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SUBSTITUTE ANCHORS FOR EARTH, ROCK AND ROCKY SOILS - AN UPDATE

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ABSTRACT

Various substitute anchors for hauler lines have been developed for conditions where suitable tree stumps are not available. Tipping plate anchors for soils are now being used to some degree in the United States. In limited New Zealand testing on relatively weak soils these anchors have not shown much promise. Anchors developed in the United States for rock and rocky soils resist relatively large loads and may have potential in some situations in New Zealand.

INTRODUCTION

As the amount of cable logging of new crop radiata pine in New Zealand increases, so will the number of situations where available stumps are inadequate as guyline anchors and tailholds. Buried deadman anchors perform well in many of these cases, but alternatives are needed where access for a digger is not available or where soil is too shallow for excavation.

Two previous LIRA Technical Releases described work in the United States with three versions of tipping plate earth anchors: arrowheads, Manta Rays (Model MR1) and soil toggles (Hemphill, 1988, 1989). Arrowheads have little holding capacity and therefore have not been used with haulers. Approximately 250 of the MR1 and 50 soil toggle anchors have been used on actual hauler operations, most of them in the Pacific Northwest (Figure 1). Only one has failed: a soil toggle anchoring a guyline and installed to 2m depth, pulled loose resulting in the overturn of a Madill 071 hauler working in Virginia. A court case is still in progress, so no conclusions about the failure have been released.

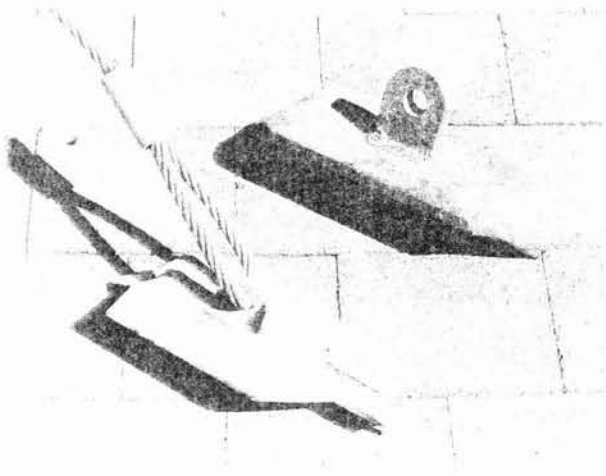

Figure 1 - Manta Ray MR1 and soil toggle anchors

NEW ZEALAND TESTS

During 1989/90, LIRA tested the holding capacities of tipping plate anchors on several New Zealand forests (Duggan, 1990). On average, the anchors held less than in tests in the United States. Two or more anchors would be required to equal the breaking strength of even a small guyline (e.g. 19mm rope has a breaking strength of 23 tonnes) on the sites where they were tested by LIRA (Figure 2). A larger Manta Ray (Model MRSR) should provide higher capacities in weak soils. Prices in New Zealand are, for MRSR: $250, for MR1: $110, for MR2 : $93.

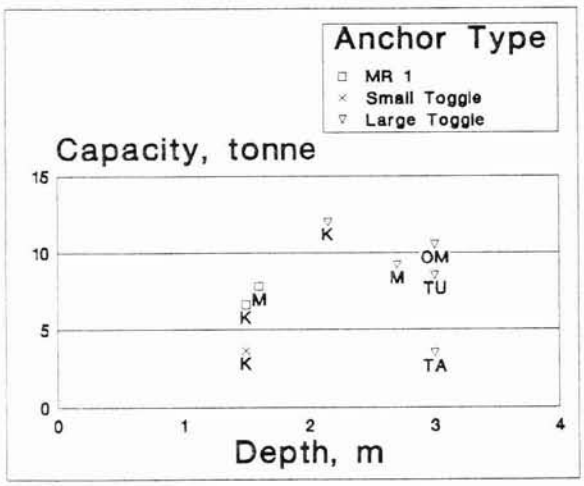

Figure 2 - Pullout results for anchors tested - Kinleith pumice soil (K), Mangatu wet silt (M), Omataroa pumice (OM), Tairua wet clay (TA), and Tuatapere clay with iron pan (TU)

ROCK ANCHORS

Recent work in the United States has focused on two areas; grouted anchors for rock (Schroeder and Swanston, 1992) and tipping anchors for rocky soils (Hartsough, et al. 1992a,b). Epoxy-grouted anchors were tested in two types of poor quality bedrock in Alaska. The rocks, phyllite schist and a harder diorite gniess, were substantially weathered and fractured. The anchors use commercially available threaded steel bar; a typical bar of 42 mm diameter has a yield strength of over 50 tonnes. To install an anchor, a hole of the smallest diameter that will accept the bar is drilled in the rock, then the bar and grout are inserted according to the grout manufacturer's directions. After the grout sets, a connector such as a D-ring and nut or threaded eyebolt is screwed on to the top of the threaded bar, as close as possible to the ground surface (Figure 3).

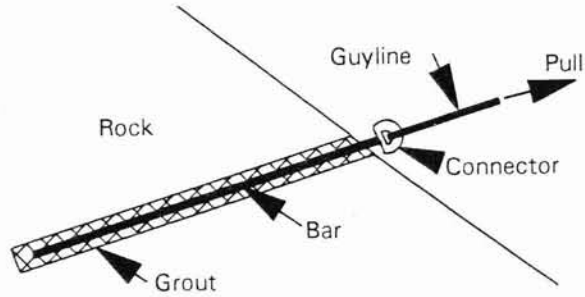

Figure 3 - Schematic of grouted rock anchor and attachment to line

Tests showed that the pull capacity depended mainly on rock strength and on the bond length (length of bar grouted into rock). Capacities of 35 to 70 tonnes were obtained with anchors embedded to depths of more than 2m (Figure 4). During the tests, all pulls were along the axis of the anchors, and this is the recommended orientation because it prevents bending of the bar. If the anchor were to be pulled off-axis a larger bar would be needed.

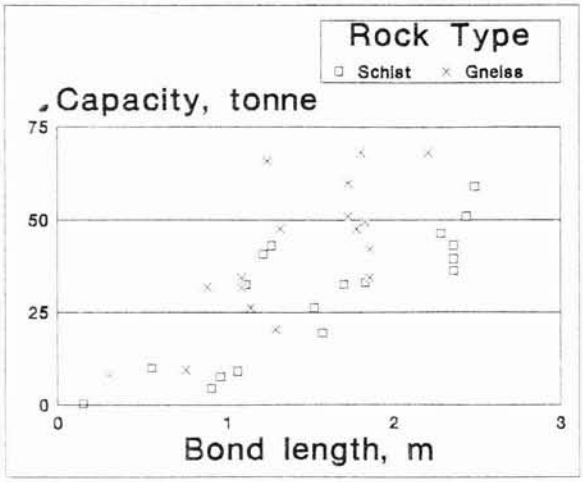

Figure 4 - Pullout capacities for grouted rock anchors tested in Alaska

ROCKY SOIL ANCHORS

Modified tipping plates, including small Manta Rays (Model MR2) and stronger cylindrical anchors designed by Visser (1992) at University of California at Davis were tested in the rocky soils (Figure 5). The anchors were successfully installed in weathered vertically bedded shale, in a gravelly-clay loam underlaid by volcanic greenstone, and in a soil consisting of a high percentage (approximately half by volume) of 5cm to 20cm round-angular rock fragments in a silty matrix. For successful installation to depths of 2 to 3m, a 75mm pilot hole of about the same cross-section as the anchor (90mm for the MR2 and 75mm for the cylindrical anchor) was drilled, then the anchor was driven into the hole.

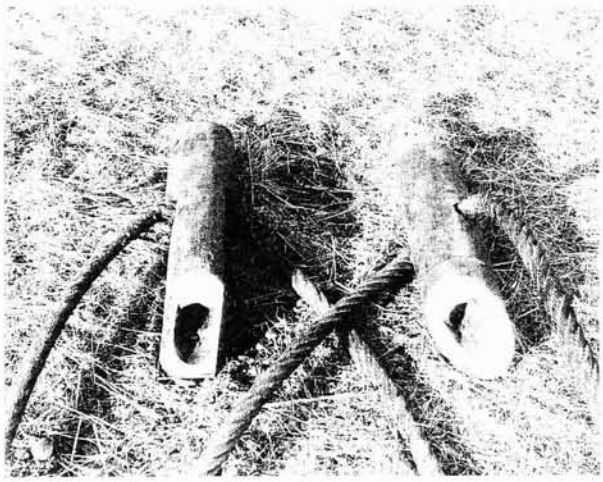

Figure 5 - Cylindrical anchors for rocky soils

Three sizes of rotary percussion drills were tested: a 25kg jackhammer drill powered by a 3.5m^3/min compressor, a 35kg feedleg drill mounted on a small support frame and driven by a 5m^3/min unit (Figure 6) and a crawler drill (Figure 7). Table 1 shows the daily costs and estimated times needed to install an anchor to a depth of 2.5 m. The times include drilling, driving and set-up, assuming the equipment is already at roadside within 50m of the anchor location.

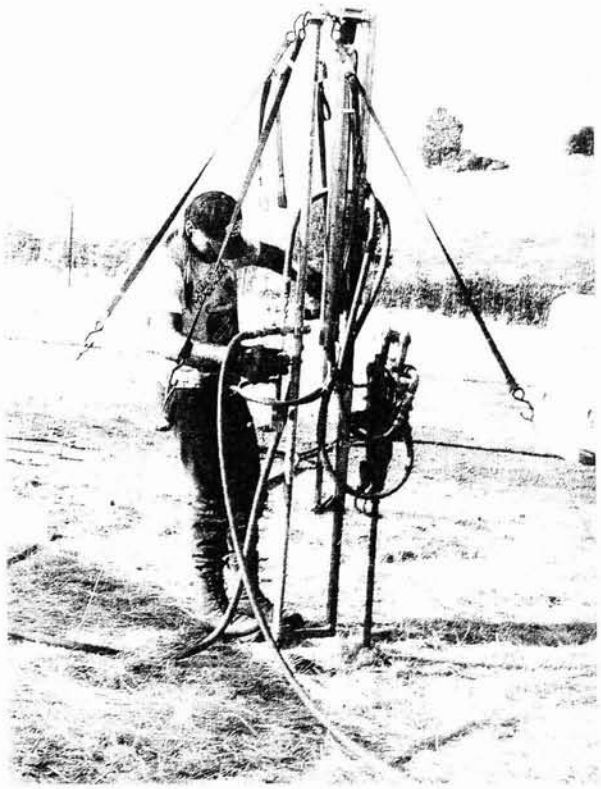

Figure 6 - 35kg drill and frame

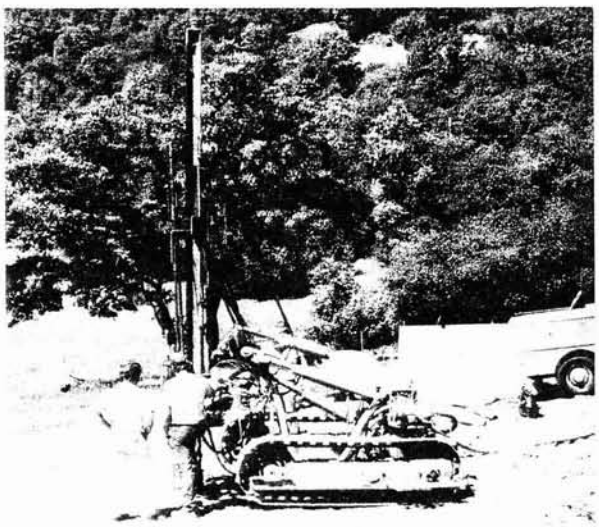

Figure 7 - Crawler drill

The cost and time data should be viewed in the context of the trials. During the tests with the hand-held jackhammer, an experienced driller ran the equipment. The work was exhausting and the chances of sticking the 75mm bit were high even for

Table 1 - Daily equipment costs and times to install an anchor to 2.5m depth

Equipment	Hire Cost ($/day)	Installation Time (minutes)
25kg jackhammer drill	180	60
35kg drill and frame	NA	70
Self-contained crawler drill	1400*	15

* 5 operating hours @ $200/hr and 4 transport hours @ $100/hr

the knowledgeable driller. Some holes could not be drilled to the desired depth. Using the 35kg rig, an inexperienced crew of two consistently installed anchors to 2.5m depths. Physical effort was much less than with the jackhammer.

Hand-held jackhammers and crawler drills are available for hire in New Zealand. The 35kg drill and frame was purpose-built for the anchor tests. Either the jackhammer or the 35kg rig can be hand-carried to an anchor location but must be within 50m of the compressor which usually must remain on the road. Self-contained crawler drills can travel off road on slopes up to 35%.

Maximum loads during field tests of MR2 and cylindrical anchors driven to depths of 2.5 m or more have been in the 20 to 40 tonne range (Figures 8 and 9).

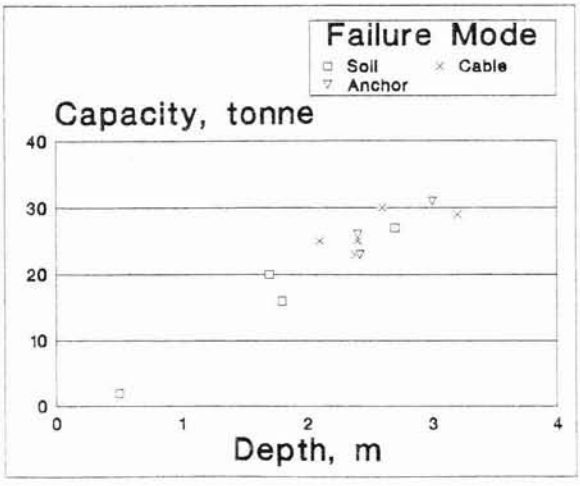

Figure 8 - Capacities for MR2 anchors tested in California and Oregon

For the MR2 anchors, either the anchor body or cable failed in most of the pull tests. The cylindrical anchors were designed to resist higher loads and the field results show that either the soil or cable was the weak link. The cylindrical anchors can be machined from 75mm cold drawn mild steel round stock.

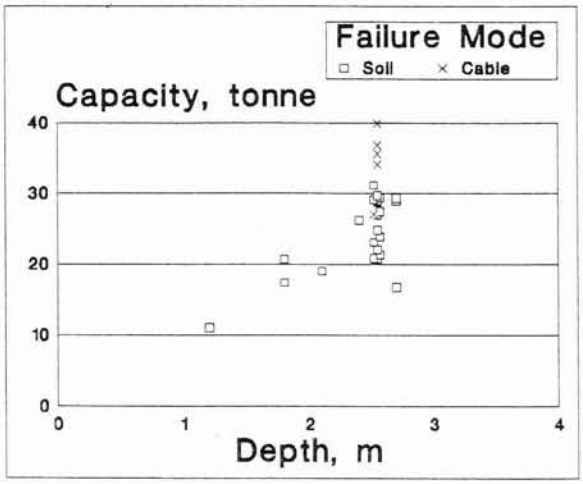

Figure 9 - Capacities for cylindrical anchors tested in California

CONCLUSIONS

Manta Rays and soil toggles have been successfully used in U.S. cable operations. New Zealand tests of these options suggested that multiple anchors would be required in the weaker local soils tested.

More recent U.S. work on anchors for rock has shown that grouted bars inserted 2m or more had capacities of 35 to 70 tonnes - adequate for most guylines. In rocky soils, small Manta Ray and cylindrical anchors inserted 2.5m or more in drilled holes had holding capacities of 20 to 40 tonnes.

At locations accessible by excavator where soils are not rocky, buried log deadmen anchors are likely to be the cheapest alternatives to stumps. For inaccessible or rocky sites however, substitute anchors may be feasible options.

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LIRO NOTE :

For further information on Manta Ray anchors, contact Pendleton Corporation Limited, P.O. Box 30-249, Lower Hutt.

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