American Rental Association

Tent Stake Study

Guidance Document

v.08.06.2025

Scope & Purpose

The tenting industry has long grappled with accurately determining the holding strength of tent stakes in different soil types and compactions. Knowing the holding capacity of a staked tent is crucial for ensuring the safety and stability of the temporary structure. To address this critical need, The American Rental Association (ARA) funded a study with Clemson University Multiscale Manufacturing Laboratory.

The implications of this study are far-reaching for the tenting industry. With a reliable method for determining the holding strength of tent stakes, installers will be equipped with critical information to make informed decisions about site selection, stake choice, and the appropriate number of stakes to ensure overall tent stability. In some cases, the information learned from a site survey may lead installers to use alternative ballasting solutions instead of staking if soil conditions are not compatible with the manufacturer's requirements for proper anchoring.

This guidance document will focus on the first of two distinct parts of the study with Clemson University. The second part will be discussed in a subsequent document.

Part 1: Tent Stake Study

Objective 1: Compare tent stake holding force depending on tent stake age, surface rust or surface corrosion, and pitting.

Objective 2: Compare tent stake holding force depending on the guy angle off the top of the tent stake (i.e. 45˚ guy angle vs. 60˚ guy angle).

Objective 3: Determine the effects of stake holding force based on moisture content of soil.

Part 2: ARA GT Tool

(Not covered in this guidance document)

Objective 1: Establish a correlation between the scale on the ARA GT Tool and the holding forces expected from tenting stakes in different soil types.

Objective 2: Validate the ARA GT Tool's scale and function in quickly evaluating the estimated holding power of tent stakes across a potential installation site.

The overall objective of this study is to:

- Prevent accidents, personal injuries, and property damage.
- Establish and provide an understanding of the holding power of tent stakes and how different variables in installation, soil moisture content, soil type, and soil density/compaction can affect the holding power of the tent stake.
- Promote safe installation of staked tents by ensuring proper holding power requirements are met, per the manufacturer's requirements.
- Increase overall awareness and education for installers of staked tents.

Background Information

Soil

Most soils have three types of mineral particles: Sand, silt, or clay. Soils with different amounts of sand, silt, and clay are given different names. Classifications are typically named after the primary constituent particle size or a combination of the most abundant particle sizes. There are twelve types of soils based on their texture: sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. These types are divided into four groups according to their stability (run-off potential): Type O, Type A, Type B, and Type C. Type A is the most stable of the four, with clay soils being its primary constituent, whereas Type C is the least stable.

Soil types differ in terms of physical, chemical, and geotechnical qualities. Physical properties include texture, structure, porosity, consistency, temperature, color, and horizonation. Geotechnical properties include grain-sized distribution, plasticity, compressibility, and shear strength. Both physical and geotechnical properties are critical in determining the use of soil for various agricultural, engineering, construction, and recreational purposes.

NOTE: In areas where natural soil layers have been disrupted or modified (examples being urban areas, cities, or construction and building sites), there is always an unknown aspect of soil layers. In most cases, modified fill could be beneath the topsoil. It is common for filler soil to be made up of construction debris that can include block, brick, rock, asphalt, wood, roots, pipes, cement, clay, or other miscellaneous materials. It is important for tent installers to take into consideration the site conditions, including potential anomalies, abnormalities, and unknown fill beneath the topsoil.

Soil Horizons

Soil is made up of distinct horizontal layers known as soil horizons. We examined four distinct types of soil layers that can be visibly, chemically, and/or physically categorized as O, A, B, and C. Typically, most soils have three major soil layers- Topsoil A, Subsoil B, and Substratum C.

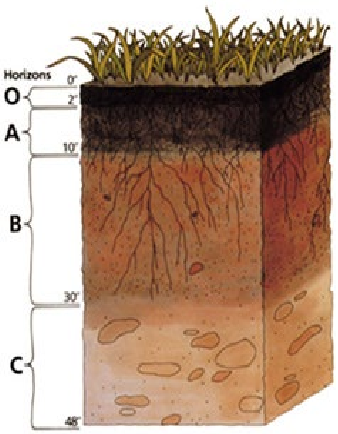

Figure 1. *USDA Soil Profile Diagram.*

- **Organic Horizon O:** This layer has various stages of decomposed organic matter. Because of its organic content, it is typically dark brown or black in color. It is up to two inches thick below the surface.
- **Topsoil\Surface Horizon A:** This layer is comparatively darker in color than the other horizons (B, C) due to its organic content. It is also coarser compared to underlying layers. It is five to ten inches thick below Layer O.
- **Subsoil B:** This subsoil has more clay content than other layers due to clay accumulation. It is much thicker than topsoil. It is ten to twelve inches below working depth and nearly 20-25 inches thick.
- **Substratum C:** This layer consists of slightly broken bedrock. Very little organic matter is found in this layer, which makes it lighter in color as compared to other layers (except E). It is around 15-20 inches thick.

An arrangement of these soil horizons (soil profile) is shown in Figure 1.

Soil Compaction

Soil compaction is the pressing of soil particles and reduction of pore space between them. Soil compaction increases the ability of soil to resist being moved by an external force. Soil compaction depends on soil structure, texture, and soil moisture. Clay-like soils are difficult to compact because the moisture retained allows movement of clay particles. Sand is also less susceptible to compaction due to large grain size. Moderately textured soils like silt loam, sandy loam, and loams are more easily compressed.

Dry soils are difficult to compact because the friction between particles prevents movement. At the same time, very wet soils are also difficult to compress; water must be squeezed out for the compaction to occur.

Moisture Holding Capacity

Moisture can interfere with the accuracy of test results; hence, it is critical to understand the moisture retention capacity of soil. The factor that primarily affects soil moisture is its texture. Moisture holding capacity increases as soil structure changes from coarse to fine grained. Coarse grained soil has lower water holding capacity, as it has large pores and is more prone to free drainage. Soil cohesion is also significantly affected by water content. As water content increases, cohesion decreases. This is because increased water content induces clay particle separation (and hence easier sliding) as well as weakening of soil cements.

Testing Equipment

Testing was conducted using the equipment below.

Rhino Multipro Tent Stake Driver 	MSI 7300-5000 Dynalink 2 Dynamometer 	Humboldt Proving Ring Penetrometer 
Warn 45S Powersports Winch 	NW Quik Pull Fence Post Puller 	Reotemp Moisture Meter 

Stake Pull Test

The testing rig was comprised of a variety of standard tent stakes (40" length x 1" diameter). Tent stakes were fully driven into the soil, and a pull test was implemented. The peak force was measured until the tent stake visually failed by pulling out of the soil.

The stake pull tests were all conducted with the same pulling rig. Measurements on the pull angle were taken prior to each pull test to ensure they were tested at a true 45˚angle and then again at a true 60˚ angle (Fig. 2-4). Stake pull tests were conducted within close proximity to one another with the attempt to ensure similar soil characteristics.

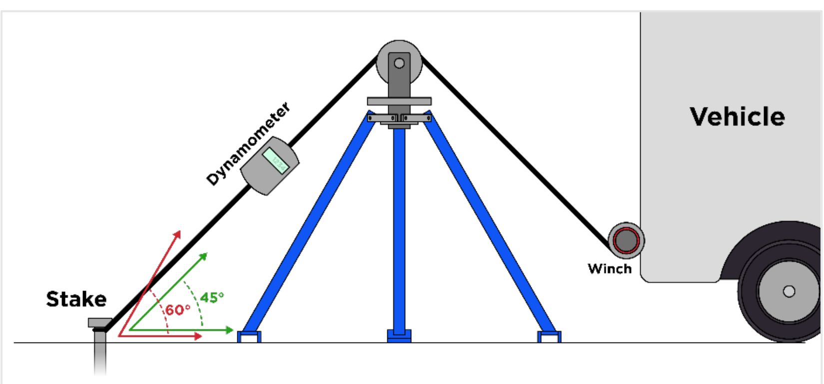

Figure 2.

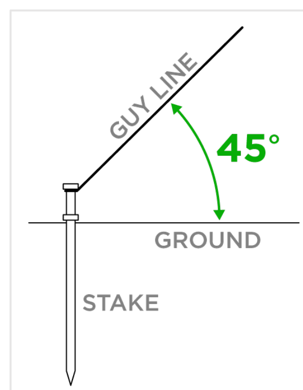

Figure 3.


Picture 1.

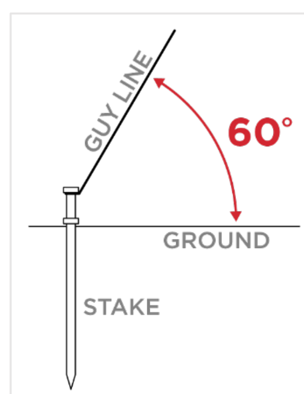

Figure 4.

Moisture Meter Test

In the moisture meter test, a 10-inch-deep hole was drilled into the ground using an auger and power drill. The moisture meter probe was carefully inserted into the hole, reaching the subsoil level, and the moisture content was monitored. This test provided valuable information about the soil's water content at a deeper level (fig. 5).

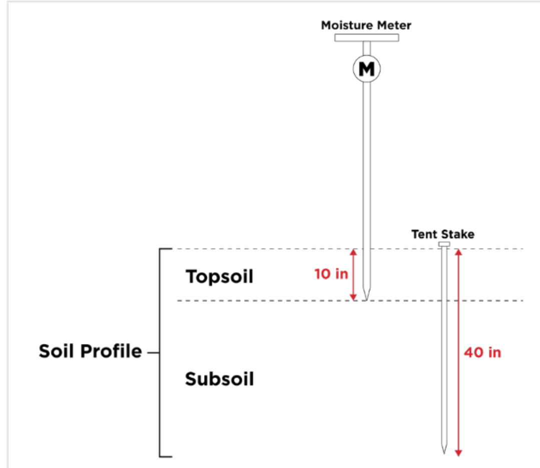

Figure 5.

Impact of Stake Age

To assess the performance of the stake based on its age, a comprehensive series of tests were conducted across multiple sites. The objective was to compare the holding capacity of new, older, and medium-aged stakes. ARA supplied different stakes labeled as new, older, and medium-aged stakes that provided varying levels of surface rust and pitting. The results obtained from the data revealed that there was no statistically significant difference between the stakes in relation to their age (Fig. 6). The analysis of the various stake samples consistently demonstrated comparable performance across all age categories. **These findings indicate that age and amount of surface rust/corrosion does not appear to have a substantial impact on the holding capacity of the stakes, suggesting that their effectiveness remains consistent regardless of their age.**

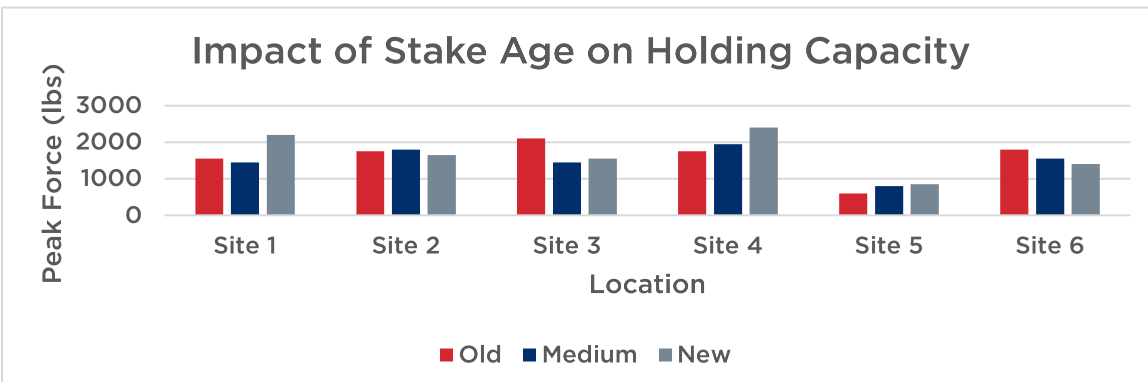

Figure 6.

Impact of Pull Angle

During this evaluation, tent stakes were driven straight into the soil. A comparative analysis was conducted by pulling the tent stakes out at both 45° and 60° angles. All testing results were recorded in order to properly analyze the trending points. **The results revealed that changing the angle from 45° to 60° led to a reduction in the holding power of the stakes (Fig. 7). The extent of this reduction varied, with the typical percentage reduction ranging from 10% to 50%. Notably, the highest observed reduction in holding power reached 81%.** Figure 8 is a sample of the different trending points that best represent the total data collected.

Test Site	60˚ Peak Force (lb)	45˚ Peak Force (lb)	% Change
Site 1	1992	2514	-24%
Site 2	448	692	-35%
Site 3	1476	2396	-38%
Site 4	332	698	-52%
Site 5	576	1056	-45%
Site 6	1014	1356	-25%
Site 7	134	688	-81%

Figure 7.

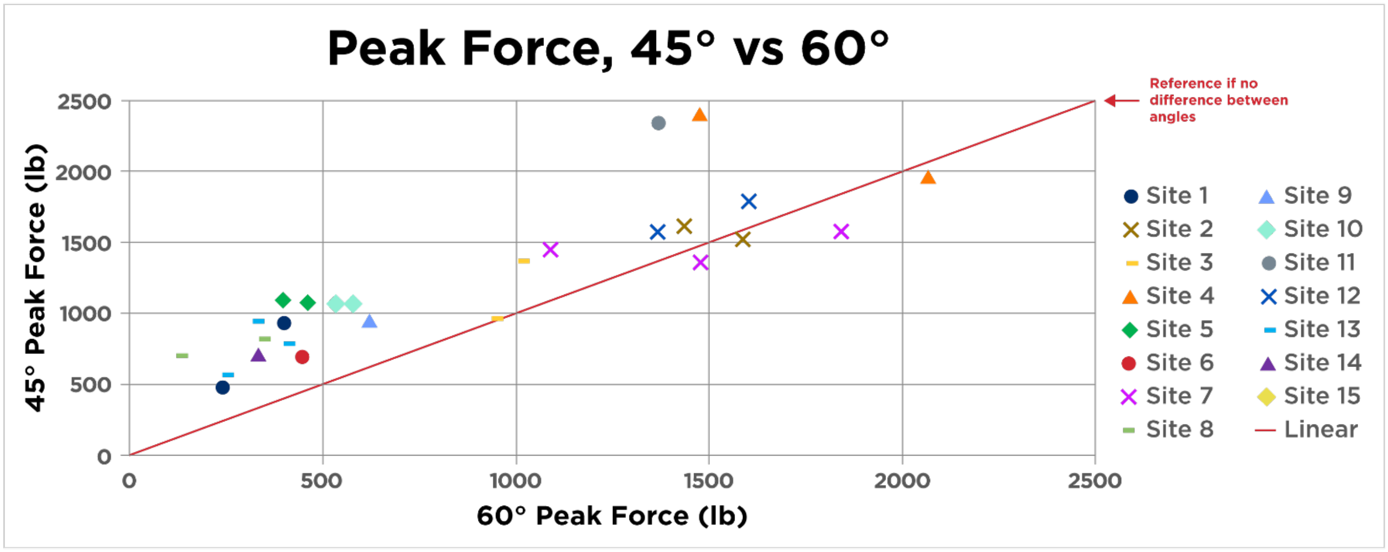

Figure 8.

It is important to note that the inconsistencies in some of the data may be attributed to soil disturbances and anomalies at engineered sites. These disturbances, such as compacted or disrupted soil conditions, could contribute to variations in the performance of the stakes. Overall, these findings highlight the significance of the tent stake guy angle and soil conditions in determining the holding power of a stake. The findings also underline the importance of accounting for potential soil disturbances or anomalies in engineered sites when interpreting data.

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Impact of Soil Saturation

To gain a better understanding of the relationship between soil moisture and the performance of tent stake holding capacity, the testing site was intentionally saturated with a water hose for a predetermined period, as established by the testing protocol. The objective was to assess how soil moisture levels impact the performance of tent stakes to maintain their holding capacity. Below is a sample of the data points collected during this testing process (Fig. 9).

Picture 2.

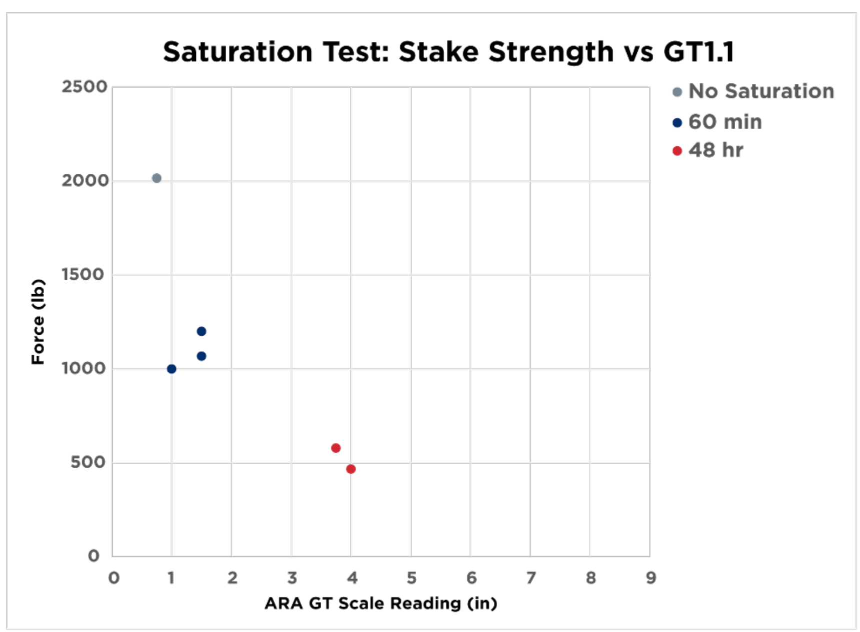

Figure 9.

The results of this test indicated a general trend, as shown in Fig. 9: as moisture levels increase, there is a corresponding decrease in stake holding capacity. This suggests that higher soil moisture content tends to facilitate less holding power per tent stake. These findings provide valuable insights into the influence of soil moisture on tent stake holding capacity, enabling installers to make informed decisions regarding site preparation and stake selection based on anticipated soil moisture conditions.

ARA recognizes the opportunity for additional testing and data collection in order to advance the industry. This additional research will enable ARA to continue to serve our members with advanced content, educational courses, and tenting tools.

Acknowledgements & Thank You!

Thank you to the following Associate Members that donated tools to aid in the completion of this study...

RHINO

NW QUIK PULL®

We'd also like to say thank you to our Members who assisted us with additional testing sites:

CLASSIC TENTS & EVENTS	TOPTEC Event Tents	Party Reflections SPECIAL EVENT RENTALS	EVENT RENTALS tents • tables • chairs • specialty décor	EVENTWORKS
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