Rigging

1. Basic Scaffolds and ladders

As the working level of a structure rises above the reach of crew members on the ground or deck, temporary elevated platforms, called scaffolding, are erected to support the crew members, their tools, and materials. The term *scaffold* refers to a temporary elevated platform used to support personnel and materials for immediate usage or for a particular phase of construction throughout the course of the work. Scaffolds are used to perform various jobs that cannot be done safely from securely placed ladders. Take a look at a few of the different types of scaffolds you may need from time to time on the job.

There are two types of scaffolding in use today, wood and prefabricated. The wood types include the swinging scaffold, which is suspended from above, and the pole scaffold, which is supported on the ground or deck. The prefabricated type is made of metal and put together in sections, as needed.

1.1. Swinging Scaffold Construction

The simplest type of a swinging scaffold consists of an unspliced plank made from 2 x 8 inch (minimum) lumber. Place hangers between 6 and 18 inches from the ends of the plank. Ensure the span between hangers does not exceed 10 feet. Make sure also to secure the hangers to the plank to stop them from slipping off. In addition, a guardrail must be constructed. The guardrail should be made of 2 x 4 inch material between 36 and 42 inches high. Construct a mid-rail, if required, of 1 x 4 inch lumber.

Suspend swing scaffolds by wire or fiber line secured to the outrigger beams. Suspension ropes require a minimum safety factor of six. The blocks for fiber ropes should be the standard six inch size consisting of at least one double block and one single block. The sheaves of all blocks should fit the size of rope used. Space the outrigger beams no more than the hanger spacing and construct them of no less than 2 x 10 inch lumber. The beam should not extend more than six feet beyond the face of the building. The inboard side should be nine feet beyond the edge of the building and securely fastened to the building.

1.2. Pole Scaffold Construction

The poles on a job-built pole scaffold should not exceed 60 feet in height. If higher poles are required, an engineer must design the scaffolding.

• All poles must be setup perfectly plumb.

• The lower ends of poles must not bear directly on a natural earth surface. If the surface is earth, a board footing two inches thick and 6 to 12 inches wide, depending on the softness of the earth, must be placed under the poles.

• If poles must be spliced, splice plates must not be less than four feet long, not less than the width of the pole wide, and each pair of plates must have a combined thickness not less than the thickness of the pole. Adjacent poles must not be spliced at the same level.

1.3. Prefabricated Scaffold Erection

Several types of scaffolding are available for simple and rapid erection; one of these types is shown in *Figure 31*. The scaffold uprights are braced with diagonal members, and the working level covered with a platform of planks. All bracing must form triangles, and the base of each column requires adequate footing plates for the bearing area on the ground or deck. The steel scaffolding is usually erected by placing the two uprights on the ground or deck and inserting the diagonal members. The diagonal members have end fittings that permit rapid locking in position.

Figure 31 Assembling prefabricated independent-pole scaffolding

Prefabricated scaffolding comes in three categories: light, medium, and heavy duty. Light duty has nominal two inch outside diameter steel tubing bearers. Posts are spaced no more than six to ten feet apart. Light-duty scaffolding must be able to support 25 pounds per square foot loads. Medium duty scaffolding normally uses two inch outside diameter steel tubing bearers. Posts should be spaced no more than five to eight feet apart. If 2 1/2 inch outside diameter steel tubing bearers are used, posts are to be spaced six to eight feet apart. Medium duty scaffolding must be able to support 50 pounds per square foot loads. Heavy duty scaffolding should have bearers of 2 1/2 inch outside diameter steel tubing with the posts spaced not more than six feet to six feet six inches apart. This scaffolding must be able to support 75 pounds per square foot loads. To find the load per square foot of a pile of materials on a platform, divide the total weight of the pile by the number of square feet of platform it covers.

1.4. Bracket Scaffolding

The bracket, or carpenter's scaffold, is built of a triangular wood frame with not less than 2 x 3 inch lumber or metal of equivalent strength. Each bracket is attached to the structure in one of four ways: (1) a bolt, at least 5/8 inch, that extends through to the inside of the building wall; (2) a metal stud attachment device; (3) welded to a steel tank; or (4) hooked over a secured supporting member. The brackets must be spaced no more than eight feet apart. No more than two persons should be on any eight foot section at any one time. Tools and materials used on the scaffold should not exceed 75 pounds. The platform is built of at least two 2 x 10 inch nominal size planks. The planks should extend between six and twelve inches beyond each support.

1.5. Scaffold Safety

When working on scaffolding or tending others on scaffolding, observe all safety precautions. Construction supervisors must not only observe the safety precautions themselves, but must also issue them to their crew and ensure that the crew observes them. The following is a list of the minimum safety precautions that must be followed.

- Always keep scaffolds clear of accumulations of tools, equipment, materials, and rubbish.
- Do not use a scaffold to store materials in excess of those currently required for the job.
- Tools not in immediate use on scaffolds must be stored in containers to prevent them from being knocked off. Tool containers must be tied down or otherwise secured to the scaffolds.
- Throwing objects up to the scaffold or dropping them from a scaffold is absolutely prohibited. Always use hand lines for raising or lowering objects you cannot pass hand to hand.
- A standard guardrail and toe board should be provided on the open side of all platforms five feet or more above ground; otherwise, safety belts tied off to safety lines must be used.

• No person should remain on a rolling scaffold while it is being moved.

2. Cranes and Hoists

At times, due to the very nature of heavy construction, such as when constructing pre-engineered buildings, piers, bridges, and many other components related to AdvancedBase Functional Components (ABFC), steelworkers must erect heavy structural members. Usually you will hoist these members into position using cranes, forklifts, or other construction equipment. In contingency/ combat operations, however, this equipment may not be available because of operational commitments, and structural members must be hoisted without the heavy equipment. This section will present some of the methods you can use for the erection process when heavy equipment is unavailable.

2.1. Work Practice and Safety

Lifting any load safely takes two personnel, an equipment operator and a signalman. In the following paragraphs, we will discuss the importance of the signalman and a few of the safety rules all hands engaged in hooking on must observe.

2.1.1. Signalman

One person and one person only should be designated as the official signalman for the operator of a piece of hoisting equipment, and both the signalman and the operator must be thoroughly familiar with the standard hand signals. When possible, the signalman should wear some distinctive article of dress, such as a bright-colored helmet. The signalman must maintain a position from which he or she can see the load and the crew working on it, and the operator can see him or her.

Some of the signals shown apply only to mobile equipment; others to equipment with a boom that can be raised, lowered, and swung in a circle. The signalman uses two-arm hoist and lower signals when he or she desires to control the speed of hoisting or lowering. The one-arm hoist or lower signal allows the operator to raise or lower the load. To dog off the load and boom means to set the brakes so as to lock both the hoisting mechanism and the boom hoist mechanism. The signal is given when circumstances require that the load be left hanging motionless. With the exception of the emergency stop signal which may be given by anyone who sees a necessity for it, and which the operator must obey instantly, only the official signalman gives the signals. The signalman is responsible for making sure members of the crew remove their hands from slings, hooks, and loads before giving a signal. The signalman should also make sure all persons are clear of bights and snatch block lines.

Standard Hand Signals for Controlling

When there is a lot of traffic at a worksite, it is essential for workers to be able to use hand signals.

2.1.2. Attaching a Load

Some common ways of attaching a load can be seen in figure 32. A sling can be made of line, wire, or wire rope with an eye at each end, also called a strap, or an endless sling. When a sling is passed through its own bight or eye, or shackled or hooked to its own standing part so it tightens around the load like a lasso when the load is lifted, the sling is said to be choked, or it may be called a choker. A two-legged sling that supports the load at two points is called a bridle.

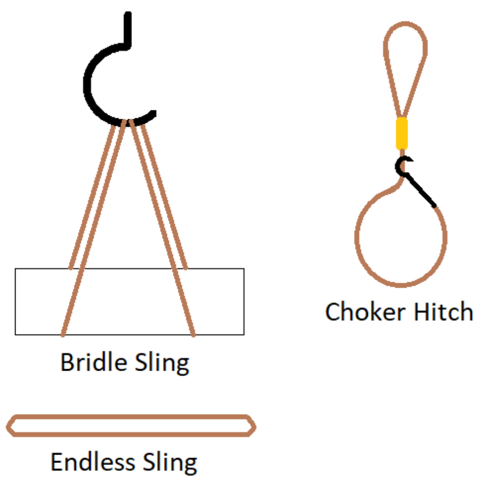


Figure 32 Ways of hitching a sling

Safety Rules

The following safety rules must be given to all hands engaged in hooking on. They must be strictly observed.

• The person in charge of hooking on must know the safe working load of the rig and the weight of every load to be hoisted. The hoisting of any load heavier than the safe working load of the rig is absolutely prohibited.

• When a cylindrical metal object such as a length of pipe, a gas cylinder, or the like, is hoisted in a choker bridle, give each leg of the bridle a round turn around the load before hooking or shackling it to its own part, or have a spreader bar placed between the legs. The purpose of this is to ensure that the legs of the bridle will not slide together along the load, upsetting the balance and possibly dumping the load.

• The point of strain on a hook must never be at or near the point of the hook.

• Before the hoist signal is given, the person in charge must be sure the load will balance evenly in the sling.

• Before the hoist signal is given, the person in charge should be sure that the lead of the whip or falls is vertical. If it is not, the load will take a swing as it leaves the deck or ground.

2.2. Crane Types

In general, rotating cranes are characterized by a topping boom attached to a kingpost or a pedestal that resists the overturning forces created by the boom and attached load, or a boom rigidly attached to a rotating column or base. No rotating cranes are characterized by a bridge and trolley arrangement.

Hoisting equipment is located on the trolley that, in turn, is transported on movable bridge girders and wheel trucks.

Other specific application factors include an ability and need to travel with the load and collateral facilities (such as rails, availability of power and support, safety, cost, mobility, clearances, and accuracy of spotting).

In general, the following types of cranes offer advantages for the reasons given:

a. Rotating, Topping Cranes; ability to clear heights or obstacles

b. Rotating, No topping Cranes; cost and space savings

c. Non-rotating Cranes; high load capacity and ability to operate within enclosed spaces

d. All Traveling Cranes; broad area of coverage.

TYPES OF CRANES

Type	Description
Rotating	
Topping	
1. Kingpost Crane	A crane with topping boom commonly used where heavy lifts and long boom outreach is required. The kingpost provides an axis of crane rotation and resists the bending moment of the load
2. Pedestal Crane	A crane with topping boom which utilizes large bearings to absorb the major stresses imposed by crane motions. Occasionally, these cranes are provided with counterweights and aid stabilization. The base structure may be fixed or traveling

Type	Description
	Rotating
3. Portal Crane	A crane with a topping boom, mounted on an elevated platform so that it can travel (on rails) over objects and personnel on deck
4. Mobile Crane (Truck)	A crane with a topping boom and an independent power plant, mounted on a self-propelled truck. Its primary advantage is mobility.
Nontopping	
1. Jib Crane	A fixed crane consisting of a fixed vertical member supported at top and bottom, and a horizontal revolving arm carrying a trolley
2. Pillar Crane	A fixed crane consisting of a vertical member, held in position at the base to resist the overturning moment, and a constant-radius revolving boom supported by a tension member
Raised Runway	
Overhead Traveling Crane	A crane on a pair of elevated parallel rails adapted to lift and lower a load, and carry it horizontally parallel or at right angles to the rails. Consists of one or more trolleys operating on top or bottom of a bridge, which consists of one or more girders or trusses mounted on trucks operating on elevated rails. Operational area is limited to the space between the bridge rails
Traveling Support	
Gantry Crane	A crane, similar to an overhead traveling crane, except that the bridge for carrying the trolley(s) is rigidly supported on two or more gantry legs. The assembly moves on fixed rails

2.3. Block and Tackle

A block 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.

A machine's mechanical advantage is the amount the machine can multiply the force used to lift or move a load. A person's strength determines the weight he or she can push or pull; this is referred to as the amount of force the individual can exert. To move any load heavier than the force a person can exert requires the use of a machine to provide a mechanical advantage. If you use a machine that can produce a force (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 sheave(s) of blocks, as shown in Figure 33.

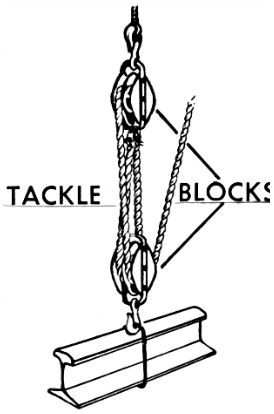


Figure 33 Block and tackle

3. Wire Rope and Chains

3.1. Construction

Wire rope consists of three parts; wires, strands, and core, as shown in Figure 34. In the manufacture of rope, a number of wires are laid together to form the strand. Then a number of strands are laid together around a core to form the rope.

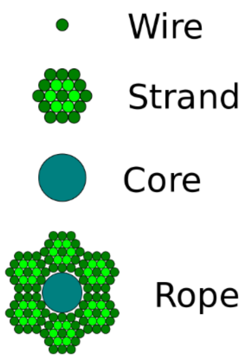
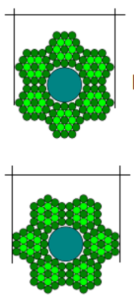


Figure 34 Rope components

The basic unit of wire rope construction is the individual wire, which may be made of steel, iron, or other metal, in various sizes. The number of wires to a strand varies, depending on the purpose for which the rope is intended. Wire rope is designated by the number of strands per rope and the number of wires per strand. Thus a ½ inch 6 X 19 rope will have 6 strands with 19 wires per strand; but it will have the same outside diameter as a 1/2 inch 6 X 37 wire rope, which will have 6 strands with 37 wires of much smaller size per strand. Wire rope made up of a large number of small wires is flexible, but the small wires are easily broken, so the wire rope does not resist external abrasion. Wire rope made up of a smaller number of larger wires is more resistant to external abrasion, but is less flexible.

3.2. Grades of Wire Rope

Wire rope is made in a number of different grades. Three of the most common are mild plow steel, plow steel, and improved plow steel. Mild plow steel rope is tough and pliable. It can stand up under repeated strain and stress and has a tensile strength of from 200,000 to 220,000 pounds per square inch (psi). Plow steel wire rope is unusually tough and strong. It has a tensile strength, or resistance to lengthwise stress, of 220,000 to 240,000 psi. This rope is suitable for hauling, hoisting, and logging. Improved plow steel rope is one of the best grades of rope available, and most, if not all, of the wire rope in your work will probably be made of this material. It is stronger, tougher, and more resistant to wear than either plow steel or mild plow steel. Each square inch of improved plow steel can withstand a strain of 240,000 to 260,000 psi.



Incorrect diameter measurement

Correct diameter measurement

Figure 35 Rope diameter measurement

3.3. Safe Working Load

The term safe working load (SWL), in reference to wire rope, means the load that can be applied and still obtain the most efficient service from and prolong the life of the rope. Most manufacturers provide tables that show the safe working load for their rope under various conditions. In the absence of these tables, you must apply a formula to obtain the SWL. There are rules of thumb you can use to compute the strength of wire rope.

$$SWL = 8 \cdot D^2$$

D represents the diameter of the rope in inches, and **SWL** represents the safe working load in tons. This particular formula provides an ample safety margin to account for such variables as the number, size, and location of the sheaves and drums on which the rope runs. It also includes dynamic stresses, such as the speed of operation and the acceleration and deceleration of the load. All can affect the endurance and breaking strength of the rope. Let’s work an example. Suppose you want to find the SWL of a 2 inch rope. Using the formula above, your figures would be:

$$SWL = 8 \cdot 2^2 = 8 \cdot 4 = 32$$

The answer is 32, meaning that the rope has a SWL of 32 tons. It is very important to remember that any formula for determining SWL is only a rule of thumb. In computing the SWL of old rope, worn rope, or rope that is otherwise in poor condition, you should reduce the SWL as much as 50 percent, depending on the condition of the rope. Use the manufacturer's data concerning the breaking strength (BS) of wire rope if available. But if you do not have that information, one rule of thumb recommended is:

$$BC = C^2 \cdot 8{,}000\ Pounds$$

Wire rope is measured by the diameter **(D).** To obtain the circumference **(C)** required in the formula, multiply **D** by pi **(π),** which is approximately **3.1416**. Thus, the formula to find the circumference is:

$$C = \pi \cdot \mathrm{D}$$

3.4. Wire Rope Failure

Wire can fail due to any number of causes. Here is a list of some of the common causes of wire rope failure.

- Using the incorrect size, construction, or grade of wire rope
- Dragging rope over obstacles
- Having improper lubrication
- Operating over sheaves and drums of inadequate size
- Overriding or cross winding on drums
- Operating over sheaves and drums with improperly fitted grooves or broken flanges
- Jumping off sheaves
- Subjecting it to acid fumes
- Attaching fittings improperly
- Promoting internal wear by allowing grit to penetrate between the strands
- Subjecting rope to severe or continued overload

3.5. Wire Rope Attachments

Many attachments can be fitted to the ends of wire rope to connect it to other wire ropes, pad eyes, or equipment. The attachment used most often to attach dead ends of wire ropes to pad eyes or like fittings on earthmoving rigs is the wedge socket, shown in Figure 36. Apply the socket to the bitter end of the wire rope as shown in the figure.

Figure 35 Wedge socket

3.6. Chain Slings

Chain slings are suited to applications requiring flexibility and resistance to abrasion, cutting, and high temperatures. However, their use should be limited to specific lifts to meet a particular requirement. This guidance will be repeated in Topic 3.0.0 which provides additional guidance concerning chains: “In the NCF, never use a chain when it is possible to use wire rope.” Alloy steel chain grade 80 is marked with an 8, 80, or 800; grade 100 is marked with a 10, 100, or 1000. Alloy steel chain is the only type that can be used for overhead lifting.

As with all slings and associated hardware, chain slings must have a design factor of 5. In North America, chain manufacturers usually give working load limits based on a design factor of 3.5 or 4. Always check with manufacturers to determine the design factor on which their working load limits are based. If the design factor is less than 5, calculate the working load limit of the chain by multiplying the catalog working load limit by the manufacturer’s design factor and dividing by 5.

$\frac{Catalog\ WLL}{5}$ x Manufacturer’s D.F. = WLL (based on design factor of 5)

Example – 1/2” Alloy Steel Chain

Catalog WLL = 13,000 lbs.

Design Factor = 3.5

$\frac{13{,}000}{5}$ x 3.5=9,100

This chain sling must be de-rated to 9,100 lbs. for construction applications. Wherever they bear on sharp edges, chain slings should be padded to prevent links from being bent and to protect the load. Never tie a knot in a chain sling to shorten the reach. Slings can be supplied with grab hooks or shortening clutches for such applications.

Inspect chain slings for inner link wear, and wear on the outside of the link barrels. Manufacturers publish tables of allowable wear for various link sizes. Many companies will also supply wear gauges to indicate when a sling must be retired or links replaced. Gauges or tables from a particular manufacturer should be used only on that brand of chain since exact dimensions of a given nominal size can vary from one manufacturer to another. A competent worker should check chain slings for nicks and gouges that may cause stress concentrations and weaken links. If nicks or gouges are deep or large in area, or reduce link size below allowable wear, remove the chain from service. Any repairs must be done according to manufacturer specifications.

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 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.

3.6.1. Safe Working Loads

The safe working load is ordinarily one-sixth of the breaking strength, giving a safety factor of 6. The table below lists various typical safe working loads.

Table Chain Safe Working Loads.

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	1240
3/8	1.7	1350	1490	1650	3200
1/2	2.5	2250	2480	2630	5250
5/8	4.3	3470	3810	4230	7600
3/4	5.8	5070	5580	6000	10500
7/8	8.0	7000	7700	8250	14330
1	10.7	9300	10230	10600	18200
1 1/8	12.5	9871	10858	11944	21500
1 1/4	16.0	12186	13304	14634	26300
1 3/8	18.3	14717	16188	17807	32051

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

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

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

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:

Converting the fraction to a decimal, SWL = $8D^2$ = $8 \cdot 0.75^2$ = 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 and stopped. The impact load is several times the weight of the load.

3.6.2. Handling and Care

When hoisting heavy metal objects using chains 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, and then fasten the two nearby links together with a connecting link.

4. Fiber Rope and Knots

Fiber line is made from either natural or synthetic fiber. Natural fibers, which come from plants, include manila, sisal, and hemp. Synthetic fibers include nylon, polyester, and polypropylene.

4.1. Types of Ropes

4.1.1. Natural Fiber Ropes

The two most commonly used natural fiber ropes are manila and sisal, but the only type suitable for construction rigging is a good grade of manila. High quality manila is light cream in color, smooth, clean, and pliable. The quality of the line can be distinguished by varying shades of brown; Number 1 grade is very light in color, Number 2 grade is slightly darker, Number 3 grade is considerably darker. The next best line making fiber is sisal. Sisal fiber is similar to manila, but lighter in color. This type of fiber is only about 80 percent as strong as manila fiber.

4.1.2. Synthetic Fiber Ropes

Synthetic fiber rope, such as nylon and polyester, has rapidly gained wide use by the Navy. It is lighter in weight, more flexible, less bulky, and easier to handle and store than manila line. It is also highly resistant to mildew, rot, and fungus. Synthetic rope is stronger than natural fiber rope. For example, nylon is about three times stronger than manila. When nylon line is wet or frozen, the loss of strength is relatively small. Nylon rope will hold a load even though several strands may be frayed. Ordinarily, the line can be made reusable by cutting away the chafed or frayed section and splicing the good line together.

4.2. Fabrication of Line

The fabrication of line consists essentially of three twisting operations. First, the fibers are twisted to the right to form the ***yarns***. Next, the yarns are twisted to the left to form the strands. Finally, the strands are twisted to the right to form the line.

The operation just described is the standard procedure, and the resulting product is known as a right-laid line. When the process is reversed, the result is a left-laid line. In either instance, the principle of opposite twists must always be observed. The two main reasons for the principle of opposite twists are these: to keep the line tight to prevent the fibers from unlaying with a load suspended on it, and to prevent moisture penetration.

4.3. Size Designation

Line that is 1 3/4 inches or less in circumference is called small stuff. The size is usually designated by the number of threads, or yarns, that make up each strand. You may use from six to 24 thread strands, but most commonly, 9 to 21 thread strands are used. You may hear some small stuff designated by name without reference to size. One such type is marline; a tarred, two strand, left-laid hemp. Marline is the small stuff you will use most for seizing.

When you need something stronger than marline, you will use a tarred, three-strand, left laid hemp called houseline.

Line larger than 1 3/4 inches in circumference is generally size designated by its circumference in inches. A six-inch manila line, for instance, is constructed of manila fibers and measures six inches in circumference. Twelve inches is about the largest manila carried in stock. Anything larger is used only on special jobs. If you have occasion to order line, you may find that the catalogs designate it by diameter and that's how you order it. The catalog may also use the term rope rather than line.

4.4. Strength of Fiber Line

Overloading a line poses a serious threat to the safety of personnel, not to mention the heavy losses likely to result through damage to material. To avoid overloading, you must know the strength of the line with which you are working. This involves three factors: breaking strength, safe working load (SWL), and ***safety factor***. Breaking strength refers to the tension at which the line will part when a load is applied. Rope manufacturers determine breaking strength through tests, and they provide tables with this information. In the absence of a manufacturer table, a rule of thumb for finding the <u>breaking strength of manila line</u> is the formula:

$$BS = C^2 \cdot 900$$

BS equals the breaking strength in pounds and C equals the circumference in inches.

To find BS, first square the circumference, then multiply the value obtained by 900.

For example, with a three inch line you will get a BS of 8,100 pounds as follows:

$$BS = 3^2 \cdot 900 = 8{,}100\ Pounds$$

The breaking strength of manila line is higher than that of sisal line because of the difference in the two fibers. The fiber from which a particular line is constructed has a definite bearing on its breaking strength. The breaking strength of nylon is almost three times that of manila line of the same size.

The best rule of thumb to find the breaking strength of nylon is as follows:

$$BS = C^2 \cdot 2{,}400$$

Briefly defined, the safe working load of a line is the load that can be applied without damaging the line. Note that the safe working load is considerably less than the breaking strength. A wide margin of difference between breaking strength and safe working load is necessary. This difference allows for such factors as additional strain imposed on the line by jerky movements in hoisting or bending over sheaves in a pulley block.

You may not always have a chart available to tell you the safe working load for a particular line. Here is a rule of thumb that will adequately serve your needs on such an occasion:

$$SWL = C^2 \cdot 150$$

In this equation, SWL equals the safe working load in pounds, and C equals the circumference of the line in inches. Simply take the circumference of the line, square it, and then multiply by 150. For a 3 inch line:

$$SWL = 3^2 \cdot 150 = 1{,}350\ Pounds$$

The safe working load of a three inch line is equal to 1,350 pounds. If a line is in good shape, add 30 percent to the SWL derived by means of the preceding rule; if it is in bad shape, subtract 30 percent from the SWL. In the example given above for the three inch line, adding 30 percent to the 1,350 pounds gives you a safe working load of 1,755 pounds. On the other hand, subtracting 30 percent from 1,350 pounds leaves you with a safe working load of 945 pounds.

Remember that the strength of a line decreases with age, use, and exposure to excessive heat, boiling water, or sharp bends. Especially with used line, give these and other factors affecting strength careful consideration and make proper adjustments in determining the breaking strength and safe working load capacity of the line. Manufacturers of line provide tables that show the breaking strength and safe working load capacity of line. Those tables are very useful in your work. You must remember that the values given in manufacturers' tables apply only to new line used under favorable conditions. For that reason, you must progressively reduce the values given in these tables as the line ages or deteriorates with use.

4.5. Fiber Line Sling

Fiber line slings are preferred for some applications because they are pliant, grip the load well, and do not mar the load's surface. They should be used only on light loads, however, and must never be used on objects that have sharp edges capable of cutting the line or in applications where the sling will be exposed to high temperatures, severe abrasion, or acids.

The choice of line type and size will depend on the application, the weight to be lifted, and the sling angle. Before lifting any load with a fiber line sling, be sure to inspect the sling carefully. Fiber slings, especially manila, deteriorate far more rapidly than wire rope slings and their actual strength is very difficult to estimate. Like other slings, fiber line slings should be inspected regularly. Look for external wear and cutting, internal wear between strands, and deterioration of fibers.

Open up the line for inspection along the length of the line by untwisting the strands, but take care not to kink them. The inside of the line should be as bright and clean as when it was new. Check for broken or loose yarns and strands. An accumulation of powder like dust indicates excessive internal wear between strands as the line is flexed back and forth during use.

4.5.1. Synthetic Web Slings

Web slings are available in two materials – nylon and polyester (Dacron). Nylon is resistant to many alkalis, whereas polyester is resistant to many acids. Consult the manufacturer before using web slings in a chemical environment. Nylon slings are more common, but polyester slings are often recommended where headroom is limited since they stretch only half as much as nylon slings. Synthetic web slings offer a number of advantages for rigging purposes.

• Their relative softness and width create much less tendency to mar or scratch finely machined, highly polished, or painted surfaces, and exhibit less tendency to crush fragile objects than either fiber rope, wire rope, or chain slings.

• Because of their flexibility, they tend to mold themselves to the shape of the load.

• They do not rust and thus will not stain ornamental precast concrete or stone.

• They are non-sparking and can be used safely in explosive atmospheres.

• They minimize twisting and spinning during lifting.

• Their light weight permits ease of rigging, their softness precludes hand cuts, and the danger of harm from a free-swinging sling is minimal.

• They are elastic and stretch under load more than either wire rope or chain, so they help absorb heavy shocks and cushion loads. In cases where sling stretching must be minimized, a sling of larger load capacity or a polyester sling should be used. Synthetic web slings are available in a number of configurations useful in construction. In place of sewn eyes, web slings are available with metal end fittings. The most common are triangle and choker hardware. Combination hardware consists of a triangle for one end of the sling and a triangle/rectangle (choker attachment) for the other end. With this arrangement, choker and basket as well as straight hitches may be rigged. Such attachments help reduce wear in the sling eyes and thus lengthen sling life.

Inspect synthetic web slings regularly. Damage is usually easy to detect. Cuts, holes, tears, frays, broken stitching, worn eyes and worn or distorted fittings, and burns from acid, caustics, or heat are immediately evident and signal the need for replacement. Do not attempt repairs yourself.

4.6. 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. Use jacks 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, you should use only heavy-duty hydraulic jacks or screw jacks. The number of jacks you use 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.

The types of jacks typically used by steelworkers are the following:

1. Ratchet lever jacks are rack bar jacks with 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.

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.

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.

4. Hydraulic jacks are available in many different capacities and are used for general purposes.