

# Post installation tools

Necessity shows why she is the mother of invention

By David R. Bohnhoff, Ph.D., P.E.

In 2003, I headed up a research project that involved the construction of a post-frame machinery storage building for the University of Wisconsin-Madison. Existing site topography required the placement of as much as 6 feet of fill. Because of the characteristics of the fill material and method in which it was placed, a decision was made to place footings 5.75 feet below grade (i.e. on undisturbed soil). Additionally, because the building was located in a high snow load area of Wisconsin and was designed to meet the state's commercial building code, some of the footings were specified with a 6-inch thickness and 26-inch diameter.

Prior to construction, I sensed it would be difficult to keep posthole sides from collapsing during drilling and footing and post placement (this due to the required posthole diameter and depth as well as the characteristics of the fill). Also, I was concerned it would be difficult to get a flat, level base for placement of the larger diameter footings we were using, and realized that transport and placement of the larger, 280 lbm footings would require more than just manual labor.

My footing/post placement concerns led me to fabricate three new and unique embedded-post foundation installation tools: a posthole installation shield, a posthole-bottom leveler, and a footing transport and placement cart. An overview of each of these tools follows. For material and construction details on these designs, readers are referred to Bohnhoff, D.R. 2005. Post installation tools. ASAE Paper No. 054117. This article can be downloaded from <http://bse.wisc.edu/bohnhoff/>

## Posthole Installation Shield (The Wisconsin Hole Shield)

**The need.** Sloughing of posthole sides is associated with drilling in non-cohesive soils (e.g., sands and gravels with low clay contents) of low density, poorly compacted, very wet because of a recent rain or because they are poorly drained, or saturated because they are near or below the water table. Vibrations that occur when hitting rocks and/or tree roots generally increase the likelihood of posthole collapse.

When a posthole side sloughs, the diameter at the top of the posthole becomes larger. This makes it more difficult to throw material away from the posthole by spinning the auger after it has been brought to the surface. It also becomes more difficult for workers to prepare the base of the posthole for a footing, to place the footing, and to properly position, brace and backfill the post, even when planking is used to bridge the large opening.

Prior to erecting the building for UW-Madison, I contacted Leo Souder of MPB Builders in Ripon, Wis., and asked how he dealt with collapsing posthole sides. Leo noted one approach that worked for them was to press steel tubes into the ground and then drill inside the tubes. The tubes were fabricated by cutting the ends out of old steel barrels. However, since the steel tubes were left in the ground, MPB Builders had to maintain an



Figure 1. The Wisconsin Hole Shield (left) is separated into two halves (right) by simply withdrawing two L-shaped pins (center).

inventory of old barrels.

My design goal was to develop a posthole installation shield that would function like the modified barrels used by MPB Builders, but unlike the modified barrels, could be easily removed and reused. A secondary goal was to design a system for shield removal that would not require the use of power equipment.

**Design overview and use.** The Posthole Installation Shield (or The Wisconsin Hole Shield) consists of a 3-foot long tube that can be split in half by simply removing two pins (figure 1). This particular shield, which has an actual inside diameter that varies between 25.5 and 26.3 inches, was designed for use with a 24-inch diameter auger. Each half was fabricated from a 36- by 40.75-inch piece of .188-inch thick low carbon steel and weighs about 80 lbm.

As shown in figure 2, the shield is inserted into the posthole after posthole sides have already collapsed. The tube not only keeps soil near the base of the hole from collapsing into the posthole while drilling is completed, but it also prevents removed soil from sliding back into the posthole. With the shield in place, workers level and compact the base of the hole, but it also prevents removed soil from sliding back into the posthole. With the shield in place, workers level and compact the base of the hole, install the precast footing, insert and plumb the post, brace and compact soil around the post up to the base of the shield. The shield is then pulled above grade and the rest of the posthole backfilled.

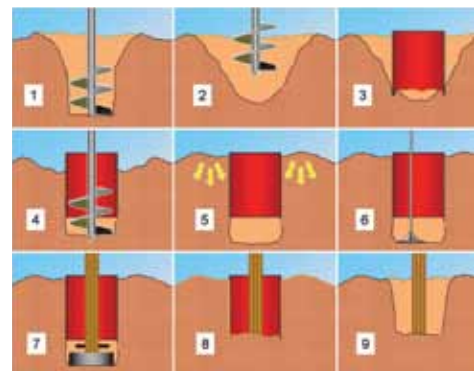


Figure 2. Using a posthole installation shield: (1) auger removes soil, (2) posthole sides slough, (3) posthole insulation shield inserted into hole, (4) remainder of posthole drilled, (5) shield keeps posthole sides from collapsing and provides stable working surface around posthole, (6) base of posthole is prepared for footing, (7) footing and post are installed and post is plumb and braced, (8) soil is tapped around footing and base of post and (9) shield is removed and remainder of posthole is backfilled.

Slots cut into the top of the shield facilitate its removal. During testing, we have been able to extract the shield by removing the

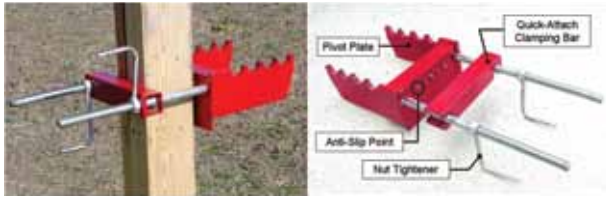


Figure 3. Fulcrum for removal of the posthole installation shield.

pins and then manually pulling out each half of the shield. This can require measurable personal strength. Obviously, the shield can be exacted with a skid steer loader, rough terrain forklift or other piece of equipment with forks. However, to enable shield removal without the

fulcrum, and the lever is attached to the shield with chains on opposing sides of the post (figure 4). With the mechanical advantage designed into the system, one average-sized person pulling downward on the lever should be able to easily withdraw the shield (figure 5).

**Discussion.** To date, the Wisconsin Hole Shield has been tested at three different sites. While the system worked as designed, it is important to note there was not a major problem with posthole sides collapsing on these sites, although some sloughing did occur on one site.

The main concern prior to testing was auger teeth would catch and spin the shield. Although the shield was contacted by the auger several times, the



Figure 4. Lever is rested on quick-attach fulcrum and then chained to the posthole installation shield.

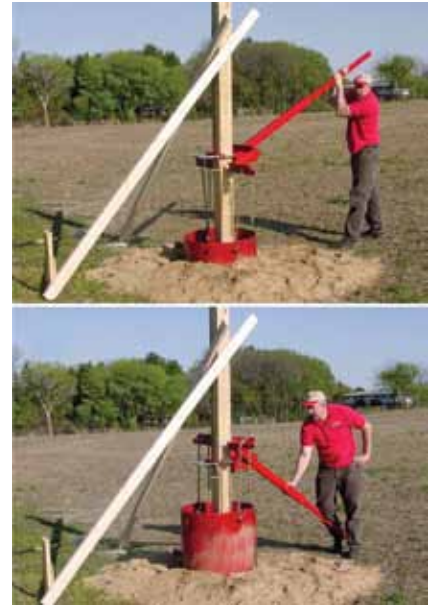


Figure 5. Withdrawal of the posthole installation shield.

contact did not spin the shield, it only removed paint. This tends to indicate the .188-inch thick steel used for the shield is close to optimal.

The shield is easy to assemble and

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easy to roll into place. There is no recommended depth to which it should be inserted. When left partially above grade, it helps restrain soil brought to the surface. If the shield does not drop to its desired depth when rolled into the posthole, wood blocking can be laid over the shield and downward pressure applied to the blocking by the auger.

It is recommended that all major post-frame companies stock one or more posthole installation shields for use on jobsites with soil conditions that make it difficult to keep posthole sides from collapsing. More than one shield is recommended on sites where it is desirable to keep the drill rig a few holes ahead of the post-setting crew. Transporting multiple shields is relatively easy since the split shields are stackable. Regardless of the number of shields, only one fulcrum and lever are needed on a jobsite.

As previously noted, a rough terrain forklift or other piece of equipment with forks can be used to withdraw a shield. To make it easier to lift a shield with forks, it may be helpful to add a two- or three-inch wide lip to the shield.

With the speed at which the fulcrum can be attached to a post, the manual shield withdrawal system is likely to save labor (when compared to the use of power equipment) in addition to freeing up power equipment. An additional benefit of the manual withdrawal system is it preloads the footing, and thus could help reduce the amount of post-construction settlement that would otherwise occur. Note the total downward force applied to the post by the manual withdrawal system is equal to the sum of

the shield uplift force and the downward force applied by the worker.

The fulcrum should be attached to the post at a location about 3.5 feet above grade to give room between the grade and fulcrum for the entire shield. The L-pins holding the two halves of the shield together can be pulled out before any lifting takes place. A single action of the lever can pull the shield upward about a foot. At this point, each half of the shield can generally be pulled out without any mechanical advantage by simply pulling upward on the attached chain.

### Posthole-Bottom Leveler (The Badger Hole Leveler)

**The need.** The bottom of a posthole is typically prepared for a precast concrete footing by using a tamper to somewhat level and compact soil disturbed by drilling. Disturbed soil includes soil that has fallen off auger flighting as the auger was withdrawn from the posthole, soil sloughed off posthole sides, soil accidentally knocked into the posthole and soil purposely placed back into the posthole to lessen post embedment depth. Soil not purposely placed back into a posthole is generally concentrated in the corners of the posthole as shown in figure 6.a.

The objective when compacting disturbed soil at the bottom of a posthole is to obtain a surface that is both flat and level (figure 6.b). If the surface is not flat (i.e., there are high and low points), the soil-to-footing contact pressure will be uneven (see figures 6.d, 6.e, and 6.f) and there will be an increased likelihood of future foundation settlement. If the surface is not level, the footing will not be level resulting in a reduced area of contact between the footing and post (see figures 6.c, 6.e and 6.f).

The ability to obtain a flat and level footing base depends on posthole conditions prior to compaction, footing diameter and tamper size. Obviously, the



**Figure 7.** The *Badger Hole Leveler* in use. Note telescoping shaft consists of round aluminum stock that slides inside a square aluminum tube.

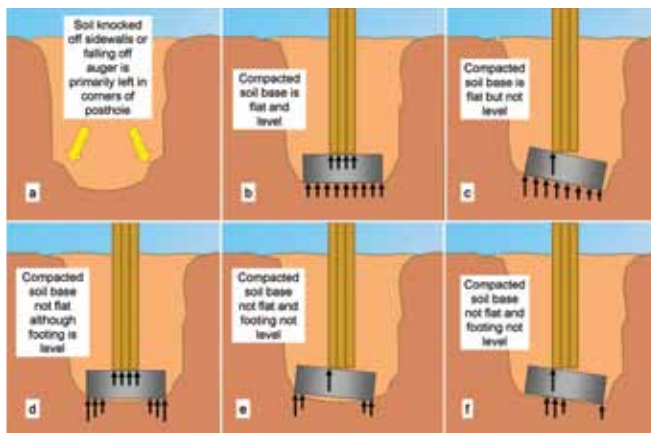
more rounded the posthole bottom prior to compaction, and/or the greater the footing diameter, and/or the smaller the tamper, the more difficult it is to obtain a flat and level footing base. Suffice it to say it is virtually impossible to obtain a satisfactory footing base with a small tamper when the area to be compacted is very large and extremely uneven.

It is important to note it is very difficult to determine how flat and level a footing base is because you are at the worst possible viewing angle (i.e., directly above the surface) when compacting the base of a posthole. The goal of this project was to develop a device for leveling the base of a posthole prior to soil compaction.

Several different posthole-bottom leveler designs were fabricated and tested. These included designs with multiple small cutting blades, rollers and rake-like sections. The final design, which we refer to as the *Badger Hole Leveler*, is shown in figures 7 through 9. This design consists of three separate components: a T-bar handle, a telescoping shaft, and a leveling head. These three components are held together with 3/8-inch diameter cotterless hitch pins that can be quickly removed to “knock-down” the assembly for more effective storage and transport.

The T-bar handle (figure 8) contains a bull’s eye level to help with overall positioning of the leveler during use.

The shaft consists of a .875-inch diameter piece of round aluminum stock that slides inside a 1.25-inch square aluminum tube with a .125-inch wall thickness (figure 7). Aluminum was used to



**Figure 6.** Various conditions at the base of a posthole.

decrease overall weight of the unit. The round stock has a centering/pivot point and extends through and is pinned to the leveling head as shown in figure 9. Holes in the round stock and square tube enable the total length between the leveling head and handle to be varied between 6 and 10 feet in 6-inch increments. The square shape of the outer tube facilitates attachment of a laser level receiver as shown in figure 8.



Figure 8. T-bar handle on the *Badger Hole Leveler* contains a bull's-eye level. Square outer tubing of the telescoping shaft facilitates attachment of a laser level receiver.

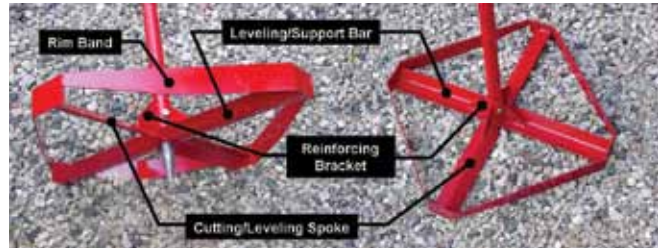


Figure 9. Underside (left) and topside (right) views of a leveling head on a *Badger Hole Leveler*.

Figure 9 shows two views of a leveling head. Five different parts comprise each head: a leveling/support bar, two cutting/leveling spokes, a rim band, a center mounting tube and reinforcing brackets.

The leveling/support bar has a one-inch wide flat bottom and sides that slant upward at a 45-degree angles. A flat bottom keeps the leveler from sinking in soft material, and can be used to tamp the bottom of the hole. Angled sides help level material as the unit is turned, and provide a bearing area that increases the more the leveler sinks into soft material.

The two cutting/leveling spokes are attached perpendicular to the leveling/support bar. These spokes serve as cutting tools when the unit is turned counter-clockwise, and as leveling tools when the unit is turned clockwise. This occurs because the bottom portion of the spoke is tilted at a 45-degree angle to the horizontal. The cutting edge is sharpened and positioned about

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1/8-inch below the leveling/support bar. This lower position helps ensure the edge will keep cutting when the leveling/support bar is riding on hard soil.

The rim band has multiple functions. First, it ties the ends of the leveling/support bar and cutting/leveling spokes together, and thus provide stability to the unit. Second, it can cut through soil. Third, it helps move material toward and away from the center of the unit. Like the bar and spokes, the rim band will move material away from the center of the unit when the leveler is turned clockwise. However, when the leveler is rotated counter-clockwise, the rim band will move material toward the center of the unit. This change in action results from tapering the bottom edge of the rim band (see Figure 9) so the entire bottom edge is not in contact with the soil. If the entire bottom edge of the rim band was straight so the entire edge was in soil contact, then regardless of which way the unit was turned, material inside the rim band would have a tendency to



**Figure 10.** The latest version of the footing transport and placement cart during a recent test. Drawn to the underside of the cart is a 6-inch thick by 20-inch diameter precast concrete footing weighing approximately 165 lbm.

stay inside the rim band, and material outside the rim band would have a tendency to stay outside the rim band.

We have manufactured and used three different sized leveling heads. All are identical with the exception that their cutting/leveling spokes, leveling/support bars, and rim bands have different lengths. Our leveling heads were sized to sweep an area with a diameter about 2 inches less than the auger used to dig the holes.

**Discussion.** Testing has shown the Badger Hole Leveler is capable of redistributing/leveling soil without leaving any humps, and it can work in all soil conditions (e.g. clays or gravels) without plugging. While some alternative designs tested better in a specific condition, they did not work well in all tested conditions which included loose sandy soils, hard clays and gravel/rocky fills.

On one jobsite, the leveler was used with an attached laser level receiver to level the bottom of postholes to a predetermined elevation. This took, on average, no more than an extra minute per hole. Soil at the bottom of each hole was then compacted, precast footings installed, and the laser level was used to measure the installed depth of each footing. These measurements revealed a standard deviation on final footing elevation of only .35 inches. Had additional time been taken to recheck hole depth after soil compaction (i.e., right before footing placement) and adjustments made with the leveler, an even tighter placement tolerance could have

been obtained.

Accuracy in the placement of footings, and hence use of a device like the Badger Hole Leveler, becomes more important when precast concrete piers are used, in which case there is a desire to keep the top of all piers at the same elevation for both functionality and aesthetic reasons.

Given the Badger Hole Leveler should always be used with large diameter footings and can enhance the quality of small diameter footings, no construction crew placing precast footings should be without one, or at least a similarly functioning tool.

### Footing Transport and Placement Cart (Big Dave's Cookie Cart)

**The need.** Round, precast footings (a.k.a. cookies), especially those with diameters less than 17 inches, are frequently dropped into postholes. Unfortunately, regardless of its size, the likelihood of a "dropped" footing landing properly in a hole is extremely remote. When one edge of a footing hits first, the result is a localized soil bearing failure — a failure involving the movement and "loosening up" of a good portion of the surrounding soil.

To avoid damage to the footing base, some contractors use special tongs to lower smaller footing. Others have wrapped steel banding around the footing, and then removed it after the footing was in place. Neither of these methods works very well with larger/heavier footings.

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Footings too large for one person to lift are typically handled with a rough terrain forklift, skid steer loader, front-end loader tractor or similar piece of equipment. This equipment is not only used to move footings around on the jobsite, but they are also frequently used to lower larger footing into postholes. In addition to the equipment operator, another worker is typically required to attach/detach footings to/from the equipment and to guide the footings so they do not hit the posthole sidewalls when being lowered. In other words, it requires two workers and a larger piece of equipment to properly install large precast footings. The goal of this project was to develop a device that would enable one person, without relying on self-propelled equipment, to move precast concrete footings around on a job site and also lower them into place.

**Discussion.** Of the three tools presented in this paper, the footing transport and placement cart went through the most design changes. The original ver-

sion of the cart was a "back-of-the-napkin" design largely dictated by materials on-hand within the BSE Department shop (this because of a rush to get a device fabricated for use). The original design had two wheels and relied on a hand crank to raise and lower footings.

Figures 10 through 14 show different views of the latest footing transport and placement cart which is more commonly referred to as Big Dave's Cookie Cart. Unlike the original design, this design has a single-wheel frame and a screw-gun powered winch.

Switching to a single-wheel frame lowered overall cost and weight and provided for a more maneuverable cart. Conversely, the single-wheel design is less stable than the two-wheel design (i.e. it handles like a wheelbarrow) and unlike the two-wheel design, cannot be pushed directly over a posthole.

Use of a screw gun was made possible with the incorporation of a two-stage planetary gear set (figure 12). The planetary provides an overall speed reduc-





Figure 11. Top view of the footing transport and placement cart.

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tion of 20 to 1, which enables virtually any screw-gun to lift a 350 lb footing. Shown to the left (drill side) of the two-stage planetary in figure 12 is a spring-loaded locking mechanism engaged during footing transport to ensure heavier footings stay in place.

During transport, the footing is drawn up against two steel tubes which keep the footings from swinging (see figures 10 and 11). These tubes also function as legs when the cart is folded for storage (see figure 13).

Figure 13 shows side and top views of the cart after it has been folded for storage. The overall folded height is dictated by the distance between the top of the winch system and the bottom of the stabilizers. This height ensures footings can still be drawn up tightly to the stabilizers when larger lifting tongs are being used.

When folded for storage, the cart can still be moved about like a small wheelbarrow (see top view in figure 13). This makes it very easy to slide the folded cart onto a truck or trailer bed for transport.

One person can easily fold or unfold the cart in less than a minute (figure 14). To unfold the cart, it is first stood on its front. Once in this position, the legs and handles are unfolded. This involves

pulling out, and then reinserting two .5-inch diameter cotterless hitch pins. The cart is then lowered so it is resting on its legs. Next, the two wing nuts holding the wheel frame in its stored position are removed, the front of the cart is lifted slightly thus causing the wheel frame to rotate into position, the wing nuts are reinstalled and you are ready to roll. This process is reversed to ready the unit for storage.

To attach a screw-gun to the winch drive requires that the gun have at least a 3/8-inch chuck. Once the chuck has been tightened on the shaft, the base on the gun is strapped to a screw-gun support plate with a bungee cord as shown in figure 11.

Lifting tongs were designed and fabricated for specific footing diameters and with a relatively low profile to minimize overall cart height.

The cart weighs a total of 88 lbm, not including screw gun and lifting tongs. Overall working length, width and height are 112, 27.5 and 32 inches, respectively. Overall length, width and height when folded for storage are 49-, 27.5- and 16.5-inches, respectively.

**Discussion.** The “cookie cart” works well and is fun to use. One person can transport and lower a footing in less

time than two people can transport and lower the same footing using a self-propelled piece of equipment. When loaded, the cart is more stable than a typical, fully-loaded wheelbarrow. However, because of its length, is not quite as maneuverable as the typical wheelbarrow. Preparing the cart for use takes little more than a minute — probably less time than it takes to outfit a skid steer or forklift with lifting tongs.

The planetary gear set was relatively expensive as it cost 1.5 times more than all other materials combined. In addition to being costly, the planetary does not provide any additional braking outside of that associated with its gear reduction. It was for this reason that a locking mechanism was added to the cart for handling heavier footings. A probable solution to both the cost and the braking issues would be to replace the planetary gear set with a worm gear drive system.

Any company that stocks and uses footings that cannot be lowered into a posthole by a single person should own at least one cookie cart. Even when it is not needed for heavy footings, the cart is still recommended for use because it provides for safer and more accurate footing placement.

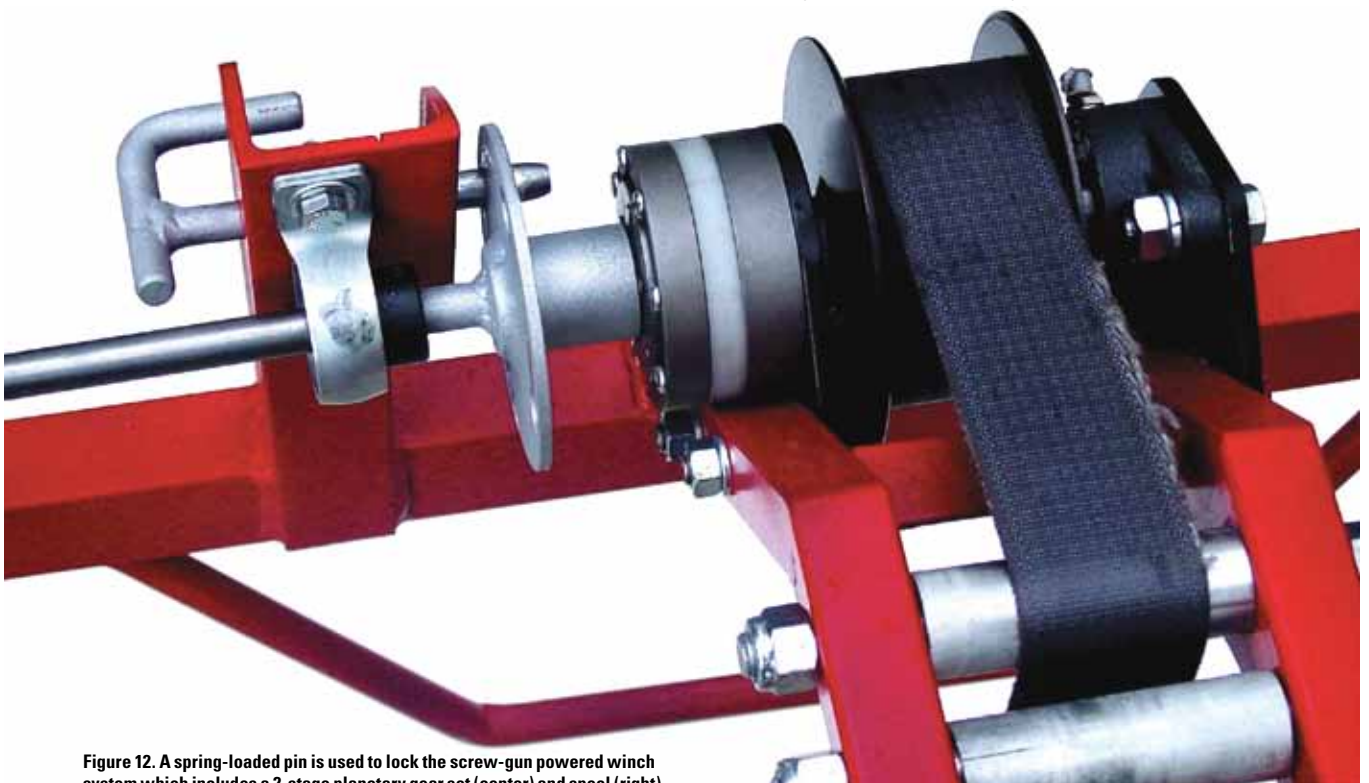


Figure 12. A spring-loaded pin is used to lock the screw-gun powered winch system which includes a 2-stage planetary gear set (center) and spool (right).

**Conclusion.** Embedded post foundations are largely responsible for the cost effectiveness of the post-frame building system. However, like other foundation systems, installation of embedded post foundations has its unique challenges. To help overcome some of these difficulties, prototypes of three different tools: a posthole installation shield, a posthole-bottom leveler, and a footing transport and placement cart were designed and tested by the author of this paper.

The posthole installation shield is used to prevent posthole sides from collapsing during hole drilling and anytime prior to footing and post installation. It is recommended all major post-frame companies stock one or more post-hole installation shields for use on jobsites where conditions make it difficult to maintain proper posthole geometry.

A posthole-bottom leveler is a simple, inexpensive device used to ensure that the base of a posthole is flat and level prior to soil compaction and footing installation. It is recommended such a tool be present on any jobsite where precast concrete footings are being placed.


The footing transport and placement cart enables a single person to transport and place precast concrete footings as large as 350 lbm and 34 inches in diameter, without the use of self-propelled equipment. Any company that stocks and/or routinely uses footings weighing in excess of 100 lbm should not be without a footing transport and placement cart.

The designs herein presented are not protected by patent.



Figure 13. Side and top views of the footing transport and placement cart after it has been folded for storage. Note from the top view that when folded for storage, the cart can still be moved about like a wheelbarrow.

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For material and construction details on these designs, readers are referred to Bohnhoff, D.R. 2005. Post installation tools. ASAE Paper No. 054117. This paper can be downloaded from <http://bse.wisc.edu/bohnhoff/>

*(Any design plans or opinions are those of the author and not necessarily those of the NFBA or the publishers by fact of publication.)*



To unfold Big Dave's Cookie Cart (1) stand the cart on its front (left), (2) unfold the legs and handles and pin them in place (center), (3) lower the cart so it is resting on its legs (upper right), and (4) swing and lock the wheel frame into place (lower right).

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