INDUSTRY ADVISORY
Ground Anchors

Introduction:
Recently both the Professional Ropes Course Association, as well as another well known ropes course association, were made aware of a ground anchor failure at a camp in central Florida. The incident involved a heavily utilized giant swing style element supported between an "Alpine Tower" and an adjacent single pole. The single pole was guyed to the anchor that failed.
A camp counselor weighing approximately 140 lbs. was on the swing when the ground anchor pulled completely free of the ground allowing the pole to shift and the cables to sag resulting in the participant striking the ground. Thankfully the only human consequence was a sprained ankle to the counselor.

The course had been recently (March 2007) inspected and the element had passed. Reportedly there had been no previous signs of problems or concerns regarding the holding strength of the anchor.

The anchor was an A.B. Chance (Hubbell Power Systems) No-wrench model 816, with a 66" length 1"diameter rod and an 8" anchor helix. The anchor had been installed in April 2002 in sandy soil with a grass cover. It is not known at what depth, angle or method was utilized to install the anchor at this time. Central Florida has been experiencing a sustained drought and water tables have been substantially lowered in this area.

Based on this information it is believed that the combination of Class 6 or 7 soil (including finer sands), combined with the heavy use of the element and the lower moisture level (usually a strengthening factor) in this instance allowed the fine soil to flow around the anchor helix. This would be compounded by the forces exerted upon the pole, guy cable and subsequently the anchor by the initial fall loading and swinging of the participant. This repetitive process would cause the anchor helix and anchor itself to slowly rise through the soil layers until failure occurs.

Background:
A.B. Chance, a subsidiary of Hubbell Power Systems, produces the model 816 No-Wrench ground anchor with a 66" length 1"diameter rod and an 8" anchor helix. The anchor if properly installed has a holding (pull) strength of 11,000 lbs. in Class 5 soil, 9,000 lbs. in Class 6 soil, and 6,000 lbs. in Class 7 soil (see soil chart below). The manufacturer states that if this ground anchor is hand installed pull strength may be reduced by as much as 10 to 20%. Further if the anchor is not installed within 10˚ of alignment with the guy load the anchor may have "significantly lower strength".
The manufacturer also states that "It is advisable to install anchors deep enough, by the use of extensions, to penetrate a Class 5 or 6, under laying the Class 7 or 8 soils".

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SOIL CLASSIFICATION	
0	Unweathered, sound hard rock
1	**Very dense** / cemented sand; coarse gravel and cobbles
2	**Dense** fine sands; very hard silt and clay (may be preloaded)
3	**Dense** sand and gravel; hard silt and clay
4	**Medium dense** sand and gravel; very stiff to hard silt and clay
5	**Medium dense** coarse sand, sandy gravel; stiff to very stiff silt and clay
6	**Loose to medium dense**-fine to coarse sand, stiff clays and silts
7	**Loose** fine sands; Alluvium; loess; medium - stiff and varied clays; fill
8	Peat, organic silts; fly ash very loose sands, very soft to soft clays

Potential anchoring problems:
Soft soil layer is sandwiched between two harder or dense layers.

a. If the anchor helix remains rigid and is located in the soft layer, and the soft layer fails due to water incursion or other reason, it may flow around the anchor creating an upward creeping movement or pocket for upward movement.
b. If the guy anchor helix remains moves and is located in the soft layer, it may flow around the anchor creating an upward creeping movement or pocket for upward movement. This movement may be due to repetitive force loading of an element that is guyed by the anchor.

Hard soil layer below soft soil layer.

a. Anchor placement in a hard layer below a soft layer can result in sudden anchor failure. Unless there is an extreme uncommon load force applied this is commonly evidenced by bulging of the anchor area, anchor “jacking”, or creep.

Anchor placed in area of deep frost penetration.

a. When frozen soil behaves as a harder denser soil, with the thaw cycle, the upper soil will become water-saturated while the lower layer (where the anchor is) will remain frozen. This condition is analogous to a hard layer beneath a soft layer, and can result in sudden anchor failure. Anchor placement below the frost line is required to prevent this type of failure.
b. Frost heaving or anchor "jacking" (movement out of the ground) may occur under these conditions.
c. In areas with permafrost, the anchor helix should be minimally three to five feet below the permafrost line, and steps taken to prevent solar energy from being conducted down the anchor.

Anchor placed in high water content soil.

a. Generally, anchor pull strength decreases as the soil moisture content increases. If a anchor is installed at the water table level, the pull strength in granular soil can be reduced by as much as 50%. (Water tables are usually defined as the elevation at which the water will stabilize in a drilled hole after 24 hours.)

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Loaded anchors placed in fine grained soils.

a. Water draining from fine grain soil under guyed load, will permit anchor creep.
b. Normally rapidly applied loads due to wind or ground tremors have minimal effect on creep if they do not exceed soil shear strength.
c. Repetitive multi-directional force loading of the guy and anchor rod, could result in creep.

Analysis:

The camp in central Florida indicated that their soil was sandy with a grass covering. The description of the soil would indicate that it fell into Class 6 or 7. As this area is known for fine sandy soil with some layers of peat content (Class 8) and a normally relatively high water table, although this was an extended drought period, it would most likely be classified as Class 7 soil at the depth where the anchor helix may have been placed if in line with the load at 45˚. (At an ideal angle of 45˚ the anchor helix would have been at the maximum reach 47" below the ground.) This would result in maximum anchor strength of 6,000 lbs. in Class 7 soil. If the anchor had been hand placed we would see a further reduction of 10-20% or 5,400 lbs to 4,800 lbs pull strength.

The use of the giant swing style element, initial fall loading and swinging of the participant, depending on the angle of the supporting cables may have closely approached the pull strength of the anchor, combining with the rocking movement of the pole, guy and anchor rod, although minimal, would have caused a displacement of the fine grained sandy soil around the anchor helix. This would result in a creeping of the anchor. Whether this was in line with the load applied or upward at an angle to the surface would have depended upon the orientation of the anchor helix blade. The creep resulted in less soil retaining the anchor hence less pull strength. The "creep" would have continued with each use until the applied force finally exceeded the remaining pull strength and the anchor failed as it did.

Recommendations:

Planning, designing, installing, re-tensioning and re-installing ground anchors should be performed by Qualified Ropes Course Professionals only.

However, in order to identify potential anchor failures the PRCA recommends that all ground anchor rods be painted at the point where they contact the ground surface with high visibility paint. Thus if in the course of use the anchor begins to creep, "jack, heave or is shifting in a helix pocket beneath the ground it may be indicated by a simple visual inspection of the rod showing the unpainted surface below the paint line. This doesn't guarantee that you will always be aware of a problem but it is a good early warning system of common problems. Any indications of anchor creep should be reported to a qualified ropes course professional immediately for assessment and repair.

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The use of high visibility paint also serves to help identify tripping hazards on your course. (See photos below)

Marked Ground Anchor

Marked Ground Anchor showing Creep

Unmarked Ground Anchor **hiding** Creep

If you have more questions or need additional information you may contact us at:

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