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Tractor Mobile Anchoring Methods

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Figure 1 - Tractor mobile anchor

Summary

Tractors are commonly used as mobile anchors in hauler operations. They are used to anchor skylines, tailropes, and to a lesser extent, load-bearing guylines.

Load-bearing ropes can be attached to tractors by a range of methods. However, some of these methods are inadequate, resulting in hazardous situations.

This report provides an overview of the effects of tractor size, ground slope, spar height, use of the blade, attachment methods, and configuration on tractor stability. In addition, a list of points to consider when securing and shifting a tractor anchor is presented.

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Introduction

A mobile tailhold anchor is usually an old logging tractor or excavator. Tractors are more commonly used in New Zealand because of their availability, relatively low cost and ease of operation. Although the addition of a tractor increases the daily cost of a cable operation, it is often offset by increased productivity through faster line shifts. More importantly, when of adequate size, and positioned and rigged correctly, tractors are a strong and reliable anchor. However, if best practices are not adhered to, the anchor will be less reliable, and may expose the harvesting crew to unnecessary hazards.

Tractor size

The weight of a tractor, and the ground conditions upon which it is situated have a significant effect on the anchorage capacity of a tractor. Even a very large tractor parked on flat dry ground would not withstand the forces imposed from medium to large hauler line-loads.

The coefficient of traction, between the tractor tracks and the ground, depends on the condition of the ground surface. Coefficients of traction in a range of soil conditions are given in Table 1. The anchorage capacity of a tractor can be estimated using the following:

Anchorage Capacity (flat ground; line pull parallel to the ground)
= tractor weight (tonnes; t) x coefficient of traction

The resulting Anchorage Capacity does not incorporate any factor of safety.

Ground condition (flat ground)	Coefficient of traction
Dry unpaved road	0.90
Dry ground	0.90
Wet ground	0.85
Dry loose ground	0.60
Loose sand	0.30
Loose gravel	0.25
Muddy ground	0.25
Packed snow	0.15
Ice	0.12

Table 1 - Effect of ground condition on the anchorage capacity of a tractor anchor

Example 1:

What is the anchorage capacity of a 20 tonne tractor located on flat, dry loose ground?

Anchorage capacity = 20 tonnes x 0.60 (from Table 1)
= 12 tonnes (no factor of safety)

Ground slope

The ground slope beneath the tractor alters the anchorage capacity of a tractor relative to that calculated for flat ground:

- anchorage capacity increases if the pull is upslope
- anchorage capacity decreases if the pull is downslope

When the line pull is upslope, the tractor's anchorage capacity is increased because the hauler is pulling against both the tractor's coefficient of traction and the slope resistance.

The effect of ground slope on anchorage capacity can be approximated using the following equations:

Anchorage capacity (pulling tractor upslope)
= anchorage capacity (flat) + (tractor weight x slope factor)

Anchorage capacity (pulling tractor downslope)[1]
= anchorage capacity (flat) - (tractor weight x slope factor)

The slope factors for a range of slopes are shown in Table 2.

Ground slope (°)	Slope factor	Ground slope (°)	Slope factor
2	0.035	18	0.309
4	0.070	20	0.342
6	0.105	22	0.375
8	0.139	24	0.402
10	0.174	26	0.438
12	0.208	28	0.470
14	0.242	30	0.500
16	0.276		

Table 2 - Slope factors

[1] This equation is only suitable for slopes up to 20^0

Example 2:

What is the anchorage capacity of a 20 tonne tractor located on dry loose ground with a uphill slope of 12°?

Anchorage capacity = 12 tonnes (Example 1) + (20t x 0.208)
= 12 + (4.2)
= 16.2 tonnes (no factor of safety)

Example 3:

What is the anchorage capacity of a 20 tonne tractor located on dry loose ground with a downhill slope of 8°?

Anchorage capacity = 12 tonnes (Example 1) - (20t x 0.139)
= 12 - (2.8)
= 9.2 tonnes (no factor of safety)

Tractor spars

An important consideration with any productive cable logging operation is deflection. A steel spar mounted on the mobile tractor anchor is one method of increasing deflection.

A block can be hung from the top of the spar to accommodate running skyline systems (Figure 2) or the skyline itself can be attached directly to the spar.

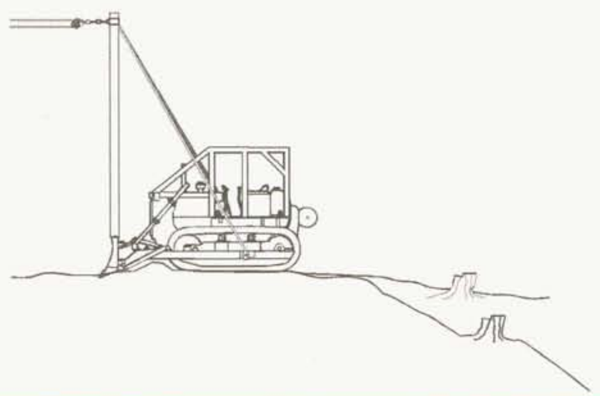

Figure 2 - Spar mounted on the blade of a tractor to help increase deflection

However, if the tractor blade is anchored behind a solid object (such as a stump or rock) to prevent any forward movement, the spar acts as a lever.

The tractor can fail by overturning forward or by tilting forward and sliding sideways, when the tension in the load-line exceeds the anchorage capacity of the tractor. This leverage increases with spar height, further reducing the tractor's anchorage capacity. An example for a Komatsu D65 tractor is shown in Table 3.

Spar height (m)	Overturn tension (tonnes)
1	46.9
2	23.4
3	15.6
4	11.7
5	9.4
6	7.8

Table 3 - Tension required from load-line to overturn Komatsu D65 tractor anchor (16.8 tonnes) with a spar mounted on the blade (flat ground and tower not guyed to the ground)

To help prevent tractor tailspar failures, guylines should be fixed to the top of the spar and anchored back to the ground (e.g. to stumps) to oppose the resulting forces of the working ropes (Figure 3).

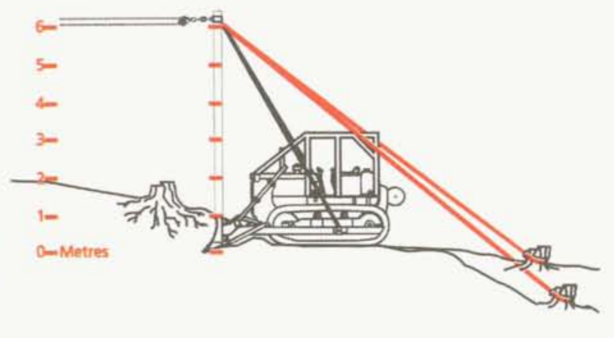

Figure 3 - Guylines attached to top of spar and anchored back to stumps

Use of the blade

All mobile tailhold tractors should be equipped with a fully operational blade, and this should be used. However, the advantage of burying the blade varies with soil type. For example, a D7 size tractor with the full width of the blade buried in a pumice type soil (with the cutting edge one metre below the ground surface) will only increase the anchorage capacity of the tractor by approximately 2 tonnes. If the tension from the load-line exceeds the anchorage capacity of the tractor, the soil will fail in a line from the bottom of the blade to a point out in front of the tractor on the ground surface (Figure 4). The tractor will push forward a wedge of soil as the blade rides upward and forward.

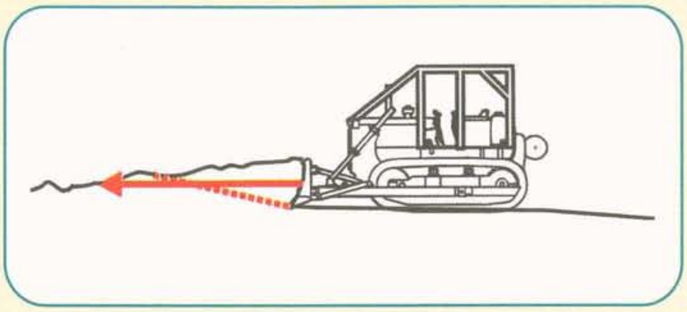

Figure 4 - Failure of the soil structure anchoring the tractor

This result is undesirable as loose soil in front of the tractor blade will have little effect in opposing the forces generated in cable logging operations.

An attachment method which forces the blade downward into the soil, proportionate to the load being applied, should be utilised. This can be achieved by passing the load-line over the top of the blade and attaching it to the under-side of the tractor's body. If the soil fails in front of the blade, the tractor will move forward. However, the downward pressure from the loaded line will force the blade downward into the ground, rather than riding up (Figure 5). If the hydraulics creep, the effectiveness of this decreases.

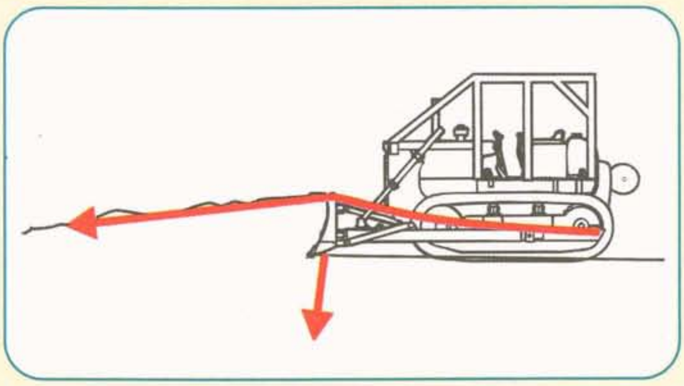

Figure 5 - The load-line puts a downward pressure on the blade proportionate to the tension

When a tractor anchor is pulled uphill, with the blade forced down, the anchorage capacity is significantly increased. This is because the hauler is pulling against the tractor's coefficient of traction, the grade resistance, and the mass of hillside in front of that tractor. This is the best situation and is what should be aimed for.

Passing the load-line over the blade and attaching it to the C- frame does not induce a substantial downward force on the blade (Figure 6).

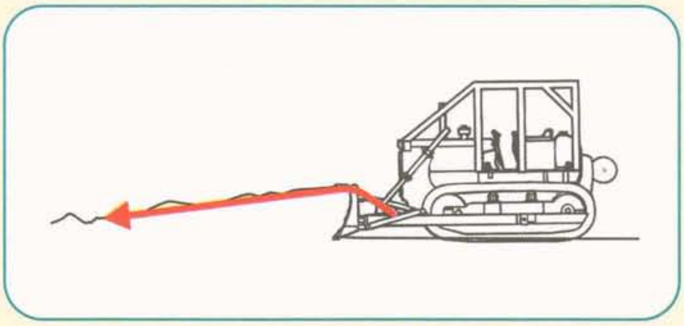

Figure 6 - This method provides little benefit over attaching the load-line directly to the blade

The resulting downward force is the same as attaching the load-line to the top of the blade. The load-line must be able to move freely over the blade so that the blade can move independently without restriction.

Anchoring the tractor

The largest tension generated in any working rope of a true skyline system, is in the skyline itself. Therefore, the skyline should be attached to the tractor so that the force on the skyline does not twist the tractor sideways. Ideally, this requires the skyline to pass over the centre of the blade, with the tractor tracks parallel to the line of pull.

In many situations, a corner of the blade is used to mount a tail-block. Cable systems that require the haulback brake to be partially engaged during inhaul (which opposes the mainrope) to provide suspension of the drag, will create a resulting force that twists the tractor sideways. If the tractor is able to twist, its anchorage capacity will be reduced because it makes less effective use of the blade area. A bank should be formed to park the tractor parallel against. This will prevent the tractor from twisting sideways (Figure 7).

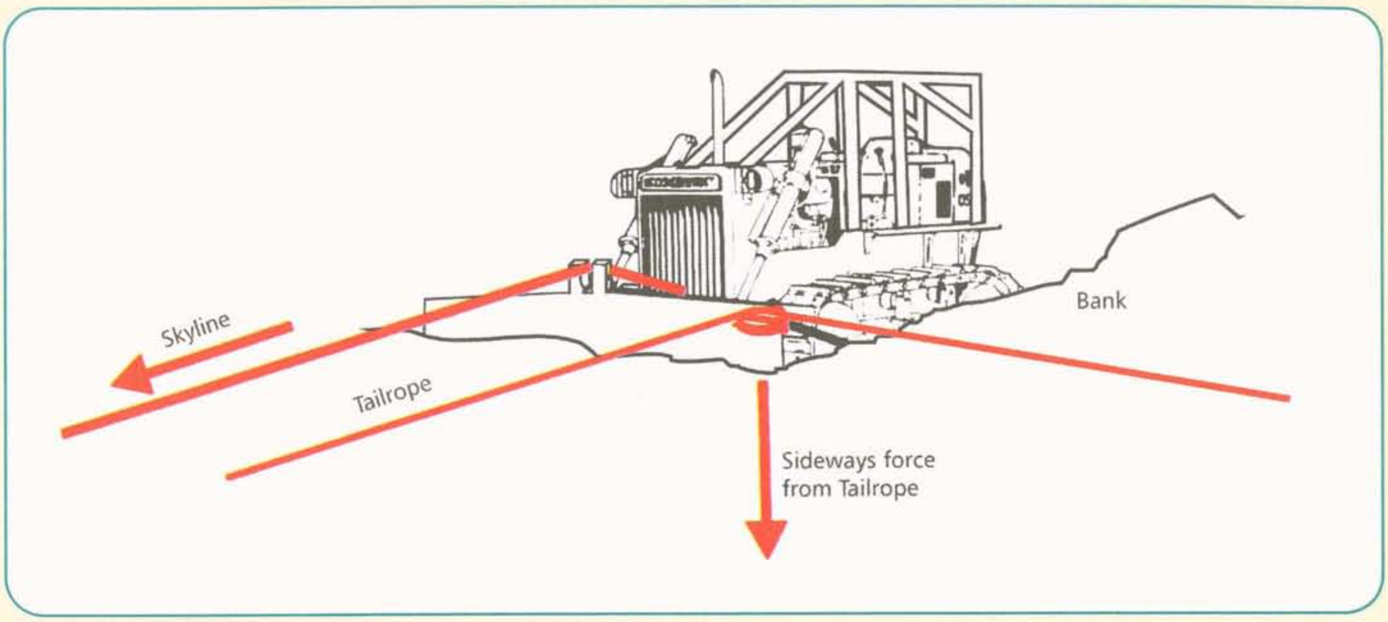

Figure 7 - Solid earth in front and beside the tractor preventing the tractor from moving forward or twisting sideways

If there is any doubt about the tractor's ability to withstand the tension from the working ropes, the tractor winch rope should be attached to a notched stump opposite to the direction of pull (Figure 8).

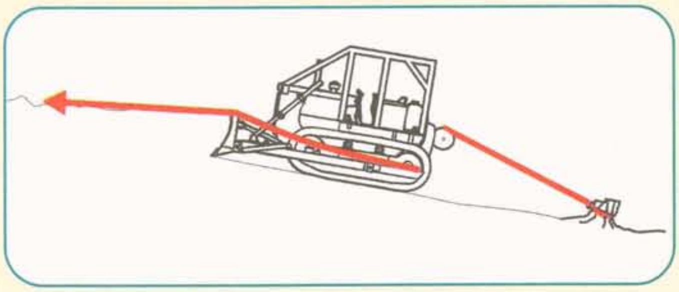

Figure 8 - Tractor winch rope tied back to a stump

Attaching load-lines

The top of tractor blades are usually made of softer steel than that used for wire rope. The top of the blade quickly becomes roughened from contact with the wire rope. This can damage the rope. A hard faced sheave or shoe, of a diameter appropriate for the rope it is to contain, should be fitted to the top-centre of the blade (Figure 9).

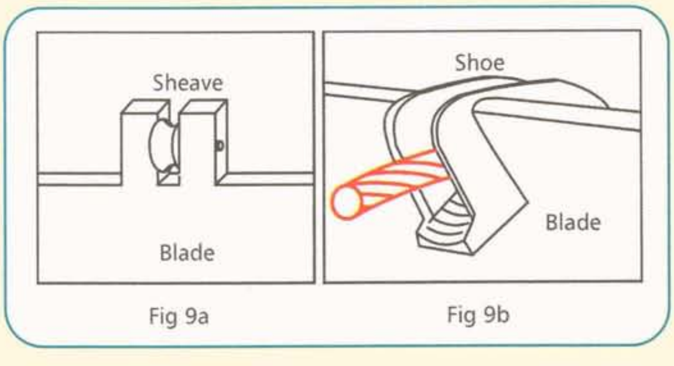

Figure 9 - Two blade - mounted fixtures to accommodate rope

Attaching the load-line to any fixture attached to the belly-pan, relies on the strength of the plate steel and the bolts anchoring the belly-pan to the tractor. These components are often not strong enough to withstand forces generated by cable haulers. The tractor draw-bar is designed to withstand heavy loadings, making it a suitable point of attachment. However, ensure that the draw-bar connection is not one which might induce a kink, or cause other damage to the load-line. An attachment which is secured to the draw-bar can accommodate a straight line of pull under the tractor. This will reduce this cause of rope damage (Figure 10).

An extension can be permanently shackled to the tractor draw-bar. The skyline is connected to the extension just in front of the blade, rather than threading the line under the tractor each time the load-line is re-attached to the draw-bar (Figure 10). This method reduces the time required to disconnect or reconnect the skyline to the tractor. Also, this eliminates the need to cut the end off the skyline if it becomes damaged.

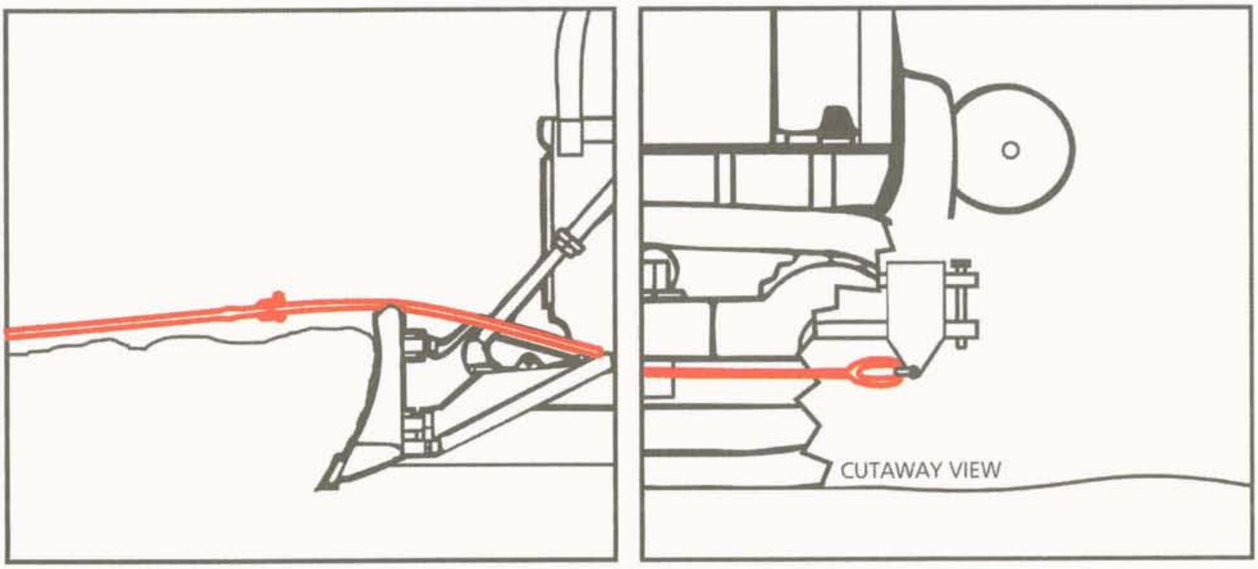

Figure 10 - Draw-bar attachment accommodating the load-line with a straight line of pull under the tractor. Extension cut to length so the eye is just in front of the blade.

Running skylines

When using running skyline systems, blocks are often hung from either corner of the blade to anchor and separate the tailrope (Figure 11). This creates a double purchase situation and the resulting force on the anchor can be equal to that of many true skyline systems.

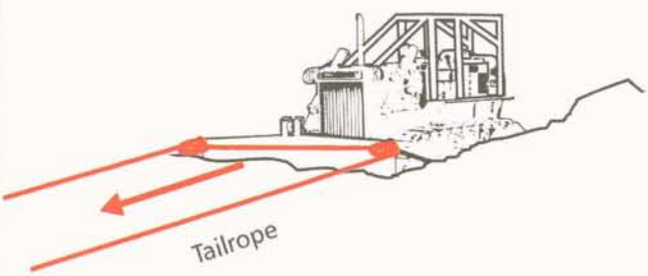

Figure 11 - Blocks hung on both corners of the blade (running skyline system)

Therefore, running skyline systems should also be attached to a tractor tailhold in a way that directs the resulting forces downward proportionate to the tension in the working ropes. However, such an attachment would be quite complex to rig, requiring the use of extensions routed over the blade and back to the draw-bar.

Conclusions

- Tractor anchorage capacity is greater when pulling the tractor in an uphill direction.
- Relying solely on the tractor weight (i.e., if the blade is not dug into the ground or the tractor tied back) the anchor is unlikely to provide sufficient anchorage capacity.
- A spar attached to a tractor should be guyed to the ground to avoid failure by overturning forward
- An attachment system should be used which forces the blade downward into the soil, proportionate to the load being applied. This can be achieved with true skyline systems by passing the load-line over the blade, under the tractor and attaching the rope eye to the draw-bar. If this is not practical, an alternative is to attach the winch rope to a notched stump, opposite the direction of pull.
- Running skyline systems can potentially generate equal tensions to true skyline systems, and equal attention to detail will be required to ensure the security of the tractor anchor.

Points to consider when securing a tractor anchor

- The brake is locked on.
- The blade is facing towards, and at right angles to the load-line (working lines or guyline).
- The blade is dug into the ground to at least half the depth of the blade, and preferably behind a mass of stump roots as well (when practicable).
- The tractor is positioned to maximise the grade resistance (eg. being pulled uphill, into the slope).
- The method of attaching the working ropes to the tractor results in the blade being forced into the ground, proportionate to the tensions generated in the load-line. If this is not practical, an option is to attach the tractor winch rope to a notched stump.
- If there is lateral tension induced from the working ropes, the tractor is positioned in a trench, or against a bank to prevent the tractor from twisting sideways.
- If you are in doubt about the tractor's anchorage capacity, tie it back to a notched stump.

Points to consider when shifting the tractor

- Have a direct communication system with the hauler operator.
- Wear the seat belt.
- When it is necessary to tension the working ropes during a line shift, ensure the blade is square to the line of pull from the working ropes.
- Wind in excess slack from the ropes regularly to avoid large bights developing in the ropes.
- Retreat to a safe position clear of the machine before the working ropes are fully tensioned.

These points should not be treated as the sole source of information and should be used in conjunction with the relevant codes of practice and standards.