The four strands of rope were tied off in a giant figure eight. Not very pretty, but totally bombproof.

Grounded

Choosing & rigging the right anchor

STORY, ILLUSTRATION & PHOTOS BY TOM PENDLEY

For years I taught rescue classes and warned students about catastrophic anchor failure and the need for redundant secondary anchors. I always spoke figuratively because it had never happened to me. Main-anchor failure is something no one wants to happen to them. But, while teaching a State Fire Marshals Office Rope Rescue II class in central Arizona, it finally happened to me.

We were conducting high-angle litter evolutions on a 100' cliff and all safety checks had been made. It was a routine evolution: Lower two attendants with the basket down 40 feet or so, stop, have one of the attendants climb into the basket and switch over to a raising system to bring them back up. The problem arose when the haul team began to raise. The haul team struggled with the inefficient system (there was a lot of friction loss). Suddenly, there was a loud crack, and an intermediate anchor snapped, dropping the load (two students hanging 60 feet off the ground) about 2 feet. The main anchor, a mature paloverde tree 6 inches in diameter, had pulled out of the ground and was hanging by one large root. This big root somehow held the load just inches from the tandem prusik belay. The belayer set the prusiks, and for a moment I looked in disbelief at this tree on its side with roots sticking up in the air. We quickly backed up the damaged anchor and aborted the evolution without injury, but it was a sobering wakeup call. I learned a lot about rescue systems and rescue anchors that day. The following will help you tune up your rescue anchor skills.

AN ART FORM

Many aspects of rescue rigging are by the numbers. But constructing anchor systems for rope rescue is an art form that takes years to develop. Building anchors requires knowledge of geology, building construction, physics and material strengths to name a few. In some cases, it's easy: Just tie your webbing or rope around a 100-year-old 3'

DEFINITIONS

- *Natural anchors:* Naturally occurring trees and rocks.
- *Artificial anchors:* Anything placed by man, including fire trucks and structural members.
- *Bombproof anchor:* An anchor that you confidently believe will hold the intended load and any potential impact force the load unintentionally generates.
- *Marginal anchor:* An anchor that you don't believe is bombproof.
- *Single-point anchor:* Single point of origin.
- *Shock load:* Shock-load or shock-force is the force felt when a mass accelerates (usually down the gravity well) and comes to a sudden stop, releasing its developed kinetic energy.
- *Multi-point anchor:* A collection of marginal point-anchors collected together into a bombproof anchor system.
- *Back-tie anchor:* A marginal anchor in a good location that is linearly connected with a tensioning unit to a bombproof anchor somewhere back from the edge.

KEY CONCEPTS

- Safety test all anchors in the direction of use with a force comparable to the working load.
- Watch for signs of weakness or failure.
- Distribute force equally between all anchors in a multi-point system.
- On multi-point anchors, keep the distributing link small to minimize any potential impact-force. Better yet, tie it off to create a load-sharing anchor.
- Try to have independent anchors for the working and belay lines.
- Choose strong points like joints and corners on structural members for anchors.
- Prevent side-loaded or tri-loaded carabiners when using pre-sewn straps.

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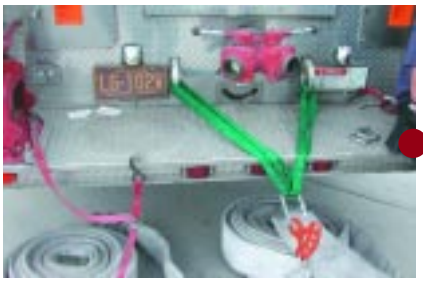


You can use apparatus for anchor points, but be sure to use approved structural elements. Chock the wheels and post a guard to prevent anyone from operating the truck while it's being used as an anchor.

diameter oak tree and you're in business. More often, though, you're scratching your head to find a suitable anchor in the right spot.

BACK TO BASICS

Anchors are either natural or artificial. Simply put, if man placed it, it's artificial; everything else is natural. Fire trucks, guardrail posts, light poles, rock-climbing gear (pitons, etc.), rock bolts, picket stakes and structural components of buildings are examples of artificial anchors. Natural anchors include trees, rocks and rock outcroppings.

We use both natural and artificial anchors for rescue, but sometimes deciding if an anchor is strong enough can be a bit tricky. The first thing is to determine the load you intend to carry. Is this anchor going to be used for one person to rappel on, or will it anchor a 600-lb. load and a haul system to raise it?

The term "bombproof" has become the standard description for an anchor that can hold the weight of the intended load and then some. It means there is no question in the rigger's mind that the anchor will hold (even if a bomb went off). The thing is, what constitutes bombproof varies from person to person. It's really based on experience and judgment. As one gains more experience, it's easier to judge an anchor's integrity.

In order to choose an anchor, first determine the fall line. The fall line refers to the natural plumb line as a result of gravity. Keep in mind, however, that the fall line is also affected by the slope's angle and aspect. Once our rope systems go over an edge, we are, for the most part, committed to that fall line. We can move left or right like a pendulum, but will still end up hanging straight down the gravity well.

In many cases, the best anchors dictate the best fall lines. Sometimes, we must stay within a particular fall line because obstacles or hazards (like rock fall) prevent us from operating in a particular area. To stay within a fall line, we must find or create anchors within that fall line.

TYPES OF ANCHORS

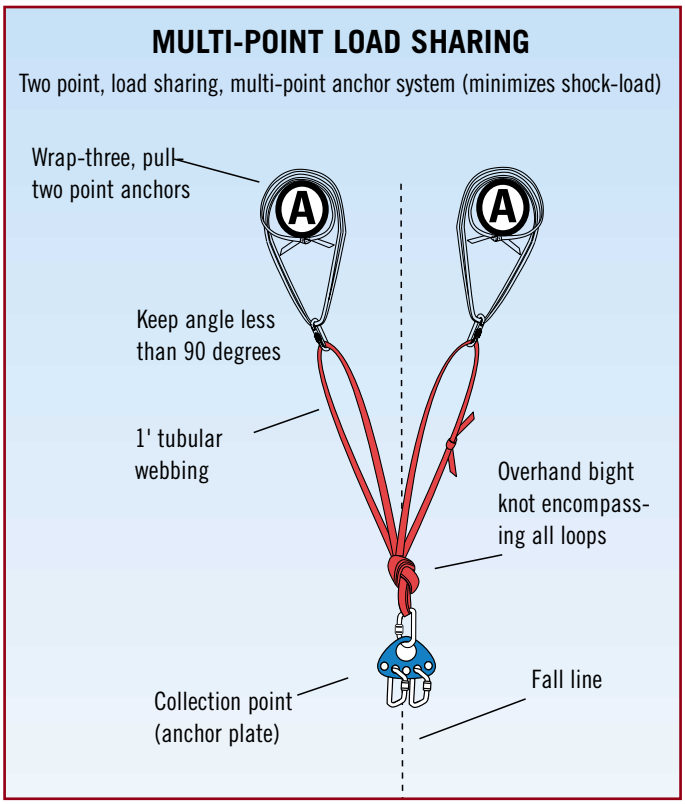
A single-point anchor is the fundamental type of anchor. When a single-point

A classic single-point anchor made out of 1' tubular webbing is the wrap three-, pull two-anchor. Note that the knot is positioned so that it is visible for safety check and in the spot that puts the least tension on it. The two loops the system is connected to provide about 12,000 lbs. of minimum break strength.

anchor is not deemed bombproof on its own, we group two or more points into an anchor system. Anchor systems are either in-line with or perpendicular to the fall line.

IN-LINE ANCHOR SYSTEMS

Constructing a single-point anchor and backing it up to another anchor behind it makes the most basic in-line anchor system. We call this a backed-up anchor. For a backed-up anchor to be effective, it should have no slack in the backup between the two anchors. In many cases, backing up an anchor is more of a psychological tool because it comes into play only if our primary anchor fails.

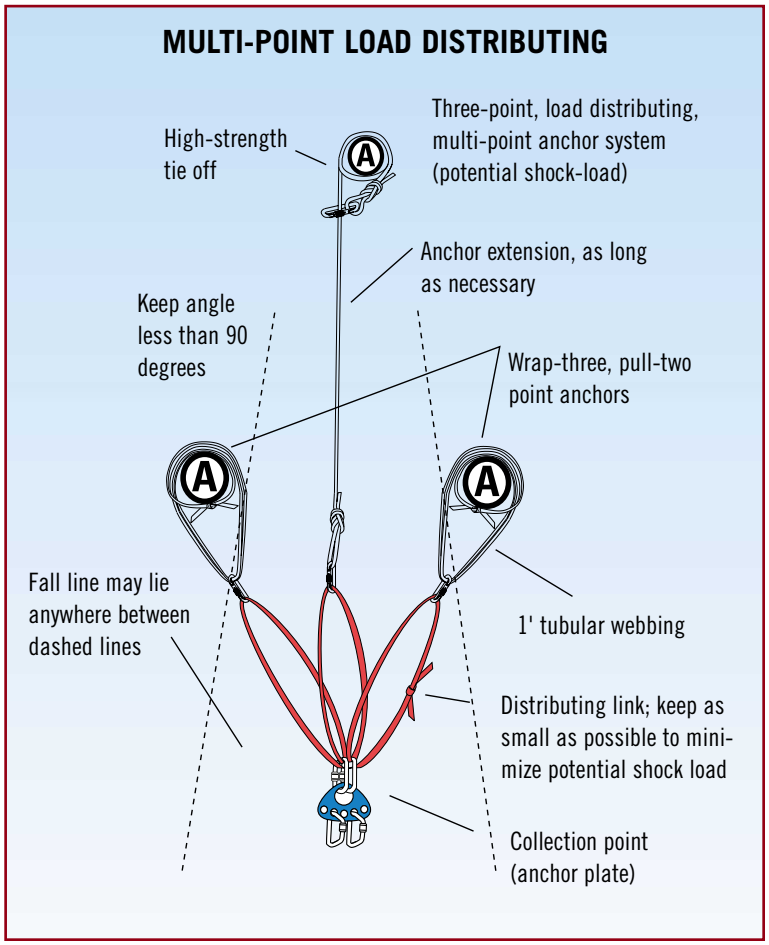


A back-tied anchor is a more substantial in-line anchor. A back-tied anchor has a rope-tensioning component that actually pulls tension between the forward-anchor and a more substantial rear-anchor. The tension adds integrity to the forward-anchor. In effect, the forward-anchor becomes a focal point of the rear-anchor, which is actually the main anchor. The forward-anchor can be quite small if the rear-anchor is considered bombproof. In fact, it only needs to be large enough to provide resistance to pull stretch out of the tension component.

PERPENDICULAR ANCHORS

Multi-point anchors that sit more or less perpendicular to the fall line have a central collection point and either share the load or distribute it. A multi-point, load-distributing anchor distributes the load if the fall line changes, but has more shock-load potential than a multi-point, load-sharing anchor. A load-sharing anchor has very little shock-load potential and is a better choice for rescue work.

The fact that the angle size between the anchors affects the amount of force on each anchor is an important concept for multi-point anchors. The angle should



never exceed 90 degrees. Multi-point anchors are most often two-point anchors, but can incorporate three- or four-point anchors.

ANCHORING MATERIALS

One-inch tubular webbing is one of the most common materials used for making anchors. We also use low-stretch rescue rope to anchor around big objects, and manufactured anchor-straps in structural settings.

SELECTING ANCHORS

You must carefully select natural anchors. The tree mentioned in the beginning of the article was bombproof by all appearances, but it was in shallow soil over solid rock. It was, in effect, a potted plant that uprooted disturbingly easy.

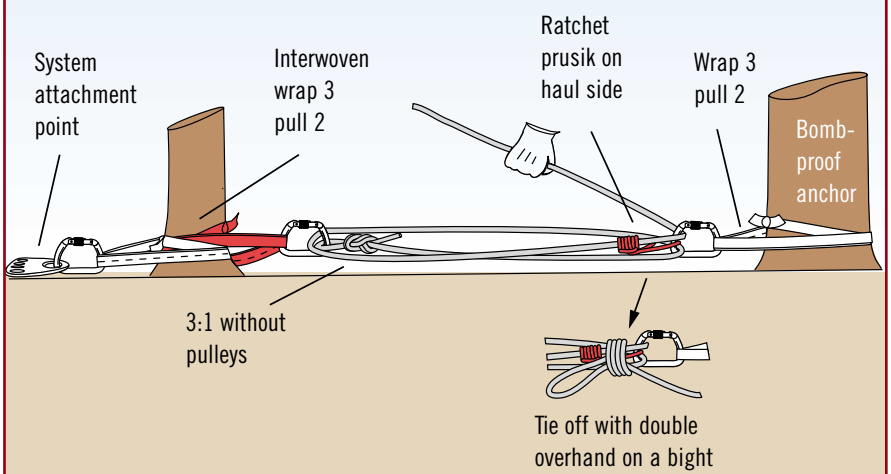
A visual inspection is the first test for both trees and rocks (or any other object, for that matter). The tree must

Take great care when anchoring off rocks. The rock must have enough of a lip to prevent the anchor material from slipping off. If the rock is loose, it must be large enough and wedged against other rock so that it cannot move in the direction of use.

BACK-TIE ANCHORS

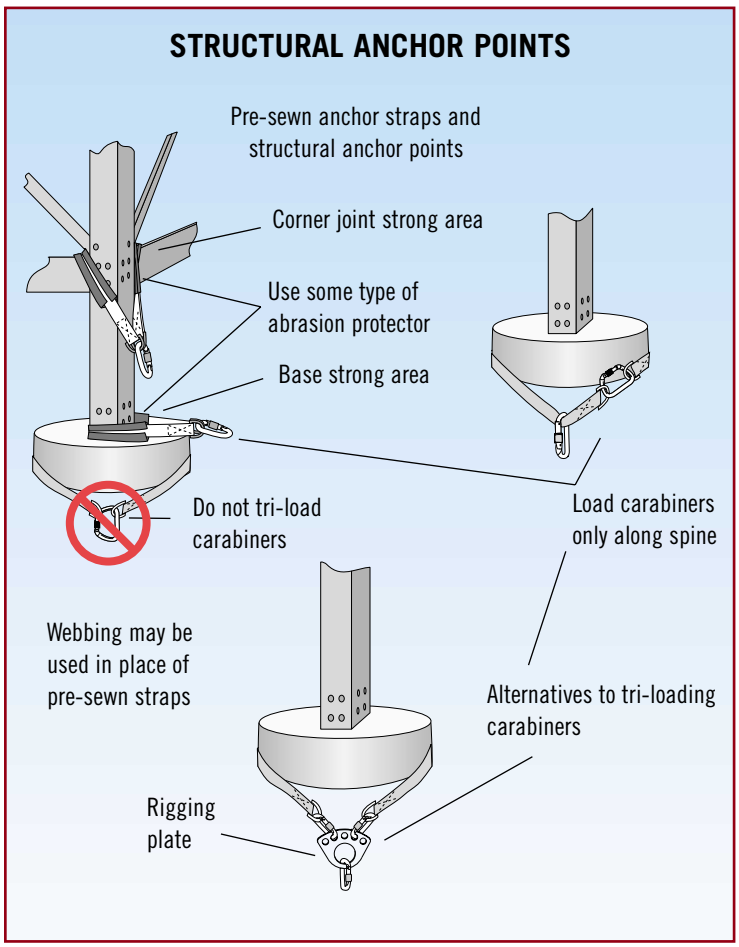
A back-tie anchor is used to focus a marginal anchor to a bombproof anchor. It is built with low-stretch rope and a system prusik.

1. Construct back-tie system as shown with ratchet prusik on line closest to haulers.
2. Three wraps of ½' rope is ideal, but distance between anchors and available rope may limit number of wraps.
3. Pull tension on system and set ratchet so that all ropes stay under tension but do not damage forward-anchor.
4. Tie off back-tie tension unit.



This anchor was set up as an example of what *not* to do. First, visually inspect all anchors, and then physically test them by pushing and pulling to look for any signs of weakness.

All anchors must have a safety inspection. This short-tail on a water bend requires retying. Also check for and pad any sharp edges.

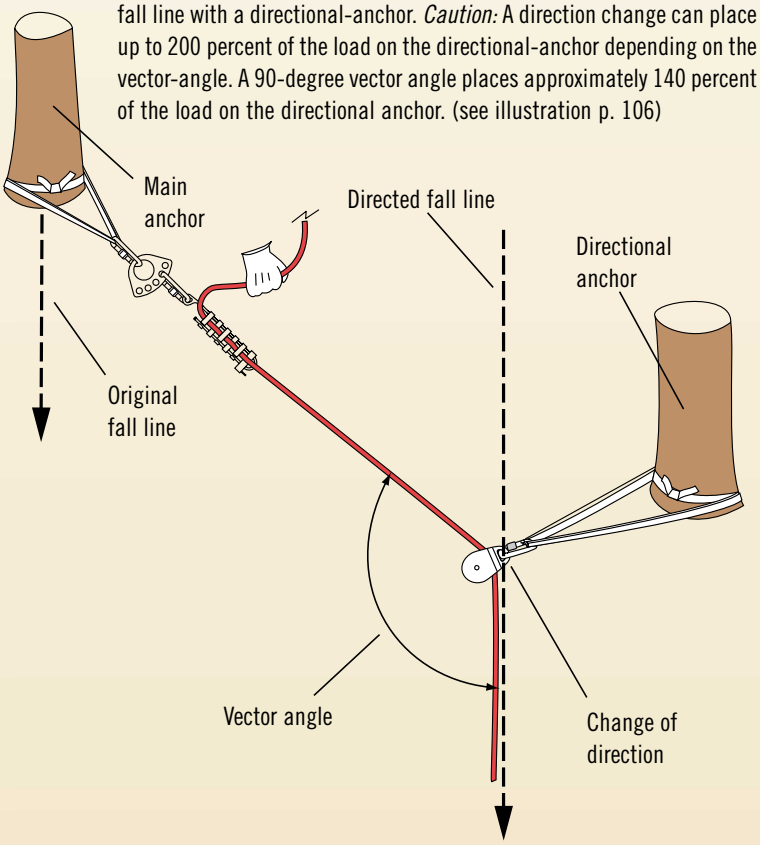


Wrapping the rock allowed the rope to be threaded through a natural tunnel, which was ideal because it prevented the rope from moving over the top of the rock.

An excellent single-point anchor to set up a fixed-line for rappel or highline is the high-strength-tie-off (sometimes referred to as the tensionless hitch). Four to six wraps of rope provide enough friction to prevent the knot from having any tension on it, but it's not well suited to attach a system to.

DIRECTIONAL ANCHORS

A suitable anchor location relative to the desired fall line is always a critical factor. Occasionally, it's safest to redirect the system into a directed fall line with a directional-anchor. *Caution:* A direction change can place up to 200 percent of the load on the directional-anchor depending on the vector-angle. A 90-degree vector angle places approximately 140 percent of the load on the directional anchor. (see illustration p. 106)



ANCHOR DRILL

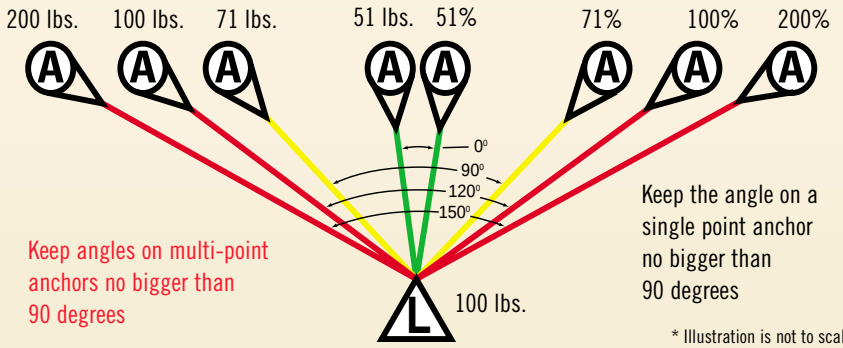
You can set up a quick anchor-training drill just about anywhere. It can be done in an hour with one or more crews. You need an area with various natural or artificial anchors, several ropes and typical webbing and hardware. Designate stations and assign two rescuers to each station. Station one can be a single-point anchor, station two a two-point distributing-anchor and station three a two-point sharing anchor. Mark the fall line for each station and have the teams build their anchors and load them in the direction of use. Have each team break down their anchor and then rotate. Then choose different fall lines for each station and repeat the process. Emphasize rigging fast and clean, with clean being more important than fast.

be alive and at least six inches in diameter (personal rappel anchors can be smaller on a case-by-case basis). A rock should be continuous with the greater rock mass or wedged among other rocks in such a way that it can't move in the pull direction.

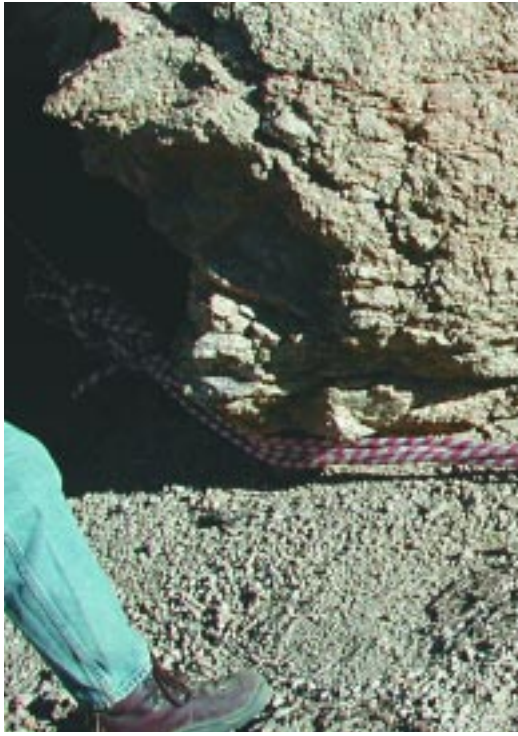
Physical force is the second test. Give it a good solid boot and push to see if it budges. If the potential anchor passes the first two tests, give it one final test. Construct your anchor around the object and get several rescuers to pull hard in the direction of use. Watch the anchor closely for movement or signs of

VECTOR-FORCE ON TWO-POINT ANCHORS

A load suspended in balance between two anchor points will place tension equally on each anchor. 100 lbs. hanging on an angle at or near 0 degrees will put about 51 lbs. of force or tension on each anchor point. As the angle gets bigger, the tension on each anchor point increases as shown below. A 90 degree angle will put about 71 lbs. of force or 71 percent of the load on each anchor. A 120 degree angle will put about 100 lbs. of force or 100 percent of the load on each anchor which defeats the purpose of a multi-point anchor.



* Illustration is not to scale



failure or instability. Several rescuers can't generate true impact-force, but this test will give you a pretty good look at the anchor to back up your gut feeling.

CLIMBING ANCHORS

I think it's important at this point to differentiate between climbing anchors and rescue anchors. Rescue evolved from mountaineering and climbing. Even though the two share many similarities, rescue-anchors must be more substantial than the types of anchors used in climbing. For example, in climbing, it's common to create a multi-point anchor using rock pro (pitons, cams, wired nuts and the like) or small-diameter trees.

Multi-point anchors have made their way into the fire service standards (the two-point, load-distributing anchor for example), and we have taught it as a common anchoring skill for many years. However, collecting marginal anchors into a multi-point anchor system is not as good as a single, bombproof anchor. In 15 years of practicing rope-rescue, I can count on one hand the multi-point anchors I have

This anchor was set up with an entire 200', ½" rope. The rope was doubled and then doubled again. The four strands of rope were wrapped around a large rock outcropping. The end result had two loops for the working line and two loops for the belay line. It was bomber.

used on actual rescues. You can almost always find a bombproof single-point anchor or an in-line, multi-point anchor (there are exceptions).

If you have no other choice than to create a multi-point anchor system, tie the webbing off at the collection point to make it a load-sharing anchor. The load-distributing, multi-point anchor simply has too much potential for shock-load, and should be used only in cases where the fall line is expected to change dramatically and the individual anchors are close to bombproof.

CONCLUSION

Building anchor systems is a skill that takes years to develop. Most anchors will be bombproof, and you will make them with confidence. However, the sketchy situations with marginal anchors will challenge your skills and test your confidence. If in doubt, error on the side of finding a bigger, stronger anchor, even if it means using 400 feet of rope to do so. Remember, if you don't have a good anchor, you don't have much.

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