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:

- o Management should provide these items and encourage their use.
- o Workers should understand the importance of their use.
- o 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:

- o Adequate space to perform manual materials handling activities
- o A clear, unobstructed path if transportation of objects is required
- o 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:

- o Address the types of manual handling activities inherent to the activities of the workers participating in the program
- o Illustrate the dangers of unsafe techniques
- o Emphasize the recommended techniques
- o 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]
- o A spirit level at the outrigger controls for leveling [33]
- o Adequate lighting for night operation, including backup lights for mobile units [33]
- o Wheel chocks on mobile units to block movement on slopes when the equipment is left unattended or is undergoing maintenance [33]
- o A fire extinguisher and a first-aid kit [32]
- o Rearview mirrors on both sides of mobile equipment [33]
- o Self-closing filler caps and flame arresters on fuel tanks [33]
- o Slip-resistant material on crane surfaces subject to foot traffic [33].

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

- o 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)
- o 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
- o Check for freedom of rotation of all swivels
- o 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
- o 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)
- o Inspect wire ropes (including standing ropes), rigging hardware, and attachments
- o 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
- o Daily, visually inspect the equipment for fluid or air leaks
- o 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

- o 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)
- o Sound an audible alarm (horn) before moving a crane and whenever the crane is approaching other workers
- o Sound an audible alarm whenever a suspended load is approaching employees to give them time to move
- o Never operate the crane within 10 feet of energized high-voltage powerlines.

(c) During operations, management should:

- o Prohibit employees from performing any maintenance work on equipment while it is in service
- o 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
- o Prohibit oilers, helpers, or other workers from areas within the swing radius of the crane carriage while the crane is rotating or under load
- o 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:

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

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

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

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

(e) Slings, ropes, or chains should not 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 not permitted on industrial vehicles.

(6) Employees should not 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 not run onto floors, platforms, or other surfaces that will not safely support the loaded vehicle.

(10) Vehicle loads must not exceed rated capacities. A loaded industrial vehicle should not 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 never 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 not be used as substitutes.

(4) Cranes or hoists should not be used to remove products lodged or stuck to the forms. The crane's safe lifting capacity should not 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:

- o Employees must be instructed and required to use correct lifting techniques.
- o 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.
- o Mechanical lift assistance should be provided to safely lift pieces too bulky or heavy to be handled manually.
- o Bundles of reinforcing steel moved by crane or other means should be securely tied and wedged together to prevent slipping.
- o 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 possible 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

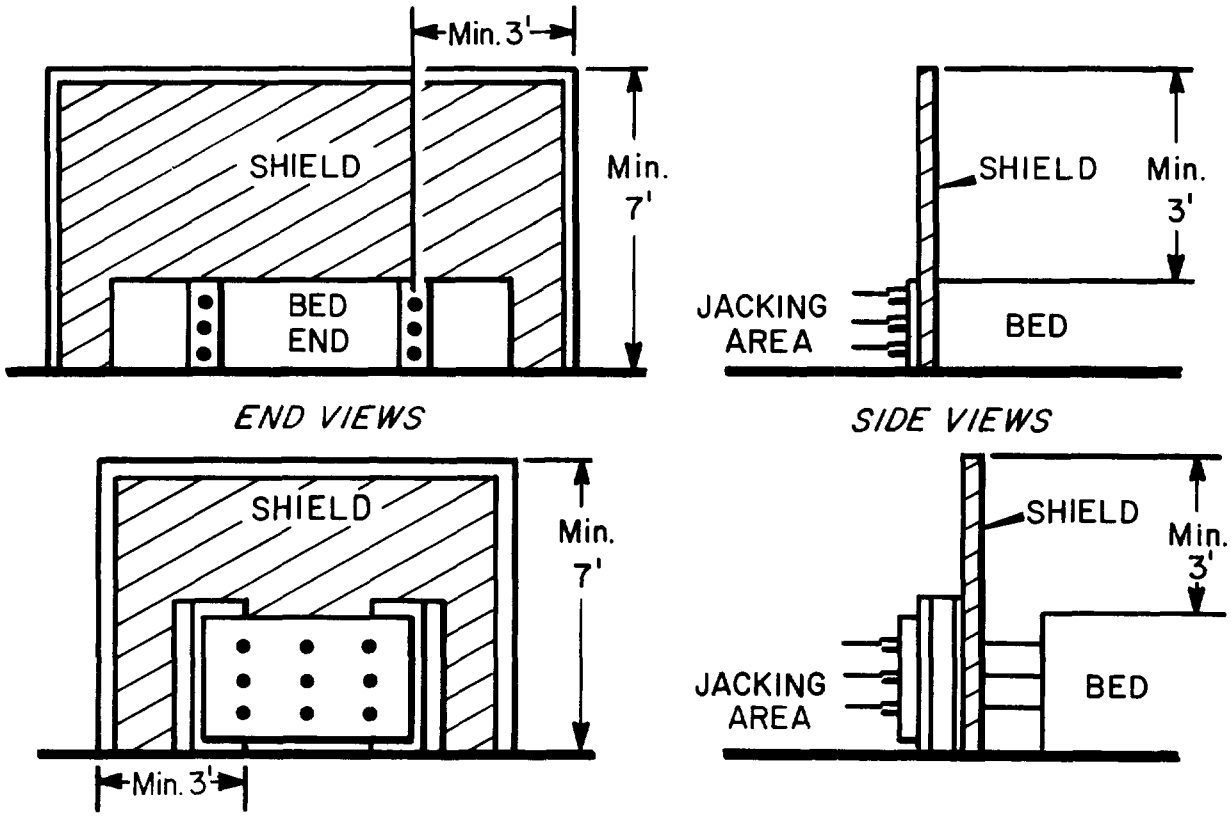

FIGURE IV-1. EXAMPLE OF MAIN SHIELD BED END PROTECTION
Adapted from PCI Safety and Loss Prevention Manual [39].

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

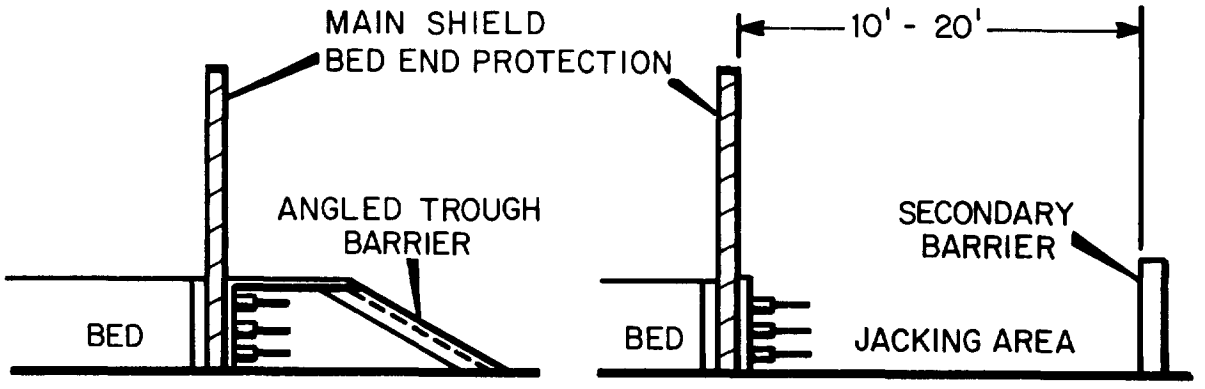

FIGURE IV-2. EXAMPLE OF SECONDARY BARRIER PROTECTION

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 not 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.
Respiratory	Respirators, dust masks	Harmful dusts, fumes, mists, and vapors	NIOSH/MSHA-approved respirators must be worn by employees exposed to toxic agents. Respirators may be required when spraying, 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 adequately 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, one or more 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].