forces are accidentally released, workers within range of strand whiplash are exposed to potentially serious injury.

(c) Metalworking Machinery (1.3%)

Metalworking machinery (cage rollers, rebar benders and cutters, press brakes) are used in the precast concrete products industry to manufacture the shapes necessary for reinforcing concrete. More than 1% of the accidents that occurred to precast concrete workers happened during metalworking tasks related to the production of the reinforcing steel shapes. Inadequate and nonexistent guarding was the major accident causal factor associated with metalworking tools and operations. Cage rollers (0.6%) accounted for nearly one-half of these accidents. Failure to guard in-rolling nip points on the cage rollers resulted in two of the more serious injuries. Other accidents occurred while handling the metal items during bending, cutting, or rolling operations. Frequently, these were either lacerations of the hands caused by sharp edges or crushing injuries due to hands-on manipulation of the metal while the machine was in operation. Additional information concerning injuries from machinery can be found in Table III-5.

(3) Oiling

Analysis of the accident reports failed to identify accidents which were specifically ascribed to the oiling process. Factors which may influence the occurrence of accidents during oiling procedures include contact with form release agents, access to forms or product, and working/walking surfaces. These factors are discussed in the paragraphs on Chemical Handling in section a, and in the paragraphs on Personal Protective Equipment, Access, and Working/Walking Surfaces in section c.

(4) Concrete Mixing and Transport (2.6%)

(a) Concrete Mixing (1.8%)

Failure to lockout or tagout an energy source before entering or reaching into concrete mixing equipment accounted for 25% of the accidents involving concrete mixing and 3 of the 6 lockout/tagout related fatalities. Twelve percent of these accidents occurred when workers were attempting to access mixers. Fifteen percent of these accidents involved workers who were caught in or struck by chutes or hatches when they were not secured in place.

(b) Concrete Transport (0.8%)

Ready-mix concrete delivery trucks accounted for most of the accidents in this category. Usually the worker was struck by or caught between the delivery chute and the form. The more serious injuries happened during cleaning/maintenance operations on the trucks and were caused by lack of adequate energy control procedures.

(5) Casting Concrete (4.0%)

(a) Casting Concrete (3.1%)

The accidents that occurred during casting operations were most commonly caused by lack of access to the casting beds or between forms. Workers must continually get up onto and down from forms, or move back and forth between forms. In these instances, access was either not provided or was located in an area away from the work activity. Slipping or tripping on working surfaces caused almost 24% of the casting accidents. Most of the accidents were falls from or onto the casting bed, or involuntary recovery from slips or falls resulting in sprains, fractures, and contusions. Accidents that

were more task or tool specific (concrete delivery, pipe machine, scaffolds), yet still operationally part of the overall casting procedure, were included in the more specific category.

(b) Concrete Buckets (0.5%)

The injuries occurring to workers using concrete buckets were caused by the opening and closing mechanisms on the bucket's pour hatch. The latch bar frequently caught fingers and hands between the handle and the bucket.

(c) Pipe Manufacturing Equipment (0.4%)

The serious injuries to workers during mechanical pipe operations (packerhead and horizontal pipe spinning) were the result of inadequate machine guarding or isolation of the operation and the moving mechanical parts. A packerhead table with a gap between the table and the adjacent working surface caused a serious leg injury. Inadvertent entanglement with a horizontal pipe spinner injured another worker. Workers' eyes are also at risk in these operations. The rotating speeds used in these casting operations tend to "throw" cement and aggregate out into the adjacent work area.

(6) Sandblasting (0.3%)

The accidents that occurred during sandblasting operations were attributable to misuse of the sandblaster and/or the pressurized air system. Inadvertent activation of the sandblaster caused two of the reported accidents.

(7) Curing

Analysis of the accident reports failed to identify accidents which were specifically ascribed to the curing process. Factors which may influence the occurrence of accidents during curing procedures include contact with curing agents and hot steam, access to form and product, and cluttered or slick passageways, aisles, or other working/walking surfaces. These factors are discussed in the paragraphs on Chemical Handling in section a, and in the paragraphs on Personal Protective Equipment, Access, and Working/Walking Surfaces in section c.

(8) Product Handling and Transport (5.0%)

(a) Vehicles (3.4%)

This classification of equipment is comprised of various types of trucks (flatbeds, pickups) that are used to

transport products on or off of the plant premises. More than 82% of these accidents occurred while workers were attempting to get onto or off of the vehicle bed (access). The beds of these vehicles are typically 3 or more feet above the ground. Adequate foot and hand holds are seldom provided in places which would assist workers getting onto or off of the vehicles. Slippery or cluttered surfaces contributed to these accidents, resulting in all types of injuries (lacerations, fractures, contusions) to all parts of the body. Additionally, the SDS data (Table III-5) indicate that 1% of the injuries were sustained by occupants of motor vehicles involved in accidents. The SDS data also indicate that 2% of the injuries were attributed to workers falling off vehicles (see Table III-5, "Working/walking Surfaces").

(b) Product Removal (0.8%)

The most serious accident occurred when a crane was used to lift a product from a form to which the product remained adherent. When the crane attempted to hoist the product, the weight of the adhered form, an unknown force, resulted in crane overload and failure. One worker was killed.

Inadequate cribbing or blocking of the product during product removal tasks also resulted in serious injuries to workers (one was fatal). Workers under the product attempting to position rigging material or guide the load were injured when the product shifted, catching them under the load.

(c) Rolling Stock (Pipe) (0.8%)

Handling and storage of rolling stock (concrete pipe) resulted in 0.8% of the injuries in the industry. More than 55% of these accidents were the result of improper or nonexistent binding or chocking of the pipe. Although the back, hands and fingers were the most frequent parts of the body injured, the lower extremities were more seriously injured. Most of the remaining accident case histories cited rigging failure during stacking as the cause of the accident.

c. Accident Causal Factor Patterns

The method used to analyze the accident case histories allowed the identification of significant accident patterns by the grouping of related accident causal factors. For example, injuries attributed to wet, icy, or slippery surfaces; tripping; or puncture; are

discussed below under the general heading "Working/Walking Surfaces." These accident patterns indicate hazardous activities or conditions that encompass various tasks, industrial processes, tools, and items of equipment utilized in the precast concrete products industry. The arrangement of these patterns by percentage, in order from highest to lowest, is not intended to suggest that one accident pattern represents greater hazard to workers than another pattern, since data clarifying worker exposure are not available.

(1) Manual Materials Handling (17.6%)

There are two major accident types that occur as the result of improper manual materials handling procedures: overexertion accidents that cause sprains and strains of the back and shoulders, and materials movement accidents (dropped load, load placed on fingers) that usually result in lacerations, contusions, and fractures of fingers or toes. There is very little task specificity in manual materials handling accidents. Workers are required to lift and handle materials and tools throughout all precasting operations. They appear to be injured in proportion to the expected amount of manual materials handling likely to be used in any given task.

(2) Working/Walking Surfaces (12.4%)

The production processes of forming, pouring, stripping, and cleaning forms produce water, excess concrete, forming material, and a variety of tools and equipment that clutter walking and working surfaces. These hazards result in worker falls to the working surface and/or involuntary recovery injuries (sprains and strains that happen when a worker attempts to recover his balance). The SDS data (Table III-5) indicate that bodily motion (not including lifting, pushing or pulling) was the source of injury in 5% of the industry's accidents. Additionally, working surfaces were the source of injury in 12% of the accidents when workers fell while performing their duties.

Workers in form stripping operations (most likely responsible for exposed nails) are not the individuals usually injured by nails. The pattern of accidents related to nail puncture indicates that frequently (56%) it is a person walking through the area who steps on an exposed nail. Table III-5 indicates that nails were involved in 1% of all injuries, resulting most frequently in punctures to the foot.

(3) Personal Protective Equipment (10.7%)

The lack of personal protective equipment is not, in itself, a cause of accidents. However, during activities associated

with some tasks or tools, workers are exposed to hazards likely to result in injuries. For example, cutting torch tasks cause metal particles to fly through the air, increasing the probability of eye injuries; or, mixing and placement of concrete may result in material splashes that cause eye injuries; or, loads may fall or be dropped onto workers feet resulting in toe injuries.

In precasting operations, 10.7% of the injuries were likely to have been prevented by the employee wearing proper personal protective equipment. In most instances resulting in injury, the type of protective device found lacking was eye protective equipment. Concrete splashes, slag from cutting operations, metal particles from grinding, sawdust, particles falling from or blowing off forms, curing compounds, and general airborne dirt all resulted in eye injuries. Although safety glasses (eye protection) may not have prevented all of the reported injuries, their use certainly would have lowered the incidence of occupational eye injury.

Two fatal accidents in this category involved employees working from elevated areas and were directly attributable to the lack of fall protective devices. In both cases, the workers were performing tasks, on or from forms, without the protection of a safety belt and lanyard. The use of an adequate scaffold, including guardrails, would also have provided worker protection.

Crushing injuries to toes and feet resulting from the impact of heavy products and materials are not likely to be entirely eliminated by the wearing of safety-toed boots. However, such protective footwear would likely have prevented some of the injuries and reduced the severity of others in many of the cited instances.

(4) Access (9.8%)

Inadequate or nonexistent access to work areas was the primary causal factor in 9.8% of the accidents. As an accident causal factor, lack of adequate access resulted in workers being injured while performing most tasks and activities directly involved in the manufacture of precast concrete products. Workers attempting to move or work on casting beds and/or forms accounted for 38% of the "access" accidents. Most of these accidents were falls to lower levels; that is, off of the form or casting bed and onto the adjacent working surface (see Table III-5, "Working/walking surfaces"). Injuries ranged from simple bruises and lacerations to fractures. Many of the remaining "access" accidents were related to equipment; more than half of the vehicle access accidents involved

workers climbing onto or down from truck beds. Again, the injuries usually were caused by falls to below.

(5) Mechanical Materials Handling (7.6%)

Mechanical materials handling accidents comprised 38% (13) of the fatalities analyzed; half of these occurred to coworkers that were struck by a moving vehicle (crane, forklift). Twenty-three percent of the fatalities in mechanical materials handling were caused by rigging overloads. There were two incidents of crane "two-blocking" that resulted in fatal injury to workers.

The use of hoists, cranes, and forklifts is common throughout the industry. In many instances, the product is simply too heavy to move by other means. In some instances, the material is also too heavy to be moved by the selected mechanical method. Employees frequently work in close proximity to moving equipment. This interface, man and moving equipment, when compounded by the distractions of ongoing work and background noise, contributes to fatal accidents in precasting operations.

(6) Guarding (2.7%)

Inadequate or nonexistent guards were cited in 2.7% of the accidents. All but 2 of these 36 accidents occurred in conjunction with exposed moving parts of machinery and/or tools. Unguarded saws injured workers most frequently (31%), and unguarded grinders (abrasive stone) accounted for 17% of the injuries related to guarding.

(7) Chocking, Bracing, and Cribbing (2.6%)

The data indicate that most of the accidents that were caused by inadequate chocking, bracing, or cribbing occurred to employees engaged in tasks or activities related to partially assembled or dismantled forms. Form structures may adhere to concrete surfaces and then release suddenly. In some instances, employees were working (chipping, cleaning, welding, rigging) on or from forms that were braced or cribbed inadequately or not at all. Almost 12% of the fatal accidents in this industry occurred because of inadequate chocking or bracing.

(8) Lockout/Tagout (Control of Hazardous Energy) (1.6%)

Approximately 29% of the accidents caused by failure to control an energy source prior to performing maintenance or servicing activities were fatal. Inadequate control of hazardous energy resulted in 18% of the total fatalities.

Employees reaching or climbing into concrete mixing equipment (pan mixers, drum mixers, ready-mix trucks) without controlling the energy source accounted for three of the six fatal accidents.

Conveyors may jam during operation. Workers were injured while attempting to remove the jammed objects without first controlling the systems' energy sources.

D. New Employee Injury Rates

Analysis of the 1,319 accident case histories shows that 513 (54%) of the 950 reports that included length of employment information involved workers employed less than 1 year. In fact, 408 (43%) of the injuries were actually sustained by workers employed for less than 6 months.

Several factors may influence the apparent prevalence of injuries to new employees. Although some plants experience a relatively high turnover rate, many smaller plants seem to have a stable work force. These plants will layoff and rehire the same workers in accordance with seasonal or economic demands. Therefore, an injured employee reported as "new" on an injury report form, may actually be an experienced worker. Further, new employees may perform the more hazardous tasks. Or, new employees may typically comprise about 50% of the work force. No information which identifies either the distribution of tasks among workers of varying experience or the number of relatively new employees that make up the worker population at any given time is available. However, there is evidence to suggest that new employees or employees performing new tasks suffer significantly higher rates of injury than the employed population in general [25,26].

E. Summary of the Problem

Accident and injury statistics for 1980 indicate that the injury and illness incidence rate for the precast concrete products industry (SIC 3272) was 2.5 times the rate for all private sector industries. Not only does the precast concrete products industry have the problem of high injury incidence rates relative to all private sector industries, but within the manufacturing sector where there are similar tasks and operations, only 8, or 3.4%, of the 235 four-digit SIC code industries had higher incidence rates than this industry in 1980.

Analysis of 1,319 accident case histories has demonstrated how employees in the precast concrete products industry are injured while performing those tasks necessary to manufacture concrete products. Furthermore, patterns of accident causal factors common throughout the industry have been identified.

It is concluded that the primary safety needs of the precast concrete products industry are: 1) implementation of the recommendations for safe work practices presented in Chapter IV; and 2) implementation of a safety management program, such as the one presented in Chapter V.

CHAPTER IV
RECOMMENDATIONS FOR SAFE WORK PRACTICES FOR THE PRECAST CONCRETE PRODUCTS INDUSTRY

The safe work practices recommended in this chapter are presented as ways to reduce and control injuries resulting from precasting operations. The hazardous tasks identified, as well as the patterns of accident causal factors developed in Chapter III, indicate potential problem areas that have been given insufficient emphasis by the precasting industry. The solutions offered in the following safety recommendations may not be entirely suitable for a specific plant. In some instances, management may even view the recommendations as counterproductive to their operations. In these instances, the responsible persons (plant managers, safety managers, and/or plant owners) should interpret and modify the recommendations to make them applicable to their specific needs. It is essential that, in any modification of the recommended safe work practices, a similar quality of worker protection be provided.

Considerable emphasis has been placed on the safety recommendations directed at hoist and crane activities. In the cases analyzed, 41% of the fatal accidents occurred due to misuse of hoists and cranes. Expertise specific to hoisting equipment may be less developed than supervisory expertise particular to production; therefore, hoist and crane safety has been presented in detail.

The goal of this study has been to identify hazards in precasting operations and to recommend applicable and manageable means to alleviate them. The safety recommendations presented are not meant to be all-inclusive or to supersede the OSHA General Industry Standards, which offer adequate regulatory guidelines for many of the tasks, tools, and equipment used in the precast concrete products industry. Emphasis has been placed on recommendations for safe work practices which address tasks, activities, and tools commonly associated with injuries.

The safety recommendations are organized and presented in three major categories:

A. General Safety Recommendations
B. Safe Work Practices for Precasting Processes
C. Safety Recommendations for Accident Causal Factor Patterns

A. General Safety Recommendations

This preliminary section presents safe work practices for the tasks, activities, and tools that are commonly used throughout precasting operations. Included in this section are the recommendations for manual and mechanical

materials handling, handtools, worker proximity to operations, welding and cutting, chemical handling, ladders and scaffolding, and chipping/cleaning.

1. Manual Materials Handling

A wide range of manual materials handling activities are inherent to the precast concrete products industry. Workers may be required to lift, carry, push and pull raw materials and/or finished products during loading/unloading, processing, storage and cleanup operations. The handling and manipulation of loads can markedly increase the stresses imposed on workers' musculoskeletal systems and increase the likelihood of injuries to certain body areas (e.g. back, extremities) [27]. The application of proper handling techniques can minimize these stresses and help reduce the incidence of musculoskeletal injuries.

A number of factors can directly influence the likelihood of an individual suffering a musculoskeletal injury during the performance of manual materials handling activities. These are discussed in NIOSH's "Work Practices Guide for Manual Lifting" [28] and include:

- o Using safe handling techniques which emphasize proper body mechanics in performing materials handling activities
- o Selecting and using assistive devices
- o Providing adequate work space
- o Training workers and reinforcing their activities.

a. Safe Handling Techniques

The proper use of safe handling techniques by workers performing manual materials handling activities is one of the most important factors in avoiding injury, since the techniques reduce body stresses and their application are at the discretion of the worker. NIOSH's publication "How to Lift Safely" [29] illustrates several of the important points in materials handling. Key points include:

- o Workers should assess the size, shape and weight of objects to be lifted or carried. Objects deemed to be beyond the physical capacity of one worker should be handled by two or more workers.
- o Workers should spread their feet apart to provide a wide base of support during manual materials handling.
- o When lifting objects, workers should bend their knees to a degree which is comfortable to them and then get a good firm grip on the item to be lifted. Lifting should be accomplished through the use of leg muscles in straightening the knees rather than using the back muscles.
- o Workers should handle objects as close to the body's center of gravity as possible.
- o Workers should avoid twisting the trunk when handling objects.

b. Assistive Devices

A number of assistive devices can reduce or eliminate the need for stressful manual materials handling. For example, rebar can be stored on surfaces which correspond to the height of the bending and cutting machines so that the worker does not need to lift the rebar from the floor level to the cutting or bending surface. It is even better to have the rebar storage surface gently slope toward the cutting and bending machine. This reduces the stress required to pull the rebar to the cutting or bending position. Other assistive devices useful in the precast concrete products industry include: hooks and handles, prybars or crowbars, conveyors, dollies and handtrucks, and mechanical or electric chain hoists. To make effective use of these items:

- Management should provide these items and encourage their use.
- Workers should understand the importance of their use.
- Workers should select and properly utilize the appropriate tool.

c. Adequate Work Space

Even with the intention to use proper manual handling techniques and/or assistive devices, workers may be confronted with an inadequate work space which restricts the use of recommended techniques. The physical work environment should have:

- Adequate space to perform manual materials handling activities
- A clear, unobstructed path if transportation of objects is required
- Clean and dry floor surfaces to allow for a firm base of support.

d. Training

Training workers in the principles of safe manual materials handling techniques has been generally accepted as a means of promoting worker safety. Training methods include booklets, movies, slide-tape programs, lecture-demonstrations, and back-school courses [30]. These methods also represent a wide range of costs to employers under various financial restraints. A training program should:

- Address the types of manual handling activities inherent to the activities of the workers participating in the program
- Illustrate the dangers of unsafe techniques
- Emphasize the recommended techniques
- Provide workers with criteria for assessing the stress of handling various objects.

Training programs are means of conveying information to workers. A goal of training programs is that workers will alter their work habits by substituting safer work practices for various unsafe techniques. This form of behavioral modification usually requires feedback to the workers. Supervisors and employers must take the time to positively reinforce safe practices and constructively criticize unsafe practices. Effective training is approached as an ongoing interaction among all plant employees and not a one time exposure to the training material [31].

2. Mechanical Materials Handling

a. Powered Hoists and Cranes

Safety in hoisting operations is a function of the interaction of four major areas:

- o Selection, inspection, and integrity of the equipment
- o Competent operation
- o Rigging of the load
- o Handling of the load.

(1) Selection, inspection, and integrity of powered hoisting equipment

(a) The proper selection of equipment <u>type</u> and <u>capacity</u> is dependent upon consideration of:

- o The weights, dimensions, and lift radii of the heaviest and largest anticipated loads
- o The direction the load is to be moved; i.e., whether horizontally, vertically, or both
- o The type of lifting and load placement precision
- o The ground conditions on which the equipment must operate.

(b) Cranes should be equipped with the following safety features and devices:

- o Approved boom stops installed to preclude travel beyond the angle of 85 degrees above the horizontal plane [32]
- o Boom angle indicators for booms capable of moving in the vertical plane [33]
- o Automatic devices to stop boom drum motion when the maximum permissible boom angle is reached [33]
- o Boom length indicators for telescopic booms [33]
- o Automatic "anti-two-blocking" devices for hydraulic extending booms [33]
- o An effective audible warning signal (horn) mounted

outside the cab with controls easily within reach of the operator [33]
- A spirit level at the outrigger controls for leveling [33]
- Adequate lighting for night operation, including backup lights for mobile units [33]
- Wheel chocks on mobile units to block movement on slopes when the equipment is left unattended or is undergoing maintenance [33]
- A fire extinguisher and a first-aid kit [32]
- Rearview mirrors on both sides of mobile equipment [33]
- Self-closing filler caps and flame arresters on fuel tanks [33]
- Slip-resistant material on crane surfaces subject to foot traffic [33].

(c) Equipment should be safety inspected frequently (daily to weekly). Inspectors should [33]:

- Check brakes, clutches, and safety devices for proper adjustment and operation (if possible, check load brakes by lifting a capacity or near capacity load a few inches off the ground)
- Daily, visually inspect each component of the equipment used in lifting, swinging, or lowering the load and components used to lift and lower the boom, for any defects that might result in unsafe operation
- Check for freedom of rotation of all swivels
- Check all functional, operating mechanisms such as sheaves, drums, brakes, locking mechanisms, hooks, boom, jib, hook roller brackets, outrigger components, limit switches, safety devices, hydraulic cylinders, instruments, and lights
- On cranes, daily, visually inspect the boom and jib for straightness and for any evidence of physical damage such as cracking, bending, or other deformation of the steel elements or welds (this precaution is especially important on lattice and tubular booms, where every component should be straight and free from dents)
- Inspect wire ropes (including standing ropes), rigging hardware, and attachments
- On cranes, check that the counterweight is secure and that the weight and capacity are permanently and legibly stamped on jibs, blocks, equalizer beams, and all other accessories
- Daily, visually inspect the equipment for fluid or air leaks
- Ensure that all walking surfaces of the equipment are clean and free from tackle, grease, and oil.

(d) All capacities listed on the load chart for machine "on outriggers" and "on tires" are based on the crane being level and on solid support. The importance of leveling cannot be overemphasized. The manufacturers' capacity tables should be referred to for both outriggers and tires, since lifting capacity is reduced markedly when the crane is not level [33].

(e) If a crane has to make its lifts on rubber, always use wheel chocks to block the wheels and apply the airbrakes to hold the crane in position. If the machine is of two-engine design, keep the carrier engine running to maintain air pressure. Ensure that the tires are properly inflated; if they are not, then the capacity and crane stability will be reduced [34].

(f) Dunnage under outriggers must be strong enough to support the imposed load. If more than one layer is needed, then proper "cross-hatched" stacking must be used to prevent tipping. Reset outriggers before a lift if necessary. If floats are allowed to settle into the ground, they lose their effectiveness, making continued operation unsafe [34].

(2) Competent operation of equipment

(a) Only thoroughly trained and tested workers are permitted to operate a crane. When an operator is assigned to a new crane, competence with that crane must be demonstrated. Training and testing must be sufficient to demonstrate that the operator fully understands and is capable of safely performing all tasks. The testing should include a performance evaluation of:

- o Hoist control functions and positions, including all emergency shutdown controls
- o Load charts, boom angles, radii, and their relationships
- o Signals
- o Outriggers, leveling, and stability.

(b) During operations, the crane operator should:

- o Never allow his attention to be diverted from the operation of the crane (coworkers should not be permitted to talk to the operator while he is working)
- o Allow no passengers (excepting an oiler) on a crane in motion or operating, especially during mobile yarding operations

- Not back up the machine without first making certain that no one will be endangered (when vision of the area behind the crane is blocked, use a signalman)
- Sound an audible alarm (horn) before moving a crane and whenever the crane is approaching other workers
- Sound an audible alarm whenever a suspended load is approaching employees to give them time to move
- Never operate the crane within 10 feet of energized high-voltage powerlines.

(c) During operations, management should:

- Prohibit employees from performing any maintenance work on equipment while it is in service
- Barricade the swing radius of the crane structure to prevent employees from being trapped and crushed between rotating portions of the crane and adjacent structures
- Prohibit oilers, helpers, or other workers from areas within the swing radius of the crane carriage while the crane is rotating or under load
- See that oilers, helpers, or other workers are not under any portion of the crane body while a load is suspended.

(3) Rigging the Load

The proper selection and integrity of rigging material and the methods used to attach the load to the hoist are vital to safe hoisting operations [33, 34].

(a) The load should be rigged so that the load is stable in the saddle of the hook.

(b) The worker should know the safe load limits of rigging equipment, which must not be exceeded. The employer can accomplish this by permanently attaching tags to, or painting a section on, each sling, rope, and chain that identifies its capacity.

(c) The employer should train all riggers in the safe operating procedures of rigging, including:

- Keeping hands away from pinch points as the slack is being taken up
- Examining all hardware, equipment, tackle, and slings before use and destroying defective components
- Making sure that all slings are of the same capacity and length when two or more slings are used on a load

- Making sure that the hoist rope or chain is <u>never</u> wrapped around the load or completely wrapped around a hook
- Attaching the load to the hook by slings or other rigging devices that are adequate for the load being lifted
- Securing the unused legs of a multileg sling before lifting loads with one leg
- Remembering when a bundled load is picked up that the material will tend to "nest" and create pinch points, and when a load is landed, it will tend to roll or spread out
- Making sure wood blocks or short lengths of steel are not carried loosely on tops of loads
- Making sure wire rope or chain is <u>never</u> allowed to lie on the ground for any length of time or on damp or wet surfaces, rusty steel, or near corrosive substances
- Avoiding draping rope slings from beneath loads
- Keeping all rope or chain clear of flame cutting and electric welding operations
- Making sure shackles are <u>not</u> rigged with the running rope against the pin, causing it to "spin out" and drop the load
- Ensuring proper load/shackle alignment by using spacers such as washers
- Keeping the load under control with guide ropes or tag lines.

(d) Workers should be supervised by competent personnel who:

- Plan the job
- Ensure the care of rigging equipment
- Supervise rigging operations.

(e) Slings, ropes, or chains should <u>not</u> be left on the floor or ground where they can be subjected to abrasion or create a tripping hazard. They should be hung from a rack and looped so that they do not touch the floor.

(f) All hooks should have safety latches.

(g) Sharp bends, pinching, and crushing of ropes and slings must be avoided. Sharp edges or corners of heavy loads should be padded as protection for slings by the use of large-diameter split pipe sections, corner saddles, or other, softer material.

(4) Handling of the load

(a) Standard hand signals must be used. The load should not be "picked" until the signal is received from the signalman. All signals must be clearly understood by the operator. If there is any doubt, the operator should stop operations until the signal has been clarified. The crane operator should receive signals from only one person; this does not exclude relay signaling or emergency stop signals. Signalmen may be supplied with orange gloves for maximum signal visibility.

(b) Crane/hoist operators should remain at the controls whenever a load is suspended.

(c) When preparing for new and near-capacity picks, the operator should make a practice run, going through all the motions without the load, anticipating the actions that should be taken to make a safe lift and a smooth operation.

(d) The crane should never be loaded beyond its rated capacity.

(e) Handling loads during high winds should be avoided.

(f) Safety precautions for walking a crane while it is supporting a load should include:

- o Tagging the load to the crane body
- o Prohibiting employees from walking the load with "hands-on" guidance
- o Keeping the load as close as practical to the ground
- o Avoiding ground irregularities that could cause a loaded crane to pendulum sideways.

(g) Overhead and gantry crane operators must be instructed to:

- o Board or leave the crane only at authorized locations
- o Examine and test controllers before each shift, and keep latches in working condition
- o Use limit switches for emergency purposes only
- o Never operate the hoist with inoperative limit switches
- o Center the trolley and bridges over the load.

b. Straddle Carriers

(1) Straddle carrier operators must be thoroughly trained.

(2) Straddle carriers must be thoroughly inspected before beginning operation each day. Particular attention should be given to brakes and hydraulic systems. Visual inspections of the bridge, rigging, and lifting hardware should be made to ensure their integrity. All wire ropes should be inspected and special safety devices should be in working order. The inspection should be performed and documented by qualified maintenance personnel.

(3) The rated load of the straddle crane should be posted in a conspicuous location on the equipment and in the operator's cab.

(4) When operator visibility is restricted, a signalman must be provided.

(5) Visible and audible alarms should be in operation during any moving task.

(6) No one should ride on the carrier unless such a procedure is approved by the plant manager. Where approval is granted, a seat or cage, located so that it will not interfere with operator vision or in itself be a hazard, should be provided. The rider should be in the seat or cage before the carrier is moved and should not move around on the carrier until it is stopped.

c. Forklifts

(1) Only workers authorized by the employer and trained in the safe operation of industrial trucks, forklifts, or industrial tow tractors should be permitted to operate these types of vehicles.

(2) Forklifts and industrial vehicles should be equipped with audible backup alarms.

(3) Industrial vehicles must be inspected and tested to ensure that:

- o Brakes are in working order
- o Backup alarms are functioning
- o Hydraulic systems are working properly
- o Horns and lights are in working order.

(4) Employees should <u>not</u> be permitted to place any part of their bodies outside the cab or protected area of an

industrial truck or between mast uprights or other parts of a truck where shearing or crushing hazards exist.

(5) Passengers are <u>not</u> permitted on industrial vehicles.

(6) Employees should <u>not</u> be allowed to stand, pass, or work under the elevated portion of any industrial vehicle, loaded or empty, unless it is effectively blocked to prevent it from falling.

(7) When loading or unloading trucks or trailers, the brakes must be set and the rear wheels chocked.

(8) Forklift forks should be carried as low as possible.

(9) Industrial vehicles should <u>not</u> run onto floors, platforms, or other surfaces that will not safely support the loaded vehicle.

(10) Vehicle loads must <u>not</u> exceed rated capacities. A loaded industrial vehicle should <u>not</u> be moved until the load is secure.

(11) When leaving the vehicle, the worker should shut off the engine, set the brakes, and lower the lifting forks to the ground.

(12) All traffic regulations should be observed including plant speed limits. The operator of an industrial vehicle is required to slow down and sound the horn at cross aisles and other locations where vision is obstructed.

(13) No person should operate or be in physical control of a motorized vehicle or piece of equipment if he is under the influence of or is using alcohol or drugs.

d. Chain Hoists

(1) Chain hoists or "come-a-longs" should be inspected and maintained as part of a preventative maintenance program. Inspection should include:

- o Checking the integrity of the chain or wire rope for worn links, deformations, kinks, rust, or excessive stretch
- o Examining the hook for deformity, cracks, or bending
- o Ensuring that the clutch and brakes are within the manufacturers' tolerances.

(2) Employees lifting material with mechanical hoists should:

- o Use proper and accepted rigging methods

- o Use safety latch hooks
- o Chock or block loads before working under them
- o Not use "cheaters" on the hoist handles. The handle length is matched to the safe lifting capacity of the hoist, and while the cheater extension may temporarily enable a greater load to be lifted, it may tax the hoist and lead to failure.

e. Conveyors

(1) Conveyors should be adequately guarded to prevent workers from being caught on moving parts or being injured by falling materials.

(2) Conveyors should have delay startup warning devices with controls for emergency stops. All chain drives, gears, nip or shear points, and revolving shafts should be guarded.

(3) Personnel working near conveyors should wear close-fitting clothing that cannot be caught in moving parts.

(4) Employees should be instructed in safe practices for freeing "jammed" conveyors, including use of special tools. A lockout system should be mandatory.

(5) Chutes or other devices that depend on gravity for moving materials should be guarded.

(6) Employees should not climb onto a gravity conveyor unless the equipment is locked out.

f. Front-end Loaders

(1) Mounting and dismounting accidents can be reduced if operators utilize the following safe procedures [35]:

- o Take adequate time when mounting and dismounting
- o Mount and dismount facing the equipment
- o Clean boots of excess mud before attempting to get on or off the machine
- o Keep access platforms and steps clean
- o Use the access facilities provided on the machine
- o Avoid jumping from the machine.

(2) Front-end loaders should be equipped with a backup warning device. The device should be audible and sufficiently distinct to be heard under the prevailing conditions. The device should operate automatically upon commencement of backward motion and should operate during the entire backing operation [36].

(3) Loader operators should be sure other workers are in the clear before starting or moving the machine [36].

(4) Operators should not move loads over the heads of other workmen or over truck cabs [36].

(5) The loader bucket should be carried as low as possible and tilted back. This provides better operator visibility and minimizes machine bounce [36].

3. Handtools

a. Powered

Handtools (powered) should be used according to the following safety recommendations:

(1) Hand-held powered circular saws, chain saws, and percussion tools without a positive accessory holding means must be equipped with a constant pressure switch [32].

(2) Portable, power-driven circular saws must have guards above and below the base plate or shoe. The upper guard should cover the saw to the depth of the teeth, except for the minimum arc required to permit the base to be tilted for bevel cuts. The lower guard should cover the saw to the depth of the teeth, except for the minimum arc required to allow proper retraction and contact with the work. When the tool is withdrawn from the work, the lower guard must automatically and instantly return to the covering position [32].

(3) Abrasive wheels and stones must have a safety guard covering the spindle end, nut, and flange projections. The safety guard should be mounted to maintain proper alignment with the wheel; the strength of the fastenings should exceed the strength of the guard [32].

(a) Prior to use, abrasive stone wheels should be inspected to ensure that:

- o They have not been damaged in transit or handling, which is checked by means of sounding with a ring test
- o Wheels fit freely on the spindle and remain free through an entire turn of the wheel, and that the free clearance between wheel and guard does <u>not</u> exceed one-fourth inch
- o A controlled clearance between the wheel hole and the machine spindle (or wheel sleeves or adaptors) is

sufficient to prevent excessive pressure from mounting and spindle expansion

- o All contact surfaces of wheels, blotters, and flanges are flat and free of foreign matter˙
- o When a bushing is used in the wheel hole, it does not exceed the width of the wheel and does not contact the flanges.

(b) The safe operating speeds of abrasive grinding stones should not be exceeded [32].

(4) Hand-held powered drills; tappers; fastener drivers; horizontal, vertical, and angle grinders; disk and belt sanders; reciprocating, saber, scroll, and jig saws; and similar tools must be equipped with constant pressure switches. Other handheld powered tools, such as platen sanders; grinders; disk sanders; routers; planers; and saber, scroll, and jig saws, should be equipped with either a positive on-off control or a constant pressure switch [32].

b. Unpowered

The following safe practices should be observed when unpowered handtools are being used [37]:

(1) Train employees to select the correct tool for the job, and ensure that the tools are available.

(2) Keep all hand tools in a safe condition. Handles of tools shall be kept tight in the tool. Wooden handles shall be free of splinters or cracks. Wedges, chisels, and other struck tools should be dressed as soon as the struck surfaces begin to mushroom. Discard wrenches which are sprung to the extent that slippage occurs.

(3) Instruct employees in the correct use of tools.

(a) When using shovels, workers should keep their feet well separated to maintain balance. The worker should use the leg muscles to carry the majority of the load, and should grasp the handle as near the load as possible.

(b) Hammer blows should always be struck squarely with the hammer striking face parallel with the surface being struck. Glancing blows should be avoided. Hammers should be of suitable size and weight for the job. Redressing of mushroomed hammer heads is not recommended; the hammer should be discarded.

(c) Crowbars or prybars of proper size and kind should be selected for the particular prying task. The crowbar should have a point or toe that will grip the object to be moved, and a heel to act as a pivot point. Sometimes it is necessary to use a block of wood under the heel to prevent the crowbar from slipping and injuring the hand. Workers should position themselves so that their bodies will not be in the path of travel if the prybar slips. Additionally, they should brace/position themselves so that they will not fall if the prying forces are released suddenly. Guardrails may be necessary to prevent workers from falling to lower levels.

(d) Employees should be aware that when using torsion tools such as wrenches, there is always a possibility that the tool may slip. Therefore, the employee should be in a braced position to maintain bodily balance should the tool slip. Wrenches should be inspected for flaws. Wrenches should <u>never</u> be ground to change their dimensions to make them fit in close quarters. A wrench of proper size for the job must be selected.

4. Worker Proximity to Operations

a. Walking Through Work Areas

Work areas should be kept free of litter, trash, gravel, excess concrete spills, welding rod stubs and other junk. All scrap, salvageable material, unused forming or reinforcing materials and equipment should be removed. Protruding nails in wood forming material should either be removed or bent over. Aisles around work areas should be kept clear of such items as reinforcement, welding hoses or leads, lumber, power cords, and concrete working tools.

b. Working Near Operations

Of particular interest in this category is the need to protect workers in the vicinity of welding operations from flash burns. Whenever possible, resistance welding operations should be isolated to protect workers in the vicinity of the welding operations from exposure to the direct or reflected light rays. This can be accomplished either by use of booths for regular welding production operations or by portable welding screens for welding being performed intermittently throughout the plant [38].

5. Welding, Cutting, Burning

Welding, cutting, and burning necessary for making precast concrete

products should be done in accordance with the following safe work practices:

a. Workers performing welding and cutting tasks should be trained.

b. Before starting welding or cutting operations, the work area should be inspected to ensure that:

   o There are no potential fire hazards
   o An approved fire extinguisher is readily available
   o There is no fire hazard on the opposite side where welding is being performed on a floor, deck, wall, bulkhead, or other partition
   o The work area is clear of tools, scrap, wood, or other objects that might fall or otherwise cause injury to another worker if struck by the welder.

c. Welding and cutting should be done in an area having a nonflammable floor, such as concrete, but not on the concrete floor, because of the possibility of explosive spalling of the concrete. The material to be cut should be raised above the concrete or the concrete shielded from the flame. If welding must be done over wooden floors, a noncombustible covering material should be placed over the floor to provide fire protection and to prevent spatter from dripping through openings in the floor. The use of wet sand or metal coverings, however, may create electric shock hazards that otherwise would not exist.

d. Welding screens should be used to protect other workers from ultraviolet (UV) light and sparks from welding operations. Curtain and screen placement should not hamper the operator's movements.

e. Personal protective equipment should be worn by all welders and helpers as needed, including:

   o Welding hoods with approved UV filter plates and cover plates
   o Safety glasses under the welding hood
   o Flameproof aprons made of leather or other fire-resistant material
   o Flameproof gauntlet gloves and shirts with long sleeves
   o Cuffless trousers that hang below shoe tops and are attached by clips or elastic bands around the trouser bottoms to prevent slag from entering the shoes.

f. Avoid burning while wearing ragged or oily clothes. Sparks may lodge in rolled-up sleeves or pockets of clothing, or in cuffs of overalls or trousers.

6. Chemical Handling

Persons working with chemicals such as fresh (moist) concrete, form release agents, or epoxies should:

- o Avoid direct contact between skin surfaces and chemicals or clothing saturated by chemicals
- o Soon after contact between skin surface areas and chemicals or clothing saturated by chemicals, skin areas involved should be washed thoroughly and saturated clothing areas rinsed out with clean water
- o Begin each workday with clean clothing
- o Use barrier creams
- o Wear full length trousers, long sleeve shirts, waterproof gloves, boots, and knee, elbow or hand pads
- o Wear eye protection
- o Conclude each workday with a shower or bath
- o Periodically be updated on recommendations for safe usage contained on the appropriate chemical's material safety data sheet.

7. Ladders and Scaffolds

a. Portable ladders should be:

- o Equipped with safety feet
- o Chocked and/or tied off to prevent accidental displacement (if necessary, a coworker should be used to hold the ladder)
- o Of sufficient length to ensure that the vertical to horizontal placement maintains a 1 to 4 ratio (for each 10 feet in height, the ladder feet should be 2-1/2 feet out).

b. Scaffolding should be:

- o Free from holes and tripping hazards on the platforms
- o Provided with adequate guardrails on all exposed sides, including the one next to the form if a floor gap exists
- o Provided with a safe means of access.

8. Chipping/Cleaning

The most common type of accident that occurs during chipping/cleaning tasks involves fragments flying into workers' eyes. The following recommendations are made to alleviate this problem:

- o Persons involved in grinding, chipping, wire brushing, and/or scraping should wear goggles or safety glasses with side shields under a face shield.
- o Since the chipping/cleaning tasks which utilize power tools can cause particles to be airborne for considerable distance (10 - 30 feet), the operations should be isolated from other workers. If

this is not practical, then workers in the vicinity of these operations should also wear adequate eye and face protection.

B. Safe Work Practices for Precasting Processes

Safe work practices for procedures used in the manufacture of precast concrete products are presented in this section. Included are safety recommendations that address the hazards of processes used in the precasting industry as well as the application of tools or equipment used in a specific process.

1. Form Work

a. Forms and Forming

(1) Forms and beds for casting should be:

- o Arranged or laid out to provide a working space, aisleway, or working platform clear of obstructions and sufficiently wide to provide ample room for the safe movement of materials and vehicles
- o Provided with access steps or ramps at convenient intervals along the bed or form
- o Equipped with standard guardrails, if over 4 feet high.

(2) Forms should be structurally sound so that they do not present a hazard to employees as they are built, repaired, cleaned, modified, or moved.

(3) During form assembly, components should be chocked and/or braced to prevent displacement.

(4) Safe access during vertical pipe form assembly should be provided for workers during assembly, aligning of hoisted parts, and attaching of hoist hooks.

(5) The floor, yard, platform, or other surface on which a form is placed, built, or erected should be free of litter, debris, and other loose materials that can cause tripping hazards. Also, these surfaces should be well drained and free of potholes, cracks, unevenness, or standing water that may contribute to slips and falls.

(6) Tilt tables should be capable of supporting the temporary loads of employees during forming operations in addition to the imposed load of product. They should also be chocked when in the upright position for cleaning, product removal, or maintenance to avoid collapse.

b. Form Stripping

(1) Employees should be instructed that form bulkheads, etc., may temporarily adhere to the concrete product. The bulkheads may release suddenly. Workers (and their body parts) should not be positioned where they may be caught between either the bulkhead, the product, and/or the form.

(2) During form stripping and product removal tasks, it is important that form bulkheads and components be cribbed, braced, or suspended by hoist to prevent their falling unexpectedly.

(3) Prying tasks should only be performed with the proper tool (crowbar or prybar). Shovels should <u>not</u> be used as substitutes.

(4) Cranes or hoists should <u>not</u> be used to remove products lodged or stuck to the forms. The crane's safe lifting capacity should <u>not</u> be exceeded. Use of properly adjusted crane load indicating devices will help avoid exceeding crane capacities.

(5) As forms are stripped, all excess material, wood, nails, and bits of wire should be removed so that the area is clean and safe. After forms are stripped, all nails should be bent or pulled immediately.

2. Reinforcing

a. Reinforcing Materials/Assemblies

(1) Reinforcing assemblies should be fabricated with a working level jig to avoid constant bending over to tie or weld.

(2) In the handling of reinforcing steel and fabricated assemblies, the following precautions should be taken:

- Employees must be instructed and required to use correct lifting techniques.
- Finished cages for pipes, columns, and beams should be moved to their final locations in the forms with consideration of their weight and the physical capabilities of the employees assigned.
- Mechanical lift assistance should be provided to safely lift pieces too bulky or heavy to be handled manually.
- Bundles of reinforcing steel moved by crane or other means should be securely tied and wedged together to prevent slipping.
- Rebar bundles lifted by hoist should be rigged by 2-point

suspension chokers and moved in a balanced horizontal position. They should not be moved in the vertical plane.

- o When bars carried by hand are long, bulky, or heavy, more than one worker should be utilized.
- o Rebar materials used in cutting and bending operations should be located such as to minimize or eliminate the need for the worker to lift the bar from ground level to the cutting or bending height.
- o Gloves should be worn during strand stringing, vise placing, rebar tying or handling, mesh placement, and cage handling tasks [39].

b. Metalworking Equipment

Metalworking equipment should meet the following requirements:

- o Cage rollers should be equipped with deadman switches and positive braking mechanisms that immediately stop the movement of the rollers.
- o Cage or wire rollers should be equipped with trip wire mechanisms at the in-rolling nip points, that automatically shut down the rollers when inadvertent contact is made.
- o Shearing machines should be equipped with physical guards and/or proximity detectors.

c. Stressing

(1) General safety recommendations for stressing include the following:

(a) Strand should be inspected as it is placed in the bed to detect defects that could cause failure, such as:

- o Nicks
- o Kinks
- o Broken wires
- o Excess corrosion.

(b) Welding or cutting should not be allowed in any stressing bed where strand has been strung or tensioned, or in any other location where strand is stored. If an electric arc jumps to or from the strand, the molecular structure of the strand is altered and a loss of strength occurs. Heat from molten metal or torch cutting will also change the mechanical properties of steel wire strand.

(c) Strand vises used to secure strand at the anchor abutments should be placed away from a burned end to avoid the area of altered strand strength. This distance

should be at least 12 diameters of the strand or 6 inches, whichever is greater.

(d) Strand previously gripped by vises, and therefore nicked, must not be reused. Strand vises should be cleaned and inspected between each use and lubricated as necessary. Grips that become visibly worn or distorted, or allow excessive slippage should be discarded.

(e) Check that the strands in the form are not crossed or tangled before tensioning.

(f) Audible and visible alarm signals should be turned on and remain on during tensioning. Any personnel not directly involved in stressing operations should be cleared from the "designated area" and remain clear until audible and visual signals are turned off.

(g) The "designated area" should be the entire length of the bed being stressed, including both ends and the sides out to the center line of any adjacent bed, or one-half the length of the longest member, but not less than 20 feet.

(h) Only stressing crew personnel directly involved in tensioning are to be permitted in the vicinity of the bed.

(i) Personnel in the stressing crew must not stand behind the jack or in line with the tensioned steel, since ruptured strand tends to retract along the line of tension.

(j) No employees should be in the jacking area (the area within the possible swing radius of the stressing jacks) during stressing.

(k) Elongation should be measured by means of a template, jig, or scale attached to the stressing jack that can be viewed from a safe distance.

(l) Workers involved in tensioning should be protected by bed end protection, a pumphouse, or a portable booth to shield them from flying strands or bulkheads resulting from strand breakage.

(m) An employee should be posted in a location with an unobstructed view of the designated area in order to warn personnel who inadvertently approach the restricted area.

(2) Bed End Protection

(a) Bed end protection should be provided at the jacking abutment end of each stressing bed and should consist of a main shield at or near the bed end (such as the example shown in Figure IV-1) and a secondary barrier downstream of the jacking area. Shields must be designed to withstand the forces applied against them by recoiling strand, flying bulkheads, and other material that may be launched as a result of strand failures during stressing. Shields can be fabricated of sheet steel; heavy duty, small aperture expanded metal; or concrete with a supporting frame of angle iron, channel, or pipe. The purpose of bed end protection is to shield those workers who are involved in the tensioning or detensioning operation from flying chucks, strand, or bulkheads resulting from chuck or strand breakage. The following recommendations describe <u>possible</u> methods of bed end protection. Staff engineers should develop measures which are specific to the protection needs in each plant [39].

(b) Bed end protection is in addition to:

- o Safe plant layout
- o Clearing the area of those not involved in stressing
- o Minimizing the number of people involved in stressing
- o Keeping people as far as possible from the jack during stressing
- o Using warning signals.

(c) In addition to bed end protection, a secondary barrier (such as the example shown in Figure IV-2) should be provided to block the path of strand retracting through the abutment or pulling head as a result of tensioned strand failure. Without such protection, the retracting strand may continue along its path for several hundred feet. The secondary barrier should be constructed of concrete, steel, or other material able to withstand the force of a chuck and strand retracting through the pulling head. Alternatively, an angled trough that is of sufficient strength and dimension to collect a retracting strand and direct it toward the ground should be permanently installed at the pulling head.

(3) Harping

Before harping, the operator should be knowledgeable of the recommended depressing sequence and mark the required distance

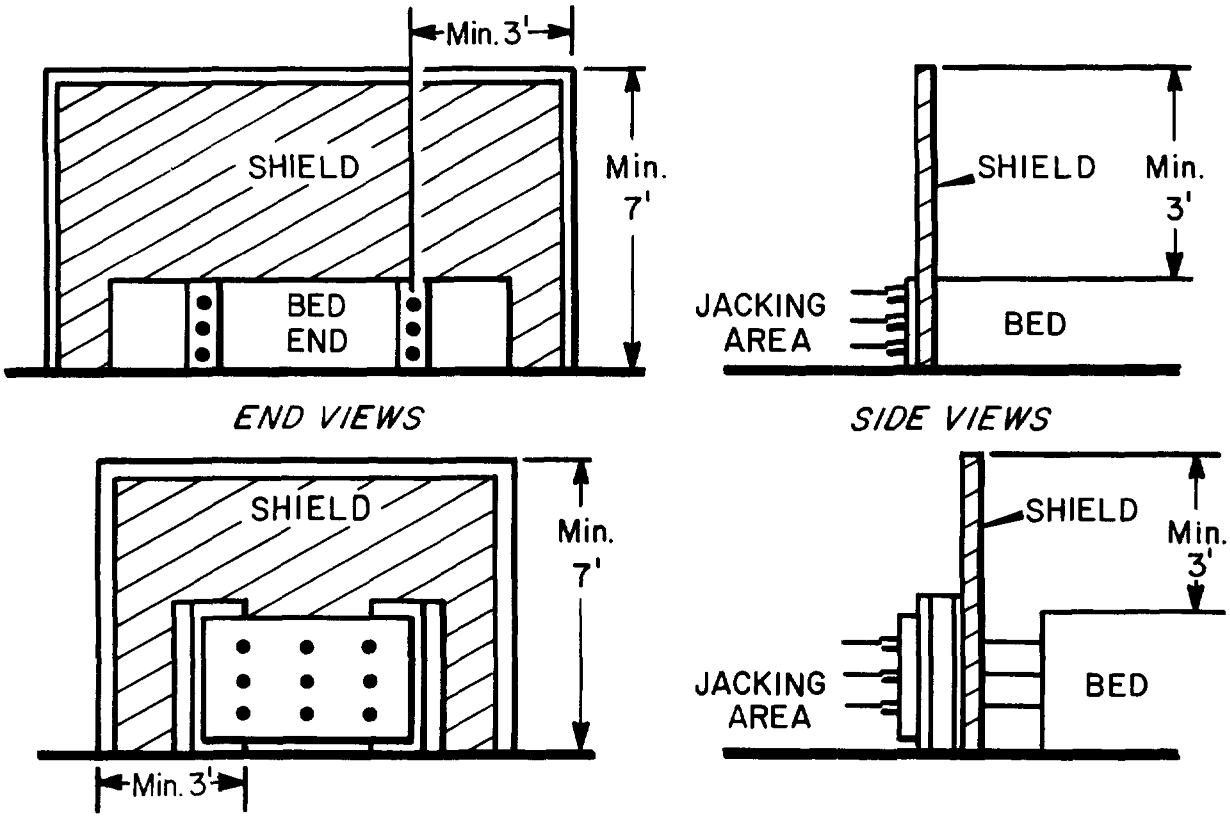

FIGURE IV-1. EXAMPLE OF MAIN SHIELD BED END PROTECTION
Adapted from PCI Safety and Loss Prevention Manual [39].

on the harping dowel large enough to be visible from a safe location during the harping sequence. During harping the following safety recommendations should be followed:

- o All unnecessary employees should be cleared from the immediate area.
- o Audible and visible alarms should alert personnel that harping operations are taking place.
- o An employee should be stationed in a safe area to ensure that personnel do not enter the "designated area" while harping operations are in progress.
- o A mirror can be set up on the form so that an employee can observe the depressing clip from a safe location.
- o Entangled or misaligned strand should be restored to its original position and then correctly harped. Workers must not attempt to shift strand while it is depressed.

There are different types of harping operations, and each type requires special precautions. More detailed procedures and safe work practices are contained in the Prestressed

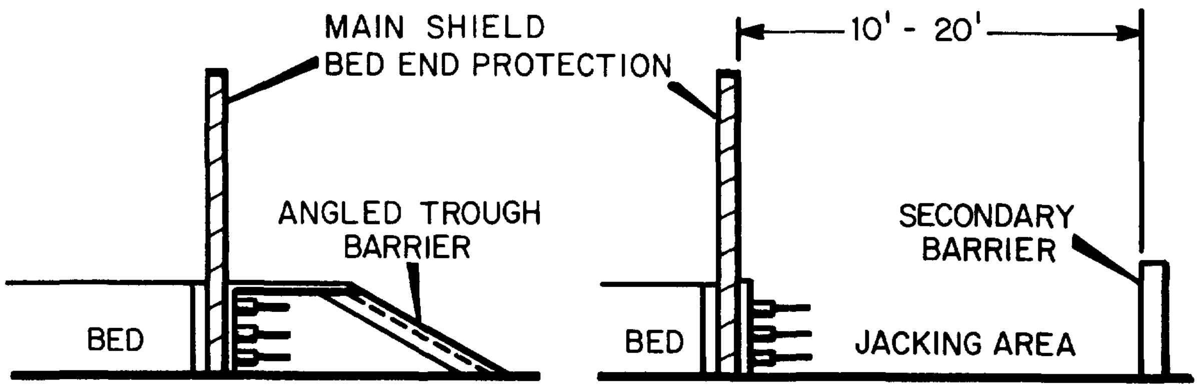

FIGURE IV-2. EXAMPLE OF SECONDARY BARRIER PROTECTION

Adapted from PCI Safety and Loss Prevention Manual [39].

Concrete Institute publication, "PCI Safety and Loss Prevention Manual" [39].

(4) Dejacking

Dejacking, used to release a strand that is misplaced or fouled, requires extreme care. The following precautions should be taken:

- o Hands and fingers must not be placed between the chuck face and the jackhead.
- o Jaws should be removed with a hook tool or other device recommended by the manufacturer.
- o Tension on strand should be released slowly.

(5) Detensioning

(a) Detensioning of cured product by cutting torch should be performed as follows:

- o a specific order for strands to be cut should be determined. Strands should then be cut at both ends of the bed simultaneously in the predetermined sequence.
- o The method of cutting should minimize shock loading. Each strand should be preheated to partially relieve tension prior to cutting.
- o No employees other than the torch cutters should be allowed in the "designated area."

- o A strand should be cut with the torch cutter working from the side, not the rear, of the strand.

(b) Strand release by "detensioning stand" in beds only partially utilized should be performed as follows:

- o Prior to stressing, place a solid steel cylinder, called a spacer (approximately 2 inches long and slotted to fit the strand), between the chuck and the jackhead and tape it to the chuck.
- o After casting and curing, remove the tape; place a "detensioning stand" over the strand; and stress the strand slowly until the spacer falls out.
- o Use long-handled pliers or tongs to insert a removal tool in its place; remove the chuck cap, and slowly release tension until the removal tool has forced the jaws from the barrel. When the jaws are accessible, pull them free of the retaining ring, remove them from the strand, and release tension slowly.
- o Keep hands out of the "detensioning stand" by using long-handled tools.
- o Allow no employees other than the detensioning crew in the "designated area."
- o Do not regrip the strand on or near the previous jaw marks.
- o Use warning lights and horns and enforce "designated area" precautions as when tensioning.

3. Oiling

a. Supplied air pressure vessels, used for spraying form release agents, should have both a visible pressure gauge and a pressure relief valve in proper operating order. Supplied air sprayers should be labeled for their maximum safe operating pressure and this pressure should not be exceeded.

b. Form release agents should be stored neatly in cabinets or areas specially set aside for that purpose. Aisles should be maintained to allow unobstructed movement of personnel and equipment, and to avoid tripping and slipping hazards.

c. Material Safety Data Sheets for all form release agents should be requested, and all applicable safety and health precautions should be followed.

d. Eye and face protection, such as a face shield, should be mandatory during spray application of form release agents.

e. A minimum of safety glasses should be used during hand applications (swabbing, rolling) and during all transfers of form release agents.

4. Concrete Mixing and Transport

a. Concrete Mixing

(1) Mixer energy sources should be locked out and tagged before cleaning, maintenance, or repair procedures.

(2) Employees should be adequately instructed in preventive measures to avoid skin burns that can occur from prolonged, direct contact between skin surfaces and fresh (moist) concrete or clothing saturated by it.

(3) Where cement, sand or gravel are stored in silos, bins or hoppers, the following procedures should be followed:

(a) Workers should be made aware that fine materials such as cement, sand and gravel can freeze or bond and crust over in cold or wet conditions. This crust can collapse under the weight of an employee standing or walking on it to free it up. The individual could sink into the quicksand-like material and suffocate.

(b) Before entering the confined space of any silo, bin or hopper, the worker should review the guidelines appropriate for safe entry and emergency exit, including:

- o Anyone entering such a confined space must wear a safety harness with a lifeline attached and attended by another worker outside the confined space but near the entry port.
- o There must be effective communication by sight and/or sound between an employee inside a confined space and the individual outside.
- o If excessive dust levels exist inside confined spaces proper respiratory equipment should be used.
- o Exhausting the dust and lighting the interior of a confined space may be necessary.
- o Eye protection should be worn.
- o Hatches on mixers should have a primary and a secondary latch to hold them in the open position.

Further information on working safely in confined spaces is contained in the NIOSH criteria document "Working in Confined Spaces" [40].

(4) NIOSH/MSHA-approved respirators should be worn in areas where dust levels are excessive. The threshold limit value (TLV) for specific dusts and exposure levels are cited in the 1981 TLV booklet of the American Conference of Governmental Industrial Hygienists (ACGIH) [41].

(5) In high-noise areas, the following recommendations should be adhered to [32]:

- o A continuously effective hearing conservation program, including annual audiometric testing of exposed employees, must be established when noise levels are found to exceed 85 dB(A) for an 8-hour time-weighted average (TWA).
- o Administrative or engineering controls, including rotation of exposed employees and acoustical booth isolation where feasible, should be applied to reduce exposure time.
- o All employees must be provided with hearing protection devices if feasible engineering controls are inadequate in reducing noise to levels below 85 dB(A) for an 8-hour TWA.

b. Concrete Transport

(1) A signalman should be available at times of entry, movement, and exit to ensure safe passage of concrete delivery trucks to casting areas.

(2) Backing lanes should be free of equipment, material, and workers [39].

(3) Movement of personnel and job equipment should be routed to avoid crossing truck lanes, tracks, aisleways, or transfer areas.

(4) Concrete delivery transporters should be equipped with audible and visible alarms, including backup alarms to warn of their approach, and mirrors to eliminate blindspots.

5. Casting Concrete

a. General

During the casting of concrete product, the following safety recommendations should be followed:

(1) Concrete buckets should not be transported over workers [42]. Workers should <u>not</u> step under overhead buckets.

(2) Buckets should have a positive locking gate [39].

(3) Concrete buckets should be equipped with a release latch (bar, handle) designed and located to prevent fingers from being caught between the latch bar and the bucket.

(4) Electric cords must meet OSHA standards and be free of breaks and in safe condition. The cords should be placed or protected so that they will not be run over and damaged or be allowed to rest in water.

(5) Safe access to the points of concrete placement and consolidation should be provided by stairs, ramps, or ladders. Also, a properly guarded walking and working surface must be available.

(6) Safe work platforms should be provided for elevated casting operations such as vertical wet casting of pipe.

(7) Rolling stair scaffolds must be equipped with adequate guardrails on all exposed sides, particularly the ends of the scaffold and the interface between the form and the scaffold if a floor or wall opening exists.

(8) Employees should be trained in the proper methods of shoveling, lifting, and moving heavy materials.

(9) Electric vibrators should be inspected for electrical continuity and should be properly grounded.

b. Vertical Casting Pipe Machine

(1) Inadvertent entry onto the moving table of pipe machines should be prevented by one or more of the following techniques:

- o Provide visible and audible alarms to warn employees when the rotating table is ready to move.
- o Use remote control devices so that no employee is required to be on the table during any rotational cycle.
- o Incorporate a short time delay into the control mechanism to activate alarms before movement of the table, allowing workers to get off the table or prepare themselves for its motion.
- o Guard the outer edge of the machine to prohibit entry onto the moving table.

(2) The interface (gap) between the rotating table of vertical casting machinery and the adjacent floor should be guarded or designed to prevent the entrapment of workers' hands and feet. Holes on vertical casting tables should be covered when not occupied by pipe forms.

c. Centrifugal Extruding Pipe Machine

(1) Employees should be protected from the hazards of being caught in or struck by machine parts, or struck by flying particles (aggregate and cement) during centrifugal or spinning pipemaking processes by the following techniques:

- o Guard all areas where projections, bolts or nip points,

form release clamps, or other nonsmooth, spinning surfaces create a hazard.
- o Use remote control operating devices.
- o Interlock all removable guards to the remote operating controls to prevent start up when guards are not in position.
- o Provide a well-drained working surface to minimize the amount of spilled concrete and eliminate standing water.

(2) During troweling operations, a proximity detector or tripwire mechanism with a positive stop braking system should be used to prevent the inadvertent entrapment of the worker in adjacent moving parts.

(3) Housekeeping and cleanup of discharged aggregate and/or water should not be performed while spin casting machines are in motion.

6. Finishing

a. Finishers should neither stand on nor work under suspended loads.

b. Adequate and safe work platforms should be provided for all elevated finishing activities.

c. Grinders (abrasive stone) should be equipped with properly adjusted guards. A maximum of one-fourth inch of the working surface should be exposed. The distance between the guard and the stone should be no greater then one-fourth inch [32].

d. The exposed blades of concrete saws should be guarded. A retractable lower-blade guard should be used.

e. Where caustic or acidic materials are used, the following protective measures should be provided and used in case of spills on employees' skin or clothing:

- o Employees should be kept informed of the irritant materials which they use and instructed in appropriate emergency procedures in case of accidental contamination of skin or clothing.
- o Eyewash facilities and showers must be readily accessible to finishers.
- o Gloves and safety goggles should be worn when workers are using or chipping epoxy [39].
- o Contaminated clothing should be removed immediately and the affected skin area flushed with water for a minimum of 15 minutes.

7. Curing

a. Employees should be protected against contact with steam and hot

water lines used for accelerated curing of concrete products by insulation, location, or guarding.

b. Curing compounds should be stored in cabinets designated for them.

c. Aisles, passageways, and walkways should be maintained in a neat and uncluttered condition during curing operations.

8. Product Handling and Transport

a. Only drivers and equipment operators authorized by the employer should use product handling equipment such as automatic unloaders, vault trucks, flatbed carriers, or tractors. Operators should be trained in the safe operation of, and be licensed to operate, a specific piece of product handling or moving equipment.

b. Product handling equipment should be checked at the beginning of each shift and deficiencies reported, including:

- o Brake systems, steering, lights, backup alarms, and other warning and safety devices
- o Loose wires, impaired visibility, and defective electrical connections
- o Fire extinguishers, flares, fuses or flags, chains, and other weather condition requirements.

c. Before loading, trailers detached from a tractor should be securely braced, the wheels chocked, and the landing gear supported to prevent settling, tipping, or any other movement.

d. Worker access to tractor-trailer rigs and pickup beds can be maintained by:

- o Ensuring that broken or missing handholds and footholds are repaired or replaced [42]
- o Removing and refitting unsuitable handholds and footholds [42]
- o Adding new handholds and footholds where they are needed for worker access [42]
- o Providing non-skid surfaces on all access systems which might become slippery [42]
- o Providing a handhold, long enough to be accessible by the majority of drivers, on the right of the tractor driver's door
- o Providing portable access stairs for pickup and trailer beds.

e. Loads to be shipped should be:

- o Palletized or strapped
- o Individually crated
- o Secured to an A-frame

- o Chocked and chained, or
- o Chained and provided with proper dunnage.

f. Concrete products should be unloaded in accordance with the following safety recommendations:

- o The safe lifting capacity of the equipment should not be exceeded.
- o Loads that are long, oddly shaped, or difficult to rig should be raised only a short distance until it is apparent they will not spring, slip, or tip.
- o Pipe or circular products should be off-loaded with skids, ropes, or automatic unloaders.
- o The job site unloading area should be examined for access, stability, and temporary storage capability.
- o Before unattended vehicles are unloaded, all wheels should be chocked and the parking brakes set.
- o Trailers should be loaded and unloaded evenly so as not to tip the load or the trailer.

C. Safety Recommendations for Accident Causal Factor Patterns

Safe work practices addressing the accident causal factors or clusters of factors identified by the accident analysis in Chapter III are presented in this section. Since the accident patterns encompass various general and specific tools and operations which have already been covered in sections A and B of this Chapter, the preceding recommendations are cited where appropriate.

1. Manual Materials Handling

Recommendations for control of hazards encountered in manual materials handling activities are contained in paragraphs A.1., B.2.a.(2), and B.5.a(8) of this chapter.

2. Working/Walking Surfaces

Recommendations addressing hazards associated with working/walking surfaces are contained in paragraphs A.1.c., A.2.a(3)(e), A.4.a, B.1.a.(5), B.1.b(5), B.3.b., B.5.c(1)., B.5.c(3), and B.7.c. of this chapter.

3. Personal Protective Equipment

To protect workers, the use of various personal protective equipment should become an integral part of the safety program. The most common personal protective equipment that should be used are contained in Table IV-1.

Requirements for personal protective equipment are covered in the OSHA standards [32].

TABLE IV-1
RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

Type	Type of Equipment	Protection Provided Against	Comments
Foot	Steel-toed safety boots, covering at least the ankle	Falling or dropped objects, striking against products, ground-level obstacles, spilled concrete, ankle sprains	Safety boots should be worn by all employees. Boots should have rubber or synthetic composition, nonslip soles without high or narrow heels and steel insoles.
	Knee-high safety boots	Caustics and slipping	Knee-high safety boots should be worn by employees performing casting operations. Boots should be rubber, steel-toed, and non-slip worn over heavy socks, with trousers tucked in or bloused.
Head	Hardhats	Falling objects, strike-against hazards, low beams, and other head-level obstacles	Hardhats should be worn by all employees. Hats should be resistant to impact, fire, and moisture, and if necessary, be made of nonelectrical conductor materials.
Face	Face shields	Particles thrown off by such operations as spraying or grinding	Shields should be worn by all employees performing spraying or grinding tasks. Shields should be replaced when plastic is cracked, brittle, or badly scratched.
Skin	Clothes suitable for work performed	Caustic materials, entanglement in machinery	Loose sleeves or torn, ragged clothing should not be worn. Buttoned, long-sleeved shirts and trousers without cuffs should be worn when casting, finishing, welding, or burning.

TABLE IV-1
RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT (Continued)

Type	Type of Equipment	Protection Provided Against	Comments
Skin (Cont.)	Gloves	Abrasions, caustics, minor cuts, and scratches resulting from handling rough material	Gloves should be worn when handling materials or products, or rebar bending, except when operating machinery with revolving parts or when they interfere with the safe operation of controls.
	Rubber gloves	Abrasions and caustics resulting from handling wet material	Rubber gloves should be worn, as needed, during some mixing and finishing tasks.
	Leather, wool, or fire-retardant cotton	Flame, heat, or sparks	These materials are recommended where flame, heat, or sparks are present.
	Protective creams Barrier creams	Irritating effect of cement or chemicals	Should be used by workers handling cement or finishing or mixing concrete, as needed.
Eye	Goggles	Grinding, chipping, or burning, or working in areas where the possibility of flying objects exists	Goggles offer good protection in general yard and plant work against dusts and particles and are recommended for all employees
	Safety eyeglasses with side shields	Small-sized particles thrown off by such operations as metal sawing, sanding, and chipping of concrete	Welders must also wear safety glasses in addition to a welding helmet.
	Welder's helmet	Molten metal splashes; ultraviolet and visible radiation depending upon the correct type of filter lens for the exposure	Helmets must be worn by all welders. Helmets protect the face, forehead, neck, and ears from direct exposure to radiation from the arc

TABLE IV-1
RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT (Concluded)

Type	Type of Equipment	Protection Provided Against	Comments
Hearing	Earplugs	Noise levels between 90 and 130 dB(A), depending on the type and quality of earplug	All employees exposed to an 8-hour time-weighted average of 85 decibels or greater must be provided with hearing protection.
	Ear muffs	Noise levels between 90 and 135 dB(A) depending on the quality and type of earplug used with the ear muff	Employers must administer effective hearing conservation programs to all employees exposed to noise levels equal to or exceeding an 8-hour time-weighted sound level of 85 decibels in accordance with the provisions of 29 CFR 1910.95.
Knee	Knee pads	Abrasion, caustics	Should be worn by employees performing finishing, screeding, bull floating, or other tasks which require working in a kneeling position.
Respir-atory	Respirators, dust masks	Harmful dusts, fumes, mists, and vapors	NIOSH/MSHA-approved respirators must be worn by employees exposed to toxic agents. Respir-ators may be required when spray-ing, sand blasting, mixing, or working in storage silos.
Fall	Lifelines, safety belts and lanyards	Falls from elevations	Should be worn by employees working from elevated work surfaces which are not adequate-ly guarded against fall hazards.

4. Access

Recommendations addressing hazards associated with inadequate or nonexistent access to work areas are contained in paragraphs A.2.a(1)(b), A.4.a., A.7.a., A.7.b., B.1.a(1), B.5.a(5), B.5.a(6), B.6.b., and B.8.d. of this chapter.

5. Mechanical Materials Handling

Recommendations for control of hazards encountered in mechanical materials handling activities are contained in paragraph A.2. of this chapter.

6. Guarding

Guarding of machinery should conform to the following:

(a) Drives for machinery must be properly guarded at chains, belts, and pulleys in full accordance with the following requirements:

- o Pulleys, belts, or chain drives 7 feet (within reach) or less from the floor should be guarded.
- o Gears should be guarded by a complete enclosure.
- o Sprocket wheels and chains should be enclosed if less than 7 feet above the floor or platform [32].

(b) Keys, setscrews, and other projections in revolving parts must be removed, made flush, or guarded.

(c) To protect the operator and other employees from in-going nip points, rotating parts, flying chips, or sparks, <u>one or more</u> of the following guarding methods should be used:

- o Barrier guards
- o Electronic safety devices
- o Two-hand tripping devices
- o Remote operation.

(d) Circular, hand-fed ripsaws and crosscut table saws must be guarded by a hood that encloses the portion of the saw above the table prior to cutting and above the material being cut (the hood should automatically adjust itself to the thickness of, and remain in contact with, the material being cut) [32].

(e) All portions of the saw blade on bandsaws must be [32]:

- o Enclosed or guarded, except for the working portion of the

blade between the bottom of the guide rolls and the table (bandsaw wheels should be fully encased)

- o Guarded to prevent hands from contact with the in-running rolls.

(f) Radial saws should be provided with:

- o A hood to protect the operator from flying splinters, broken sawteeth, and sawdust
- o A guard on the upper hood completely enclosing the upper portion of the blade down to the end of the saw arbor
- o A lower blade guard that automatically adjusts to the thickness of the stock and that remains in contact with the stock being cut
- o Nonkickback fingers or dogs located on both sides of the saw to oppose the tendency of the saw to pick up the material or throw it back toward the operator.

(g) Other woodworking machinery in the plant should meet the following requirements:

- o Each planing and molding machine must have all cutting heads and saws covered by a guard.
- o Each disk sanding machine should have the exhaust hood or other guard arranged to enclose the revolving disk, except for that portion of the disk above the table if a table is used.
- o Belt sanding machines should have guards at each nip point where the sanding belt enters a pulley. The unused run of the sanding belt should be guarded against accidental contact.

(h) Recommendations contained in: A.3.a(2), A.3.a(3), B.2.b., B.5.b(1), B.5.b(2), B.5.c(1), B.6.c., and B.6.d. of this chapter.

7. Chocking, Bracing, and Cribbing

Recommendations addressing hazards associated with chocking, bracing, and cribbing are contained in paragraphs A.2.a(1)(f), A.2.c(7), A.7.a., B.1.b(2), B.8.c., B.8.e., and B.8.f. of this chapter.

8. Lockout/Tagout (Control of Hazardous Energy)

Recommendations for control of hazards associated with energy control are contained in paragraphs A.2.e(4), A.2.e(6), and B.4.a(1) of this chapter.

Further information regarding hazardous energy control is contained in the NIOSH document "Guidelines for Controlling Hazardous Energy During Maintenance and Servicing" [43].

Chapter V
SAFETY MANAGEMENT

There should be little disagreement that safety is ultimately the responsibility of management. In addition to the fact that the Occupational Safety and Health Act of 1970 (OSHA) requires each employer to furnish each employee a place of employment that is free from recognized hazards likely to cause death or serious physical harm, worker accidents and injuries are counter-productive and costly. As shown in Chapter III of this document (specifically Table III-3), the occupational injury and illness incidence rate for the precast concrete products industry in 1980 was in the top 3% of the durable goods manufacturing industries. Since 1977, the estimated cost of actual paid-out medical and indemnity expenses of occupational injuries in this industry has averaged more than $30.9 million per year. The National Safety Council estimates that the full costs of work-related accidents have been 3.4 times greater than the cost of actual paid-out claims, or over $105 million per year (see Chapter III).

These needless losses can be controlled by managing successful safety programs. However, safety programs can only be successful when plant management provides an environment responsive to worker safety and is <u>committed</u> to providing a safe workplace. Safety recommendations such as those presented in Chapter IV or safety standards such as those promulgated by OSHA will not, by themselves, reduce occupational injuries. Management must accept the responsibility of implementing a safety program which is designed for successful accident prevention. Such success requires an organized approach. No individual level of management can do the job by itself. It takes a combined effort of all -- from the plant manager down through the first-line supervisor to the employees.

This chapter presents the basic elements of safety program management. It outlines criteria for evaluation of present safety programs and suggests implementation of critical elements which are indicative of safety being a management function. It is recognized that each company will need to tailor its safety program to fit the various characteristics of its particular operation.

A. Pre-Assessment of Present Program

Before revising an on-going safety program or attempting to design a new program, it is advisable that management assess its existing safety status within the plant. An evaluation of the present safety status will help outline where changes and additions are essential. It will yield answers to the seriousness of the plant's accident problem, it will identify the major organizational deficiencies which have an adverse effect on the safety

program, and it will identify the major accident prevention deficiencies within the program itself.

Assessment of the following basic elements of the safety program should be made:

1. Management leadership
2. Assignment of responsibility
3. Identification and control of hazards
4. Employee and supervisory training
5. Accident reporting and investigation
6. Emergency plans
7. Employee awareness.

Utilization of pre-assessment tools such as the American Society of Safety Engineers (ASSE) Safety Audit contained in Appendix C, or the example assessment forms contained in Appendix D can provide insight into safety program weaknesses which need management's attention.

B. Basic Elements of a Safety Program

It is difficult to outline a safety program that will be applicable to all precast concrete plants, since a program must vary with the specific needs of each company. It is important that a safety program be tailored for the processes and operations of an individual company. It becomes the responsibility of management to design and define a program within the constraints of a specific plant's operation. A safety program should, however, include aspects of the following basic elements:

1. Management Leadership

Management's interest in safety must be sincere and visible to employees. Therefore, senior management must establish achievable safety program objectives and communicate these to all employees. The safety program objectives should receive the same management scrutiny as that given for the control of quality, cost, and production. Once the objectives are established, then management must plan, organize and control the overall program to meet the objectives.

Management's leadership and support should contain the following key elements:

a. Written Policy

A written safety policy is management's method of communicating a direction to be followed. It is the first step in organizing to meet the stated objectives. It is important that the policy be in writing to reduce confusion concerning direction and assignment of responsibility.

The written policy should be concise, to the point, and should address the following areas:

- o Management's intent
- o Scope of activities covered
- o Measurement of safety performance
- o Safety staff
- o Safety committee
- o Delegation of authority
- o Safety rules and procedures [44].

Policy statements signed by top management are indicative of their concern for employee safety and health. Such concerns by top management for safety makes it easier:

- o For supervisors to implement and enforce company policy
- o For the company to promote safe and healthful work practices
- o For employees to observe the stated policy
- o To purchase equipment with specified safety features
- o To maintain and repair equipment according to good engineering control and safety practices [45].

Figures V-1 and V-2 are shown to provide examples of plant safety policies. Selection of these examples are not indicative of their overall quality except that a published safety policy available to employees is better than none at all.

b. Employee Participation

A written safety policy is management's way of informing employees that safe performance of work is a requirement of the job. However, management cannot always expect employees to work or perform safely. The employee makes that decision based upon the safety attitude he has developed through his work experiences. Management can motivate workers to accept the safety program by encouraging their participation. Employees should participate in the program because:

- o Participation ensures that employees know their jobs and the associated hazards
- o Participation promotes morale
- o Employee participation is indicative of management's concern
- o Employee participation encourages suggestions for improved safety and health conditions [45].

Employee participation can be encouraged by conducting safety meetings and by forming a plant safety committee. Holding safety meetings is a useful technique for communicating safety to employees. These meetings are more commonly referred to as safety huddles, tailgate sessions, or toolbox sessions. These are short

SAFETY AND HEALTH POLICY

It is the policy of this company to provide every employee with a safe and healthful workplace.

When a person enters the employ of our company, they have the right to expect to be provided with a proper place in which to work, as well as proper and safe machines and tools with which to do the job, and that the employee will be able to devote his or her energies to the work without undue danger.

Only under these circumstances can the association between employee and employer be mutually profitable and harmonious. It is our desire, intention, and responsibility to provide a safe workplace, safe equipment, and proper materials and to establish and insist on safe methods and practices at all times.

People are our most important asset--their safety is our greatest responsibility.

It is a basic responsibility for <u>all</u> employees of this company to make the SAFETY of fellow human beings a part of their daily, hourly concern. This responsibility must be accepted by each person who conducts the affairs of the company, regardless of the capacity in which they function.

Employees are expected to know the SAFETY rules applicable to their job and must use the SAFETY equipment provided. Rules of conduct and rules of SAFETY shall be observed by all employees. SAFETY equipment must not be destroyed or abused.

The joint cooperation of employees and management in the observance of this policy will provide safe working conditions and accident-free performance to our mutual advantage.

We consider the SAFETY of our personnel to be of first importance, and we ask your full cooperation in making this policy effective.

____

Company President

FIGURE V-1. EXAMPLE OF A PLANT SAFETY AND HEALTH POLICY

Adapted from American Society for Personnel Administration, 19 Church Street, Berea, OH 44017.

As we are known and recognized for our products and service, so should we be known for our safety performance. No job must ever become so routine or so urgent that every safety precaution is not observed. Prevention of personal injury and damage to the property and equipment of both the company and its customers must always remain uppermost in the mind of every employee.

It is the policy of ABC PRECAST CONCRETE CORPORATION to develop and maintain safe and efficient operations. Our safety program has been designed, in accordance with the Williams-Steiger Occupational Safety and Health Act of 1970, to develop safe working conditions. The success of our program requires the full support of each and every employee.

____
President

FIGURE V-2. EXAMPLE OF A PLANT SAFETY POLICY STATEMENT

Adapted from Summary Plant Observation Report and Evaluation [46].

meetings usually conducted by the supervisor with all his employees. The primary functions of such meetings are to foster communication between management (supervisor) and employees relating to safety consciousness,and to disseminate safety concepts. The subject should be specific to work being performed or planned for the upcoming week. The session should take place at the work site and last 10-15 minutes. Employees knowledgeable in specific safety subject areas should be requested to lead the safety discussions, thereby encouraging peer participation.

Establishment of a safety committee is another technique which demonstrates management's desire that employees participate in the plant safety program. Committees may vary considerably in different organizations, but should have the basic functions of developing, promoting, and maintaining safety practices in the plant. Such committees should also serve as a means for communicating safety policies to both management and labor.

c. Leading by Example

Leading by example expresses interest and concern in the safety program as well as indirectly motivating others to show the same concerns. Management which participates in injury accident

investigations, safety meetings, and safety committees; which conducts periodic housekeeping inspections; or which observes the plant safety rules while conducting a plant safety walk-through is seen by the employees as being serious about the program. Management thereby communicates its concern about the program.

d. Rewarding Performance

Management should establish procedures for rewarding effective safety performance. Worker behavior patterns are strengthened by positive reinforcement rewards. Reinforcing safety performance has the following advantages:

- o It removes the unwanted side effects of discipline, confrontation, conflict, and frustration
- o It increases employee job satisfaction
- o Employees see the foreman or supervisor as a helpful resource
- o It creates an atmosphere of mutual reciprocity between supervisor and employee
- o It increases the probability of an employee continuing the safe behavior[45].

2. Assignment of Responsibility

Management has the responsibility for controlling unsafe acts of employees and unsafe working conditions. Ultimately, the plant manager has the overall responsibility for meeting the plant's safety program objectives.

Since plant size and organizational structure vary widely throughout the precast concrete products industry, assignment of safety responsibilities must be appropriate for the management structure within the plant. In very small plants, the owner/operator may have sole responsibility; in larger plants, responsibility is assigned to the plant manager, middle managers and first-line supervisors.

Additionally, the employees must also be assigned responsibilities in order to meet the stated safety program objectives.

a. Plant manager responsibilities include:

- o Adopting and implementing a safety program within all plant departments
- o Establishing and communicating the safety objectives
- o Providing managers and supervisors with the time, money, manpower, and authority necessary to implement the safety program
- o Motivating all subordinate managers to fulfill their assigned responsibilities
- o Auditing the safety program and evaluating its effectiveness

- o Ensuring that the plant complies with the various federal, state, and local safety standards and codes [47].

b. Middle manager responsibilities include:

- o Supplementing basic formal accident prevention training provided subordinate supervisors with personal and group instruction
- o Conducting safety meetings with subordinate supervisors
- o Participating in accident investigations and implementing recommended corrective actions to prevent recurrence
- o Conducting planned safety inspections
- o Ensuring subordinate supervisors properly orient and instruct employees assigned to new job positions
- o Maintaining safety discipline
- o Ensuring subordinate supervisors enforce use of personal protective equipment where required
- o Recommending safety program improvements [47].

c. First-line supervisor responsibilities include:

- o Being responsible for the safety of all regularly assigned employees
- o Ensuring that assigned personnel know plant and department safety rules and regulations, established safe job procedures, and all major hazards associated with their tasks and work areas
- o Developing cooperative safety attitudes of employees through application of approved methods of preventive and corrective discipline
- o Conducting planned safety inspections within the assigned work area
- o Maintaining satisfactory standards of housekeeping
- o Providing prompt medical treatment for all injuries no matter how slight
- o Investigating all reported accidents to personnel and equipment within his assigned area
- o Ensuring assigned personnel use the required safety apparel and equipment
- o Knowing safety standards which apply to the operations he supervises
- o Knowing how to operate emergency equipment installed within his assigned work area
- o Recommending safety program improvements [47].

d. Employee responsibilities include:

- o Obeying plant safety rules and safe operating procedures
- o Reporting hazards to immediate supervisors
- o Reporting accidents promptly and factually to their immediate supervisors.

3. Identification and Control of Hazards

Whenever management decides to either implement an accident prevention program or to overhaul an existing program, employees are inclined to be skeptical of projected results and tend to take a "wait and see" attitude. A vigorous management effort to eliminate longstanding hazards and to provide a safer workplace can convince employees that management is truly concerned about their on-the-job well being.

However, prior to eliminating these hazards, management must first identify them. Identification of hazards requires a fairly complete inspection of all precast operating areas. The inspection should be made by a small group composed of someone from production, someone from maintenance, and the safety program coordinator. The hazard identification process should be done in phases to reduce interference with normal work routines.

Safety inspection checklists may be helpful in directing the group's inspection to the operating areas with the more hazardous work exposures. Management can either obtain checklists from insurance companies, or develop one specifically for their plant after analysis of the injury data presented in Chapter III, Table III-5. As an example, analyze nails as a source of injury. The table shows that nails mostly resulted in puncture injuries to employee's feet. Therefore, it is assumed that when wooden forms are removed from cured product, the nails are not bent over or removed, thereby creating a hazard to workers. Analysis of the "machinery" source indicates that lack of adequate guards are creating a hazard. If these sources of injury are present within the plant, the checklist should address these items.

After the initial inspection has been performed, a program for correcting the noted deficiencies and performing periodic inspections should be established. Identifying hazards by means of inspection and promptly eliminating or controlling them is one of the best methods management can use to demonstrate its interest and concern for accident prevention to employees.

Periodic inspections are essential to:

- o Identify new or recurring hazards
- o Ensure safe operation of equipment
- o Detect use of required personal protective equipment
- o Keep check on general housekeeping
- o Ensure availability of first aid materials
- o Ensure fire fighting equipment is in proper operating condition
- o Check on condition of storage areas [48].

4. Safety Training

In ranking of importance, employee training is of top priority in a safety management program. Training is necessary to guide and instruct

both new employees and employees new to a particular task. Newly hired employees should always receive instruction and orientation about the company, the plant, the product, organizational arrangements, lines of authority, and safety policies and rules. Specific training, including supervised on-the-job training, must be provided to each employee.

During orientation to the plant, a new employee should be given copies of the company's safety policy, and safety rules and regulations. If an employee starts a new task, changes tasks, or uses new or modified equipment, it is essential that quality training for this job be provided. Training may be necessary to develop a particular skill that cannot be performed safely without specific knowledge; e.g., working at a rebar bender, casting concrete, or operating a forklift. Safety training is based on the general assumption that the development of a positive mental attitude predisposes an individual to safe habits of work and conduct. A job should be explained in detail by breaking it down into manageable parts. If personal protective equipment is required, employees must understand why it must be used and what may happen if it is not used properly. Hazards should be identified, and precautions or safe work practices demonstrated. Training should take a new employee through each step, and each step should be fully demonstrated. In addition, the supervisor should verify, at regular intervals, that the original lessons are being followed and that the employee is not developing bad habits or taking dangerous shortcuts. The type of training required, by employee group, is presented in Table V-1.

Other training, such as first-aid courses, cardiopulmonary resuscitation (CPR), fire extinguisher use, and other emergency procedures may be required.

Training is a continuous process, and attention must be paid to all employees. An employee who continues to repeat an unsafe procedure is not working safely, even if an accident has not occurred. The following indicators might show a need for training or retraining:

- High incidence of injury
- An increase in the number of "near misses" that could have resulted in accidents
- A change in a process or introduction of a new process
- A recent upswing in actual accident experience
- Excessive waste or scrap due to poor housekeeping.

5. Accident Investigation

The investigation of accidents is an important part of the safety/accident prevention program. It identifies accident causes so that similar situations can be prevented by management actions such as mechanical improvements, better supervision, or employee training. It determines the "changes" or deviation that produced an "error" resulting in an accident; it

TABLE V-1
EMPLOYEE TRAINING

Training Activity	Personnel to Receive Training	Sources of Training
Orientation	All new employees	Personnel department, safety personnel, supervisors, foremen; PCI safety orientation slide/tape
Manual materials handling, including lifting, pulling, pushing	All employees, including foremen, management personnel	National Safety Council's "Lift Safely" booklet, NIOSH's "Work Practices Guide for Manual Lifting," safety personnel, insurance companies
Housekeeping, storage	All employees, including foremen, management personnel	PCI storage slide/tape, safety personnel, foremen
Cranes, hoists	All operators, oilers, mechanics, foremen	Operator certification programs, formal training through equipment manufacturers or schools, dry runs
Mechanical materials handling, rigging	All drivers, riggers, leadmen, supervisors	PCI handling slide/tape, equipment manufacturers, on-the-job training
Forklifts	Forklift operators, helpers	National Safety Council, equipment manufacturers, on-the-job and certification training
Road vehicles	Truck drivers, over-the-road vehicle operators	Insurance companies, on-the-job training, state licensing requirements
Personal protective equipment	All employees	Safety personnel, foremen
Respirator use	Welders, helpers, finishers, foremen	Safety personnel, equipment manufacturers
Welding	All welders, helpers, foremen	On-the-job training, unions, equipment manufacturers
First aid	Foremen, leadmen, supervisors	Red Cross, safety/medical department
Plant operations	All workers, leadmen, foremen	Supervisors, foremen, safety involved personnel

publicizes the particular hazard among employees and their supervisors; and it directs attention to accident prevention in general. Since nothing is learned from unreported accidents, even minor injuries and near misses should be investigated.

The investigation of accidents is the responsibility of all levels of management. However, the firstline supervisor is perhaps the best qualified, since he is close to the jobs, working conditions, and workers. The supervisor must be trained and have the ability to recognize the cause of accidents. This evaluation may require the assistance of management, equipment suppliers, and insurance representatives. Figure V-3 shows an example of an accident investigation form.

The basic problem confronting any supervisor interviewing a person involved in an accident is obtaining complete facts. Often a worker is reluctant to cooperate for fear of ridicule, sarcasm, or reprimand. It is important to stress the need for facts so that recurrence can be prevented in the future. It is also helpful to ask individuals involved in accidents for their ideas on making the job safer.

Witnesses are important sources of accident information. When a fatal injury occurs, a witness may be the only direct source of information available. When a serious injury occurs, a witness may be the only means of verifying incoherent pieces of the injured's account. For minor injuries, a witness may be able to clarify some of the circumstances surrounding the accident better than the injured person himself. This is also true of near accidents that have a potential for serious injury.

In all cases, all levels of management can learn how to prevent accidents through investigations. By investigating accidents, similar unsafe practices and conditions can be monitored in the future. The information compiled can also help to design better training programs, emphasize areas needing management's attention, and generally prevent future potential problems.

Management's participation is highly important to a functioning safety program in the precast concrete products industry. Efforts should be made to reduce the unnecessary costs of worker injury and illness, loss in production time, as well as repair and replacement of damaged machinery and products.

6. Emergency Plans

Management should have a written plan of action outlining procedures to be taken in emergency situations such as employee injury and fire. The purpose of the plan is to eliminate as much confusion as possible in order that immediate positive response will be taken to minimize the dangers of the emergency.

ACCIDENT INVESTIGATION REPORT FORM

NAME ____ OCCUPATION ____ HOW LONG AT THIS JOB ____

LOCATION IN PLANT ____ DATE & TIME OF INJURY ____

FOREMAN ____ WITNESSED BY ____

INJURY ____ ESTIMATED TIME LOSS ____

MEDICAL DISPOSITION ____

Complete and return to the safety office for review by top management within two days: SENT OUT ____ RETURNED ____

WHAT HAPPENED? ____ Describe what took place, what task and operation was being done.

WHAT COULD HAVE HAPPENED? ____

WHY DID IT HAPPEN? ____ Get all the facts by studying the job and situation involved. Question by use of WHY-WHAT-WHEN-WHO-HOW.

WHAT SHOULD BE DONE? ____ Determine which of the 12 items require additional attention:

EQUIPMENT	MATERIAL	PEOPLE
Selection	Selection	Selection
Arrange	Placement	Placement
Use	Handling	Training
Maintain	Processing	Leadership

WHAT HAVE YOU DONE THUS FAR? ____ Take or recommend action, depending upon your authority.

Investigated by Foreman ____ Date ____ Reviewed by Safety ____ Date ____

Management ____ Date ____

FIGURE V-3. ACCIDENT INVESTIGATION REPORT FORM

The plan should include:

- o Diagrams showing exits, fire extinguisher locations, and egress routes
- o Procedures for reporting fires and emergencies to authorities
- o Posting requirements of emergency telephone numbers for ambulance, doctor, hospital, fire, and police
- o Requirements for drills and training

- Provision of first-aid treatment
- Provision of medical treatment.

C. Post-Assessment of Program

The primary purpose of assessment is to ensure that the safety program is being applied effectively and correctly by all levels of management.

The post-assessment of a safety program is performed after additions or alterations have been implemented into the program. The post-assessment of the program is accomplished to:

- Determine serious weaknesses in applications of the program
- Identify corrective actions needed to improve the quality of the program
- Motivate middle managers and supervisors to apply the safety program.

Assessment of the program should be made in the following areas:

- Accident investigations
- Control of hazards
- Conduct of safety inspections
- Safety training
- Safety attitude
- Safe work procedures
- Management participation.

The example forms contained in Appendix D can be utilized as post-assessment tools. Analysis of the results obtained from the forms can provide plant management with indicators as to which basic elements of the overall program need management's attention. Management must make application of the safety program happen. This requires planned implementation of controls, continuous management involvement, and periodic assessment to ensure effective program operations.

Suggested Reading List on Safety Management:

Anton, T.J. Occupational Safety and Health Management. New York, NY: McGraw-Hill, 1979. 295 pp.

Bird, F.E.; Loftos, R.G. Loss Control Management. Loganville, GA: Institute Press, 1976. 562 pp.

Chissick, S.S.; Derricot, R., eds. Occupational Health and Safety Management. New York, NY: Wiley, 1981. 705 pp.

Denton, D.K. Safety Management, Improving Performance. New York, NY: McGraw-Hill, 1982. 304 pp.

Griffiths, R.F., ed. Dealing with Risk: the Planning, Management, and Acceptability of Technological Risk. New York, NY: Wiley, 1981. 144 pp.

Grimaldi, J.V.; Simonds, R.H. Safety Management, 3rd. Ed. Homewood, IL: R. D. Irwin, 1975. 694 pp.

Hammer, W. Occupational Safety Management and Engineering, 2nd. Ed. Englewood Cliffs, NJ: Prentice-Hall, 1981. 494 pp.

Heinrich, H.W.; Petersen, D.; Roos, N.R. Industrial Accident Prevention: A Safety Management Approach. New York, NY: McGraw-Hill, 1980. 468 pp.

Kochan, T.A.; Dyer, L.; Lipsky, D.B. The Effectiveness of Union-Management Safety and Health Committees. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research, 1977. 127 pp.

Petersen, D. Human Error Reduction and Safety Management. New York, NY: Garland STPM Press, 1982. 229 pp.

Petersen, D. Analyzing Safety Performance. New York, NY: Garland STPM Press, 1980. 328 pp.

Petersen, D. Techniques of Safety Management, 2nd. Ed. New York, NY: McGraw-Hill, 1978. 314 pp.

Schenkelbach, L. The Safety Management Primer. Homewood, IL: Dow Jones-Irwin, 1975. 150 pp.

Tarrants, W.E. The Measurement of Safety Performance. New York, NY: Garland STPM Press, 1980. 414 pp.

CHAPTER VI
RECOMMENDATION FOR RESEARCH NEEDS

During the development of this document, specific topics concerning the development of the comprehensive safety recommendations for precast concrete products operations were identified which require further research. To more fully assess the safety and health problems in the industry, the following analyses are also needed:

- o Development and testing of standards for bed end protection in stressing operations
- o Onsite testing for the adequacy of moving vehicle warning systems, and the development of recommendations for minimum standards for such systems coordinated with different industrial environmental constraints
- o Research and testing of machine guarding and/or work practices for the interface between the worker and pipe spin casting equipment
- o Research to determine the safest manual materials handling methods for common tasks in this industry
- o A research study to determine the efficacy of training programs for lifting properly.

REFERENCES

1. Pedersen, D. Profile of SIC 3272--Profile Summary of Dun and Bradstreet Data in NIOSH Industrial File. Unpublished report by National Institute for Occupational Safety and Health, Cincinnati, OH: March 17, 1981. 1 p.

2. Pennsylvania Department of Labor. 1979 Pennsylvania Industrial Directory, 26th ed. Harrisburg, PA: Bureau of Statistics, Research, and Planning, Office of Management Services. 1979. pp. 732-5.

3. U.S. Department of Commerce. Concrete, Plaster, and Cut Stone Products. Publication No. MC77-1-32D. Industry Series 1977 Census of Manufacturers. Washington, DC: Bureau of Census. 1977. 45 pp.

4. Duffy, J. J. American Concrete Pipe Association. Unpublished report. Vienna, VA: August 5, 1981. 1 p.

5. Freedman, S. Prestressed Concrete Institute. Unpublished report. Chicago, IL: July 21, 1981. 1 p.

6. Tilford, J. E. National Precast Concrete Association. Unpublished report. Indianapolis, IN: July 29, 1981. 1 p.

7. Bennett, W. B. Jr. Prestressing Improves Concrete's Competitive Advantage. Concrete Construction. March 1981. pp. 235, 237, 239.

8. American Concrete Pipe Association. Concrete Pipe Handbook. Vienna, VA: 1980. pp 2-8 to 2-17.

9. U.S. Department of Labor. Occupational Injuries and Illnesses in the United States by Industry, 1978 and 1979. Washington, DC: Bureau of Labor Statistics.

10. U.S. Department of Labor. Occupational Injuries and Illnesses in the United States by Industry, 1976. Washington, DC: Bureau of Labor Statistics. 1979. p. 26.

11. U.S. Department of Labor. Occupational Injuries and Illnesses in the United States by Industry, 1977. Washington, DC: Bureau of Labor Statistics. 1980. p. 25.

12. U.S. Department of Labor. Occupational Injuries and Illnesses in the United States by Industry, 1979 and 1980. Washington, DC: Bureau of Labor Statistics. 1980. p. 3.

13. National Council on Compensation Insurance. Workers' Compensation Experience--Codes 3030 and 4034. New York, NY: 1975-1978. Unpaginated.

14. Workers' Compensation Insurance Rating Bureau of California. Classification Experience Class Code 4034. San Francisco, CA: 1977. 1 p.

15. Compensation Rating and Insurance Bureau for New Jersey. January 1, 1981 Rate Revision. NJ: 1977. p. 320.

16. New York Compensation Insurance Rating Board. Classification Experience--Codes 4034 and 3030. New York, NY: 1977. 1 p.

17. The State of Texas--State Board of Insurance. Raw Data Cards for Classification Codes 3030 and 4034. Austin, TX: 1977. 1 p.

18. Workmen's Compensation Fund, State of West Virginia. Class C-4. Charleston, WV: State Compensation Commissioner. June 30, 1977. 5 pp.

19. Pennsylvania Compensation Rating Bureau. States of Pennsylvania and Delaware for Class 511. Philadelphia, PA: 1975-1978. pp. 40, 86.

20. Department of Labor and Industries, State of Washington. Statistics for Fiscal Years (June through July) 1976 through 1978. Olympia, WA: October 1981. 3 pp. Unpublished Report.

21. State of Wyoming Workers' Compensation Division. Major Classification #32--Stone, Clay, Glass, and Concrete Products--Total Reported Payroll, Premium Collected, No. of Injuries, Total of Claims Paid. WY: October 1981. 2 pp. Unpublished Report.

22. National Safety Council. Accident Facts, 1979 ed. Chicago, IL: 1979. pp. 4-5.

23. Root, W.; McCaffrey, D. Providing More Information on Work Injury and Illness. Monthly Labor Review 101(4): 16-21, 1979.

24. U.S. Department of Labor. Bureau of Labor Statistics. Supplementary Data System (SDS). Unpublished Accident and Injury Data for 1976-1979.

25. Hinze, J. Turnover, new workers, and safety. J. Const. Div. (ASCE) 104 (CO4): 409-17. 1978.

26. Mason, K. Some Aspects of Accident Causation Related to Occupation, Age and Experience of Worker. Vancouver, Canada: Workers' Compensation Board of British Columbia. 1977. 44 pp.

27. Safety in Manual Materials Handling. DHEW (NIOSH) Pub. No. 78-185. U.S. Department of Health, Education, and Welfare. Public Health Service. Centers for Disease Control. National Institute for Occupational Safety and Health. July 1978.

28. Work Practices Guide for Manual Lifting. DHHS (NIOSH) Pub. No. 81-122. U.S. Department of Health and Human Services. Public Health Service. Centers for Disease Control. National Institute for Occupational Health and Safety. March 1981.

29. How to Lift Safely. U.S. Government Printing Office #1980-660-964. Cincinnati, OH: National Institute for Occupational Safety and Health. 1980.

30. Audiovisual Resources in Occupational Safety and Health. DHHS (NIOSH) Pub. No. 82-102. Cincinnati, OH: National Institute for Occupational Safety and Health. Division of Standards Development and Technology Transfer. October 1981.

31. Margolis, B. L.; Kroes, M. H. The Human Side of Accident Prevention. Springfield, IL: Charles C. Thomas. 1975.

32. U.S. Department of Labor. OSHA General Industry Standards--29 CFR 1910. Occupational Safety and Health Administration. 1978. 820 pp.

33. Dickie, D. E. Crane Handbook, 1st ed. Toronto, Canada: Construction Safety Association of Ontario. 1975. pp. 69, 75, 79-89.

34. Dickie, D. E. Rigging Procedures and Precautions--Chapter 7 of Rigging Manual, 1st ed. Toronto, Canada: Construction Safety Association of Ontario. 1975. pp. 169-88.

35. Construction Safety Association of Ontario. "Most injuries to dozer loader and backhoe operators related to poor mounting and dismounting." The Counsellor. Ontario, Canada: October 1981. pp. 4-5.

36. U.S. Army Corps of Engineers. Wheel-Type Front End Loaders. EP 385-1-51. July 1979.

37. National Safety Council. Accident Prevention Manual for Industrial Operations--Engineering and Technology, 8th ed. Chicago, IL: 1980.

38. National Safety Council. Supervisor's Safety Manual, 5th ed. Chicago, IL: 1978.

39. Prestressed Concrete Institute. PCI Safety and Loss Prevention Manual Section IV, A through K, M. Chicago, IL: Unpaginaged.

40. Criteria for a Recommended Standard. . .Working in Confined Spaces. DHEW (NIOSH) Pub. No. 80-106. U.S. Department of Health, Education, and Welfare. Public Health Service. Centers for Disease Control. National Institute for Occupational Safety and Health. December 1979.

41. TLVs. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1981. American Conference of Governmental Industrial Hygienists. Cincinnati, OH: 1981. 94 pp.

42. Centre for Occupational Health and Safety, University of Waterloo. Human Factors Engineering Report on Mounting and Dismounting Construction Equipment. Report prepared for Construction Safety Association of Ontario. September 1980.

43. Guidelines for Controlling Hazardous Energy During Maintenance and Servicing. DHHS (NIOSH) Pub. No. 83-125. Morgantown, WV: National Institute for Occupational Safety and Health. Division of Safety Research. September 1983.

44. Peterson, D. Techniques of Safety Management. New York, NY: McGraw-Hill. 1971. pp. 29-32.

45. Cal./OSHA Consultation Service. Evaluation of Safety and Health Program. San Francisco, CA: California Department of Industrial Relations. 1982.

46. Enviro Control, Inc. Summary Plant Observation Report and Evaluation (SPORE). (Unpublished report submitted to NIOSH under contract No. 210-80-0040). Rockville, MD: October 1981.

47. Euniger, M. Operation Zero Accident Prevention Fundamentals. Pittsburgh, PA: Normax Publications, Inc. 1972.

48. National Safety Council. Handbook of Occupational Safety and Health. Chicago, IL: 1976. pp. 2-6.

49. Canadian Standards Association. Precast Concrete--Materials and Construction, 3rd Ed., CAN3-A23.4-M78. Ontario, Canada: 1978. 77 pp.

50. Canadian Standards Association. Qualification Code for Manufacturers of Architectural and Structural Precast Concrete, CSA-A251-1971. Ontario, Canada: 1971. 121 pp.

51. U.S. Department of Labor. OSHA Construction Industry Standards--29 CFR 1926. Occupational Safety and Health Administration. 1979. 618 pp.

52. Diekemper, R. F.; Spartz, D.A. A Quantitative and Qualitative Measure of Industrial Safety Activities. ASSE J. 15:12-19, December 1970.

APPENDIX A
EXAMPLES OF MANUFACTURED CONCRETE PRODUCTS WITHIN SIC 3272

Appendix A
Examples of Manufactured Concrete Products within SIC 3272

This appendix contains a listing of the various manufactured concrete products concerned within the scope of this document.

Areaways, basement window: concrete
Art marble: concrete
Architectural precast concrete panels
Ashlar: cast stone
Bathtubs: concrete
Beams and joists: concrete
Bridge products: precast concrete
Building stone, artificial: concrete
Burial vaults: concrete and precast terrazzo
Catch basin covers: concrete
Ceiling squares: concrete
Chimney caps: concrete
Church furniture: concrete
Columns: concrete
Conduits: concrete
Copings: concrete
Cribbing: concrete
Doorframes: concrete
Drain tile: concrete
Fireplaces: concrete
Floor slabs: precast concrete
Floor tile: precast concrete
Fountains, wash: precast terrazzo
Garbage boxes: concrete
Grave markers: concrete
Grease traps: concrete
Hollow-core prestressed planks
Housing components, prefabricated: concrete
Incinerators: concrete
Irrigation pipe: concrete
Laundry trays: concrete
Lintels: concrete
Manhole covers and frames: concrete
Mantles: concrete
Mattresses for river revetment: concrete articulated
Meter boxes: concrete
Monuments: concrete
Panels and sections, prefabricated: concrete
Paving materials: prefabricated concrete, except blocks
Pier footings: prefabricated concrete

Piling: prefabricated concrete
Pipe: concrete
Poles: concrete
Posts: concrete
Septic tanks: concrete
Shower receptors: concrete
Siding: precast stone
Silos: prefabricated concrete
Slabs, crossing: concrete
Steps: prefabricated concrete
Storage tanks: concrete
Structural precast prestressed concrete products
Tanks: concrete
Thresholds: precast terrazzo
Tombstones: precast terrazzo or concrete
Wall base: precast terrazzo
Wall squares: concrete
Well curbing: concrete
Window sills: cast stone

APPENDIX B
REVIEW OF STATE, FEDERAL, AND FOREIGN SAFETY STANDARDS AND TRADE ASSOCIATION GUIDELINES

APPENDIX B

REVIEW OF STATE, FEDERAL, AND FOREIGN SAFETY STANDARDS AND TRADE ASSOCIATION GUIDELINES

This appendix contains a review of existing State, Federal, and foreign safety standards as well as trade association guidelines that apply to the precast concrete products industry.

A. State and Foreign Standards

A review of the standards of the States that administer their own occupational safety and health programs shows that no State has vertical standards that specifically address safety in the manufacturing of precast concrete products. Safety matters in the remaining States are regulated by the OSHA General Industry Standards, 29 CFR 1910 [32].

Occupational safety and health standards that address operations in the precast concrete products industry were requested from Germany, the United Kingdom, France, the Netherlands, Belgium, Australia, Canada, and Mexico. The Canadian standards [49, 50] that regulate architectural and structural operations are included for evaluation. Australia, France, and Belgium have standards for the concrete construction industry, but do not regulate manufacturing operations. The remaining countries do not have safety standards that specifically address precast concrete operations.

B. Trade Association Guidelines

The ACPA has published a "Concrete Pipe Handbook" [8] that contains some suggestions on handling, unloading, and site storage. The PCI has developed a "Safety and Loss Prevention Manual" [39] that includes sections on subjects such as training motivation, yard storage, tensioning equipment, stressing operations, steel placement, travelifts, chucks, and harping. These subjects are specifically related to tasks or operations in the architectural and structural sectors of the industry.

C. Foreign Standards vs. Trade Association Guidelines

International standards and guidelines are incorporated, where appropriate, in the comprehensive safety recommendations presented in Chapter IV. A comparison of these standards and guidelines are presented topically, by operation, in the following section.

1. Forming

Canada requires that, in facilities for making forms and accessories, the construction of the forms be within the tolerances required for the product. They also require that all form-making shops have exits and

firefighting equipment appropriate to the work space, materials, and expected hazards.

Canada also requires that facilities for producing prestressed concrete elements include measuring equipment for setting up and checking alignments and levels. Canada requires that there be adequate dust-collecting and ventilating capabilities when personnel are in woodworking shops where wood or plastic forms are made.

2. Reinforcing

Canada requires that work benches or gigs where welding is performed be arranged so that employees are protected from welding flashes and that the areas be ventilated to avoid exposure to excessive welding fumes.

PCI refers to the OSHA General Industry Standards in 29 CFR 1910.217 and requires welding areas to be ventilated and protected to prevent welding flash.

3. Stressing

Both Canada and the PCI have safety requirements for stressing operations. The PCI requires that a shield or guard be provided for bed end protection of the jacking area. There are suggestions for the materials for a barrier, but no specific requirements.

4. Oiling

There are no unique safety standards in any international or consensus standards that address the tasks of this operation, except those discussing walking and working surfaces in the PCI "Safety and Loss Prevention Manual" [39].

5. Mixing

The PCI has no specific safety standards regarding batching and mixing that relate to safety. The Canadian standards require that the batch plant be kept clean at all times.

6. Casting

The PCI recommends that gloves, long-sleeved shirts, and long trousers be worn when employees are performing any of the various tasks related to concrete operations, such as shoveling, raking, vibrating, and screeding. The PCI requires that personnel performing the shoveling tasks be trained in proper procedures to reduce the potential for back strains. They also require that extruder hoppers have guards and that all electrical connections be insulated or guarded.

The PCI refers to requirements regarding noise in 29 CFR 1926.52 and CFR 1910.95.

7. Stripping

There are no specific requirements in the PCI, ACPA, or Canadian standards that apply to tasks in the stripping operation.

8. Curing

The PCI has both recommendations and specific requirements concerning steam, hot oil, electric, and moisture curing. They include requirements for the insulation of steam, hot oil, and hot water lines and for thermostats, timers, and circuit breakers for electric curing.

9. Finishing

The PCI "Safety and Loss Prevention Manual" [39] recommends the use of rubbersoled shoes where there are slippery surfaces and requires the use of hard hats, eye protection, knee pads, and gloves in the performance of certain operations; e.g., gloves are required for all finishers working with concrete; eye protection is required while concrete is poured; and eye protection is required whenever finishers are chipping, burning, drillling, or grinding.

During special finishing processes such as sand blasting, the PCI requires adequate exhaust ventilation and respiratory protective equipment. When acid etching is used as a finishing technique, the PCI requires that warning signs be posted and visible, that all caustic and acid products be labeled, and that employees know the location of the nearest portable water supply. It also recommends the use of protective face, hand, foot, and body clothing for employees performing these tasks.

10. Materials Handling

PCI refers to 29 CFR 1926.600 for certain general requirements, but also specifies in its "Safety and Loss Prevention Manual" [39] that operators be trained and qualified, be able to pass at least a verbal examination, be specifically designated to a particular task, and make a daily minimum check of their equipment. PCI also requires that the grounds be properly maintained for safe operations and prohibits the carrying or holding of loads over work areas where other employees are present.

The ACPA requires that product handling conform with the standard recommendations in its handbook.

Canada requires that all physical production facilities be laid out, designed, and constructed so that there will be adequate space for materials, storage, equipment, and production facilities, with sufficient capacity so that production can be adequately maintained without adversely affecting the safety of plant, personnel, or products.

The PCI has both general and specific recommendations for yard storage, including storage area, dunnage, stacking, personnel safety, strand, and

rebar storage. They also have recommendations regarding product transportation, including operating rules for driving in hazardous weather. The PCI prohibits the use of drugs and alcohol; it also requires that drivers wear hardhats and safety shoes.

The OSHA General Industry Standards in 29 CFR 1910 [32] regulate safety and health in the precast concrete products industry (SIC 3272); however, the standards do not apply to all operations, tasks, and conditions specific to the industry. Those items in the existing standards that are related to the manufacture and delivery of precast concrete products are presented in Table B-1.

Although SIC Code 3272 is regulated by OSHA standards under 29 CFR 1910, the OSHA construction standards in 29 CFR 1926 contain elements which are related to certain operations within the precast concrete products industry. The standards in CFR 1926 that impact on working conditions in the industry are included in Table B-1 for informational purposes.

E. Summary

OSHA General Industry Standards apply to many of the operations, tasks, and conditions typical of precast concrete manufacturing operations. These OSHA regulations address subjects such as walking and working surfaces, handtools, ventilation, noise, fire prevention, respiratory protection, machine guarding, ladders, scaffolding, and welding or cutting. OSHA standards do not, however, regulate some of the tasks, equipment, and operations that are specific to the precast concrete products industry, such as forming, stressing, detensioning, oiling, concrete transport and casting.

Existing international standards and trade association guidelines address many of the hazards that are unique to tasks in the precast concrete industry. PCI provides guidelines for worker protection in such areas as tensioning, architectural and structural product storage, yard layout and cleanliness, product shipping, and steel placement. ACPA guidelines address the areas of pipe handling and unloading.

The recommendations for safe work practices in Chapter IV include applicable standards from OSHA and foreign sources and from trade association guidelines. Additional recommendations are presented to include:

- Employee training
- Manual materials handling
- Housekeeping
- Personal protective equipment.

TABLE B-1
OSHA STANDARDS THAT IMPACT ON THE MANUFACTURE AND DELIVERY
OF PRECAST CONCRETE PRODUCTS

Applicable Standard	Area of Impact
1910	
Subpart D	Walking and Working Surfaces
.22	General requirements
.23	Guarding openings & holes
.24	Fixed stairs
.25	Wood ladders
.26	Metal ladders
.27	Fixed ladders
.28	Scaffolding
.29	Mobile scaffolds
Subpart E	Means of Egress
.36	General
.37	Means of egress
Subpart G	Occupational Health and Environmental Control
.94	Ventilation
.95	Noise
.97	Nonionizing radiation
Subpart H	Hazardous Materials
.101	Compressed gases (general requirements)
.102	Acetylene
.104	Oxygen
.106	Flammable and combustible liquids
.110	Storage and handling of liquefied petroleum gases
Subpart I	Personal Protective Equipment
.133	Eye and face protection
.134	Respiratory protection
.135	Occupational head protection
.136	Occupational foot protection
Subpart J	General Environmental Controls
.141	Sanitation
.144	Color coding
.145	Signs and tags

TABLE B-1
OSHA STANDARDS THAT IMPACT ON THE MANUFACTURE AND DELIVERY
OF PRECAST CONCRETE PRODUCTS (Continued)

Applicable Standard	Area of Impact
1910 (Cont.)	
Subpart K	Medical and First Aid
.151	Medical services and first aid
Subpart L	Fire Protection
.157	Portable fire extinguishers
.158	Standpipe & hose systems
.159	Automatic sprinkler systems
.160	Fixed dry chemical extinguishing systems
.161	Carbon dioxide extinguishing systems
.163	Local fire alarm signaling systems
Subpart M	Compressed Gas and Compressed Air Equipment
.166	Inspection of compressed gas cylinders
.169	Air receivers
Subpart N	Materials Handling and Storage
.176	Handling materials, general
.178	Powered industrial trucks
.179	Overhead & gantry cranes
.180	Crawler, locomotive, and truck cranes
Subpart O	Machinery and Machine Guarding
.212	General requirements for all machines
.213	Woodworking machinery requirements
.215	Abrasive wheel machinery
.217	Mechanical power presses
.219	Mechanical power-transmission apparatus

TABLE B-1
OSHA STANDARDS THAT IMPACT ON THE MANUFACTURE AND DELIVERY
OF PRECAST CONCRETE PRODUCTS (Continued)

Applicable Standard	Area of Impact
1910 (Cont.)	
<u>Subpart P</u>	<u>Tools, Hand and Portable Powered</u>
.242	Hand & portable powered tools & equipment, general
.243	Guarding of portable powered tools
.244	Other portable tools & equipment
<u>Subpart Q</u>	<u>Welding, Cutting and Brazing</u>
.252	Welding, cutting & brazing
<u>Subpart S</u>	<u>Electrical</u>
.309	National Electrical Code
<u>Subpart Z</u>	<u>Toxic and Hazardous Substances</u>
.1000	Air contaminants
1926	
<u>Subpart C</u>	<u>General Safety and Health</u>
.21	Safety training & education
.25	Housekeeping
<u>Subpart E</u>	<u>Personal Protective Equipment</u>
.102	Eye and face protection
.103	Respiratory protection
.104	Safety belts, life lines, and lanyards
.105	Safety hats
<u>Subpart G</u>	<u>Signs, Signals, and Barricades</u>
.201	Signaling
<u>Subpart H</u>	<u>Materials Handling, Storage, Use, and Disposal</u>
.250	General Storage
.251	Rigging equipment
.252	Disposal of waste materials
<u>Subpart K</u>	<u>Electrical</u>
.400	General
.4012	Grounding and bonding
.402	Installation & maintenance

TABLE B-1
OSHA STANDARDS THAT IMPACT ON THE MANUFACTURE AND DELIVERY
OF PRECAST CONCRETE PRODUCTS (Concluded)

Applicable Standard	Area of Impact
1926 (Cont.)	
Subpart N	Cranes, Derricks, and Hoists
.550	Cranes and derricks
Subpart O	Motor Vehicles
.600	Equipment
.601	Motor vehicles
.602	Materials handling equipment
Subpart Q	Concrete, Concrete Forms, and Storage
.700	General provisions
.701	Forms and storing
Subpart W	Rollover Protective Structures
.1000	Rollover protection
.1001	Performance criteria
.1002	Frame test procedures
.1003	Overhead protection

Adapted from OSHA General Industry Standards, 29 CFR 1910 [32] and OSHA Construction Industry Standards, 29 CFR 1926 [51].

APPENDIX C
SAMPLE SAFETY AUDIT

A. ORGANIZATION & ADMINISTRATION

Activity	Poor
1. Statement of policy, responsibilities assigned	No statement of Loss Control Policy. Responsibility & accountability not assigned
2. Safe operating procedures (SOP's)	No written SOP's.
3. Employee selection & placement	Only pre-employment physical examination given
4. Emergency & disaster control plans	No plan or procedures
5. Direct management involvement	No measurable activity.

SAMPLE SAFETY AUDIT

Fair	Good	Excellent
A general understanding of Loss Control, responsibilities & accountability, but not written	Loss Control Policy & responsibilities written & distributed to supervisors.	In addition to "Good" Loss Control Policy is reviewed annually & is posted. Responsibility & accountability is emphasized in supervisory performance evaluations.
Written SOP's for some, but not all, hazardous operations	Written SOP's for all hazardous operations.	All hazardous operations covered by a procedure, posted at the job location, with an annual documented review to determine adequacy.
In addition, an aptitude test is administered to new employees.	In addition to "Fair" new employees' past safety record is considered in their employment.	In addition to "Good" when employees are considered for promotion, their safety attitude & record are considered.
Verbal understanding on emergency procedures	Written plan outlining the minimum requirements.	All types of emergencies covered with written procedures. Responsibilities are defined with backup personnel provisions.
Followup on accident problems	In addition to "Fair," management reviews all injury & property damage reports & holds supervision accountable for verifying firm corrective measures.	In addition to "Good" reviews all investigation reports. Loss Control problems are treated as other operational problems in staff meeting.

A. ORGANIZATION & ADMINISTRATION (Continued)

Activity	Poor
6. Plant safety rules	No written rules.

B. INDUSTRIAL HAZARD CONTROL

Activity	Poor
1. Housekeeping--storage of materials, etc.	Housekeeping is generally poor. Raw materials, items being processed & finished materials are poorly stored.
2. Machine guarding	Little attempt is made to control hazardous points on machinery.
3. General area guarding	Little attempt is made to control such hazards as: unprotected floor openings; slippery or defective floors; stairway surfaces; inadequate illumination, etc.
4. Maintenance of equipment, guards, handtools, etc.	No systematic program of maintaining guards, handtools, controls & other safety features of equipment, etc.

Fair	Good	Excellent
Plant safety rules have been developed & posted.	Plant safety rules are incorporated in the plant work rules.	In addition, plant work rules are firmly enforced & updated at least annually.

Fair	Good	Excellent
Housekeeping is fair. Some attempts to adequately store materials are being made.	Housekeeping & storage of materials are orderly. Heavy & bulky objects well stored out of aisles, etc.	Housekeeping & storage of materials are ideally controlled.
Partial, but inadequate or ineffective attempts at control are in evidence.	There is evidence of control which meets applicable Federal & State requirements, but improvements may still be made.	Machine hazards are effectively controlled to the extent that injury is unlikely. Safety of operator is given prime consideration at time of process design.
Partial, but inadequate attempts to control these hazards are evidenced.	There is evidence of control which meets applicable Federal & State requirements--but further improvement may still be made.	These hazards are effectively controlled to the extent that injury is unlikely.
Partial, but inadequate or ineffective maintenance.	Maintenance program for equipment & safety features is adequate. Electrical handtools are tested & inspected before issuance, & on a routine basis.	In addition to "Good" a preventative maintenance system is programmed for hazardous equipment & devices. Safety reports filed & safety department consulted when abnormal conditions are found.

B. INDUSTRIAL HAZARD CONTROL(Continued)

Activity	Poor
5. Materials handling--hand & mechanized	Little attempt is made to minimize possibility of injury from the handling of materials.
6. Personal protective equipment--adequacy & use	Proper equipment not provided or is not adequate for specific hazards.

C. FIRE CONTROL & INDUSTRIAL HYGIENE

1. Chemical hazard control references	No knowledge or use of reference data.
2. Flammable & explosive materials control	Storage facilities do not meet fire regulations. Containers do not carry name of contents. Approved dispensing equipment not used. Excessive quantities permitted in manufacturing areas.

Fair	Good	Excellent
Partial but inadequate or ineffective attempts at control are in evidence.	Loads are limited as to size & shape for handling by hand, & mechanization is provided for heavy or bulky loads.	In addition to controls for both hand & mechanized handling, adequate measures prevail to prevent conflict between other workers & material being moved.
Partial but inadequate or ineffective provision, distribution & use of personal protective equipment.	Proper equipment is provided. Equipment identified for special hazards, distribution of equipment is controlled by supervisor. Employee is required to use protective equipment.	Equipment provided complies with standards. Close control maintained by supervision. Use of safety equipment recognized as an employment requirement. Injury record bears this out.
Data available & used by foremen when needed.	In addition to "Fair" additional standards have been requested when necessary.	Data posted & followed where needed. Additional standards have been promulgated, reviewed with employees involved & posted.
Some storage facilities meet minimum fire regulations. Most containers carry name of contents. Some approved dispensing equipment in use.	Storage facilities meet minimum fire regulations. Most containers carry name of contents. Approved equipment generally is used. Supply at work area is limited to one day requirement. Containers are kept in approved storage cabinets.	In addition to "Good" storage facilities exceed the minimum fire regulations & containers are always labeled. A strong policy is in evidence relative to the control of the handling, storage & use of flammable materials.

C. FIRE CONTROL & INDUSTRIAL HYGIENE (Continued)

Activity	Poor	Fair	Good	Excellent
3. Ventilation--fumes, smoke and dust control	Ventilation rates are below industrial hygiene standards in areas where there is an industrial hygiene exposure.	Ventilation rates in exposure areas meet minimum standards.	In addition to "Fair" ventilation rates are periodically measured, recorded & maintained at approved levels.	In addition to "Good" equipment is properly selected & maintained close to maximum efficiency.
4. Skin contamination control	Little attempt at control or elimination of skin irritation exposures.	Partial, but incomplete program for protecting workers. First-aid reports on skin problems are followed up on an individual basis for determination of cause.	The majority of workmen instructed concerning skin-irritating materials. Workmen provided with approved personal protective equipment or devices. Use of this equipment is enforced.	All workmen informed about skin-irritating materials. Workmen in all cases provided with approved personal protective equipment or devices. Use of proper equipment enforced & facilities available for maintenance. Workers are encouraged to wash skin frequently. Injury record indicates good control.
5. Fire control measures	Do not meet minimum insurance or municipal requirements.	Meets minimum requirements.	In addition to "Fair" additional fire hoses &/or extinguishers are provided. Welding permits issued. Extinguishers on all welding carts.	In addition to "Good" a fire crew is organized & trained in emergency procedures & in the use of fire fighting equipment.
6. Waste--trash collection & disposal, air/water pollution	Control measures are inadequate.	Some controls exist for disposal of harmful wastes or trash. Controls exist but are ineffective in methods or procedures of collection & disposal. Further study is necessary.	Most waste disposal problems have been identified & control programs instituted. There is no room for further improvement.	Waste disposal hazards are effectively controlled. Air/water pollution potential is minimal.

SAMPLE SAFETY AUDIT (Continued)

D. SUPERVISORY PARTICIPATION, MOTIVATION & TRAINING

Activity	Poor	Fair	Good	Excellent
1. Line supervisor safety training	All supervisors have not received basic safety training.	All shop supervisors have received some safety training.	All supervisors participate in division safety training session a minimum of twice a year.	In addition, specialized sessions conducted on specific problems.
2. Indoctrination of new employees.	No program covering the health & safety job requirements.	Verbal only	A written handout to assist in indoctrination.	A formal indoctrination program to orientate new employees is in effect.
3. Job hazard analysis (JHA).	No written program.	JHA program being implemented on some jobs.	JHA conducted on majority of operations.	In addition, job hazard analyses performed on a regular basis & safety procedures written & posted for all operations.
4. Training for specialized operations (Fork trucks, grinding, press brakes, punch presses, solvent handling, etc.)	Inadequate training given for specialized operations.	An occasional training program given for specialized operations.	Safety training is given for all specialized operations on a regular basis & retraining given periodically to review correct procedures.	In addition to "Good" an evaluation is performed annually to determine training needs.
5. Internal self-inspection.	No written program to identify & evaluate hazardous practices &/or conditions.	Plant relies on outside sources; i.e., Insurance Safety Engineer & assumes each supervisor inspects his area.	A written program outlining inspection guidelines, responsibilities, frequency & follow up is in effect.	Inspection program is measured by results; i.e., reduction in accidents & costs. Inspection results are followed by top management.
6. Safety promotion & publicity.	Bulletin boards & posters are considered the primary means for safety promotion.	Additional safety displays, demonstrations, films, are used infrequently.	Safety displays & demonstrations are used on a regular basis.	Special display cabinets, windows, etc. are provided. Displays are used regularly & are keyed to special themes.

D. SUPERVISORY PARTICIPATION, MOTIVATION & TRAINING (Continued)

Activity	Poor	Fair	Good	Excellent
7. Employee/supervisor safety contact & communication.	Little or no attempt made by supervisor to discuss safety with employees.	Infrequent safety discussions between supervisor & employees.	Supervisors regularly cover safety when reviewing work practices with individual employees.	In addition to items covered under "Good" supervisors make good use of the shop safety plan & regularly review job safety requirements with each worker. They contact at least one employee daily to discuss safe job performance.

E. ACCIDENT INVESTIGATION, STATISTICS AND REPORTING PROCEDURES

Activity	Poor	Fair	Good	Excellent
1. Accident investigation by line personnel.	No accident investigation made by line supervision.	Line supervision makes investigations of only medical injuries.	Line supervision trained & makes complete & effective investigations of all accidents; the cause is determined; corrective measures initiated immediately with a completion date firmly established.	In addition to items covered under "Good" investigation is made of every accident within 24 hours of occurrence. Reports are reviewed by the department manager & plant manager.
2. Accident cause & injury location analysis & statistics.	No analysis of disabling & medical cases to identify prevalent causes of accidents & location where they occur.	Effective analysis by both cause & location maintained on medical & first aid cases.	In addition to effective accident analysis, results are used to pinpoint accident causes so accident prevention objectives can be established.	Accident causes & injuries are graphically illustrated to develop the trends & evaluate performance. Management is kept informed on status.
3. Investigation of property damage.	No program.	Verbal requirement or general practice to inquire about property damage accidents.	Written requirement that all property damage accidents of $50 & more will be investigated.	In addition, management requires a vigorous investigation effort on all property damage accidents.
4. Proper reporting of accidents & contact with carrier.	Accident reporting procedures are inadequate.	Accidents are correctly reported on a timely basis.	In addition to "Fair" accident records are maintained for analysis purposes	In addition to "Good" there is a close liaison with the insurance carrier.

RATING FORM

	Poor	Fair	Good	Excellent	Comments
A. ORGANIZATION & ADMINISTRATION					
1. Statement of policy, responsibilities assigned.	0	5	15	20	
2. Safe operating procedures (SOP's).	0	2	15	17	
3. Employee selection and placement.	0	2	10	12	
4. Emergency and disaster control planning.	0	5	15	18	
5. Direct management involvement.	0	10	20	25	
6. Plant safety rules.	0	2	5	8	
Total value of circled numbers	____	+____	+____	+____	X .20 Rating______
B. INDUSTRIAL HAZARD CONTROL					
1. Housekeeping--storage of materials, etc.	0	4	8	10	
2. Machine guarding.	0	5	16	20	
3. General area guarding.	0	5	16	20	
4. Maintenance of equipment guards, hand tools, etc.	0	5	16	20	
5. Material handling--hand and mechanized.	0	3	8	10	
6. Personal protective equipment--adequacy and use.	0	7	20	20	
Total value of circled numbers	____	+____	+____	+____	X .20 Rating______
C. FIRE CONTROL & INDUSTRIAL HYGIENE					
1. Chemical hazard control references.	0	6	17	20	
2. Flammable and explosive materials control.	0	6	17	20	
3. Ventilation--fumes, smoke and dust control.	0	2	8	10	
4. Skin contamination control.	0	3	10	15	
5. Fire control measures.	0	2	8	10	
6. Waste--trash collection and disposal, air/water pollution.	0	7	20	25	
Total value of circled numbers	____	+____	+____	+____	X .20 Rating______

	Poor	Fair	Good	Excellent	Comments
D. SUPERVISORY PARTICIPATION, MOTIVATION & TRAINING					
1. Line supervisor safety training.	0	10	22	25	
2. Indoctrination of new employees.	0	1	5	10	
3. Job hazard analysis.	0	2	8	10	
4. Training for specialized operations.	0	2	7	10	
5. Internal self-inspection.	0	5	14	15	
6. Safety promotion and publicity.	0	1	4	5	
7. Employee/supervisor contact and communication.	0	5	20	25	
Total value of circled numbers	____	+____	+____	+____	X .20 Rating______
E. ACCIDENT INVESTIGATION, STATISTICS & REPORTING PROCEDURES					
1. Accident investigation by line supervisor.	0	10	32	40	
2. Accident cause and injury location analysis and statistics.	0	3	8	10	
3. Investigation of property damage.	0	10	32	40	
4. Proper reporting of accidents and contact with carrier.	0	3	8	10	
Total value of circled numbers	____	+____	+____	+____	X .20 Rating______

SUMMARY

The numerical values below are the weighted ratings calculated on rating sheets. The total becomes the overall score for the location.

A. Organization & Administration __________
B. Industrial Hazard Control __________
C. Fire Control & Industrial Hygiene __________
D. Supervisory Participation, Motivation & Training __________
E. Accident Investigation, Statistics & Reporting Procedures __________

TOTAL RATING __________

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APPENDIX D
EXAMPLES OF SAFETY PROGRAM ASSESSMENT FORMS

Accident Investigation Assessment Form

		Yes	No
1.	Are employees required to report <u>all</u> injuries and property damage incidents?	_____	_____
2.	Do the accident investigation procedures urge employees to report near miss accidents?	_____	_____
3.	Are first-line supervisors required to investigate and report minor injury accidents?	_____	_____
4.	Is a written record made of all accident investigations?	_____	_____
5.	Does a management level above the first-line supervisor participate in serious injury accidents?	_____	_____
6.	Are the majority of accidents investigated on the day of the occurrence?	_____	_____
7.	Have supervisors been trained in techniques of accident investigation?	_____	_____
8.	Do accident reports clearly identify the cause(s) of the accident?	_____	_____
9.	Are recommendations for corrective action to prevent recurrence implemented in a timely manner?	_____	_____
10.	Is someone assigned the responsibility of keeping OSHA records, and are they kept up to date?	_____	_____

Assessment for Control of Hazards Form

		Yes	No
1.	Is safety and health data readily available to all employees?	_____	_____
2.	Are material safety data sheets available to supervisors?	_____	_____
3.	Are safe job procedures and safety rules available to all employees?	_____	_____
4.	Are routine safety and health inspections conducted?	_____	_____
5.	Is there a procedure for handling employee safety and health complaints?	_____	_____
6.	Are noted safety deficiencies promptly corrected?	_____	_____
7.	Is there an engineering and administrative control program in effect?	_____	_____
8.	Is management knowledgeable in the selection, care and maintenance of personal protective equipment?	_____	_____
9.	Are employees instructed in the correct use and care of personal protective equipment?	_____	_____
10.	Is there a program in effect for good housekeeping and and routine maintenance?	_____	_____

Assessment of Safety Inspection Form

		Yes	No
1.	Does the safety program provide for periodic safety and health inspections?	_____	_____
2.	Are individuals assigned responsibility for conducting inspections?	_____	_____
3.	Do management and employees conduct joint inspections?	_____	_____
4.	Does management have an abatement program in effect?	_____	_____
5.	Does the inspection cover materials storage and material handling?	_____	_____
6.	Does the inspection cover housekeeping in general and and particularly for walking and working surfaces?	_____	_____
7.	Does the inspection cover the use, care and maintenance of personal protective equipment?	_____	_____
8.	Does the inspection cover access and exit to work areas?	_____	_____
9.	Does the inspection cover use, care and maintenance of hand tools (powered and unpowered)?	_____	_____
10.	Does the inspection cover physical and chemical hazards?	_____	_____

Assessment of Safety Training Form

		Yes	No
1.	Are all new employees given a safety orientation before they start work?	_____	_____
2.	Are employees, old or new, provided with safety job instruction when assigned to a new job?	_____	_____
3.	Is the training directed to the specific hazards of the new job?	_____	_____
4.	Has management identified those persons responsible for training employees?	_____	_____
5.	Are safety rules and practices periodically discussed with all employees?	_____	_____
6.	Is a portion of each safety meeting devoted to providing safety instruction for upcoming work?	_____	_____
7.	Have safety training responsibilities been assigned to someone?	_____	_____
8.	Are training priorities being assessed?	_____	_____
9.	Are the training objectives clearly defined?	_____	_____
10.	Is the training program periodically evaluated?	_____	_____

Assessment of Safety Attitude Form

		Yes	No
1.	Do supervisors observe stated safety rules and safe job procedures?	____	____
2.	Do employees perceive management as doing a good job at correcting reported unsafe conditions?	____	____
3.	Are employees given the opportunity to take an active role in the safety program?	____	____
4.	Are plant safety rules posted and made available to all employees?	____	____
5.	Are reasons for the safety rules explained to the employees?	____	____
6.	Does management reinforce safe employee behavior?	____	____
7.	Are noncooperative employees reprimanded for infractions of plant safety rules and practices?	____	____
8.	Does management support supervisor efforts to enforce plant safety rules and practices?	____	____
9.	Do employees feel that management is interested and involved in the safety program?	____	____
10.	Does management feel that the employees are interested and involved in the safety program?	____	____

Assessment of Safe Work Procedures Form

		Yes	No
1.	Have accident repeater jobs been identified and analyzed to develop safer procedures?	_____	_____
2.	Have safe job procedures been standardized for hazardous jobs?	_____	_____
3.	Are hazardous tasks covered by written safe job procedures?	_____	_____
4.	Do supervisors develop written safe job procedures?	_____	_____
5.	Are employees encouraged to participate in development of written safe job procedures?	_____	_____
6.	Are written safe job procedures prepared prior to initiation of new jobs or tasks?	_____	_____
7.	Do supervisors periodically observe hazardous jobs or tasks to determine if safe work procedures are being utilized?	_____	_____
8.	Are hazardous jobs or tasks accomplished the same by all work crews or shifts?	_____	_____
9.	Are written safe job procedures used to train employees?	_____	_____
10.	Are written safe job procedures periodically updated for improving work methods?	_____	_____

Assessment of Management's Participation in Safety Form

		Yes	No
1.	Is the plant safety program a topic on the manager's staff meeting agenda?	_____	_____
2.	Do middle managers periodically conduct safety meetings with subordinate supervisors?	_____	_____
3.	Do middle managers conduct safety inspections?	_____	_____
4.	Does the plant manager review periodic reports of plant accidents?	_____	_____
5.	Does management promptly correct unsafe conditions?	_____	_____
6.	Does management encourage employees to report hazardous conditions?	_____	_____
7.	Does management encourage employee safety suggestions?	_____	_____
8.	Does the plant have procedures for handling emergencies?	_____	_____
9.	Do members of management observe the plant's stated safety rules and practices?	_____	_____
10.	Are all levels of managers held accountable for their safety responsibilities?	_____	_____

Summary

The assessment forms address samples of various questions which may be asked concerning the safety program. The questions presented on the sample forms are not intended to represent the most important to be answered. They are intended to be examples only. Management may desire to find answers to other areas of the safety program which are considered problem areas and should develop an assessment tool which would yield those answers.

Adapted from Evaluation of Safety and Health Program and Operation Zero Accident Prevention Fundamentals [45,47].

GLOSSARY

aggregate	Hard, inert mineral rock fragments or materials such as sand, gravel, or slag used for mixing with a cementing material to form concrete. Fine aggregate is sand and other finely graded materials. Coarse aggregate is the large material that passes through sieve openings of one-fourth inch or more.
bull float	A tool used to spread out and smooth the concrete.
bush hammer	An air-powered reciprocating tool used to give a textured appearance to architectural concrete products by roughening the surface.
camber	(a) The upward deflection that occurs in prestressed concrete elements due to the net bending resulting from stressing forces and self-weight. It specifically does not include dimensional inaccuracies. (b) A built-in upward curvature in some molds for precast concrete other than prestressed to avoid deflection under load to below a defined line of finished product.
cement	Any of various construction adhesives, consisting essentially of powdered, calcined rock and clay materials, that form a paste with water and can be molded or poured to set as a solid mass.
concrete	A mixture of cement, sand, and aggregate with water that hardens by chemical curing into a final product similar to stone in texture, weight, and durability.
connection	A device for attachment of precast concrete elements to each other or to a building structure.
curing	The maintenance of humidity and temperature of freshly placed concrete during some definite period following placing, casting, or finishing to ensure satisfactory hydration of the cementitious materials and proper hardening of the concrete. When the curing temperature remains in the normal environmental range (generally between 10^{o} C and 30^{o} C), the term "normal curing" is used. When the curing temperature is increased to a

	higher range (generally between 30° C and 70° C), the term "accelerated curing" is used.
deflecting of strand	The process of creating draped strand.
detensioning of strand or wire	The release of tension from the tendon, usually occurring at the time the prestressing force is transferred from the bed anchorage to the individual pieces cast in the bed.
detensioning strength or transfer strength	The minimum concrete strength specified for individual concrete elements before the prestressing force may be transferred to them.
draped strand	A strand that is held up at specific points, and held down at others, to form a special desired profile.
dry-mix concrete	Concrete designed with very low water/cement ratios and slumps to be used with special consolidation methods, tamping, or extrusion production equipment.
dunnage	Materials (usually wood) used for keeping concrete products from touching each other or other materials during storage and transportation.
form	A structure or mold for the support of concrete while it is setting and gaining sufficient strength to be self-supporting.
form release agent	A substance applied to the forms for the purpose of preventing a bond between the form and the concrete cast in it.
formwork	The system of support for freshly placed concrete, including the mold or sheathing that contacts the concrete as well as all supporting members.
grips	The parts of a strand vise that actually contact or grip the wires or strands.
hardware	A collective term used to cover all items embedded in the concrete (other than reinforcement) or otherwise used in connecting precast elements or attaching or accommodating adjacent materials or equipment.
jig	A device to align parts of an assembly, usually for pre-assembling reinforcing steel and hardware cages, with a minimum of measurement and consistent accuracy, from one cage to the next.

lifting frame (or spreader beam)	A device designed to provide two or more lifting points of a precast concrete element with predictable load distribution and prearranged direction of pulling force during lifting.
machine-cast products	Products cast by one or more machines specifically designed for the purpose. Slipform and extrusion machines are types of casting equipment used to make solid or hollow-core slabs.
machine finish	Finishes applied by special tools while the concrete is still in the forms and plastic.
no-slump concrete	Concrete with a near-zero slump to be used with special consolidation methods, tamping, or extrusion production equipment.
precast concrete	A concrete element cast in a location other than its final position in service. Precast concrete may be produced at the job site, in temporary plants, or in permanent factories.
precast concrete element	A general term for any precast product regardless of classification or application. The term includes any nonconcrete items incorporated in the element at the time of manufacture.
prestressing bed	The platform and abutments needed to support the forms and maintain the tendons in a stressed condition during placing and curing of the concrete.
retarder	An admixture that delays the setting of concrete paste.
screeding	The smoothing or leveling off of freshly cast concrete by manual or mechanical means. A screed usually has a wooden or metal edge that is moved horizontally across the concrete, pushing excess material in front of it and filling in low places.
self-stressing forms	Equipment that, in addition to serving as forms for concrete, accommodates the pretensioned strands (or wires) and sustains the total prestressing force by suitable end bulkheads and sufficient cross-sectional strength.
slump	The drop from the top of a slump cone to the top of the unsupported concrete after the sudden removal of the supporting slump cone. The difference in height, measured in inches or centimeters, is the slump of the concrete. A wet or soft mix slumps more than a dry or stiff mix.

strand chuck or vise	A device for holding a strand under tension.
stripping	The process of removing a precast concrete element from the form in which it was cast.
two-blocking	The action of the crane hook block being pulled into the crane boom head.
water/cement ratio	The weight of water relative to the weight of cement in a concrete mix. Enough water must be added to the mix to provide hydration. Excess water improves workability but reduces strength.

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