CHAPTER TWO, PART TWO: Staking and Anchoring

2.2

This part of the handbook deals with anchoring the tent to the ground.

A tent will not remain erect unless it is properly anchored to the ground on which it sits. Anchoring is typically accomplished by fastening guy ropes or adjustable rachet straps to the tent at the top of the side poles and to stakes which are driven into the ground at some distance outboard from the side poles. The adequacy of such anchoring is fundamental to the safe and proper function of a tent. For example, when a tent is subjected to the forces of wind, it takes on a new shape. This new shape significantly affects the forces which the anchors—or stakes—must resist in order to keep the tent from collapsing.

SAFETY FACTORS

In order to account for the inevitable uncertainties which occur in the design, manufacture, installation, and use of structures of all kinds, safety factors must be employed. There is always at least a small chance that the loads imposed on a tent stake (or tent anchor in general) will exceed its ability to resist that load.

For example, if test data indicates that a stake has a 1000-pound capacity at a certain pull angle, and if the tent guy rope load has been determined to be 500 pounds acting at the same angle (and in the same kind of soil) then:

$$SF = \frac{1000\#}{500\#} = 2.0$$

In conventional building design the normal safety factor is approximately 1.7. For wind, approximately 1.3. For tents practice varies, but most industry groups feel that a safety factor of somewhere between 1.5 and 2.0 is appropriate for staking.

Stake failure can occur primarily in two ways:

- The first way to fail is in tension. Here the resisting frictional forces between the soil and the stake are insufficient to keep the stake from yielding to pull-out forces along its axis.

- The second most common way for a tent stake to fail results when the sideways force imposed by the stake against the surrounding soil is greater than the soil can push back; so the soil yields by bulging up above the surface. Consequently, the stake simply pushes the unconfined soil out of its path.

The most common tent stake, which is a slender cylindrical shaft of steel, must be regularly, easily, and economically installed, removed, and reinstalled.

The ground conditions in which the tent stake must perform its function are not a constant. These variables will cause the same stakes on the same tent to perform differently depending upon the following:

1. Soil (geological—possibly) variations

2. Water table variations—month-to-month and seasonal

3. Surface and subsurface variations and man-made disturbances

4. Paved sites

By soil variations, we mean those site factors which arise out of the fact that a tent will usually be installed at many different sites. For example, tent stakes installed in clay will not perform in the same way when installed in sand. The water table is relatively close to the ground surface in many parts of the world. Where this is true, month-to-month and seasonal variations can mean the difference between staking a tent in soil that is saturated one day and dry the next.

When we refer to surface and subsurface variations and man-made disturbances, we are referring to alterations in the subsurface which would not be apparent to the tent installer when he inspects the site. For example, a site that had been used for dumping refuse or debris would have underlying soil of unknown (and probably non-uniform) properties.

Another example involves a site that has been altered by bringing in fill material to raise the surface. This kind of site is suspect because of the unknown quality of compaction which was accomplished when the fill material was added.

Many tent installations occur on asphalt-paved or compacted stone upper crusts. This kind of upper crust has a significant affect on the performance of the stake.

A SYSTEMATIC APPROACH TO STAKING

The objectives of this part of this chapter are to lay the groundwork for a systematic approach to staking of the tent. This involves, primarily, two general activities:

- The first activity focuses on developing a systematic approach to staking which necessitates a discussion of the general engineering principles at work in the performance of a tent stake.

- The second activity concerns the evolution of a method for obtaining, accumulating, correlating, and presenting data on stake performance. In time a large bank of data will be developed that will be reliable and, consequently, will take much of the guesswork out of the process.

By equipping the tent installer with these two types of technical information, tent staking safety should be enhanced.

Engineering principles

This section of the chapter presents a general explanation of some of the engineering principles which relate to establishing the best stake position for a tent.

The larger the stake diameter, the greater the holding power.

Logic would seem to dictate that the larger the stake diameter, the greater the holding capacity of the stake. See ***Figure 8***. Stake capacity is a direct function of stake diameter.

In the first place, a larger diameter stake will displace more earth as it is driven in than the smaller stake. See ***Figure 9***. This greater compaction should produce greater soil pressure against the side of the stake. This greater sideways pressure will increase the friction acting along the sides of the stake and provide more resistance to pullout due to stake tension. Since the sideways earth pressure on the stake is directly proportional to the surface area of the stake, There is more resistance to stake pullout due to tension in the larger diameter stake. Finally, when a stake pushes laterally against the earth due to sideways pull of the guy rope, a pressure results.

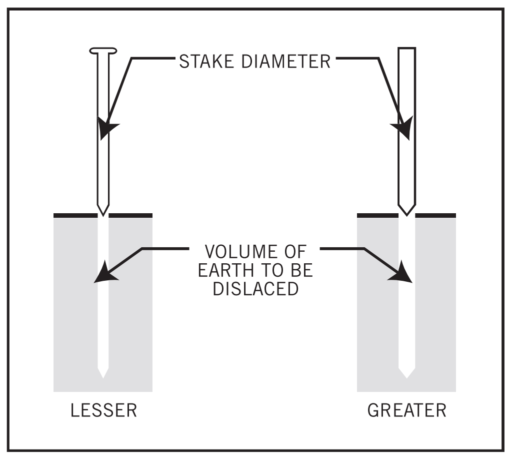

Figure 8. *Stake Performance & Volume of Displaced Earth*

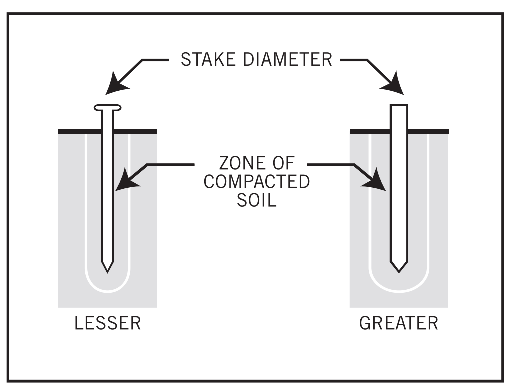

Figure 9. *Stake Performance & Zone of Displaced Earth*

The deeper the stake, the greater the holding power.

Stake pullout strength is directly related to stake depth. See ***Figures 10 and 11***. This is true for several good engineering reasons.

1. Greater surface area
2. Soil pressure usually increases with depth
3. Larger soil wedge(bulb)

The holding capacity of a tent stake is due to a significant degree to friction developed between the stake and the soil which surrounds it. It follows that the deeper the embedment of the stake in the soil, the greater the surface area of the stake which is in contact with the soil; thus the greater the holding power. Thus it is obvious that the deeper the tent stake, the more the earth presses up against the stake and produces greater forces, which increase its holding power.

The sideways component of forces on the tent stake, which is produced because of the angle of the guy rope, is resisted by a wedge of earth in front of it. This wedge of earth is deeper the deeper the stake is driven. The larger the wedge(bulb), the more sideways resistance it exerts to keep the stake from failing by pulling over.

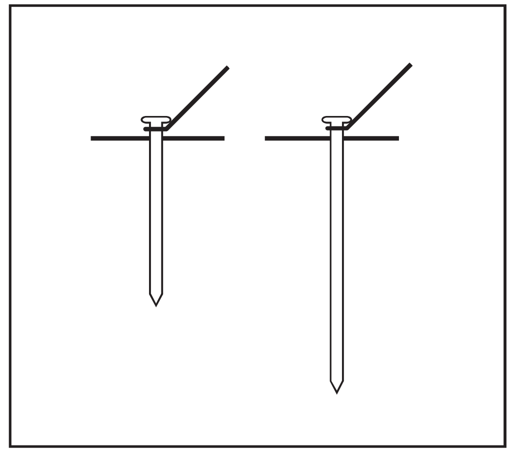

Figure 10. *Stake Holding Power and Stake Depth*

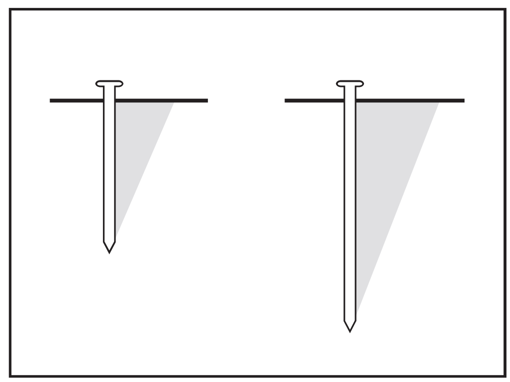

Figure 11. *Soil Wedge(Bulb) Size and Sideways Resistance*

Optimum guy rope angle provides optimum holding power.

A number of factors must be taken into account in the process of finding the right angle for any given situation. See ***Figure 14***. Significant factors include:

1. Tent geometry—unloaded
2. Tent geometry—wind factor
3. Tent geometry—ponding factor
4. Presence or absence of sidewalls
5. Soil type
6. Ground moisture
7. Presence or absence of pavement
8. Need to keep side poles in compression
   Note: When staking against wind lift forces, the guy rope must be at an angle that will keep the side poles from jumping. Consequently, the stake should be located relatively closer to the tent. A pull angle of 45degrees produces vertical forces on the stake which are equal to the lateral forces. At 45 degrees or slightly steeper, the pole tent could reasonably be expected to withstand the forces of wind uplift while maintaining a balance between vertical and lateral stake forces. If alternate sidepole heights are used, that should be taken into account in maintaining proper guy rope angles. See figure 14.

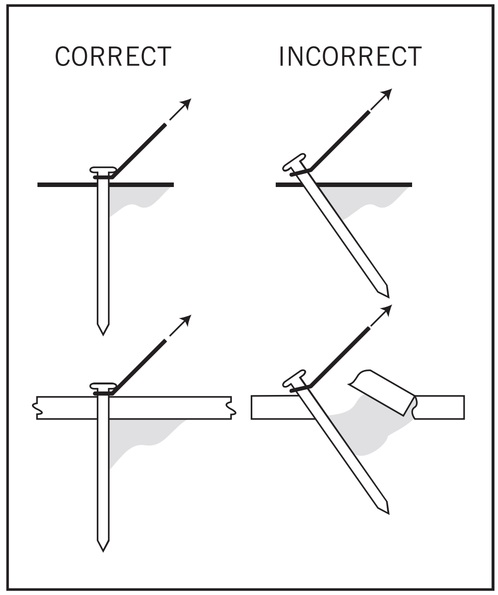

Figure 13. *Stake Driving Angle*

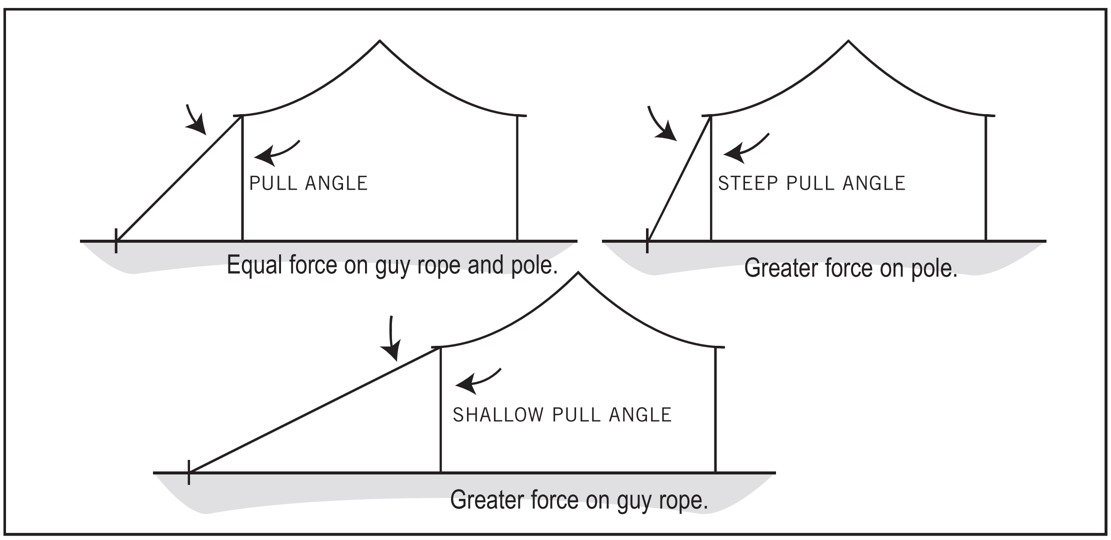

Figure 14. *Pull Angles and Stake Location*

Increasing the height of the stake knot above the ground decreases stake holding capacity.

The overturning moment generated on the stake varies with the distance above the ground where the guy rope is secured to the stake. See ***Figure 15***. The greater this distance, the greater the overturning moment on the stake. It is absolutely essential that the guy rope be kept as low as possible on the stake, not higher than two or three inches, to minimize the overturning moment.

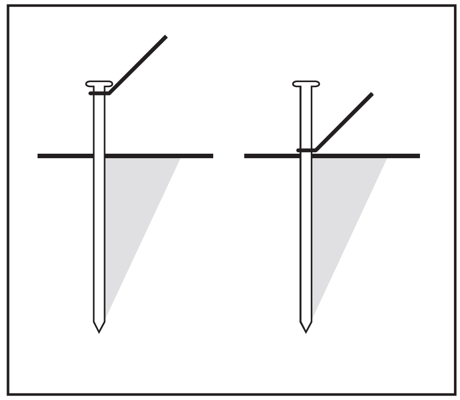

Figure 15. *Stake Knot Height*

Holding power varies with anchor types.

The basic straight shaft, steel "nail head" type of tent stake is the basis of most of the discussion in this chapter. Several other types are in common use throughout the industry. See ***Figure 16***. Aside from the simple straight shaft stakes, most others function on the general "deadman" principle of gathering a cone or similar block of heavy earth above the projecting element on the stake thereby impeding pull-out. These have the potential of generating much greater holding power.

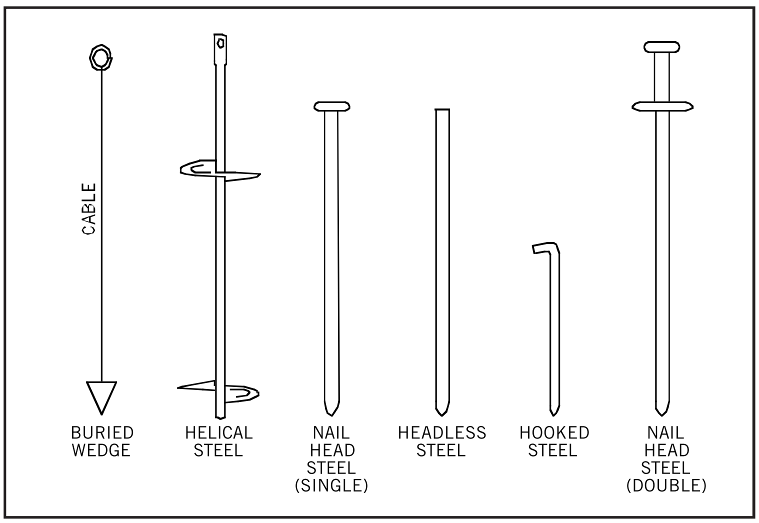

Figure 16. *Various Tent Stakes*

Alternate Staking Methods

Some popular methods may be employed generally for increasing staking capacity.

Double Staking

Double staking is the practice of driving another stake a short distance behind the primary stake and close-tying both stakes together with the free end of the guy rope. Triple and/or quadruple staking may also be used in applying the same concept.

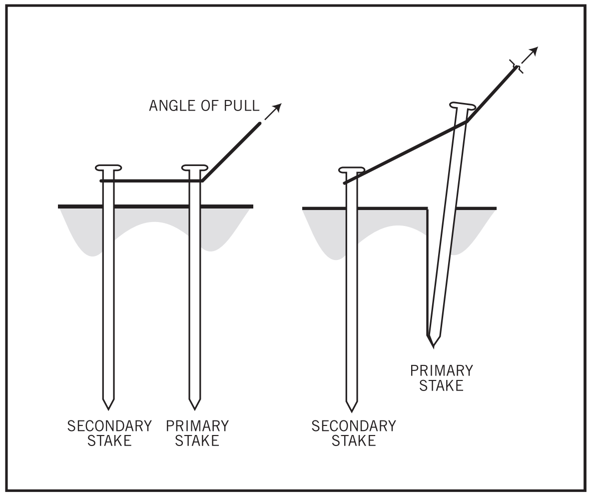

Figure 17. *Double Staking*

This would appear to be beneficial where there is a likelihood that the primary stake might not be sufficient by itself, or when the particular guy rope location is a critical link in the stability of the tent. In ***Figure 17***, the arrangement is shown where there are no significant loads on the primary stake, when no wind is blowing, for example. The stake in ***Figure 17*** is loaded to the point where it is on the verge of failing. But as it creeps forward, and at the same time rises as if to pull out, the close-tie to the secondary stake tightens. At this point, the secondary stake resists the tendency for the primary to move sideways or up.

Note the void which has developed behind the primary stake in ***Figure 18***, which depicts various staking errors. If the secondary stake is too close behind the primary stake, it will have only limited side-load resistance since the earth in front of it will collapse forward into the void. On the other hand, if the secondary stake is too far away from the primary stake, the close-tie will be fairly long and may actually allow the primary stake to pull free which is undesirable. See ***Figure 18***. A rule of thumb for double staking suggests that the distance between stakes be equal to one-third of the depth of the stake in the ground.

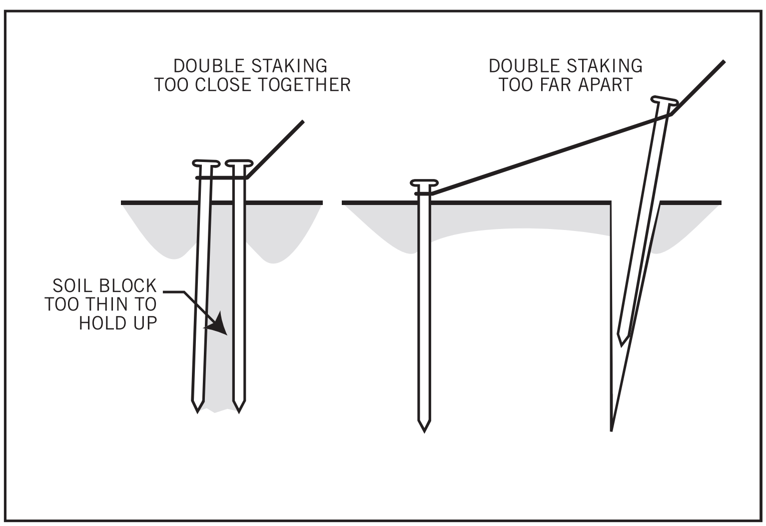

Figure 18. *Double Staking Errors*

Gang Staking

A staking technique related to double staking, in that it also increases staking capacity, is called gang staking. There are several different techniques.

These involve the use of a rigid ground plate or bar with holes punched in it for the stakes. This is schematically shown in ***Figure 19 and Figure 20.***

Multiple staking methods will probably grow in popularity as designs meeting specific higher wind speed criteria are required.

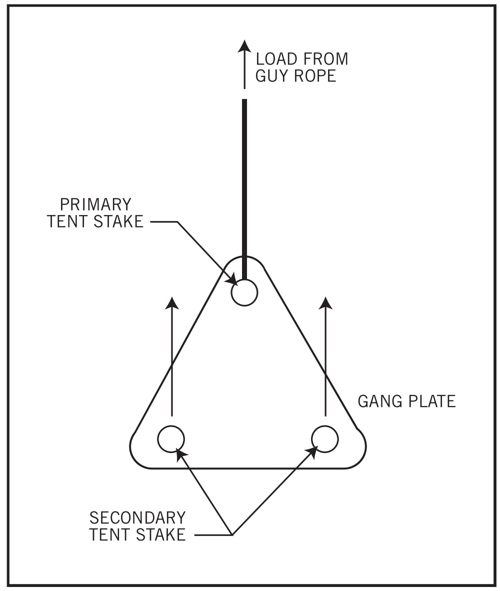

Figure 19. *Gang Staking*

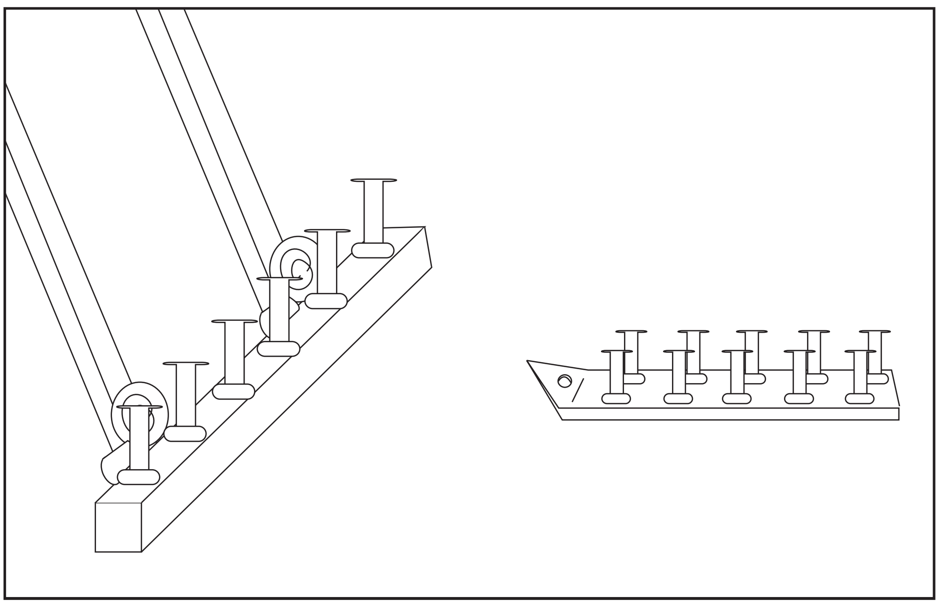

Figure 20. *Stake bar & gang plate*