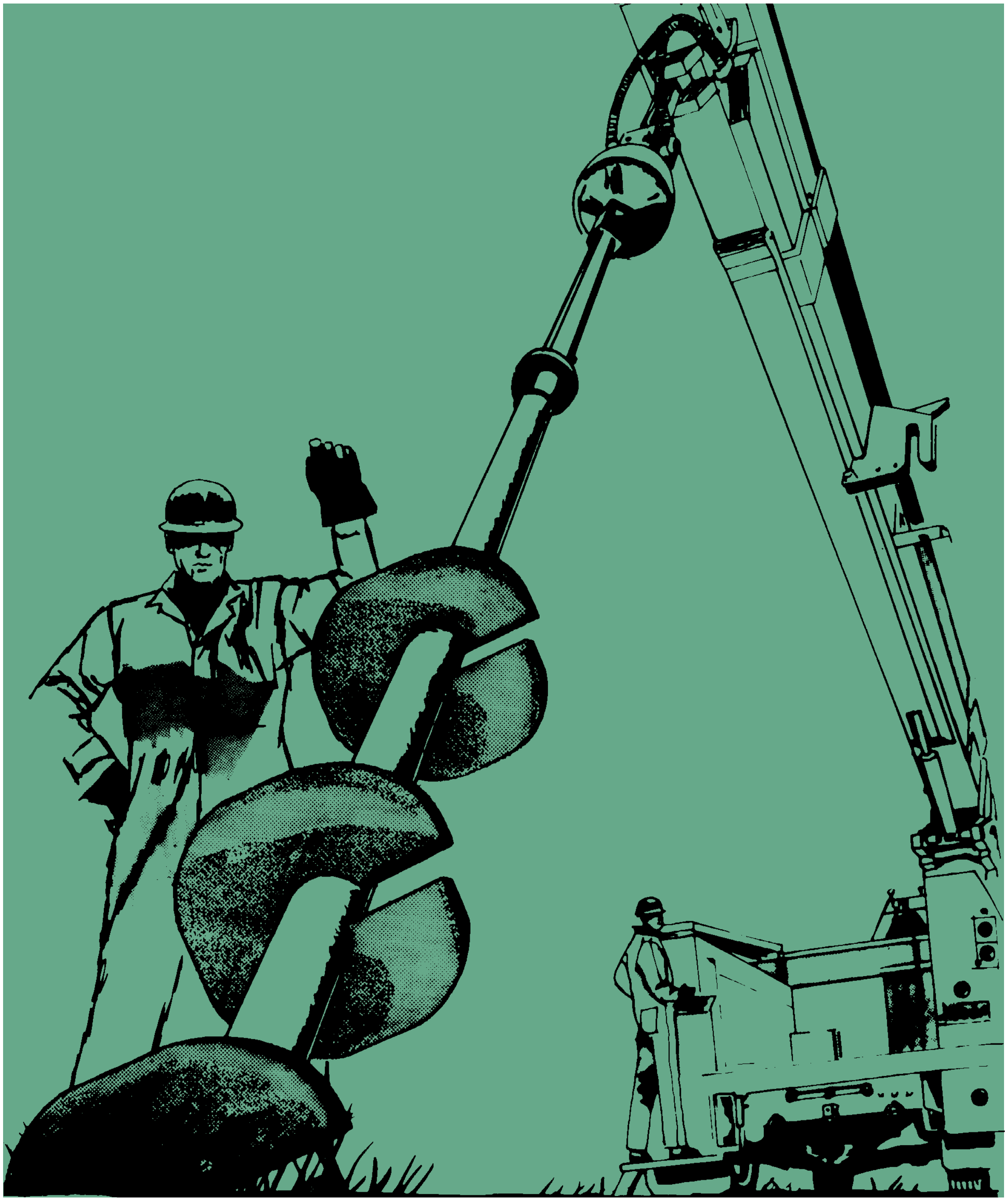
ENCYCLOPEDIA OF ANCHORING



PRINCIPLES AND APPLICATIONS OF EARTH ANCHORS

SECTION A

www.hubbellpowersystems.com
E-mail: hpsliterature@hps.hubbell.com
Phone: 573-682-5521 Fax: 573-682-8714

HUBBELL / CHANCE — CENTRALIA, MO 65240

INTRODUCTION

The Chance Encyclopedia of Anchoring is based on more than 100 years of Chance anchoring leadership. It is an accumulation of anchoring knowledge that is unsurpassed. Rely on the Encyclopedia as your source for anchoring know-how, and look to your Chance Man — the man in the green hat — to bring you even more expertise. Your anchoring will be better for it.

100 years experience under this hat

The Encyclopedia has been prepared to assist engineering and operating personnel in selecting the best anchor for each application. Because it is not possible to select a single anchor for general applications, Chance provides many different anchor designs for specialized applications.

Final anchor selection for a specific installation is dependent upon a number of considerations including subsurface soil conditions, holding capacity requirements and installing equipment. Rely on your Chance Man to help you weigh all the variables that affect anchoring. He's an expert backed by the best anchoring know-how in the world.

CHANCE ANCHORING CONTRIBUTIONS

- THIMBLEYE® Guying Fixtures
- Cone Anchors
- Expanding Rock Anchors
- Swamp Screw Anchors
- Soil Classification Methods
- 8-Way Expanding Anchors
- Pole Keys
- Cross-Plate Anchors
- Portable Anchor Test Units
- Soil Test Probe
- Power-Installed Screw Anchors (PISA®)
- Power-Installed Foundations
- INSTANT FOUNDATION® System
- Extra High-Strength Plate Anchors
- Multiple-Helix Screw Anchors
- Pipeline Screw Anchors
- Screw Anchors for Industrial, Farm or Recreational Applications
- Anchor Training Materials
- SQUARE ONE® High-Strength Anchors
- Torque Indicators
- Anchor Installers
- TOUGH ONE® High-Strength Anchors
- Corrosion-Resistant Anchors
- High Strength Tooling
- SOIL SCREW® Retention Wall System

HISTORY OF EARTH ANCHORS

In the beginning, there were convenient trees to tether an animal, tie up a boat or guy a structure. With the clearing of land, wood stakes were often used.

With heavier loads to support (and no available trees), the log deadman became the forerunner of the patent anchors. Deadmen are still occasionally used today. Early patent anchors were attempts to simulate the root structure of a tree with steel. Unfortunately, only God can make a tree, so the early drive-type anchors had little use.

The earliest patent anchor was a screw foundation designed in 1833 by a blind English brickmaker, Alexander Mitchell. Mitchell's screw foundations were used in the construction of lighthouses and beacons throughout the world. There were few improvements in patent anchoring until February 1, 1876 when the Picket Stake was assigned patent number 172915. However, acceptance was limited. While these were the earliest of the patent screw anchors, it was not until the late 1950s when Chance introduced the Power-Installed Screw Anchor (PISA®) that screw anchoring found favorable, wide-spread acceptance.

The world's first practical earth anchor was invented in 1912 by Albert Bishop Chance. A disastrous ice storm hit the Centralia, Missouri telephone system managed by Mr. Chance. New poles had to be put in, new wire strung and almost every pole had to be straightened and reanchored. There wasn't time for deadman anchor installations. The elements became the mother of invention as Mr. Chance invented the anchor that became known as the "Never-Creep." Anchoring took its first step toward becoming a science with the Never-Creep.

Originally, this anchor consisted of a half of a two-foot length of pole with a hole through the middle for the rod. The rod had an eye hand forged and welded by a blacksmith. It was fitted with a threaded end and nut — no galvanizing.

In practice, the rod was driven to hit a pre-drilled anchor hole. The log anchor was held in the hole by one lineman lying on the ground while a second lineman pushed on the rod until it threaded the hole. The nut was held by a wire device on the end of a broom handle while the rod was rotated to engage the thread.

This was the state of the art practiced at Centralia when a Western Union inspector came to inspect "SKY-ROCKET" lightning arrestors manufactured by Mr. Chance for rural telephone and telegraph wires. The inspector liked the anchor he saw and sold Western Union on the use of the anchor. He prodded Mr. Chance into obtaining a patent and going into anchor manufacturing. Chance was on its way to becoming the world's leading manufacturer of anchors.

The first commercial "NEVER-CREEPS" were cast iron. They were so fragile they were shipped packed in barrels like dishes. With the addition of creep guards and a change to malleable iron, there was little further improvement until World War II forced a change to wrought steel.

To complement the line, A. B. Chance bought the patent rights and tooling of a Canadian Expanding Anchor in 1927. A base plate, nut retainer, forged top plate and new sizes were added until the steel expanding anchor encompassed sizes from six-inch 2-Way through a 12-inch 4-Way design. This was the standard of the utilities until the introduction of the Chance "8-Way" Expanding Anchor in 1947. Expanding anchors originally evolved from drive and drive-pull anchors.

In the 1930's, Mr. Chance purchased the "Wej-Lock" Anchor Company and moved the operation to Centralia.

The "Cone" anchor was originated by the Bierce Company* and Mr. Chance received a patent on an improved cone soon afterward. The holding capacity of a cone anchor was not understood at first. Now we know when holding capacity of an expanding anchor, plate anchor and cone anchor are com-pared, results show the entire surface of the cone compares

*The Specialty Device Company, a successor to the Bierce Company, was purchased by Chance in 1953.

A. B. Chance with his Never-Creep Anchor.

with the projected area of the other anchors if the load is reduced to pounds per square inch. This finding gave rise to a long-held-belief that a cone shaped top surface of an anchor resulted in higher holding capacity with less creep. When we coupled to this the "cone of earth" theory, we had a problem. It took a long time to lay these two misconceptions to rest. We now know that a cone anchor does well in rocky or otherwise firm soil because the tamper working on the steeply coned surface actually increases the density of the undisturbed soil surrounding the excavation. Also, the holding capacity of an anchor depends on the firmness of the soil into which it is placed, rather than on the depth of the installation.

When the "cone of earth" theory was first expounded, it was to explain the seemingly greater holding capacity per square inch of a well installed expanding anchor over a Never-Creep. The truth lies in the compactness of the backfill, not an inverted cone of earth above it. The Never-Creep pulls against undisturbed earth that has not been improved by compaction.

The Expanding Rock Anchor was the Chance solution to a telephone company problem of needing an anchor for rock. The Chance Rock Anchor eliminates the need to excavate in order to pour concrete or lead around a bolt. This anchor is still unchanged and is widely used in solid rock to support both electrical and communication lines.

Chance had long considered and been asked by utilities to develop an anchor which could be installed by power equipment with less expenditure of human effort, more uniform results and lower installed cost. The result is the Power Installed Screw Anchor (PISA®) concept of anchoring.

The "Old Men" of the utilities cut their "anchor teeth" on the business end of a spade. They knew what to expect of any specific anchor in their own back yards. It was as simple as that! They knew what they wanted, and Chance made it and sold it to them!

Then came a magic date after the depression. Most of these "Old Men" were supplanted by young engineers. The new breed had no background or experience and believed only what was found in a textbook. Without a ready vocabulary, it was difficult to communicate with them. To fill this gap, Chance developed the first anchoring manual in 1945. This manual described a number of classes of earth producing different holding capacities. It also explained selection and proper anchor installation.

The Chance soil classification chart still left a gap in communications between the field and the manufacturer. It was necessary to make an excavation before soil could be correctly classified. This was too late to be of much assistance in placing orders for anchors.

This problem resulted in the development of an earth probe on which patents were issued in 1963. Using the probe (Soil Test Probe), reproducible numerical data may be obtained concerning the firmness of the soil beneath the surface without disturbing the soil. Earth characteristics from Pakistan, from Puerto Rico, from Holland and any place in the United States are perfectly described by a series of numbers and depths. From the findings, an anchor user can make an accurate recommendation of the proper anchor for the load.

Chance introduced Power-Installed Screw Anchors (PISA®) during 1959. These PISA® anchors, as they are popularly called, were originally restricted to plastic soils. With improvements in anchors, wrenches and power equipment, utilities now make successful installations in packed sand and gravel in minutes as compared to hours for other anchors and methods. The addition of multiple-helix designs results in holding capacities of 60,000 pounds in swamp country — a load unheard of even in firm soils years ago.

During the 1980s, Chance again advanced the science of anchoring by introducing a patented 10,000 foot-pound anchor series called Square One® anchors. Unlike previously introduced PISA® designs, the high-strength Square One® series of anchors was driven by a wrench which slides into the hub of the anchor, thus allowing the screw anchor to be driven internally. Other PISA® models are driven externally with the drive wrench fitting over the outside of the anchor hub.

Because different soils have different anchoring requirements, anchoring systems need to be "tailor" designed to ensure maximum anchor performance. Chance has many different anchors to penetrate and reach the optimum holding strata of various soils. Chance anchors are being used in dozens of applications in a variety of soils.

During the early years, as the science of anchoring was "feeling its way," knowledge of soil mechanics was minimal. Some even felt anchor depth alone determined holding capacity. Pioneering studies by Chance proved otherwise. Through the years, Chance soil and anchor studies have resulted in the compilation and documentation of a wealth of anchor knowledge, knowledge that enables us to accurately predict anchor performance in most soils. This know-how, coupled with Chance engineered anchoring systems, helps ensure dependable anchoring at the lowest installed costs found anywhere.

Today, we are using anchors for applications undreamed of before — for anchoring major gas and petroleum product pipelines, guy-supported towers, huge retaining walls and in supporting building foundations. As anchoring needs continue to emerge, Chance anchoring R & D will find new anchor applications and the science of anchoring will continue to grow with Chance at the forefront.

The latest product addition to Chance PISA® anchoring was the Tough One® anchor series. These 15,000 ft.-lb. maximum installing torque anchors provide the best soil penetrating ability of any anchor to date. The patented design provides superior resistance to helix closure when anchoring in the most difficult soils.

SOIL CLASSIFICATIONS

A

SOIL CLASSIFICATION DATA

Class	Common Soil-Type Description	Geological Soil Classification	Probe Values in.-lbs. (NM)	Typical Blow Count "N" per ASTM-D1586
0	Sound hard rock, unweathered	Granite, Basalt, Massive Limestone	N.A.	N.A.
1	Very dense and/or cemented sands; coarse gravel and cobbles	Caliche, (Nitrate-bearing gravel/rock),	750 - 1600 (85 - 181)	60-100+
2	Dense fine sands; very hard silts and clays (may be preloaded)	Basal till; boulder clay; caliche; weathered laminated rock	600-750 (68 - 85)	45-60
3	Dense sands and gravel; hard silts and clays	Glacial till; weathered shales, schist, gneiss and siltstone	500 - 600 56 - 68	35-50
4	Medium dense sand and gravel; very stiff to hard silts and clays	Glacial till; hardpan; marls	400 - 500 (45 - 56)	24-40
5	Medium dense coarse sands and sandy gravels; stiff to very stiff silts and clays	Saprolites, residual soils	300 - 400 (34 - 45)	14-25
6	Loose to medium dense fine to coarse sands to stiff clays and silts	Dense hydraulic fill; compacted fill; residual soils	200 - 300 (23 - 34)	7-14
**7	Loose fine sands; Alluvium; loess; medium - stiff and varied clays; fill	Flood plain soils; lake clays; adobe; gumbo, fill	100 - 200 (11 - 23)	4-8
**8	Peat, organic silts; inundated silts, fly ash very loose sands, very soft to soft clays	Miscellaneous fill, swamp marsh	less than 100 (0 - 11)	0-5

Class 1 soils are difficult to probe consistently and the ASTM blow count may be of questionable value.
**It is advisable to install anchors deep enough, by the use of extensions, to penetrate a Class 5 or 6, underlying the Class 7 or 8 Soils.

Soil Types

The simplest way to classify soils is cohesive and non-cohesive. Fine grained soils such as clay are considered cohesive, while sand and other coarse grained soils are non-cohesive.

The general headings of cohesive and non-cohesive soils may be further sub-divided by several other characteristics such as origin, method of deposition and structure. Soil structure may be classified as deposited or residual. Deposited soils have been transported from their place of formation to anchor location. Residual soils are formed by physical and/or chemical forces breaking down parent rocks or soil to a more finely divided structure. Residual soils are sometimes referred to as weathered.

Soil structure properties can be categorized into loose, dense, honeycombed, flocculated, dispersed or composite. Unfortunately, these soils do not necessarily retain consistency at various depths. Often, they are in layers of different thickness of unlike soils.

Anchoring problems are more complicated for example, when a soft soil layer is sandwiched between two hard or dense layers. Under such circumstances, the relative position of an anchor helix in the soil matrix becomes critical. In these cases, assuming the helix remains rigid and the soil fails, the anchor begins to creep. If the soil fails near the helix, it begins to “flow” around it.

Successful, trouble-free anchoring demands the careful evaluation of local soil conditions and anchor types. Without proper soil/anchor planning, maximum anchor performance can never be assured.

Frost, Water and Soil

Armed with knowledge of soil type or class, the potential effects of frost and water on soil and anchors can be evaluated.

If an anchor helix is in a zone of deep frost penetration, frozen soil will behave as a stiffer soil and will generally yield greater holding capacity. However, when spring thaws begin, soil in the overlying zone will be water-saturated while the layer “housing” the helix will remain frozen. This condition is analogous to a hard layer under a soft layer, and may result in sudden anchor failure. Sometimes anchor “jacking” or movement out of the ground occurs during these conditions.

In areas with permafrost, the helix should be at least three to five feet below the permafrost line, and provisions made to prevent solar energy from being conducted down the anchor.

Anchor holding capacity decreases as moisture content increases. If a helix is installed at the water table level, anchor capacity should be determined based on the water table above the helix. Such a condition can reduce helix capacity by as much as 50 percent in granular soil. (A water table is usually defined as the elevation at which the water will stabilize in an open hole 24 hours after the hole is drilled.)

Water, draining from fine grain soil under load, will permit creep. This is similar to the consolidation phenomena under a foundation. Rapidly applied loads due to wind or ground tremors have little effect on creep so long as they do not exceed soil shear strength. However, line angle structures having high normal loading can cause clay pore water to slowly drain off. Under such circumstances, creep could become troublesome even though the anchor/soil system has not structurally failed. This results in the guy having to be periodically retensioned.

Effective Anchoring

The guiding principle to be used in selecting an anchor system is: FIELD CONDITIONS SHOULD DICTATE THE SYSTEM USED. The office solution, based on the best engineering analysis of the site, is subject to field changes. When a soil change occurs, one must consider how it affects the original solution. Steps must then be taken to compensate for difference due to changes.

SOIL TEST PROBE

A

It has been the custom to select guy anchors on the basis of surface conditions. Maximum guy loads in the order of 20 Kip (20,000 lbs.) permit this practice. Presently, guy loads have shown an increase to 120 Kips and more with the move to guyed transmission lines. This practice calls for guys at every structure. Formerly, only poles at deadends and at angles required guying.

Foundations have long depended upon excavation, penetration and laboratory tests of cores. When construction is concentrated in an area, this is still desirable, but for an overhead line or underground pipe line which may extend for hundreds of miles, economic feasibility requires a less costly yet dependable determination of soil properties.

$$B = \frac{P - 25}{100}$$

B = Bearing Strength (safe working load) Ton/Sq. Ft.
P = Probe Reading

BLOWS/FT	DEPTH	PROBE	DESCRIPTION
	0 —— 0	——	TOPSOIL
	——	——	
13	——	100	
	——	150	GRAY CLAY
	——	225	
	5 —— 5	200	
	——	175	
10	——	175	GRAY CLAY SOME RED CLAY
	——	150	
	——	125	
	10 —— 10	150	
	——	175	
13	——	175	RED CLAY SOME GRAY CLAY TRACES OF SAND
	——	225	
	——	225	
	15 —— 15	250	
	——	225	
20	——	250	LIGHT RED CLAY TRACES OF GRAY CLAY WITH SAND, LIGHT ROCK-WET
	——	300	
	——	225	
	20 —— 20		

Typical Soil Profile

Comparison of an ASTM Penetration Test and Earth Probe Data

The portable Soil Test Probe provides a new dimension. This instrument, portable and operable by one man, will provide reproducible numerical data related to resistance of the soil to flow under load. It may be used in soils up to the consistency of hard pan, to any depth below the surface and without the need to make an excavation or otherwise disturb the soil.

The probe shown consists of a head on a square shaft with a number of extensions, all of which may be coupled together. A ratchet wrench with a torque measuring handle is used to install, remove or take readings. Corner marks at one-foot intervals provide means to determine the depth below the surface when a reading is taken.

The hub of the probe head is forced into the ground by application of torque acting on the blade of the probe. Thus the torque required to turn the probe is proportional to the resistance of the soil to penetration of the hub. It is this property of soil which is of interest in making an anchor selection in determining the bearing strength — especially for end bearing screw foundations or footings.

Probe readings can be related back to general soil classifications to determine anchor holding capacities (see chart on page A-4).

For end bearing foundation work, the bearing strength of the soil may be calculated directly from the probe reading.

This heavy-duty probe will withstand torque to 1800 on the scale, so it will not penetrate packed gravel, shale or rock. Thus, for foundation work, other means such as augering will be required to determine the thickness of the hard strata. When the hard strata is penetrated, the probe can be used to evaluate the quality of an underlying softer soil.

As is the case with any instrument, the value of the data taken with the probe will be no better than the care used in conducting the tests. It is best to average the results of several tests in the same area for, even within a few feet, some variances will be found.

The main requirement during probe testing is to ensure the probe advances a full pitch before readings are taken. This is accomplished by application of heavier down pressure on one handle of the wrench while the probe is being screwed into the ground.

When extensive probing is to be done, speed can be increased by using a 1/2-inch, heavy-duty drill motor with reversing switch to install and to remove the probe. Readings are taken while the motor is at rest by engaging the shaft with a crow-foot wrench on the torque handle.

DETERMINING ANCHOR HOLDING CAPACITY

A

Tabulated anchor holding capacities of earth anchors are the result of field tests in different soils as defined by prior Soil Test Probe studies and other recognized soil investigation procedures.

For ease in conducting the soil study, the Soil Test Probe is installed into the earth vertically to the depth at which the anchor is to be placed. An average of probe readings for 3 feet above the anchor and excluding the reading at the anchor is the basis of soil classification.

All Probe and Pull Test data is recorded on Engineering Test Report Sheets (see below).

DATE OF TEST: 12-06-89 PROJECT NO: PA-1514
SHEET 6 OF 8 REQUEST NO: 1-033-89

ANCHOR TYPE: TOUGH ONE - 15 (15000 FT.-LBS.) CAT. NO: C102-5001
DESCRIPTION: 10" DIA HELIX WITH 50 KIP ROD, INSTALLED WITH TOUGH ONE WRENCH AND LEBOW TORQUE INDICATOR

TESTED FOR: ENGINEERING RESEARCH

LOCATION: ODOM'S SINK HOLE NEAR ELDRIDGE, MO
LACLEDE COUNTY, MISSOURI WEATHER: CLOUDY, COLD 35-40 DEGREES
DEPTH INSTALLED: 7 FEET (ALONG ROD) 7 FEET (VERTICAL) 90 DEGREES (ANGLE)

LOAD TEST RESULTS

TEST LOAD (KIPS)	TIME ELAPSED (MIN)	SCALE READING (IN)	DEFLECTION (IN)
5		0.00	0.00
10		0.03	0.03
10	0.50	0.03	0.03
20		0.22	0.22
20	0.50	0.22	0.22
30		0.38	0.38
30	0.50	0.44	0.44
30	0.50	0.44	0.44
40		0.56	0.56
40	0.50	0.63	0.63
40	0.50	0.63	0.63
45		0.72	0.72
45	0.50	0.78	0.78
45	0.50	0.88	0.88
45	0.50	0.94	0.94
45	0.50	0.97	0.97
45	0.50	0.97	0.97
50		1.25	1.25
50	0.50	1.69	1.69
50	0.50	1.72	1.72
50	0.50	1.72	1.72
55	0.50	1.97	1.97
55	0.50	2.28	2.28
55	0.50	2.34	2.34
55	0.50	2.34	2.34
60		2.56	2.56
60	0.50	2.91	2.91
60	0.50	2.91	2.91
62.5		3.00	3.00
62.5	0.50	3.22	3.22
62.5	0.50	3.28	3.28
62.5	0.50	3.28	3.28
65		3.38	3.38
65	0.50	3.63	3.63
65	0.50	3.72	3.72
65	0.50	3.75	3.75
65	0.50	3.75	3.75
5.0		3.19	3.19

INSTALLATION TORQUE

DEPTH ALONG ROD (FT)	INSTALL. TORQUE (LB-FT)	COMMENTS
0.5		
1		
1.5		
2	3.6	
2.5	5	
3	6	
3.5	3.3	
4	3	
4.5	3.2	
5	3.5	
5.5	3.8	
6	14	
6.5		
7	15 +	

ANCHOR RETRIEVED WITH SLIGHT CONE DOWN OF HELIX.

SOIL TEST RESULTS

VERTICAL DEPTH (FT)	TEST DATA	SOIL CLASS

-- SOIL INFORMATION --

SOIL CONSISTED OF ORANGE-RED CLAY MIXED WITH COBBLES OF LIMESTONE. A HARD, TORQUE BUILDING LAYER OF DETERIORATED LIMESTONE AND CLAY WAS PRESENT AT THE 2.5 FT. LAYER AND AT THE 5-6 FT. LAYER.

RESULT SUMMARY

EFFECTIVE TORQUE (LB-FT): 12260 ULTIMATE LOAD (LB): 65000
LOAD @ <= 4" (LB): 65000 LOAD @ <= 1" (LB): 45000

SITE CONDITIONS

CLAY(X) SILT() SAND() GRAVEL(X) COBBLES(X) BOULDERS()
ROCK (TYPE): LIMESTONE
DRY(X) MOIST() SATURATED() HARD() FIRM(X) SOFT()

EQUIPMENT USED: ALTEC D1000 DIGGER DERRICK WITH 20 FT-KIP DIGGER MOTOR, LEBOW TORQUE INDICATOR, TRANSIT, BI-POD PULL TEST UNIT.

TESTED BY: DAN HAMILTON, G. SEIDER
OBSERVED BY: TIM STAELENS, KEVIN CLIZER, TIM QUALHEIM, MIKE DENNIS

REPORT BY: G. SEIDER
APPROVED BY: [signature]

Chance has anchor testing equipment to help utilities plan anchoring requirements.

During the anchor installation, care is taken to ensure regular practices are observed. If any special treatment is used, this is noted on the test data sheet.

The anchor is pulled in line with the intended guy so the results represent the usable holding capacity on the guy. Creep* is measured in line with the pull after some initial load is applied to seat the anchor. The initial load is generally in the order of 2000 pounds. The load is slowly increased throughout the test with stops at increments of load for creep reading. Creep is read with the load stable and the anchor holding.

*Creep-measurement of a point on the anchor rod in relation to a fixed position on the ground and in line with the direction of pull.

Using a transit, anchor creep is monitored as load is applied to the installed anchor.

DETERMINING ANCHOR HOLDING CAPACITY

The holding capacity is the load at 4-inches creep or the maximum load before the creep totals 4-inches.

For foundations, negligible creep is allowable under maximum sustained loads. For foundation anchor tests, using a jacking beam, each increment of load is held until all motion stops before a creep reading is taken. Due to the plastic flow characteristic of earth under load, it may require 15 minutes (more or less) at each increment of load.

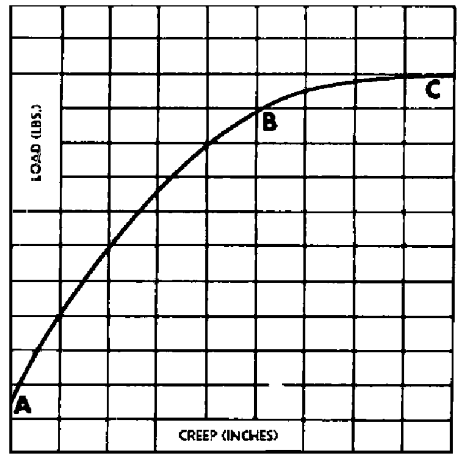
For guyed transmission structures, particularly "Y" and "V" towers, the sustained load is specified some of the time. Sustained high loads in plastic soils will result in less load at 4-inches creep than that obtained by a regular guy anchor test. Because the anchors will be subject to a static load of some magnitude, it is proper that this load should be sustained without creeping. Dynamic loads in excess of the static load are likely to be of very short duration in the form of impulses, so it is hardly necessary to support these high loads without creep.

The method of evaluating an anchor is a load vs. creep (stress-strain) curve. This curve is developed (as shown below) by plotting from the field test data the various loads in pounds with resulting creep in inches. The total load portion of the curve is somewhere between points A and B. This is the actual calculated maximum anchor load plus safety factor. It is common practice today that point B is the general creep range of four to six inches. This is considered the point of maximum load after which the anchor begins to lose its effective holding capacity. Between points B and C the curve will approach a horizontal line. This is called the pull-out load. The shape of the load-creep curve will vary somewhat with different types and sizes of anchors.

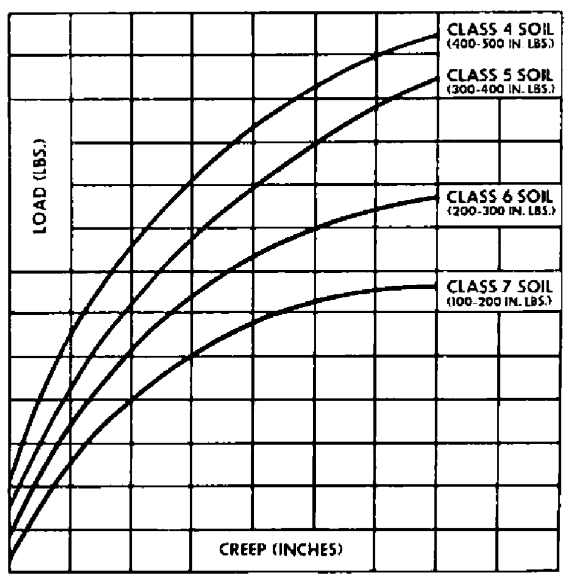
ANCHOR LOADING CHARACTERISTICS

Anchor testing under field conditions is usually done for one of the following reasons:

1. To evaluate a new anchoring method.
2. To determine effect of varied field construction practices.
3. To determine the holding capacity of a given anchor in various soil types.
4. To evaluate several types of anchors in the same type of soil.



Typical Load vs. Creep Curve



Typical Family of Curves

ANCHOR TESTS IN SEVERAL SOILS

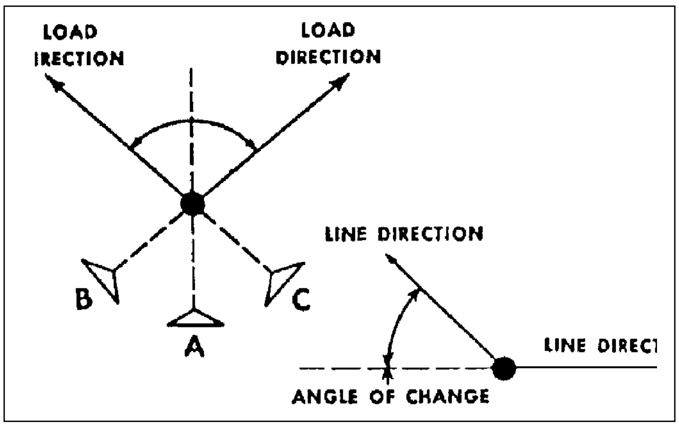
The type of soil will also have an effect on the curve. If a specific type and size of anchor is tested in two or more classes of soils, a family of similar curves will result. A typical curve relationship shows the variations in holding capacity of an anchor tested in Class 4,5,6 and 7 soils.

DETERMINING GUY LOADS

Factors to be considered in guying pole lines are: the weight of the conductor, the size and weight of cross arms and insulators, wind pressure on poles and conductors, strains due to the contour of the earth, line curvatures, pole heights and deadend loads, plus the vertical load due to sleet and ice. To reduce unbalanced stresses to a minimum, correct angling and positioning of guy wires is essential. Where obstructions make it impossible to locate a single guy in line with the load or pull, two or more guys can be installed with their resultant guying effort in line with the load.

Where lines make an abrupt change in direction, the guy anchor is normally placed so it bisects the angle formed by the two extended tangents. Under heavy load conditions, it may be necessary to use two anchors, each deadending a leg of the line load along the extended tangents. Long straight spans require occasional side and end guys to compensate for heavy icing and crosswinds on conductors and poles.

These, and all other factors that might make it advisable to use guys, should be carefully considered in initial designs for line construction.



LINE LOADS ON DEADENDS

To compute the load on the guy, the line load must first be determined. When the line is deadended, the line load can be calculated by multiplying the ultimate breaking strength of the conductor used (S) times the number conductors (N).

For example, if three 1/0 ACSR conductors are deadended on a pole, the line load will be 12,840 pounds:

S	x	N	=	Line Load
4280	x	3	=	12,840

The ultimate breaking strength of selected conductors is found in the conductor size tables on page A-13.

LINE LOADS ON ANGLE LINES

To determine the line load to be guyed on a single anchor where the line changes direction, multiply the ultimate breaking strength of the conductor used (S) times the number of conductors used (N), then refer to the chart on page A-10. Locate your line load in pounds. Read across until under angle change of line direction in degrees, then read your line load to be guyed in pounds.

HOW TO DETERMINE THE GUY LOAD

After the line load is known, the chart at right (page A-9) is used as a quick reference for determining the load on the guy at different angles of pull.

In using breaking strength of conductor, it should be considered that conductor properly sagged (N.E.S. code) will not exceed 60% of its breaking strength when fully loaded. This automatically allows a safety factor of $1^2/_3$*. However, additional safety factors will be required on important crossings, especially over highways, railroads or rivers where safety factors of 2 and 3 are generally used. After the guy has been found, select an anchor with holding capacity in desired soil class allowing for the desired safety factor.

*Obviously, many may prefer to calculate line loads based on actual maximum tensions rather than ultimates, then apply the approximate safety factor.

ANCHOR ROD STRENGTH

NOMINAL ROD DIAMETER	ULTIMATE STRENGTH
5/8"	16,000 lbs.
3/4"	23,000 lbs.
1"	36,000 lbs.
1" High Strength	50,000 lbs.

GUY LOAD REFERENCE

When the line is deadended

Guy Load in Pounds

Line Load in Pounds	Guy Angle from Pole in Degrees															
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
1,000	5,759	3,864	2,924	2,366	2,000	1,743	1,556	1,414	1,305	1,221	1,155	1,103	1,064	1,035	1,105	1,004
2,000	11,518	7,727	5,848	4,732	4,000	3,487	3,111	2,828	2,611	2,442	2,309	2,207	2,128	2,071	2,031	2,008
3,000	17,276	11,591	8,771	7,099	6,000	5,230	4,667	4,243	3,916	3,662	3,464	3,310	3,193	3,106	3,046	3,011
4,000	23,035	15,455	11,695	9,465	8,000	6,974	6,223	5,657	5,222	4,883	4,619	4,414	4,257	4,141	4,062	4,015
5,000	28,794	19,319	14,619	11,831	10,000	8,717	7,779	7,071	6,527	6,104	5,774	5,517	5,321	5,176	5,077	5,019
6,000	34,553	23,182	17,543	14,197	12,000	10,461	9,334	8,485	7,832	7,325	6,928	6,620	6,385	6,212	6,093	6,023
7,000	40,311	27,046	20,467	16,563	14,000	12,204	10,890	9,899	9,138	8,545	8,083	7,724	7,449	7,247	7,108	7,027
8,000	46,070	30,910	23,390	18,930	16,000	13,948	12,446	11,314	10,443	9,766	9,238	8,827	8,513	8,282	8,123	8,031
9,000	51,829	34,773	26,314	21,296	18,000	15,691	14,002	12,728	11,749	10,987	10,392	9,930	9,578	9,317	9,139	9,034
10,000	57,588	38,637	29,238	23,662	20,000	17,434	15,557	14,142	13,054	12,208	11,547	11,034	10,642	10,353	10,154	10,038
11,000	63,346	42,501	32,162	26,028	22,000	19,178	17,113	15,556	14,359	13,429	12,702	12,137	11,706	11,388	11,170	11,042
12,000	69,105	46,364	35,086	28,394	24,000	20,921	18,669	16,971	15,665	14,649	13,856	13,241	12,770	12,423	12,185	12,046
13,000	74,864	50,228	38,009	30,761	26,000	22,665	20,224	18,385	16,970	15,870	15,011	14,344	13,834	13,459	13,201	13,050
14,000	80,623	54,092	40,933	33,127	28,000	24,408	21,780	19,799	18,276	17,091	16,166	15,447	14,898	14,494	14,216	14,053
15,000	86,382	57,956	43,857	35,493	30,000	26,152	23,336	21,213	19,581	18,312	17,321	16,551	15,963	15,529	15,231	15,057
16,000	92,140	61,819	46,781	37,859	32,000	27,895	24,892	22,627	20,887	19,532	18,475	17,654	17,027	16,564	16,247	16,061
17,000	97,899	65,683	49,705	40,225	34,000	29,639	26,447	24,042	22,192	20,753	19,630	18,757	18,091	17,600	17,262	17,065
18,000	103,658	69,547	52,628	42,592	36,000	31,382	28,003	25,456	23,497	21,974	20,785	19,861	19,155	18,635	18,278	18,069
19,000	109,417	73,410	55,552	44,958	38,000	33,125	29,559	26,870	24,803	23,195	21,939	20,964	20,219	19,670	19,293	19,073
20,000	115,175	77,274	58,476	47,324	40,000	34,869	31,114	28,284	26,108	24,415	23,094	22,068	21,284	20,706	20,309	20,076
21,000	120,934	81,138	61,400	49,690	42,000	36,612	32,670	29,698	27,414	25,636	24,249	23,171	22,384	21,741	21,324	21,080
22,000	126,693	85,001	64,324	52,056	44,000	38,356	34,226	31,113	28,719	26,857	25,403	24,274	23,412	22,776	22,339	22,084
23,000	132,452	88,865	67,248	54,423	46,000	40,099	35,782	32,527	30,024	28,078	26,558	25,378	24,476	23,811	23,355	23,088
24,000	138,210	92,729	70,171	56,789	48,000	41,843	37,337	33,941	31,330	29,299	27,713	26,481	25,540	24,847	24,370	24,092
25,000	143,969	96,593	73,095	59,155	50,000	43,586	38,893	35,355	32,635	30,519	28,868	27,584	26,604	25,882	25,386	25,095
26,000	149,728	100,456	76,019	61,521	52,000	45,330	40,449	36,770	33,941	31,740	30,022	28,688	27,669	26,917	26,401	26,099
27,000	155,487	104,320	78,943	63,887	54,000	47,073	42,005	38,184	35,246	32,961	31,177	29,791	28,733	27,952	27,417	27,103
28,000	161,246	108,184	81,867	66,254	56,000	48,817	43,560	39,598	36,551	34,182	32,332	30,895	29,797	28,988	28,432	28,107
29,000	167,004	112,047	84,790	68,620	58,000	50,560	45,116	41,012	37,857	35,402	33,486	31,998	30,861	30,023	29,447	29,111
30,000	172,763	115,911	87,714	70,986	60,000	52,303	46,672	42,426	39,162	36,623	34,641	33,101	31,925	31,058	30,463	30,115
31,000	178,522	119,775	90,638	73,352	62,000	54,047	48,227	43,841	40,468	37,844	35,796	34,205	32,990	32,094	31,478	31,118
32,000	184,281	123,639	93,562	75,718	64,000	55,790	49,783	45,255	41,773	39,065	36,950	35,308	34,054	33,129	32,494	32,122
33,000	190,039	127,502	96,486	78,085	66,000	57,534	51,339	46,669	43,078	40,286	38,105	36,411	35,118	34,164	33,509	33,126
34,000	195,798	131,366	99,409	80,451	68,000	59,277	52,895	48,083	44,384	41,506	39,260	37,515	36,182	35,199	34,525	34,130
35,000	201,557	135,230	102,333	82,817	70,000	61,021	54,450	49,497	45,689	42,727	40,415	38,618	37,246	36,235	35,540	35,134
36,000	207,316	139,093	105,257	85,183	72,000	62,764	56,006	50,912	46,995	43,948	41,569	39,722	38,310	37,270	36,555	36,138
37,000	213,075	142,957	108,181	87,549	74,000	64,508	57,562	52,326	48,300	45,169	42,724	40,825	39,375	38,305	37,571	37,141
38,000	218,833	146,821	111,105	89,916	76,000	66,251	59,118	53,740	49,605	46,389	43,879	41,928	40,439	39,340	38,586	38,145
39,000	224,592	150,684	114,028	92,282	78,000	67,994	60,673	55,154	50,911	47,610	45,033	43,032	41,503	40,376	39,602	39,149
40,000	230,351	154,548	116,952	94,648	80,000	69,738	62,229	56,569	52,216	48,831	46,188	44,135	42,567	41,411	40,617	40,153
41,000	236,110	158,412	119,876	97,014	82,000	71,481	63,785	57,983	53,522	50,052	47,343	45,238	43,631	42,466	41,632	41,157
42,000	241,868	162,276	122,800	99,380	84,000	73,225	65,340	59,397	54,827	51,273	48,497	46,342	44,695	43,482	42,648	42,160
43,000	247,627	166,139	125,724	101,747	86,000	74,968	66,896	60,811	56,133	52,493	49,652	47,445	45,760	44,517	43,663	43,164
44,000	253,386	170,003	128,647	104,113	88,000	76,712	68,452	62,225	57,438	53,714	50,807	48,549	46,824	45,552	44,679	44,168
45,000	259,145	173,867	131,571	106,479	90,000	78,455	70,008	63,640	58,743	54,935	51,962	49,652	47,888	46,587	45,694	45,172
46,000	264,903	177,730	134,495	108,845	92,000	80,199	71,563	65,054	60,049	56,156	53,116	50,755	48,952	47,623	46,710	46,176
47,000	270,662	181,594	137,419	111,211	94,000	81,942	73,119	66,468	61,354	57,376	54,271	51,859	50,016	48,658	47,725	47,180
48,000	276,421	185,458	140,343	113,578	96,000	83,685	74,675	67,882	62,660	58,597	55,426	52,962	51,081	49,693	48,740	48,183
49,000	282,180	189,321	143,266	115,944	98,000	85,429	76,230	69,296	63,965	59,818	56,580	54,066	52,145	50,729	49,756	49,187
50,000	287,939	193,185	146,190	118,310	100,000	87,172	77,786	70,711	65,270	61,039	57,735	55,169	53,209	51,764	50,771	50,191

ANGLE LOAD REFERENCE

When guy and anchor bisects the angle formed

Line Load to be Guyed in Pounds

Line Load in Pounds	Angle Change of Line Direction in Degrees															
	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
1,000	261	347	433	518	601	684	765	845	924	1,000	1,075	1,147	1,218	1,286	1,351	1,414
2,000	522	694	866	1,036	1,202	1,368	1,530	1,690	1,848	2,000	2,150	2,294	2,436	2,572	2,702	2,828
3,000	783	1,041	1,299	1,554	1,803	2,052	2,295	2,535	2,772	3,000	3,225	3,441	3,654	3,858	4,053	4,242
4,000	1,044	1,388	1,732	2,072	2,404	2,736	3,060	3,380	3,696	4,000	4,300	4,588	4,872	5,144	5,404	5,656
5,000	1,305	1,735	2,165	2,590	3,005	3,420	3,825	4,225	4,620	5,000	5,375	5,735	6,090	6,430	6,755	7,070
6,000	1,566	2,082	2,598	3,108	3,606	4,104	4,590	5,070	5,544	6,000	6,450	6,882	7,308	7,716	8,106	8,484
7,000	1,827	2,429	3,031	3,626	4,207	4,788	5,355	5,915	6,468	7,000	7,525	8,029	8,526	9,002	9,457	9,898
8,000	2,088	2,776	3,464	4,144	4,808	5,472	6,120	6,760	7,392	8,000	8,600	9,176	9,744	10,288	10,808	11,312
9,000	2,349	3,123	3,897	4,662	5,409	6,156	6,885	7,605	8,316	9,000	9,675	10,323	10,962	11,574	12,159	12,726
10,000	2,610	3,470	4,330	5,180	6,010	6,840	7,650	8,450	9,240	10,000	10,750	11,470	12,180	12,860	13,510	14,140
11,000	2,871	3,817	4,763	5,698	6,611	7,524	8,415	9,295	10,164	11,000	11,825	12,617	13,398	14,146	14,861	15,554
12,000	3,132	4,164	5,196	6,216	7,212	8,208	9,180	10,140	11,088	12,000	12,900	13,764	14,616	15,432	16,212	16,968
13,000	3,393	4,511	5,629	6,734	7,813	8,892	9,945	10,985	12,012	13,000	13,975	14,911	15,834	16,718	17,563	18,382
14,000	3,654	4,858	6,062	7,252	8,414	9,576	10,710	11,830	12,936	14,000	15,050	16,058	17,052	18,004	18,914	19,796
15,000	3,915	5,205	6,495	7,770	9,015	10,260	11,475	12,675	13,860	15,000	16,125	17,205	18,270	19,290	20,265	21,210
16,000	4,176	5,552	6,928	8,288	9,616	10,944	12,240	13,520	14,784	16,000	17,200	18,352	19,488	20,576	21,616	22,624
17,000	4,437	5,899	7,361	8,806	10,217	11,628	13,005	14,365	15,708	17,000	18,275	19,499	20,706	21,862	22,967	24,038
18,000	4,698	6,246	7,794	9,324	10,818	12,312	13,770	15,210	16,632	18,000	19,350	20,646	21,924	23,148	24,318	25,452
19,000	4,959	6,593	8,227	9,842	11,419	12,996	14,535	16,055	17,556	19,000	20,425	21,793	23,142	24,434	25,669	26,866
20,000	5,220	6,940	8,660	10,360	12,020	13,680	15,300	16,900	18,480	20,000	21,500	22,940	24,360	25,720	27,020	28,280
21,000	5,481	7,287	9,093	10,878	12,621	14,364	16,065	17,745	19,404	21,000	22,575	24,087	25,578	27,006	28,371	29,694
22,000	5,742	7,634	9,526	11,396	13,222	15,048	16,830	18,590	20,328	22,000	23,650	25,234	26,796	28,292	29,722	31,108
23,000	6,003	7,981	9,959	11,914	13,823	15,732	17,595	19,435	21,252	23,000	24,725	26,381	28,014	29,578	31,073	32,522
24,000	6,264	8,328	10,392	12,432	14,424	16,416	18,360	20,280	22,176	24,000	25,800	27,528	29,232	30,864	32,424	33,936
25,000	6,525	8,675	10,825	12,950	15,025	17,100	19,125	21,125	23,100	25,000	26,875	28,675	30,450	32,150	33,775	35,350
26,000	6,786	9,022	11,258	13,468	15,626	17,784	19,890	21,970	24,024	26,000	27,950	29,822	31,668	33,436	35,126	36,764
27,000	7,047	9,369	11,691	13,986	16,227	18,468	20,655	22,815	24,948	27,000	29,025	30,969	32,886	34,722	36,477	38,178
28,000	7,308	9,716	12,124	14,504	16,828	19,152	21,420	23,660	25,872	28,000	30,100	32,116	34,104	36,008	37,828	39,592
29,000	7,569	10,063	12,557	15,022	17,429	19,836	22,185	24,505	26,796	29,000	31,175	33,263	35,322	37,294	39,179	41,006
30,000	7,830	10,410	12,990	15,540	18,030	20,520	22,950	25,350	27,720	30,000	32,250	34,410	36,540	38,580	40,530	42,420
31,000	8,091	10,757	13,423	16,058	18,631	21,204	23,715	26,195	28,644	31,000	33,325	35,557	37,758	39,866	41,881	43,834
32,000	8,352	11,104	13,856	16,576	19,232	21,888	24,480	27,040	29,568	32,000	34,400	36,704	38,976	41,152	43,232	45,248
33,000	8,613	11,451	14,289	17,094	19,833	22,572	25,245	27,885	30,492	33,000	35,475	37,851	40,194	42,438	44,583	46,662
34,000	8,874	11,798	14,722	17,612	20,434	23,256	26,010	28,730	31,416	34,000	36,550	38,998	41,412	43,724	45,934	48,076
35,000	9,135	12,145	15,155	18,130	21,035	23,940	26,775	29,575	32,340	35,000	37,625	40,145	42,630	45,010	47,285	49,490
36,000	9,396	12,492	15,588	18,648	21,636	24,624	27,540	30,420	33,264	36,000	38,700	41,292	43,848	46,296	48,636	50,904
37,000	9,657	12,839	16,021	19,166	22,237	25,308	28,305	31,265	34,188	37,000	39,775	42,439	45,066	47,582	49,987	52,318
38,000	9,918	13,186	16,454	19,684	22,838	25,992	29,070	32,110	35,112	38,000	40,850	43,586	46,284	48,868	51,338	53,732
39,000	10,179	13,533	16,887	20,202	23,439	26,676	29,835	32,955	36,036	39,000	41,925	44,733	47,502	50,154	52,689	55,146
40,000	10,440	13,880	17,320	20,720	24,040	27,360	30,600	33,800	36,960	40,000	43,000	45,880	48,720	51,440	54,040	56,560
41,000	10,701	14,227	17,753	21,238	24,641	28,044	31,365	34,645	37,884	41,000	44,075	47,027	49,939	52,726	55,391	57,974
42,000	10,962	14,574	18,186	21,756	25,242	28,728	32,130	35,490	38,808	42,000	45,150	48,174	51,156	54,012	56,742	59,388
43,000	11,223	14,921	18,619	22,274	25,843	29,412	32,895	36,335	39,732	43,000	46,225	49,321	52,374	55,298	58,093	60,802
44,000	11,484	15,268	19,052	22,792	26,444	30,096	33,660	37,180	40,656	44,000	47,300	50,468	53,592	56,584	59,444	62,216
45,000	11,745	15,615	19,485	23,310	27,045	30,780	34,425	38,025	41,580	45,000	48,375	51,615	54,810	57,870	60,795	63,630
46,000	12,006	15,962	19,918	23,828	27,646	31,464	35,190	38,870	42,504	46,000	49,450	52,762	56,028	59,156	62,146	65,044
47,000	12,267	16,309	20,351	24,346	28,247	32,148	35,955	39,715	43,428	47,000	50,525	53,909	57,246	60,442	63,497	66,458
48,000	12,528	16,656	20,784	24,864	28,848	32,832	36,720	40,560	44,352	48,000	51,600	55,056	58,464	61,728	64,848	67,872
49,000	12,789	17,003	21,217	25,382	29,449	33,516	37,485	41,405	45,276	49,000	52,675	56,203	59,682	63,014	66,199	69,286
50,000	13,050	17,350	21,650	25,900	30,050	34,200	38,250	42,250	46,200	50,000	53,750	57,350	60,900	64,300	67,550	70,700

Bisect — to divide into two equal parts.

GUY STRAND REFERENCE

Sizes and strengths of Galvanized Strand

Zinc-Coated Steel Wire Strand

Nominal Diameter of Strand in Inches	No. of Wires in Strand	Minimum Breaking Strength of Strand in Pounds				
		Utilities Grade	Common Grade	Siemens-Martin Grade	High-Strength Grade	Extra High-Strength Grade
1/8	7	—	540	910	1,330	1,830
5/32	7	—	870	1,470	2,140	2,940
3/16	7	—	1,150	1,900	2,850	3,990
3/16	7	2,400	—	—	—	—
7/32	3	—	1,400	2,340	3,500	4,900
7/32	7	—	1,540	2,560	3,850	5,400
1/4	3	3,150	1,860	3,040	4,730	6,740
1/4	3	4,500	—	—	—	—
1/4	7	—	1,900	3,150	4,750	6,650
9/32	3	—	2,080	3,380	5,260	7,500
9/32	7	4,600	2,570	4,250	6,400	8,950
5/16	3	6,500	2,490	4,090	6,350	9,100
5/16	7	—	3,200	5,350	8,000	11,200
5/16	7	6,000	—	—	—	—
3/8	3	8,500	3,330	5,560	8,360	11,800
3/8	7	11,500	4,250	6,950	10,800	15,400
7/16	7	18,000	5,700	9,350	14,500	20,800
1/2	7	25,000	7,400	12,100	18,800	26,900
1/2	19	—	7,620	12,700	19,100	26,700
9/16	7	—	9,600	15,700	24,500	35,000
9/16	19	—	9,640	16,100	24,100	33,700
5/8	7	—	11,600	19,100	29,600	42,400
5/8	19	—	11,000	18,100	28,100	40,200
3/4	19	—	16,000	26,200	40,800	58,300
7/8	19	—	21,900	35,900	55,800	79,700
1	19	—	28,700	47,000	73,200	104,500
1	37	—	28,300	46,200	71,900	102,700
1 1/8	37	—	36,000	58,900	91,600	130,800
1 1/4	37	—	44,600	73,000	113,600	162,200

Sizes and strengths of Aluminum-Coated Strand

Aluminum-Coated Steel Wire Strand

3/16	7	—	1,150	1,900	2,850	—
3/16	7	2,400	—	—	—	—
1/4	3	3,150	—	—	—	—
1/4	3	4,500	—	—	—	—
1/4	7	—	1,900	3,150	4,750	6,650
9/32	7	4,600	—	—	—	—
5/16	3	6,500	—	—	—	—
5/16	7	—	3,200	5,350	8,000	11,200
5/16	7	6,000	—	—	—	—
3/8	3	8,500	—	—	—	—
3/8	7	11,500	4,250	6,950	10,850	15,400
7/16	7	18,000	5,700	9,350	14,500	20,800
1/2	7	25,000	7,400	12,100	18,800	26,900

GUY STRAND REFERENCE

A

Sizes and strengths of Aluminum-Clad Strand

Aluminum-Clad Steel Wire Strand

Designation No. and Size of Wire (AWG)	Nominal Diameter (in.)	Minimum Breaking Strength of Strand in Pounds				
		3 Wire	7 Wire	19 Wire	37 Wire	M-Strand
3#10	.220	4,532	—	—	—	—
3#9	.247	5,715	—	—	—	—
3#8	.277	7,206	—	—	—	—
3#7	.311	8,621	—	—	—	—
3#6	.349	10,280	—	—	—	—
3#5	.392	12,230	—	—	—	—
7#12	.242 (1/4)	—	6,301	—	—	—
7#11	.272	—	7,945	—	—	—
7#10	.306 (5/16)	—	10,020	—	—	—
7#9	.343 (11/32)	—	12,630	—	—	—
7#8	.385 (3/8)	—	15,930	—	—	—
7#7	.433 (7/16)	—	19,060	—	—	—
7#6	.486 (1/2)	—	22,730	—	—	—
7#5	.546	—	27,030	—	—	—
19#10	.509	—	—	27,190	—	—
19#9	.572	—	—	34,290	—	—
19#8	.642	—	—	43,240	—	—
19#7	.721	—	—	51,730	—	—
19#6	.810	—	—	61,700	—	—
19#5	.910	—	—	73,350	—	—
37#10	.713	—	—	—	52,950	—
37#9	.801	—	—	—	66,770	—
37#8	.899	—	—	—	84,180	—
37#7	1.010	—	—	—	100,700	—
37#6	1.130	—	—	—	120,100	—
37#5	1.270	—	—	—	142,900	—

Sizes and strengths of Aluminum-Clad M-Strand

Aluminum-Clad Steel Wire M-Strand

4M	.220	—	—	—	—	4,000
5M	.247	—	—	—	—	5,000
6M	.242	—	—	—	—	6,000
7M	.277	—	—	—	—	7,000
8M	.272	—	—	—	—	8,000
10M	.306	—	—	—	—	10,000
12.5M	.343	—	—	—	—	12,500
14M	.363	—	—	—	—	14,000
16M	.386	—	—	—	—	16,000
18M	.417	—	—	—	—	18,000
20M	.444	—	—	—	—	20,000
25M	.519	—	—	—	—	25,000

CONDUCTOR SIZES AND STRENGTHS

A

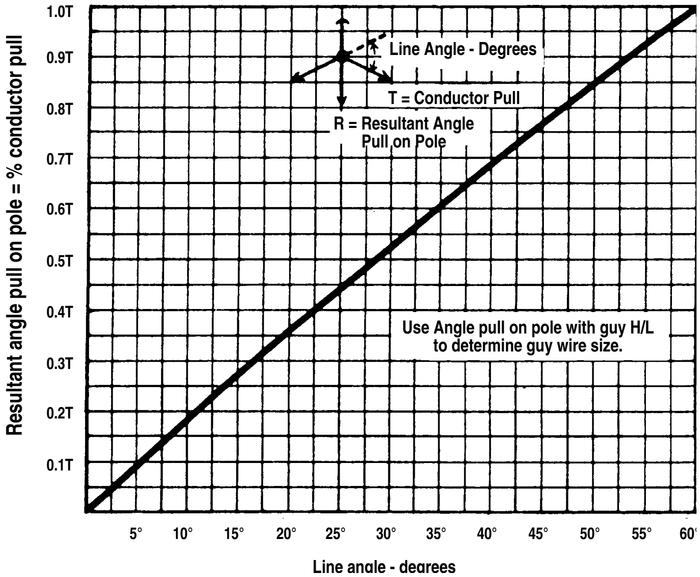
ALUMINUM STRANDED

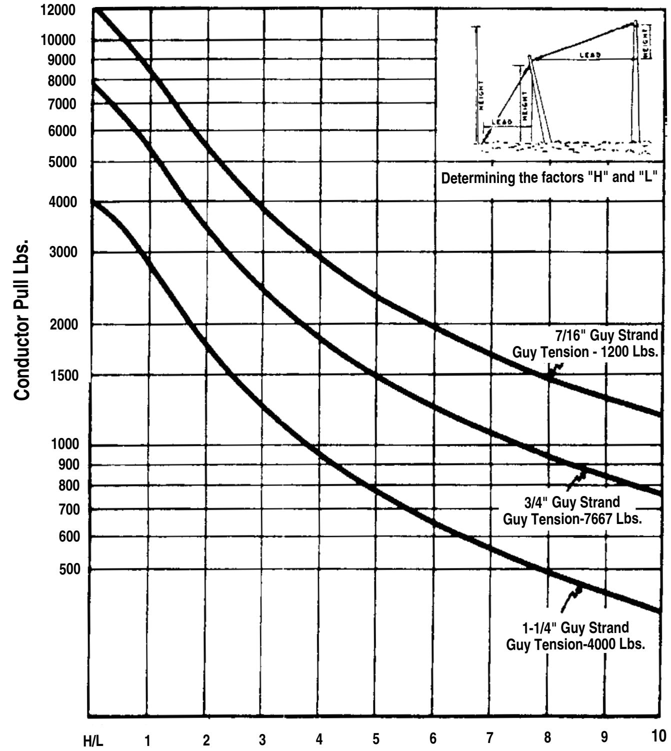
Circular Mils or A.W.G.	No. of Strands	Dia. Inches	Ultimate Strength Pounds
6	7	.184	528
4	7	.232	826
3	7	.260	1022
2	7	.292	1266
1	7	.328	1537
1/0	7	.368	1865
2/0	7	.414	2350
3/0	7	.464	2845
4/0	7	.522	3590
266.8	7	.586	4525
266.8	19	.593	4800
336.4	19	.666	5940
397.5	19	.724	6880
477	19	.793	8090
477	37	.795	8600
556.5	19	.856	9440
556.5	37	.858	9830
636	37	.918	11240
715.5	37	.974	12640
715.5	61	.975	13150
795	37	1.026	13770
795	61	1.028	14330
874.5	37	1.077	14830
874.5	61	1.078	15760
954	37	1.124	16180
954	61	1.126	16860
1033.5	37	1.170	17530
1033.5	61	1.172	18260
1113	61	1.216	19660
1272	61	1.300	22000
1431	61	1.379	24300
1590	61	1.424	27000
1590	91	1.454	28100

ACSR

Circular Mils or A.W.G.	No. of Strands	Dia. Inches	Ultimate Strength Pounds
6	6x 1	.198	1170
6	6x 1	.223	1490
4	6x 1	.250	1830
4	7x 1	.257	2288
3	6x 1	.281	2250
2	6x 1	.316	2790
2	7x 1	.325	3525
1	6x 1	.355	3480
1/0	6x 1	.398	4280
2/0	6x 1	.447	5345
3/0	6x 1	.502	6675
4/0	6x 1	.563	8420
266.8	18x 1	.609	7100
266.8	6x 7	.633	9645
266.8	26x 7	.642	11250
300	26x 7	.680	12650
336.4	18x 1	.684	8950
336.4	26x 7	.721	14050
336.4	30x 7	.741	17040
397.5	18x 1	.743	10400
397.5	26x 7	.783	16190
397.5	30x 7	.806	19980
477	18x 1	.814	12300
477	24x 7	.846	17200
477	26x 7	.858	19430
477	30x 7	.883	23300
556.5	26x 7	.914	19850
556.5	26x 7	.927	22400
556.5	30x 7	.953	27200
605	24x 7	.953	21500
605	26x 7	.966	24100
605	30x19	.994	30000
636	24x 7	.977	22600
636	26x 7	.990	25000
636	30x19	1.019	31500
666.6	24x 7	1.000	23700
715.5	54x 7	1.036	26300
715.5	26x 7	1.051	28100
715	30x19	1.081	34600
795	54x 7	1.093	28500
795	26x 7	1.108	31200
795	30x19	1.140	38400
874.5	54x 7	1.146	31400
900	54x 7	1.162	32300
954	54x 7	1.196	34200
1033.5	54x 7	1.246	37100
1113	54x19	1.292	40200
1272	54x19	1.382	44800
1431	54x19	1.465	50400
1590	54x19	1.545	56000

These curves were furnished through the courtesy of the Puget Sound Power and Light Company and illustrate utility practices in determining the pull on angle structures and in selecting guy wire sizes. Similar practices were reported by other utilities.





Determining Pull on Angle Structure

Extend the vertical line for the line angle degree until it intersects the curve. The intersecting horizontal line is the percentage of conductor pull. Multiplying the conductor pull times this percentage will give the resultant pull on the pole.

Determining Size of Guy Strand

Extend the horizontal line for the particular conductor pull at deadends, unbalanced pull in angle construction or on crossarms, until it intersects the vertical line for the ratio of H/L at which the guy will be installed.

Use the size of guy wire indicated by the curve above this intersection point. In case the intersection point is above the 7/16 inch guy strand curve, multiple guys should be used, or the conductor tensions reduced.

NOTE—The maximum working tensions shown for the curves above are 2/3 of minimum ultimate strengths for utility grade guy strand.