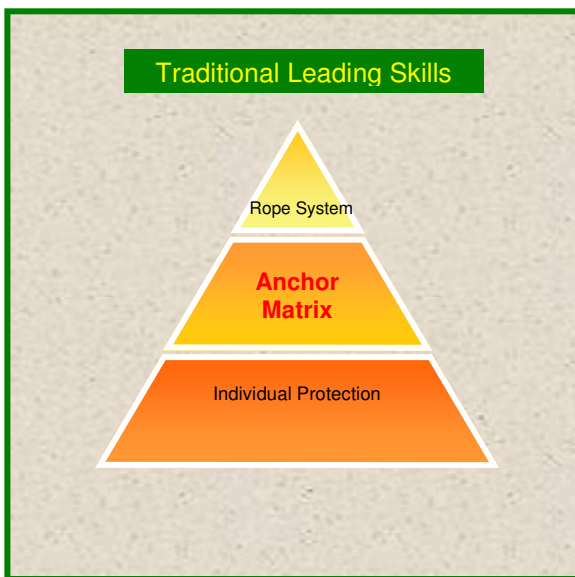


# Anchor Rigging Skills

The pyramid of skills for traditional climbing started with individual protection. The next step is creating an *anchor matrix*. This section will introduce the following concepts:

1. How forces are distributed in an anchor system.
2. Understanding the necessary rigging concepts needed to create anchors in a variety of situations.
3. The equipment needed to rig artificial, natural and extended master point anchors.
4. The advantages and disadvantages to different rigging methods
5. Present a system for deciding on the best rigging method for the given situation.



The foundation for a reliable anchor begins with great protection, but a climber needs to be able to create an anchor matrix for safer climbing. To build a great anchor matrix a leader needs to be able to determine the proper location for the anchor, determine the

load directions, select the best rigging configuration, safely connect the protection to the rigging, and create a master point in the proper location. All this is based on the situation at hand and there is no one perfect rigging system or anchor matrix for all situations. A good leader can control the distribution of forces between protection, limit the consequence of extension, anticipate the strength requirements, and do all of this in a short amount of time.

This article will present concepts and techniques for constructing an anchor matrix. It will begin by presenting concepts on the physics behind anchors. This will present information on forces, energy, and vectors. From this, the article explains specific anchoring concepts of strength, distribution, extension, and redundancy. The next section presents different rigging methods and compares self-aligning versus pre-aligned. The final section presents a systematic method for determining which type of rigging to utilize for the given situation.

## Physics of Anchors

Physics 101 for rigging anchors is simple, yet will help you understand rigging, so you can determine the best setup for the given situation. There are concepts one should understand related to physics and rigging: force, energy and vectors.

## Force

Force is what most climbers want to know about. How much force will you generate if you fall? This is an important question, but it may be better to understand what causes high peak forces and what reduces high peak forces

rather than spending the time finding the actual peak force for every situation.

Force is an interaction between two objects. Most equate this with a pushing motion or pulling motion, but there are others. It is important to understand that the weaker object limits the amount of force. The weaker object's maximum capacity is the upper limit of interaction between the objects. For example, if one person holds a sheet of paper in the air, you could not hit it with 50 lbs of force. The paper is not capable of interacting with 50 lbs of force. In climbing, our anchors are constructed with cams and stoppers in rock. This equipment is tested in a facility, but was the rock? The point is our protection must be adequate to do the job; rigging alone will not make up for protection in weak rock or placed poorly.

An impulse more accurately describes the forces in falls. An impulse is the change in momentum divided by the time the change takes place. In climbing terms, momentum is the mass and speed of the falling climber when the rope begins to stop the fall. How long the rope takes to bring the climber to a stop is the time. If the climber stops quickly, there will be a higher impulse force. The slower the stop, the lower the force, which is a good thing; longer stops mean lower peak forces, faster stops mean higher peak forces.

Peak force is controlled by a dynamic rope system. The dynamic rope system is composed of the rope, the belayer, slack and friction. A dynamic rope stretches as it stops a falling climber. Most rope will have around 30% dynamic stretch. The belayer might give a little, or have some rope slip through the device, taking longer to stop the falling climber. Slack moving

through all the carabiners in the system creates friction and again, takes longer to stop the climber.

## **Energy**

Energy is more elusive to understand. Energy is simply the ability to produce change in a system. Potential energy is stored energy, like an object that can fall, perhaps a climber. If the climber falls, the energy is converted from potential into kinetic energy (KE) or energy in the form of motion. Obviously, the amount of energy in this system (falling climber) is determined by how far they can fall. The more they can fall, the more KE there will be for the dynamic protection system to absorb.

### **Energy-Force connection**

In climbing, the peak force is limited by the stretch in the dynamic protection system. The design of dynamic ropes limits the force of a long leader fall to around 2600lbs. All ropes must pass this drop test before they can have the CE rating. The duration that anchors must hold these peak forces is longer with falls that have high energy (or long falls). Long falls may have the same peak force as shorter falls, but will have much more energy in the system. Failure of the anchor can be a result of high peak forces and/ or sustained loads.

### **Vector**

A force occurs with a direction (vector), and at times, there may be multiple vectors (force and direction) placed on a climbing anchor. There are two terms to use with vectors on anchors: primary and secondary. Primary forces are aligned with the top protection point (straight down) due to the pull of gravity, whether it is the anchor as in top roping, or a protection piece as in leading. Primary forces are the greatest forces placed on an anchor,

as with a lead fall, or at the bottom of a pendulum fall in top roping.

Secondary forces are forces not aligned with gravity and the top anchor point. Secondary forces can occur: when following a traversing pitch, from not climbing under the anchor when top roping, or anytime where features prevent the rope from aligning with gravity. Even though secondary forces are typically lower than primary forces, the direction of pull can compromise the security of the placement.

### **Anchor Rigging Concepts**

#### **Strong**

Anchors must be strong enough to do the job. In institutional climbing, being “just strong enough” may not be appropriate. Bomber is a term most climbers use to indicate *absolutely strong*. What are the loads placed on anchors?

There are three: body weight, second or top rope falls, and lead falls. Body weight loads refer to clipping in and leaning back on an anchor or the weight of one person, about 200lbs. In a top rope setting, leaning back on the rope with a belayer on the other end will create 400lbs of load (double) on the anchor, due to the pulley effect. Second falls refer to falls on top rope or falls by a second climbing a pitch. Top rope falling by a climber could produce up to 700 lbs of force if there is some slack in the system (there always is). Therefore, the anchor could experience up to 1400lbs of force in a top rope fall. These numbers have been confirmed by tests in the field. The belay method one chooses for belaying the second will influence the forces in a second fall. Direct belay off the anchor would, in theory, be half that of a redirect style of

belay. Therefore, forces on the anchor would be similar to the top rope. Lead falls produce the largest forces. The worst case scenario in a lead fall is if the leader falls while there is no protection between the leader and the belayer. In this case, the leader will fall twice the length of the rope or a factor 2 fall. The fall factor is determined by taking the length of the fall divided by the length of the rope. A 20-foot fall on 10 feet of rope is a fall factor of 2 and should hit the peak force of approximately 2600 lbs limited by CE certified ropes. Actual tests are conducted on a slightly lower fall factor.

Anchors could feel load force ranging from 200lbs to 2600lbs, so how strong do you build the anchor? It is not possible to determine accurate loads from anchors given so many variables. The limits of equipment can help define what we need. A three-strand cordelette rigging begins to fail in the 6000 lbs range, and most pieces of gear used in anchors will be 10 KN rated strength or higher. Three pieces of gear at 10 KN each equals 30 KN or approximately 6600lbs. This is about as good as it gets with good gear. This is well above the maximum load from a lead fall, but more pieces of gear should be used if using smaller pieces or in less ideal conditions.

#### **Distribution**

Since anchors are a matrix of individual pieces brought together to create a master point, most climbers believe that it is best to equalize the load evenly between points. However, *equalization is a myth*. Once one has more than two points of protection in an anchor, equalization between points is not possible. Angles between points affect this. An angle of 90° creates a force multiplication of 71%. At 120,°

this reaches 100%. Angles can change the load distributions. Keep the angles less than 90°, preferably at 60°. The length of the cord affects the load. Longer legs of the anchor stretch more and have less load. Also, protection that is more aligned with the direction of load will have more force on it.

Angles, leg length, and alignment make true equalization impossible. It is better to focus on controlling distribution of the load. Which piece is the strongest, which pieces are more secure, which pieces are weaker, and what placements are available are more important than equalization. Recognizing these variables and being able to distribute the loads to best utilize the placements are the skills a climber needs to build quality anchors.

Guidelines for distributing loads are:

1. Place more load on stronger pieces,
2. Split loads on weaker pieces,
3. Shift secondary forces onto more secure pieces that are not likely to shift.

### **Redundancy**

Redundancy is having backups or fail-safes within a system. Why is redundancy important? Three reasons: human limits, gear limits, and rock limits. Climbers can make mistakes in determining the strength of placements or in making placements. Gear has failed, and even though this is rare, trusting one piece for anchors is not acceptable in institutional climbing. Rock failure is one of the more common reasons for protection failure. Being redundant gives safe guards against these three potential problems. However, do not go overboard.

Redundancy should be focused in three areas: protection pieces, the master point, and rigging materials. Even if a single piece of gear is rated strong enough to get the job done, if it fails the consequences are high. Unless you are using a huge tree well rooted, place three or more protection points depending on load expectations. The master point is another location for redundancy. The master point will see movement and possibly wear as it rubs on the rock. Do not tie a single figure eight; use two figure eights or a BHK knot. At the master point use two carabiners opposite and opposed. Carabiners can rub on the rock and open up. Other considerations for redundancy include top rope anchors. Even if the loads are less, over building the anchors is a good idea since, in a bottom belay, no one will be able to see if things go wrong. If the carabiner can rub on the rock, add a second to insure that the gate opening will not be a problem. Lockers will not work here; they rub the barrel open and get stuck with the gate open. Add redundancy where it is needed but do not go too wild. You end up carrying too much gear that is not necessary.

### **Extension**

Extension refers to the lengthening or extension of the master point should a single point of the anchor fail. The sudden drop in the master point is the chief concern. The additional drop will result in a shock load when the remaining points stop the master point. This can occur with self-aligning rigging. Long extensions are dangerous; full 2 ft and 4 ft sling extensions can cause carabiner failure. The use of load limiter knots will minimize the extension and eliminate this risk. Keep the extension to a few

inches. Rarely does one need the dramatic aligning capabilities of a 2 ft sling without load limiters. Pre-aligned anchors do not extend at all if a single point fails; however, each type of rigging method has limitations and strengths.

### **Rigging Methods**

Rigging is a method of creating a matrix with individual protection points. This section will discuss various materials used in rigging today, techniques for rigging, and finally, a discussion that will help you decide which method will work in the given situation.

Materials for rigging anchors include software and hardware. Software can be sewn two-foot and four-foot runners, 7mm cordelette, and 10mm-11mm static rope. Hardware choices include locking carabiners and non-locking. Careful selection of materials can have benefits.

When selecting sling material you will have the choice of dyneema or nylon. Dyneema slings are lighter, thinner, do not absorb water, and are easier to work with. The reduced bulk makes them easier to work with, particularly when ice climbing. Dyneema will not absorb water, which is another benefit when working in a winter environment. Sling lengths of 2, 4, and 8 feet are available in dyneema. The down side to thin (8mm) dyneema slings is the low cut resistance. This type of sling will cut extremely easily. Use dyneema in multipitch ice climbing and top roping, and in multipitch rock climbing in areas with no sharp, blocky rock. For example, in North Carolina, Looking Glass Rock is a rounded smooth dome with only a few hazards of

sharp rocks on the popular climbing areas. However, Colorado has much more angular and blocky rock formations; it would be wiser to use thicker dyneema slings or nylon. For top roping on rock, sling material should be nylon. Nylon is about 3-4 times more cut resistant than dyneema slings, given the larger size of nylon.

Cordelette material should be 7mm cord. The 7mm size is strong enough when used properly, ties easily, and is readily available. To create a cordelette, select a 18 to 25 foot length of 7mm cord and tie it into a loop using a grapevine knot (two double fishermen) or two Patagonia knots. The grapevine knot with 2" tails is a reliable knot that should not come untied from cyclic use. Check it periodically. It does not come untied easily once weighted. The Patagonia knot is two inline overhand knots. The first knot holds the loop together and the second knot keeps the first from rolling. Tie the second right up against the first and have 6-8" tails. The advantage of this knot is that it comes untied easily, and can be converted into a snake runner or can be threaded around objects. The disadvantage is that it comes untied easily. Check this knot every time you use it. Check this knot every time you use it. Check...get the point?

To extend the master point for top roping, use a static rope 10-11mm in diameter. In the past, most people used 1" webbing. Webbing material is not used anymore for various reasons. First, rope is easier to work with because it uses the same group of knots that climbers use with the climbing rope: figure 8, overhand, bowline, clove, munter hitch, and the double fishermen. Second, it is more durable than webbing. It is more cut resistant and tends to roll

over rock rather than slide like webbing. Third, one can easily create a leash for setting up top ropes with static rope, but when using webbing you will have to have a separate leash system. For those who have used webbing in the past, expect to have a learning curve when switching to rope.

## **Hardware**

Carabiner selection should be considered carefully, because each type has a purpose. Decisions on which carabiner to use should be based on the intended use. Carabiners are connection points and there are three connections: protection point to rigging, rigging to rigging, and rigging to climbing rope (master point).

A protection point to rigging connection does not require large locking carabiners. Carabiners can be small ovals or D shaped carabiners; bent gates are not recommended. Lockers are not necessary and can even be a liability. The reason lockers are not necessary at this junction is because it is part of a larger system, and in general, one should strive to keep these carabiners off any objects to prevent rubbing causing the gate to open. This is called gate interference. There are two forms of gate interference: rubbing and levering. Rubbing happens when the nose of the carabiner slides across the rock and opens the gate. Some carabiners have a hooded gate that greatly reduces the chance of this happening. Strongly consider this feature in carabiner when in areas where carabiners are frequently laying on the rock, such as slab climbs. Even if the carabiner is touching rock, simply clipping the carabiner gate in and flipping it to gate out will help to keep the gate away from the rock. If this cannot be accomplished, add a second

carabiner, gates opposite and opposed. I prefer to do this because I have seen lockers actually unlock and relock themselves with the gate stuck open in top rope setups.

Levering occurs when the carabiner rests on a nubbin of rock like a teeter-totter. When loaded, the carabiner rests on the fulcrum. This can cause the gate to open or even break the carabiner. The solution is to adjust the location of the carabiner by using a sling, moving the protection, or clipping the carabiner further up on the protection, an option on some cams.

The considerations for protection points to rigging connections are the same for rigging to rigging connections. Small light asymmetrical “D” shaped carabiners work fine for most applications. Carrying a few small light asymmetrical D shaped lockers will also be helpful for critical connection points. Master point carabiners, however, are different.

At the master point, large HMS shaped carabiners are the preferred type. Round bar stock is better than thinner stamped carabiners. Round stock carabiners have more rope bearing surface, which is easier on the rope. The flatter bar stock shape does not force the rope against the spine as much, which reduces friction while belaying, and is easier to work munter hitches. A locking feature is also necessary for master points. It is required that tope rope anchors always have two carabiners, gates opposite and opposed, but having a locking feature here makes sense. The master point will have the greatest amount of movement in an anchor system, and lockers add one more level of security. Screw gate or tri-act style auto lockers (made by Petzel) are the type of choice. Auto lockers that

simply twist and open are not recommended for this type of application.

### Types of Rigging Methods

There are two basic anchor-rigging methods available to climbers. Pre-aligned anchors and self-aligning anchors. Pre-aligned anchors assume that there will be one load direction placed on the anchor. These anchoring methods are quick, effective and provide simple solutions to most anchoring problems. Self-aligning anchors are more complex to construct, take more gear and time, but adjust to variable load direction, and control the distribution of load better.

A third option is the compound anchor rigging method. This method blends both systems in an attempt to provide dual benefits with minimum complications. Each method will be presented so that one can construct each type of anchor, understand when to use each, and the advantages and disadvantages to each method.

### Self-Aligning

Most climbers use the term self-equalizing when referring to this method. Looking back on the discussion on distribution, self-equalizing is not an accurate description of what occurs beyond a simple two point configuration. The best asset of this method is *self-alignment*, or being able to adjust from a secondary force to a primary force or vice versa. It is an excellent choice for master points that have to deal with two or more different force directions. Additionally, a simple self-aligning rig will divide the load between two weaker pieces when needed.

To construct a simple self-aligning anchor one will need two protection points and three carabiners

#### Steps

1. Clip and flip a carabiner into each protection point
2. Clip one strand of a single sling (2 or 4 foot) into each protection point
3. Pull down on one strand creating a triangle.
4. Pull down on the upper strand and put one half twist to create a loop in it
5. Clip a carabiner into the loop and over the first strand pulled down.



Analysis of this rig reveals that one can pull in various directions and both points remain loaded. The load at the master point carabiner is divided relatively equally between each protection point regardless of direction. The angle between the two points will determine the amount of load on each point. If one of the protection points fails, the master point carabiner will slide down the sling and the second protection point will catch the fall. However, this redundancy is not

complete. If the sling fails, the master point carabiner will slide off the sling and there will be total failure. Also, if one point fails there is a fairly large shock load on the system. This can cause failure of the master point carabiner, particularly if the sling catches the gate. This can happen depending on which point fails. Eliminate these problems by tying load limiters in the system.

A load limiter is an overhand knot tied with both strands of the sling on each leg near the master point carabiner. Keep these knots within 2" of the master point carabiner for the best performance. One can adjust these knots to account for changes in load direction. If you slide one knot up the sling, the master point carabiner will travel further in that direction.



Analysis of this reveals that a failure at either protection point does not result in any significant extension of the master point carabiner. Additionally, if the sling fails at any point, the system is completely redundant. There are two independent loops created at the master point and independent loops on each leg. The disadvantages of this system are the time to create and tear down and that the load limiting knots are difficult to untie once weighted.

### Complex Self-Aligning Anchor System

The complex self-aligning system requires three protection points, one 2 foot sling, one 4 foot sling and five carabiners. To create this system, build a simple self-aligning system with two protection points. It is best to choose two points close together, or the weakest two of the three points. Also, if you know the direction of the secondary force, choose the two points opposite of the secondary force. They will need to be secure for this direction of pull. Once this simple self-aligning sling is constructed, add another sling between the master point of the two points and the third protection point. A 4 foot sling will be required, or a cordelette shortened with a figure 8 on a double bight. Pull one strand down, then the second, putting in one-half twist in one strand. Clip both strands, being sure to go through the loop created by the twist.

#### Steps

1. Create the first two-point self-aligning sling anchor.
2. Clip a 4 foot sling to the third protection point and the master point of the first sling.
3. Pull one strand down
4. Pull the second strand down and put one half twist in it to create a loop
5. Clip both strands going through the loop in the one strand
6. Add load limiting knots to the 4 foot sling.

Analysis of this system reveals that if one pulls in any downward direction all three points will continue to be loaded. There is redundancy with three points of protection; however, without the load limiter knots, redundancy is not complete. It is particularly important to tie the load limiters on the 4 foot sling. A failure on the third protection point

would result in a large shock load. *In theory*, the load distribution will have 50% of the load on the third protection point and 25% on each of the other protection points. This will allow one to divert more of the load on the strongest protection point if rigged correctly. The disadvantages to this system are the amount of gear needed, the time to construct and tear down, and the master point is extended from the protection points, creating an awkward situation. This extension could be awkward in some situations.

### **Complex self-aligning system with a cordelette**

Constructing a self-aligning system with a cordelette can be accomplished by using three basic steps: clipping one loop into a piece of protection, tying load limiters, and clove hitching individual strands. The advantages of this system include: using the cordelette and saving slings, and having a self-aligning master point. The disadvantages of this system include time to construct, complexity, and distribution limitations.

It would be good to know this system in order to save slings and carabiners. It might be an advantage to use a master point carabiner at the clip in point if multi-pitch climbing. This would prevent the possibility of missing the second strand when clipping additional carabiners into the master point.

#### Steps for construction

1. Clove hitch the cordelette into the first piece of protection so that the grapevine knot is cinched up close to the carabiner.
2. Come down 16" to 20" and tie an overhand knot with both strands (load limiter).

3. Put a twist in one strand of the cordelette after the load limiter and clip a master point carabiner through the loop and over the other strand
4. Approximately 10" down, tie another load-limiting knot keeping the master point carabiner between the load limiting knots.
5. Split the strands at this point. Clip one strand into the second piece of protection with a clove hitch.
6. Repeat with the third piece of protection.
7. Adjust clove hitches to distribute load between protection points 2 and 3.

The self-aligning cordelette has advantages and disadvantages. The use of this method can be beneficial for a variety of reasons: minimal gear use, self-alignment and distribution control are all reasons for using this method. When determining whether to use this method or not, first ask, "Do I need a self-aligning system here?" Using this method would be appropriate if one did not have enough slings to construct a self-aligning 3-point anchor. It is essential that you clip the master point carabiner through both strands and one strand must have a half twist in it. If you fail to do this, failure of protection piece one will result in total failure of the anchor.

### **Pre-Aligned Anchor Systems**

All pre-aligned systems of anchoring are fundamentally a loop pulled between protection points that are tied in the direction of the load to keep this alignment. The benefits of this system are speed, simplicity and

minimal gear. Creating a pre-aligned system is the fastest method of construction given the use of 4-foot slings and cordelettes, is simple and uses minimal gear.

This simplicity also creates a system with distribution of loads between all pieces with some degree of control, but only if it is properly aligned. The problem with this system is the lack of distribution control. One can never be certain that each protection point is receiving the expected amount. For example, on a two-point anchor, if the knot is directly in between each protection point and the force is in this direction, each protection point should hold 50% in theory. These are two big if's.

### Simple Pre-Aligned anchors

There are two possible ways to construct a simple pre-aligned anchor. The first is with a 2-foot sling.

1. Clip a carabiner into each protection point.
2. Clip a 2-foot runner into the first point and then the second.
3. Pull down on both strands of the runner towards the direction of pull.
4. Mark this position and unclip the strand from one carabiner
5. With both strands, tie an overhand knot
6. Re-clip the sling back into the carabiner. This creates two loops.
7. Clip a master point carabiner through both loops.
8. If necessary, adjust the location of the knot by feeding the sling through the knot.

This method produces a redundant pre-aligned system that will not extend if

one piece fails. The limitation is the amount of material in the rigging, just one two foot sling. You must have two close points of protection or you will need to add a sling to the system in order to achieve a narrow angle between protection points. This system works well within a larger system when one needs to connect two points.

### 4-foot sling

With a 4-foot sling, one can produce a pre-aligned anchor system with two protection points.

1. Clip a carabiner into each protection point.
2. Clip a 4-foot runner into first point and then the second.
3. Pull down on both strands of the runner towards the direction of pull.
4. With both strands, tie an overhand knot or a figure eight *on a bight*
5. Clip a master point carabiner through both loops.



This method works slightly better than the 2-foot sling system. It has more room for the protection points to be farther apart, reduces the angle by having a lower master point, is a redundant master point, and is efficient to construct. This system is a common system

for a two-point bolt anchor.

#### Complex pre-aligned anchors

The tool of choice in constructing a three point pre-aligned anchor is the cordelette. A cordelette is a 7mm cord tied into a loop. The length of cord is personal preference, but generally is between 18' to 25'. This length is generally dependent on the terrain. If most anchors you build have the protection points close together, a shorter length will be better. A larger cordelette will be beneficial if you typically have anchors with protection points that are far apart, or work with large trees or boulders frequently.

There are two knots of choice when tying the loop together: the grapevine or the Patagonia. The grapevine knot is two double fishermen knots butted against each other. This knot is self-tightening, and if tied correctly it is reliable. Weight this knot with body weight to seat the knot and you can be confident that it will stay tied. You should have 2 to 3 inch tails coming out of each fishermen's knot. The Patagonia knot is preferred if one needs to untie the cordelette frequently to pass it around large boulders, or create a rabbit runner. The liability of this knot is that it will come untied, and must be tied perfectly. Because of this, one should check this knot every time you use it.

Handling the cordelette has a few tricks. The knot on the cordelette can get in the way when building an anchor. If you are using this in a three-point anchor, clove hitch the knot close to the first point of protection (within 5"). If one needs to place the cordelette around a tree, grab the knot and the other strand opposite the knot. Pull the cord through

your hand until the knot is in your hand and you have two loops of approximately the same length. When you are done fold the cordelette into thirds and tie an overhand knot in the middle. Fold the loops together and clip a large carabiner through all the loops. Now one can begin working with the cordelette.



Constructing a three-point anchor.

1. Clove hitch the cordelette into the first piece of protection, keeping the grapevine knot within 5" of the first carabiner.
2. Clip one strand into the second, then the third point of protection, creating a loop.
3. Grab the strand between the first and second points, and pull down
4. While holding the first strand you pulled down, grab between the second and third points and pull down.
5. One should have a "W" at this point
6. Bring all the legs together to one point and even them up.
7. Point the strand toward the direction of load and hold this alignment
8. While holding this alignment, tie a figure 8 knot, or overhand knot.
9. Clip a carabiner into the master point using all three loops.

This rigging method produces a redundant anchor that distributes the loads between each point of protection,



as long as all the legs of the anchor align with the load with even tension. This produces a fast and effective anchor for most situations. There are two master points with this anchor: the loops below the figure 8 knot and the shelf. The shelf is the point where each leg comes together above the figure 8 knot. Do not use the shelf if the master point is not being used. When constructing a cordelette anchor in a vertical crack always begin with the top piece when pulling the cordelette. Work from top to bottom. In vertical cracks, cordelette anchors adapt to secondary loads more effectively. One may be able to use a cordelette in place of a self-aligning system with vertical cracks.

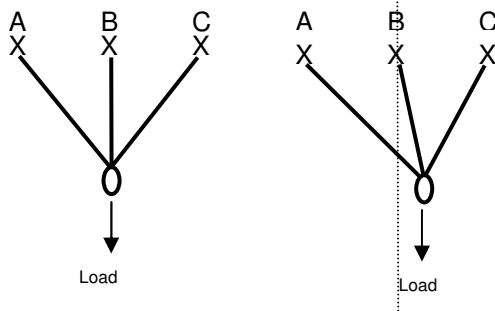
The main concern with the use of the cordelette is being diligent with aligning all the legs toward the anticipated load. Many times while tying the cordelette, people will mistakenly point the legs in the wrong direction, creating an uneven alignment between legs. Then, when the anchor is loaded, one point will hold more or even all of the load. Be diligent in creating the master point. In vertical cracks, you must make sure that all the legs are evenly loaded. If the master point is not

aligned with the load it will be too high or too low. This will result in the top piece or bottom piece being loaded more than the rest. Be diligent in pointing all of the legs directly toward the load. If you are on a large ledge, this will be straight towards the edge of the ledge. However, even if one takes the time to properly tie the cordelette, it may be off just slightly. If this is the case, do not retie it. Find the loose leg of the cordelette; it will be the one with slack. Wrap an additional loop of cord through the carabiner on the protection point. This will snug up that leg. Check the other legs. It may be such that one will have to put two wraps in one leg and one wrap in another to get it right.

Adapting the cordelette to a variety of situations involves a few simple skills. If the master point is too low, add additional wraps to the figure 8. This will take up cord material and raise the master point. This will also make it easier to untie after being weighted. If the points are too far apart, you can do one of two tricks. First, add a sling to the farthest point of protection. Clip the cordelette to the sling. This should provide enough additional extension to tie the cordelette. The second option is to create a rabbit runner with the cordelette. Untie the cordelette. Tie a figure 8 on each end of the cordelette. Clip each end of the cordelette to the farthest points of protection. Clip the middle of the rabbit runner into the middle point of protection and create the cordelette.

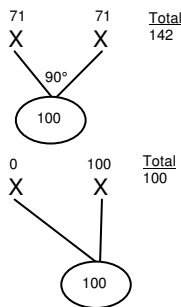
Controlling distribution with a cordelette anchor is possible. First understand that in an ideal rigging configuration the legs A and C are longer and have more stretch with the cord. More stretch will lower the load on A and C. Because the angle between

A and C is the largest, this should cause a force multiplication on A and C, increasing the load on these points. However, protection piece B is the most aligned to the load and has the shortest leg. In theory, B will always have the greatest load, providing the angle between A and C is not extreme. Controlling distribution of the load can



be as simple as shifting the master point towards A or C. This will place the load between the middle and one of the far left or right pieces. Take the diagram as an example. The master point is shifted between B and C. The result is a lower load on A and more on B and C. One might do this if pieces B and C are obviously stronger than A and you need to shift more load to the other protection points. This is accomplished by tying the master point offset to one side or shortening legs C and B by wrapping additional cord in the carabiners on points C and B.

This load control can easily be seen in a two-point anchor. In a two-point anchor with a 90° angle between each leg, a 100 lbs load will produce 71 lbs of load on each point.



This results in a total load on the anchor of 142 lbs. If you shift the load all the way under one of the pieces, the load on the first piece is 0 lb and the load on the second is 100 lbs. This results in a total load of 100 lbs. This is a total load reduction of 42 lbs, but an increase of 29 lbs on one piece and a decrease of 71 lbs on the first piece.

Be aware that with pre-aligned rigging perfect distribution of loads is almost impossible; one will hold more than the other, even when one tries to get even distribution. With two equally strong pieces, this is not an issue. However, with a three-point anchor with one unequal piece it may be wise to intentionally offset the load to the two stronger pieces to insure it holds more of the load. **Do not** get carried away with this concept. A slight offset is all you need. Additionally, beware of the load directions. If the load is coming slightly from the side, the offset is from the load direction, not straight down. Do not offset load when using only two pieces of protection. This will transfer the entire load onto a single piece. The two-point diagram is only for the purpose of illustration.

### Combination Anchor Rigging

A combination anchor blends the self-aligning and the pre-aligned anchor methods. This creates rigging that has properties of both, and reduces limitations of each. However, there is not perfect rigging system. You need to decide which method best suits the situation. The combination anchor has self-aligning ability, but not with all protection points. It does not extend if one point fails. One can control distribution on the anchor more reliably. The rigging is more complex and takes additional time.

To construct the combination anchor, one will need either a 4 foot sling or cordelette, a 2 foot sling, and carabiners. These are the steps for a 3-point anchor:

1. Clip a 2-foot sling into two points of protection and create a self-aligning connection.
2. Clip a 4-foot sling into the carabiner of the magic X and to the third protection point.
3. Pull down on both strands of the 4-foot sling, creating a master point in the direction of load by tying an overhand or figure 8 knot.



Note how when one pulls the master point to one side, two points of protection will be loaded. Pull the master point in the other direction and one point of protection will be loaded. The combination anchor has limited self-alignment. One will have to anticipate which direction the secondary load will come from and build the anchor with this in mind. Always place the self-aligning component on the opposite side of the secondary load. This will allow for two points of protection to hold the load of the secondary force. The primary load (straight down) will have

all three components loaded. The combination anchor works best while multi-pitch climbing, when the previous or future pitch traverses. For example, the leader traverses into the belay from the left and the next pitch moves straight up from the belay. If the leader builds a cordelette anchor, only one point will be holding the second in case of a fall. The leader has to build the anchor for the primary load, which would be a lead fall on the next pitch. If the leader builds the combination anchor with the self-aligning component on the right side of the anchor, a fall from the second will load two components, not just one. A lead fall on the next pitch would load all three.

### Determining Which Rigging to Use

The best rigging method is the one that maximizes the benefits and limits the liabilities of a given situation. There is not one perfect system. Learn to determine which system works best in a given situation. Accomplish this by asking questions about the situation and letting the data make the decision as to which system to utilize. Seek the simplest solution to the given situation. This will usually be the most effective and efficient solution. Once you determine the location for the anchor, ask these questions about the situation to determine the proper rigging.

#### Question sequence

- 1) Will the anchor be loaded in one direction?
  - a) Yes, use a pre-aligned system; go to step 2
  - b) No, use self-aligned or combination system go to step 5
- 2) Is the protection reliable, such as 2-bolt anchor?
  - a) Yes, use pre-aligned 4 foot sling

- b) No, three point artificial anchor;  
Go to 3
- 3) Are all three points sufficiently strong?
  - a) Yes, create a cordelette anchor
  - b) No, go to 4
- 4) How many smaller pieces of gear are there?
  - a) One, create a combination anchor with the self-aligning component on the two weakest pieces.
  - b) Two, add more protection and create a four piece self-aligning anchor or move to a new location.
- 5) Is the secondary force from a single direction?
  - a) Yes, use a combination anchor with the self-aligning component opposite the secondary force.
  - b) No, use a self-aligning sling anchor with load limiters

This process of questioning will direct one to deciding on the best possible rigging configuration for a given situation. This assumes the load direction as the first and primary consideration for determining the anchor type. Load direction is first because whether one builds a pre-aligned or self-aligned or combination anchor, knowing the load directions will determine the type of rigging, as well as placement orientation. Have you ever built the perfect anchor only to have one piece loaded because direction of force was different than you anticipated? This happens frequently. Determining load direction is critical for selection of the proper anchor rigging.

#### Anchor Evaluation

After constructing the anchor, one should evaluate the anchor matrix. Begin this evaluation at the connection points. Are any of the carabiners

levering across the rock? Is there gate interference? These are two important checks to make. It is not necessary to have two carabiners on the connection point or even having lockers at this point. However, if the gate does rub on the rock, place a second with the gates opposite and opposed. If you use a locking carabiner, place it on top of a non-locking carabiner that rubs the rock. This will keep the locking mechanism from being locked in the open position. This can happen when a locking carabiner rubs the rock. This works better than a locking carabiner. I have seen locking carabiners locked in the open position from rubbing. If the spine of the carabiner is actually pivoting on a nubbin of rock, one should remove the carabiner. This teeter-totter effect can break the carabiner. If the protection does not have a wire connection, such a stopper or wired hex, basket a sling through the protection, or move the protection so the carabiner is not levering on the edge. One must eliminate any levering effect on the carabiner.

Next, one should evaluate the rigging. If you have gone through the question sequence, you should have selected the appropriate rigging configuration. Double check, did you tie the load limiters? Did you check the load direction? Are all the legs holding the load? This is when you add wraps to cordelette anchors if the alignment is off a little. A useful acronym for rigging evaluation is NERDSS (Chauvin, 2005).

- ⇒ **N**on **E**xtending
- ⇒ **R**edundant
- ⇒ **D**istributed
- ⇒ **S**trong
- ⇒ **S**imple

**Non-extending** means that if one protection point fails the master point will not significantly drop. This avoids additional shock loading. **Redundant** refers to more than one component holding the life of an individual. Redundancy ends at certain points, such as the climbing rope or the belay carabiner. However, in the anchor, one should have system redundancy, as this point is critical and may have to hold high loads. For example the belayer will feel only 1/3 the force of a fall whereas the anchor will receive 100% of the load. Overbuild top roping anchors because typically no one checks the anchor after each climb. Cyclic loading can cause protection to shift and carabiners to open. Overbuilding top rope anchors is more for redundancy than strength.

**Distribution** of force is the concept of spreading the load among all components of an anchor matrix rather than one individual piece. The art in building anchors is controlling distribution. Can you shift more of the force on a stronger piece and less on a weaker one? Are all the pieces strong? Can you evenly distribute the load among all pieces?

**Strong** refers to the level of strength necessary for that anchor to hold. There are three levels of anchor matrixes needed: body weight, top rope or second falls, and lead falls. Make sure the anchor is absolutely bomber for the level required. Build each anchor to the highest level necessary.

Keep the anchor matrix **simple**. This avoids confusion and reduces the amount of time for setup and tear down. Usually the simple solution is the best, but do not over simplify to the point of increasing risks. Taking short cuts can lead to accidents.

Finally, check the master point. Is it in free space or is it rubbing rock. Keep the master point free floating. Did you use locking carabiners with gates opposite and opposed? Are the gates pointing down? Is the master point knot redundant? Did you pad the rigging on sharp edges? Your check system should work from the protection to the master point. Remember, even if the rigging is fantastic, if the protection is bad then the rigging really does not matter. Use a system to eliminate the possibility of missing a critical point. Check the **Protection, Connections, Rigging** and finally the **Master Point**. This system begins from the protection and moves down to the master point, but whatever system you utilize, be consistent.

### **Conclusion on Rigging**

Construct quality anchors by using a systematic process. This process begins by evaluating the situation and discerning which steps to take to make the best use of the situation. Quality anchors will limit extension, distribute the load, be redundant, and self-align when necessary. It is up to the leader to determine the techniques necessary to accomplish this.

Critical concepts to analyze include strength requirements, load direction or directions, and location. Will the anchor need to hold lead falls or top roping? What direction will the load come from? Will there be multiple load directions? By learning to ask these questions, one will become proficient at constructing anchors for a variety of situations. Evaluate anchors using a consistent systematic method. Start with connections and work down to the master point.

## Extending Master Points

It is a rare that one can simply use an anchor close enough to the edge of the cliff to rig with just a cordelette. Additionally, it is usually a bad idea to stand right on the edge of a cliff to construct an anchor. This section will present a system to create an anchor away from the cliff edge, extend that anchor to the edge and create a leash for safely working at the edge of a cliff. The concepts to learn are:

- ⇒ What materials to use
- ⇒ Which knots to use
- ⇒ How to rig the extend/leash combination
- ⇒ How to adapt to different situations

### Materials

The materials to extend a top rope anchor will include, static rope, 2 large HMS carabiners and a grigri. The static rope is replacing the use of 1 inch webbing in many places throughout the country. This is largely due to superior cut resistance, simplification of knots, and the ability to create a leash that can be used to rappel with a grigri to the edge for protection. Rope rolls over edges rather than sliding like webbing and it has a core. These two features greatly increase the cut resistance over webbing. The knots used with static rope are the same one uses with the climbing rope. This eliminates the need to work with additional knots. Rope will work with any rappel device, allowing one to approach an edge with great security and use a simpler system. The only draw back is the cost. Rope does cost more than webbing, but if you pad sharp edges, it should last longer under the same conditions as webbing. When considering all of these issues, using

static rope is the best option for anchor extension.

The master point will need to have two carabiners at all times. These carabiners should be locking large HMS (pear shaped) carabiners. The larger size will accommodate redundant master point rigging and have a smooth round surface. Round stock is preferred because it places less stress on the rope.

A grigri or similar device is the method of choice when lowering to the edge. It auto locks when you need to stop and a simple overhand knot will back up the grigri. A traditional rappel device backed up with a prusik will also work, but is more complicated when coming back up the rope.

### Extension methods

Extending the anchor master point may seem complicated, but once one learns the steps it becomes simpler and faster than using slings. There are two or three knots used depending on the type of anchor.

For anchors using natural protection such as trees and boulders, the knots of choice are the bowline family. There are two methods for tying the bowline and either method is effective. The traditional method of tracing the tail through the loop is in many books and other resources.

#### Bowline Knot

- ⇒ This knot is used to make anchors with static rope and sometimes is used to tie in with.
- ⇒ This knot can become untied, so use a stopper knot!

The second method is a variation from the bowline on a coil.

1. Wrap the tail around the object that you wish to tie the rope to.
2. On the LOAD STRAND create a small loop

3. Pull a bight of rope from the LOAD STRAND below this loop and pass it through the loop. If you do this incorrectly the loop will fall apart.
4. Pass the tail through the bight of rope that was passed through the loop
5. Pull enough slack through to tie the backup knot.
6. Let go of the tail and sharply pull on the load strand below the knot. This should invert the knot and turn it into a bowline.
7. Tie a stopper knot against the bowline.

#### Variation #2

This variation of the bowline is used when there are excessive amounts of tail material to be pulled through the bight. Pulling 15 feet of rope through the bowline gets annoying. The difference is in step 4. Instead of pulling the tail through the bight, pull a second bight of rope (tail end) through the first bight of rope in the bowline knot. Tie the backup knot using a bight rather than a single strand. Understand that the tail is NOT load bearing and should be stacked out of the way to avoid confusion.

#### Variation #3

This variation creates two load bearing strands. This is useful when tying a bowline in the middle of the rope to create a leash or a second anchor line. The trick to tying this knot is to treat both rope strands as one. People tend to get confused, but really this knot is not very different than the other two.

1. Wrap a large bight of rope around the object; you will need enough rope to tie the bowline and the backup so pull more, not less.

2. On the LOAD STRANDS, create a small loop with BOTH LOAD STRANDS
3. Pull a bight of rope from **both** LOAD STRANDS, below this loop and pass them through **both** loops. If you do this incorrectly, the loops will fall apart.
4. Pass a bight (tail strand) through both bights of rope that were passed through the loops
5. Pull enough slack through to tie the backup knot.
6. Let go of the tail and sharply pull on the load strands below the knot. This should invert the knot and turn it into a bowline.
7. Tie a stopper knot against the bowline using the tail bight.

The result of this knot will be two load strands coming from the bowline knot. This allows for the creation of a leash or two anchor strands.

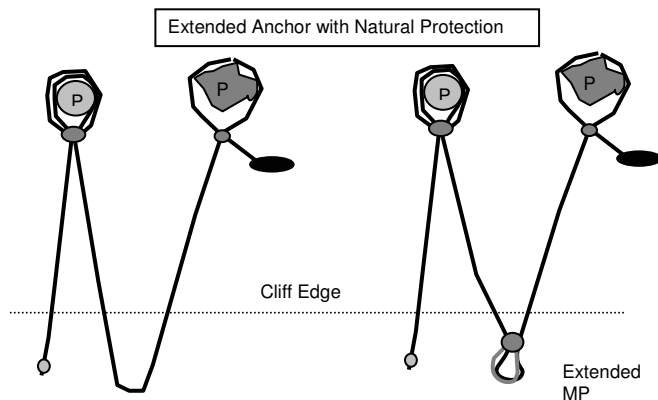
The benefits from these knots are less equipment needed, such as cordelettes, carabiners and separate slings, and having the static rope around possibly sharp edges from rocks. Pad all sharp edges, but the idea is that the most cut resistant material is around sharp objects, since pads can move out of place.

#### **Creating a master point with two natural points of protection**

In this situation, there are two solid natural features to create an anchor using a bowline. This could be a tree and a boulder, two boulders or two trees. The goal is to construct a typical top rope rigging. This rigging requires a master point that is past the cliff edge, so the climbing rope will not rub, and create a leash to move to the edge safely. It is best to be at the edge to create the master point and toss the climbing rope.

Too often, people simply create a master point, clip in the climbing rope and toss the whole system over the edge. This can create problems. I have done this in the past only to realize that the carabiners have flipped around or are cross loaded after I hike all the way back down the cliff. In addition, tossing a rope at a top rope site usually means that there are people below. Being hit with a rope hurts, but worse is being hit with a rock that was dislodged from tossing the rope. Finally, you may end up realizing that you set up the wrong climb.

Study the diagram *Extended Anchor with Natural Protection* to see



how the set up should look. The diagram on the left illustrates what the anchor should look like before you move down to the edge. It is a simple leash with a big U going over the edge. Move down to the edge pulling the ends of the climbing rope. Construct the master point then thread and lower the climbing rope. The advantages of this method are three pieces of equipment (a static rope and two master point carabiners), being at the edge to distribute loads on the anchor, seeing which climb you set up, and avoiding hitting anyone while tossing the rope. The disadvantage is that both points of the anchor need to be independently bomber. Remember that you are rappelling to the edge with only

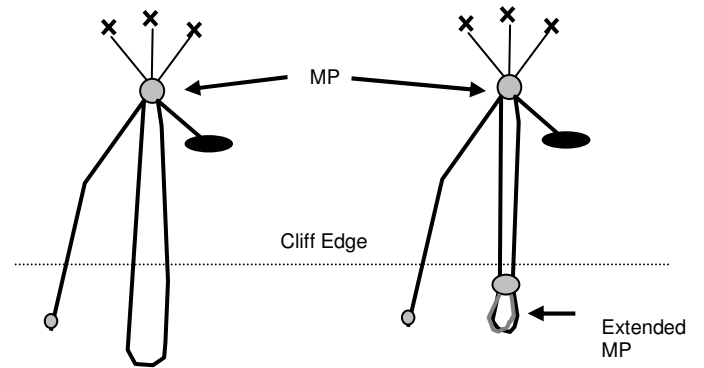
one point of protection. Choose wisely. Memorize the steps and practice the set up on trees in your yard.

#### Steps for Extended Natural Anchors

1. Look around, Just think, don't do.
2. Organize gear, static rope, carabineers, climbing rope
3. Tie stopper knot on one end of static rope
4. Toss 6 feet over edge
5. Tie bowline on a bight around tree or boulder and toss bight 3 feet down cliff edge
6. Tie Bowline around second tree or boulder
7. rappel down leash with both ends of the climbing rope
8. Distribute load between strands and tie BHK knot MP and clip carabiners gates opposite and opposed
9. Thread one tail of climbing rope through carabiners, pull and toss.

Variations of this rigging include extending the master point directly from an all gear anchor, a combination of natural and artificial gear and creating dual master points. When working with a gear anchor there will be three pieces of protection with rigging to distribute the load and minimize extension. To adapt to this situation simply change from using bowline knots to using overhand or figure eight knots. Clip each extension to the master point of the original anchor. The gray circle represents the master point from the gear anchor. This is the location to clip an overhand on a bight from the static rope. The steps are essentially the same.

1. Tie a knot on the end of the static rope and toss it over the edge.
2. Tie an overhand on a bight and clip it to the anchor.
3. Toss a bight of rope down over the edge and tie another overhand on the second leg and clip it to the anchor.
4. Rappel down and create the master point using a BHK.



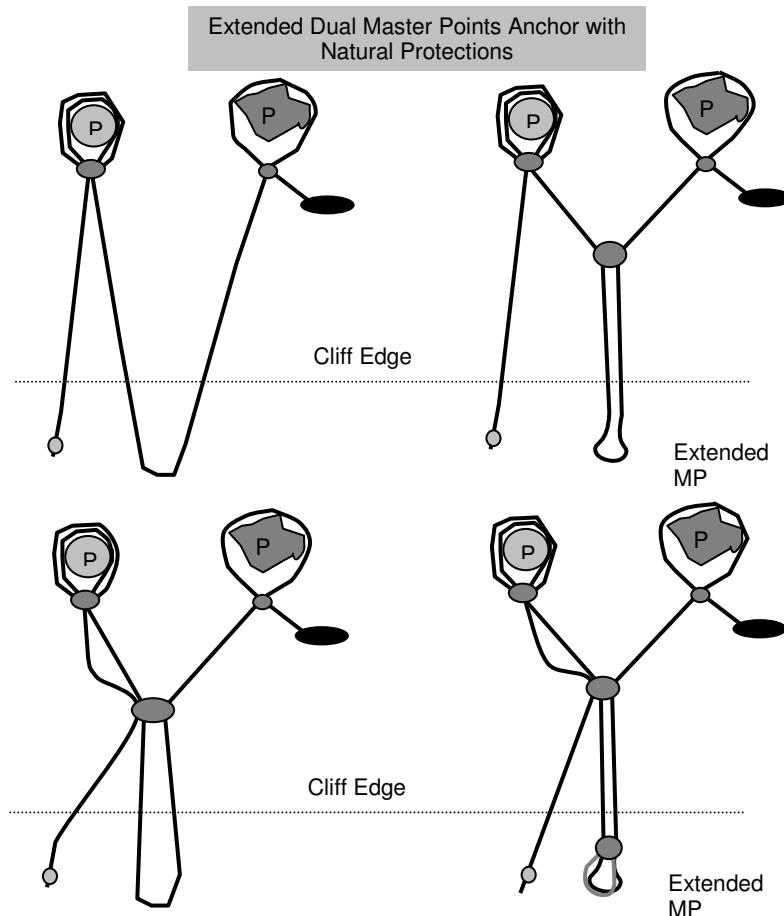
gear it really should be two pieces, because your life depends on it.

### Variation #2

When using a combination of natural and artificial protection, simply use two pieces of gear and connect them with a sling. Two gear placements equal one bomber natural protection. The reason for two pieces of gear is redundancy. If you are rappelling off the anchor point constructed of artificial

### Variation #3

The last variation is a dual master point. This variation is used when top belaying, rappelling, or creating a redundant master point up high is necessary to rappel to the edge due to the lack of two solid gear placements or one questionable natural point of protection. Always try to get great gear for anchors, however if using variation #2 and there



is only one gear placement, create a master point between both protection points, clip the leash into this master point and then rappel down to create a second master point for the top rope. This is a great way to set up a top belay system or rappel site and convert it to a bottom belayed top rope site later. Construct the system for the bottom belay top rope, but then tie a master point up higher on the static line and pull the extended master point to the side until needed. Use the upper anchor for top belays or rappelling, then untie it and convert to a bottom belay.

#### Conclusions

Working with different rigging methods, equipment and techniques may involve a paradigm shift in thinking. However, always keep seeking out new ways of doing things. See if you can incorporate these new methods into your system. If the new system is safe and more efficient for you to construct, it may be worth investing the time and energy to master the new technique. The methods of anchor extension discussed here do have advantages over previous techniques that incorporated sling material for anchoring: faster set ups, security for the person up top, simpler equipment, and less overall gear to carry. Compare this method to your method and see for yourself.