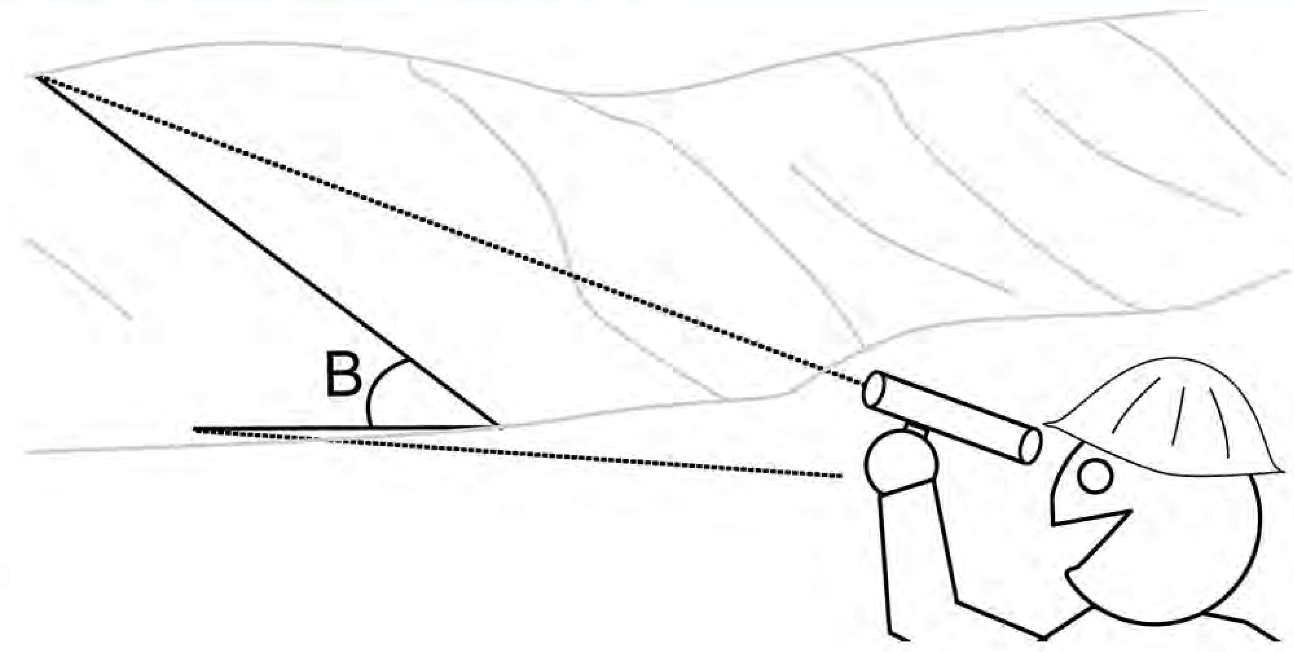
Equipment Anchor Quick Reference

This reference is intended as general guidance only.
Final anchor design should be prepared by qualified personnel.

Step 1. Establish the bearing area for your equipment anchor.

- ✓ Use a clinometer or a level to approximate the slope angle, β.
- ! Ensure sufficient equipment setback from any change in slope, including ravines or precipitous drops.
- ✗ Do not select bearing areas that are exceedingly steep, vegetated or debris-covered as sliding may occur.



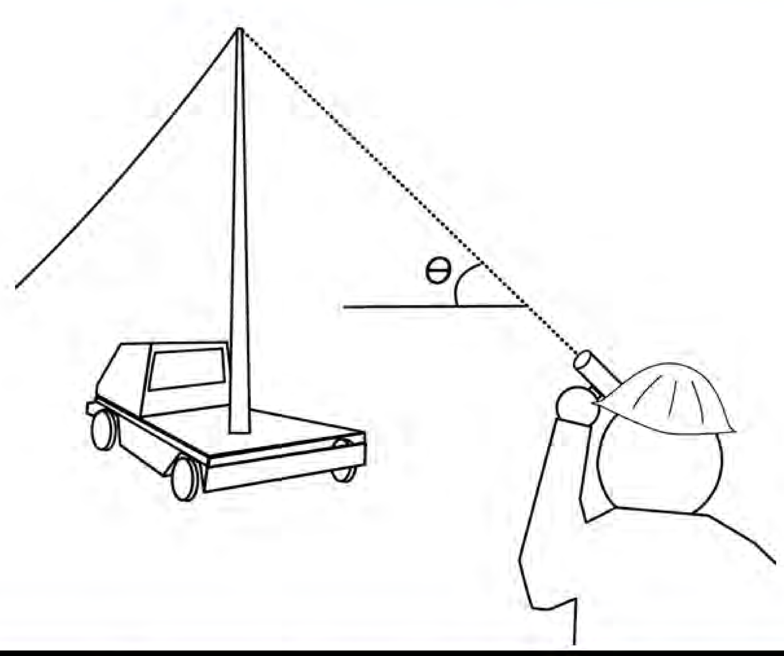
Step 2. Establish the soil properties for your bearing area.

- ✓ Estimate the soil strength using field testing.
- ! For clayey soils, silts or loams, establish undrained shear strength (cohesion) using a vane shear apparatus.
- ! For sands, gravels or other coarse-grained soils, establish the soil shear strength using based on in-situ or laboratory strength tests.
- ✓ Estimate soil density using drive cylinder (ASTM D2937), sand cone tests (ASTM D3156) or other appropriate methods. A conservative value to use would be 80 pcf.

Basic Soil Types and Example Values.

Soil	ϕ (°)	δ (°)	c (psf)	γ (pcf)
Dry Gravel	44	22	0	100
Wet Gravel	44	22	0	100
Dry Silt or Loam	28	28	500	80
Wet Silt or Loam	14	14	250	80
Dry Clay	0	0	1000	80
Wet Clay	0	0	500	80

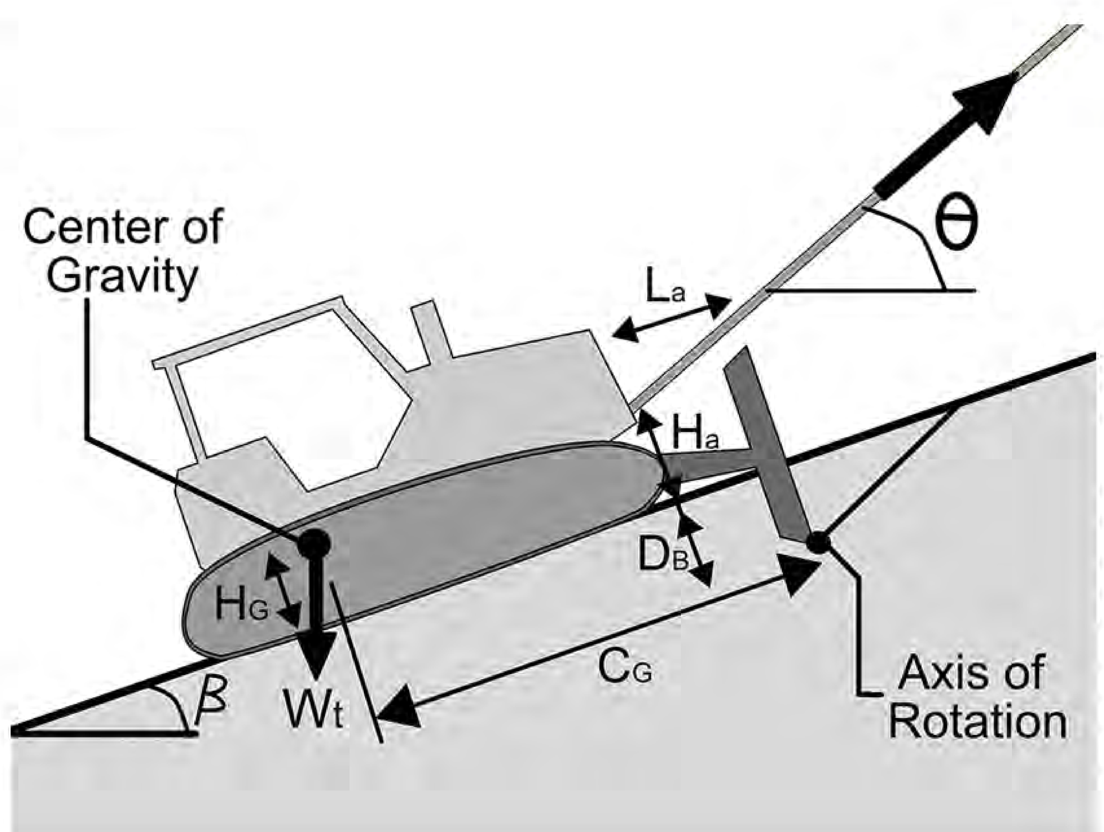
Step 3. Establish the expected angle of pull (ϴ) for the skyline or guyline.



- ✓ Use a clinometer or level to measure the cable angle.
- ✗ When serving as a guyline, OR-OSHA guidelines restrict this angle to a maximum of 50 degrees from the horizontal surface.

Step 4. Establish the equipment dimensions and properties.

- ✓ Necessary information includes the equipment weight (with attachments), blade width, blade embedment, clearance of cable attachment form the surface, and distance from the front of the equipment (or embedded blade) to the equipment center of gravity.
- ✓ Often, equipment specifications can be found in documentation provided by the manufacturer.
- ! Note that added equipment attachments may change equipment weight and shift the center of gravity.



Step 5. Establish expected tensions of the anchored cable.

A payload analysis like SkylineXL or LoggerPC can provide estimates for working skyline tensions during yarding. This represents required resistance for equipment anchors serving as skyline anchoring (maximum skyline tension) or guyline design (dependent on number of guylines and direction of pull).

IMPERIAL	6x26 Improved Plow Steel		6x26 Swaged		Swaged Compacted-Strand	
Diameter (inches)	Weight (lbs/ft)	Breaking Strength (tons)	Weight (lbs/ft)	Breaking Srength (Tons)	Weight (lbs/ft)	Breaking Srength (Tons)
1/2	0.46	11.5	0.6	15.2	0.63	18.6
9/16	0.59	14.5	0.75	19	0.78	23.7
5/8	0.72	17.9	0.93	23.6	1.01	28.5
11/16			1.1	28.8	1.18	35.3
3/4	1.04	25.6	1.37	34.6	1.41	42.2
13/16			1.56	39.6	1.63	49.3
7/8	1.42	34.6	1.83	46.5	1.91	56
15/16			1.95	53.3	2.2	66.1
1	1.85	44.9	2.42	60.6	2.53	73.7
1-1/8	2.34	56.5	2.93	75.1	2.97	92.9
1-1/4	2.89	69.3	3.52	92.8	3.83	112.1
1-3/8	3.5	83.5	4.28	108.2	4.62	128.6

Source: Cable Yarding Systems Handbook. 2006. WorkSafe BC. Table lists typical breaking strengths. See manufacturer's specifications for specific lines.

Step 6. Calculate the anchor resistance.

Use MACS V2.0 with a mobile device or use supplementary charts with site properties from steps 1-4 to calculate the maximum anchor resistance to both sliding ($F_{sliding}$) and overturning ($F_{overturning}$).

$$F_{sliding} = 0.5\gamma D_b^2 w_b N_b + c' w_b N_c + c' A_t N_{ct} + W_t N_w$$

$$N_b = \frac{K_p A_1}{A_2}\,;\ N_c = \frac{2\sqrt{K_p} A_1}{A_2}\,;\ N_{ct} = \frac{A_1}{A_2}\,;\ N_w = \frac{1}{A_2}$$

$$F_{overturning} = \frac{W_t\left[C_G \cos\beta - (D_b + H_G)\sin\beta\right] + \left[0.5\gamma D_b^2 w_b N_b + c' w_b N_c\right]\left[\frac{1}{3} D_b\right]}{\cos(\theta - \beta)\left[D_b + H_A\right] + \sin(\theta - \beta)\left[L_A\right]}$$

$$A_1 = \sin\beta + \cos\beta \frac{\cos\beta - \tan\delta_t \sin\beta}{\sin\beta + \tan\delta_t \cos\beta}$$

$$A_2 = \sin\theta + \cos\theta \frac{\cos\beta - \tan\delta_t \sin\beta}{\sin\beta + \tan\delta_t \cos\beta}$$

The lesser of the anchor resistance values ($F_{sliding}$, $F_{overturning}$) may be expected anchor resistance. Ensure that the anchor resistance is greater than the safe working load:

$^1/_3$ x Cable Breaking Strength / Factor of Safety

Step 7. If anchor resistance is inadequate, adjust configuration.

a) Anchor sliding resistance can be increased by (1) increasing blade or equipment embedment depth with a berm, (2) using a new bearing area with a higher uphill grade, and (3) lowering the angle of pull for the cable.

b) Anchor overturning resistance can be increased by (1) reducing blade or equipment embedment depth, (2) using a new bearing area with a higher uphill grade, and (3) attaching the cable to a lower point on the equipment.

c) In consideration of methods of improving resistance, restart the design at Step 7a with new configuration.

Step 8. Once configuration is adequate, ensure safe equipment anchor application.

Ensure that the equipment serving as an anchor is turned off, in gear, and the brakes engaged.

Ensure that the cable is attached to a point on the equipment intended for logging. It is critical that the attachment point is low to the ground to prevent overturning. One suggestion would include insuring that the distance from the resisting face of the vehicle to its center of gravity is at least twice that of the summed depth of blade embedment and clearance between the ground and anchor attachment point.

Ensure that the anchor cable is adequately protected agains sharp surfaces on the equipment (example: bulldozer blade, gears underneath equipment). Use of cable sheaths present a means of reducing self-inflicted cable damage during operation.

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