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SUBSTITUTE EARTH ANCHORS – TIPPING PLATE TYPE

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ABSTRACT

Tipping plate anchors are considered to be the most successful type of substitute earth anchor tested for cable logging by the U.S. Forest Service. Portable installation equipment can make them more attractive than other artificial anchoring systems, particularly where access for machinery is limited.

Operational tests carried out on the Willamette National Forest in Oregon showed that a battery of six Manta Ray type tipping plate anchors per guyline had ample strength to support a mobile hauler with a 15 m tower. It is thought that four or five anchors would have been sufficient.

There is a need to further improve the portability of installation equipment so that this type of anchor can be more readily used as a skyline tailhold. It is recommended that the New Zealand industry monitor developments in the U.S. until full operational implementation has been achieved.

INTRODUCTION

Cable logging is feasible only when adequate anchors for guylines, skylines and running lines are available. Normally, these are stumps but where adequately-sized and rooted stumps are not available, the logger has to find alternatives.

A log buried in the ground, commonly called a deadman anchor, is one option but these can be expensive and are limited to areas where there is ready machine access for installation.

A bulldozer or other heavy machine is sometimes used as an anchor and this gives an advantage of mobility in a tailhold application, but it is expensive and may be limited by ground conditions or environmental constraints.

The logging layout could be changed in order to locate the guyline circle and the tailhold zone within standing timber but this may then mean a sub-optimal layout, e.g. logging across slope or in a blind lead.

A smaller tower with fewer guylines could be selected and various rigging modifications may be used to adapt to a scarcity of tailhold stumps, but these can be expensive to rig, and it may be necessary to select a rigging system that is otherwise sub-optimal for production, thus increasing costs.

Anchoring problems are increasing in the western United States, particularly where logging takes place near forest fringes next to alpine clearings, swamps or old cutovers. The latter type of problem is common also in New Zealand, because of the rapid decay of radiata pine stumps and the frequent presence of an immature plantation in the desired anchoring zone.

In recent years, U.S. Forest Service research engineers have tested a wide variety of substitute earth anchors. The most successful, practical type has been found to be the tipping plate anchor, described below. Implementation has reached the point of operational demonstrations of tipping plates applied as guyline anchors on 50-foot (15 m) towers. Thirty test pullouts to failure have been conducted.

TIPPING PLATE ANCHORS

Description

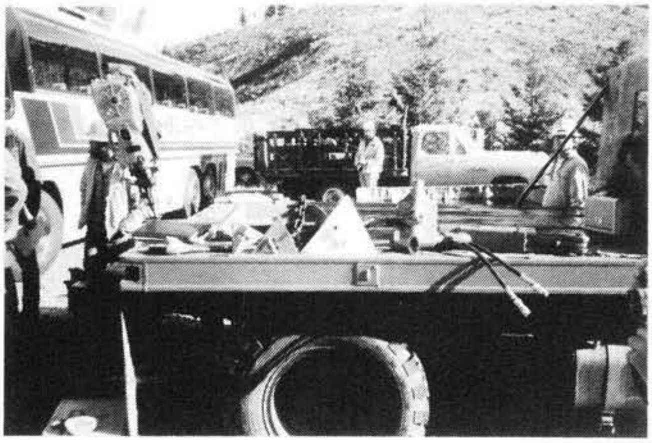

Figure 1 - Arrowhead tipping plate anchors in centre of photo; manta ray type to right and a hydraulic hammer used for installation

The tipping plate anchor consists of a small plate that is driven into the ground with a pneumatic hammer. The line to be anchored to it is attached by means of a chain before installation and an upward pull on the line causes the plate to tip sideways. The pull is then resisted by a cone of soil above the plate.

Figures 1 and 2 show the two types of tipping plate anchor found most successful for logging. Both are driven into the ground with a steel rod inserted into a hole in one end of the plate. They have been adapted from designs used on a large scale by power and telephone companies for guying poles and pylons.

Figure 2 - Manta ray type tipping plate anchor (foreground)

The arrowhead type has been less successful than the manta ray type because of reported casting failures, and it has a smaller surface area than the comparable manta ray type. The manta ray type is presently made of bronze aluminium (required for conductivity by the power industry) but for logging use it would be made of mild steel. Foresight Products, manufacturer of the manta ray type, is keenly interested in perfecting its product for logging.

The cost per anchor is $US50, including cable and chain.

Anchor Installation

An advantage of the tipping plate anchor is that it can be installed with portable equipment. The procedure is to make a 10 cm hole with a portable auger, then drive the tipping plate in with a steel rod. The steed rod is driven by a pneumatic, petrol or hydraulic hammer, and is withdrawn after the anchor is in place (Figure 3).

Figure 3 - Petrol-powered hammer used to drive plate into the ground. The chain will be connected to a guyline.

The U.S. Forest Service has found that augering a hole first (Figure 4) aids appreciably in installation, without significantly diminishing holding capacity. Furthermore, the hole serves the purpose of a test bore. If rock if found near the surface, then a fresh location can be selected for a new hole. On the other hand, if a plate is driven in first and shallow rock is encountered, the plate must then normally be abandoned.

Figure 4 - Augering a hole for plate placement. The tripod behind is for test purposes only and is not used for anchor installation

The Little Beaver auger and wheeled 7 h.p. (5 kW) power plant shown in Figure 4 can be transported by two people in most terrain. The cost is $US1,200.

The Forest Service has so far buried all of its tipping plates to a 1.5 m depth. It has been suggested that a substantial increase in pull-out resistance would be obtained by going to 2.1 m for a modest increase in installation time.

Steel rods of 29 mm diameter, milled to 22 mm at one end to fit the plate, are used for driving the plates in. It has been found advantageous to use two 75 cm rod sections rather than a single 1.5 m rod.

The Forest Service has successfully used three different tools for driving plates :

- A petrol-powered Pionjar drill (Figure 3)
- A Stanley 30 kg hydraulic hammer (Figure 5) powered by a portable power plant (Figure 6)
- A pneumatic 32 kg hammer connected to a 2.83 m^3/min compressor.

Figure 5 - Hydraulic hammer to install plate

Figure 6 - Portable hydraulic system used to power hammer in Figure 5. It is transported in two parts with a total weight of 73 kg.

The plate is driven into the hole, with the attached chain kept out so a line can be connected to it. Once the plate is in place, the hole is stemmed and lightly tamped to help the plate set quickly once a pull is applied.

The time for anchor installation, excluding the time to get the tools and material to the site, was observed to be about 2 minutes for drilling the hole, and 4 to 9 minutes to install the plate. This was done by two men, on easy terrain.

Some plates might be recovered with a tractor or backhoe, although it would be wise to regard them as expendable.

Rigging

A recent demonstration installation on the Willamette National Forest in Oregon consisted of six tipping plate anchors each on the two centre guys of a Madill 071 (Figure 7). This was done to tie the machine down to a previously-logged hillside without sound stumps. The two outside guys were anchored conventionally to stumps. The soil was a clayey silty sand. One to two feet of silty sand overlaid pyroclastic lapilli tuff. Many hill soils in New Zealand would have comparable characteristics.

Figure 7 - Madill 071 tied down to stumps on the outside guys, and substitute anchors on the two inside guys. Each inside guy is anchored by a cluster of 6 tipping plate anchors (foreground).

The guylines were 28 mm diameter with a breaking strength rated at 51,500 kg. Each guyline was connected to the six tipping plate anchors by means of 16 mm wire ropes (Figure 8). The anchors were installed in a V-pattern, and 16 mm lines were cut to approximate lengths for rigging. They were shortened with a come-along to equalize the lengths under load, and fastened to the eye in the strap connected to the anchor with line clamps. It has been suggested that some kind of ratchet-and-chain shortening arrangement would be much more efficient.

With line clamps, a moderately experienced crew of two or three can reportedly install a six-anchor tiedown in 1½ hours.

Figure 8 - Lengths of 16 mm line connect the tipping plates to the guyline

Strength

In a test environment, tipping plates installed in soil have withstood pulls up to 90,000 kg. The specific models of tipping plate demonstrated with the Madill 071 have been tested to failure at 4,000 kg to 18,000 kg. The lower values were recorded in tests on an area that had previously been used for burning piled slash. Pull-out resistance values in normal cutover sites were mostly over 9,000 kg. A group of six anchors would then have a combined pull-out resistance in excess of 54,000 kg. It is now felt that four or five anchors per guyline would have been adequate, instead of the six used.

No tipping plate anchors are known to have failed in an operational logging application. There is one instance of a skyline parting where tipping plate anchors held. Guyline tensions in excess of the safe working load of the guyline have been recorded on the Willamette demonstration anchors.

When failure occurs in a test situation, a cone of earth some 2 m in diameter is slowly lifted out of the ground. Sudden failure does not occur with this type of anchor. Soil deformation is approximately linear up to failure.

There is no operational experience yet in sandy soils comparable to pumice or decomposed granite. Tests in a gravelly sand river bottom have shown pull-out resistances of 2,7000 kg - 6,800 kg.

So far tipping plates have not been tested with 27 m towers. A demonstration is scheduled for 1988, however, with plans to install tipping plate anchors to a depth of 4 m in 25 cm holes as anchors for a 27 m tower. A pull-out resistance of 48,000 kg has been projected for these anchors.

Relationships between pull-out resistance and soil classification are not yet fully developed, although this is a topic of ongoing research. It is clear however that the soils most suitable for deadman installation - dense, cohesive soils - will also be the most suitable for tipping plate anchor installation.

Figure 9 - Line clamps were used on this demonstration. Possibilities exist for less time consuming methods of attachment.

POTENTIAL FOR NEW ZEALAND

Where there is a mixture of age classes within a forest, an economic method of anchoring without stumps would permit more efficient logging in many cases. The logger could then select equipment sized to the logs rather than to the stumps, and a layout and rigging configuration for maximum production rather than being limited by the anchoring facilities.

While other methods of anchoring without stumps exist, as noted above, they are generally costly. Tipping plate anchors would be cheaper in many cases, and feasible in many situations where conventional solutions are not.

Tipping plates have not yet been adopted by the forest industry in the U.S. This is because the concept is still new to logging, and no areas have been laid out with this type of anchor in mind. There is also an attitude that conventional solutions to anchoring problems already exist - possibly without a proper appreciation of the real cost involved.

The contract logger who staged the Willamette National Forest demonstration, Mr Closen Christian, feels that substitute earth anchors have a definite future. He sees the greatest potential of the tipping plate anchor at the tailhold end, since conventional solutions are generally workable if stumps are lacking at the landing. He sees the need for a reliable substitute tailhold to limit the risk to the expensive radio controlled skyline carriages increasingly used by American loggers. He likes the tipping plate for its predictability of pull-out resistance compared to a stump. However he considers there is a definite need to improve the portability of the installation equipment for practical application on difficult sites. He regards the present rigging procedures as excessively costly.

For the smaller 15 m towers, the tipping plate can be regarded as a proven concept. However operational testing is confined to a limited range of situations so far. In particular, for non-cohesive soils such as pumice and decomposed granite, the concept cannot be regarded as proven yet and operational rigging procedures need refinement.

It is strongly recommended that the New Zealand logging industry closely monitor substitute earth anchor developments in the U.S. Operational implementation, which appears to be a year or two away yet in the U.S., should not yet be considered in New Zealand. Initial tests should be in soil types similar to American soils where tipping plates have been successful. There may well be potential for New Zealand loggers to improve on present American installation procedures by adapting local hill-country agricultural power tools. It is still too early to say how applicable the method would be in pumice soils. In more suitable soils, the prospects for operational implementation appear good.

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