Failure Mode of Mud Anchors
or
“Gumbo, It’s Not Just For Food Anymore”

Presented by:

Scott Blackburn

Failure Mode of Mud Anchors
or “Gumbo, It’s Not Just For Food Anymore”

Developed by Michael Dunn
Presented by Scott Blackburn

Sometimes a boat or other floating object will be caught in a strainer in moving water with no suitable near-by solid anchor points to use in setting up a haul system to free the pinned object. Can south Louisiana-style pickets, driven into riverbank mud, provide sufficient strength to allow their use as a hauling system anchor? This series of tests will utilize four different types of picket anchoring techniques; a single picket, a 1-1 picket combination, a 1-1-1 picket combination and a combination log and picket holdfast to compare the holding power between the various anchoring techniques.

The OSHA definition for the classification of soils found in *29 CFR 1926 Subpart P - Excavations, Appendix A - Soil Classification* and the American Society for Testing and Materials (ASTM) Standard designation *D2488 - "Standard Recommended Practice for Description of Soils (Visual - Manual Procedure)."*) will be used to identify the soil type found at the testing location along the Mississippi River in Baton Rouge, Louisiana.

One fixed immovable object, one south Louisiana style of picket anchor, a simple rope-based hauling system attached between the two points, and a maximum force indicating 5,000 pound mechanical dynamometer will be used to determine the force at which each type of picket anchor reaches its failure point in the identified soil type.

About the Presenters

Michael Dunn is the President/CEO of Emergency Response Training, Inc., a Port Allen, LA., based contract training and consulting firm that also provides confined space rescue and swift water rescue teams for industrial clients. He was a state industrial firefighting and rescue instructor for 16 years, is a second generation firefighter, and has been actively involved in the fire service since 1967. He graduated with a degree in Fire Protection Technology from Oklahoma State University in 1974. Dunn is a member of the American Society for Testing and Materials and the National Fire Protection Association.

Scott Blackburn is the Vice President/CFO of Emergency Response Training, Inc., a Port Allen, LA., based contract training and consulting firm that also provides confined space rescue and swift water rescue teams for industrial clients. He is a nationally registered paramedic, has been involved in emergency medical response since 1978 and is a Louisiana state EMT and paramedic instructor. Blackburn is an Adjunct Instructor for the National Fire Academy's Course "Infection Control For Emergency Responders". He is also a specialist in moulage and conducts realistic disaster drills for clients nationwide.

Failure Mode of Mud Anchors or "Gumbo, It's Not Just For Food Anymore"

Developed by Michael Dunn
Presented by Scott Blackburn

Abstract

Sometimes a boat or other floating object will be caught in a strainer in moving water with no suitable near-by solid anchor points to use in setting up a haul system to free the pinned object. Can south Louisiana-style pickets, driven into riverbank mud, provide sufficient strength to allow their use as a hauling system anchor? This series of tests will utilize four different types of picket anchoring techniques; a single picket, a 1-1 picket combination, a 1-1-1 picket combination and a combination log and picket holdfast to compare the holding power between the various anchoring techniques.

The OSHA definition for the classification of soils found in *29 CFR 1926 Subpart P - Excavations, Appendix A - Soil Classification* and the American Society for Testing and Materials (ASTM) Standard designation *D2488 - "Standard Recommended Practice for Description of Soils (Visual - Manual Procedure)."* will be used to identify the soil type found at the testing location along the Mississippi River in Baton Rouge, Louisiana.

One fixed immovable object, one south Louisiana style of picket anchor, a simple rope-based hauling system attached between the two points, and a maximum force indicating 5,000 pound mechanical dynamometer will be used to determine the force at which each type of picket anchor reaches its failure point in the identified soil type.

Testing Goals

Determine the holding power of a single picket used as an anchor in south Louisiana Mississippi River soil

Determine the holding power of multiple pickets and a combination log and picket holdfast used as anchors in south Louisiana Mississippi River soil

Definitions from *29 CFR 1926 Subpart P Excavations, Appendix A - Soil Classification*

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical side slopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. There is no reliable cohesive soil along the river levee system in south Louisiana. The levees are often constructed of a sand/dirt mix with a clay cap.

Granular soil means gravel, sand, or silt (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry. There is a lot of granular soil along the riverbank.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles. There is no moist cohesive soil along the riverbank.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. There is a lot of saturated soil along the riverbank.

Soil classification system means a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. According to the Baton Rouge regional area OSHA office, all Louisiana soil is Type "C". Our analysis of the soil at the test location revealed Type "C" soil.

Type "C" means granular soils including gravel, sand, and loamy sand or submerged soil or soil from which water is freely seeping.

Test Site Soil Determination

OSHA regulations mandate that in any trenching or shoring operation, a competent person shall classify the soil based on the results of at least one visual and one manual test. The soil type at the test site was classified by two visual tests and one manual test and was found to be Type C soil. OSHA says under *"Visual tests"* to observe the soil as it is excavated for cohesiveness and to observe the area adjacent to the excavation and the sides of the opened excavation for evidence of water. The excavated soil had the consistency of thick pudding and as the soil was excavated, water began to fill the hole. OSHA says under *"Manual tests"* to determine the plasticity of the soil. Plasticity means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-

inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive. Attempting to roll the ball of soil at the test site into a thread merely smeared the mud in between my hands.

Picket Anchor Testing Method

South Louisiana-style pickets for this series of tests consisted of 1-1/4" by 5' steel schedule 40 pipe. All pickets were driven into the soil at an approximate angle of 15 degrees away from the immovable object to a measured depth of 1 meter. A 5:1 block and tackle hauling system was attached between the fixed object and the picket anchor. A maximum force indicating 5,000 lb mechanical dynamometer was placed between the picket anchor and the block and tackle. The haul system was tensioned, initially by hand and later with a cable come-a-long, until either the picket anchor system failed or the dynamometer reached 2,000 lbs/f. Failure was defined in this series of tests as:

$ Picket anchor system pulling far enough forwards so no more force was being applied to the dynamometer or;
$ The test team becoming very uncomfortable applying any more force to the system

Each additional picket system anchor test was conducted on a new, undisturbed section of soil.

Conditions During the Tests

River stage - This was reported by the National Weather Service to be 4.5 feet at Baton Rouge on the day of the testing. Flood stage in Baton Rouge is 35 feet. This means that at flood stage our test site is under 30+ feet of water.

Temperature - The temperature at the start of the testing was 80E F and it quickly rose to 91E F with bright sunny skies.

Humidity - The humidity was reported as 61%

Heat Index - The heat index was 100E F. Add 10E to 15E F to the heat index for working in direct sunlight.

Picket Test Results

Single picket test (two tests were conducted)

Test #1 - Failed. Two rescuers pulling on a 5:1 block and tackle reached 800 lb/f on the dynamometer. The single picket moved 6" forwards. All movement measurements on the front picket were taken at the location on the anchor strap which was at ground level.

Test #2 - Failed. A cable come-a-long pulling on the block and tackle reached 900 lb/f. The single picket moved 12" forwards and rescuers were concerned about the picket pulling free of the ground. The cable come-a-long was attached between the block and tackle haul line and the dynamometer which created a 6:1 hauling system.

1-1 picket test (two tests were conducted)

Test #1 - No results. The cable come-a-long pulling on the block and tackle reached 1000 lb/f. The front picket moved 5" forwards before the haul system ran out of room.

Test #2 - Passed but was marginal. The cable come-a-long pulling on the block and tackle reached 2000 lb/f. The front picket moved 10" forwards and the rear picket moved 3-½" forwards. All picket movement measurements were taken at the rear of the picket at ground level. It was obvious from the amount of movement in the front picket that it was under a considerable amount of strain.

1-1-1 picket test (two tests were conducted)

Test #1 - Failed. The front picket bent at the site of the anchor strap at 2000 lb/f. The front picket moved 12" forwards, the middle picket moved 4" forwards and the rear picket moved 7/8" forwards. The picket that bent was used repeatedly in the same position - front - for each test.

NOTE: We added another failure definition at this point of the testing!

Test #2 - Failed. This was a previously unused picket. The front picket bent at the anchor strap at 1650 lb/f. The front picket moved 7" forwards, the middle picket moved 4" forwards and the rear picket moved 7/8" forwards.

Log and picket holdfast test (one test was conducted)

Test #1 - Passed. The cable come-a-long pulling on the block and tackle reached 2000 lb/f and there was no visible movement of the pickets and no cracking sounds from the log.

Failure Mode of Mud Anchors

July 31, 2006

Test #	Picket Type	Pass/Fail	lb/f Reached	Comments
1	Single Picket	F	800	6" movement of picket

2	Single Picket	F	900	12" movement of picket - Haul team scared to apply any more force to the system
3	1-1 Picket	N/R	1000	5" movement - haul system ran out of room - No Results

4	1-1 Picket	P	2000	10" movement on front picket - 3-½" movement on rear picket
5	1-1-1 Picket	F	2000	Front picket had 12" movement and bent towards the fixed object at the strap - Middle picket had 4" movement - Rear picket had 7/8" movement

6	1-1-1 Picket	F	1650	Front picket moved 7" and bent towards the fixed object at the strap
7	Log/Picket Holdfast	P	2000	No movement of log or pickets was observed

Additional Tests

Because of filming difficulties during the first picket test a second picket test was performed on September 22, 2006.

Conditions During the Tests

River stage - This was reported by the National Weather Service to be 7.2 feet at Baton Rouge on the day of the testing

Temperature - The temperature at the start of the testing was 86E F with bright sunny skies

Humidity - The humidity was reported as 58%

Heat Index - The heat index was 91E F. Add 10E to 15E F to the heat index for working in direct sunlight.

Picket Test Results

Single picket test (two tests were conducted)

Test #1 - Failed. A cable come-a-long was used to pull on a 5:1 block and tackle. The cable come-a-long was attached between the block and tackle haul line and the dynamometer which created a 6:1 hauling system. The single picket began to move at 300 lb/f and moved 5-½" forwards at 450 pounds of force. All additional force applied to the picket anchor merely resulted in the dynamometer needle returning to the 450 pound mark after the pull was stopped.

Test #2 - Failed. The single picket began to move at 100 lb/f and moved 5" forwards at 450 pounds of force. No more force could be applied to the picket.

1-1 picket test (two tests were conducted)

Test #1 - Failed. The front picket began to move at 400 lb/f and the rear picket began to move at 800 lb/f. The front picket moved 2" forwards and the rear picket moved 1" forwards at 1000 lb/f before no more force could be applied to the picket.

Test #2 - Failed. The front picket began to move at 300 pounds of force and the rear picket began to move at 550 lb/f. The front picket moved 2-½" forwards and the rear picket moved 3-½" forwards at 1200 lb/f before no more force could be applied to the picket.

1-1-1 picket test (one test was conducted)

Test #1 - Passed. The front picket began to move at 450 lb/f and the middle and rear pickets began to move at 1100 lb/f. The front picket moved 2-1/4" forwards, the middle picket moved 1" forwards and the rear picket moved 1-½" forwards at 2000 lb/f.

Log and picket holdfast test (one test was conducted)

Test #1 - Passed. The front riverside picket began to move at 1100 lb/f and the rear riverside picket began to move at 1400 lb/f. The front riverside picket moved 2-1/4" forwards and the rear riverside picket moved 1-½" forwards while the front levee side picket moved ½" and the rear levee side picket moved 1-3/4" forwards at 2000 lb/f. There was no measurable movement of the middle pickets.

Conclusions

The picket anchoring system along the south Mississippi River in Baton Rouge might be a viable system depending upon conditions. While it didn't pull out of the ground, a single picket anchor had significant movement at relatively low amounts of force to the point that the rescuers felt uncomfortable in applying any more force to it.

A 1-1 picket in the first test series, while holding 2000 lb/f, passed the test criteria but also had significant movement of both pickets and the testers felt that the system was rapidly approaching the failure point.

A 1-1-1 picket system failed both tests in the first series when the front picket bent under the forces being applied to it. A different type of picket or a thicker gage of pipe may have performed better.

A log and picket holdfast performed the best of all the anchoring systems tested but a "field expedient" log was used for the first test. Any log along the riverbank is questionable for use in an anchor system and definitely would not be "OSHA approved". The log may be fairly recent and strong, good wood or it may have been have been there for months, be hollow, rotten and insect-ridden, and just recently have been uncovered by changes in the water level. Some types of wood have much greater compressive strength than others but determining the log type along the riverbank in times of an emergency is difficult. Carrying a log or log substitute on the rescue vehicle to use in a log/picket holdfast is also a problem when wheeled vehicles frequently can't reach the site where the holdfast will have to be used.

Anchoring the picket system farther back from the water may have added strength to the system due to the soil being dryer but that would also potentially require increasingly longer ropes (depending upon the type of hauling system used) to reach the trapped object in the river you are trying to free.

High river stages may change these results dramatically. The forces a high river stage puts on

any object trapped in a strainer increase exponentially. The earthen levee becomes saturated by the constant pressure of the high water. At flood stage in Baton Rouge, the Mississippi River flows 1.5 million cubic feet of water per second. Putting additional forces on the levee from a picket anchoring system could cause a catastrophic failure of the levee and massive flooding.

The picket anchoring systems tested here may work very well in different soils types along rivers in other areas of the country or it may not be as strong as our results.

WARNING!! Do not use these limited test results as an indication of what will happen under your local conditions. As with any rescue system.....test it thoroughly before trusting anyone's life to it.

Thanks: As with any testing project like this one, it is very much a team effort. I want to thank Kenny Wilkins, Al Bobbett, Nick Hines and Scott Blackburn from Emergency Response Training, Inc., for their help, suggestions and patience; Scott Blackburn for his photography expertise and for agreeing to give the presentation when my availability status changed since my father became ill and moved in with me and Ascension Parish Fire District #7 for the use of their 4-wheel drive mule to haul all of our testing equipment through the mud, rocks and weeds to and from the test site.

Failure Mode of Mud Anchors

September 22, 2006

Test #	Picket Type	Pass/Fail	lb/f Reached	Comments
1	Single Picket	F	450	NMF 5-½" movement
2	Single Picket	F	450	NMF 5" movement
3	1-1 Picket	F	1000	NMF F = 2" movement R = 1" movement
4	1-1 Picket	F	1200	NMF F = 2-½" movement R = 3-½" movement
5	1-1-1 Picket	P	2000	F = 2-1/4" movement M = 1" movement R = 1-½" movement
6	Log/Picket Holdfast	P	2000	WF = 2-1/4" movement WR = 1-½" movement LF = ½" movement LR = 1-3/4" movement

Notes:

NMF = No More Force able to be applied to picket anchor

F = Front picket

M = Middle picket

R = Rear picket

WF/WR = Waterside front/Waterside rear picket

LF/LR = Levee side front/Levee side rear picket