## Anchors and Anchor Systems

An anchor is the means of securing the ropes and/or system to something solid. Anchors can be natural elements such as trees or rocks, artificial, such as beam clamps or removable swivel bolts or they can be man-made such as structural beams and apparatus.

An anchor (also called an anchor point) is a stationary object capable of supporting the load attached to it. An anchor system is the rope, slings, and hardware used to attach a load to the anchor, and includes the anchor. All anchors must be able to hold the anticipated load that will be applied to it, in the direction the load will be applied from. A significant safety factor shall be included to compensate not only for the anticipated load, but also for unanticipated loads, dynamic loads, shock loads, and stress from the application of hauling systems.

The result of an inadequate anchor or anchor system is failure of the system.

In the absence of an obvious “bombproof” anchor, the primary anchor shall be backed up by a secondary anchor to provide support. This backup anchor must be in line with the primary anchor and the load, and must also act to counter the type of force that the load is applying to the primary anchor. (See “Anchor Systems” below for details).

All anchors must be inspected to identify any sharp or abrasive edges that may damage software and provide padding for protection (edge-pro) of the same.

Test the anchor prior to the application of its intended load by “pre-loading” to test the alignment and reaction of the system components.

The Rigging Team Leader (RGL) and the Technical Safety Officer (TSO) must approve the anchor and connecting components prior to application of the intended load.

Natural Anchors can be a trees or rocks to which webbing, straps or rope are wrapped around. Caution should be used and each should be evaluated for potential failure before using. A tree's diameter as well as root system and ground there in should be examined. A rock or boulder may easily be moved with the stresses of rope systems.

Tree – Tensionless Hitch

Source: www.mountainproject.com

Tree – Wrap 3 Pull 2

www. swoutdoorsports.wordpress.com

Using a tree as an anchor:

- Ensure that any tree utilized as an anchor is solid (alive) and has sufficient girth to safely hold the expected load.
- Ensure that the root system of the tree is not too shallow of depth, and that the supporting soil is not water saturated in such a manner to make the question of stability an issue.
- Secure the anchor down low on a tree if possible to maximize the strength of the tree and prevent the load from applying a leverage force to the trees base. If the tree is of sufficient girth, a balance may be sought between keeping the anchor low on the tree for the above reason, and elevating the anchor to provide a better angle to the load and/or keeping the rope system from digging through the earth when moving.
- If a tree is deemed not "bombproof", use a backup anchor for support that will act to counter the type of force that the load is applying to the primary anchor. The backup anchor must be located directly behind the primary anchor, in line with the load. (See "Anchor Systems" below for details).

Rock

Source: jive-assanchors.com

Rock

Source: www.globalsecurity.org

Using a rock as an anchor:

- Ensure that any rock utilized as an anchor has sufficient mass to hold the expected load and that the ground surrounding the rock is solid and not water saturated.
- Pad all sharp edges in which software will be positioned against.
- Particular attention must be given to the anchor strapping, as it may be prone to "popping" off of the top of a rock or slipping under the rock.
- Separate rope systems may have to be placed to prevent these potential occurrences.

Structural Anchors should be evaluated for be structurally sound. Anchor points may deteriorate over time; corroded metal, weathered and deteriorated stone or motor work should be avoided. Inherently week structural features such as sheet metal vents, flashing & gutters; light brickwork and standpipe systems should also be avoided.

Stronger inherent parts of the building structure may be considered when selecting an anchor point;

- Structural Columns
- Projections of Structural Beams
- Supports for Large Machinery
- Stairwell Support Beams
- Brickwork with Large Bulk
- Anchors for Window-cleaning equipment
- Roof Scuppers
- Elevator and Machine Housings
- Walled Section between Windows

Structural Columns

Source: Firehouse.com

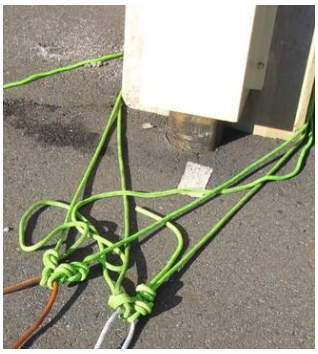
Structural Beams

Source: Firehouse.com

Structural Beams

Source: www.d2000safety.com

Roof Structures



Source: Firehouse.com

Window Washing Anchors

Source: www.ropeaccessorlando.com

Using structural members as an anchor:

- Structural members are numerous in industry and “bombproof” anchors are either readily available or are easy to backup to provide additional support.
- Pad all sharp edges including “square” shaped anchors such as girders or beams to protect software.
- Structural members must be thoroughly inspected for corrosion, cracks, damage and the manner that the structural member is attached to ground or other members. (Example: Inspection of the anchor bolts that attach a sound steel member to a concrete floor with as well as an inspection of the stability of the concrete at the point the members connect).
- Visualize the type of force that will impact the structural member once the load is applied and determine if the structural member can withstand that force. (Example: Will an anchor tied high on a vertical member apply a leverage force to the anchors base).

Artificial Anchors use special hardware specifically designed for anchoring when no other points may be available. Artificial anchors used in rescue may be bolts placed in rocks or beam clamps used in structures. Most require competent personnel selecting and securing these devices.

Beam Clamp

Anchor

Vehicle Anchor Points can usually be found on fire apparatus or service vehicles. Potential anchor points include the following:

- Vehicle Bumpers
- Bumper Brackets
- Tow Hooks/Eyes
- Wheels
- Suspension Components

The weight of the vehicle and the surface the vehicle sits on must provide sufficient mass and friction to prevent the vehicle from sliding once the load is applied. Ensure that any anchor point utilized on a vehicle is one that is either specifically designed for that purpose or is positively structurally significant. Avoid exposing software to any fuel, grease, oil, or contaminate.

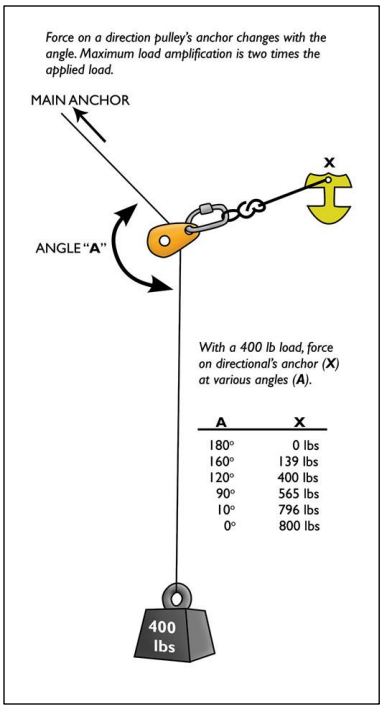
Source: www.fireapparatusmagazine.com

Safety Considerations for Vehicles:

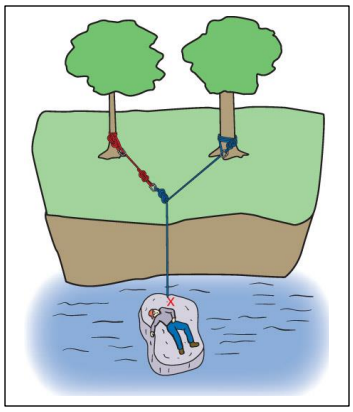
- Park the vehicle on a solid surface. High loads can possibly drag a vehicle across loose gravel, sand or soft ground.
- Set Parking Brake or Service Brake
- If the service vehicle has an automatic transmission, set in “park”. If the vehicle has a manual transmission, set it the gear opposite the direction of pull (ex.; reverse if pulling from the front)
- Chock wheels. Forces in a High-Angle System can move a vehicle.
- Remove key from the ignition, assign to Incident Commander.

## Change of Direction Anchor Points

A change of direction is a method of deviating the direction of the main line. When the main line does not fall in direct line from the objective or victim and the anchor point the line must deviated so the system falls in line. A Change of Direction (COD) can become force multipliers for the anchoring system of the COD, as angle increase in the system from being in line so does forces on the COD anchor.




Safety Considerations for COD or System Deviations:



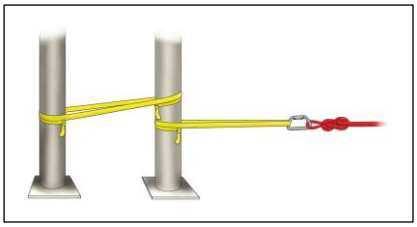
- If the COD is greater than 60°, ensure it is capable of supporting the load.
- If the COD is greater than 60°, back up the COD if necessary.
- Eliminate the need for a COD by finding additional anchor points for a Multi-point System.

## Backing up Anchor Points

Backing up an anchor point is essential when the primary anchor point is in line with the objective and may not provide the required strength to support the system. When there is second anchor point directly behind the primary a tieback should be considered if the second anchor is strong enough to sustain the systems load.

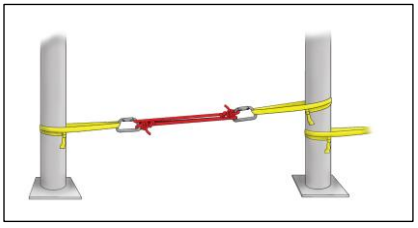
Tieback

A rope or webbing may be used to run between the two anchor points.



Pretension Tiebacks

If an anchor system receives shock that anchor point may fail. A pretension tieback is used to lessen the chance of shock loading anchors. Using a mechanical advantage system removes slack in a tieback before the system is loaded.



Safety Considerations for Tieback or Pretension Tiebacks

- If secondary anchor point must be as strong as or stronger than the primary anchor point.
- Tieback should have no slack to allow shock loading, which would lead to both anchor points to fail.

## Full Strength Tie off Anchors

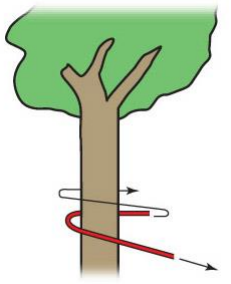
Full strength tied off anchors are simplistically made, quick to assemble, and retains most of the strength in the rope (on larger diameter anchors), ex.; Tensionless Hitch. Full strength tied off anchors are most often utilized as a means of securing a "far side" anchor for Track Lines on either a Highline system or as a Track Line across a river for a boat based platform. The full strength tie off can be secured using no hardware by using a Figure 8 follow through or with one carabineer attached to a Figure 8 on a Bight as shown below.

### Tensionless Hitch

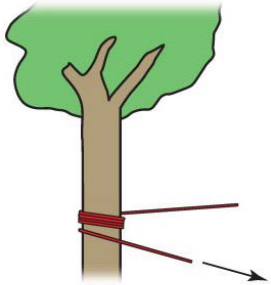
The tensionless anchor is a quick and easy anchor that requires a minimum amount of equipment. It is also the strongest method of anchoring a rescue line. The tensionless anchor is designed to wrap around a round or oval shaped anchor. The anchor must be at least four times the diameter of the rope to maintain full strength of the rope. The running end of the rope is wrapped at least four times around an anchor point, such as a tree, in a neat series of wraps. As with all anchor systems, the tensionless anchor should be applied as low on the anchor point as possible. A figure eight on a bight is tied in the running end, and a carabineer is snapped into it. The carabineer is then snapped onto the standing part of the rope.

Safety Considerations for a Tensionless Hitch:

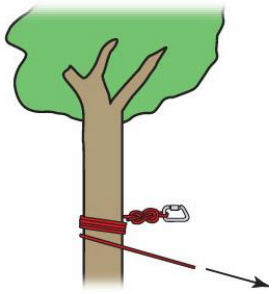
- The object is preferably round and should be a minimum of 4 inch diameter.
- The smaller the diameter of the object, the more wraps will be needed.
- The smoother the surface of the object, the more wraps will be needed.
- Consider Edge Protection



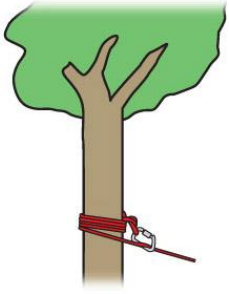
Take at least two wraps with the rope around the object to be used as the anchor point.



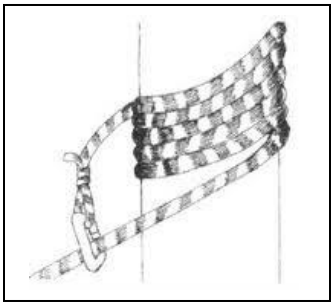
Make sure there is no rope cross in the turns.

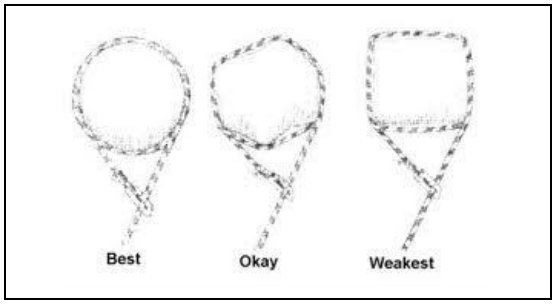


Tie a figure 8 on a bight in the running end of the rope and clip a locking carabiner into the figure 8 knot.



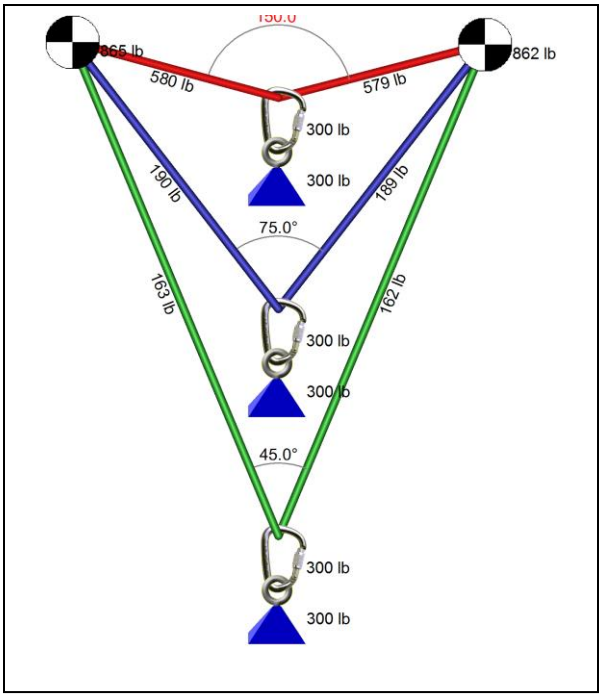
Clip the carabiner across the standing end of the rope at the bottom of the spiral.

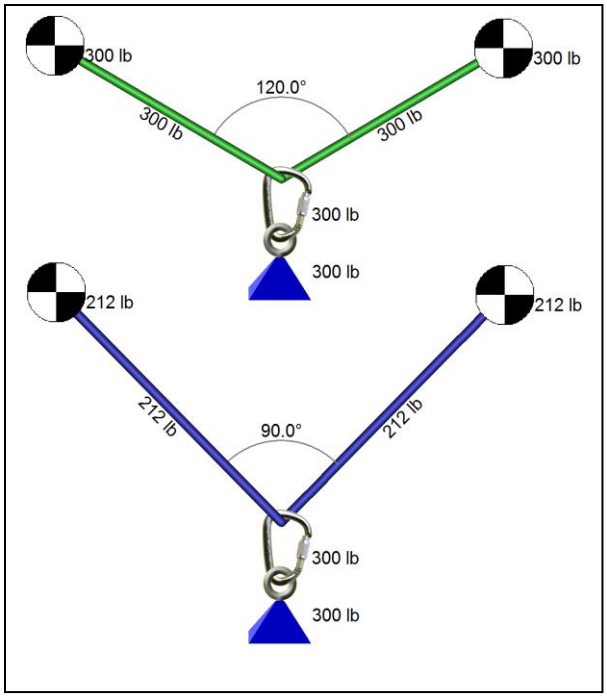




**Anchor Systems Critical Angles**

- A concern when rigging any anchor system is to avoid creating too wide an angle between the legs of the system. Try to select anchors that are relatively close together, and use lengths of webbing and rope that are long enough to avoid creating wide angles.
- Ensure that the "critical angle" between the rigging legs that connect the anchor to the load or in any system component is 90 degrees or less. (An exception would be in High Line Systems). Evaluate force vectors between the anchor and the load and the type of force that will be applied to the anchor where the load connects.
- The angle between anchor points, known as "field angle" **should never exceed 90°**. Angles greater than this **critical 90°** begin to exert forces on the anchors that will be greater than the load itself. Anchors and material used to build anchors can easily be over stressed and fail under these forces. A 90° angle distributes 92.5% of the load to each anchor. A 120° angle distributes 100% of the load to each anchor. These defeats the entire purpose of constructing multiple point anchors.



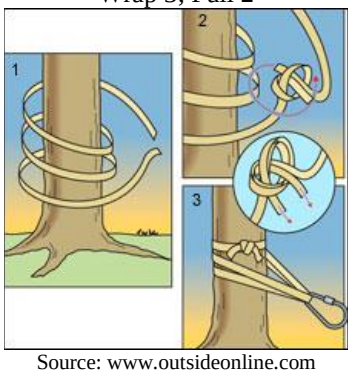
## Anchor Straps and Webbing for Anchor Points:

Anchor Straps and Webbing work well for single point anchor systems. Ensure the software is the proper length in order to avoid unwanted directional loads.

The anchor connection should never be the weakest link in rope system. Anchor Straps and Webbing have considerably lower breaking strengths than anchor systems that use rope. Use a double prusik rope grab if the systems has the potential of being shocked.

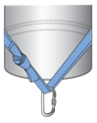
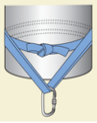
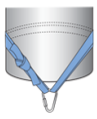
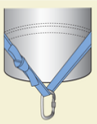
Avoid exceeding critical angles when using straps or webbing. Angles of 90° or less are optimum and may cause the failure of the system.

Wrap 3; Pull 2




Source: www.outsideonline.com

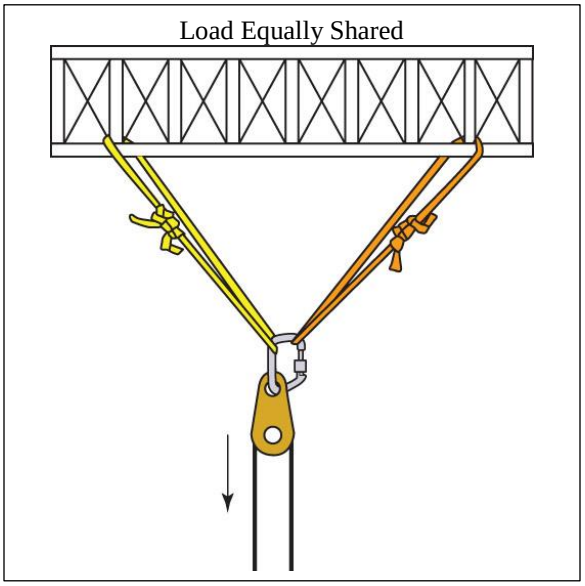
**One-Inch Webbing Anchors: Minimum Breaking Strength of Common Configurations**

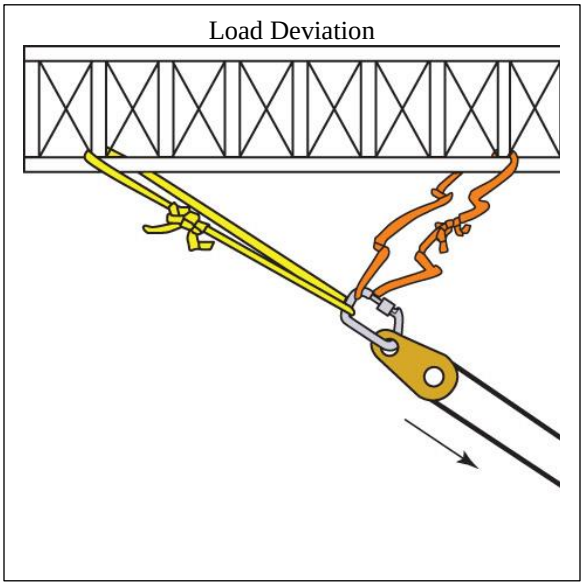
| | | Tubular Web lbf (kN) | Flat Web lbf (kN) |
|---|---|---|---|
| Web Strength |  | 4,340 (19.31) | 6,000 (26.00) |
| Girth Hitch |  | 4,799 (21.35) | 8,776 (39.04) |
| Single Loop (90° Internal Angle) |  | 4,832 (21.50) | 6,130 (27.27) |
| Wrap 2, Pull 1 (90° Internal Angle) |  | 5,510 (24.51) | 8,098 (36.02) |
| Redundant Double Loop (90° Internal Angle) |  | 7,777 (34.59) | 10,786 (47.98) |
| Wrap 3, Pull 2 (90° Internal Angle) |  | 7,899 (35.14) | 10,507 (46.74) |
| Basket (90° Internal Angle) |  | 8,464 (37.65) | 12,989 (57.78) |
| Double Loop (90° Internal Angle) |  | 8,716 (38.77) | 10,538 (46.88) |
| Redundant Wrap 2, Pull 1 (90° Internal Angle) |  | 9,700 (43.15) | 11,458 (50.97) |

CMC Rope Rescue Manual, 4th Edition

**Load Sharing Anchor Systems:**

A load sharing anchor is when the legs and point of the anchor system equally sharing the load potential. The load should not be allowed to deviate and cause slack onto the other leg(s) of the system.



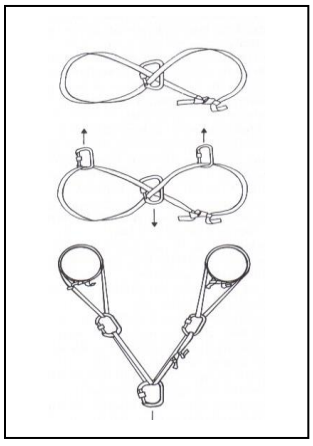




**Self-Adjusting or Load Equalizing Anchor Systems:**

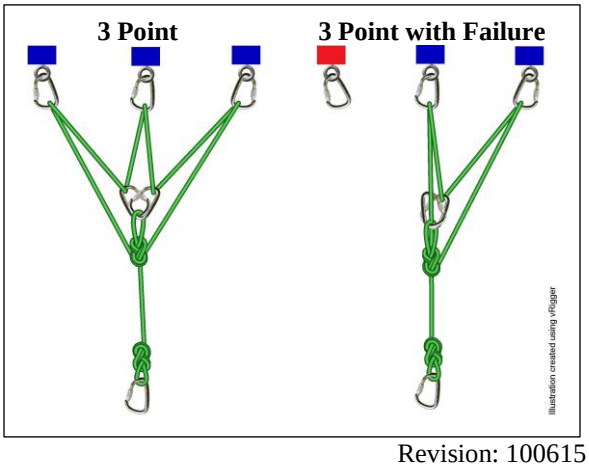
The self-adjusting anchor system, also known as self-equalizing anchor system, centers the system between two or more anchor points. It allows the load to be distributed to each anchor point by permitting the point of attachment to shift within the anchor as the system is loaded.

**Caution**; once the full load is on the system, the friction is too great to allow further equal distribution during a load shift. The inability for the system to provide equal distribution on the anchor points could cause an anchor to fail. If one of the anchor points fails, the shift to the remaining anchor points will cause a drop in the system toward the load. If the anchor legs are long, this drop can create a shock load on the remaining anchor points that may result in their failure. Keeping the adjusting anchor sling legs short (12" maximum) reduces this problem. When the anchor points are not close together, tag lines are used to extend them to a collection point where the self-adjusting anchor is attached. This allows the adjusting legs of the system to remain short.

**Two Point:**



**Three Point:**



## Using Pickets as an Anchor:

Pickets may be utilized in an anchor poor environment, but should be assessed carefully in regard to their ability to safely hold a large load due to the variety of factors that directly impact a pickets holding power. These factors include the type of material the picket is made from, how the pickets are arrayed, depth the pickets are driven into the soil, the type of soil, compactness of the soil, and the moisture content of the soil.

Pickets should be driven 2/3 of their length into the ground at a 15 degree angle away from the load. Pickets must be oriented in line with the load and they may be bundled together to provide additional strength.

Lash pickets together with rope or webbing by tying a clove hitch to the base of the rear picket, go up and around the top of the forward picket, and continue with four to six wraps between the pickets finishing with a round turn and two half hitches on the forward picket. The hitches securing the lashing to the pickets should be located below the wraps on the forward picket to prevent the wraps from sliding down and above the wraps on the rear picket to prevent the wraps from sliding up.

Place a stake between the wraps and tension the pickets by twisting the wraps until the forward picket just begins to move back. Drive the stake into the ground to maintain tension. (aka a “Windlass”).

### Picket Capacities

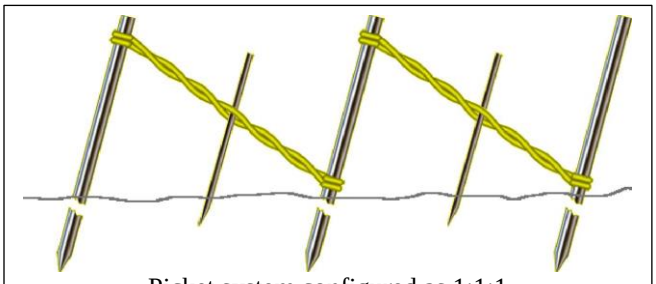
The load capacity of a picket is determined using loamy soil of average compactness. Many variables affect the load capacity of pickets.

A single picket can hold up to 700 lbf. A 1-1-1 combination picket or three pickets in line.

Pickets hold longer under a gradual pull than if they are exposed to a sudden shock force The type of soil is most important;

- Clay and gravel mixtures have only about 90% of the holding power of ordinary soils.
- The holding power of river clay and sand is only about 50% of ordinary soils
- The soil's moisture content and compactness affect the holding power
- The material used for pickets, the dimensions, and how they are placed affect the holding power

Be aware that the process of “twisting” webbing to provide the necessary tension in the windlass that permits distribution of the load throughout the picket system may damage the webbing by stressing the fibers with the application of a tension (tearing) force. This type of damage may not be readily apparent in the webbing upon inspection after the windlass is disassembled. Prudence dictates that webbing utilized to make a windlass in a picket system should be removed from service after use.



Picket system configured as 1:1:1