# CHAPTER 6

# RIGGING

Rigging is the method of handling materials using fiber line, wire rope, and associated equipment. Fiber line and wire rope were discussed in chapters 4 and 5. We will now discuss how these materials and equipment can be used in various tackle and lever arrangements to form the fundamental rigging necessary to move heavy loads. Additionally, we discuss the makeup of block and tackle, reeving procedures, and common types of tackle arrangements. Information is also provided on other common types of weight-handling devices, such as slings, spreaders, pallets, jacks, planks and rollers, blocking and cribbing, and scaffolds.

**SAFETY** is paramount in importance. You will be briefed throughout this chapter on safety measures to be observed as it pertains to the various operations or particular equipment we are discussing. Also, formulas are given for your use in calculating the working loads of various weight-moving devices, such as hooks, shackles, chains, and so on. SAFE rigging is the critical link in the weight-handling process.

## BLOCK AND TACKLE

The most commonly used mechanical device is block and tackle. A block (fig. 6-1) consists of one or more sheaves fitted in a wood or metal frame supported by a shackle inserted in the strap of the block. A **tackle** is an assembly of blocks and lines used to gain a mechanical advantage in lifting and pulling.

The mechanical advantage of a machine is the amount the machine can multiply the force used to lift or move a load. The strength of an individual determines the weight he or she can push or pull. The ability to push or pull is referred to as the amount of force the individual can exert. To move any load heavier than the force you can exert requires the use of a machine that can provide a mechanical advantage to multiply the force you can apply. If you use a machine that can produce a push or pull on an object that is 10 times greater than the force you apply, the machine has a mechanical advantage of 10. For example, if the downward pull on a block-and-tackle assembly requires 10 pounds of force to raise 100 pounds, the assembly has a mechanical advantage of 10.

In a tackle assembly, the line is reeved over the sheaves of blocks. The two types of tackle systems are simple and compound. A simple tackle system is an assembly of blocks in which a single line is used (fig. 6-2, view A). A compound tackle system is an assembly of blocks in which more than one line is used (fig. 6-2, view B).

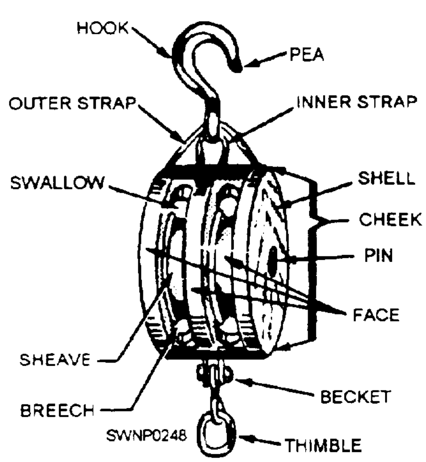


**Figure 6-1.—Parts of a fiber line block.**

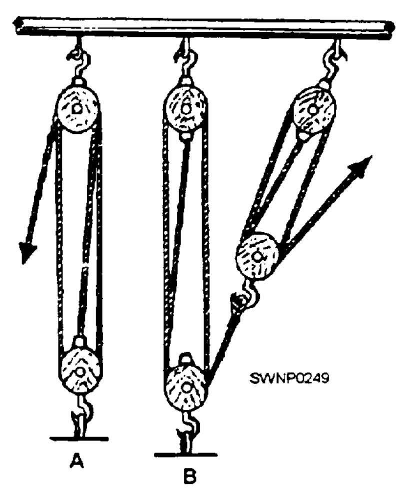


**Figure 6-2.—Tackles: A. Simple tackle; B. Compound tackle.**

The terms used to describe the parts of a tackle (fig. 6-3) and various assemblies of tackle are as follows:

• The block(s) in a tackle assembly change(s) the direction of pull, provides mechanical advantage, or both.

• The fall is either a wire rope or fiber line reeved through a pair of blocks to form a tackle.

• The hauling part of the fall leads from the block upon which the power is exerted.

• The fixed (or standing) block is the end which is attached to a becket.

• The movable (or running) block of a tackle is the block attached to a fixed objector support. When a tackle is being used, the movable block moves and the fixed block remains stationary.

• The frame (or shell), made of wood or metal, houses the sheaves.

• The sheave is a round, grooved wheel over which the line runs. Usually the blocks have one, two, three, or four sheaves. Some blocks have up to eleven sheaves.

• The cheeks are the solid sides of the frame or shell.

• The pin is a metal axle that the sheave turns on. It runs from cheek to cheek through the middle of the sheave.

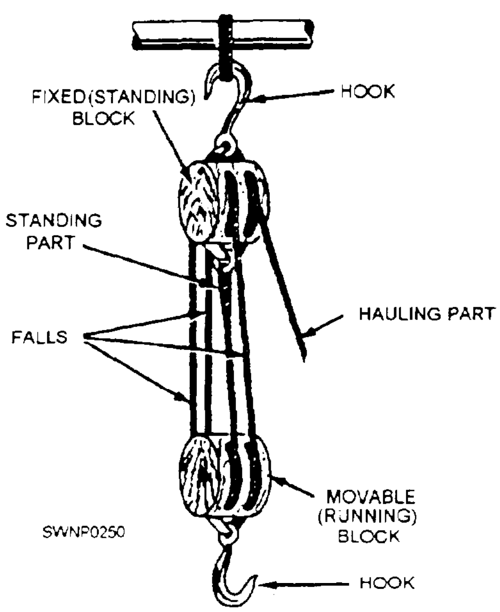


Figure 6-3.—Parts of a tackle.

• The becket is a metal loop formed at one or both ends of a block; the standing part of the line is fastened to the becket.

• The straps inner and outer) hold the block together and support the pin on which the sheaves rotate.

• The shallow is the opening in the block through which the line passes.

• The breech is the part of the block opposite the swallow.

• To overhaul means to lengthen a tackle by pulling the two blocks apart.

• To round in means to bring the blocks of a tackle toward each other, usually without a load on the tackle (opposite of overhaul).

• The term two blocked means that both blocks of a tackle are as close together as they can go. You may also hear this term called block and block.

## BLOCK CONSTRUCTION

Blocks are constructed for use with fiber line or wire rope. Wire rope blocks are heavily constructed and have large sheaves with deep grooves. Fiber line blocks are generally not as heavily constructed as wire rope blocks and have smaller sheaves with shallow, wide grooves. A large sheave is needed with wire rope to prevent sharp bending. Since fiber line is more flexible and pliable, it does not require a sheave as large as the same size that wire rope requires,

According to the number of sheaves, blocks are called **SINGLE, DOUBLE, OR TRIPLE** blocks. Blocks are fitted with a number of attachments, such as hooks, shackles, eyes, and rings. Figure 6-4 shows

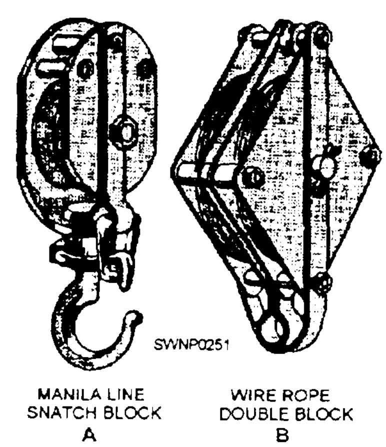


Figure 6-4.—Heavy-duty blocks.

two metal framed, heavy-duty blocks. Block A is designed for manila line, and block B is for wire rope.

## BLOCK TO LINE RATIO

The size of a fiber line block is designated by the length in inches of the shell or cheek. The size of standard wire rope block is controlled by the diameter of the rope. With nonstandard and special-purpose wire rope blocks, the size is found by measuring the diameter of one of its sheaves in inches.

Use care in selecting the proper size line or wire for the block to be used. If a fiber line is reeved onto a tackle whose sheaves are below a certain minimum diameter, the line becomes distorted which causes unnecessary wear. A wire rope too large for a sheave tends to be pinched which damages the sheave. Also, the wire will be damaged because the radius of bend is too short. A wire rope too small for a sheave lacks the necessary bearing surface, puts the strain on only a few strands, and shortens the life of the wire.

With fiber line, the length of the block used should be about three times the circumference of the line. However, an inch or so either way does not matter too much; for example, a 3-inch line may be reeved onto an 8-inch block with no ill effects. Normally, you are more likely to know the block size than the sheave diameter; however, the sheave diameter should be about twice the size of the circumference of the line used.

Wire rope manufacturers issue tables that give the proper sheave diameters used with the various types and sizes of wire rope they manufacture. In the absence of these, a rough rule of thumb is that the sheave diameter should be about 20 times the diameter of the wire. Remember, with wire rope, it is the diameter, rather than circumference, and this rule refers to the diameter of the sheave, rather than to the size of the block, as with line.

## TYPES OF BLOCKS

A **STANDING BLOCK** is a block that is connected to a fixed object.

A **TRAVELING BLOCK** is a block that is connected to the load that is being lifted. It also moves with the load as the load is moved.

A **SNATCH BLOCK** (fig. 6-5) is a single sheave block fabricated so the shell opens on one side at the base of the hook to allow a rope to slip over the sheave without threading the end through the block. Snatch

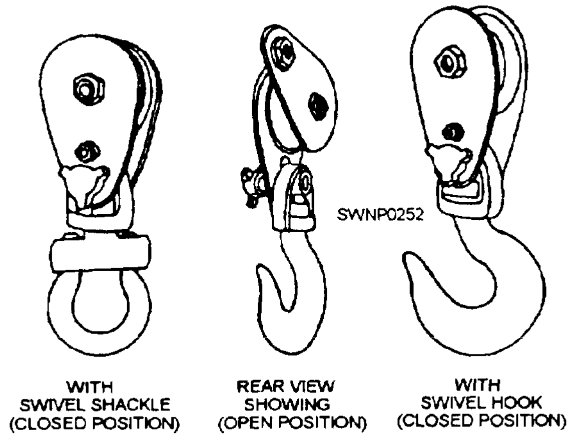


**Figure 6-5.—Snatch blocks.**

blocks are used when it is necessary to change the direction of pull on the line.

## REEVING BLOCKS

To reeve blocks in simple tackle, you must first lay the blocks a few feet apart. The blocks should be placed down with the sheaves at right angles to each other and the becket bends pointing toward each other.

To start reeving, lead the standing part of the falls through one sheave of the block that has the greatest number of sheaves. Begin at the block fitted with the becket. Next pass the standing part around the sheaves from one block to the other, making sure no lines are crossed until all sheaves have a line passing over them. Now secure the standing part of the falls at the becket of the block having the fewest number of sheaves, using a becket hitch for temporary securing or an eye splice for permanent securing.

When blocks have two or more sheaves, the standing part of the fall should be led through the sheave closest to the center of the block. This places the strain on the center of the block and prevents the block from toppling and the lines from being chafed and cut through by rubbing against the edges of the block.

Falls are normally reeved through 8-inch or 10-inch wood or metal blocks, in such away as to have the lower block at right angles to the upper. Two 3-sheave blocks are the traditional arrangement, and the method of reeving is shown in figure 6-6. The hauling part has to go through the middle sheave of the upper block or the block will tilt to the side and the falls will jam under load.

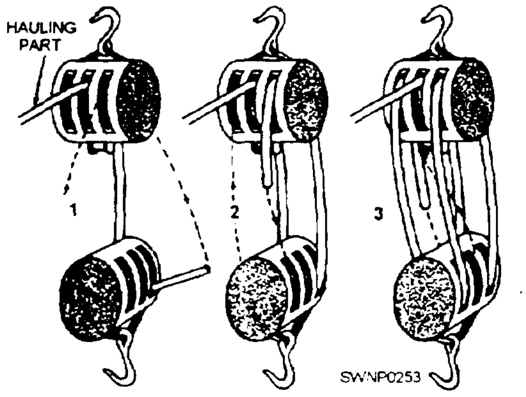


Figure 6-6.—Reeving two 3-sheave blocks.

If a 3- and 2-sheave block rig is used, the method of reeving is almost the same (fig. 6-6), but the becket for the deadman must be on the lower instead of the upper block.

You reeve the blocks before you splice in the becket thimble, or you will have to reeve the entire fall through from the opposite end. For the sake of appearance, if the becket block has a grommet, it is better to take it out and substitute a heart-shaped thimble. Splice it with a tapered eye splice, and worm, parcel, and serve the splice if you want a sharp-looking job.

## TYPES OF TACKLE

**SINGLE-WHIP** tackle consists of one single sheave block (tail block), attached to a support with a line passing over the sheave (fig. 6-7). It has a mechanical advantage of 1, and if a load of 50 pounds were to be lifted, it would require 50 pounds of force to lift it, plus allowance for friction.

A **RUNNER** is a single sheave movable block that is free to move along the line for which it is rove. It has a mechanical advantage of 2.

A **GUN TACKLE** is made up of two single sheave blocks (fig. 6-8). The name of the tackle originated when it was being used in the old days of muzzle-loading guns. After the guns were fired and reloaded, this tackle was used to haul the guns back to the battery.

A gun tackle has a mechanical advantage of 2. Therefore, to lift a gun weighing 200 pounds requires a force of 100 pounds without considering friction.

By inverting any tackle, you should gain a mechanical advantage of 1. This occurs because the number of parts at the movable block has increased.

By inverting a gun tackle, as an example, you should gain a mechanical advantage of 3 (fig. 6-9). When a tackle is inverted, the direction of pull is always difficult. This can be overcome easily by using a snatch block, It changes the direction of pull but does not increase the mechanical advantage.

A **SINGLE-LUFF TACKLE** consists of a double and a single block (fig. 6-10). This type of tackle has a mechanical advantage of 3.

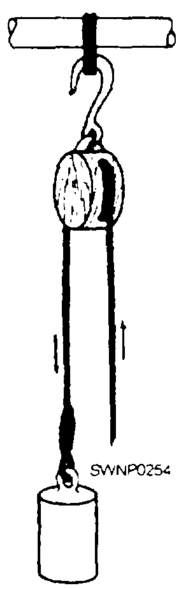


Figure 6-7.—A single-whip tackle.

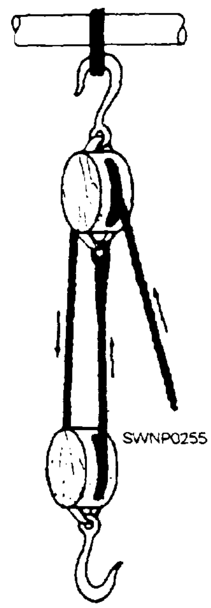


Figure 6-8.—A gun tackle.

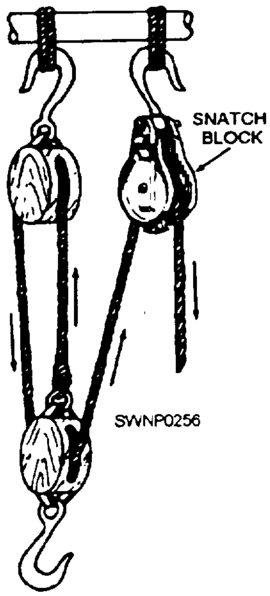


**Figure 6-9.—An inverted gun tackle.**

A **TWOFOLD PURCHASE** tackle consists of two double blocks (fig. 6-11). It has a mechanical advantage of 4.

A **DOUBLE-LUFF** tackle consists of a triple block and a double block (fig. 6-12). It has a mechanical advantage of 5.

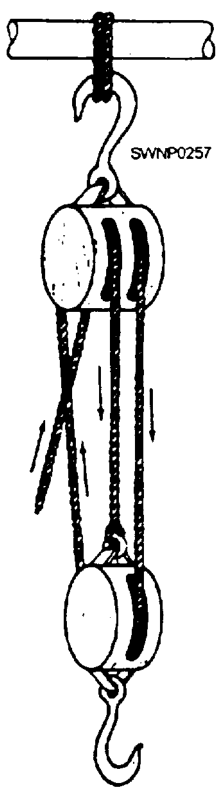


**Figure 6-10.—A single-luff tackle.**

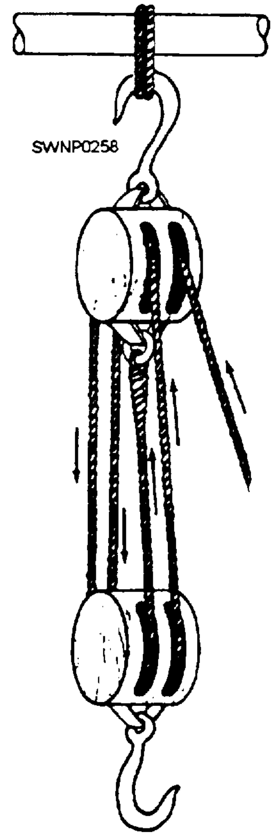


**Figure 6-11.—A twofold purchase.**

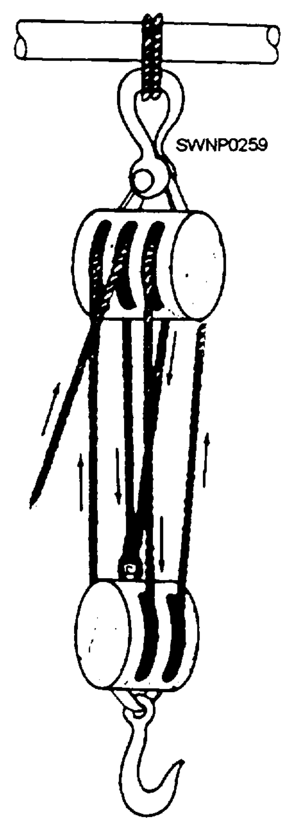


**Figure 6-12.—A double-luff tackle.**

A **THREEFOLD PURCHASE** consists of two triple blocks and has a mechanical advantage of 6 (fig. 6-13).

A **COMPOUND TACKLE** is a rigging system using more than one line with two or more blocks. Compound systems are made up of two or more simple systems. The fall line from one simple system is secured to the hook on the traveling block of another simple system, which may have one or more blocks.

To determine the mechanical advantage of a compound tackle system, you must determine the mechanical advantage of each simple system in the compound system. Next, multiply the individual advantages to get the overall mechanical advantage. As an example, two inverted luff tackles, each has a mechanical advantage of 4. Therefore, the mechanical advantage of this particular compound system is 4 x 4 = 16.

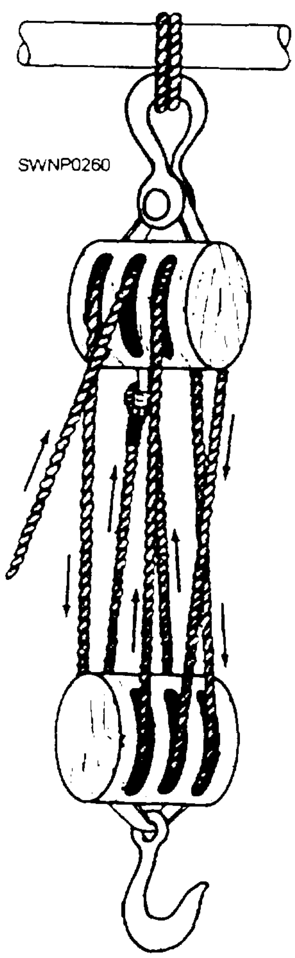


**Figure 6-13.—A threefold purchase.**

**ALLOWANCE FOR FRICTION**

Because of friction, some of the force applied to tackle is lost. Friction develops in tackle by the lines rubbing against each other or the shell of the block. It is also caused by the line passing over the sheaves or by the rubbing of the pin against the sheaves. Each sheave in the tackle system is expected to create a resistance equal to 10 percent of the weight of the load. Because of fiction, a sufficient allowance for loss must be added to the weight being moved in determining the power required to move the load.

As an example, you have to lift a 1,000-pound load with a twofold purchase. To determine the total force needed to lift the load, you take 10 percent of 1,000 pounds, which is 100 pounds. This figure is multiplied by 4 (the number of sheaves), which gives you 400 pounds. This value is added to the load; therefore, the total load is 1,400 pounds. This figure is divided by 4, the mechanical advantage of a twofold purchase, which results in 350 pounds being the force required to move the load.

**BLOCK SAFETY**

• Safety rules you should follow when using blocks and tackle are as follows:

• Always stress safety when hoisting and moving heavy objects around personnel with block and tackle.

• Always check the condition of blocks and sheaves before using them on a job to make sure they are in safe working order. See that the blocks are properly greased. Also, make sure that the line and sheave are the right size for the job.

• Remember that sheaves or drums which have become worn, chipped, or corrugated must not be used because they will injure the line. Always find out whether you have enough mechanical advantage in the amount of blocks to make the load as easy to handle as possible.

• You must NOT use wire rope in sheaves and blocks designed for fiber line. They are not strong enough for that type of service, and the wire rope will not properly fit the sheaves grooves. Likewise, sheaves and blocks built for wire rope should NEVER be used for fiber line.

**SLINGS**

Slings are widely used for hoisting and moving heavy loads. Some types of slings come already made. Slings may be made of wire rope, fiber line, or chain.

## SLINGS AND RIGGING GEAR KITS

The NCF has slings and rigging gear in the battalion Table of Allowance to support the rigging operations and the lifting of CESE. The kits 80104, 84003, and 84004 must remain in the custody of the supply officer in the central toolroom (CTR). The designated embarkation staff and the crane test director monitor the condition of the rigging gear. The rigging kits must be stored undercover.

## WIRE ROPE SLINGS

Wire rope slings offer advantages of both strength and flexibility. These qualities make wire rope adequate to meet the requirements of most crane hoisting jobs; therefore, you will use wire rope slings more frequently than fiber line or chain slings.

## FIBER LINE SLINGS

Fiber line slings are flexible and protect the finished material more than wire rope slings; however, fiber line slings are not as strong as wire rope or chain slings. Also, fiber line is more likely to be damaged by sharp edges on the material being hoisted than wire rope or chain slings.

## CHAIN SLINGS

Chain slings are frequently used for hoisting heavy steel items, such as rails, pipes, beams, and angles. They are also handy for slinging hot loads and handling loads with sharp edges that might cut the wire rope.

Chain sizes, inspection, safe working load, and handling and care will be discussed after wire rope and fiber line, as their characteristics have been discussed in previous chapters.

## USING WIRE ROPE AND FIBER LINE SLINGS

Three types of fiber line and wire rope slings commonly used for lifting a load are the **ENDLESS,** the **SINGLE LEG,** and the **BRIDLE** slings.

An **ENDLESS SLING,** usually referred to by the term *sling,* can be made by splicing the ends of a piece of fiber line or wire rope to form an endless loop. An endless sling is easy to handle and can be used as a **CHOKER HITCH** (fig. 6-14).

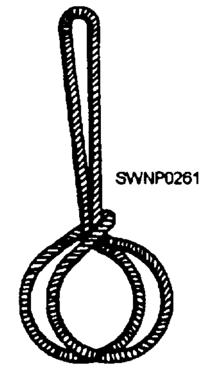


**Figure 6-14.—Endless sling rigged as a choker hitch.**

A **SINGLE-LEG SLING,** commonly referred to as a strap, can be made by forming a spliced eye in each end of a piece of fiber line or wire rope. Sometimes the ends of a piece of wire rope are spliced into eyes around thimbles, and one eye is fastened to a hook with a shackle. With this arrangement, the shackle and hook are removable.

The single-leg sling maybe used as a choker hitch (fig. 6-15, view A) in hoisting by passing one eye through the other eye and over the hoisting hook. The single-leg sling is also useful as a double-anchor hitch (fig. 6-15, view B). The double-anchor hitch works

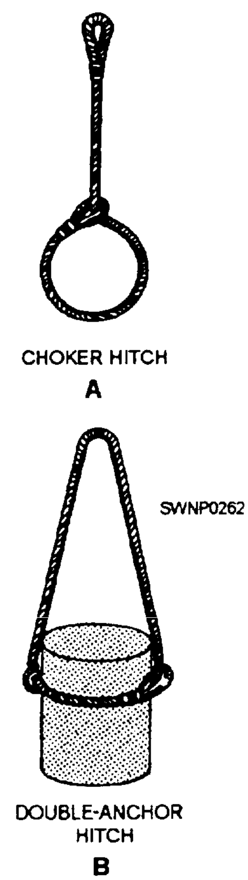


**Figure 6-15.—Methods of using single-leg slings.**

well for hoisting drums or other cylindrical objects where a sling must tighten itself under strain and lift by friction against the sides of the object.

Single-leg slings can be used to make various types of **BRIDLES.** Three common uses of bridles are shown in figure 6-16. Either two or more single slings may be used for a given combination.

The bridle hitch provides excellent load stability when the load is distributed equally among each sling leg, the load hook is directly over the center of gravity of the load, and the load is raised level. The use of bridle slings requires that the sling angles be carefully determined to ensure that the individual legs are not overloaded.

**NOTE:** It is wrong to conclude that a three- or four-leg bridle will safely lift a load equal to the safe load on one leg multiplied by the number of legs. This is because there is no way of knowing that each leg is carrying its share of the load.

With a four-legged bride sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two legs only balance it. COMSECOND/COMTHIRDNCB strongly recommend that the rated capacity for two-leg bridle slings listed in the COMSECOND/COMTHIRDNCBINST 11200.11 be used also as the safe working load for three- or four-leg bridle hitches.

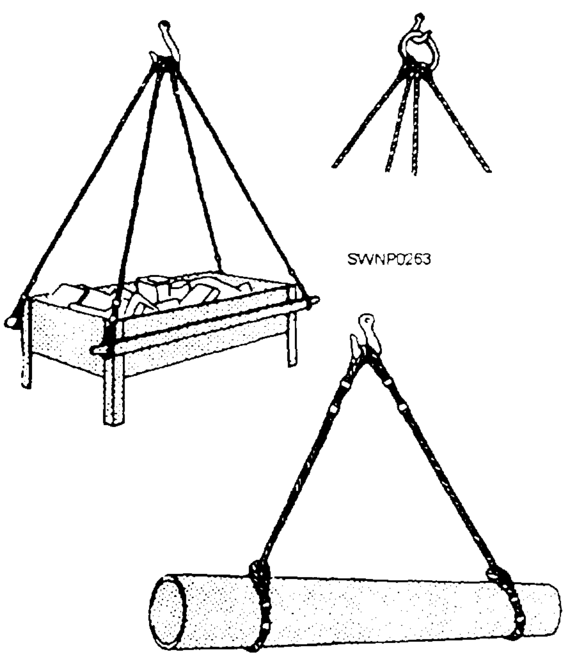


**Figure 6-16.—Multi-legged bridle stings.**

## SLING INSPECTION

All slings must be visually inspected for obvious unsafe conditions before each use. A determination to remove slings from service requires experience and good judgment, especially when evaluating the remaining strength in a sling after allowing for normal wear. The safety of the sling depends primarily upon the remaining strength. Wire rope slings must be immediately removed from service if any of the following conditions are present:

- Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay
- Wear or scraping on one third of the original diameter of outside individual wires
- Kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure
- Evidences of heat damage
- 1 End attachments that are cracked, deformed, or worn
- Hooks that have an obviously abnormal (usually 15 percent from the original specification) throat opening, measured at the narrowest point or twisted more than 10 degrees from the plane of the unbent hook
- Corrosion of the wire rope sling or end attachments

To avoid confusion and to eliminate doubt, you must not downgrade slings to a lower rated capacity. A sling must be removed from service if it cannot safely lift the load capacity for which it is rated. Slings and hooks removed from service must be destroyed by cutting before disposal. This ensures inadvertent use by another unit.

When a leg on a multi-legged bridle sling is unsafe, you only have to destroy the damaged or unsafe leg(s). Units that have the capability may fabricate replacement legs in the field, provided the wire rope replacement is in compliance with specifications. The NCF has a hydraulic swaging and splicing kit in the battalion Table of Allowance (TOA). The kit, 80092, contains the tools and equipment necessary to fabricate 3/8- through S/S-inch sizes of wire rope slings. Before use, all fabricated slings must be proof-tested as outlined in the COMSECOND/COMTHIRDNCBINST 11200.11.

## PROOF TESTING SLINGS

All field-fabricated slings terminated by mechanical splices, sockets, and pressed and swaged terminals must be proof-tested before placing the sling in initial service.

The COMSECOND/COMTHIRDNCBINST 11200.11 has rated capacity charts enclosed for numerous wire rope classifications. You must know the diameter, rope construction, type core, grade, and splice on the wire rope sling before referring to the charts. The charts provide you the vertical-rated capacity for the sling. The test weight for single-leg bridle slings and endless slings is the vertical-rated capacity (V. R. C.) multiplied by two or (V.R.C. x 2 = sling test weight).

The test load for multi-legged bridle slings must be applied to the individual legs and must be two times the vertical-rated capacity of a single-leg sling of the same size, grade, and wire rope construction. When slings and rigging are broken out of the TOA for field use, they must be proof-tested and tagged&fore being returned to CTR for storage.

Check fiber line slings for signs of deterioration caused by exposure to the weather. Ensure none of the fibers have been broken or cut by sharp-edged objects.

## SLING SAFE WORKING LOADS

There are formulas for estimating the loads in most sling configurations. These formulas are based on the safe working load of the single-vertical hitch of a particular sling. The efficiencies of the end fittings used also have to be considered when determining the capacity of the combination.

The formula used to compute the safe working load (SWL) for a **BRIDLE HITCH** with two, three, or four legs (fig. 6-17) is SWL (of single-vertical hitch) times H (Height) divided by L (Length) times 2 = SWL. When the sling legs are not of equal length, use the smallest H/L measurement. This formula is for a two-leg bridle hitch, but it is strongly recommended it also be used for the three- and four-leg hitches.

**NOTE:** Do NOT forget it is wrong to assume that a three- or four-leg hitch can safely lift a load equal to the safe load on one leg multiplied by the number of legs.

Other formulas are as follows:

**Single-basket hitch** (fig. 6-18):

For vertical legs:

SWL = SWL (of single-vertical hitch) x 2.

For inclined legs:

SWL = SWL (of single-vertical hitch) x H divided by L x 4.

**Double-basket hitch** (fig. 6-19):

For vertical legs:

SWL = SWL (of single-vertical hitch) x 4.

For inclined legs:

SWL = SWL (of single-vertical hitch) x H divided by L x 4.

**Single-choker hitch** (fig. 6-20):

For sling angles of 45 degrees or more:

SWL = SWL (of single-vertical hitch) x 3/4 (or .75).

Sling angles of less than 45 degrees are not recommended; however, if they are used, the formula is as follows:

SWL = SWL (of single-vertical hitch) x A/B.

**Double-choker hitch** (fig. 6-21):

For sling angle of 45 degrees or more:

SWL = SWL (of single-vertical hitch) x 3 divided by 4 x H divided by L x 2.

Sling angles of less than 45 degrees:

SWL = SWL (of single-vertical hitch) x A divided by B x H divided by L x 2.

When lifting heavy loads, you should ensure that the bottom of the sling legs is fastened to the load to prevent damage to the load. Many pieces of equipment have eyes fastened to them during the process of manufacture to aid in lifting. With some loads, though, fastening a hook to the eye on one end of each sling leg suffices to secure the sling to the load.

Use a protective pad when a fiber line or wire rope sling is exposed to sharp edges at the comers of a load. Pieces of wood or old rubber tires are fine for padding.

## SLING ANGLE

When using slings, remember that the greater the angle from vertical, the greater the stress on the sling legs. This factor is shown in figure 6-22.

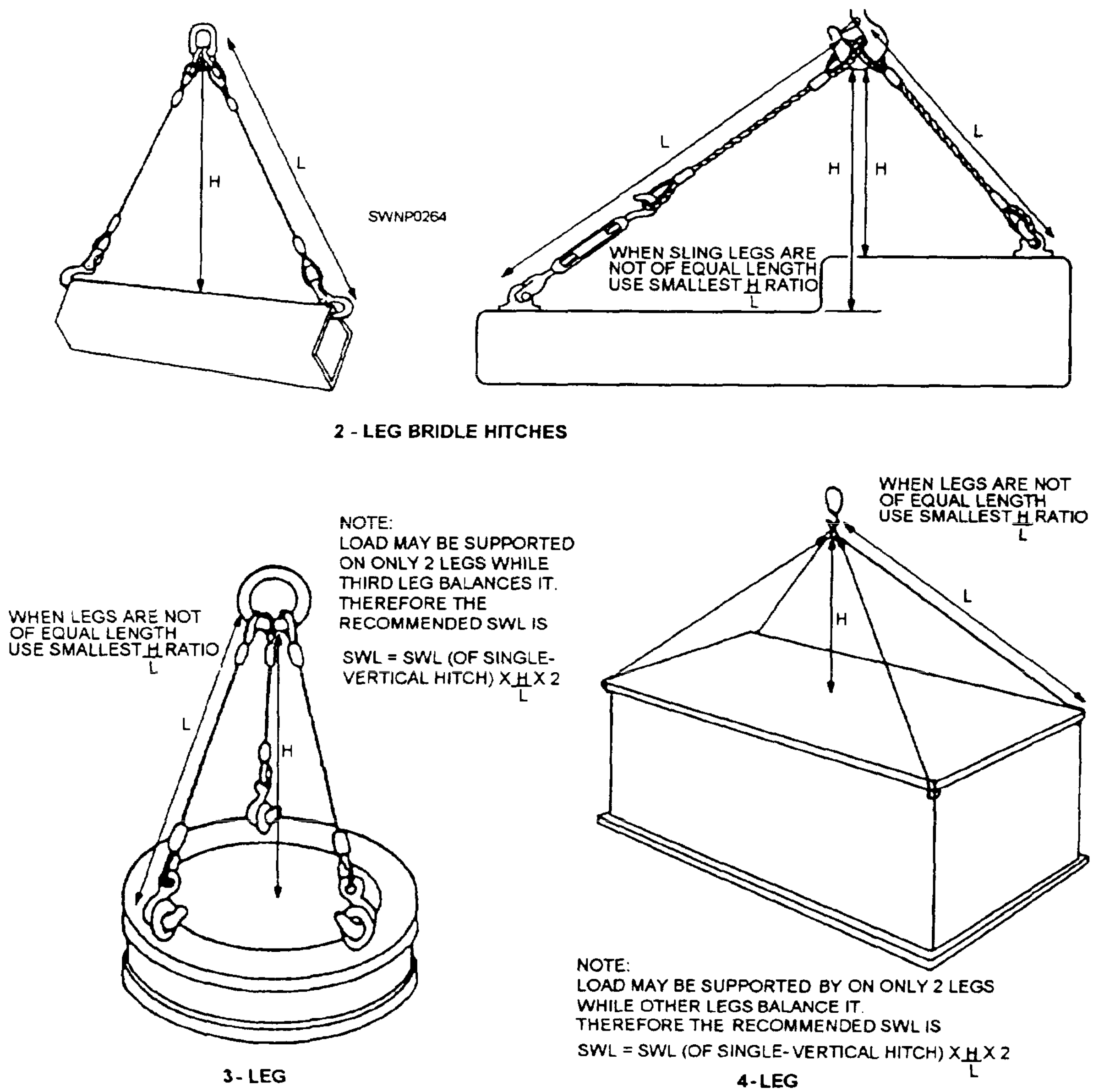


**Figure 6-17.—Determination of bridle hitch sling capacity.**

The rated capacity of any sling depends on the size, the configuration, and the angles formed by the legs of the sling and the horizontal. A sling with two legs used to lift a 1,000-pound object will have 500 pounds of the load on each leg when the sling angle is 90 degrees. The load stress on each leg increases as the angle decreases. For example, if the sling angle is 30 degrees when lifting the same 1,000-pound object, the load is 1,000 pounds on each leg. Try to keep all sling angles greater than 45 degrees; sling angles approaching 30 degrees are considered extreme] y hazardous and must be avoided.

## STORAGE

Wire rope slings and associated hardware must be stored either in coils or on reels, hung in the rigging loft, or laid on racks indoors to protect them from corrosive weather and other types of damage, such as kinking or being backed over. Slings are not to be left out at the end of the workday.

## CHAINS

Chains are made up of links fastened through each other. Each link is fabricated of wire bent into an oval and welded together. The weld usually causes a slight

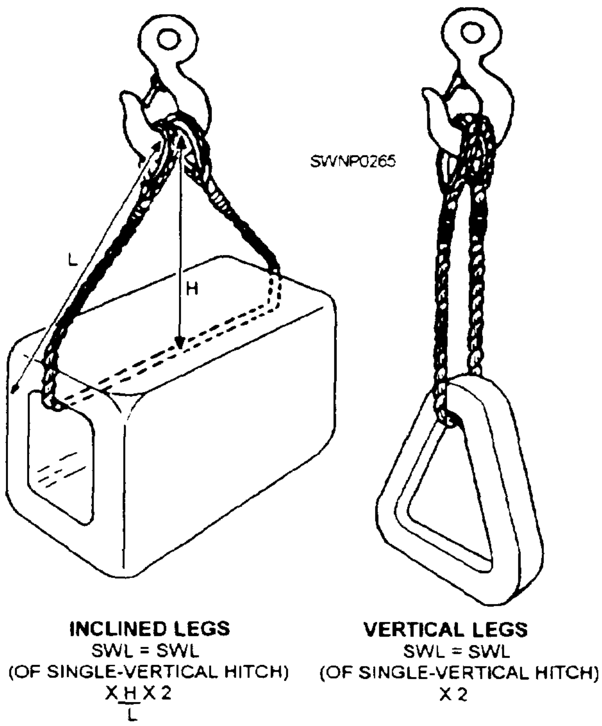


**Figure 6-18.—Determination of single-basket hitch sting capacity.**

bulge on the side or end of the link. Chain size refers to the diameter, in inches, of the wire used to fabricate the chain.

In the NCF, never use a chain when it is possible to use wire rope. **Chain does not give any warning that it is about to fail.** Wire rope, on the other hand, fails a strand at a time, giving you warning before failure actually occurs.

**NOTE:** Although chain gives no warning of failure, it is better suited than wire rope for some jobs. Chain is more resistant to abrasion, corrosion, and heat. Additionally, use chains to lift heavy objects with sharp edges that could cut wire or are hot. When chain is used as a sling, it has little flexibility but grips the load well.

## CHAIN INSPECTION

First, you must be aware that chains normally stretch under excessive loading and individual links will be bent slightly. Therefore, bent links are a warning that the chain has been overloaded and may fail suddenly under load. Before lifting with a chain, make sure the chain is free from twists and kinks. A twisted or kinked chain placed under stress could fail even when handling a light load. Additionally, ensure that the load is properly seated in the hook (not on the point) and that the chain is free from nicks or other damage. Avoid sudden jerks in lifting and lowering the load, and always consider the angle of lift with a sling chain bridle.

The strength of any chain is negatively affected when it has been knotted, overloaded, or heated to temperatures above 500°F.

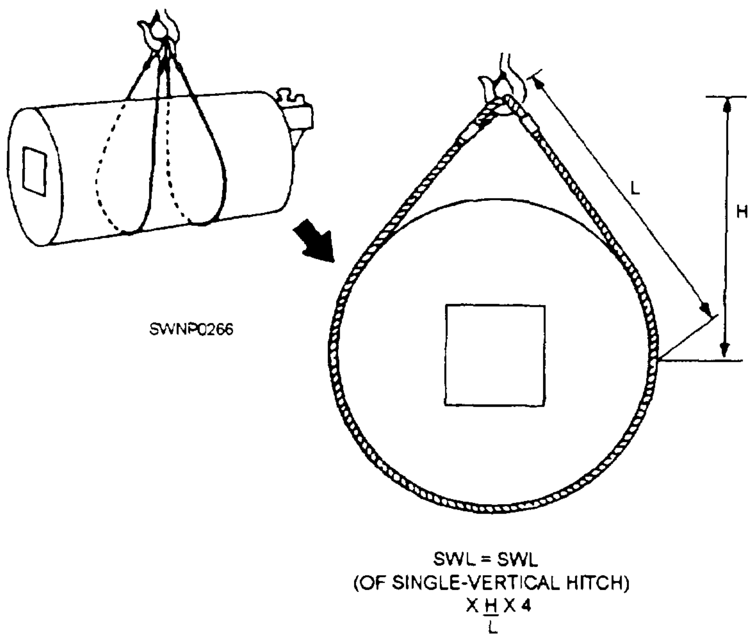


**Figure 6-19.—Determination of double-basket hitch sling capacity.**

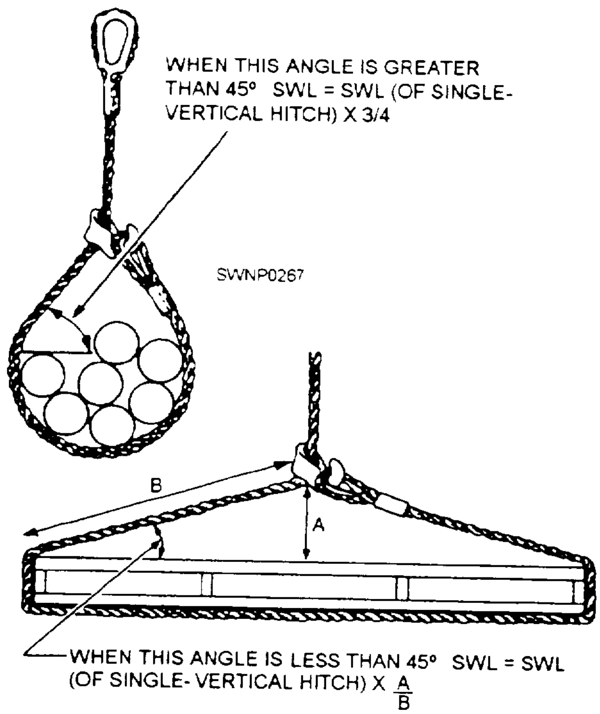


**Figure 6-20.—Determination of single-choker hitch sling capacity.**

## CHAIN SAFE WORKING LOADS

To determine the safe working load on a chain, apply a factor of safety to the breaking strength. The safe working load is ordinarily one-sixth of the breaking strength, giving a safety factor of 6 (table 6-1).

The capacity of an open link chain can be approximated by using the following rule of thumb:

$SWL = 8D^2 x\ 1$ ton

Where:

D = Smallest diameter measured in inches

SWL = Safe working load in tons

Example:

Using the rule of thumb, the safe working capacity of a chain with a diameter of 3/4 inch is as follows:

$SWL = 8D^2 = 8\ (3/4)^2 = 4.5$ tons (or 9,000 lbs)

These figures assume the load is being applied in a straight pull, rather than an impact. An impact load is when an object is suddenly dropped for a distance

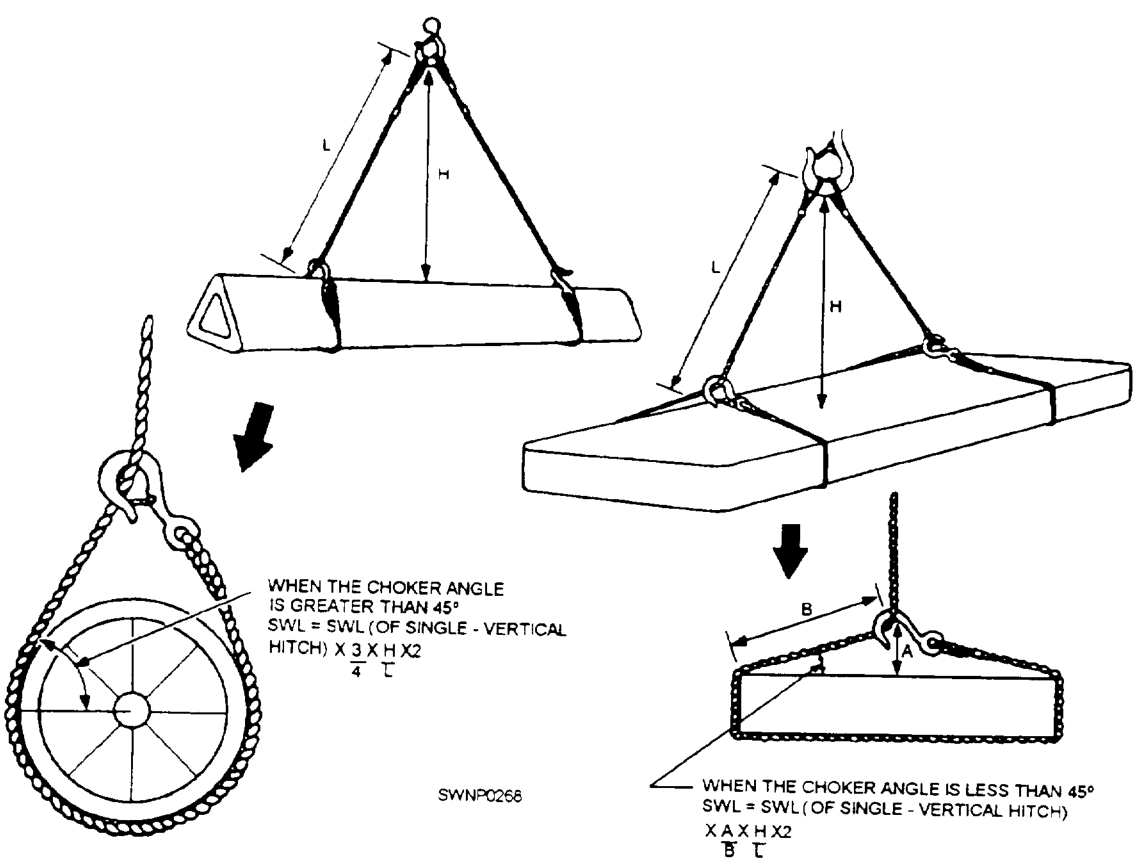


**Figure 6-21.—Determination of double-choker hitch sling capacity.**

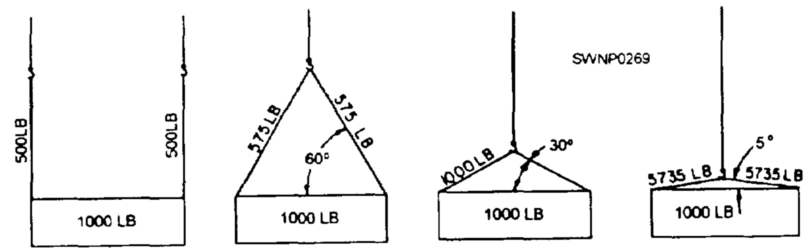


Figure 6-22.—Stress on slings at various vertical angles.

Table 6-1.—Safe Working Load of Chains

| Size* | Approximate weight per linear foot in pounds | Safe working load in pounds | | | |
|---|---|---|---|---|---|
| | | Common iron | High grade iron | Soft steel | Special steel |
| 1/4—— | 0.8 | 512 | 563 | 619 | 1,240 |
| 3/8—— | 1.7 | 1,350 | 1,490 | 1,650 | 3,200 |
| 1/2—— | 2.5 | 2,250 | 2,480 | 2,630 | 5,250 |
| 5/8—— | 4.3 | 3,470 | 3,810 | 4,230 | 7,600 |
| 3/4—— | 5.8 | 5,070 | 5,580 | 6,000 | 10,500 |
| 7/8—— | 8.0 | 7,000 | 7,700 | 8,250 | 14,330 |
| 1 —— | 10.7 | 9,300 | 10,230 | 10,600 | 18,200 |
| 1 1/8—— | 12.5 | 9,871 | 10,858 | 11,944 | 21,500 |
| 1 1/4—— | 16.0 | 12,186 | 13,304 | 14,634 | 26,300 |
| 1 3/8—— | 18.3 | 14,717 | 16,188 | 17,807 | 32,051 |

*** Size listed is the diameter in inches of one side of a link.**

and stopped. The impact load is several times the weight of the load.

## HANDLING AND CARE OF CHAIN

When hoisting heavy metal objects using chain for slings, you should insert padding around the sharp comers of the load to protect the chain links from being cut.

Store chains in a clean, dry place where they will not be exposed to the weather. Before storage, apply a light coat of lubricant to prevent rust.

**Do NOT** perform makeshift repairs, such as fastening links of a chain together with bolts or wire. When links become worn or damaged, cut them out of the chain, then fasten the two nearby links together with a connecting link. After the connecting link is closed, welding makes it as strong as the other links. For cutting small-sized chain links, use bolt cutters. To cut large-sized links, use a hacksaw.

Inspect the chain to ensure it is maintained in a safe, operating condition. A chain used continuously for heavy loading should be inspected frequently. Chain is less reliable than manila or wire rope slings because the links may crystallize and snap without warning.

Examine the chain closely link by link and look for stretch, wear, distortion, cracks, nicks, and gouges. Wear is usually found at the ends of the links where joining links rub together. If you find wear, lift each link and measure its cross section.

**NOTE:** Remove chains from service when any link shows wear more than 25 percent of the thickness of the metal.

Replace any link that shows cracks, distortion, nicks, or cuts. However, if a chain shows stretching or distortion of more than 5 percent in a five-link section, discard and destroy the entire chain.

Remove chains from service when any link shows signs of binding at juncture points. This binding condition indicates that the sides of the links have collapsed as a result of stretching.

Before lifting with a chain, first place dunnage between the chain and the load to provide a gripping surface. For hoisting heavy metal objects with a chain, always use chaffing gear around the sharp comers on the load to protect the chain links from being cut. As chafing gear, use either planks or heavy fabric. In handling rails or a number of lengths of pipe, make a round turn and place the hook around the chain, as shown in figure 6-23.

## ADDITIONAL LIFTING EQUIPMENT

In addition to block and tackle, slings, and chains, hooks, shackles, and beam clamps are also used for lifting objects and material.

## HOOKS

There are two types of hooks available: the slip hook and the grab hook (fig. 6-24).

### Slip Hooks

Slip hooks are made so the inside curve of the hook is an arc of a circle. They are used with wire rope, chains, and fiber line. Chain links can slip through a slip hook so that the loop formed in the chain can tighten under a load.

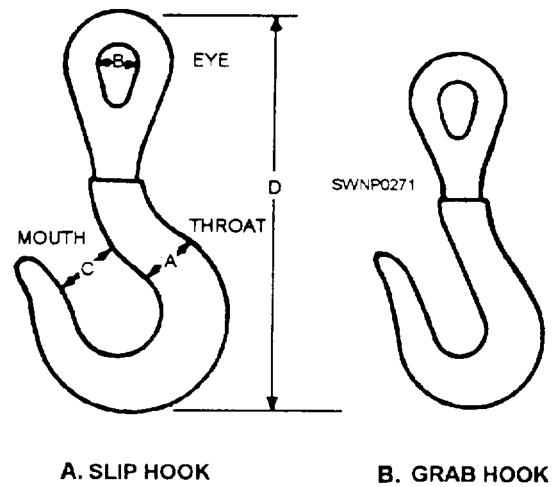


Figure 6-24.—Hooks: A. Slip; B. Grab.

### Grab Hooks

Grab hooks have an inside curve that is almost U-shaped so that the hook will slip over a link edgeways and not allow the next link to slip past. Grab hooks have a much more limited range of use than slip hooks. They are used exclusively when the loop formed in the chain is not intended to close around the load.

### Mousing a Hook

As a rule, a hook should always be moused as a safety measure to prevent slings or line from coming off. Mousing also helps prevent the straightening of a hook but does not add to the strength of the hook. To mouse a hook (fig. 6-25) after the sling is on the hook you should wrap the wire or small stuff 8 or 10 turns around the two sides of the hook. Mousing is then

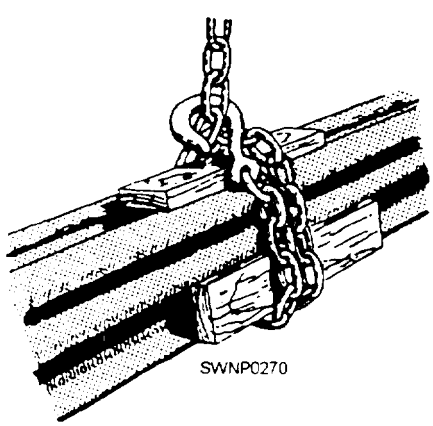


Figure 6-23.—Chain sting.

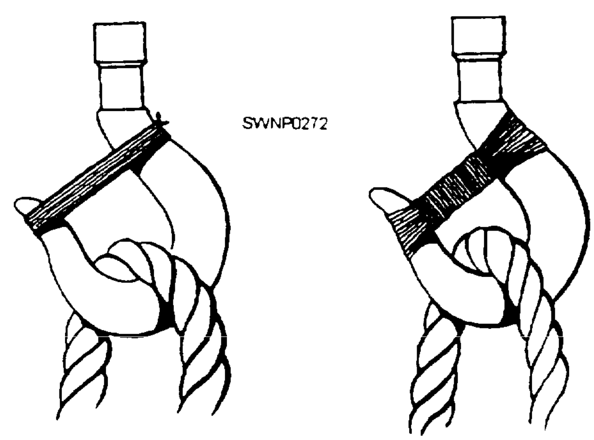


Figure 6-25.—Mousing a hook.

completed by winding several turns around the wire or small stuff and tying the ends securely.

### Inspection of Hooks

Hooks should be inspected at least once a month, but those used for heavy and continuous loading should be inspected more frequently. Attention must be given to the small radius fillets at the neck of the hooks for any deviation for the original inner arc. Additionally, each hook must be examined for small dents, cracks, sharp nicks, worn surfaces, or distortions. If any of these defects are present, the hook must be discarded.

### Hook Strength

Hooks normally fail by straightening. If any deviation of the inner arc of a hook is evident, it indicates that the hook has been overloaded. Evidence of overloading a hook is easy to detect, so it is customary to use a hook that is weaker than the chain it is attached to. Using this system, distortion of the hook will occur before the hook is overloaded. Any distorted, cracked, or badly worn hook is dangerous and should be discarded immediately.

The safe working load of a hook can be formulated by using the following rule of thumb:

SWL = 2/3 x $D^2$ x 1 ton. D is the diameter (in inches) of the hook where the inside of the hook starts to arc (fig. 6-26).

Below is an example of the safe working capacity of a hook with a diameter of 5/8 inch:

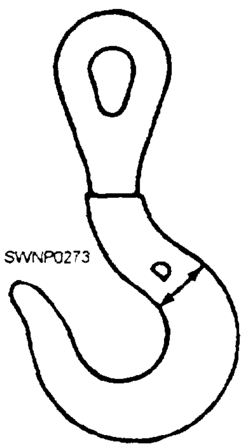


Figure 6-26.—Hook diameter.

$D^2$ = 5/8 X 5/8= 25/64

SWL = 2/3 x 25/64 x 1 ton= 25/96= 0.2604 ton

0.2604 ton x 2,000 pounds/ton= 520.8 pounds

In the metric system, the formula for the safe working load for hooks is as follows: SWL = .46 x $D^2$ x 1 tonne

Below is an example of the safe working capacity of a hook having a diameter of 1.59 cm.

D = 1.59 cm

$D^2$ = 2.52 $cm^2$

SWL= .046 x 2.52 $cm^2$ x 1 tome = .116 tonne

## SHACKLES

Shackles (fig. 6-27) should be used for loads too heavy for hooks to handle. They provide a useful way of attaching, hauling, and lifting a load without tying directly to the object with a line, wire rope, or chain. Additionally, they can be attached to wire rope, line, or chain.

### Safe Working Load of Shackles

The formula for computing the safe working load for a shackle is as follows:

SWL = $3D^2$ x 1 ton

Example:

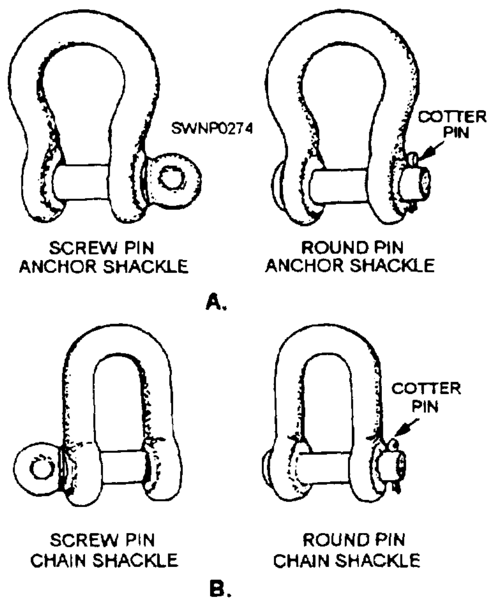


Figure 6-27.—Two types of shackles: A. Anchor; B. Chain.

D = 5/8 (See fig. 6-28)

$D^2$ = 5/8 X 5/8= 25/64

SWL = 3 X 25/64 x 1 ton = 75/64 x 1 ton=1.1719 tons

The SWL in pounds = 1.1719 x 2,000 pounds = 2,343.8 pounds

In the metric system, the formula for the safe working load

for shackles is as follows:

SWL = .417 X $D^2$ X 1 tonne

Example:

D= 1.59cm

$D^2$= 1.59 X 1.59 = 2.52

SWL = .417 x 2.52 x 1 tonne

SWL = 1.05 tomes

**NOTE:** A hook or a shackle can actually lift more than these formulas allow. These formulas give you the safe working load **UNDER ANY CONDITIONS.**

### Mousing Shackles

Mouse shackles whenever there is danger of the shackles pin working loose or coming out due to vibration. To mouse a shackle properly, you take several turns with seizing wire through the eye of the pin and around the bow of the shackle. Figure 6-29 shows what a properly moused shackle looks like.

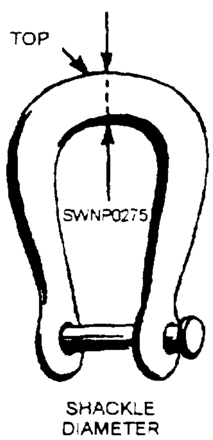


Figure 6-28.—Shackle diameter.


Figure 6-29.—Mousing a shackle.

## BEAM CLAMPS

Steelworkers are required to move and handle many steel beams and steel shapes. When off-loading steel from vehicles and storing for further use, beam clamps are much more practical than using slings or chokers, especially when the flanges are the only available parts of the load. Figure 6-30 shows three different types of beam clamps. View A shows a clamp designed for use on a beam with a flat flange, either an I or an H. The clamp in view B may be used on beams with a circular cross-sectional area or where only one side of the flange is accessible. View C shows a clamp that is useful for connection to a column with a snatch block attached. The clamps shown can all be fabricated in the shop or field.

Hooks, shackles, and beam clamps must have the rated capacities and SWL permanently stenciled or stamped on them. OSHA identification tags can be acquired at no cost from COMTHIRDNCB DET, Port Hueneme, California, or COMSECONDNCB DET, Gulfport, Mississippi. Metal dog tags are authorized providing the required information is stamped onto the tags.

## OTHER LIFTING EQUIPMENT

Other devices used for moving equipment are as follows: spreader bars, pallets, jacks, planks and rollers, blocks and cribbing, and scaffolds.

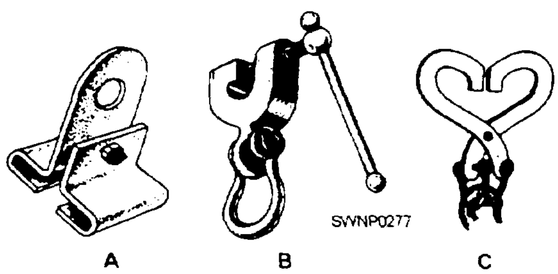


Figure 6-30.—Types of beam clamps.

## SPREADER BARS

In hoisting with slings, spreader bars are used to prevent crushing and damaging the load. Spreader bars are short bars, or pipes, with eyes fastened to each end. By setting spreader bars in the sling legs above the top of the load (fig. 6-31), you change the angle of the sling leg and avoid crushing the load, particularly in the upper portion.

Spreader bars are also used in lifting long or oversized objects to control the sling angle, as shown in figure 6-32. When spreader bars are used, make sure you do not overload the end connection. A spreader bar has a rated capacity that is the same as hooks and shackles. A good rule of thumb is the thickness of the spreaders end connection should be the same as the thickness of the shackle pin.

## PALLETS

Cargo pallets coupled with slings are an immense advantage on jobs that involve moving a lot of small items (fig. 6-33). Spreader bars can be used often to avoid damaging the pallet and the load. The pallet supplies a small platform on which a number of items can be placed and then moved as a whole instead of piece by piece. Palletizing is clearly easier and faster than moving each item by itself.

Commonly, packages of the same size are palletized together, and when shipped, remain on the pallet until they are used up. You may not have the luxury of having excess pallets at your job site; however, you need to have several to work efficiently. One can be loaded as the prior loaded one is being lifted. After each pallet is unloaded, the hoist will return for reloading. With two pallets, you are able to maintain a steady flow of material. One set of slings will be able to handle any number of pallets.

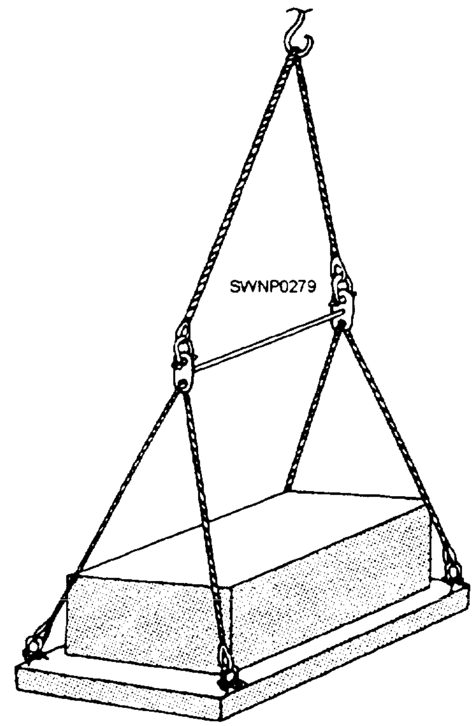


**Figure 6-32.—Spreader bar used with an oversized load.**

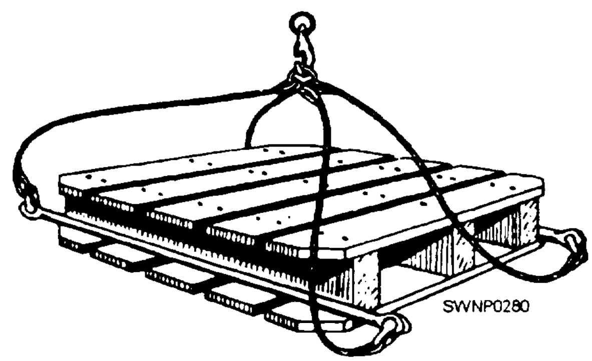


**Figure 6-33.—Cargo pallet.**

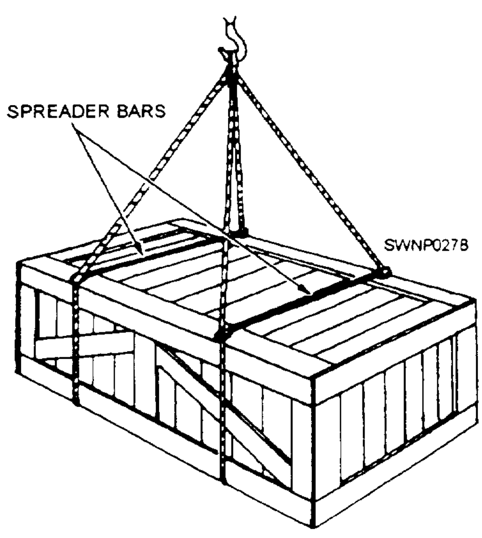


**Figure 6-31.—Using spreader bars.**

## JACKS

To be able to place cribbing, skids, and rollers, you need to be able lift a load a short distance. Jacks are designed and built for this purpose. Jacks are also used for precise placement of heavy loads, such as beams, or for raising and lowering heavy loads a short distance. There are a number of different styles of jacks available; however, only heavy-duty hydraulic jacks or screw jacks should be used. The number of jacks used is determined by the weight of the load and the rated capacity of the jacks. Ensure the jacks have a solid footing and are not susceptible to slipping.

Jacks are available in capacities from 5 to 100 tons. Small capacity jacks are normally operated through a rack bar or screw, and large capacity jacks are usually operated hydraulically (fig. 6-34).

The types of jacks used by Steelworkers are as follows:

1. Ratchet lever jacks are rack bar jacks having a rated capacity of 15 tons. These jacks have a foot lift by which loads close to the base of the jack can be engaged (fig. 6-34, view A).

2. Steamboat ratchets (often referred to as pushing and pulling jacks) are ratchet screw jacks of 10-ton-rated capacity with end fittings that permit pulling parts together or pulling them apart. They are primarily used for tightening lines or lashings and for spreading or bracing parts in bridge construction (fig. 6-34, view B).

3. Screw jacks have a rated capacity of 12 tons. They are approximately 13 inches high when closed and have a safe rise of 7 inches. These jacks are used for general purposes, including steel erection (fig. 6-34, view C).

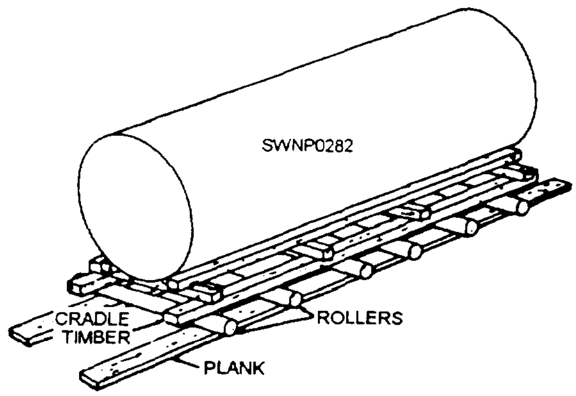


**Figure 6-35.—Use of planks and rollers.**

4. Hydraulic jacks are available in many different capacities and are used for general purposes (fig. 6-34, view D).

## PLANKS AND ROLLERS

Planks and rollers provide you with an excellent means of moving heavy loads across the ground on a jobsite or the floor of a shop (fig. 6-35).

Oak planks are appropriate for most operations involving plank skids. Planks 15 feet long and 2 to 3 inches thick should be suitable. They distribute the weight of a load and also provide a smooth runway surface in which to skid the load along or in which to use rollers to ease the effort required to move the load.

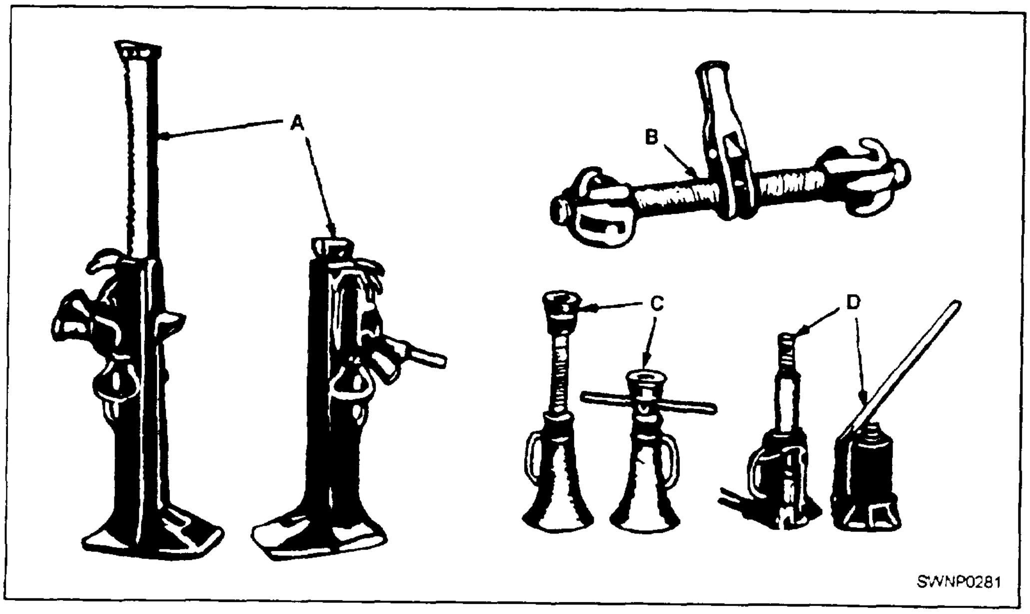


**Figure 6-34.—Mechanical and hydraulic jacks: A. Ratchet lever jack with foot lift; B. Steamboat ratchet; C. Screw Jack; D. Hydraulic jack.**

Timber skids (planks) are placed longitudinally under heavy loads to distribute the weight over a greater area. (See fig. 6-35.) The angle of the skids must be kept low to prevent the load from drifting or getting out of control. Skids can be greased only when horizontal movement is involved. **Extreme care must be exercised.** In most circumstances greasing is inherently dangerous, as it can cause the load to drift sideways suddenly, causing injuries to personnel and damage to equipment.

Hardwood or pipe rollers can be used in conjunction with plank skids for moving heavy loads into position. Planks are placed under the rollers to provide a smooth continuous surface to enable them to roll easily. The rollers must be smooth and round to aid in the ease of movement and long enough to pass completely under the load. The load should be supported by longitudinal wooden members to provide a smooth upper surface for the rollers to roll on. The skids placed underneath must form continuous support. Normal practice is to place four to six rollers under the load to be moved. Several rollers are to be placed in front of the load and the load is then slowly rolled onto these rollers. As the load passes the rollers that are left clear of the load they are then picked up and moved in front of the load. This creates a continuous path of rollers. Turns can be made using rollers; but, first the front rollers must be inclined slightly in the direction of the turn and the rear of the rollers in the opposite direction. This inclination of the rollers can be made by striking them sharply with a sledge hammer. Rollers can be fabricated and set on axles in side beams as a semipermanent conveyor for lighter loads. Permanent metal roller conveyors are available (fig. 6-36) and are normally fabricated in sections which can be joined together.

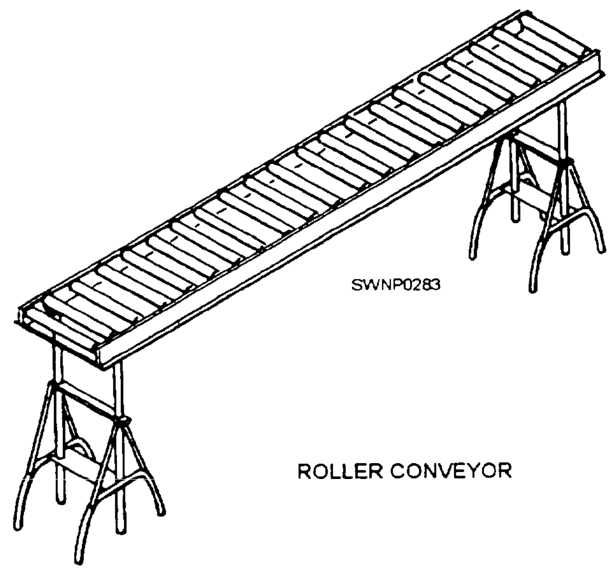


**Figure 6-36.—Permanent metal roller conveyor.**

## BLOCKING AND CRIBBING

Block timbers are commonly used to provide a foundation for heavy loads or jacks. Cribbing must be used when a heavy weight must be supported at a height greater than blocking can provide. Cribbing is made up by aligning timber in tiers that run in alternate directions (fig. 6-37). Blocking and cribbing is often necessary as a safety measure to keep an object stationary to prevent accidents and injury to personnel working near these heavy objects.

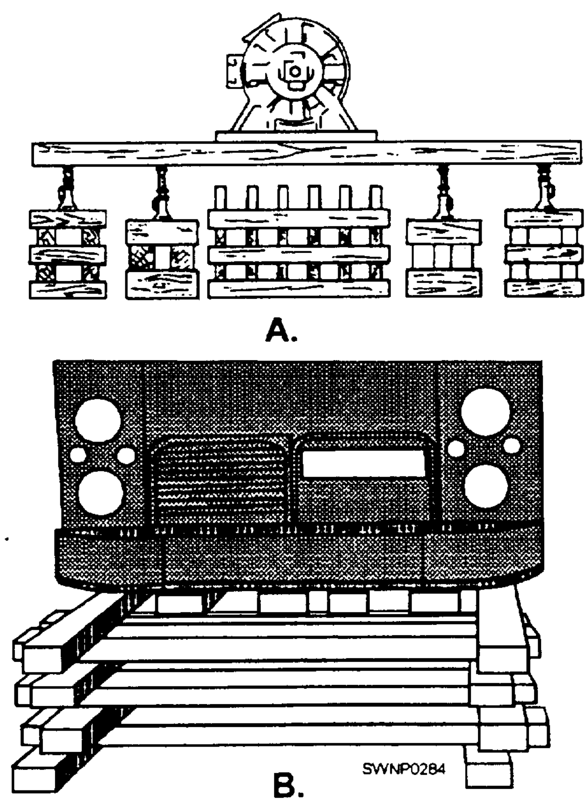


**Figure 6-37.—Examples of the use of cribbing.**

When selecting blocking as a foundation for jacks, ensure it is sound and large enough to support the load safely. It *must* be free from grease and thoroughly dry. Additionally, it *must* be placed firmly on the ground with the load (pressure) distributed evenly.

A firm and level foundation is a paramount requirement where cribbing is used. Also, equally as critical is that the bottom timbers be placed so they rest evenly and firmly on the ground.

Cribbing is desirable when lifting loads by jacking stages. This procedure requires blocking to be placed under the jacks, lifting the load to the maximum height the jacks can safely accommodate, placing the cribbing under the load in alternating tiers, *with no personnel under the load,* and then lowering the load onto the cribbing.

When cribbing is not high enough or at the correct height, build up the blocking under the jacks until the jacks can bear against the load while in their lowered position. Raise the jacks again to their maximum safe height and lower onto the added cribbing. This procedure can be repeated as many times as necessary to build up the cribbing to the desired height.

## SCAFFOLDS

The term *scaffold* refers to a temporary elevated platform used to support personnel and materials, for immediate usage, throughout the course of construction work. You will use scaffolds in performing various jobs which cannot be done safely from securely placed ladders. We will take a brief look at a few of the different types of scaffolds which you will need from time to time on the job.

### Planking and Runway Scaffold

A planking and runway scaffold shown in figure 6-38 consists of single scaffold planks laid across beams of upper floors or roofs. It is frequently used to provide working areas or runways. Each plank should extend from beam to beam, and not more than a few inches of the planks should extend beyond the end supporting beam. A short overhang is essential to safe practice to prevent personnel from stepping on an unsupported plank and falling from the scaffold. Planks should be thick enough to support the load safely and applied without excessive sagging. When the planking is laid continuously, as in a runway, make sure the planks are laid so that their ends overlap. Single plank runs may be staggered with each plank being offset with reference to the next plank in the run.

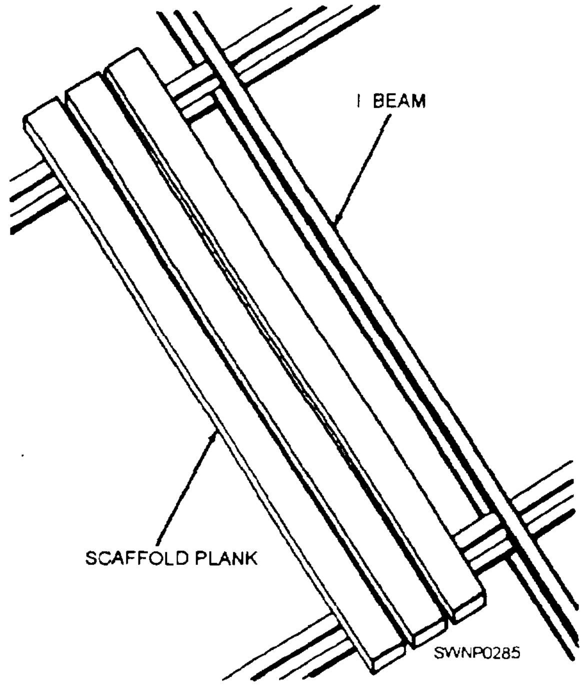


**Figure 6-38.—A planking and runway scaffold.**

### Swinging Platform Scaffold

The most commonly used type of swinging scaffolding is the platform scaffold shown in figure 6-39. The swinging platform scaffold consists of a frame with a deck of wood slats. The platform is supported near each end by iron rods, called stirrups, which have the lower blocks of fiber line fall attached to them. This tackle arrangement permits the platform to be raised or lowered as required. The tackle and platform are supported by hooks and anchors on the roof of the structure. The fall line of the tackle must be secured to a part of the platform when in final position to prevent it from falling.

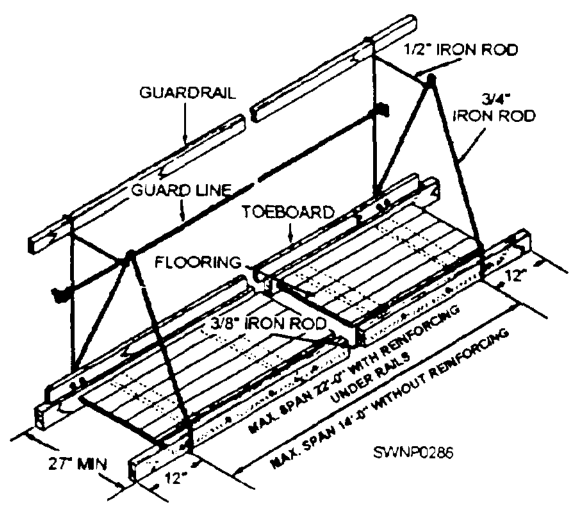


**Figure 6-39.—A platform scaffold.**

### Needle-Beam Scaffold

A needle-beam scaffold consists of a plank platform resting on two parallel horizontal beams, called needle beams, which are supported by lines from overhead. (See fig. 6-40.)

Needle-beam scaffolds should be used on-l y for the support of personnel doing light work. They are suitable for use by riveting gangs working on steel structures because of the frequent changes of location necessary and the adaptability of this type of scaffold to different situations.

Several types of patent and independent scaffolding are available for simple and rapid assembly, as shown in figure 6-41. The scaffold uprights are braced with diagonal members, and the

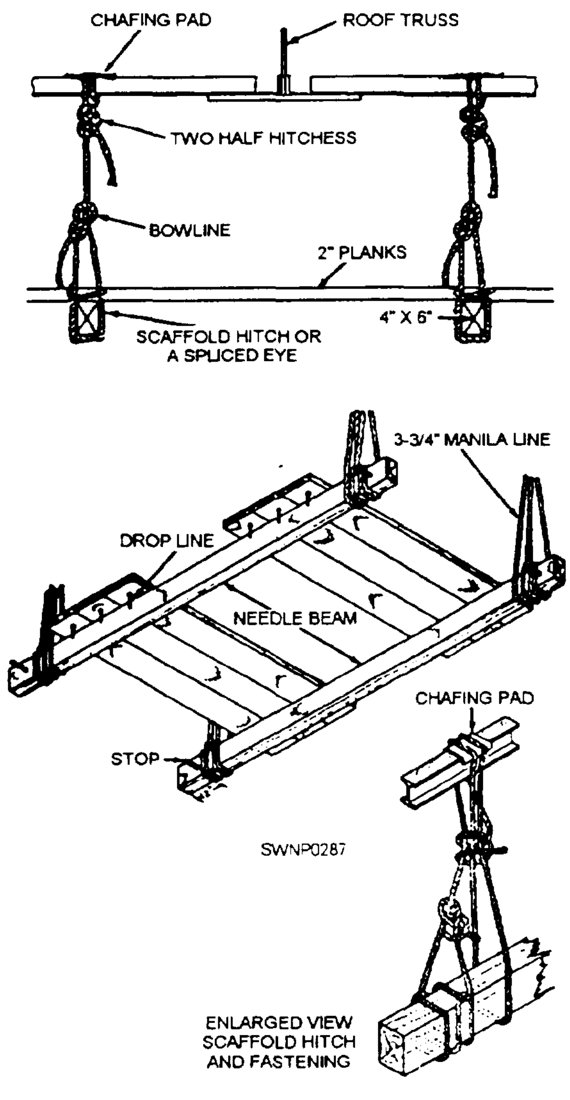


**Figure 6-40.—A needle-barn scaffold.**

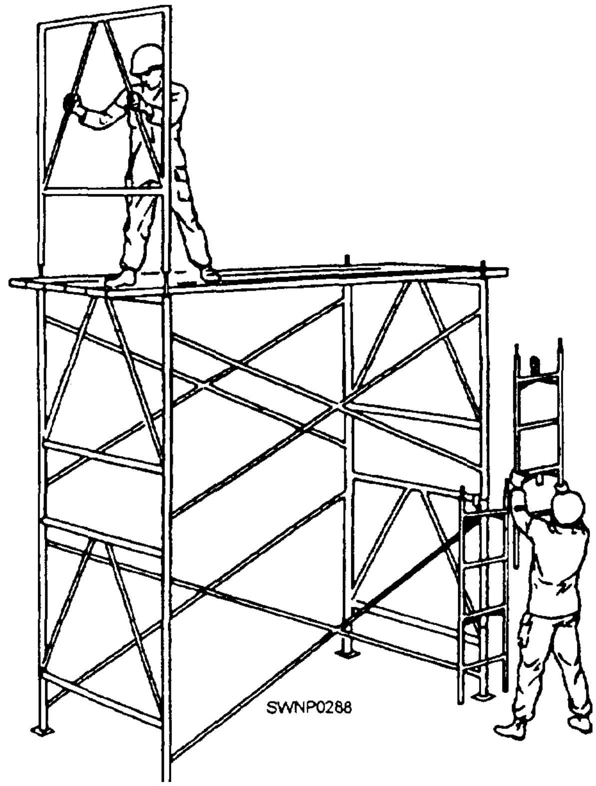


**Figure 6-41.—Assembling prefabricated independent scaffolding.**

working level is covered with a platform of planks. All bracing must form triangles, and the base of each column requires adequate footing plates for bearing area on the ground. The patented steel scaffolding is usually erected by placing the two uprights on the ground and inserting the diagonal members. The diagonal members have end fittings, which permit easy assembly. The first tier is set on steel bases on the ground, and a second tier is placed in the same manner on the first tier with the bottom of each upright locked to the top of the lower tier. A third and fourth upright can be placed on the ground level and locked to the first set with diagonal bracing. The scaffolding can be built as high as desired, but high scaffolding should be tied into the main structure.

### Boatswain's Chair

The boatswain's chair shown in figure 6-42 also comes under the heading of scaffolding. It is sometimes used to provide a seat for a person working above the ground.

The seat of the boatswain's chair should be at least 2 feet long, 1 foot wide, and 1 1/4 inches thick (60 cm

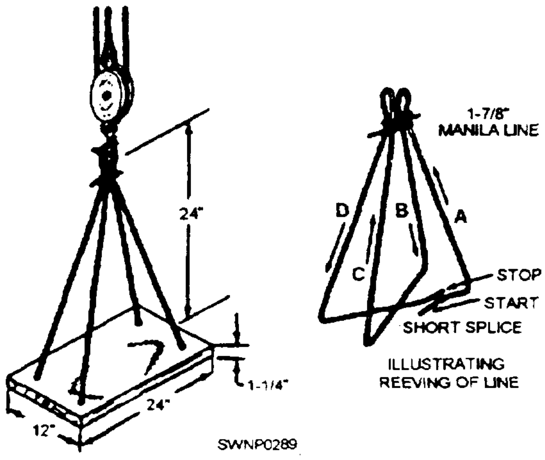


**Figure 6-42.—A boatswain's chair.**

long, 30 cm wide, and 3.1 cm thick). Make sure you always wear a safety belt when using a boatswain's chair. The safety belt should be attached to a lifeline secured to a fixed object overhead. Use a bowline to secure the lifeline to the person in the chair.

**NOTE:** A BOATSWAIN' S CHAIR SHOULD BE USED ONLY IF OTHER MEANS ARE NOT AVAILABLE.

**Scaffold Safety**

When you are using scaffolds, *SAFETY is your NUMBER ONE PRIORITY!* Failure to observe safety precautions can result in serious injury to yourself or coworkers. Some essential safety measures applicable to scaffolds are given here. Use each of them routinely. *THINK SAFETY!* Be a *SAFE WORKER!*

Structural members, support ropes, and scaffold equipment must be inspected carefully each workday before using them on the job. The use of makeshift scaffolds is strictly prohibited.

When personnel are working on a scaffold with other personnel engaged directly above, either the scaffold must have an overhead protective covering or the workers on the lower scaffold must wear Navy-approved, protective hard hats. The purpose is to provide protection against falling material. Where the upper working level is no more than 12 feet (3.6 m) above the lower, hard hats worn by workers on the lower level will satisfy this requirement.

An overhead protective covering consists of a roof of lumber, heavy wire screen, or heavy canvas, depending upon the hazard involved. The covering should extend a suffient distance beyond the edge of the scaffold to catch any material that may fall over the edge. A netting of screen should not be less than No. 18 gauge, U.S. Standard Wire, with a mesh not to exceed 1/2 inch. Screens of heavier wire or smaller mesh should bex used where conditions are such that the No. 18 gauge wire or 1/2-inch mesh will not suppl y adequate protection. Personnel should NOT be required to work underneath a scaffold. Scaffolds erected over passageways, thoroughfares, or locations where persons are working should be provided with side screens and a protective covering. A side screen is a screen paneling from the platform to an intermediate railing or from the platform to the top railing. Screening is formed of No. 16 U.S. gauge wire with 1/2-inch mesh. Screen is used for the purpose of preventing materials, loose or piled, from falling off the scaffolds.

A safe means of access should be provided to all scaffolds by means of standard stairs or fixed ladders. Additionally, ensure that a scaffold is properly secured against swaying.

Personnel should not be permitted on scaffolds which are covered with ice or snow. In such instances, clinging ice must be removed from all guardrails, then the planking sanded or otherwise protected against slipping. Workers should not be permitted on scaffolds during a storm or high wind.

No scaffold should be used for the storage of materials, except that required for the immediate needs of the job. Tools should be placed in containers to prevent their being knocked off and the containers should be secured to the scaffold by line. Always make a special effort to ensure that tools, equipment, material, and rubbish do not accumulate on a scaffold to the point where the safe movement of personnel is jeopardized.

NEVER throw or drop objects or tools from scaffolds. Handlines should be used for raising or lowering objects when they cannot be reached easily and safely by hand. Such things as jumping or throwing material upon a scaffold platform are to be avoided at all times.

Scaffolds must never be overloaded! Furthermore, whenever possible, see that the scaffold load is uniformly distributed and not concentrated at the center of the platform.

Wire ropes and fiber lines used in suspension and swinging scaffolds should be of the best quality steel, manila, or sisal. Manila or sisal line used as lifelines should be 1 7/8 inches (51.2 mm) in circumference. Lifelines and safety belts must be used when working on unguarded scaffolds at heights of 10 feet (3 m) and above (as well as on boatswain's chairs, as explained earlier). If working over water, life jackets must be worn.

All scaffolds and scaffold equipment should be maintained in safe condition. Avoid making repairs or alterations to a scaffold or scaffold equipment while in use. Rather than take a chance, NEVER permit personnel to use damaged or weakened scaffolds!

## FIELD-ERECTED HOISTING DEVICES

Because of the nature of heavy construction, Steel workers must at times erect heavy structural members when constructing pre-engineered buildings, piers, bridges, and many other components related to Advanced Base Functional Components (ABFC). These members are usually hoisted into position using cranes, forklifts, or other construction equipment. In contingency/ combat operations, however, because of operational commitments this equipment may not be available and structural members must be hoisted without the use of heavy equipment. We will now discuss some of the methods which can be used for the erection process when heavy equipment is not available.

The term *field-erected hoisting device* refers to a device that is constructed in the field, using material available locally, for the purpose of hoisting and moving heavy loads. Basically, it consists of a block-and-tackle system arranged on a skeleton structure consisting of wooden poles or steel beams. The tackle system requires some form of machine power or work force to do the actual hoisting. The three types of field-erected hoisting devices used are *gin poles, tripods, and shears. The* skeleton structure of these devices are anchored to *holdfasts.*

## HOLDFASTS

Gin poles, shear legs, and other rigging devices are held in place by means of guy lines anchored to holdfasts. In fieldwork, the most desirable and economical types of holdfasts are natural objects, such as trees, stumps, and rocks. When natural holdfasts of suffient strength are not available, proper anchorage can be provided through the use of man-made holdfasts. These include single picket holdfasts, combination picket holdfasts, combination log picket holdfasts, log deadmen, and steel picket holdfasts.

### Natural Types of Holdfasts

When using trees, stumps, or boulders as holdfasts, you should always attach the guys near ground level. The strength of the tree, stump, or boulder size is also an important factor in determining its suit ability as a holdfast. With this thought in mind, NEVER use a dead tree or a rotten stump or loose boulders and rocks. Such holdfasts are unsafe because they are likely to snap or slip suddenly when a strain is placed on the guy, Make it a practice to lash the first tree or stump to a second one (fig. 6-43). This will provide added support for the guy.

Rock holdfasts are made by inserting pipes, crowbars, or steel pickets in holes drilled in solid rock. Using a star drill, drill holes in the rock 1 1/2 to 3 feet apart, keeping them in line with the guy. Remember to drill the holes at a slight angle so the pickets lean away

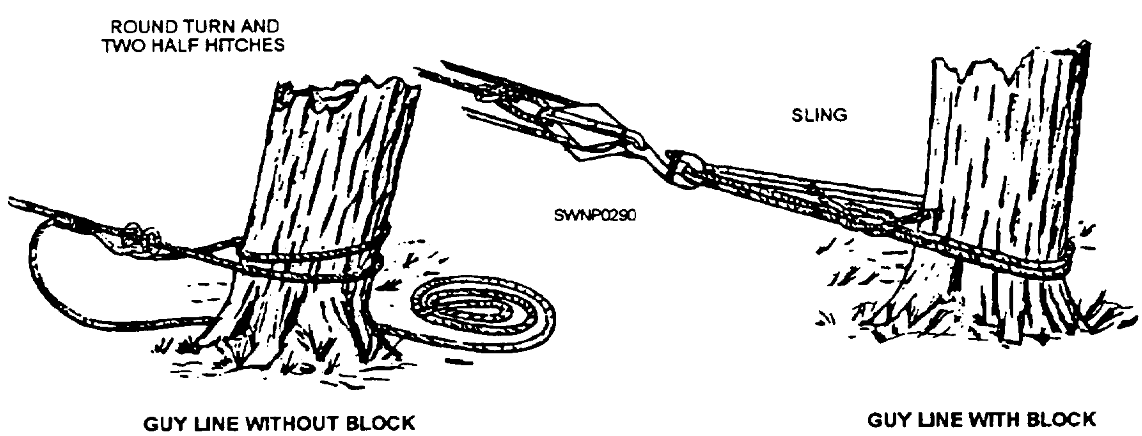


**Figure 6-43.—Using trees as a holdfast.**

from the direction of pull. Make the front hole about 1 1/2 to 3 feet deep and the rear hole 2 feet deep (fig. 6-44). After driving pickets into the holes, you should secure the guy to the front picket. Then lash the pickets together with a chain or wire rope to transmit the load.

### Single-Picket Holdfasts

Pickets used in the construction of picket holdfasts may be made of wood or steel. A wood picket should be at least 3 inches in diameter and 5 feet long. A single picket holdfast can be provided by driving a picket 3 to 4 feet into the ground, slanting it at an angle of 15 degrees opposite to the pull. In securing a single guy line to a picket, you should take two turns around the picket and then have part of the crew haul in on the guy as you take up the slack. When you have the guy taut, secure it with two half hitches. In undisturbed loam soil, the single picket is strong enough to stand a pull of about 700 pounds.

### Combination Picket Holdfast

A **combination picket** holdfast consists of two or more pickets. Figure 6-45 gives you an idea of how to

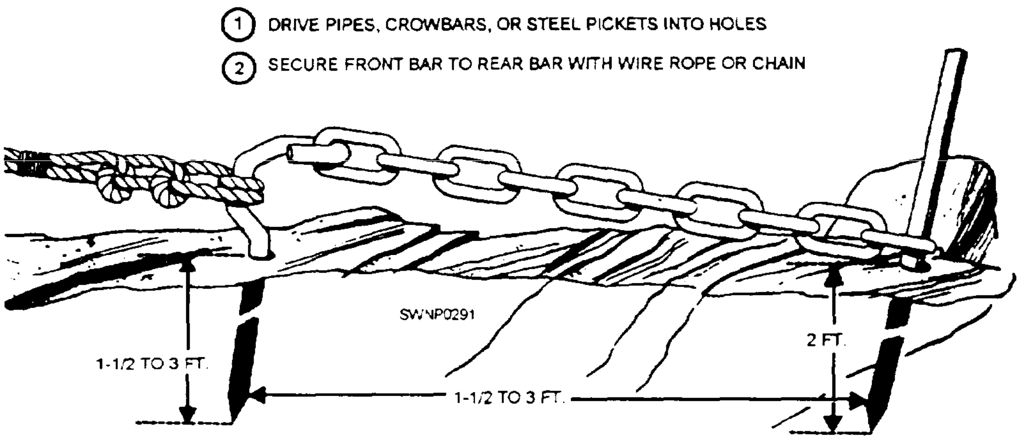


**Figure 6-44.—A rock holdfast.**

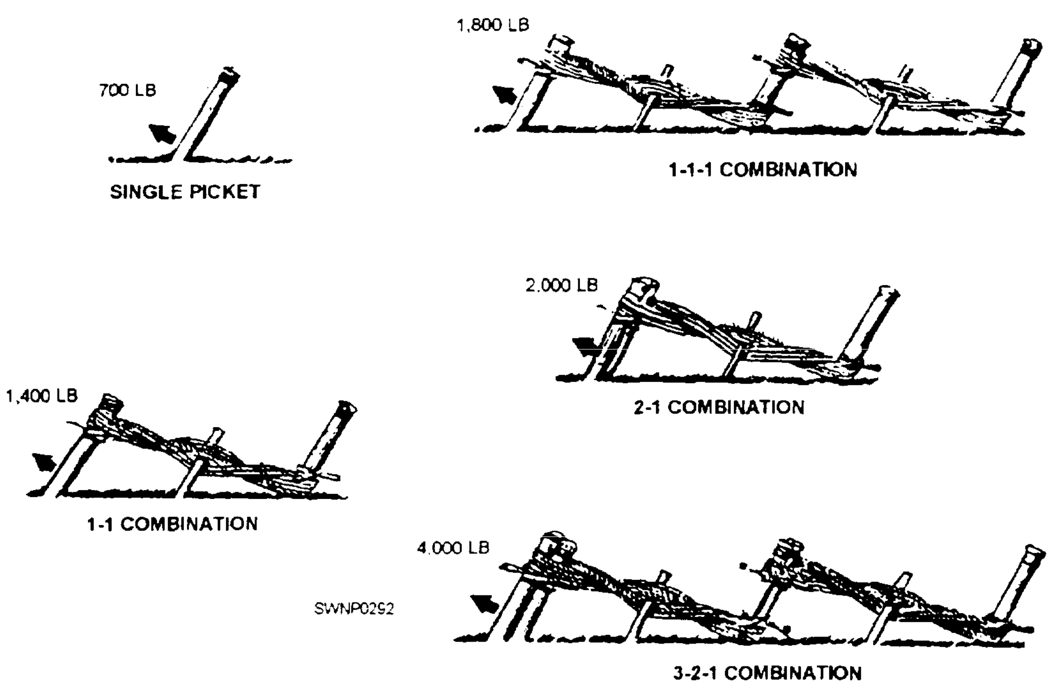


**Figure 6-45.—Combination pickets.**

arrange pickets in constructing a 1-1-1 and a 3-2-1 combination picket holdfast.

In constructing the 1-1-1 combination (fig. 6-46), drive three single pickets about 3 feet into the ground, 3 to 6 feet apart, and in line with the guy. For a 3-2-1 combination, drive a group of three pickets into the ground, lashing them together before you secure the guy to them. The group of two lashed pickets follows the first group, 3 to 6 feet apart, and is followed by a single picket. The 1-1-1 combination can stand a pull of about 1,800 pounds, while the 3-2-1 combination can stand as much as 4,000 pounds.

The pickets grouped and lashed together, PLUS the use of small stuff secured onto every pair of pickets, are what make the combination picket holdfasts much stronger than the single holdfasts.

The reason for grouping and lashing the first cluster of pickets together is to reinforce the point where the pull is the greatest. The way small stuff links each picket to the next is what divides the force of pull, so the first picket does not have to withstand all of the strain. Using 12- to 15-thread small stuff, clove hitch it to the top of the first picket. Then take about four to six turns around the first and second pickets, going from the bottom of the second to the top of the first picket. Repeat this with more small stuff from the second to the third picket, and so on, until the last picket has been secured. After this, pass a stake between the turns of small stuff, between EACH pair of pickets, and then make the small stuff taut by twisting it with the stake. Now, drive the stake into the ground.

If you are going to use a picket holdfast for several days, it is best to use galvanized guy wire in place of the small stuff. Rain will not affect galvanized guy wire, but it will cause small stuff to shrink. If the small stuff is already taut, it could break from overstrain.

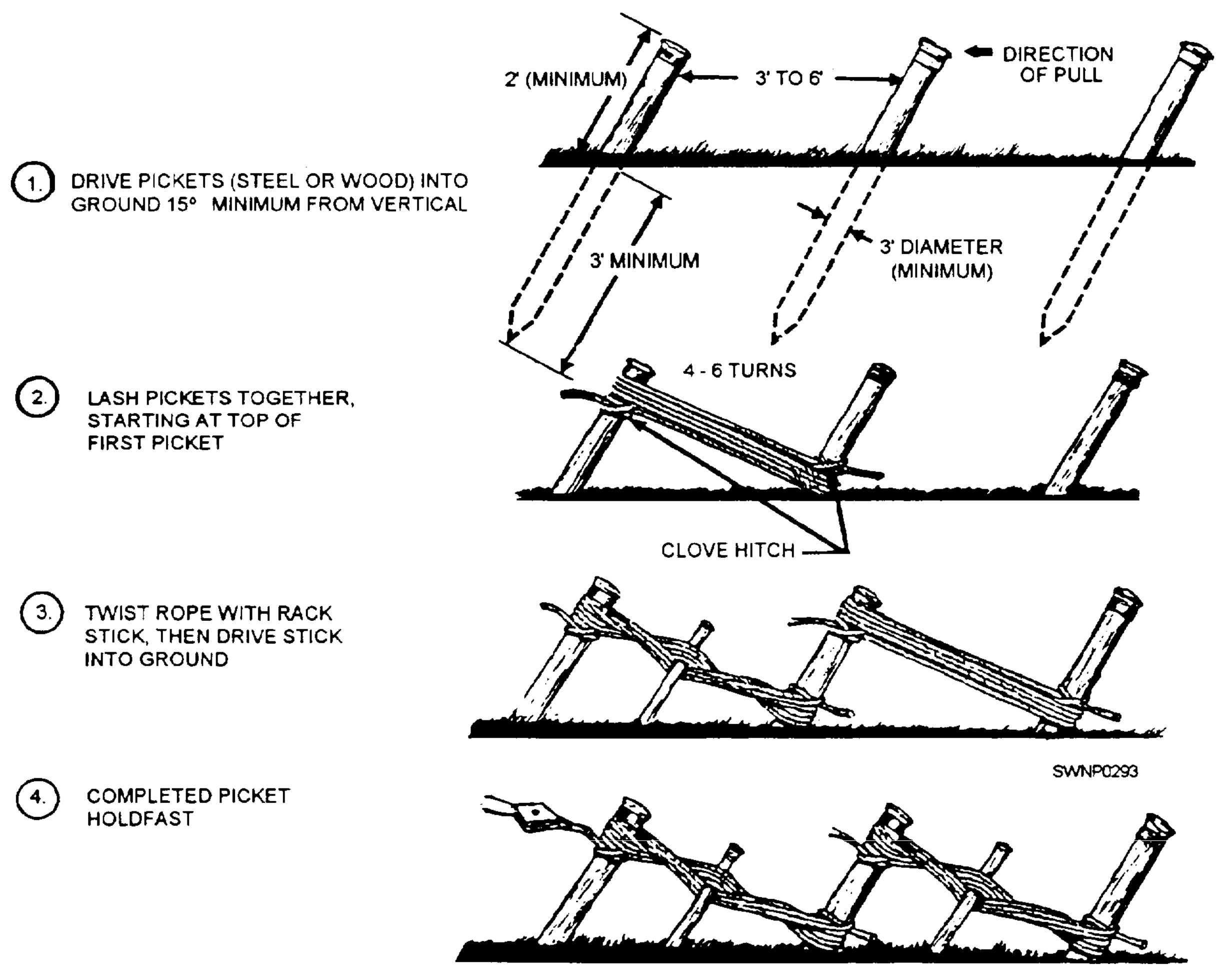


**Figure 6-46.—Preparing a 1-1-1 picket holdfast.**

Still, if you must use small stuff, be sure to slack it off before leaving it overnight. You do this by pulling the stake up, untwisting the small stuff once, and then replacing the stake.

### Combination Log Picket Holdfast

For heavy loads or in soft- or wet-earth areas, a combination log picket holdfast is frequently used. With this type, the guys are anchored to a log or timber supported against four or six combination picket holdfasts. (See fig. 6-47.) The timber serves as beam and must be placed so that it bears evenly against the front rope of the pickets. Since the holding power of this setup depends on the strength of the timber and anchor line, as well as the holdfast, you must use a timber big enough and an anchor line strong enough to withstand the pull.

### Deadman

A deadman provides the best form of anchorage for heavy loads. It consists of a log, a steel beam, a steel pipe, or a similar object buried in the ground with the guy connected to it at its center. (See fig. 6-48.) Because it is buried, the deadman is suitable for use as a permanent anchorage. When you are installing a permanent deadman anchorage, it is a good idea to put a turnbuckle in the guy near the ground to permit slackening or tightening the guy when necessary.

In digging the hole in which to bury the deadman, make sure it is deep enough for good bearing on solid ground. The less earth you disturb in digging, the better the bearing surface will be. You should undercut the bank in the direction toward the guy at an angle of about 15 degrees from the vertical. To increase the bearing surface, drive stakes into the bank at several points over the deadman.

A narrow, inclined trench for the guy must be cut through the bank and should lead to the center of the deadman. At the outlet of the trench, place a short beam or logon the ground under the guy. In securing the guy to the center of the deadman, see that the standing part (that is, the part on which the pull occurs) leads from the bottom of the log deadman. Thus, if the wire rope clips slip under strain, the standing part will rotate the log in a counterclockwise direction, causing the log to dig into the trench, rather than roll up and out. See that the running end of the guy is secured properly to the standing part.

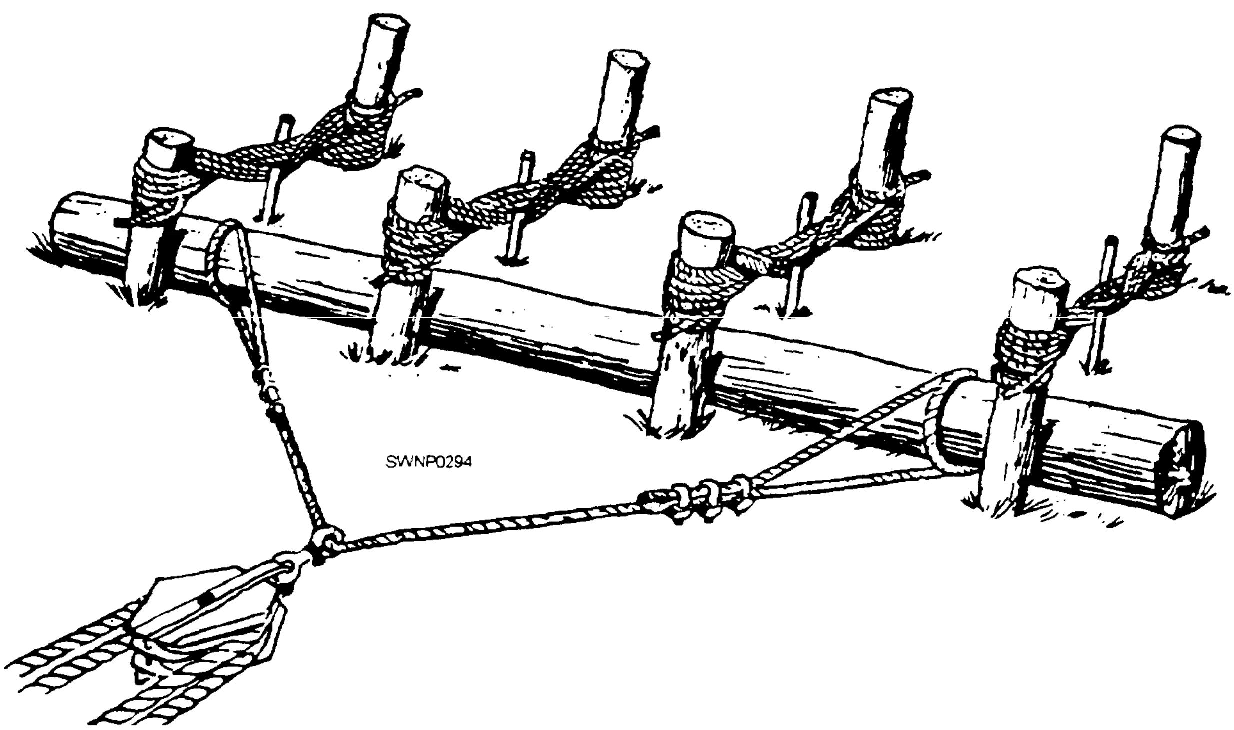


Figure 6-47.—A combination log picket

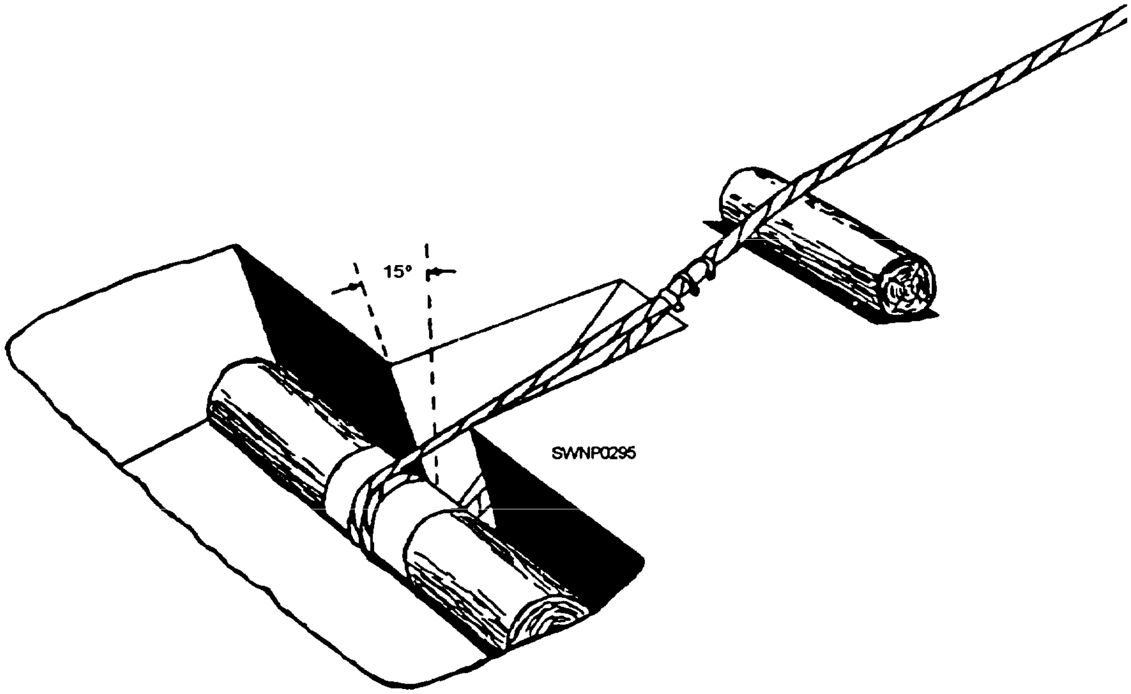


Figure 6-48.—A deadman anchorage for a heavy load.

### Steel Picket Holdfast

The steel picket holdfast shown in figure 6-49 consists of steel box plates with nine holes drilled through each and a steel eye welded on the end for attaching the guy. When you are installing this holdfast, it is important to drive steel pickets through the holes in such a manner that will cause them to clinch in the ground. You will find the steel picket holdfast especially useful for anchoring horizontal lines, such as the anchor cable on a pontoon bridge. The use of two or more of the units in combination provides a stronger anchorage than a single unit.

## GIN POLES

A gin pole consists of an upright mast which is guyed at the top to maintain it in a vertical or nearly vertical position and is equipped with suitable hoisting tackle. The vertical mast can be timber, a wide-flange steel beam section, a railroad rail, or similar members of suffient strength to support the load being lifted. The load can be hoisted by hand tackle or by the use of hand- or engine-driven hoists. The gin pole is predominately used in erection work because of the ease with which it can be rigged, moved, and operated, and it is suitable for raising loads of medium weight to heights of 10 to 50 feet where only a vertical lift is required. The gin pole can also be used to drag loads horizontally toward the base of the pole in preparation for a vertical lift. It cannot be drifted (inclined) more than 45 degrees from the vertical or seven-tenths the height of the pole, nor is a gin pole suitable for swinging a load horizontal y. The length and thickness of the gin pole depends on the purpose for which it is installed. It should not be longer than 60 times its minimum thickness because of the tendency to buckle under compression. A usable rule is to allow 5 feet of pole for each inch of minimum thickness. Table 6-2 lists values for the use. of spruce timbers as gin poles with allowance for normal stresses in hoisting operations.

**NOTE:** Safe capacity of each length shears or tripod is seven-eighths of the value given for a gin pole.

1. *Rigging.* When rigging a gin pole, lay out the pole with the base at the exact spot where it is to be erected. To make provisions for the guy lines and tackle blocks, place the gin pole on cribbing for ease of lashing. Figure 6-50 shows the lashing on top of a gin pole and the method of attaching guys. The procedure is as follows:

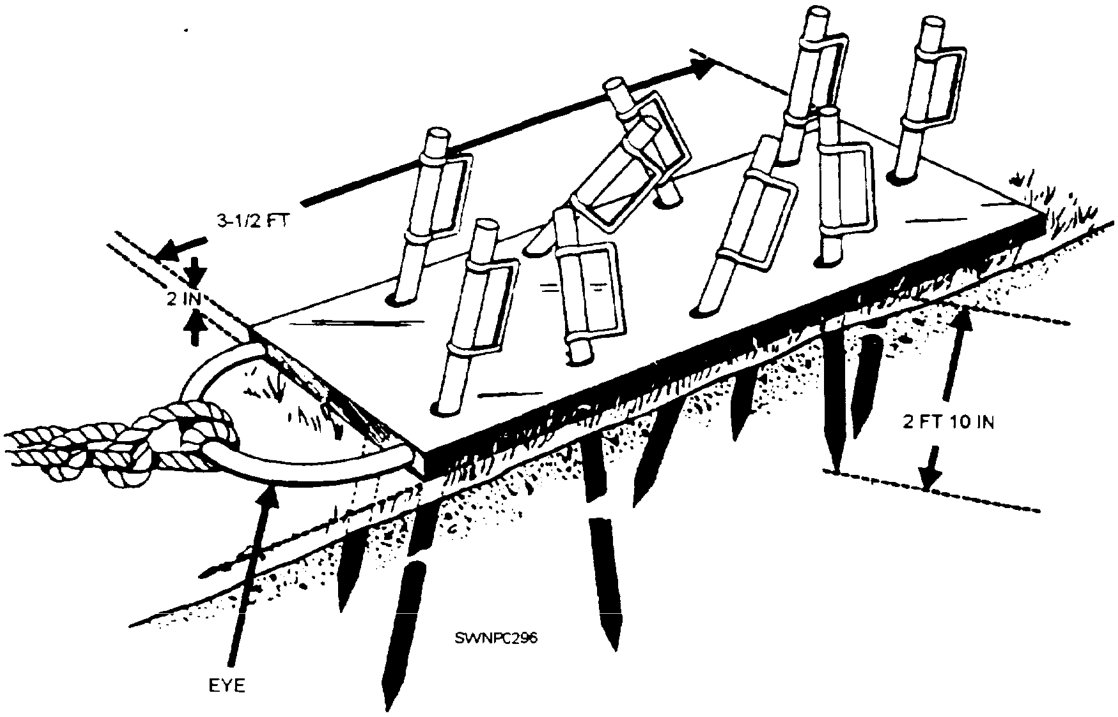


**Figure 6-49.—A steel picket holdfast.**

**Table 6-2.—Safe Capacity of Spruce Timber as Gin Poles in Normal Operations.**

| Size of timber in inches | Safe capacity in pounds for given length of timber | | | | | |
|---|---|---|---|---|---|---|
| | 20 feet | 25 feet | 30 feet | 40 feet | 50 feet | 60 feet |
| 6 dia | 5,000 | 3,000 | 2,000 | | | |
| 8 dia | | 11,000 | 8,000 | 5,000 | 3,000 | |
| 10 dia | 31,000 | 24,000 | 16,000 | 9,000 | 6,000 | |
| 12 dia | | | 31,000 | 19,000 | 12,000 | 9,000 |
| 6 x 6 | 6,000 | 4,000 | 3,000 | | | |
| 8 x 8 | | 14,000 | 10,000 | 6,000 | 4,000 | |
| 10 x 10 | 40,000 | 30,000 | 20,000 | 12,000 | 8,000 | |
| 12 x 12 | | | 40,000 | 24,000 | 16,000 | 12,000 |

a. Make a tight lashing of eight turns of fiber rope about 1 foot from the top of the pole, with two of the center turns engaging the hook of the upper block of the tackle. Secure the ends of the lashing with a square knot. Nail wooden cleats (boards) to the pole flush with the lower and upper sides of the lashing to prevent the lashing from slipping.

b. Lay out guy ropes, each one four times the length of the gin pole. In the center of each guy rope,

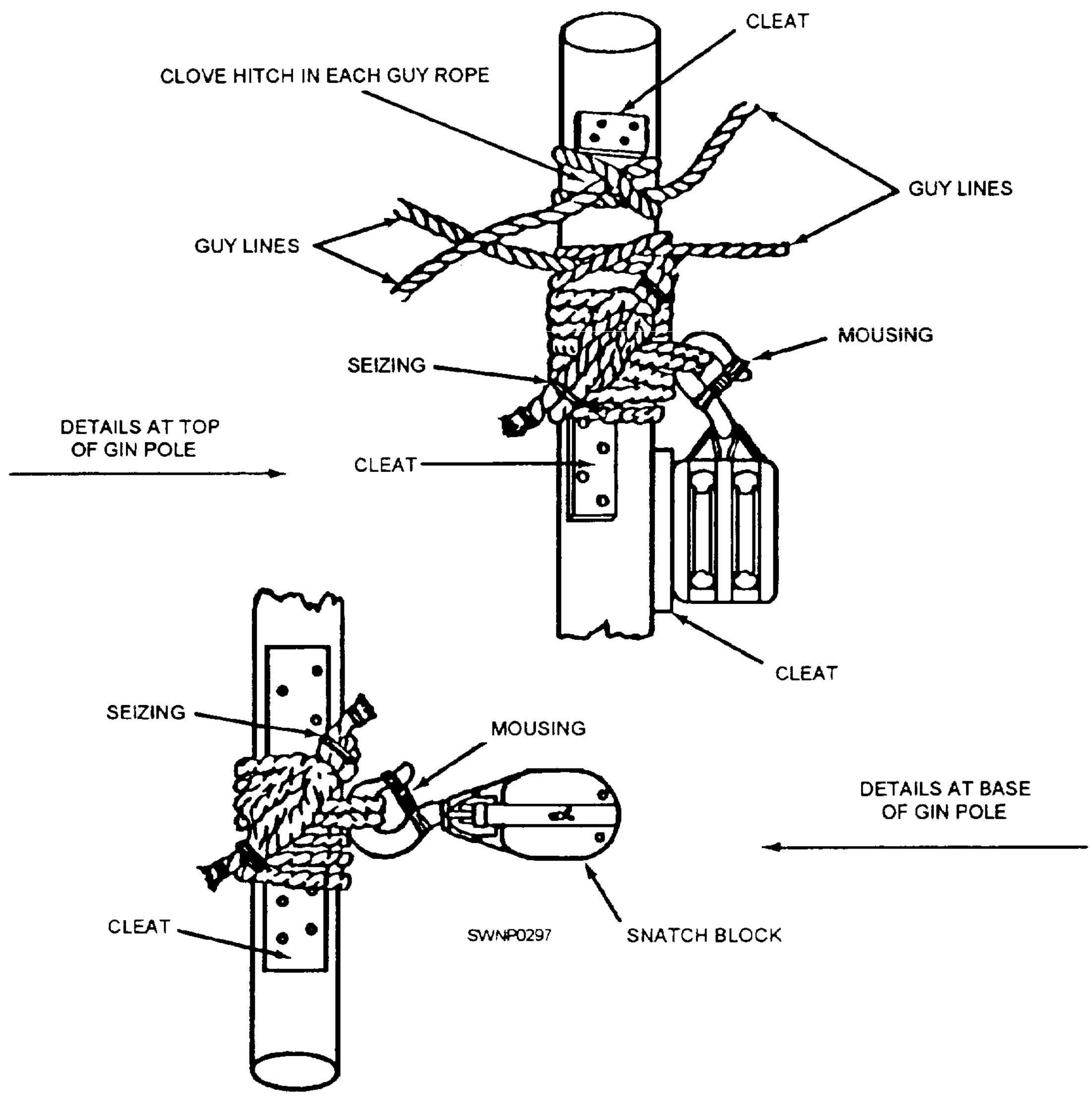


**Figure 6-50.—Lashing for a gin pole.**

form a clove hitch over the top of the pole next to the tackle lashing, and be sure the guy lines are aligned in the direction of their anchors.

c. Lash a block to the gin pole about 2 feet from the base of the pole, the same as was done for the tackle lashing at the top, and place a cleat above the lashing to prevent slipping. This block serves as a leading block on the fall line which allows a directional change of pull from the vertical to the horizontal. A snatch block is the most convenient type to use for this purpose.

d. Reeve the hoisting tackle and use the block lashed to the top of the pole so that the fall line can be passed through the leading block at the base of the gin pole.

e. Drive a stake about 3 feet from the base of the gin pole. Tie a rope from the stake to the base of the pole below the lashing on the leading block and near the bottom of the pole. This is to prevent the pole from skidding while it is being erected.

f. Check all lines to be sure that they are not tangled. Check all lashings to see that they are made up properly, and see that all knots are tight. Check the hooks on the blocks to see that they are moused properly. The gin pole is now ready to be erected.

2. Erecting. A gin pole 40 feet long can be raised easily by hand, but longer poles must be raised by supplementary rigging or power equipment. Figure 6-51 shows a gin pole being erected. The numbe of men

needed depends on the weight of the pole. The procedure is as follows:

a. Dig a hole about 2 feet deep for the base of the gin pole.

b. Run out the guys to their respective anchorages and assign a man to each anchorage to control the slack in the guy line with a round turn around the anchorage as the pole is raised. If it has not been done already, install an anchorage for the base of the pole.

c. If necessary, the tackle system used to raise and lower the load can be used to assist in raising the gin pole, but the attaching of an additional tackle system to the rear guy line is preferable. Attach the running block of the rear guy line tackle system (fig. 6-52) to the rear guy line end which at this point is near the base of the gin pole. The fixed or stationary block is then secured to the rear anchor. The fall line should come out of the running block to give greater mechanical advantage to the tackle system. The tackle system is stretched to the base of the pole before it is erected to prevent the chocking of the tackle blocks during the erection of the gin pole.

d. Keep a slight tension on the rear guy line, and *on each of the side guy lines,* haul in on the fall line of the tackle system while eight men (more for larger poles) raise the top of the pole by hand until the tackle system can take control.

e. The rear guy line must be kept under tension to prevent the pole from swinging and throwing all of its weight on one of the side guys.

f. When the pole is in its final position, approximately vertical or inclined as desired make all guys fast to their anchorages with the round turn and two half hitches. It is often advantageous to double the portion of rope used for the half hitches.

g. Open the leading block at the base of the gin pole and place the fall line from the tackle system through it. When the leading block is closed, the gin pole is ready for use. If it is necessary to move (drift) the top of the pole without moving the base, it should be done when there is no load on the pole unless the guys are equipped with tackle.

3. *Operating.* The gin pole is perfectly suited to vertical lifts. It also is used under some circumstances for lifting and pulling at the same time so that the load being moved travels toward the gin pole just off the ground. When used in this manner, a snubbing line of some kind must be attached to the other end of the load being dragged and kept under tension at all times. Tag lines are to be used to control loads being lifted vertically. A tag line is a light line fastened to one end of the load and kept under slight tension during hoisting.

## TRIPODS

A tripod consists of three legs lashed or secured at the top. The advantage of the tripod over other rigging installations is its stability, and it requires no guy lines to hold it in place. The disadvantage of a tripod is that the load can be moved only up and down. The load capacity of a tripod is approximately 1 1/2 times that of shears made of the same-size material.

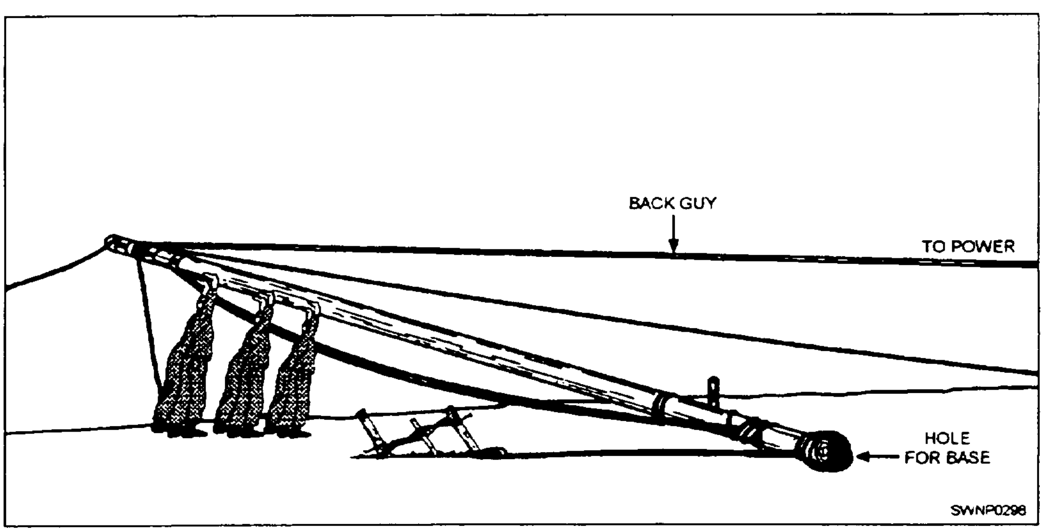


**Figure 6-51.—Erecting a gin pole.**

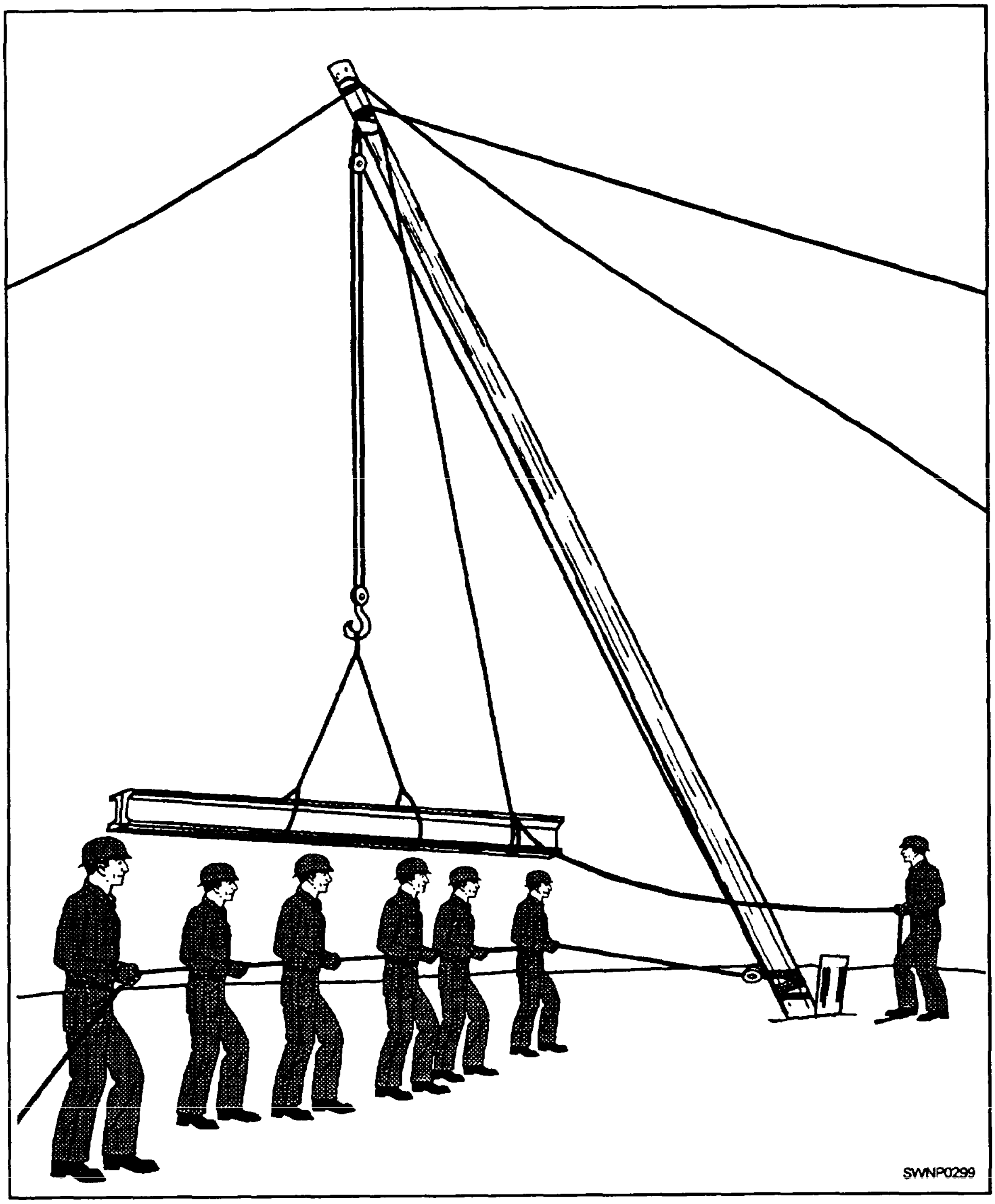


**Figure 6-52.—Hoisting with a gin pole.**

1. *Rigging.* There are two methods of lashing a tripod, either of which is suitable provided the lashing material is strong enough. The material used for lashing can be fiber rope, wire rope, or chain. Metal rings joined with short chain sections and large enough to slip over the top of the tripod legs also can be used. The method described below is for fiber rope 1 inch in diameter or smaller. Since the strength of the tripod is affected directly by the strength of the rope and the lashing used, more turns than described below should be used for extra heavy loads and fewer turns can be used for light loads.

*Procedure*

a. Select three masts of approximately equal size and place a mark near the top of each mast to indicate the center of the lashing.

b. Lay two of the masts parallel with their tops resting on a skid or block and a third mast between the first two, with the butt in the opposite direction and the lashing marks on all three in line. The spacing between masts should be about one half or the diameter of the spars. Leave the space between the spars so that the lashing will not be drawn too tight when the tripod is erected.

c. With a 1-inch rope, make a clove hitch around one of the outside masts about 4 inches above the lashing mark, and take eight turns of the line around the three masts (fig. 6-53). Be sure to maintain the space between the masts while making the turns.

d. Finish the lashing by taking two close frapping turns around the lashing between each pair of masts. Secure the end of the rope with a clove hitch on the center mast just above the lashing. Frapping turns should not be drawn too tight.

*Alternate procedure*

a. An alternate procedure (fig. 6-54) can be used when slender poles not more than 20 feet long are being used or when some means other than hand power is available for erection.

b. Lay the three masts parallel to each other with an interval between them slightly greater than

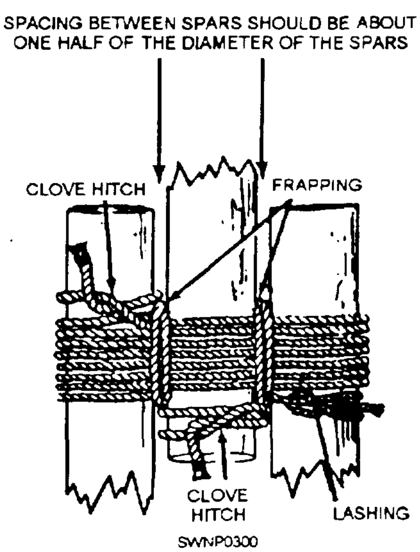


**Figure 6-53.—Lashing for a tripod.**

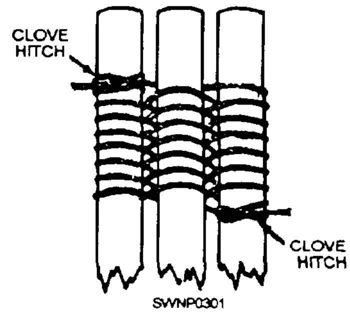


**Figure 6-54.—Alternate lashing for a tripod.**

twice the diameter of the rope to be used. Rest the tops of the poles on a skid so that the ends project over the skid approximately 2 feet and the butts of the three masts are in line.

c. Put a clove hitch on one outside leg at the bottom of the position the lashing will occupy, which should be approximately 2 feet from the end. Weave the line over the middle leg, under and around the outer leg, under the middle leg, over and around the first leg, and continue this weaving for eight turns. Finish with a clove hitch on the outer leg.

2. *Erecting.* The legs of a tripod in its final position should be spread so that each leg is equidistant (fig. 6-55) from the others. This spread should not be less than one half nor more than two thirds of the length of the legs. Chain, rope, or boards should be used to hold the legs in this position. A leading block for the fall line of the tackle can be lashed to one of the legs. The procedure is as follows:

a. Raise the tops of the masts about 4 feet, keeping the base of the legs on the ground.

b. Cross the two outer legs. The third or center leg then rests on top of the cross. With the legs in this position, pass a sling over the cross so that it passes over the top or center leg and around the other two.

c. Hook the upper block of a tackle to the sling and mouse the hook.

d. Continue raising the tripod by pushing in on the legs as they are lifted at the center. Eight men should be able to raise an ordinary tripod into position.

e. When the tripod legs are in their final position, place a rope or chain lashing between the legs to hold them from shifting.

3. *Erecting Large Tripods.* For larger tripod installations it maybe necessary to erect a small gin pole to raise the tripod into position. Tripods, lashed with the

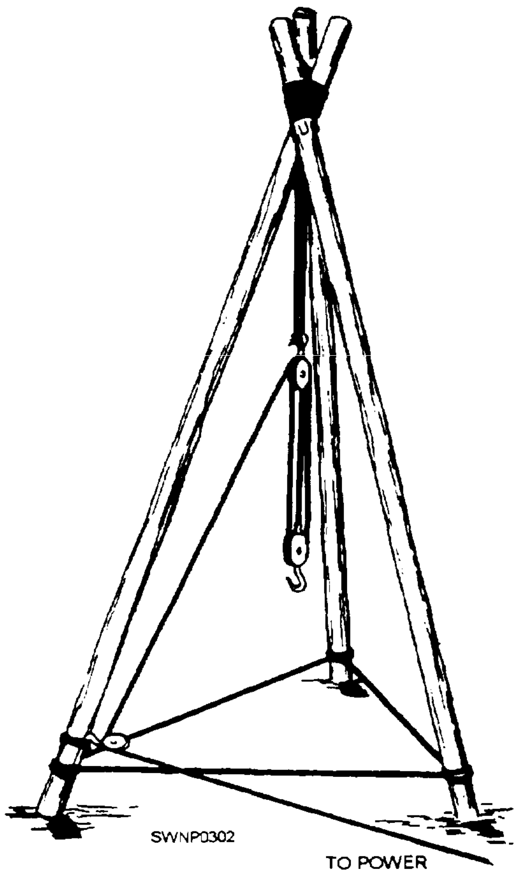


**Figure 6-55.—Tripod assembled for use.**

three legs laid together, must be erected by raising the tops of the legs until the legs clear the ground so they can be spread apart. Guy lines or tag lines should be used to assist in steadying the legs while they are being raised. The outer legs should be crossed so that the center leg is on the top of the cross, and the sling for the hoisting tackle should pass over the center leg and around the two outer legs at the cross.

## SHEARS

Shears, made by lashing two legs together with a rope, is well adapted for lifting heavy machinery or other bulky loads. It is formed by two members crossed at their tops with the hoisting tackle suspended from the intersection. The shears must be guyed to hold it in position. The shears is quickly assembled and erected. It requires only two guys and is adapted to working at an inclination from the vertical. The shear legs can be round poles, timbers, heavy planks, or steel bars, depending on the material at hand and the purpose of the shears. For determining the size of the members to be used, the load to be lifted and the ratio of the length and diameter of the legs are the determining factors. For heavy loads the length-diameter (L/ *d)* ratio should not exceed 60, because of the tendency of the legs to bend, rather than to act as columns. For light work, shears can be improvised from two planks or light poles bolted together and reinforced by a small lashing at the intersection of the legs.

1. *Rigging.* In erection, the spread of the legs should equal about one half of the height of the shears. The maximum allowable drift (inclination) is 45 degrees. Tackle blocks and guys for shears are essential. The guy ropes can be secured to firm posts or trees with a turn of the rope so that the length of the guys can be adjusted easily. The procedure is as follows:

a. Lay two timbers together on the ground in line with the guys with the butt ends pointing toward the back guy and close to the point of erection.

b. Place a large block under the tops of the legs just below the point of lashing (fig. 6-56), and insert a small spacer block between the tops at the same point. The separation between the legs at this point should be equal to one third of the diameter on one leg to make handling of the lashing easier.

c. With sufficient 1-inch rope for 14 turns around both legs, make a clove hitch around one mast, and take 8 turns around both legs above the clove hitch. Wrap the turns tightly so that the lashings are made smooth and without kinks.

d. Finish the lashing by taking two frapping turns around the lashing between the legs and securing the end of the rope to the other leg just below the lashing. For handling heavy loads the number of lashing turns is increased.

2. *Erecting.* Holes should be dug at the points where the legs of the shears are to stand. In case of placement on rocky ground, the base for the shears should be level. The legs of the shears should be crossed and the butts placed at the edges of the holes. With a short length of rope, make two turns over the cross at the top of the shears and tie the rope together to form a sling. Be sure to have the sling bearing against the masts and *not* on the shears lashing entirely. The procedures is as follows:

a. Reeve a set of blocks and place the hook of the upper block through the sling. Secure the sling in the hook by mousing. Fasten the lower block to one of the legs near the butt, so it will be in a convenient

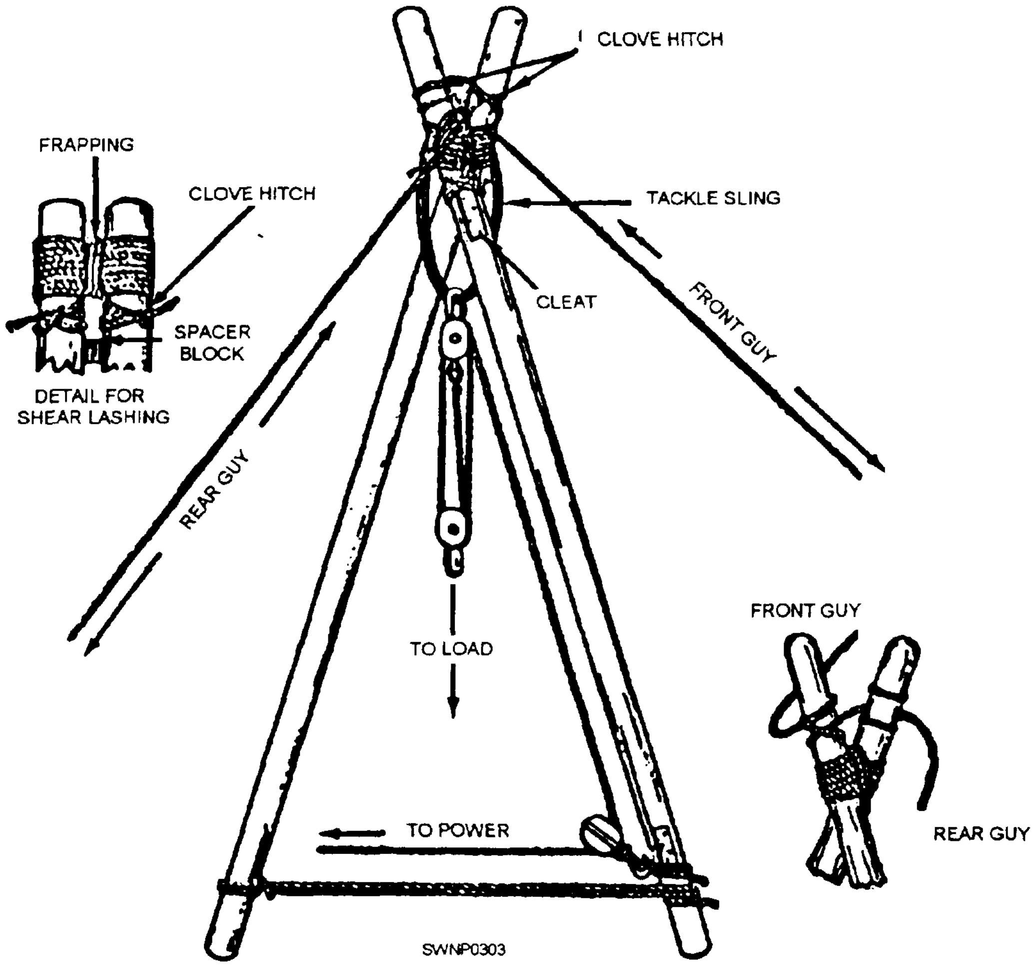


**Figure 6-56.—Lashing for shears.**

position when the shears have been raised, but will be out of the way during erection.

b. If the shears are to be used on heavy lifts, another tackle is rigged in the base guy near its anchorage. The two guys should be secured to the top of the shears with clove hitches to legs opposite their anchorages above the lashing.

c. Several men (depending on the size of the shears) should lift the top end of the shear legs and "walk" them up by hand until the tackle on the rear guy line can take affect. After this, the shear legs can be raised into final position by hauling in on the tackle. Secure the front guy line to its anchorage before raising the shear legs and keep a slight tension on this line to control movement. (See fig. 6-57.)

d. The legs should be kept from spreading by connecting them with rope chain, or bards. It can be necessary, under some conditions, to anchor each leg of the shears during erection to keep the legs from sliding in the wrong direction.

3. *Operating.* The rear guy is a very important part of the shears rigging, as it is under a considerable strain when hoisting. The front guy has very little strain on it and is used mainly to aid in adjusting the drift and to steady the top of the shears when hoisting or placing the load. It maybe necessary to rig a tackle in the rear guy for handling heavy loads. In operation, the drift (inclination of the shears) desired is set by adjustment of the rear guy, but this should not be done while a load is on the shears. For handling light loads, the fall line of the tackle of the shears can be led straight out of the upper block. When heavy loads are handled, you should lash a snatch block (fig. 6-58) near the base of one of the shear legs to act as a leading block, The fall line should be run through the leading block to a hand- or power-operated winch for heavy loads.

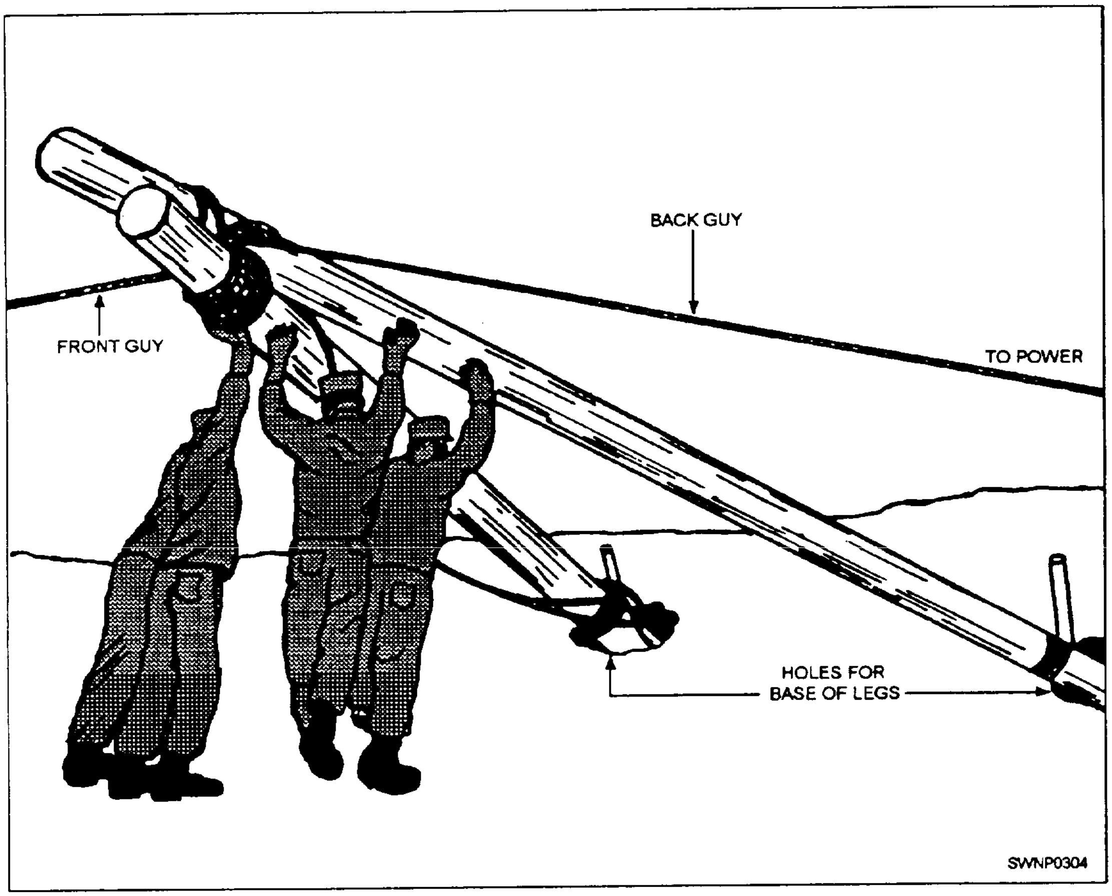


**Figure 6-57.—Erecting shears**

## RIGGING SAFE OPERATING PROCEDURES

All personnel involved with the use of rigging gear should be thoroughly instructed and trained to comply with the following practices:

1. Wire rope slings must not be used with loads that exceed the rated capacities outlined in enclosure (2) of the COMSECOND/COMTHIRDNCBINST 11200.11. Slings not included in the enclosure must be used only according to the manufacturer's recommendation.

2. Determine the weight of a load before attempting any lift.

3. Select a sling with sufficient capacity rating.

4. Examine all hardware, equipment, tackle, and slings before using them and destroy all defective components.

5. Use the proper hitch.

6. Guide loads with a tag line when practical.

7. When using multiple-leg slings, select the longest sling practical to reduce the stress on the individual sling legs.

8. Attach the sling securely to the load.

9. Pad or protect any sharp comers or edges the sling can come in contact with to prevent chaffing.

10. Keep slings free of kinks, loops, or twists.

11. Keep hands and fingers from between the sling and the load.

12. Start the lift slowly to avoid shock loading slings.

13. Keep slings well lubricated to prevent corrosion.

14. Do not pull slings from under a load when the load is resting on the slings; block the load up to remove slings.

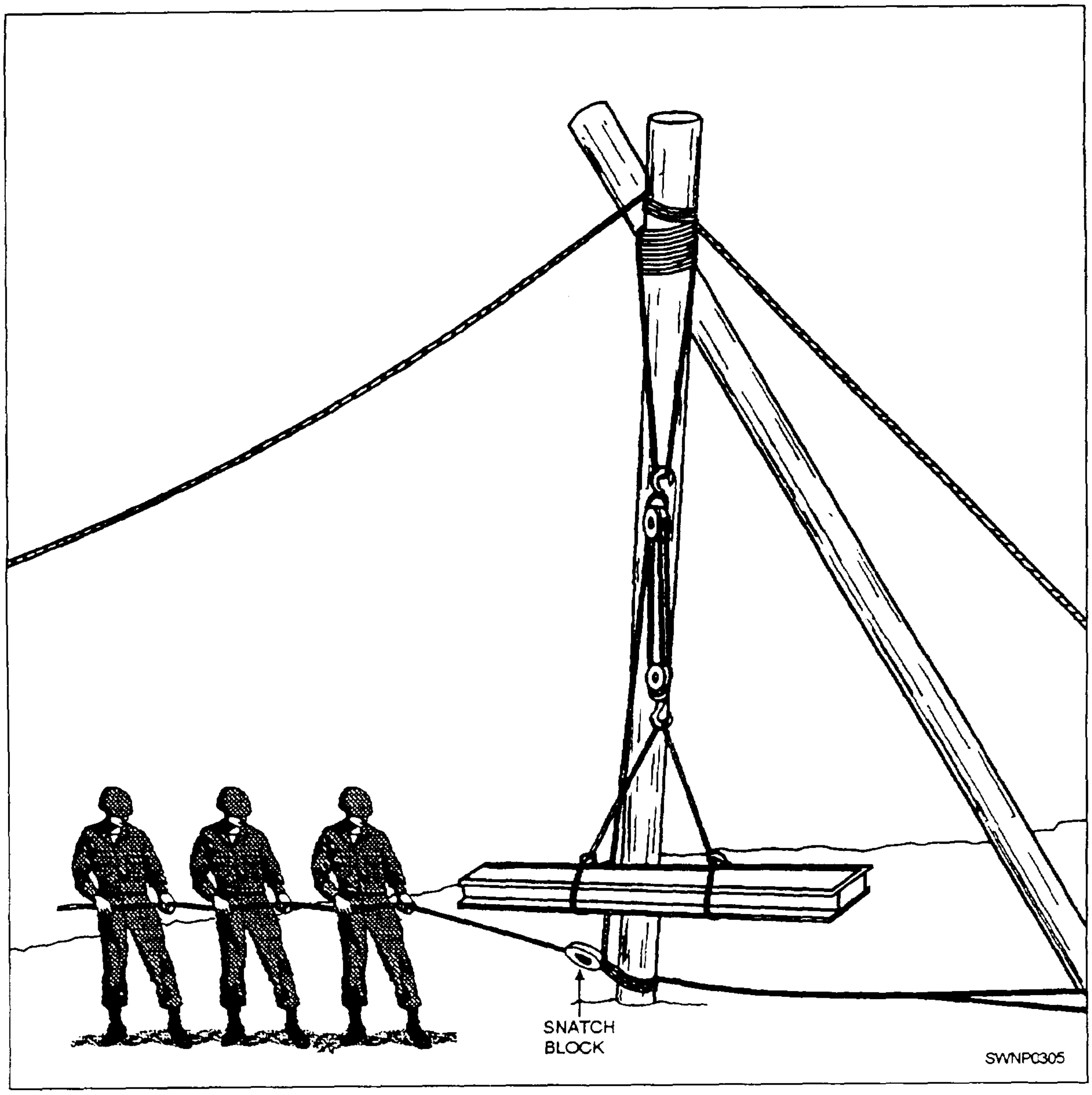


**Figure 6-58.—Hoisting with shears.**

15. Do not shorten a sling by knotting or using wire rope clips.

16. Do not inspect wire rope slings by passing bare hands over the rope. Broken wires, if present, can cause serious injuries. When practical, leather palm gloves should be worn when working with wire rope slings.

17. Center of Balance. It is very important that in the rigging process that the load is stable. A stable load is a load in which the center of balance of the load is directly below the hook, as shown in figure 6-59. When a load is suspended, it will always shift to that position below the hook. To rig a stable load, establish the center of balance (C/B). Once you have done this, simply swing the hook over the C/B and select the length of slings needed from the hook to the lifting point of the load.

18. When using a multi-legged bridle sling, do not forget it is wrong to assume that a three- or four-leg hitch will safely lift a load equal to the safe load on one leg multiplied by the number of legs. With a four-legged bridle sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two only balance it (fig. 6-60).

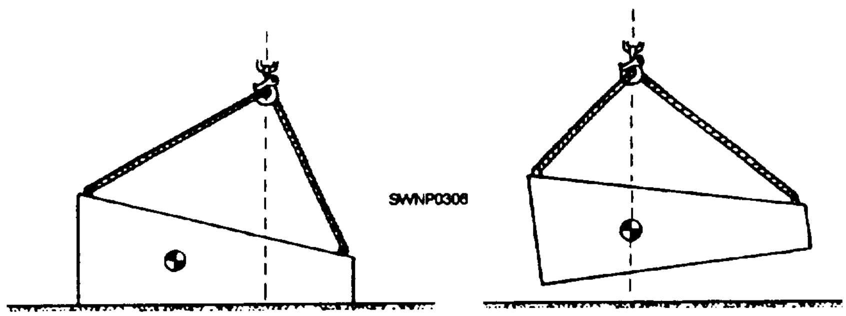


Figure 6-59.—Example of a load shifting when lifted.

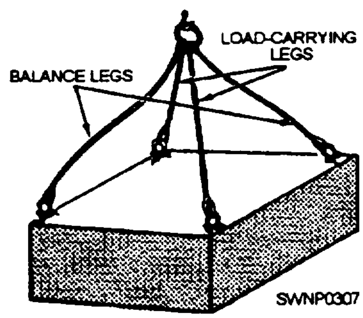


Figure 6-60.—Multi-legged bridle sling lifting a load.

**NOTE:** If all the legs of a multi-legged sling are not required, secure the remaining legs out of the way, as shown in figure 6-61.

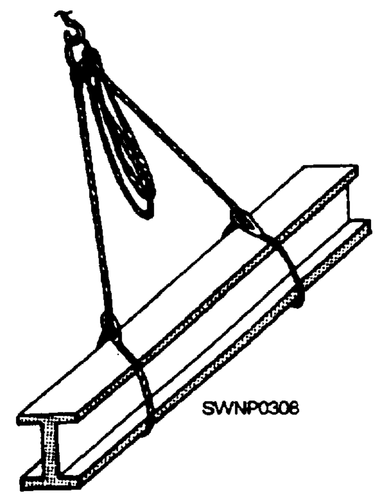


Figure 6-61.—Secure sling legs that are not used.