15

ANCHOR SYSTEMS

INTRODUCTION

We are now ready to tie together all of the individual anchor techniques and materials we have discussed in previous chapters to make a complete **anchor system**. We have looked at the **anchor principles** by which we want to abide (Solid, Redundant, Equalized, and No Extension—SRENE). We have studied how to choose the **anchor points** from which we will hang the system. We have discussed **anchor materials,** including the **equipment** (rope, biners, webbing, static rope and static cord) chapter in this manual. We have learned the **anchor techniques** used in putting together the materials in the system, including the **knot** chapter in this manual. We have examined the **anchor physics** to understand the forces acting on anchor systems.

TYPES OF ANCHOR SYSTEMS

Let's review some basic anchor systems. A **slingshot anchor system** is always set so that the rope hangs suspended from a **master point** (rope-bearing biners) at the cliff edge above both belayer and climber; the belayer stands at the bottom of the climb or at the top just under the master point while the climber stands at the bottom of the climb. The rope extends from the belayer up through the master point and back down to the climber. A **top belay anchor system** means that the belayer is sitting or standing at the top of the climb, with the anchor system above and/or behind the belayer. Both of these anchor systems are examples of **top-rope anchor systems**, in which there is an anchor system above the climber. A **rappel anchor system** is used for rappelling, and may or may not be appropriate for top-roping. A **belayer anchor** prevents the belayer from losing control of the belay. A **lead belayer anchor** is used when the climber is leading. A **hanging belay** is used when there is no place to stand or sit, and is used in lead climbing.

The anchor systems we are discussing in this chapter are intended to be used for top-roping. The principles apply equally to lead climbing, but there are further considerations in lead climbing. There may be times when you are forced to build a "sub-standard" anchor (such as a single bolt hanger) because you didn't know there was a problem until you reached the belay stance. If there is no other way down, you may not have any choice. However, there is no excuse when top-roping for building a sub-standard anchor. If you do not have the right gear, safe anchor points and a safe environment, do not set this climb at this time.

COMPARISON OF SLINGSHOT AND TOP BELAY ANCHOR SYSTEMS

SLINGSHOT ANCHOR SYSTEM
- longer falls (more rope to stretch out)
- only used for pitches of half a rope's length or less
- belayer and climber usually can see each other; good communication
- no rope re-throw required
- faster climbing process for a group
- additional bottom anchor can be required
- doubled force on anchor (belayer and climber) but less force on the belayer

TOP BELAY ANCHOR SYSTEM
- shorter falls (less rope to stretch out)
- can be used for any length pitch up to the length of the rope
- belayer may not be able to see climber; communication may be more difficult
- rope must be re-thrown after each climb
- slower climbing process for a group
- only top anchor system required
- climber weight force on the anchor and more force on the belayer

ANCHOR SYSTEM CONSTRUCTION

Anchor systems are built at the top of cliffs, from which it is possible to fall far enough to be fatally or seriously injured. Since building the anchor system will always involve work near the cliff, make it a habit to set up and clip into a **personal anchor** before going near the edge. The hazards (some controllable, some not) include loose rock that breaks or rolls away, fellow climbers accidentally bumping into you, and your own footing and actions. **Always use a personal anchor near the edge**.

As discussed above, building an anchor system involves knowing how all the anchor principles, anchor points, anchor materials, anchor techniques, and anchor physics fit together. The main idea is to build at least two lines of gear connecting the master point (or the top belayer) to an anchor point in a way that will allow the climbing rope to be used without incurring damage. Although each anchor system is unique, you can follow these four steps to build an anchor system:

First, identify the best location for the master point (rope-bearing biners) or top belayer. You may have to work with someone at the base of the climb or at some other vantage point to determine where the rope must hang. This decision has to account for any side-to-side motion such as traverses or pendulums, and obstacles that may interfere with a "clean" line such as bulges, cracks or horns. The rope should hang as freely as possible and other parts of the system should be positioned so that no individual component can fail, such as biners side-loading or slings cutting.

Second, identify at least two solid anchor points from which to hang the system. These can be two trees, two boulders, a tree and a boulder, a tree and a pro placement, several pro placements, or two bolt hangers. These "two" anchor points can also be the same anchor point if "they" are strong enough to handle the stress of the whole anchor system, such as a large tree in no danger of being uprooted. If there is any doubt about the strength of a given anchor point, do not use it alone as a dual anchor point. Ensure that the anchor points will not result in too great an angle between the lines of gear in the anchor system and that they can safely position the rope-bearing biners or top belayer in the line of action. If the anchor points are artificial, removable protection, use at least three pieces of pro to provide three different anchor points.

Third, build at least one line of gear from each anchor point to the rope-bearing biners or the top belayer in the desired position. A line of gear can consist of any appropriate combination of equipment that is connected by the appropriate techniques. For example, you may girth-hitch a sling around a tree, then girth-hitch another sling to the first, and hang rope-bearing biners from the second sling. You may place a bomber SLCD in a crack, add a biner to the wire cable on the cam, connect a sling to the biner, and connect rope-bearing biners to the end of the sling. You may girth-hitch two slings around the same tree, then girth-hitch two more slings to both of these original slings, and connect a top belayer to the second pair of slings. A variation is to run lines of gear to a central point, then extend redundant lines of gear from that point to the biners or belayer. There are many combinations you may choose, but try to keep the anchor system simple; the more complicated the system, the more unpredictable the results if some part fails.

Fourth, evaluate the anchor system. Check to make sure you have followed all guidelines and ask yourself what will happen to the system if any given component fails.

ANCHOR SYSTEM EVALUATION

This step is the difference between having an "OK" anchor and a "bombproof" anchor. Perhaps you have heard the adage "A chain is only as strong as its weakest link." This is especially true with anchor systems.

After you have built the anchor system, evaluate it systematically as follows, looking for **single-point failure** possibilities. This means that if one component fails, the whole anchor system fails. Such a system is not redundant.

Start from the anchor point and work toward the rope-bearing biners or top belayer, or vice versa. Examine each anchor **component** in a line of gear in sequence, asking yourself questions such as those listed below. Then, look at the anchor **system** as a whole, again asking yourself questions such as those listed below. Test the system with a moderate pull, imagining what will happen in normal use and if one line of gear or anchor point fails. (This is a sampling of questions, not a complete list. The parenthesized words following each question indicate the chapter that explains how to check the feature being examined.)

1. Is the **component** damaged in some way? Is it oriented properly? Is it able to withstand the load without breaking?
    - Is the anchor point—tree, boulder, bolt, or piece bombproof?
    - Are protection pieces properly placed to withstand force in the intended direction of load?
    - Are biners intact, oriented properly, lockers locked, and reversed and opposed where there are two?
    - Have you inspected the full length of all webbing for rips or worn spots? Are all knots properly tied?
    - Is the sheath on all static rope and static cord intact, with no core showing? Have you inspected its full length for worn spots, hard spots, soft spots, etc.?
2. Is the **component** connected properly to the next piece in the chain?
    - Are all knots tied and dressed properly? Are hitches properly dressed?
    - Are the rope-bearing biners reversed and opposed? Are they properly positioned to avoid side-loading?
    - Are locking biners locked?
3. Does each **component** have a backup somewhere in the system? Ask yourself "If this particular piece fails, what will back it up?" (REDUNDANT)
4. Is each of the **component** anchor points weighted equally? (EQUALIZED)
5. How will the **system** react to the forces generated in a climbing situation? (NO EXTENSION)
    - Where does the line of action lie and will the anchor system suddenly be pulled toward it in a fall?
    - Is the system creating leverage or torque on an anchor point?
    - Is there too much or too little friction in the rope-bearing biners?
    - If part of the system fails, how badly will the rest of the system be shock loaded?
    - Is there too much multiplication of force due to a large angle somewhere in the anchor system?
    - Are any components lying on sharp edges, or can any components be pulled onto sharp edges?
6. Does the **system** allow enough belayer comfort for the duration of the climb(s)?
7. What will happen in a redistribution of forces due to partial anchor failure? (NO EXTENSION)
    - Will the **system** fail if one anchor fails?
    - If one anchor point or line of gear fails, are the remaining anchors strong enough to hold the extra weight?

By forcing yourself to ask questions systematically, you can avoid overlooking mistakes in the chain. By partially loading the anchor system in a controlled test before trusting body weight to it, you can identify potential problems that aren't obvious when the system just lies on the ground. Make sure you are anchored to your own personal anchor before load testing.

SLINGSHOT ANCHOR SYSTEMS

Slingshot anchor systems are commonly used for groups because they allow socializing and control. A guide or leader can watch most of what is going on much more easily. The illustrations on the facing page show examples of slingshot anchor systems. A slingshot anchor system (fig. 15-01a) consists of the anchor points, rope-bearing biners, and the lines of gear connecting them. The belayer and climber are positioned below the anchor system. The rope extends from the belayer up through the anchor system rope-bearing biners and back down to the climber. Remember: **always use a personal anchor near the edge**.

Anchor System Construction

First, identify the best location for the rope-bearing biners.

Second, identify at least two solid anchor points from which to hang the anchor system such that the system will hang in the line of action (or at least three if the anchor points are artificial, removable pro).

Third, build at least one line of gear from each anchor point, joining them to secure the rope-bearing biners in the desired position, or run at least one line of gear from each anchor point to a central mid-point and run further redundant lines of gear from the central mid-point to the rope-bearing biners.

Rope-Bearing Biners

These are the keys to a well-set slingshot anchor (fig. 15-01b). They must be hanging over the cliff edge. The rope should be free to run through these biners without a lot of drag and without the rope being trapped against the wall (which happens if the biners twist to one side). Trapping the rope can cause abrasion and possibly force the rope onto a sharp edge. The biners should not be levered over any irregularity in the rock that allows the possibility of breaking the biner (side-loading). They should not be on the horizontal rock above the cliff edge; the edge or horizontal rock may abrade or cut the rope.

The rope-bearing biners absolutely must be reversed and opposed (fig. 15-01c). When they are, it is almost impossible for the biner setup to fail during a climbing activity, no matter what else goes wrong. They should be oriented nose-down. There must be a minimum of two biners.

The biners can do several things while the climbing is occurring. The most common action is to twist laterally, trapping the rope against the wall. To create a more stable platform against the wall, it may help to add more biners of the same size and shape.

Rope-bearing biners can also rotate, so that the gates are up, then down, then up again. This happens less frequently than twisting. Each climber should check the biners just before being lowered, but if it is too difficult to correct and the biners are reversed and opposed, you can safely get by without correcting it.

Non-locking biners work better; a locking biner's gate nut acts as an unstable point around which the biners pivot. Also, a locker's gate nut causes an offset effect, lifting the rope higher in the biners, closer to the sharp edges many biners have on the inside of the gate. If you do use lockers, remember that they may unlock themselves by the back and forth action of rubbing against the rock. Ovals create the least amount of drag in the setup. Use the same size biners for the rope-bearing setup, so the rope settles in and weights the biners equally. Although these tips will make a smoother-running top-rope, any two reversed and opposed biners will work quite well.

Belayer Anchor

Normally, the belayer will stand close to the start of the climb. You normally don't need to set a belayer anchor, but you should under the following circumstances: if the climber significantly outweighs the belayer, if the belayer can be pulled into something dangerous, or if the belayer can be moved suddenly and lose control of the belay.

Special Considerations

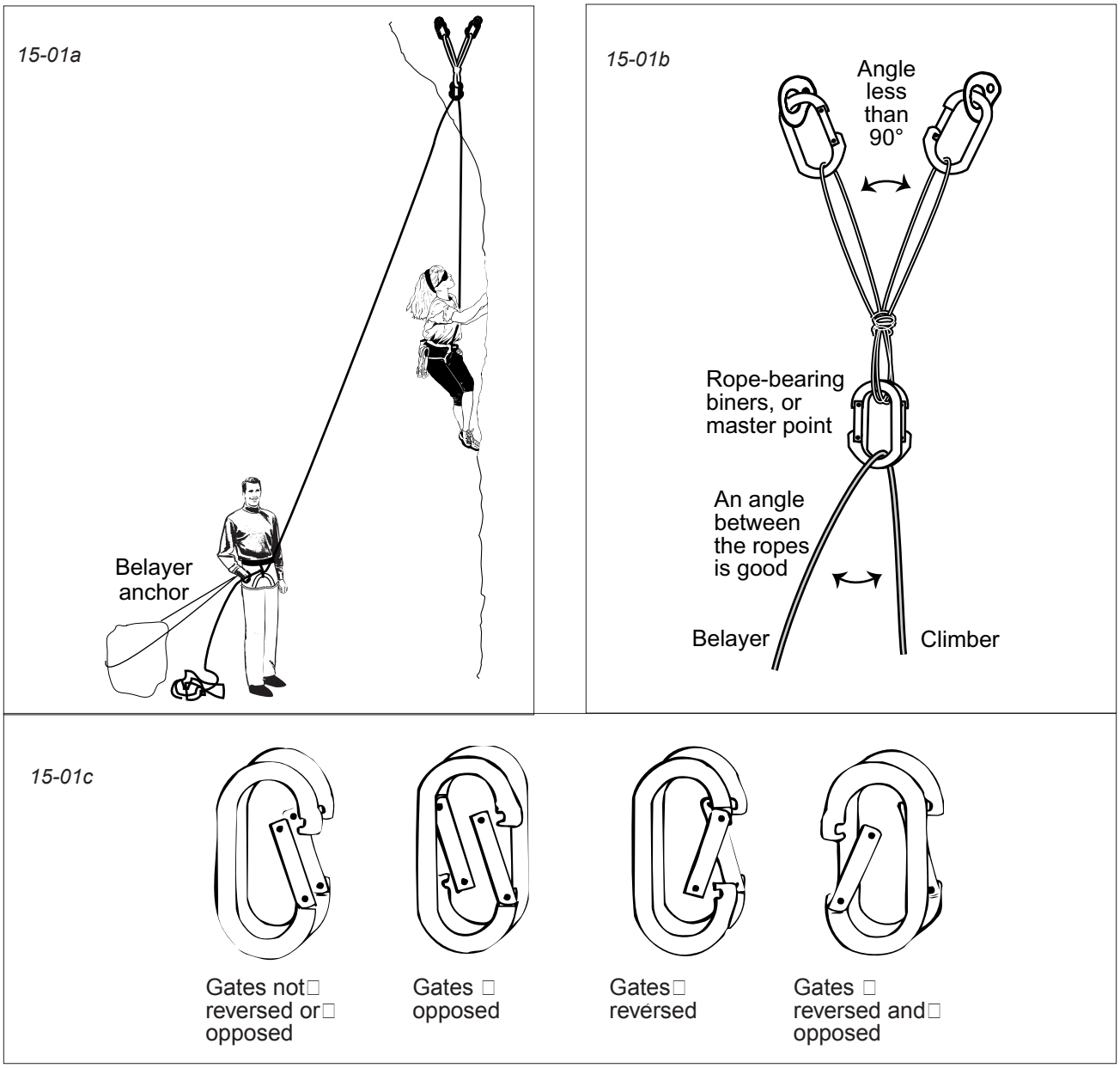
The slingshot climb is usually about 80 feet or less. An 80' climb allows enough rope for the climber's tie-in, but utilizes so much of the rope that there is a chance of the belay end of the rope slipping all the way through the belay device and dropping the climber. If this is even a remote possibility, tie a stopper knot (any knot will do) in the belay end. The knot will jam in the belay device and ensure that the climber is not dropped.

If the climb is longer than half a rope's length, tie two ropes together to make a longer slingshot. Position the knot near the anchor; the rope going from the knot through the anchor and back down to the climber is the climber's rope. This rope will probably be longer than the climb, resulting in a pile of rope on the ground. Tying into the end of the rope can be problematic because the knot connecting the two ropes eventually will interfere with the belay. Instead, have the climber place two reversed and opposed locking biners through the rope tie-in area. Tie a butterfly or figure-eight-on-a-bight in the climber's rope just off the ground and clip it into the two biners, locking them. As the climber ascends, be careful of the trailing rope so that it does not get snagged on the rock.

Directionals

On some climbs, the rope will tend to get stuck in a crack or around some other natural feature. Add a directional to help keep the rope running free. The directional can be weight-bearing or be set only to keep the rope from getting caught. The directional can be on the climber's rope or the belayer's rope. If it is on the climber's, the climber simply unclips on the way up and re-clips on the way down.

Remember that on a slingshot anchor, the anchor setup is not readily available for inspection. It is out of sight and you won't be able to truly monitor it. For this reason, it is not a good idea to use a dynamic rope as part of a slingshot anchor system. A dynamic rope will stretch under load and return when un-weighted. This causes the components to move across the rock, which is potentially dangerous. In addition to every climber checking the rope-bearing anchors on every trip up the rock, it would be wise to periodically check an anchor system being used all day.



15-01a–A typical slingshot setup
15-01b–In a typical slingshot setup, an angle between the climber's and belayer's ropes helps to keep the rope away from the climber during the ascent. The master point should always contain at least two reveresd and opposed biners. If more are added to stabilize the master point against the cliff, it is generally better to orient them with the spine against the rock.

TOP BELAY ANCHOR SYSTEMS

Top belay anchors are commonly used when the climb is too long for a slingshot. It is also used when: there is too much of a traverse or pendulum for a slingshot; a leader has just finished a pitch; the start is not reachable for the belayer (perhaps a climb on a lakeside cliff that starts in the water); or the climbing team simply doesn't want to take the time to set a slingshot. It is more critical that each climbing team member is proficient, as a guide or leader may not be able to monitor the action of all climbers. The illustrations on the facing page show examples of top belay anchors. A top belay anchor consists of the anchor points, the belayer, and the lines of gear connecting them. The rope extends from the belayer at the top to the climber at the bottom (although there are a few climbs that are pure traverses, which are a horizontal version of the top belay with belayer on one end and climber on the other). Remember: **always use a personal anchor near the edge**.

Anchor System Construction

First, identify the best location for the belay stance, with the belayer either sitting or standing on the cliff edge.

Second, identify at least two solid anchor points from which to hang the anchor system such that the system will hang in the line of action (or at least three anchor points if they are artificial, removable pro).

Third, build at least one line of gear from each anchor point. Join them to provide an anchor point for the belayer in the desired stance, or run at least one line of gear from each anchor point to a central mid-point and run further redundant lines of gear from the central mid-point to the belayer.

Belayer Anchor

The top belay anchor does not need a separate belayer anchor, as the belayer is part of the anchor system. Clip in directly to the anchor system or to a tie-in point somewhere in the system, such as a butterfly. The anchor must allow you to belay with the rope hanging free over the edge. Do not let the rope run over the cliff edge if you can avoid it. If you need to lower the climber due to inability to finish the climb, running the rope over the edge will abrade your rope and risk cutting it under the load.

Set the anchor so that you sit or stand on the edge of the cliff, overlooking the climb (fig. 15-02a). The more directly you are above the climb, the safer the rope. You can put yourself into the anchor to help reduce the impact force on the anchor. To do this, clip in to the end of the anchor you set (typically slings running back to anchor points behind you), then belay the climber from your belay device (fig. 15-02b).

If you decide to stand on the belay ledge, the anchor must be set high enough above and behind you to prevent a falling climber from pulling you to your knees or to a sitting position. This can potentially hurt you and cause you to lose control.

The top belay anchor can create a painful situation for the belayer. Since there is no slingshot to reduce the necessary braking force, the top belayer must hold the entire weight of the climber. If the climber outweighs the belayer, this can be very painful in a fall or when lowering. One way to avoid this is to set a "mini-slingshot" hanging belay instead of one of the normal top belay anchors. Clip in to your personal anchor, extend the climber anchor over the side as you would with a slingshot anchor, put one end of the rope through your belay device, and step over the edge backward to hang off the side of the cliff. This will give you the benefit of the slingshot anchor's reduced force on the belayer. If you are anchoring from artificial, removable pro, set a directional anchor below you to resist upward pull. Although awkward, it will prevent you from accidentally loading the pieces in the wrong direction.

Directional Anchors

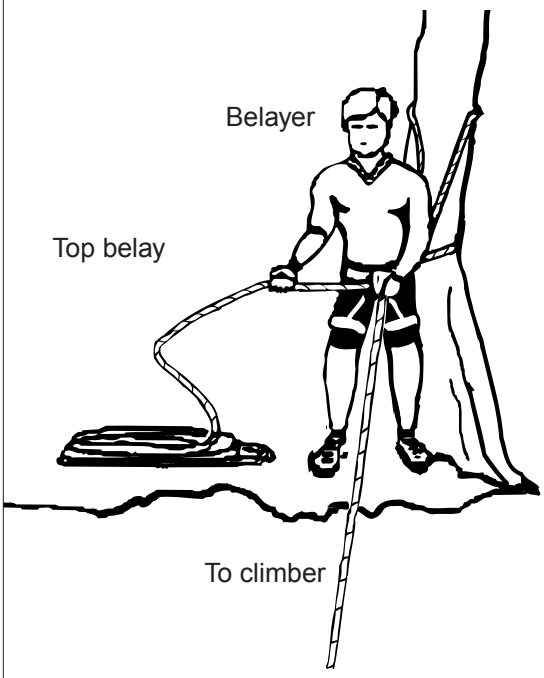
Just as with slingshot anchor systems, the rope may get stuck in a crack or around some other natural feature. Add a directional to help keep the rope running free (fig. 15-02c). The directional can be weight-bearing or be set only to keep the rope from getting caught. Since you don't normally lower a person on a top belay anchor, if there are other climbers waiting to do the same climb, each climber should trail a rope and clip it to the directional after unclipping and passing it on the way up.

Belay

Haul up the excess rope (after the climbing call "Ready") before putting it into your belay device. If there will be more than one person on the climb, tie it off "short" so that you don't have to haul the extra rope every time. If the "short tie-off" is intended to double as a rappel anchor, use an anchor-strength knot such as a figure-8-on-a-bight or a bowline.

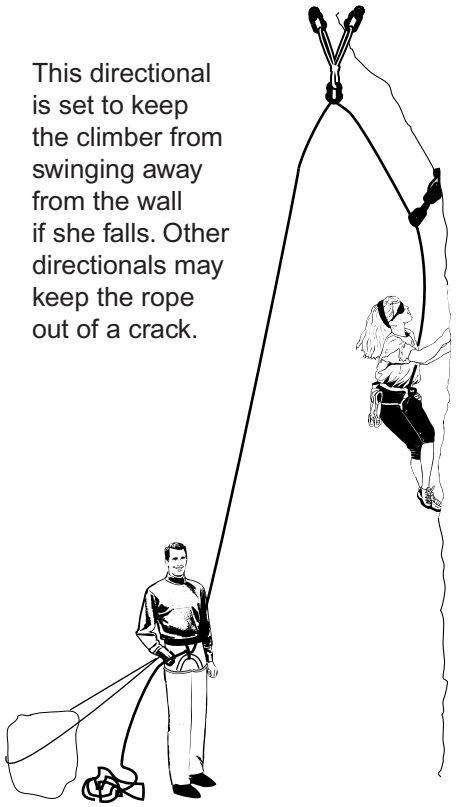
If the top belay anchor system is intended for all day use, set it so that you can convert the top-rope temporarily to a rappel instead of lowering the climber. Lowering a climber from a top belay can be painful to the belayer and damaging to the rope. After the climber anchors into the top belay anchor system and says "off belay," untie the climber's knot and throw the rope back down the route. Rappel down. The climber can convert the rappel back to a belay for the next climber.

15-02a

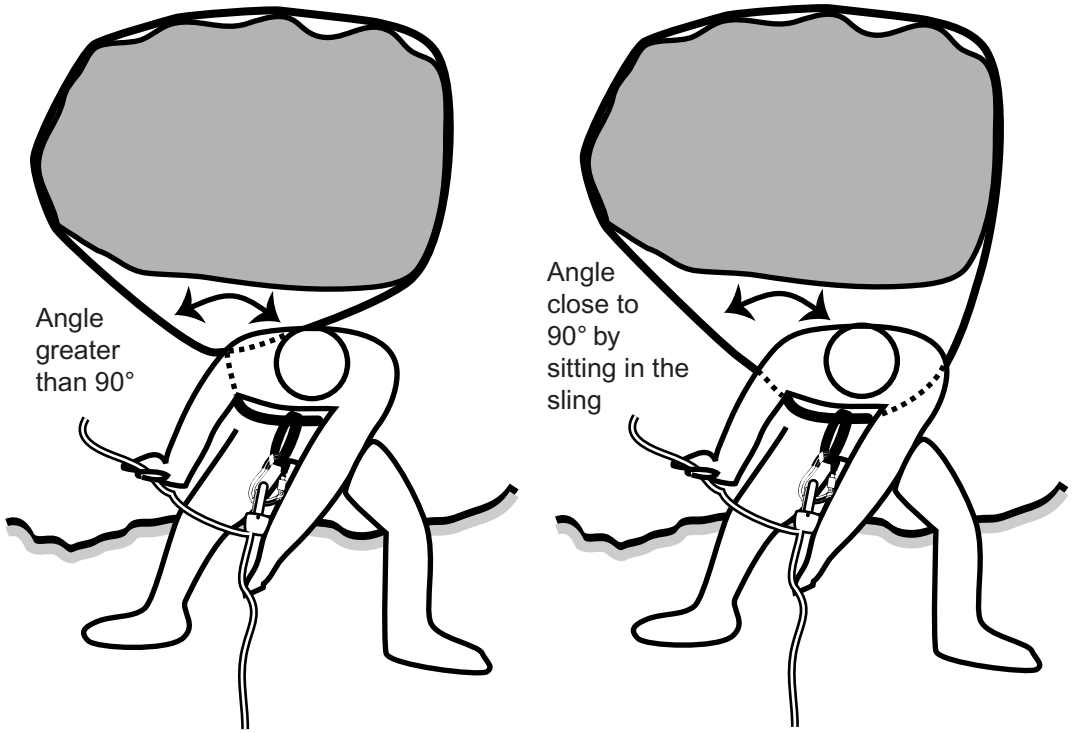


15-02c

This directional is set to keep the climber from swinging away from the wall if she falls. Other directionals may keep the rope out of a crack.



15-02b



RAPPEL ANCHOR SYSTEMS

Rappel anchor systems are set either as an alternative to walking off or as a necessity because there is no walk off, such as from a pinnacle or wall. If the rappel is set as an alternative to walking off, it can be almost identical to a slingshot anchor system. If the rappel is set as the only way down, it must be set so that it can be pulled down after the last rappeller, and should be set with a minimum but safe amount of gear, as the gear cannot be retrieved. A rappel anchor system consists of the anchor points, rope-bearing hardware, and the lines of gear connecting them. Remember: **always use a personal anchor near the edge**.

Anchor System Construction

First, identify the best location for the rope-bearing hardware.

Second, identify at least two solid anchor points from which to hang the system such that the system will hang in the line of action (or at least three if the anchor points are artificial, removable pro).

Third, build at least one line of gear from each anchor point, joining them to secure the rope-bearing hardware in the desired position, or run at least one line of gear from each anchor point to a central mid-point and run further redundant lines of gear from the central mid-point to the rope-bearing hardware.

Rope-Bearing Hardware

There are several types of rope-bearing hardware for rappel anchor systems. In addition to the normal reversed and opposed biners, you can use rappel rings, some bolt hangers, cold shuts, chains, replacement chain links, or quick links. Occasionally, other hardware makes its way into the anchor system.

This hardware is explained thoroughly in the chapter on Anchor Points. However, there are a few points worth mentioning or reiterating here.

Rappel rings are made of aluminum, and if they have been used long enough, the process of pulling the rope each time will start to wear a groove in the aluminum. As long as there is no wear inside the ring, it should be safe to use. We have stretched a rappel ring using a car's hydraulic jack as an experiment, and the ring merely deformed to an oval; it did not break.

Cold shuts are designed for direct threading, subject to the warnings about cold shuts enumerated in the Anchor Points chapter. Chains, replacement chain links, and quick links are also designed so that a rope can be threaded through them, subject to the same cautions, although some replacement links can also contain sharp internal surfaces that can be dangerous. Make sure the rope will pull freely enough through chain links to be retrievable before the last person goes down.

It is also possible to thread the rope through two slings in an emergency. Do not use a "single sling with a twist" arrangement, even backed up properly. The sling will cinch down on the rope and prevent it from being pulled. If slings were left by the previous rappel party, replace them; more than likely, they pulled the rope through the slings and partially "burned" or weakened the slings left in place.

Some bolt hangers are specifically designed to provide a thick enough rope-bearing surface through which the rappel rope can be threaded directly. Do not thread the rope through any other bolt hangers. If you have no choice but to use regular bolt hangers, girth hitch a separate sling through each hanger. Pass the sling through the hanger twice in each case before cinching down on the girth hitch. Make sure the water knots are tight, then thread the rope through the two slings. (Threading the rope through the hangers, even with the padding of a sling, may make it impossible to pull the rope down afterward.) Note that the slings will then be unsafe for rappelling due to being burned from pulling the rope.

The rope-bearing hardware does not necessarily have to hang over the cliff edge for a rappel. The rope will be stationary until it is pulled down. However, the rope should not have too much surface contact with the horizontal rock. This may make it impossible to retrieve the rope due to friction. Also, the knot should be moved over the edge by the last rappeller before descending, as knots generate more friction than the rest of the rope. Another solution is to use the flat overhand knot, which handles edges nicely.

If you use rope-bearing biners, they absolutely must be reversed and opposed. When they are, it is almost impossible for the biner setup to fail during a rappel activity. There must be a minimum of two biners.

Directionals

The only use for directionals in a rappel anchor system is at the top to hold the rappel line stable in the proper position.

Using Existing Rappel Anchor Systems

Many rappel stations will still be rigged from the last use. Never assume that the previous rappellers knew how to set a safe anchor. You must decide whether or not to use the existing materials or to remove and replace them, and whether or not to re-rig the anchor. Check each sling for structural integrity along its entire length. If the sling feels

stiff or brittle, replace it. It has been damaged by too much exposure to the sun and weather. Check white slings very carefully; it may be a bleached out colored sling. Try looking inside the knot to see if there is still some color. Bleaching is a sign the sling has been out in the sun too long, but if the sling is still supple, it may still be safe. If you are not absolutely certain that the slings are okay, remove at least two and replace them from your own supply.

Check the knots to be sure they are properly tied and dressed. If the previous rappellers did not equalize the system, re-tie the slings to do so. Evaluate the anchor system the way you would an anchor system you and your climbing team would build today and make adjustments as necessary.

Check the hardware. Make sure quick links are closed, and verify that there are no sharp edges where the rope will run.

BELAYER ANCHORS

The belayer anchor is discussed above in the various sections describing the different types of anchor systems. Those descriptions deal with the criteria you consider when deciding whether or not to place a belayer anchor. This section deals with how to place the anchor. Keep in mind that the belayer in a top belay anchor system is part of the anchor; this section deals with a belayer anchor for a slingshot or lead situation.

We normally set a less complex anchor "system" for the belayer than for the climb itself. Typically, it consists of a single sling around a rock or tree or connected to a strategically placed piece, shortened to a comfortable length for the belayer. The reason we don't build as much redundancy in the belayer anchor is that we are mainly protecting against the belayer losing control or the belayer being pulled into an injurious situation. Remember, the force needed to catch a fall, even a leader fall, is far less than the force the climber feels, due to the coefficient of friction in the top piece of protection (the anchor system in a top-rope belay).

A falling climber simply can't lift the belayer up very far, even when the belayer is significantly outweighed and it is a lead fall. However, the bigger the difference in weight between the two (with the climber the heavier one), the more force the belayer will feel, and the more likely he/she is to lose control and increase the length of the climber's fall. This is the real danger. It is not incorrect to build a more substantial anchor for the lighter belayer if either of you feel it is necessary, unless it locks the belayer down too much and he/she can't adjust to move out of the way of rockfall.