The prestressed concrete industry, records show, is as safe as most other construction operations. The major hazards have been identified and steps have been initiated to educate and protect workers. This is a specialized type of construction; however, which requires special training for workers if incidents are to be avoided.

1. In addition to the precautionary measures necessary on any construction work, it must be remembered that a prestressed concrete steel strand, under tension as high as 180,000 psi, can whip across working areas with deadly results if stored energy is suddenly released by some type of equipment or material failure.

2. This data sheet discusses the principal hazards involved with prestressed concrete and suggests measures that should be taken to avoid injury. Statistically, the most common types of incidents and injuries occurring in prestressed concrete plants or on jobsites are eye, hand or foot injuries resulting from improper use of air hoses, saws and other equipment.

3. In this specialized type of construction, there are factors inherent to prestressed concrete that require special attention from an incident prevention standpoint. Therefore, various components or phases that warrant special attention will be covered separately.

4. There are two basic methods of prestressing concrete—pretensioning and post-tensioning. This data sheet is limited to the pretensioning method.

5. In pretensioning, the wire strands or bars are tensioned before the concrete is poured. After the concrete has cured, the load is removed from end abutments and transferred by strand resistance to the concrete member.

Strands and bars

6. Generally, the strands and bars are made of high-carbon steel, which makes them very susceptible to mechanical damage. A nick or kink can cause failure when tensioned to the high stresses normally required. When moving the reels, the strands should be protected as much as possible. Consequently, lifting and handling equipment should be attached to the flanges or through the center hole of the reel. Most mechanical damage occurs after the strands have been pulled into the bed and before they are tensioned. This is caused by
7. Careful handling of welding equipment cannot be overemphasized. A strand failure can result from a single drop of molten weld metal on the strand. Failure will be instantaneous if the strand is under tension when the high temperature occurs. However, a strand not under tension, but subjected to high temperature, will fail during the tensioning operation. Many damages may not be visible to the naked eye and unfortunately are discovered only when the strands fail while being tensioned.

8. When strands must be kept for prolonged periods, they should be stored indoors or otherwise protected from the weather. Only a light coat of rust is permissible; therefore, it is most important to inspect for pitting. Strands that are pitted from rust should not be used.

9. The method in which strands are cut is most important. There have been many strand failures as a result of their being cut off with a burning torch. Cutting the ends off a finished member is permissible, but to use a burning torch or welding equipment in or around a bed prior to placing the concrete is extremely dangerous. Hence, routine cutting of strands, other than at ends of finished members, should be done with a portable strand cutter especially designed for this purpose or with a fast-cutting abrasive wheel on a portable grinder. It is especially important that strands that are to be spliced be cut with a shear or grinding wheel. The wheel should be properly guarded and the operator should be wearing safety goggles.

Stressing or tensioning strands

11. The most common method of stressing is by means of hydraulic jacking. The manufacturer’s recommendations on the use of jacks should be strictly followed. All hoses, hose connections, valves and other components should be checked daily for defects and should be repaired promptly according to the manufacturer’s recommendation. Extreme care should be exercised to avoid damaging strands when they are pulled into the bed with a tugger hoist or similar equipment. The wedge-type temporary anchor or grip used for holding strands under load should be handled in accordance with the instructions issued by the manufacturer.

12. It is most important that the grips and strands be perfectly clean. A small piece of sand or dirt between a wedge (jaw) and the steel case (barrel) will retard the motion of the wedge into the case and may cause premature failure or slippage of the strand. Strand guides should be cleaned after every usage. The importance of using the correct size anchor grip cannot be overemphasized. Different sized anchor grips should be physically separated, preferably in different buildings. A nonflammable solvent should be used for cleaning the grips.

13. When several strands are to be tensioned simultaneously, they should first be tensioned to a specific low tension in order to equalize the
load on each strand. The most accurate way to determine strand load is with a dynamometer. After the strand has been pulled to the predetermined amount, the temporary anchor grip should then be pushed up tight against the face of the anchor plate. After each strand has been equally tensioned and anchored, all the strands can be stressed simultaneously to the predetermined total load. Stressing levels and elongation calculations are normally determined by the plant engineering department.

14. The amount of stress on a single strand or on several strands stressed simultaneously can be determined by measuring strand elongation and jack pressure on a calibrated gage. The load elongation properties of strand are not the same for all manufacturers; therefore, this should be taken into consideration when computing the amount of elongation.

15. There are two operations that should be carefully checked during stressing:

- Measure the actual movement (elongation) of the crosshead in relation to a predetermined fixed point.
- While gradually applying pressure to the jacks, note the gage reading; it should not exceed the predetermined amount of pressure.

16. When there is a difference of more than 5 percent between steel stress (determined from elongation) and from the gage reading, the cause for this difference should be determined and corrected immediately.

17. Strands and bars should not be stressed in excess of 80 percent of their ultimate strength, which is to be based on the data furnished by the manufacturer. In members where the strands are deflected prior to prestressing, the hold-down and support devices should be the roller type, which will reduce the amount of friction on the strand.

18. When the strands are deflected after tensioning, care should be exercised when transferring the strand to the hold-down or support devices.

Raising or lowering a strand increases its tension; therefore, this should be taken into consideration in all computations. Placing the strands in their final path, under and over the roller-type, hold-down and support devices (prior to tensioning), is by far the safest method of deflecting strands.

19. During the period of actual stressing, all personnel should be removed from the casting bed. A physical barrier, preferably a concrete wall, should be placed across the entire width of the casting bed on both ends. If a strand should break, the wall will prevent it from flying about (generally, end-first like a projectile). A steel wire fence should not be used as a barrier because broken strands often fly end-first and many penetrate the openings in the fence. The jack operator also can work safely behind this wall.

Placement of reinforcing steel and concrete

20. Reinforcing steel is normally placed in the casting bed after the tendons are stressed; therefore, prefabrication into mats outside the bed is desirable to minimize personnel exposure to the stressed tendons. Care must be taken to prevent contact between the tendons and the reinforcing steel or lifting equipment. Hold-downs or anchors that hold the tendons in position also should be protected.

21. Trucks conveying ready concrete impose traffic problems that should be considered. The ideal arrangement is to have the beds laid out in a way that makes backing unnecessary; however, where backing is necessary, it should be controlled by a signaler, properly positioned in an area behind the truck and clearly visible to the driver.

22. All roadways should be properly laid out, and equipment should be carefully routed to provide a systematic flow of traffic throughout the working area. Traffic should be arranged so that placing concrete can take place with a minimum of handling to avoid damage to the strands.
• Where concrete cannot be conveyed directly from the truck into the beds, and concrete buckets are required, care should be taken to prevent the bucket from injuring the hands and feet, or pinning the workers against other objects. The buckets also shall be kept clear of the tendons and anchors. Dropping of concrete on the tendons should be avoided.

• Vibrators, electrical or mechanical, should be kept completely clear of the tendons. Vibrations of the tendons or reinforcing steel should not be permitted. Electrical vibrators should be moisture-proofed.

• Normal personal protective equipment for concreting operations should be provided and worn, with particular emphasis on safety glasses or full goggles.

**Detensioning and handling**

23. After the concrete has cured sufficiently to attain adequate compressive strength, the transfer of the prestressing force or detensioning follows. Detensioning of the strands in a member should be done gradually and smoothly. In multiple-strand detensioning, strands should be unjacked and not served while under tension. If the force in the strand is transferred individually, single-strand detensioning should be done in an approved, balanced pattern and schedules incorporated to avoid propelling excessive stresses into the remaining strands and the member. Single strands are generally released by heat cutting; and when the heat cutting is performed at both ends simultaneously, the sliding of the member will be minimized.

24. Stripping the forms and handling the finished members will vary considerably from plant to plant. Specially designed equipment, properly tested before use, has proven to be safer and more efficient than ordinary, conventional types.

25. Before handling long, slender members, such as piles, or any other type of member that was designed without lifting eyes, consult the design engineer to ascertain the exact center of gravity and the lifting point of the member to place rigging for hoisting. The lifting eyes or loops should be carefully inserted within the member and in compliance with the specification. (Short lengths of strands and eye-bolts have proven satisfactory.) If more than one lifting strand is required to carry the weight, the strands should be handled cautiously and placed evenly so equal stress is placed on all lifting strands.

26. The strength of the concrete is another factor that should not be overlooked. The blocking up and chocking of members is extremely dangerous. Therefore, the weight, height, width, location, wind forces, equipment vibration and other variables will dictate the necessary precautionary measures. All hoisting equipment should be carefully inspected daily. Worn ropes and old socket fittings should be replaced. A hoisting line failure can cause inestimable damage. Contact with overhead electrical power lines can produce fatal shocks. These lines should be placed underground whenever possible. Otherwise, hoist lines should be placed at least 10 feet away, by positive swing stops on the crane or by a watchman on foot.

27. To avoid collapse of erected precast structural members they should be braced or guyed until all members are safely secured by their permanent fastening.

28. Prestressed members should be stored on a level base and should be adequately supported during storage and transportation. They should be handled at pick points specified by the designer and with the lifting devices recommended by the manufacturer or the engineer in charge. No one should be allowed under stressed members during lifting or erection.

**Safety program**

29. The large tensioning forces, which are necessary to all prestressing operations, inevitably result in

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**Note:** The document contains instructions and precautions for concrete handling, detensioning, and safety considerations in construction projects. It emphasizes the importance of proper equipment, safety gear, and handling techniques to prevent injuries and ensure the structural integrity of the construction.
all such constructions being very hazardous. A carefully planned program of good safety practice should be developed for each prestressing plant, and each employee should be required to comply with the program in all respects.

30. The operation of tensioning has more potential for serious incidents than most of the other phases of prestressed concrete production. The following basic rules applicable to tensioning should be included in the safety requirements of all plants:

- Prior to tensioning any bed, a visible and audible signal should be given and all personnel not required to perform the tensioning should leave the area adjacent to the bed.
- Jacks should be adequately secured to prevent the jack from flying longitudinally or laterally in case of tendon failure or sudden release of tension.
- Personnel should never be permitted to stand at either end of the bed directly in-line with the tendon being tensioned.
- Personnel should not stand over tendons being tensioned to make elongation measurements. Such measurements should be made by jigs or templates from the side or from behind shields.

31. Some general safe practices include, but are not limited to, the following:

- Installation and maintenance should comply with pertinent provisions of the National Electrical Code. All electrical circuits and equipment should be properly grounded in compliance with the code. This means a three-wire polarized system on all tools, extension cords, receptacles and the like, except where double-insulated tools are used.
- Require all personnel to wear safety hats.
- Require all personnel to wear proper footwear.
- Require all personnel to wear safety glasses.
- Have all debris removed immediately from the work area.
- Have the proper type and amount of fire fighting equipment installed and train the workers in proper usage.
- Have flammable gasses, liquids, etc., stored out of the immediate work area.
- Keep hand tools in good condition—sharp, free of broken handles, free of mushroomed heads, etc.
- Keep wire rope, slings, shackles and other rigging equipment in good condition.
- Ensure saws and other equipment are properly guarded.
- Provide adequate shielding for all welding operations.
- Prohibit anyone from riding slabs that are being moved by crane or other handling devices.
- Require ground observer to be utilized with travel lifts.

Sources of information

Preston, H.K., “Practical Prestressed Concrete.” McGraw-Hill Education, P.O. Box 182605 Columbus, OH 43218.

“Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products.” Prestressed Concrete Institute, 200 West Adams St., Suite 2100, Chicago, IL 60606.


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