ISSN 0111-4743

LOGGING INDUSTRY RESEARCH ASSOCIATION
NEW ZEALAND

TECHNICAL RELEASE

Vol. 11 No. 3 1989

# PROGRESS WITH TIPPING PLATE EARTH ANCHORS

A Report by Dallas C. Hemphill, Consultant Logging Engineer, Eugene, Oregon, U.S.A.

*ABSTRACT*

*Earth anchors have been successfully tested by the U.S. Forest Service in volcanic soils to anchor a guyline on a 34m tower and as a tailhold for a 35mm skyline. Both the Manta Ray and soil toggle tipping plate anchors are now regarded as practical tools in many soil types, and timber sales will now be laid out based on their use.*

*The new soil toggle type can have a holding capacity of 45,000kg in suitable soils. In volcanic ash soils with low shear strength, they have been tested to 27,700kg, when installed at depths of 4 to 5m. With this type of anchor, failure occurs very slowly.*

*Installation techniques have been refined in recent months and the cost of installation may be comparable to that for a conventional deadman.*

*Pilot operational testing may now be considered for New Zealand. Continued monitoring of American developments is recommended.*

## ACKNOWLEDGEMENTS

*The assistance of Forest Service Equipment Development Engineer, Bob Simonson, in reviewing this paper is acknowledged.*

## INTRODUCTION

American loggers are beginning to look toward earth anchors as substitutes for stumps that are conventionally used as guyline anchors and tailholds, as logging takes place near forest fringes next to alpine clearings or old cutovers. One solution is the tipping plate anchor, with the results of operational testing being reported by Hemphill (1988).

The tipping plate anchor technology has been further developed, and applied operationally to anchoring a skyline and a guyline on a 34m tower. The Manta Ray type, previously used to anchor guylines on a 15m tower, was used to anchor a guyline on the 34m tower. A new development, the soil toggle anchor, was used to anchor the 35mm skyline used with the same tower.

## TEST APPLICATION

The Manta Ray and soil toggle types were applied on a slackline operation on the Gifford Pinchot National Forest in Washington State. They were used with a Skagit BU94 tower with a 34m tube operated by contractor, Ben A. Thomas Inc., logging downhill in old growth timber.

The landing was sited on a mudflow that had resulted from a past eruption of Mt. St. Helens (Figure 1). It consisted of silty sand with some gravel fragments - a low shear-strength soil not regarded as a favourable anchoring site.

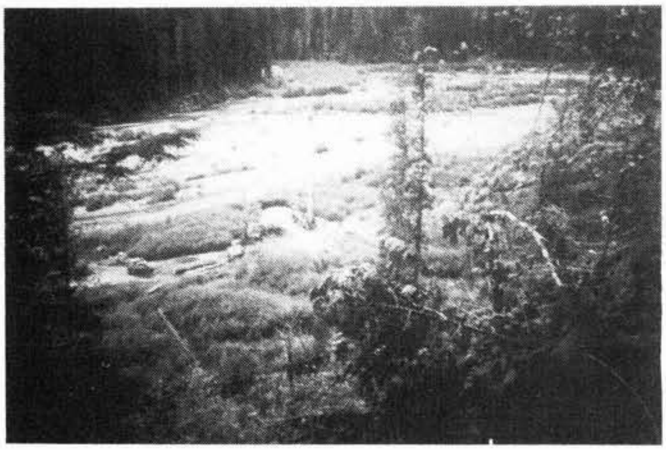

*Figure 1 - Manta Ray tipping plate anchors were used to anchor one guyline on this landing.*

A cluster of six Manta Rays was used to anchor the left squarelead guyline (Figure 2). The other seven guylines on the machine were anchored conventionally to stumps, deadmen, and guyline Cats. The Manta Rays were driven to a depth of 3m. No pilot hole was augered because the presence of rocks in the soil made this impractical. Installation in this situation next to a road took 1-1/2 hours in total.

Each Manta Ray was connected to a 16mm line with a breaking strength

*Figure 2- Cluster of six Manta Rays used as a guyline anchor on 34m tower.*

of 18,600kg. A Manta Ray had been proof tested in the same soil type nearby to 20,400kg.

The tailhold was a cluster of four soil toggle anchors installed at a depth of 4.5m on a ridgetop. A fire many years previously had swept the ridgetop clear of any large old growth trees that would normally have provided tailholds. The soils at this site were described by the U.S. Forest Service as being ".. of tephra origin.. (that are) .. classified silty sand (SMu) and contain volcanic ash, pumice, and rock fragments. They are nonplastic, and have a very low shear resistance."

## SOIL TOGGLE ANCHOR

### Design

The soil toggle (Figures 3 and 4) was fabricated by the U.S. Forest Service from 14mm steel. It is 190mm wide and 356mm long. The manufacturer of the Manta Ray,

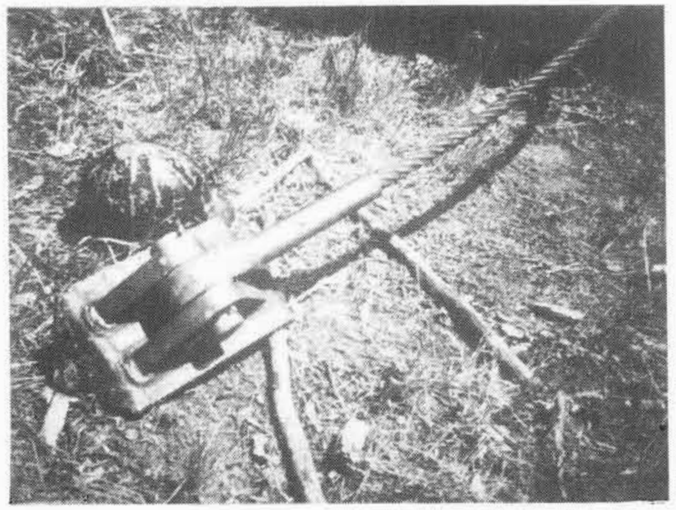

*Figure 3 - Soil toggle fabricated by U.S. Forest Service.*

Foresight Products, will eventually market the soil toggle as a casting although it is welding the product to fill orders now being received.

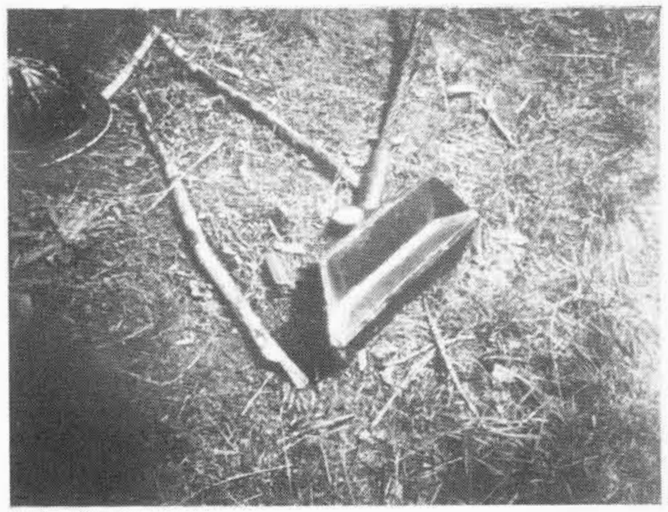

*Figure 4 - Soil toggle*

The soil toggle has the same method of operation as the Manta Ray. In suitable soils, it has a holding capacity of 45,000kg.

### Installation

The soil toggle is inserted in an augered hole, the hole stemmed, and the line on the anchor tensioned to tip or "key" it into operating position with a 20 to 30cm pull. Unlike the installation of the Manta Ray, the soil toggle is not hammered into position.

*Figure 5 - A 20cm hole is drilled with the Little Beaver auger.*

A larger 20cm hole is drilled with an auger (Figure 5). The Little Beaver auger now being used by the Forest Service is an 8kW hydraulic model. It is sled-mounted for ease of movement using a power saw winch (Figure 6). On the sled, it has a total weight of 136kg, but is attached with quick disconnects for easy dismantling and reassembly at the job site. The hydraulic unit and the engine can then each be moved by one man. This unit is still under development.

*Figure 6 - The Little Beaver auger is sled-mounted for mobility, using a powersaw winch.*



To auger a 2m hole takes 1-1/2 to 2 minutes; a 4-1/2m hole, 20 to 25 minutes. While one man can auger the hole, two are required to lift the auger out.

The soil toggle is simply lowered into the hole (Figure 7), not hammered in, thus eliminating the need for a portable hammer as previously described for installing the Manta Rays. Compacting the upper layers of stemming is regarded as good practice. This may help the toggle to key more quickly, and reduce saturation of the soil by rain water.

*Figure 7 - Lowering a soil toggle into the hole.*

### Rigging

For the test, four soil toggles were installed as a tailhold. Two were installed about 5m behind the others, to maintain as small a horizontal angle between them as possible.

Each toggle was attached by chain to approximately 15m of 25mm line. The chain and hook arrangement gave the ability to pick up slack (Figure 8). The four tieback lines were shackled to the end of the skyline (Figure 9), without an equaliser block. The lines were roughly equalised first with the chains. After the toggles were keyed, the lengths equalised themselves by differential movement of the toggles in the ground. Whichever toggle was subjected to the greatest pull would move through the soil until it reached a point where the other three shared the load with it.

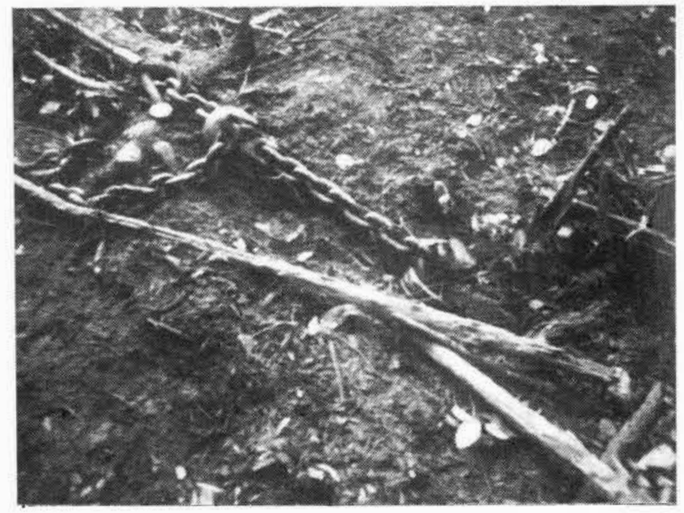

*Figure 8 - The chain and hook attached to the soil toggle can be used to equalise the lines in a cluster.*

Opinions are divided about whether this is a better method than using an equaliser block. Without a block, rigging is simpler. Furthermore, if one anchor should fail when using an equaliser block, the anchor at the other end of that line also becomes useless. On the other hand, it was observed that without the block, the four lines did not in fact fully equalise; two lines took most of the load, with the other two being relatively slack all of the time.

On the test site, the skyline was rigged in a tail tree with the point of attachment to the soil toggles behind. There was consequently no significant lateral tension on the cluster of toggles.

### Strength

The objective has been to design earth anchors to have at least the same pullout resistance as the breaking strength of the line that each is attached to.

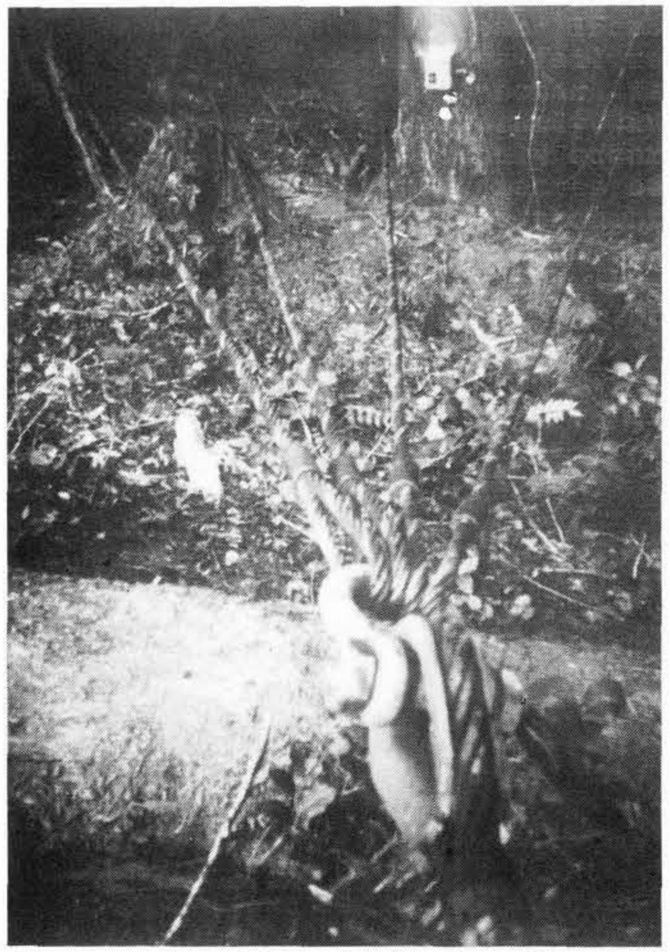

*Figure 9 - Four tiebacks attached to a cluster of four soil toggles to anchor a 35mm skyline.*

The toggles in the test tailhold had been keyed at 13,600kg, but had not been tested to failure. Tests in similar soil had been conducted on soil toggles installed at a depth of 4 to 5m nearby with a near-horizontal pull. At the maximum load exerted by the testing equipment, 27,700kg per anchor, some anchors failed while others did not. At a depth of 2.5 to 3m, however, they had failed at a lesser tension.

The total movement in 2 days' use of the tailhold had been 15cm. This was of no concern, as failure with this type of anchor is extremely slow (particularly in weak soils), and would only occur after a couple or more metres of movement. The movement is thought to have been primarily through the attachment lines cutting into the ground, and not through movement of the toggles themselves.

Tensions up to 39,000kg had been recorded in the skyline on this setup. It is believed that substantially higher tensions occurred while the recording instrument was not connected. Some large logs, over 2m diameter, were logged using the soil toggle anchor.

The hook tender (crew boss) for the contractor stated that he felt comfortable with the soil toggles as tailholds, and that he was willing to use them in locations not readily accessible for installing conventional artificial anchors.

## Cost

For a two-man crew to install a tipping plate cluster, including move-in to the site, takes about one day.

The main cost of installing soil toggles is moving the equipment to the site. To rent the necessary equipment and move it into the site costs about US$350. After that, the materials and installation cost run around US$250 per toggle. This may be cheaper than installing a deadman. It is comparable to the cost of installing a cluster of Manta Rays, as more of them are required at a materials and installation cost of US$150 per anchor.

Substantially less disturbance to the forest cover at the anchoring site is necessary with the earth anchors, compared to a deadman.

## POTENTIAL FOR NEW ZEALAND

The U.S. Forest Service is now beginning to regard earth anchor technology as operational, and it has instructed its logging engineers to incorporate earth anchors in timber sale layout where necessary.

Pilot operational testing may now be considered for New Zealand, initially on dense, cohesive soils with the greatest probability of



success, with 15m towers. The tools required for installation are stock items, as are certain models of anchor. Foresight Industries is now taking orders for the soil toggle.

While the soil toggle has been proven in ash-pumice soils, it has not been tested in, and may not be practical in, sandy non-cohesive pumice soils such as are found in much of the central North Island. However, pumice soils with a substantial ash, silt, or clay content may be regarded as suitable, and most hill country soils outside the Volcanic Plateau would also be sufficiently cohesive to permit the use of earth anchors.

The soil toggle is not believed to be suitable for organic soils (e.g. Pakihi) or rocky soils.

An application that is not yet proven is that of a tailhold where no tailtree is used. Where the North Bend or other skyline system is used to "bridle" or "sideblock" laterally, the constant off-line pulls could tend to move the anchors first on one side of the cluster, then the other, possibly resulting in eventual failure. With the expense of installing a tipping plate tailhold, the logger will naturally want to reach as far as possible between tailholds, meaning extensive sideblocking.

Where the skyline is rigged in a tail tree, this is not a problem. However, given the absence of stumps in the tailhold zone where earth anchors would be used, there may instead be the problem of guying the trail tree adequately.

Continued monitoring of American experiences and developments with earth anchors is strongly recommended.

## REFERENCE

Hemphill, D.C. (1988) : "Substitute Earth Anchors - Tipping Plate Type", LIRA Technical Release, Vol.10 No. 4.

---

*This Technical Release is the work of the author and is not the result of LIRA project work. LIRA publishes it in the interests of wider dissemination of knowledge in the industry. LIRA takes no responsibility for the accuracy of figures nor does it necessarily support or disagree with the opinions and conclusions shown.*

---

*For further information, contact:*
N.Z. LOGGING INDUSTRY RESEARCH ASSOC. INC.
P.O. Box 147,
ROTORUA, NEW ZEALAND.
Fax: (073) 462-886 Telephone (073) 487-168