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Auger and Ground Screw Application Guidelines

The use of augers and ground screws have been of interest in mounting solar systems for some time. However, the application and installation is not well understood by the engineering, installer and contractor community. Hopefully my experience and observations will help to clear the confusion surrounding the use of augers and ground screws.

I first came across the use of ground augers in the Colorado River basin in 2004 where a contractor was trying to install a solar ground array in a sandy area next to the river. He also reasoned that the support would best be supplied by an auger. He reasoned that if he did the traditional poured concrete and post method, the weight of the concrete and array would slowly sink the PV array into the sand. He purchased augers used by the power pole industry for guy wires, and fit pipe over them fastened with bolts. The ground array was built, and is still standing to this day.

Figure 1 – Auger being driven at Groundwater site with Bobcat 337

Augers in particular have a large field of application and are widely used to stabilize buildings, retaining walls, and high tension towers. A section related to the use of augers has recently been added to the International Building Code. Unfortunately, this IBC section has caused a number of otherwise good potential applications of augers or ground screws to be abandoned due to excessive conservatism by structural engineers and Authorities Having Jurisdiction (AHJ's). In reality stresses of a ground mounted solar array are fractional when compared to a multi-story building foundation. Ground augers in the poorest of soils easily provide 3000 to 10000 pounds of pullout strength, far more than the 1500 to 2500 pounds required for PV arrays. These codes and requirements are overkill,

particularly in rural and unpopulated areas where the likelihood of failure of the structure is both low, and would not result in any damage to human life.

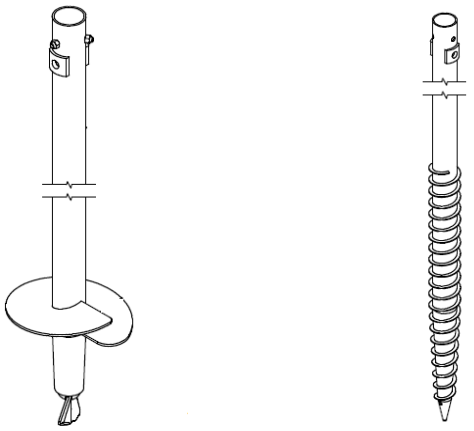
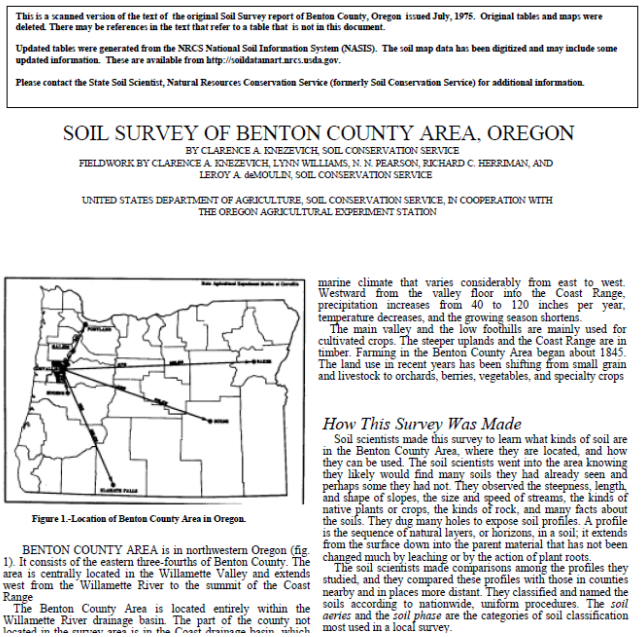


Figure 2 – Shown above are two SunModo products, the Auger (left) and the Ground Screw (right)

Qualifying a Site

A fundamental consideration when evaluating the potential use of an auger or ground screw is the soil strength and potential for rocks or solid rock. Determining the condition of the soil condition is paramount in making a decision of which product to use.

There are 3 methods to determine the soil classification and suitability for consideration of augers or screws: the empirical method, local testing, or a soil analysis by an engineer. For larger systems, it is best to spend the money and hire an engineer. This can cost as little as $1500.



This is a scanned version of the text of the original Soil Survey report of Benton County, Oregon issued July, 1975. Original tables and maps were deleted. There may be references in the text that refer to a table that is not in this document.

Updated tables were generated from the NRCS National Soil Information System (NASIS). The soil map data has been digitized and may include some updated information. These are available from http://soildatamart.nrcs.usda.gov.

Please contact the State Soil Scientist, Natural Resources Conservation Service (formerly Soil Conservation Service) for additional information.

SOIL SURVEY OF BENTON COUNTY AREA, OREGON

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE OREGON AGRICULTURAL EXPERIMENT STATION

Figure 1.-Location of Benton County Area in Oregon.

BENTON COUNTY AREA is in northwestern Oregon (fig. 1). It consists of the eastern three-fourths of Benton County. The area is centrally located in the Willamette Valley and extends west from the Willamette River to the summit of the Coast Range.

The Benton County Area is located entirely within the Willamette River drainage basin. The part of the county not located in the survey area is in the Coast drainage basin, which

marine climate that varies considerably from east to west. Westward from the valley floor into the Coast Range, precipitation increases from 40 to 120 inches per year, temperature decreases, and the growing season shortens.

The main valley and the low foothills are mainly used for cultivated crops. The steeper uplands and the Coast Range are in timber. Farming in the Benton County Area began about 1845. The land use in recent years has been shifting from small grain and livestock to orchards, berries, vegetables, and specialty crops

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in the Benton County Area, where they are located, and how they can be used. The soil scientists went into the area knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Figure 3 – Example of County soil survey.

However, with smaller PV systems one may not need to spend money on a soil engineering analysis and the cost to permit the design separately. The typical soil type in an area may be known from experience. Perhaps local experience with other construction such as a home foundation or a water line installation can provide clues to the soil type. A method used by some contractors is to use a hammer drill and ground rod available from an electric supply store and see how easily the rod can be driven into the earth. If the rod hits solid rock 6 inches below the surface, or if the rod is very hard to drive, this could either disqualify the use of ground driven foundations. In some cases this could lead to using ground screws rather than an augers. Additionally, many counties and states have published maps showing the soil types for many locations. Other sources of data are well sites where there is often a record by the foot of the surface to depths much greater than one would drive a ground driven mount.

Selecting a Ground Mount

Once a determination has been made as to the type of soil at a site, the installer should select a ground mount to use at a site. If the soil type is not heavily compacted and not rocky, one can consider the use of augers. Most typically, a ground auger driven 7 to 10 ft. will suffice for most 3 and 4 row landscape arrays.

If the ground is compacted, made up of heavy clay, or has small rocks within the first 10 ft., then a ground screw would probably be a better choice. Ground screws offer lower torque when driving them into the soil and are less likely to break in harder ground. However, in soft, loamy soils a ground screw will not provide big pullout values compared to an auger.

If the ground is too rocky, other options such as post and concrete, ballasted arrays, or rock anchors may be a better alternative. Experience with ground arrays will greatly help in the selection of a ground mounting system.

Driving Ground Mounts

Some form of tractor or track machine is required to drive ground driven foundations. This requirement may make it price prohibitive to do very small arrays with only 8 or 12 posts. The machine used will need some form of rotary head such as the small Bobcats used to dig holes for pole buildings and fence posts. Alternately, some farm tractors have a rear mounted rotary driver used for fence posts that may be used. As the number of posts increases, the options increase financially to use larger machines or for a contractor to own his machine.

Figure 4 – A small Bobcat 331 being used to drive a 10 ft auger using the technique of advancing upon the auger to vertical as it is driven.

Most equipment rental yards can supply a small track machine normally used with a hole digging auger. With the hole digging auger removed, an adaptor can be used to mate the drive head to fit augers and ground screws. A 2 inch to hex adaptor that fits the machine can be purchased by the installer if not available from the equipment rental yard with the machine.

Figure 4 – Drive adaptor to convert from hydraulic head on rental machine to 2 inch ground mount.

The amount of torque required to drive a ground mount should not be more than a nominal 3000 pounds. If more torque is required, or if the mounts are breaking, than the wrong mount was selected. If augers break, a ground screw should have been used. If ground screws break, then a non-driven mount should be used.

If occasionally a mount breaks due to an undetected boulder or other issue, a traditional post and concrete mounting should be used. In the case of Groundwater a 50 kW project

in Portland Oregon, where over 400 augers were used, 8 anchors broke due to large sporadic rocks and were replaced with 8 post and concrete mounted posts.

For larger arrays, there are commercial companies that are in the business of driving ground mounts. Typically, these commercial companies work on foundation construction and solar array projects needing 100 or more posts.

Calculations and Measurements

There are many resources available covering the use and calculations for commercial construction using augers and ground screws. These include Chance Hubble manuals, and other commercial suppliers of augers. However, there are some general guidelines one can follow summarized below.

Augers have a pitch determined by the blade angle. Our auger is a 10 to 1 auger. Using a 10 to 1 auger, each ft. lb. of torque driving the auger provides approximately 10 times the uplift capability when driven to 10 ft of depth. For example, if an auger is driven with 500 pounds of torque to 10 ft. the pullout will be approximately 5000 pounds. Typically augers are driven much harder, resulting in tested pullup values of 20,000 to 30,000 lbs. **Most often, augers driven in reasonable soil values will dramatically exceed the pullout values actually required to resist pullout or overturn of the array.**

In the case of ground screws, they are typically applied to more dense soils and solids with rock intermixed. **A ground screw should not be used in solid rock**.

Ground screws in hard soils have pullout values of 1500 to 5000 pounds at a depth of 5 ft., however this estimate is entirely based upon the soil density. The use of ground screws in soft soils will not provide a satisfactory base for a solar array.

The use of a torque measurement gauge is recommended as an additional check on the drive torque and resulting pullout capability. Some modern machines one can rent or buy have a built-in torque gauge. Additionally, there are devices that can mount between the hydraulic head and the ground mount to measure the torque. However, a careful operator will have some sense of the amount of effort required to drive the ground mounts and in most cases can successfully install and driven ground array without a torque head.

Strategies for Arrays using Driven Mount

There are few ideas used by successful operators to layout and utilize driven mounts. The ideas fall into two categories; drive the mounts to a few inches above the ground level, add posts, and adjust or cut-off for the desired post height; or drive the mounts adding extensions to the desired post height. Both of these techniques address the idea of uneven or sloping ground.

The general procedure is to place a post at each end of the array for the front and rear posts. A line or laser can be used to determine level (or ground tilt). Then the intermediate posts are placed and adjusted or cutoff to achieve the desired post lengths. This task is made easier with the SunModo product since a post can be adjusted up and down and locked into place using setscrews.

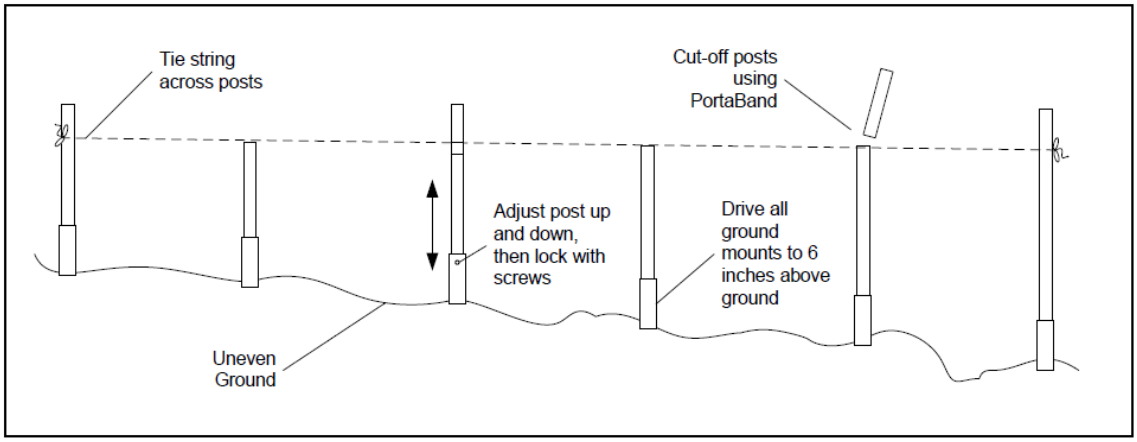

Figure 5 – Cut-off or adjustment method of obtaining desired post heights

The alternate method is to drive the auger or ground screw to within a few inches of the ground, then add an additional length (i.e. 3, 5, 7 ft.) and continue to drive down to the final post height. Similarly, if each end of the front and rear row is driven to final height, a laser or line can be used to locate and drive the intermediate posts. A word of caution, “High strength pipe with a drilled joining bolt must be used otherwise the extension pipes may break or shear.” If the appropriate auger or ground screw is selected per the soil condition, the stresses on the pipe extensions will be minimal.

Summary

The use of ground driven mounts should be carefully considered. The system size is the first consideration, where very small arrays of 8 or 12 posts are probably not cost effective to consider or permit.

The use of auger or ground screw is determined by the condition of the soil. Softer soils and sands are best addressed using the auger. Compacted soils require a ground screw to penetrate the harder soil. In areas with solid rock, driven mounts are dis-qualified from use and an alternative foundation should be used.

Extraordinary engineering should not be required although some AHJ's will insist upon it. Calculations using a single blade auger in the lowest soil classification at 10 ft. will exceed the engineering requirements for most 3 and 4 up PV racks using front and rear posts (excluding monopole arrays).

Driving machines are readily available from most local rental yards. Adaptors can be purchased for about $200 to fit most hydraulic driving heads available on rental machines. Serious installers should consider purchasing a driving adaptor to fit locally available machines.

Cliff Schrock

SunModo Engineering Dept.

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