Comparison of Cave Gate Materials

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Abstract

Many types of steel have been used over the years in building cave gates, including ¾" and 1" rebar; 1" mangalloy hardened steel bars; 3"x4" rectangular tubular bars; 2", 3", and 4" angle iron bars; and stainless steel tubular and angle iron bars There are pros and cons to each type. We compare and discuss each material, focusing on cost, weight, availability, ease of use, and most importantly, strength and cross-sectional restriction of flight space. The horizontal 4" angle iron bars (with stiffeners) long been recommended by the American Cave Conservation Association and Bat Conservation International have clear advantages to the alternatives. Designs using these materials have become the default "industry standard" for bat gates, and are widely accepted by the U. S. Fish and Wildlife Service, the National Park Service, the U. S. Forest Service, the Bureau of Land Management, The Nature Conservancy, The National Speleological Society, and other major cave management entities.

What Are We Trying to Protect?

Cave gates are designed to protect the contents of the cave (Kennedy 2006). If the gate is weak and people can get in the cave, then it is not doing a good job of protection. Likewise, if the gate modifies the natural processes of the cave by altering airflow and changing the internal microclimate, impeding the flow of water and nutrients into the cave, or restricting the movement of animals into or out of the cave, then it may be detrimental despite the good intentions behind its installation. A good gate must be both secure and biologically transparent (Currie 2002, Elliott 2006, Nieland 2004, Tuttle 1977).

CHARACTERISTICS OF A GOOD GATE

- Strong and Secure
- Environmentally friendly
- Long lasting
- Relatively easy and inexpensive to build
- Rescue/Research friendly
- Protects ALL cave resources

What is a Bat Gate, and Why Should We Use It?

"Bat Gates" are gates that are bat-friendly, meaning that they allow for free flight of bats through the gate (Powers 1985, 1993). They typically consist largely of horizontal bars, with few, widely-spaced, vertical bars (Dalton 2004). Because bats do not negotiate closely-spaced vertical elements very well, but can easily fly through horizontal elements, the spacing and placement of vertical supports must be carefully considered. The larger the resident bat colony and the higher the level of activity (such as at a maternity cave, where there are daily emergences), the more important this requirement becomes (Powers 1996). Horizontal bars should be spaced 5 ¾" from the top of one bar to the bottom of the bar above it. This requirement may be slightly modified with closer bar spacing at the bottom only on gates placed in high traffic areas where small children or pets may be tempted to squeeze through the bar openings. But the top ⅔ of any gate area should always provide maximum flight space.

Grid-type gates, including cable netting, should never be used for openings with even moderate bat traffic. They are recommended mainly for vertical openings necessary to maintain airflow into complex systems with few (if any) emerging bats, such as large, multi-level abandoned mines (Kretzmann 2004a).

Bat gates also should NEVER be built in passage restrictions, or areas with tight turns. In addition to being a possible detriment to bats, gates built in constricted areas have a much greater chance of altering airflow and microclimate. If the entrance is vertical, especially if it is a small opening, then the gate needs to be raised above the surface to give bats adequate flight space and allow predator avoidance. Cupola-style gates are recommended in this situation (Kretzmann 2004b). The bottom line is that you need to know something about the current and historic use of bats at the cave before designing the gate.

Even if the cave is not a "bat cave" and never has been, bat gates are still the preferred closure method to protect other cave resources present (Olson 2004). The only exception may be if the cave was dug into and it is important to maintain air-lock conditions to isolate surface fauna from the cave, prevent drying, or microbial contamination of a pristine environment. Gates are also impractical for extremely large vertical openings, which can only be protected by fencing.

There are many other aspects of bat gate design and construction that are beyond the scope of this paper. For difficult entrances and non-standard situations, please feel free to contact Bat Conservation International for advice.

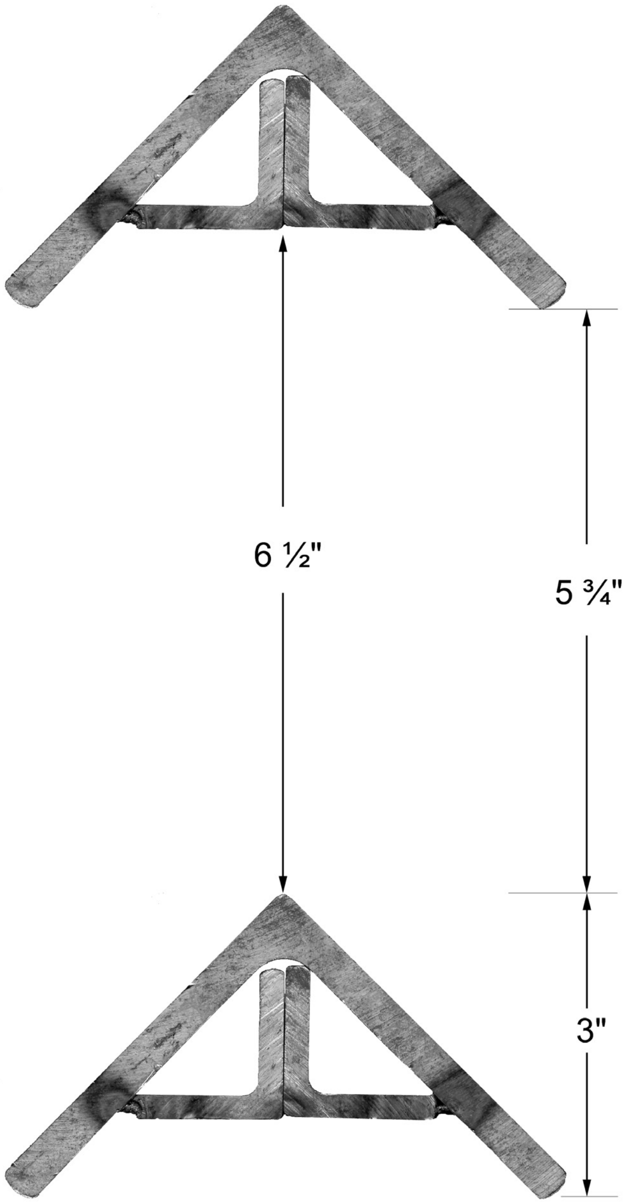

Figure 1. Angle-iron bars, even with the standard 5!" spacing between bars, provides maximum flight space for bats due to the recessed stiffeners.

Material Types

Material selection for bat gates usually is based on several factors: strength, weight, cost, and availability. Occasionally there are special conditions, such as corrosive environments or aesthetics, which require special materials such as stainless steel. But those situations are rare, and so-called "mild" (as opposed to hardened or tempered) steel is the best choice in the vast majority of cases.

There are many types of materials currently used for cave and mine gates. These include round bar (ranging from ¾" rebar to 1" hardened mangalloy); pipe; 2–4" angle iron, with and without stiffeners; and rectangular tubing ranging from 2"x4", 3"x4", 3"x3", and so on. Each material has pros and cons, but certain shapes (especially round bars and pipe) are inherently weak and easily bent. Some (like rectangular tubing) take up more potential flight space. Others may be difficult to obtain locally, have a higher per-unit weight (an important consideration when materials must be airlifted to the site), or may not be manufactured domestically (mangalloy). Odd materials, such as I-beams and others, may be components of large gates, but should never be considered a primary material for gate construction.

Rebar and Other Similar Solid Mild Steel Round Bar Stock

Rebar, short for concrete reinforcing bar, is readily available and very inexpensive. At the time of this writing, the market price for 1" (#8) rebar was approximately $3.81 per foot. It is lightweight (2.67 pounds per foot), but notoriously weak, being composed of low-grade metals and designed to be imbedded in concrete. By itself, it is easily bent, or cut with a common hacksaw, making it very vandal-prone when used as a gating material. The lack of strength necessitates forming the rebar into a grid-like pattern for gate construction, which may be suitable for sites with only a handful of bats, but very detrimental to larger colonies due to the large number of vertical supports required. Finally, the curved surface of the material makes for very small and weak welds when attached to the curved surface of other rebar pieces.

Pipe and Other Hollow Round Stock

Many budget gate builders turn to surplus steel in gate construction, including steel pipe. Pipe has all the disadvantages of rebar and other solid round mild steel stock. It can easily be bent and cut, and is difficult to make strong welds on the round surfaces. To offset the weakness, some builders insert loose rolling bars inside the pipe, such as rebar, before welding in place. Others fill the tubes with concrete, but the time and difficulty offset any cost savings.

Rectangular and Square Tubing

Rectangular tubing comes in a wide variety of dimensions and thicknesses, making it one of the most versatile materials available for cave and mine gating. It is strong, and its flat sides allow for long, strong welds. Some gate builders have even inserted other materials (such as loose rebar, or even concrete) into the hollow center of the tubes to hinder vandals who attempt to cut through the bars. It is slightly heavier on a per-piece basis than a similar-sized piece of angle iron (10.51 pounds per foot for 3"x4"x¼" rectangular steel tubing) and more expensive ($11.77 per foot)(source: metalsdepot.com). It works particularly well for small openings with low risk of vandalism (Vittetoe 2004). The chief drawback is that it restricts available flight space more than any other material, even angle iron with stiffeners.

Angle Iron with Stiffeners

Angle iron is also readily available in a variety of dimensions and thicknesses. By itself, it is relatively weak, but can be made extremely strong with two pieces of smaller angle iron welded inside the apex, as stiffeners. However,

Figure 2. Rebar gate on gray bat maternity cave. Note closely spaced vertical supports. This cave was abandoned by the bats shortly after the gate was installed. It has since been replaced witha more bat-friendly design. Photo by Bill Elliott.

this does increase the amount of materials, weight, overall project cost, and construction time. For comparison (see 3″x4″x¼″ tubing above), 4″x4″x⅜″ angle iron weighs 9.80 pounds per foot and costs $8.92 per foot (source: metalsdepot.com). With two 1½″x1½″x¼″ angle-iron stiffeners inside, the total weight increases to 14.48 pounds per foot and the cost increases to $12.96 per foot. The primary benefits, however, are increased flight space between bars (even at the same 5¾″ spacing), sloping surfaces that are less disruptive of airflow, stronger overall bar strength (more important for wide gates), and more material mass which increases difficulty of cutting by vandals (Powers 2004). Small diameter rebar can also be inserted inside the stiffeners to provide an additional barrier to cutting.

Figure 3. Rectangular tube steel gate on an abandoned mine in Arizona. Photo by Jerry Fant.

Hard Facing

All standard steel materials can all

Figure 4. Constructing an angle-iron bat gate, with stiffeners. Photo © Jim Kennedy, BCI.

have hard facing added, which is a special, high-manganese welding rod that provides a cut-resistant layer to the bars. Unfortunately for cave gate builders, the easy availability of demolition saws and cutting torches from equipment rental companies means that no cave gate is truly vandal proof.

Mangalloy

Mangalloy is a specialty steel that has a high manganese content, much like the hard-facing welding rods. Manganal® is one common brand. It is most commonly used in jail bars, tool tips (such as the edges of bulldozer blades), and mine rails. It is extremely wear-resistant, and is much harder to cut or grind. It comes in solid round, solid square (up to 2”), and angle (up to 2”) stock. It is more expensive than any other material type previously mentioned, usually about 3 times the cost of similar-sized angle iron or rectangular tubing, and it doesn’t come in large sizes. Weight is similar to mild steel. It requires special welding rods for construction, but can still be cut with a torch. It is no longer made in the USA (due to the toxic nature of the manufacturing process), which may be a concern for projects involving federal funding. Because of its smaller overall dimensions, it can still be easily bent, requiring more closely spaced (and less bat friendly) vertical supports. Gates made with this material can also more difficult to repair by non-specialists, due to the welding rods required (Werker 2004).

Stainless Steel

Stainless (high chromium) steel is used in areas with corrosive environments, such as certain bedrocks, or mines with acid drainage. Its strength and weight are comparable to regular steel. It is occasionally used in areas where aesthetics are a major concern. It comes in many sizes and shapes, but is extremely expensive ($39.20 per foot for 4”x4”x⅜” angle stock). It also requires special welding rods for construction and repairs, and is difficult to fabricate in the field (Werker 2004).

Other Gate Materials and Options Not Covered in This Paper

There are many other materials and gate designs in use that are not covered by this paper, but which may be perfectly acceptable in certain situations. These include the new concrete and steel hybrid gates that are used where vandals repeatedly steal ordinary gates to sell for scrap metal, lattice gates and grates (including cable net closures), and hybrid lattice and bar combination gates. Cave and mine gate designs continually evolve, so it is best to have current training or work with a highly experienced and knowledgeable expert when tackling a new project (Kennedy 2004). For more information on these materials and designs, or assistance in gating projects, contact Bat Conservation International.

Summary

While cave and mine gates have been built with a wide range of materials in the past, some clearly are superior for strength, weight, availability, ease of working, cost, and environmental friendliness. Our recommendations are primarily for 4"x4"x⅜" mild steel angle iron with two 1½"x1½"x¼" mild steel angle-iron stiffeners welded inside. For narrow openings (such as found at many abandoned mines) and less vandal-prone sites, 3"x4" rectangular tubing may be an acceptable substitute, especially if cost is a factor. We strongly discourage the use of pipe, rebar or other round stock, and feel that specialty steels such as mangalloy and stainless steel should only be used in very specific circumstances.

Figure 5. Mangalloy cave gate in Utah. Note how bars have been bent to illegally gain access, necessitating temporary repairs. Photos © Jim Kennedy, BCI.

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