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An Earth Anchor System: Installation and Design Guide

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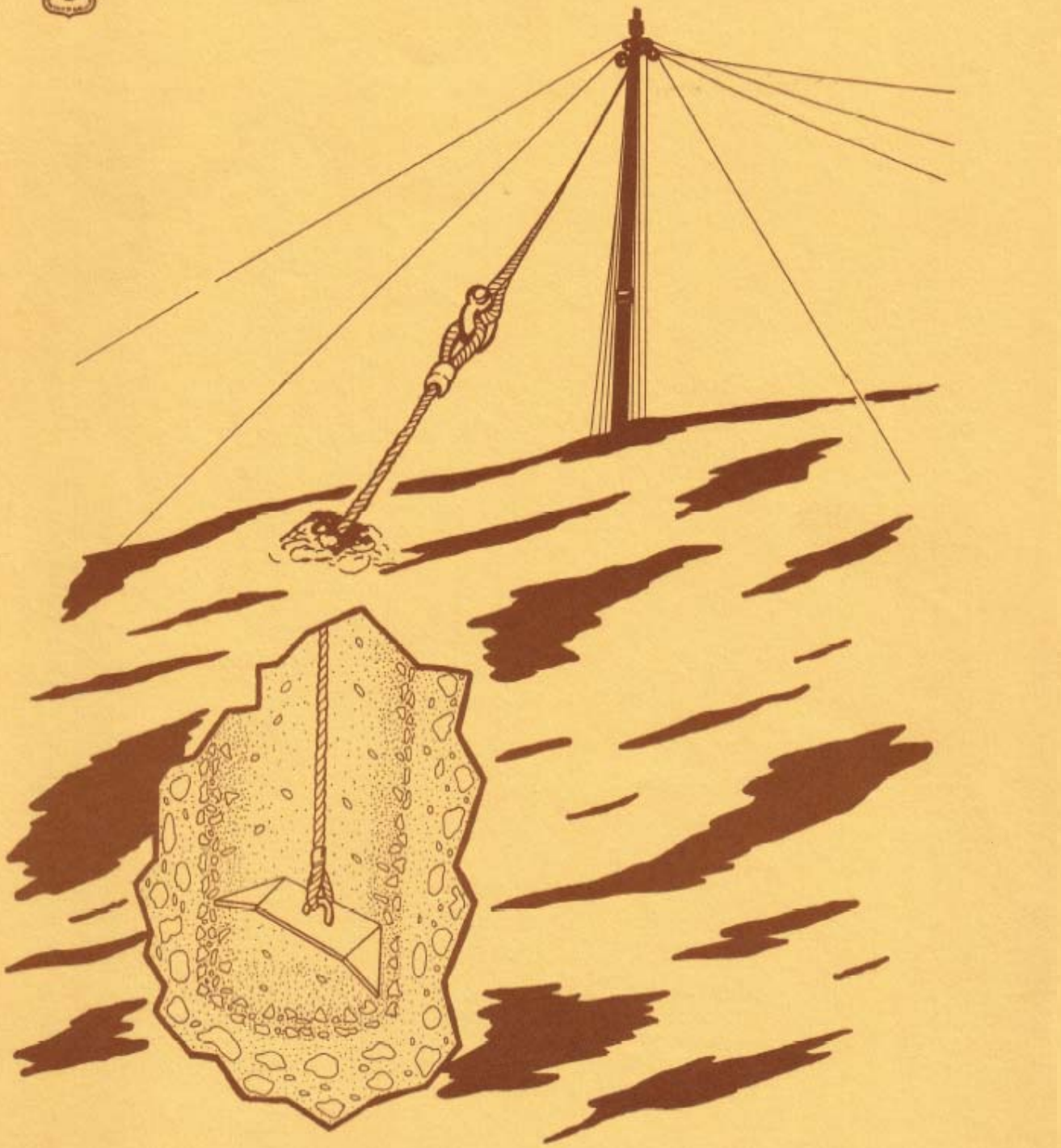

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Abstract

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A system for anchoring the guylines and skylines of cable yarding equipment is presented. A description of three types of tipping plate anchors is given. Descriptions of the installation equipment and methods specific to each type are given. Procedures for determining the correct number of anchors to install are included, as are guidelines for installing the anchors so that they will reliably withstand the forces imposed on them in this application. Charts for determining the number of anchors to install and bridle together are included. Information presented is based on field tests conducted under various of conditions in California, Oregon, and Washington.

Keywords: Logging, anchors, cable yarding, machine anchors, soft earth anchoring.

Preface

As commercial forests evolve to a more intensively managed resource with younger, smaller diameter trees, new methods and technologies such as the anchoring system described here will be required if we are to sustain or enhance productivity and meet silvicultural and environmental goals.

This guide is one of many outcomes of an effort by the Forest Service to find alternatives to stumps for anchoring harvesting machinery. A video tape presentation is also available. Additionally, the Agency has staged numerous demonstrations and worked with industry safety and trade organizations, private companies, and independent contractors and consultants to stimulate development of feasible anchoring alternatives.

Much of this material was originally written as notes distributed during a training workshop on the use of earth anchors held in November 1988 at the Forest Service Technology Development Center in San Dimas, CA. This version supercedes much of the material distributed at that workshop.

Finally, the information here resulted from collaboration of the authors with Briar Cook, program leader, and Bob Simonson, civil engineer, at the San Dimas Center. Inquiries regarding further development of the technology should be directed to them at:

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Introduction

Skyline logging systems require anchors for tying down tower guylines and securing a skyline at the tailhold. Stumps have been the most convenient, cheapest, and therefore the most widely used anchor. In many areas, sound stumps of adequate size and proper location relative to the landing are becoming scarce. Older, large stumps and their root systems become rotten and their holding capacity is difficult to predict. Quite often, new stumps are smaller than needed for anchoring skyline machinery. .

The USDA Forest Service has completed research and development of anchors that could be used as substitutes for stumps. The objective of this research was to develop an inexpensive and portable anchoring system that could be used in rough terrain. One anchoring system meeting these criteria is the tipping-plate anchor (fig. 1). This document describes the tipping-plate anchors, the installation equipment, and the procedures for designing and installing anchorages made from bridled tipping-plate anchors. Results of pull-to-failure tests for a few specific conditions are included in appendix 2.

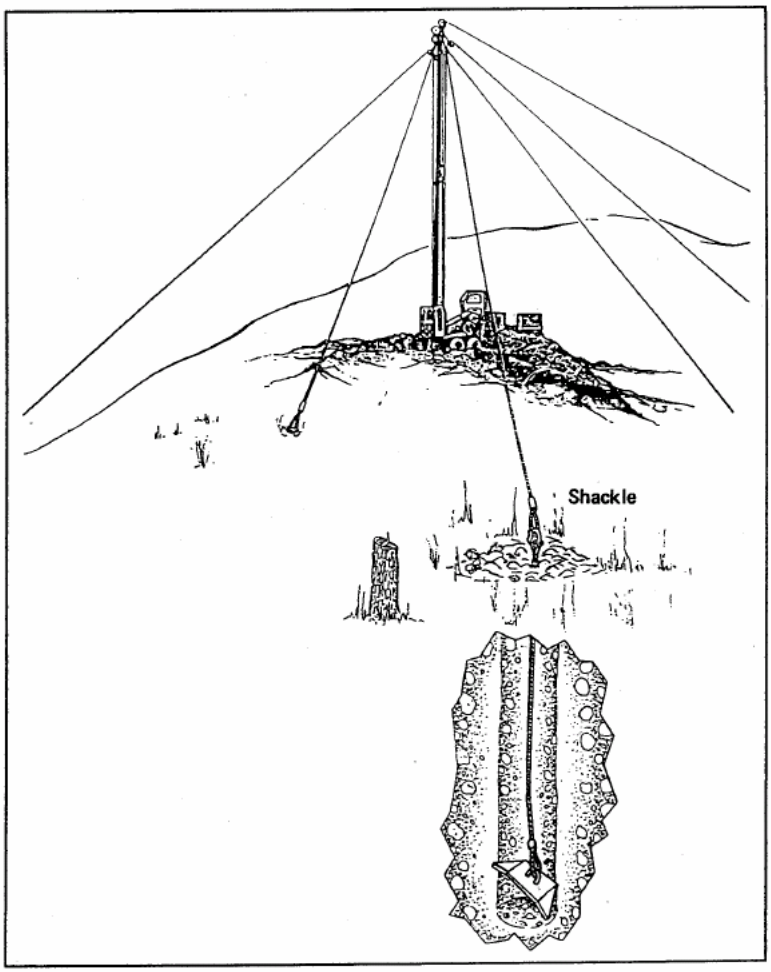

Figure 1—Guyline attached to a tipping-plate anchor.

Holding capacities of these anchors differ greatly with the soil conditions and generally are low enough so that two or more anchois must be bridled to provide a safe anchorage for a guyline or tailhold. Rigging and bridling procedures are important and are described, as are two design procedures for determining the number of anchors required to be bridled together to withstand the load. Both procedures require the installation of single tipping-plate anchors and pulling them to failure or to some predetermined load. Extrapolation of test data from one site to another is not recommended unless a thorough investigation of the soils is made at both sites to determine if they have the same engineering properties.

Tipping-Plate Anchors

Two anchors that we tested were the arrowhead anchor (Laconia Malleable Iron Company) and the Manta Ray anchor (Foresight Products, Inc.).[1] A third, the soil toggle anchor, was designed and fabricated by the Forest Service and is now being produced by Foresight Products, Inc.

Arrowhead Anchor

This anchor is shaped like an arrowhead and is cast with ductile iron. Two holes through the anchor allow attachment of, wire rope (fig. 2). The wire rope assembly may be single or double depending on the anchor size. The diameters of available wire rope are 1/8, 3/16, 1/4 and 5/16 inch. The anchor size is specified by the width as measured across the top at the broadest point. Arrowhead anchor sizes, bearing areas, weights, and cable diameters are shown in table 1.

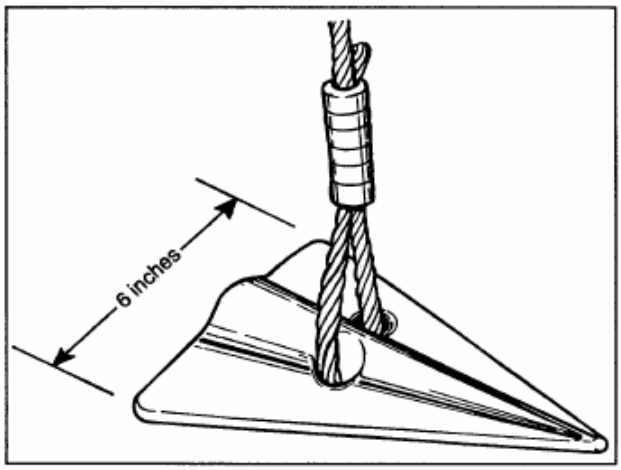

Figure 2—Arrowhead anchor.

[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

Table 1—Physical characteristics of Laconia Arrowhead anchors made from malleable iron

Size	Bearing area	Weight	Cable diameter
Inches	*Square inches*	*Pounds*	*Inch*
2	2	0.16	1/8
3	4.5	.39	1/8
4	8	.91	3/16
6	18	2.2	3/16
8	32	3.7	1/4
10	50	9.0	5/16
12	72	12.0	5/16

Manta Ray Anchor

The Manta Ray anchors are 7 inches wide and 12 inches long, are made of mild steel, and weigh 12 pounds (fig. 3). A wire rope 3/4 or 5/8 inch in diameter is permanently attached to the anchor with a pressed eye; the free end of the wire rope has a pressed eye with thimble.

Soil Toggle Anchor

Two sizes of soil toggle anchors are available (fig. 4). The smaller of the two is designed for 5/8 or 3/4 inch in diameter wire rope and the larger is designed for a 7/8 or 1 inch in diameter wire rope.

Installation Equipment

Impact Hammers

Three types of impact hammers can be used for driving Arrowhead and Manta Ray anchors: hydraulic, pneumatic, and gasoline. Hydraulic hammers require a power unit that can deliver a flow of 8 gallons per minute at a pressure of 2000 pounds per square inch. Construction equipment such as hydraulic backhoes, excavators, and yarders used for logging have hydraulic systems meeting these requirements. Unless the equipment can travel over steep and uneven terrain, however, anchor installations will be confined to a 200-foot radius from where the power unit is parked. A portable hydraulic power unit that can be carried into remote areas has been developed that meets the requirements for providing power to impact hammers. Pneumatic hammers require an air supply of at least 100 cubic feet per minute.

The hammers needed to drive anchors weigh between 60 and 90 pounds. The lighter weight hammer is used to drive the anchor in loose soils or when an augered pilot hole is used. A 90-pound hammer may be needed in dense or rocky soils if a pilot hole is not used. Some pnuematic hammers can drill holes with a rock bit and blow out the cuttings.

Gasoline-powered hammers, such as the Swedish-made Pionjar, require no external power supply and are portable. They weigh about 60 pounds and exert an impact force as well as a rotational force on the drive rod. A new model has been developed that devotes all its power to driving only; it may be able to install Arrowhead and Manta Ray anchors faster than previous models could.

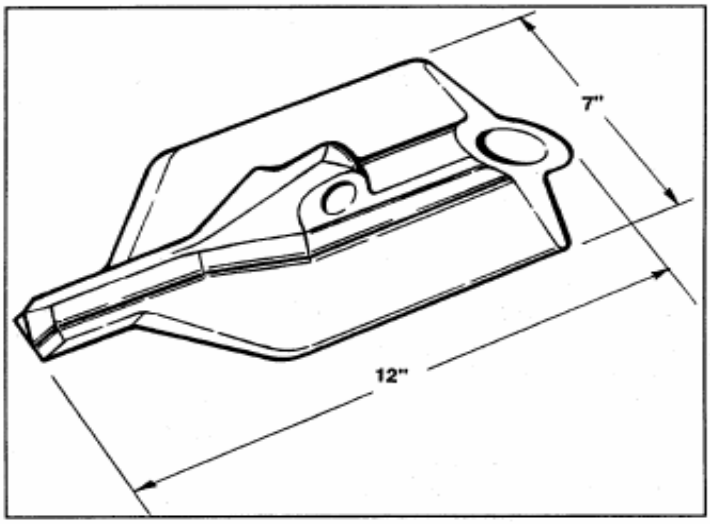

Figure 3—Manta Ray anchor.

Drive Rods

Drive rods (sometimes called drive gads) transmit the reciprocating force from the impact hammer to the anchor and must be customized to fit the anchor. Most hydraulic and pneumatic hammers require a rod 1.125 or 1.25 inches in diameter. Some smaller hammers and the gasoline hammers use a rod 0.875 inch in diameter. The end of the rod that is inserted into the anchor needs to be machined for a tight clearance. If the clearance is too small, however, the anchor may become seized on the rod during installation. The rod should also be machined so that the end of the rod does not touch the bottom of the socket in the anchor.

Drive rods can be obtained in 2.5-, 4.0-, and 5.5-foot lengths. The rods used for driving Manta Ray anchors are designed so that sections may be coupled together; rods for other anchors are a fixed length. A disadvantage of using fixed-length rods is that the depth an anchor is driven to is limited by the length of the rods. Also, if a 5.5-foot rod is used to start the driving operation, the operator will be required to hold the hammer about 6 feet above the ground. This may require standing on something to gain the proper working elevation. If the rods are shorter and additional sections can be added as the anchor is driven, the operator is usually working with the hammer below shoulder height, which is easier and safer.

Augering Equipment

Many gasoline- and hydraulic-powered portable augers can auger holes 4 to 8 inches in diameter. Auger extension flights can be obtained in several lengths and diameters to suit various conditions. Carbide tips are recommended for most forest soils. Manufacturer's specifications on installation equipment are given in appendix 3.

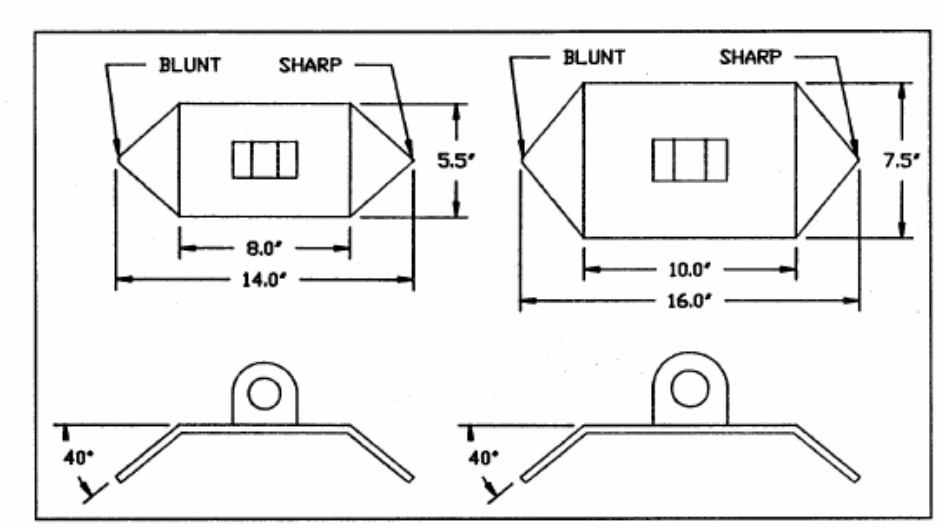

Figure 4—Small and large soil toggle anchors.

Installation Procedures

Anchors

The installation procedures differ with the type of soil and anchor. For small anchors (such as a 2-inch Arrowhead) in soft soils, the anchor is driven into the ground with a drive rod and a sledge hammer or with a driving device similar to that used for steel fenceposts. The drive rod is inserted into the hole at the top of the anchor; the anchor is positioned so that the cable faces the direction of pull and is driven at the desired angle until it cannot be driven further or the desired depth is reached—which should not be less than 36 inches. The rod is then removed, and the anchor is "set" or "keyed" so that the major plane of the anchor will be about 90 degrees to the angle of pull. This is done by pulling the anchor until the anchor strap has been pulled 8 to 12 inches out of the ground.

For the larger Arrowheads (6-inch size or larger) and Manta Rays, a hydraulic, pneumatic, or gasoline-driven impact hammer is needed to install the anchor. The installation procedure is the same as for the drive rod and sledge hammer, except that the hammer is placed on the drive rod before the rod is inserted into the anchor.

In denser soils, such as dense clays, a pilot hole can be augered before the anchor is driven. With a Manta Ray anchor, for example, a 4-inch pilot hole is augered at least 6 inches deeper than the design depth. This leaves an area at the bottom of the hole for loose soil to accumulate in. After the hole is augered, the anchor is driven by using the pilot hole as a guide. Because the Manta Ray anchor is 7 inches wide, 3 inches of its width is driven through the undisturbed soil. Once the anchor is at the desired depth, the rod is pulled out and the hole is filled with soil and tamped. The anchor must be set as described above.