

8 RODWORK

Tools of the Trade

Introduction

This section provides an overview of hazards related to hand and power tools and outlines safe practices. Because of their potential severity, it is important to make every effort to reduce tool-related injuries.

Every year the abuse of hand tools causes eye injuries, puncture-wounds, broken bones, contusions, infections, and severed fingers, tendons, and arteries.

Although some power tools have guards and other safety devices providing a degree of protection, the best controls are hazard awareness, training, and common sense.

The most versatile tools we possess, our hands, are too often damaged by tool accidents. You would be working under a severe handicap without the full use of both hands. They can be caught in machines, crushed by objects, or cut by sharp-edged tools such as knives and saws. They can also be damaged by being burned, fractured, or sprained, unless you are always alert. Your hands are invaluable. Protect them from injury by following safe work practices with tools.

Eyes are highly susceptible to injury from tool use but eye injuries are almost always preventable. Use the guards and personal protective equipment which we all know are needed but are so easy to overlook.

Noise is unavoidable on some jobs, both from tools and from the working environment. Exposure to excessive noise can impair hearing. Prolonged exposure can result in permanent hearing damage and eventually deafness. Hearing protection should be worn whenever there is exposure to excessive noise.

Common Causes of Accidents

Typical causes of hand and power tool accidents in construction include

- using the wrong tool for the job
- tools falling from overhead
- sharp tools carried in pockets
- using cheaters on tool handles
- excessive vibration
- using tools with mushroomed heads
- failure to support or clamp work in position
- carrying tools by hand up or down ladders
- using damaged electrical cords or end connectors
- failure to use ground fault circuit interrupters (GFCIs), especially outdoors.

Safe Practices

Basic hazard awareness and common sense can prevent serious injuries caused by hand and power tools. As a general rule, follow the safe practices listed below.

- 1) **Dress right for the job.**
Wear the clothing and equipment designed for use with the tools of the trade (Figure 1.1).

Always wear eye protection. There is a constant risk of flying particles and dust when using hand and power tools. Appropriate eye protection is essential and must be worn by the user and others nearby.

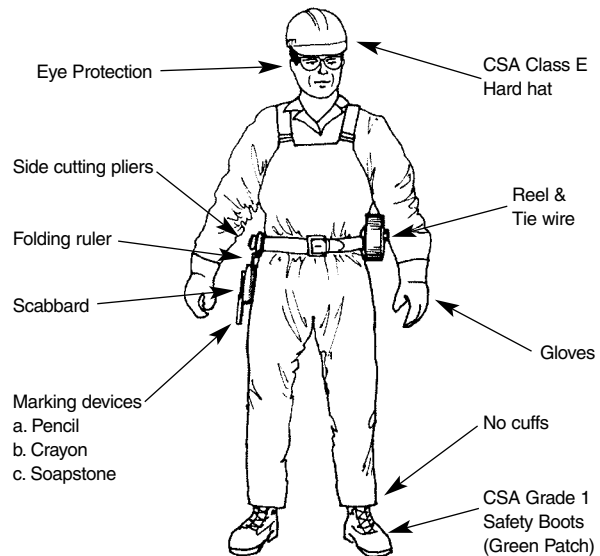


Figure 1.1: Rodworker ready to place reinforcing steel

- 2) **Use the right tool for the job.**
Using a cheater bar or pipe on a wrench handle or using pliers as a hammer are examples of the mistakes which commonly lead to accidents and injuries.
- 3) **Use tools as recommended by the manufacturer.**
For example, always use a proper wrench or hammer, not pliers. Misusing pliers will exert more force on the tool than it was designed for and cause wear, breakage, and injury.
- 4) **Remove damaged or broken tools from service.**
Hammers with cracked or loose handles, wrenches with worn jaws, damaged hickey bars, damaged extension cords, and ungrounded tools are all unsafe and should be removed from service and be either repaired or destroyed.
- 5) **Maintain tools in safe operating condition.**
Pliers with worn teeth can cause personal injury if they slip while you're tying wires.
Keep handles secure and safe.
Don't rely on friction tape to secure split handles or to prevent handles from splitting. Check wedges and handles frequently. Be sure heads are wedged tightly on handles. Keep handles smooth and free of rough or jagged surfaces. Replace handles that are split, chipped, or that cannot be refitted securely.
Keep cutting edges sharp.
Sharp tools make working easier, improve the accuracy of your work, save time, require less effort, and are safer than dull tools.
- 6) **Never climb ladders with tools in your hand.**
Tool holders and pouches free the hands while you are climbing or working on ladders, scaffolding, and other areas where access may be difficult. To carry tools up and down between levels, put them in substantial bags or boxes and raise and lower them with strong ropes.
- 7) **Non-ferrous, spark-resistant tools are recommended** where flammable materials or

explosive dusts or vapours might be present. These tools, such as brass or copper hammers or mallets, should always be used with caution. Remember—they may not guarantee safety in all explosive situations, such as the presence of gasoline vapours. It is always safer to eliminate the hazard by ensuring a safe atmosphere through isolation, ventilation, or purging.

- 8) **Protect the cutting edges of tools when carrying them.** Carry them in such a way that they will not be a hazard to yourself and others. Carry pointed or sharp-edged tools in pouches or holsters.
- 9) **Keep hand tools clean.** Protect them against damage caused by corrosion. Wipe off accumulated dirt and grease. Dip the tools occasionally in cleaning fluids or solvents and wipe them clean.
- 10) **Lubricate** adjustable and other moving parts to prevent wear and misalignment.
- 11) **When swinging a tool**, be absolutely sure that no one else is within range or can come within range of the swing or be struck by flying material.
- 12) **Falling tools** are a dangerous hazard for workers below. Keep track of tools, especially when working at heights on scaffolds or other access equipment. An unnoticed file or chipping hammer, if accidentally kicked off the work platform, is a deadly missile, as well as a tripping hazard for you. Where practical, tie tools off when working at heights.
- 13) **Hearing protection** should be worn whenever there is a risk of exposure to excessive noise. Noise is a hazard inherent in the construction industry: from your tools, from those nearby, and from the operating environment. Exposure to excessive noise can impair hearing. Prolonged exposure can result in permanent hearing damage and eventually deafness. Although power tools are only one of several possible noise sources, efforts should be made to provide the least noisy power tools which will still do the job.

Inspection and Repair

Tools should be inspected by a person qualified, through training and experience, to determine the safe condition of the tool. Worn or damaged tools should be tagged “**DEFECTIVE-DO NOT USE**” and returned to the shop for repair or replacement.

Regular inspection of all tools is necessary and should cover tool maintenance and service as specified in the operator’s manual. Observing the handling and storage of tools should also be a part of the inspection process. Responsibility for inspection is usually left to the supervisor. However, tools should be checked daily by those who use them.

Hand tools that get the heaviest use and abuse such as chisels, hammers, and wrenches should be inspected frequently and regularly.

Maintaining and repairing tools properly requires the right facilities and equipment. Only persons skilled in the repair of tools should be allowed to do so. Otherwise tools should be sent out to a qualified repair depot.

Use

The misuse of hand tools is a common cause of injury in

construction. In many cases, the injury results because it is assumed that everyone knows how to use most common hand tools. This is not the case.

It is the responsibility of the supervisor and employer to ensure that workers are trained in the safe and proper use of hand tools.

Hammers and Sledges

Hammers are made in various shapes and sizes for specific jobs. They should be selected and used only for the purpose intended. Hammers come in many types and styles, and although not a standard tool-belt item for rodworkers, they receive periodic use.

Basic Rules - Hammers

- Always wear eye protection.
- Make sure the handle is tight; never use a hammer with a loose or damaged handle.
- Always strike the work surface squarely with the hammer face; avoid glancing blows.
- Hold the hammer with wrist straight and hand tightly wrapped around the handle.
- Look behind and above before swinging the hammer.
- Never use a hammer to strike another hammer.
- Discard any hammer with dents, cracks, chips or mushrooming; redressing is **not** recommended.
- When striking another tool (chisel, punch, wedge, etc.), the striking face of the hammer should have a diameter at least 1/2 inch (1-1/4 cm) larger than the struck face of the tool.
- Never weld or reheat-treat a hammer.

Chipping hammers are designed for chipping slag off welds or burned edges. They can come in a variety of styles and handles. These hammers have long, slender or tapered points or edges, and can be resharpened many times.

Cutting Hand Tools

Rod and bar cutters

There are a few general precautions which should be followed when using these tools.

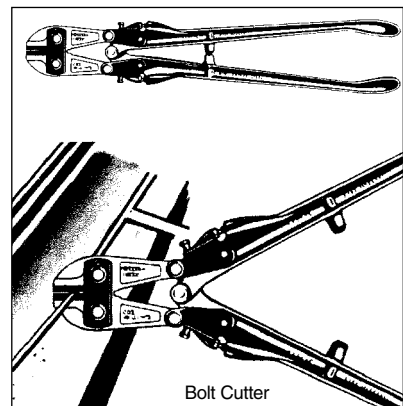
- Wear eye protection.
- Keep fingers clear of jaws and hinges.
- Cut ends can fly and cause injury; try wrapping burlap or a rag around the jaws while cutting.

Bolt Cutters

Bolt cutters typically come in lengths of 18” to 36” with the larger ones able to cut mild-steel bolts and rods up to 1/2” diameter, as well as other materials, such as wire rope.

Keep jaws at right angles to material.

Don’t pry or twist—chips can break off and fly dangerously, as well as damage the blade.



Manual Rebar Shears

These can be useful for cutting up to 15M (#6) bars or bigger.

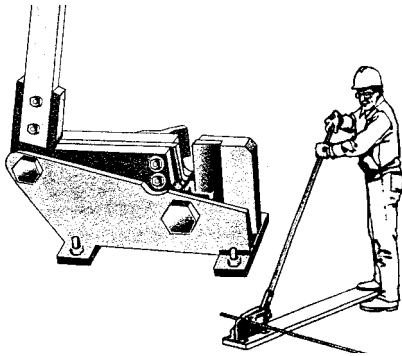


Figure 1.2
Manual Rebar Shear

Holding Tools

Wrenches

Regardless of the type of wrench, there is always the hazard that the wrench may slip off the work, or that the work may suddenly turn free. There is also the possibility that the wrench or work may break. The user should always be braced so as not to lose balance and be injured should the wrench get free for any reason. Always inspect a wrench for flaws, damaged parts, or wear, which can cause it to slip and damage fasteners.

There is a correct wrench for every job. If the wrench is too big it may not grip securely. Slippage and damage of the wrench or fastener may result, or the thread may be stripped because of over-torquing. Where possible, use penetrating oil to loosen tight nuts and bolts.

- Always grip the wrench so it will not cause injury if it slips.
- Use the correct jaw to avoid slippage. Box wrenches are safer than open-end wrenches since they are less likely to slip. Solid open-end wrenches of the correct size are generally more secure than an adjustable wrench, especially on hard-to-turn items.
- Discard any damaged box or open-end wrench. Don't attempt to repair a wrench with rounded or damaged points on the box end, or worn or spread jaws on the open end.
- Face adjustable wrench forward and turn wrench so pressure is against the permanent jaw (Figure 1.3).

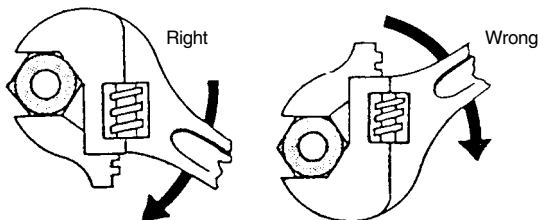


Figure 1.3

- Always **pull** on a wrench whenever possible. Do not push.
- Never overload a wrench by using a pipe extension on the handle or by striking the handle with a hammer. This can weaken the metal of the wrench and cause the tool to break. Heavy-duty box wrenches with extra long handles and “hammer” or striking-face wrenches

are available for these jobs. The striking-face wrenches with 12-point box openings are designed for striking with a ballpeen or sledge hammer. Both offset and straight styles are available but the straight type should be used when possible.

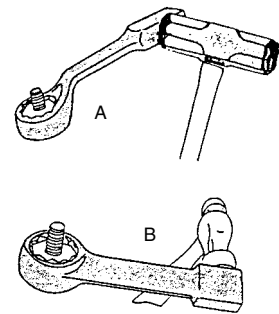


Figure 1.4: Hammer wrenches
(A) offset hammer wrench
(B) straight hammer wrench

Socket Wrenches

Socket wrench sets offer a multitude of options in both the types and sizes of the sockets and the variety of drivers available, including ratchet, universal, speeder, and their many extensions and adapters. When using adapters and adapting down in size, be careful not to over-torque a smaller socket and fastener with a larger driver.

Always use the correct size of socket; make sure it fits snugly. An oversize or sloppy fit can cause slippage and possible injury, as well as causing wear to both the socket and the fastener.

Never use “hand” sockets on a power drive or impact wrench. Hand sockets are normally brightly finished while power and impact sockets have a dull finish and usually thicker walls.

Pliers

Pliers, or specifically side-cutting pliers, are the rodworker's basic tool for tying reinforcing bars in place. The pliers used are usually 7-inch, 8-inch or 9-inch, although size is an individual preference.

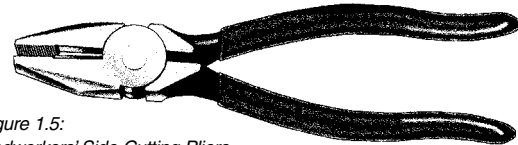


Figure 1.5:
Rodworkers' Side-Cutting Pliers

Many rodworkers prefer to use “high leverage side-cutting pliers” which are designed to give increased leverage while cutting.

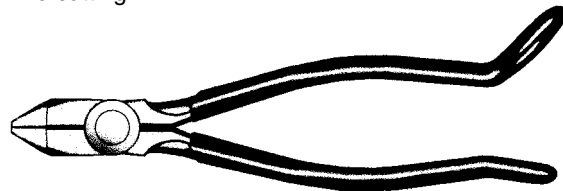


Figure 1.6: Rodworkers' High Leverage Pliers

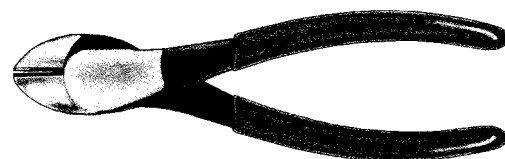


Figure 1.7: Rodworkers' Diagonal Side-Cutting Pliers

Pliers are frequently misused. They are meant for gripping and cutting and are not to be used as a wrench because their jaws are flexible and may slip.

Basic Safety Rules - Pliers

- Choose pliers with enough space between the handles to prevent pinching of the palm or fingers.
- Replace pliers when teeth or cutters are worn—they can slip and cause injury.
- Select pliers that have a grip span of 6 cm to 9 cm (2 1/2”-3 1/2”).
- Pull on pliers—don’t push.
- Side-cutting pliers may cause injuries when ends of wire are cut and fly into a worker’s eye.
- Eye protection should be worn when using side-cutters.
- Always cut at right angles; never rock from side to side against the cutting edges.
- Pliers used for electrical work should be insulated. But you must still shut off power first.
- Remember—cushion grips on handles are for comfort only and are not intended to protect against electrical shock.
- Never expose pliers to excessive heat; this may draw the temper and ruin the tool.
- Don’t use pliers as hammers; they might crack, break, or be nicked.
- Pliers should not be used to tighten nuts or bolts; use a proper wrench.

Pipe Wrenches

Pipe wrenches have been the cause of serious injuries when used on overhead jobs. Wrenches can slip on pipes or fittings, causing the worker to lose balance and fall. Pipe wrenches, straight or chain tong, should have sharp jaws and be kept clean to prevent slipping (Figure 1.8).

- The adjusting nut of the pipe wrench should be inspected frequently for cracks. A cracked nut may break under strain, causing wrench failure and serious injury.
- Use a wrench the right length and size for the job. A wrench that is too small will not provide enough leverage or grip. A wrench that is too big may strip the pipe threads or break the work, causing a sudden slip or fall.
- Face the pipe wrench forward. Turn the wrench so that pressure is against the heel jaw.
- Never use a “cheater” to extend a wrench handle to increase leverage. The cheater may strain the wrench or the work to the breaking point.

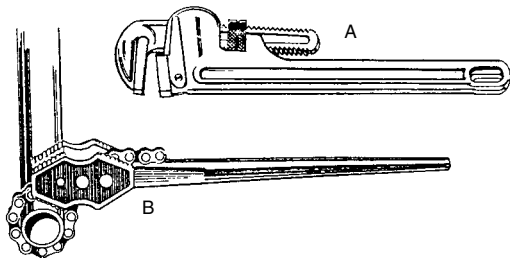


Figure 1.8: Some pipe wrenches: A Straight, B Torque Wrench Type

Hand Benders and Hickey Bars

- Generally suitable for 15M to 25M bars.
- Inspect tool before using.
- Make sure your footing and body position are such that you will not lose your balance.

- Take care when straightening or bending bars or dowels at the open edge of a structure. Rebar tends to be brittle and can snap if bent too much. Make sure you’re tied off safely before pushing or pulling outwards on bars along open edges.
- Avoid pinch points.
- Ensure there is enough clearance to make the bend.

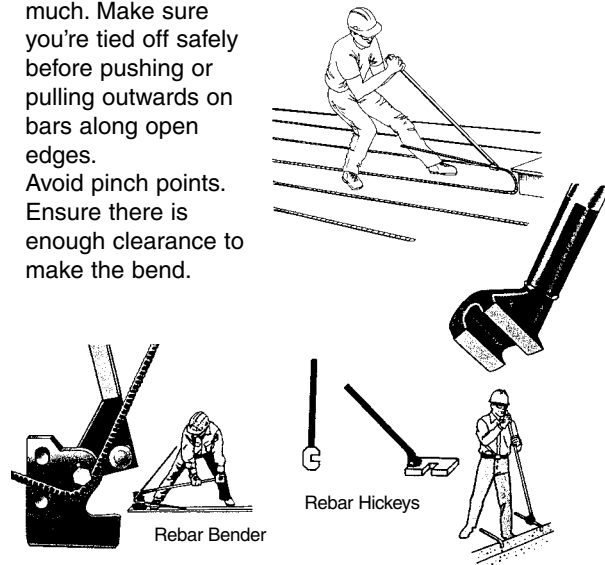


Figure 1.9: Hand Benders

Powered Rebar Fabrication Tools

The majority of rebar fabrication is done in the shop but there may be times when field fabrication is required, especially on relatively remote worksites. A selection of such tools is shown in Figures 1.10, Figure 1.11, and 1.12.

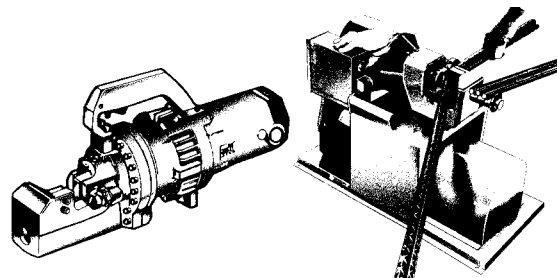


Figure 1.10: Electric or electric/hydraulic shears and cutters

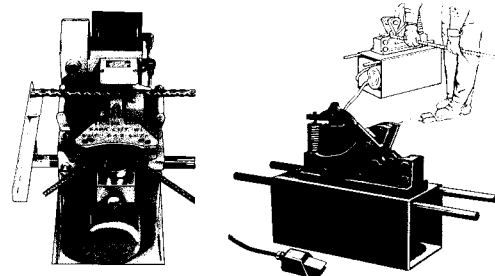


Figure 1.11: Electric or electric/hydraulic shears and cutters

Basic Precautions

- Be sure to wear eye protection.
- Keep fingers clear of blade or grip areas.
- Protect power supply lines from physical damage, such as traffic and sharp edges.

For Electric Tools

- Check that power supply matches equipment requirements.

- Use a ground fault circuit interrupter (GFCI).
- Have damaged cables replaced.

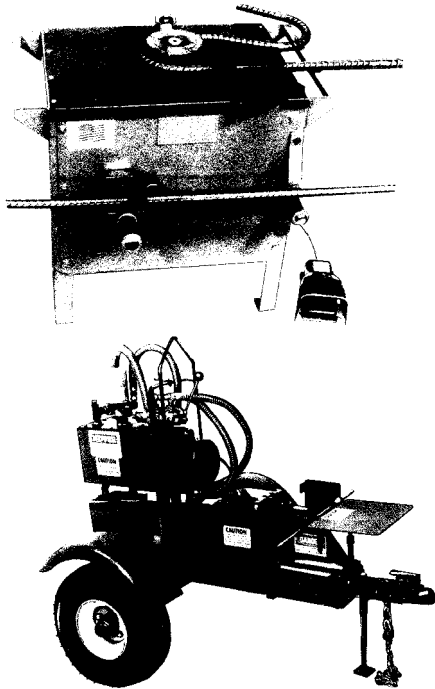


Figure 1.12: Electric/hydraulic benders and bender/cutters

For Hydraulic Tools

- Replace damaged or worn hoses.
- Make sure connections are clean and tight.
- Make sure pump and tool are matched.

Rebar-Tying Machine

The risk of work-related musculoskeletal disorders, such as low-back injury, while tying rebar with pliers is well documented. The high rate may be related to the frequency and repetition of two factors:

- 1) the static, awkward trunk posture while performing ground-level rebar tying; and
- 2) exposure to forceful hand exertion while using pliers to tie rebar.

One way to improve posture is to use an automatic rebar-tying machine. This is a battery-powered electric tool that can be applied where bars cross. When you press the trigger, the machine feeds the wire around the bars, twists it, and cuts it (see photos).



Research conducted by the Rodworkers' Labour-Management Health and Safety Committee has found that working with the rebar-tying machine can decrease repetitive forceful wrist activities such as the bending, twisting, and lateral bending associated with manual tying. Furthermore, using the rebar-tying machine can decrease static bending of the trunk, which in turn can decrease the risk of low-back injury.

When using the rebar-tying machine, several issues should be considered.

- Choose a rebar-tying machine that allows tying steel rebar at a comfortable back posture.
- Select a rebar-tying machine that can tie various rebar sizes.
- For slab-on-grade rebar, tying rebar with the rebar-tying machine will require the use of a long steel hook to lift rebar off the ground (see Photo 1).
- Many rebar-tying machines require warm-up during cold weather. Proper tying tension of the tool must therefore be adjusted on cold days.
- On very hot summer days, let the machine cool down during regular breaks and lunch. This can be done by placing the machine in a cool shady area.
- Working with the rebar-tying machine is very productive for a crew of 4-5 workers per site.
- The rebar-tying machine can help workers with low-back or hand injuries return to work.



Photo 1

Work Belts

When installing reinforcing steel on a vertical surface consisting of horizontal steel bar, a scaffold must be provided if the working height is more than 12 feet (3.7 metres). If a scaffold cannot be erected, a worker must wear a work belt while performing rebar work.

A work belt is a belt that has a back support pad and a connecting hook at the front and is capable of supporting a worker. A work belt allows both hands freedom of movement for work on a vertical wall. The belt is designed to secure the worker safely in position at the point of work but is not designed to arrest a free fall. Therefore a full-body harness with a secure anchorage system, such as an existing structural feature or temporary fixed support, must be used when a worker may fall more than 10 feet (3 metres) or onto hazardous objects or substances.

Rebar Storage

- Store near area of use.
- Use wooden spacers to separate piles.
- Check loading on floors.
- Make sure reshoring is in place on newly poured slabs.
- Keep rebar off ground on dunnage (4x4 sleepers).
- Make sure that the identification tags are clearly visible to avoid extra handling.
- Store so that bars are free of mud, oil, grease, etc.

Proper Tying and Straightening

Tying

- Before starting work, ensure that all openings and slab edges are protected by proper guardrails or coverings sturdy enough to prevent falls.
- 16-gauge wire is generally used for tying rebar unless a different size has been specified by the project engineer.
- The ends of tie wires should be bent over to prevent injury to workers rubbing or brushing against them.
- Never move backward when tying. Always advance to your work.
- When working on walls or columns use correct ties to prevent rebar from slipping.

Straightening

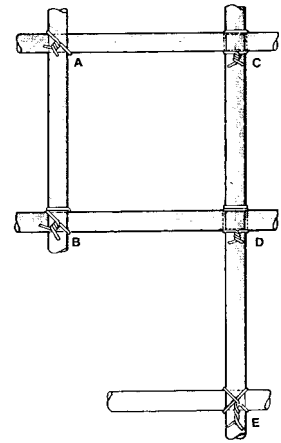
Quite often a rodworker will be assigned to straighten dowels projecting from a previous pour.

- Take particular care when straightening dowels at the open edge of a structure. Reinforcing steel tends to be brittle and can snap off when bent too much. This sudden break in a dowel rod has caused too many rodworkers to fall. Never push or pull outward on the rebar without first making sure that, if required, you are properly equipped with a fall protection system including a full-body harness tied off to a secure part of the structure.
- A hickey or pipe sleeve should be used to straighten bars larger than 15M.
- Mechanical help, such as a hydraulic jack, may be required to straighten bars over 30M.

Common Ties

There are various methods of hand-tying the intersections of bars. Some of the most common are the following:

- A. **Single Tie** is used normally to secure the bars in position against displacement.
- B. **Wrap and single tie** is normally used when tying wall reinforcement, holding the bars securely in position so that the horizontal bars do not shift during the construction progress or during concreting.
- C. **Saddle tie** is used for tying bars in beams, columns and walls in position.
- D. **Wrap and saddle tie** is used to secure heavy bars that are pre-assembled into units to be lifted by crane. These ties are subjected to considerable strain.
- E. **Figure-eight tie** is sometimes used in walls in place of the wrap and single tie.



Post-Tensioning

Pre-stressing is a means of achieving shallow, long-span, and attractive structural elements in concrete. Post-tensioning is generally used for on-site pre-stressing as opposed to carrying out precasting operations in a yard.

Post-tensioning essentially involves pouring the concrete member. Forming holes running the length of the member, where the steel tendons are located, allow the concrete to cure, and tensioning the tendons to high stress against steel anchors compresses the concrete member. Tendons usually have one fixed and one movable or floating stressing end.

Post-tensioning is not a common part of many rodworkers' activities, but it is a practice which some companies and therefore some rodworkers carry out from time to time. This area of the rodworkers' trade has some unique hazards and problems which need to be addressed.

Instruction on post-tensioning is the task of trade training. However, the following section highlights hazards, precautions, and safe practices.

Types of Post-Tensioning Systems

There are various proprietary systems, but they can generally be divided into three types with features as follows:

- 1) **Strand Systems**
 - Tendons made up normally of one or more 0.5-inch or 0.6-inch diameter 7-wire strand cables.
 - Single strand tendons held by split conical wedges in individual anchorage castings.

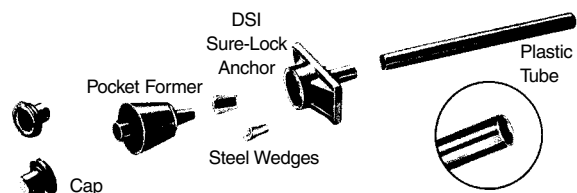


Figure 1.13
Single strand system

- Large multi-strand tendons can have from 31 to 55 strands (Figure 1.14).

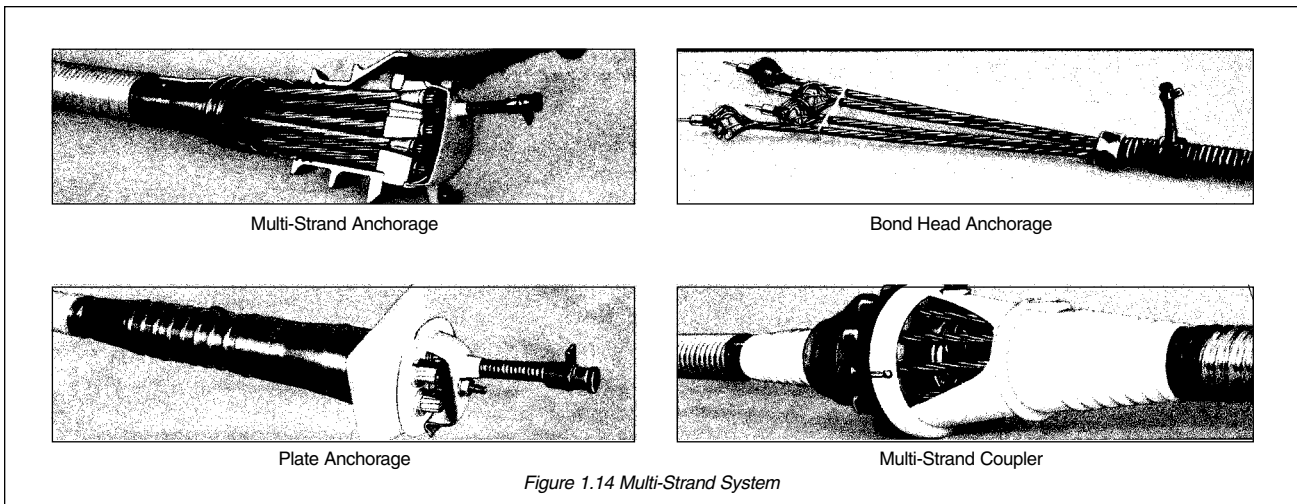


Figure 1.14 Multi-Strand System

- For multi-strand tendons, each strand is anchored by segmented steel wedges in an anchor head after passing through a “trumplate”: a welded assembly consisting of a trumpet (tube) and a bearing plate.
- 2) **Bar Systems** (Figure 1.15)
- High-strength bars (usually 1 inch to 1 3/8 inches) are used as tendons to apply compression to the concrete.
 - Threaded deformations in the bars allow anchorage, after stressing, using locknuts tightened against plate anchors.
 - The threaded deformations allow threaded couplers to attach two bars end-to-end.

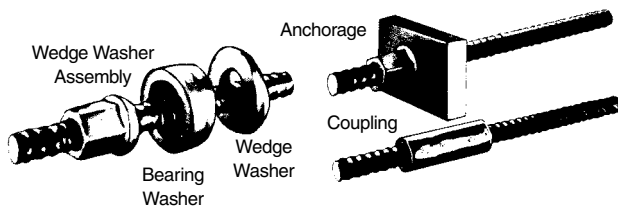


Figure 1.15: Bar Tendon with Plate Anchor

- 3) **Wire Systems** (Figure 1.16)
- They have not been used in Canada since about 1980 but could be encountered.

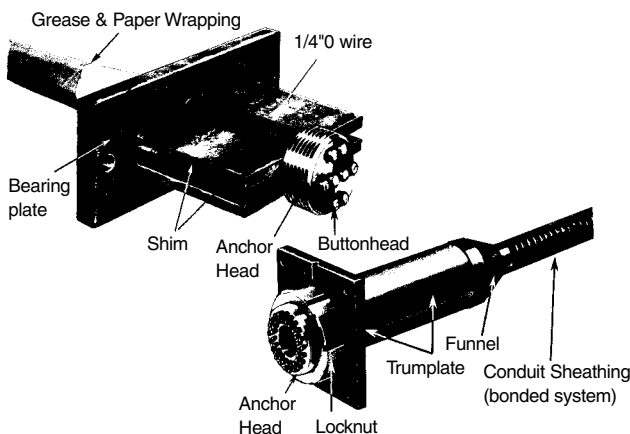


Figure 1.16: Wire Tendon Systems

- Tendons made up of high tensile wires of 1/4 inch diameter.
- Can consist of 2 to 180 wires in a tendon, although commonly from 8 to 46 wires.
- Wires are frequently prefabricated with button heads and pass through a predrilled anchorage plate, especially at the fixed end.
- Wires are stressed and anchored at movable ends by shims or a locknut against a bearing plate or a trumplate.

Bonded versus Unbonded

The three systems described above can be divided into “bonded” and “unbonded” systems depending on whether the tendon ducts are filled with grout after stressing (bonded), or whether the tendons are greased and paper-wrapped or greased and plastic-covered (unbonded). Most systems are adaptable for bonded or unbonded construction. For “bonded” installations, the duct, or conduit, is often installed first and the tendons pushed or pulled through after the concrete is poured.

Although not restricted, unbonded systems are more likely to occur in floor-slab applications which contain a large number of small tendons. Bonded tendon systems tend to have some structural advantage and tend to be used in beams and large structural members which use a small number of relatively large tendons so that grouting costs are less.

Bonded Systems

- The tendons are encased in a flexible conduit or duct.
- Conduit is placed and concrete is poured around the conduit.
- The tendons are placed (if not already in the ducts), stressed, and anchored.
- Finally, expanding grout is pumped in to fill the void inside the duct or conduit.

Unbonded Systems

- The strand, wire, or bars are greased and paper-wrapped, or greased and plastic-covered.
- The concrete is poured for the member, beam, girder, etc.
- The post-tensioning steel is then stressed and anchored.

Post-Tensioning Systems – Unloading, Handling, and Storage

The unloading, handling, storage, and distribution of all types of tendons for post-tensioning systems requires rodworkers to use their knowledge of good, safe rigging practices at all times.

General

- All types of systems, both bonded and unbonded, need to be handled with care to protect them from damage. Post-tensioning wires, 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 required.
- Extreme care with welding or welding equipment is required around post-tensioning materials. Strand failure can result from a single drop of molten weld metal on the strand. High temperature exposure before or during tensioning can cause failure of strands during tensioning.
- Post-tensioning stressing equipment is susceptible to damage and is expensive, so it must be stored in a secure, clean, and dry place.
- Coils or racks of tendons or individual tendons must be stored in a clean, dry area, at least four inches off the ground or work surface, protected from exposure to weather, etc.

Strand Systems

- Strand post-tensioning is usually shipped to the jobsite in coils held by steel banding.
- The coils are usually about five feet in diameter and about four feet high. Each coil weighs about 1,500 to 2,000 lbs. and contains about 20 to 40 individual tendons.
- Nylon web slings are generally recommended for lifting strand tendon coils to avoid any damage to the wrapping.
- Place the coils, if possible, on the deck as close as possible to where they are to be used. The steel banding holding the coil together can be cut to allow the tendons to be separated.
- Individual tendons can then be hoisted from the coil and placed on dunnage at least four inches off the ground or work surface, adjacent to the beam form in which they will be used. Individual tendons can often be manually handled.

Bar Systems

- Bar tendons are shipped to the site in pre-cut lengths and general handling practices are similar to those for other types of tendons. Since bar tendons are similar in appearance to rebar, take care to identify and separate them to avoid placing them as rebar by mistake.



Figure 1.17: Bundles of bar tendons stored on dunnage

Wire Systems

- General handling practices for wire tendons are similar to those for strand tendons but there are differences.
- Wire tendons are normally larger in diameter and weigh much more than individual strand tendons.
- Wire tendons are usually shipped on stacked metal rotatable shipping racks with metal arms separating individual tendons (Figure 1.18). Usually a number of tendons, up to eight to ten, are banded together with or without a rack.



Figure 1.18

Shipping racks help protect coiled tendons, simplify handling and placement.

- Individual wire tendons for use in slabs can usually be manually handled. Most individual beam wire tendons, however, weigh in excess of 200 lb. Hoisting equipment will be needed to lift them from the coil or shipping rack.
- Use nylon web slings to prevent damage to the sheathing.
- Take care when slinging wire tendon coils to balance the load with two or three slings and keep the coils level.
- **Hazard.** Do not attempt to cut the banding holding individual beam tendons in a coil. Each coiled wire tendon is like a large spring that, when released, will snap open and can cause serious injury. An uncoiling turntable must be used to control the uncoiling. Even though the spring forces may not be as high in wire tendons for use in slabs, take care when cutting banding.

Placing Pre-Stressing

There are many proprietary types of post-tensioning systems and each system—in some cases each application—has its own specific directions. The placement of pre-stressing strands in the beams, slabs, etc. varies and the supplier's or designer's instructions must be followed precisely in order for the system to perform properly.

If something does not check out, then let your foreman know immediately and the supplier can be contacted for clarification and correction.

Great care must be taken to follow post-tensioning placing drawings.

- Check that all tendons are accounted for and in the correct locations.
- Use extreme care to avoid damaging strands when they are being pulled into the bed with a tugger hoist or similar equipment.
- For bonded systems with ducts installed and strand-fed by a pusher or by pull-through be sure to - confirm that ducts are secure and continuously connected between anchorages

- cordon off area between pusher and strand cage when in use
- keep workers away from the front of the opposite anchorage to which the strand is pushed.
- Ensure that any added rebar needed to resist local stressing forces has been placed.

Strand Tendons

- The operation of uncoiling strand tendons can usually be accomplished by two rodworkers: one holding the end, while the other uncoils tendon on the deck.
- The tendon profile in the forms is accomplished by correct placement of slab bolsters, high chairs, and support bars. It is recommended that support bars for slab post-tensioning tendons be placed flat on the deck first at the proper spacing. After the tendons are rolled out, the support bars should be lifted and the individual chairs placed.
- Check conduit, plastic or paper-wrap, for rips or tears. These must be repaired with the tape supplied by the post-tensioning manufacturer (Figure 1.19). If concrete leaks in, it can affect proper wedge seating or result in inaccurate stressing forces.



Figure 1.19
Taping around casting, connector, and strand



Rodworker attaching anchorage assembly to forms

Wire Tendons

- Individual wire tendons for use in slabs can often be manually handled. Most individual beam wire tendons, however, weigh in excess of 200 lb. Hoisting equipment will be needed to lift them from the coil or shipping rack (Figure 1.20).
- Use nylon web slings to prevent damage to the sheathing.
- Take care when slinging wire tendon coils to balance the load with two or three slings and keep the coils level.



Figure 1.20
Rigging tendon with nylon slings being lowered on field tendon uncoiler

- **Hazard.** Do not attempt to cut the banding holding individual beam tendons in a coil.
- Always use extreme caution when cutting individual tendon coils. Each coiled wire tendon is like a large spring that, when released, will snap open and can cause serious injury. It's best to use a "field tendon uncoiler" or, as a less-desirable choice, a field-fabricated, wooden-sided "explosion box". This is usually made from 2x10 boards in a box configuration larger than the coil diameter.
- Even though the spring forces may not be as high in wire tendons for use in slabs, always take care when cutting banding. Cut the bands progressively as the tendon is pulled out—never together (Figure 1.21).



Figure 1.21
Cutting bands progressively, and crew of rodworkers using the uncoiling turntable

- Always inspect and perform any necessary repairs to wire tendon sheathing to ensure that concrete cannot enter the void during the initial pour.

- As always, care must be taken to follow the placing drawings exactly and to make sure that the tendons conform to their specified profiles.

Placing Concrete

- During concrete pouring and placing, any damage done to the sheathing must be repaired before proceeding. This is necessary to achieve full strength in the final concrete member.
- For example, during vibration of the concrete, any contact of the vibrator with the sheathing can quickly cause damage.

Stressing Operations

After the concrete for the structural member (slab, beam, girder, etc.) is poured, it must be given sufficient time to cure and reach adequate strength to resist post-tensioning forces. At this point the tendons can be stressed. The force required to stress tendons comes from a hydraulic pump and jacks (or rams) and must be transferred through whatever anchoring devices the system uses.

- Visually inspect concrete around the anchor. It should be free of voids and honeycombing. Report any significant voids.
- Ensure that the jack is securely supported and that the operating axis of the jack and the tendon are aligned.
- Before starting tensioning, operate the jack pump to check that everything is working properly. Do not run the ram to the end of its stroke or close it down and continue to pump; damage can result.
- Ensure that no one stands at either end of the tendon or below the jack during the stressing operation. Never stand between the hoses.

The hydraulic pump and jack combinations come in a variety of types to suit each type of proprietary post-tensioning system and application. Each has its own configuration for jacking against bearing plates or anchors on the end of the concrete member to apply tension to strand, wire, or bar tendons. Figures 1.22 and 1.23 show the various parts and applications of a representative system, including the rigging required to support the jacks for use.

Grouting (for bonded systems)

- Inspect the grout machine and the hoses to ensure their proper operation. Look for items such as loose fittings and damaged hoses.
- Grout is corrosive. Always wear eye protection, face protection, and gloves when grouting.
- Rinse grout off skin with water.

Good Work Practices

- Concrete quality and strength should be confirmed before stressing strands.
- Wedge plates must be shipped clean. Holes must be free of any dirt or rust. Wedges must be free of dirt and rust.
- Always follow manufacturer's instructions on jack handling and use.
- Internal jack parts must correspond to tendon size requirements.

- All hoses, hose connections, valves, and other components must be checked for defects before each use and any questionable items repaired or replaced to meet manufacturer's requirements.
- Free-cycle the jack for an operation check and bleed any air in accordance with the manufacturer's instructions.
- Unattended hydraulic pumps must be unplugged.
- It is important that the grips and strands are perfectly clean. A small piece of dirt between a wedge (jaw) and the steel case (barrel) can cause failure or slippage of the strand.
- Follow manufacturer's directions for cutting strands. Cutting with a burning torch can result in failures. Cutting off ends of a finished member may be permissible but remember—using a burning torch or welding equipment in the area can be dangerous for stressing operations.

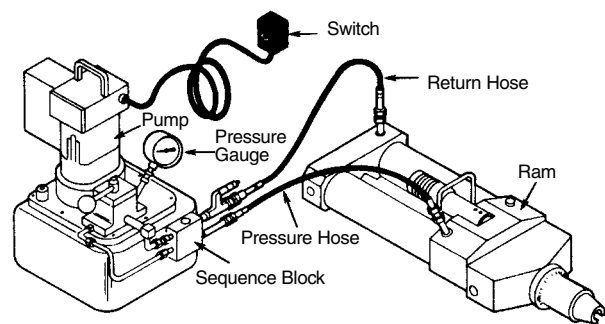


Figure 1.22
Single Strand Jacking System

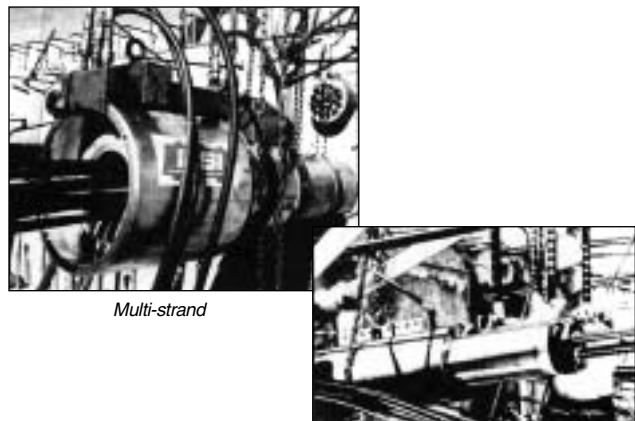


Figure 1.23: Hydraulic Pump and Jack Configurations

- Due to the heavy weight of jacks (50-ton jack with accessories weighs about 150 pounds, while a 200-ton weighs about 700 pounds), some rigging equipment will be needed to position and hold the jack for stressing operations.
- Use a crane if one is available. Another possible method of rigging the post-tensioning jacks is a rolling monorail system, such as shown in Figure 1.24.
- Sometimes a job-built jig can be used. Figure 1.25 shows a rolling scaffold used as trolley with an I-beam and chainfall arrangement being used to hoist, lower, and position a 250-ton jack. Note that counterbalance weights are needed with a good factor of safety to provide a safe platform.



Figure 1.24

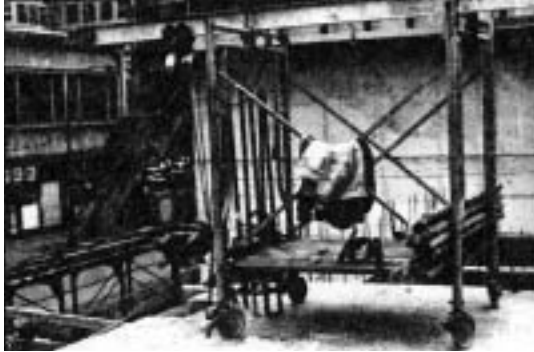


Figure 1.25
Rigs for positioning jack:

Precautions for Stressing Post-Tensioning Tendons

- Don't stand behind the jack while pressure is being applied. If threads are not fully engaged, the rod can come out of the jack like an arrow.
- Keep fingers out from between the shims or locknut and the bearing plate or anchor head. Fingers can be caught if hydraulic pressure is lost and the anchor head eases back toward the bearing plate.
- Before operating the pump make sure the rodworker operating the jack knows what you are doing and when. Communicate.
- Never stand on the concrete above or in front of the jack while pressure is being applied. If there is any honeycombing or poor concrete behind the bearing plate the jack can snap up.
- Don't run the ram out to its fullest extension or close it all the way and continue to pump. This can cause jack damage and possibly result in a high-pressure oil spray which can cause serious injury.
- Don't use pressure gauges that may be damaged or broken. They could result in inaccurate pressures, possible overstressing of tendons, and possible failures.