# The Benefits and Limitations of Using Stake Anchors

Presented by:

*Glenn Pinson*

*and*

*John Everhart*

# Stake Anchors

- Presented by Glenn Pinson, Firefighter for the Beverly Hills Fire Department, and Peak Rescue Institute Instructor and Operations officer.
- John Everhart San Diego Lifeguard Sergeant, and Peak Rescue Institute Instructor.

# Definitions:

- Stakes – for purposes of this talk, when we talk about stakes we are talking about 1 inch (2.54cm) diameter mild steel approximately 3 feet (1meter) in length.
- Stake anchors – using one or more stakes to create an anchor or anchor system – in a load sharing configuration.
- Pickets – using two or more stakes tied together.

# Background

- In certain areas of the country finding suitable anchors for vertical rescue can be difficult. Without natural anchors or vehicle access what can you use?
- San Diego Lifeguards have been using stake anchors for over forty years, performing on average 20-50 cliff rescues along the coastal bluffs.

# So the question always comes up, what are your anchors rated at?

- Crude testing has been done in the past to determine if they are strong enough (dropping weight over the side and shock loading the anchors, setting up opposable anchors and pulling with a 15-1 with a team of people, etc….)
- No hard data available that gave force measurements.

# Science vs. Data

- Our study is primarily a data collection point so far.
- Not enough tests for concrete conclusions.
- Many variables exist:  Soil type, stake type, stake depth, stake placement, weather, etc…

# Testing Locations

- Pacific Northwest – Testing done during the summer in soil that appeared to be relatively dry and medium hard. Testing was done using a come-along winch.

- Southern California – Testing was done on coastal cliffs during the summer. Hard dry soil. Testing was done using a Warn 12,000lb winch.

# San Diego Test #1

- Stakes were pounded into ground to a depth of 14.25 inches using a standard sledge hammer.
- Stakes were 16” apart, side by side (equal distance to the load).
- Self Equalizing anchor using 11mm cordage.
- Stakes angled away from pull between 10 and 15 degrees.

# Results #1

- 1st significant movement of stakes occurred at 3290 lbs (14.95 kN).
- Angle of one stake moved 2 degrees at first movement, the other 4 degrees.
- One stake moved 1inch at base, the other 1.25 inches
- Anchor failed at 4920 lbs (22.35 kN).
- Failure was due to deformation of stake, not due to soil failure.

# San Diego Test #2

- Similar soil to test #1.
- 14.5 inches in depth, 16 inches apart, one stake behind the other (less anchor angle), self equalizing anchor.
- Stakes angled between 15 and 20 degrees away from pull.
- Pull was 10 degrees above horizontal (pulling slightly up hill).

# Results #2

- 1st significant movement of stakes occurred 2770 lbs (12.59 KN).
- Angle of the back stake moved 3 degrees at first movement, the other 7.5 degrees.
- Anchor failure occurred at 4970 lbs (22.59 KN).
- As in test #1, stake was deformed and stake caps kept the rope from coming off stakes.

# San Diego Test #3

- Same general area as first two tests, ground not quite as hard, depth of stake increased to 17.5 inches.
- Two stake picket, stakes angled 20 degrees away from load, stakes 16 inches apart.
- Self Equalizing double strand of 11mm rope used.

# Results of Test #3

- No significant movement of stakes.
- No noticeable change in angle.
- Test stopped at 5600 lbs (25.4 kN) due to safety concerns.
- Significant cracks in the earth up to .3 meters in front of stakes.
- No deformity of stakes.

# San Diego Test #4

- Same stakes used from test #3.  Picket system was changed to the tandem, staggered, in line anchor configuration used in test #2.
- Stakes were not adjusted, or re-positioned after pulling from previous test.

# Results of Test #4

- Initial movement was at 4520 lbs (20.54) kN.
- Pull was stopped at 5000 lbs, anchor was holding, stake deformity seemed likely so test was stopped to preserve the stakes.

# Pacific Northwest Testing

- Stakes were similar to the ones used in San Diego.  1 inch cold rolled steel, 36 inches long.
- Ground was deemed “medium hard”
- In all tests stakes were driven into the ground 24 inches.
- In all tests, the ground failed, not the stakes – no deformity of stakes.

# Tests and Results

- Several pulls on a single stake resulted in failure at just over 1500 lbs (6.8 kN)
- Tests with two staggered stakes pulling in line resulted in 3010 lbs – 3060 lbs (13.7 kN – 13.9 kN) at failure.
- Two stakes side by side equidistant to anchor (16 inches apart) failed at 2880 lbs (13 kN).

# Tests and Results

- Two stakes tied in a picket system failed at 3920 lbs – 4040 lbs(17.8 kN – 18.4 kN).
- Three stakes tied in a picket system were pulled to just over 5000lbs (22.7 kN). The anchor held and the test was discontinued due to concerns regarding the come-along handle.

# San Diego Glider port Tests

- Stakes side by side, 16 inches apart, depth of 24.5 inches.
- Fixed and focused load sharing configuration.
- Initial angle in degrees above horizontal 75 degrees and 79 degrees.

# Results

- Force reading at first movement 2470lbs (11.2 kN).
- Movement at base on each stake 1.5 inches
- Failure of anchor at 3890 lbs (17.7 kN)

# Glider port #2

- In-line, fixed and focused anchor.
- Stake depth 24 inches, angle above horizontal 76 and 71 degrees, stakes 16 inches apart.

# Results

- Initial movement of front stake only at 1700 lbs (7.7 kN).
- Anchor failure at 3470 lbs (15.8 kN).
- Due to the short leg on the front stake, considerably more force was on that stake than the rear stake.

# Glider port #3

- Two point picket system, stakes 16 inches apart, depth of 24 inches, angle above horizontal 80 degrees.

# Results

- Anchor failed at 3690 lbs (16.8 kN).
- Ground failed, no stakes bent.

# Conclusions

- More testing needs to be done!
- All of these tests were done pulling up hill or on flat ground, not pulling down as they would be used in rescue.
- There was very little friction in these pulls.
- Not enough tests could be concluded for a large enough data base.

# Trends??

- Putting the stakes in line without using them in a picket configuration does not appear to make them stronger as one might expect with the lower anchor angle.
- This seems to be due to the short leg having less stretch and more force applied to the front stake.
- Side by side seems as strong as long as your angle is reasonable.

# Trends??

- Picket configurations seem to add strength when the stake is the weak point.
- When the ground is the weak point, pickets might not improve strength.
- When used in a load sharing capacity, stake movement will be seen well before anchor failure – steps could be taken to improve anchor or reduce forces.

# Are stake anchors strong enough?

- Depends on the operation, soil, configuration, etc…
- If the soil is strong and the stakes at an appropriate depth then doing basic rescues should still give you a 10-1 safety margin, especially give friction of the rope into the ground.
- Pick off rescue versus high line?

# Questions??

- If stronger steel is used will anchors be stronger?
- If larger diameter stakes are used will anchors be stronger?
- If the pull is done from the bottom of the cliff, how much force will be on the anchor due to friction?

We have probably generated more questions than we've answered.  Hopefully we have piqued the interest of some of you.

Thank You for your time.

# NOTES