

High Tunnel Hoop House Construction Guide

Steve Upson



Forward

This publication is the product of 17 years of experience in hoop house (high tunnel) design, construction and utilization. As an educator and consultant, I have been asked numerous times by work associates and growers to produce a 'how to' resource on hoop house construction. Currently, there are many excellent Extension- and grower-authored publications on hoop house crop culture, but few publications on construction. It is not the intent of this publication to offer a complete set of construction plans for any particular type or size of hoop house but rather to introduce the novice grower/hoop house builder to the various tools and

techniques used in constructing a wide range of hoop house models. The various guidelines contained herein are applicable to both prefabricated commercial structures as well as homemade structures. Admittedly, my experience with hoop house structures has a southern flavor; consequently, the guidelines may or may not have application in other regions of the country. It is my belief that a careful study of this publication prior to purchasing a hoop house kit or materials to custom-build a structure will save the builder time and money as well as reduce the level of frustration encountered during the construction process.

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Introduction

Market gardeners are faced with a myriad of production and marketing constraints. Some of these include escalating costs, government regulations, labor quality and quantity issues, competition, and inclement weather. While hoop house technology cannot solve all of these problems, utilization of this technology can reduce production risks associated with inclement weather.

Growing in a hoop house is a little more complicated than field production and requires additional management skill, but don't let this keep you from realizing the benefits of this growing system. If you think of hoop house culture as nothing more than gardening under cover, it's much less intimidating.

Hoop houses, also referred to as high tunnels or cold frames, are generally quonset-shaped and constructed of metal or plastic hoops (bows) covered with a single layer of 6-mil, greenhouse-grade, polyethylene film. Whereas a greenhouse is an environmentally

controlled structure, a hoop house has no permanent heating system or electrical connections. Venting is accomplished by retracting the curtains on the sides of the house. Most houses range in width from 14 to 30 feet. On some sites, houses wider than 20 feet could experience overheating on warm, sunny days due to reduced cross ventilation. Houses can extend over 100 feet in length; however, the majority of commercial houses are 96 feet in length. Compared with greenhouses, hoop houses are relatively inexpensive, ranging in price from \$1 to \$4 per square foot. Most hoop houses are permanent, but a few are designed to be movable. Some houses are designed with removable hoops and permanent bases. These hybrid structures offer some of the benefits of both permanent and movable houses. Permanent structures are generally stronger, but movable houses allow for more efficient use of the structure.



A hoop house strawberry crop ready to harvest

Benefits

Of all the technologies/growing systems currently being utilized by market gardeners, hoop houses are generating the greatest buzz because of the many benefits they offer.

Benefits of hoop house production include:

1. Protection against storms. Depending on the strength of the structure, hoop houses can provide protection against wind and rain that accompany heavy thunderstorms. Commercial greenhouse film is amazingly resilient to small hail. During the fall of 1996, a Noble Foundation hoop house tomato crop escaped the ravages of a hailstorm with ½-inch hail accompanied by 70 mph winds. Some of the hail penetrated the cover but not enough to damage the crop.
2. Damage caused by vertebrate and invertebrate pests can be reduced with careful management. As a rule, birds aren't a problem even when houses are fully vented. Installing shade fabric over the side vent openings will exclude small animals such as skunk, armadillo and opossum. Shade fabric is also effective in screening out large insects such as grasshoppers and moths. Fifty percent shade fabric is recommended as both a pest barrier and a windbreak.
3. As a general rule, expect less incidence of foliar disease in hoop houses, primarily because plants are sheltered from rainfall. An exception to this rule is powdery mildew. The high humidity common to the hoop house growing system accentuates the powdery mildew problem.
4. The greatest benefit of hoop house production is the extension of the growing season.

As a rule of thumb, a well managed hoop house growing system utilizing plasticulture technology (raised beds, mulch film and row covers) can lengthen the growing season (frost-free period) by as much as 60 days. Being able to harvest certain warm-season crops up to a month earlier is due to a combination of being able to plant a couple of weeks earlier than field planting and faster maturity as a result of the growth-enhancing effect (warmth) of the house. Because the hoop house grower can benefit from a more favorable growing environment late into the year, warm-season crop production can be sustained into November or even through the month of December in the Deep South. The season extension benefit of hoop house production is not limited to warm-season crops. Harvest of fall-planted cool-season crops such as leafy greens, root crops and broccoli can be sustained through the winter when grown in a hoop house.

Because they are not heated, hoop houses should not be considered freeze protection devices, although they can provide a few degrees of protection. The actual amount of protection you can expect will depend on factors such as wind speed, draft, residual floor/bed heat, crop height above floor/beds, proximity to sidewalls, duration of the freeze and use of row/crop covers.

Crops



Theoretically, any crop can be grown in a hoop house. Because of the increased cost of hoop house production, only high value crops have the potential for profit. A few hoop house crops that are commonly grown for market include tomato, eggplant, pepper, summer squash, cucumber, specialty melons, strawberry, raspberry and cut flowers. Public and private agricultural institutions worldwide continue to research economical methods of producing a wide range of crops in hoop houses, including peach, blueberry, okra and asparagus.

Models



Hoop house structures fall into two basic categories: permanent and movable. Permanent structures are typically anchored to the ground using ground posts driven into the ground or anchored in concrete. Movable structures are designed to be pushed or pulled on skids or rollers. They are typically anchored to the ground using a cable or chain. The shape of the hoop (bow) can vary greatly on both types of structures.

The quonset model is generally the easiest and least expensive structure to construct. The main disadvantage to this design is the lack of shoulder and headroom along the sides of the house. While satisfactory for producing low-growing crops, the shape restricts production of such crops as tomato and cucumber close to the sides of the house. This restriction can be partially overcome using wider and taller quonset structures. As a general rule, quonset structures less than 20 feet wide are inefficient for producing caged or trellised crops.

Modified quonset models



To provide more interior head and shoulder room along the sides of the house, hoop house manufacturers offer several variants of the standard quonset structure. Hoop houses equipped with straight side walls or 'bowed out' side walls provide unhindered internal access along the sides of the house while permitting plenty of vertical growing space. Ensuring this extra room doesn't come without a cost. The additional pipe and extra bending required during side wall and hoop fabrication adds to the cost of these modified models.



Triple side vent model



Ridge vent model

Growers seeking maximum ventilation and heat dissipation can equip their houses with vents located at the top of the house. The ‘sawtooth’ or ‘triple side vent’ design utilizes a third or upper vent on one side of the house to dissipate heat. The side of the house containing the third vent is several feet higher than the other. The chimney effect created by the difference in wall heights permits heated air to move up and out of the house through the upper vent. Because cross ventilation powered by summer breezes is the primary means by which hot air is exhausted from the house, the upper vent should always be located on the leeward side. In Oklahoma, our prevailing summer breezes are out of the southwest. Under these conditions, a house oriented north and south should have the upper vent located on the east side. Houses oriented east and west should have the upper vent located on the north side.

Houses equipped with a ridge vent running the length of the structure also offer excellent heat dissipation. In most of these structures, the ridge vent consists of a roll-up curtain.

Whether you purchase a kit or fabricate your own structure, expect to pay more for a top-vented model due to the extended height and additional materials required to construct the vent. This design is also more difficult to maintain due to the location of the vent.

If your goal is to extend the harvest of heat-sensitive crops, such as tomato, deep into the summer, a top-vented model is your best choice for managing heat.

Gothic model



Photos courtesy of Penn State University

Gothic models are shaped similarly to traditional glass greenhouses. Due to the peaked roof, the poly-film covering does not adhere as tightly to the frame compared to a quonset structure. Growers often use strapping to limit the amount of film flapping that occurs during windy conditions.

Growers located in areas frequented by heavy snows often choose Gothic-style structures. The enhanced slope of the roof makes snow removal easier.



Several movable hoop house options exist. The multi-bay model offers the lowest cost per square foot of covered growing space. These multiple-bay structures utilize ground (anchor) posts that are augered into the ground using a tractor or handheld power source. The ground posts, along with the structure, are removed at season's end. Although designed as a movable model, some growers choose to manage multi-bay models as permanent structures. Hoop spacing commonly used in multi-bay structures is 10 feet compared to 4 feet in most permanent models. This reduction in the number of ground posts and hoops utilized translates into a lower purchase price.

Due to their design, multiple-bay movable structures are more susceptible to storm damage. Growers will need to take special precautions such as fortifying the end walls to avert possible damage.



Several movable structures popular with growers include the skid-mounted model, the roller-mounted model, and the lift-and-tote model. Because these structures are moved intact, most are less than 20 feet wide and shorter in length compared to a similarly sized (width) permanent structure. Some of the models have removable end walls to enable them to be moved without damaging the crop. Typically, skid-mounted and roller models are only moved forward or backward, not sideways, and are pulled with a tractor or winch. Cross members strategically attached to the lower frame of lift-and-tote structures enable a crew to lift and walk the structure to another site. The downside to moving a lift-and-tote structure is the requirement for multiple individuals to perform the task. A relatively level growing site is required when using movable structures. Because they are not grounded while moving, movable structures can be damaged on windy days. Growers typically use cables or chains embedded in concrete or attached to earth (trailer house) anchors to anchor their movable houses.



The Noble Foundation poly pipe 'hybrid' hoop house



Hanley 'hybrid' model



Some growers are opting for hoop houses equipped with removable hoops and permanent ground posts. Commonly used ground post materials include steel pipe, T-post and rebar. These 'hybrid' models incorporate some of the best features of both permanent and movable structures. Most are Quonset-shaped and range from 14 to 17 feet in width and between 7 and 8 feet at the peak. Typically, rope straps placed over the top are used to secure the poly covering to the frame. Because of their simple design, hybrid structures are easier to assemble and disassemble compared to similarly sized permanent structures. Construction plans for the Noble Foundation poly pipe model are available at <http://www.noble.org/global/ag/horticulture/poly-pipe-hh-plans/nf-ho-12-02.pdf>. Construction plans for the Hanley model are available at <http://www.kerrcenter.com/pdf/hoophouse-howto.pdf>.

Building material options



Because of its strength and durability, heavy-gauge galvanized steel pipe should be your first choice of material for hoops. You can purchase pipe and have it custom bent or purchase a pre-engineered frame from a greenhouse distributor. On houses narrower than 20 feet, 1.375-inch-outside-diameter (O.D.) pipe will suffice. On houses 20 feet and wider, it is customary to use 1.66-inch-O.D. pipe or larger for hoops. Pipe strength is not only a product of diameter, but also wall thickness (gauge). The smaller the gauge, the thicker the pipe wall. The minimum gauge to use for steel hoops on structures equal to or greater than 20 feet is 14. Chain link fence 'top rail' tubing is the steel tubing of choice when fabricating hoops for small, hobby-scale hoop houses. Because top rail tubing thickness is only 16 or 17 gauge, it should only be used for hoops on structures less than 20 feet wide. Pipe used for ground (anchor) posts should be large enough to accept hoops readily and yet not have excess play. 1.875-inch-O.D. pipe is commonly used for ground posts with 1.66-inch-O.D. hoops.



A 12-foot-wide X 16-foot-long X 7-foot-tall hobby hoop house frame made from 1.375-inch-diameter, 16-gauge galvanized steel 'top rail' tubing



A 'Quick Hoops' tube bender mounted to a shop bench. For more information on this bender, go to <http://shop.hoopbenders.net>.

To save money, many hoop house enthusiasts elect to fabricate their own hoops. Manually operated benders are available from vendors for bending 16-18 gauge, 1.375-inch-diameter tubing. Plans for fabricating a tube bender capable of bending 1-inch square tubing for a 17-foot-wide hoop house are available at <http://www.kerrcenter.com/pdf/hoophouse-howto.pdf>.



A PVC pipe structure
stabilized using cable

Less preferable materials for use as hoops include polyvinyl-chloride (PVC) and polyethylene. PVC pipe should only be used for constructing small hobby structures in sheltered locations. Be sure and select the gray wall electrical conduit PVC pipe as it is treated to withstand sunlight degradation. If you select PVC pipe for your frame, be prepared to install bracing and cabling to firm up the structure.



The Noble Foundation
poly pipe hoop house

Two-inch-diameter black, oil and gas pipe (SDR-11) made of high-density polyethylene is a better choice than PVC for constructing houses up to 14 feet in width. It is more flexible and has a slower rate of photo-degradation (the process that causes brittleness) compared to PVC.

Hoops should always be positioned on 4-foot centers. Some growers choose 6-foot hoop spacing as a cost-saving measure. This is a risky proposition in Oklahoma, considering the severity of our storms. You can pay more up front for a strong structure or pay later to repair or replace a weaker one.

End wall and door options



Hoop house end wall framed using square steel tubing

Many commercial hoop house kits do not come equipped with functional end walls. Some merchandisers offer functional end wall packages as optional in order to keep the cost down. Another reason many merchandisers are hesitant to offer a one-size-fits-all end wall package is because in the real world of hoop house production, one size doesn't fit every grower's needs. Depending on location, the type of house being used (permanent or movable) and the crops being grown, end wall requirements can vary greatly.

When designing an end wall, there are several points to consider, including the choice of construction materials to be used, the size (surface area) of the end wall, structure type (permanent or movable) and accessibility requirements.

Growers have several options when choosing materials to frame end walls. Galvanized steel square tubing is the framing material of choice due to its high strength-to-weight ratio and resistance to weathering.



Pressure-treated, dimensional lumber is a popular choice among first-time hoop house builders because it is readily available and doesn't require specialized construction skills and equipment. Some of the negative aspects of using wood in hoop house construction include rotting and swelling. If you are an organic grower or plan to pursue organic certification, the use of pressure-treated lumber in hoop house construction is prohibited. Other construction materials include angle iron and steel C-purlin. As a general rule, the larger the end wall and door components, the larger the structural member requirement to compensate for greater wind loads.



Anchoring end wall posts in concrete



Tamping soil around end wall posts to set posts

To save money, some growers tamp soil around end wall support columns during installation. While this may prove satisfactory on small structures, concrete should be used for setting columns on larger structures. To provide stability under adverse conditions, plan on setting columns at a depth of 3 feet.



Accessing a hoop house through a standard 36-inch-wide door while operating equipment such as a rototiller, backpack sprayer or garden cart can be difficult. For greater ease of access, consider installing doors with a minimum width of 4 feet. If you choose not to fabricate your own doors, commercial, pre-hung greenhouse doors are available. One word of caution when purchasing a door for your hoop house; you get what you pay for. If at all possible, avoid cheap storm doors equipped with plastic hinges. With heavy use, the hinges will break and the kick plate will be knocked out within a year. Growers Supply <http://www.growerssupply.com/farm/supplies/home> offers a wide selection of doors as well as hoop house frames and supplies.



Sliding door



Scissor door

Other door options include the sliding door and the scissor door. A sliding door incorporates the use of track located at the top, or top and bottom of the door frame. The top-track-mounted model is the most popular with growers as the track is less likely to get plugged with debris.

The scissor door is a simple design consisting of two equal length pieces of metal tubing, each of which is connected at one end to the top of the end wall frame. The two pieces of tubing, oriented side by side, are attached loosely to the frame, allowing both tubes to move out and away from each other at the base in a scissor motion when the door is opened. The end wall poly film cover is cut down the middle from top to bottom and the cut ends attached to the tubing. Because this design does not incorporate the use of a true door frame for stability, it is better suited for use on small, low-profile structures.

Curtain doors



The simplest door option (it's a stretch to call it a door) consists of a rectangular piece (curtain) of poly film permanently attached along the top of the door frame. A piece of metal tubing or conduit fastened to the base of the curtain allows it to be rolled up. Fabric clips fastened along both edges of the curtain at 1-foot intervals enable the sides of the curtain to be attached to the door frame. The clips are placed over nails or screws inserted into the side (upright) members of the frame. The nail or screw heads prevent the clips from detaching unless removed by hand.

Top-hinged door



Hinged double doors equipped with a built-in pedestrian door

Some growers install oversized hinged doors in order to accommodate large equipment. Hinged double doors and top-hinged (old-style garage door) are most popular with growers. Penn State University uses a top-hinged design on their hoop houses. Plans for this design can be accessed at <http://plasticulture.psu.edu>. In order to make entering and exiting the structure more convenient when using equipment, both end walls should be designed for drive-through capability.



A movable hoop house equipped with a detachable end wall



The Noble Foundation portable end wall

Growers who use movable hoop houses typically equip their structures with detachable or portable end walls to accommodate movement of the structures without damaging crops. Some small movable frames equipped with non-detachable end walls are light enough to be lifted over the crop and moved as one unit.

For quick removal, detachable end walls are typically attached to the frame using bolts or pins. The base of a detachable end wall can be stabilized and/or anchored to the ground using a removable base plate, removable stakes or sections of chain embedded in concrete below the soil surface.



Construction plans for a portable end wall that can be used in combination with a small permanent or movable hoop house are available at <http://www.noble.org/global/ag/horticulture/high-tunnel-hoop-house/nf-ho-11-01.pdf>.

Most permanent structures requiring large equipment access are equipped with oversized doors; however, a few are equipped with removable end walls. On large (24 to 30 feet wide) permanent structures requiring tractor access, oversized attached doors are a better option than a movable end wall because they are more user friendly.





In the Southern Great Plains, growers erecting large, permanent hoop houses should incorporate some type of venting into stationary end walls. The more venting you can provide, the less heat stress your crops will be exposed to. Because heat rises, emphasis should be given to locating vents just below the roof peak which would be above a pedestrian door in most houses. These vents are typically the first to be opened in the morning to permit air exchange in order to lower the humidity in the house. Over-door vents permit air exchange without the risk of shocking the crop with cold air, a situation that can occur if the roll-up side curtains are opened prematurely on cold days.



Several materials are available to cover end walls and doors, including polycarbonate, PVC, woven poly fabric and standard greenhouse poly film. The rigid polycarbonate and PVC panels are excellent choices for stationary end walls. Because it resists puncturing, a problem often incurred when moving end wall frames, woven poly fabric is my choice for covering portable end wall frames and door panels.

Site selection and house orientation considerations



Several factors should be taken into consideration when selecting a site to erect a hoop house, including sunlight exposure, wind exposure, slope and soil type. Of these four, sunlight and wind exposure are the most critical and should take precedence when selecting a site. It is assumed there is sufficient quantity and quality of water available for irrigation. Excess slope can be corrected using a tractor blade. A small amount of slope (1 percent or less) is desirable to move water away from the hoop house. If the soil type on the site is undesirable, purchased topsoil can be applied to rectify the situation. As passively heated and cooled structures, hoop houses are dependent on sunlight and wind for heating and cooling. Therefore, when locating a hoop house, select a site that has maximum exposure to both sunlight and wind. Any object, be it a plant or a building, that blocks even an hour of sunlight or air flow can compromise the potential of the system.

Due to the abundant solar radiation in the Southern Great Plains, hoop houses can be oriented with their long axis north to south or east to west. Houses oriented north and south achieve a more equal distribution of sunlight when growing beds run parallel with the house. It is possible to achieve greater ventilation with the house oriented east and west, given that the prevailing summer wind is primarily from the south; however, on most exposed sites in Oklahoma, prevailing winds are strong and regular enough to provide adequate ventilation regardless of house orientation.

Site preparation



Construction of raised beds is recommended prior to hoop house assembly.

Preparing a site for a hoop house is similar to preparing a garden site. Start by eliminating all weeds and turf from the site. A glyphosate-based herbicide will control hard-to-kill perennial weeds such as bermudagrass and johnsongrass.

If the site you have selected has minimal or no slope, pad construction is recommended to keep surface water from entering the hoop house. You may need to purchase several truckloads of soil to construct the pad. A pad 4 to 6 inches in height is sufficient to ensure water runs away from the house. The pad should extend 6 feet beyond the periphery of the house on all sides to create an apron to walk on.

If you plan on installing permanent raised beds in your hoop house, consider constructing them first. It's much easier to fill the beds prior to constructing the house because you don't have to negotiate around the sidewalls. For detailed instructions on constructing raised beds, refer to the Noble Foundation publication 'Permanent Raised Bed Gardening' at:

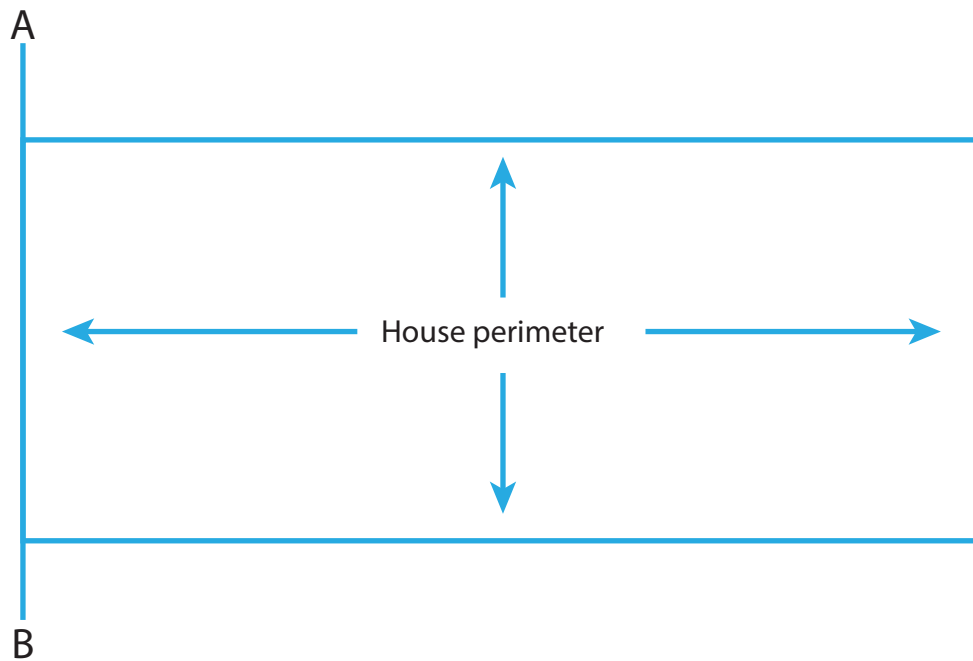
<http://www.noble.org/ag/horticulture/raised-bed-gardening>.

Hoop house perimeter layout



Once the pad is in place and has had time to settle, you need to establish the exact location of the hoop house perimeter (sides and end walls) and the elevation for the ground (anchor) posts. Depending on the model and the manufacturer's recommendations, the elevation of the ground posts can range from 6 inches to 18 inches above ground level. Instead of using a separate set of ground posts, some structures use single pieces of pipe that serve as both ground post and side wall.

You may want to enlist the help of a friend with carpentry skills when laying out the foundation. A hoop house structure is similar to any other permanent building during construction. If the foundation is square and level (or at minimum, uniformly sloped), the structure should come together without any major complications.



Note: When using a tape measure, make sure the tape is taut. Use the same tape for all measurements and be consistent in your technique. Although not required, the presence of a second person greatly simplifies and speeds up the measuring process.

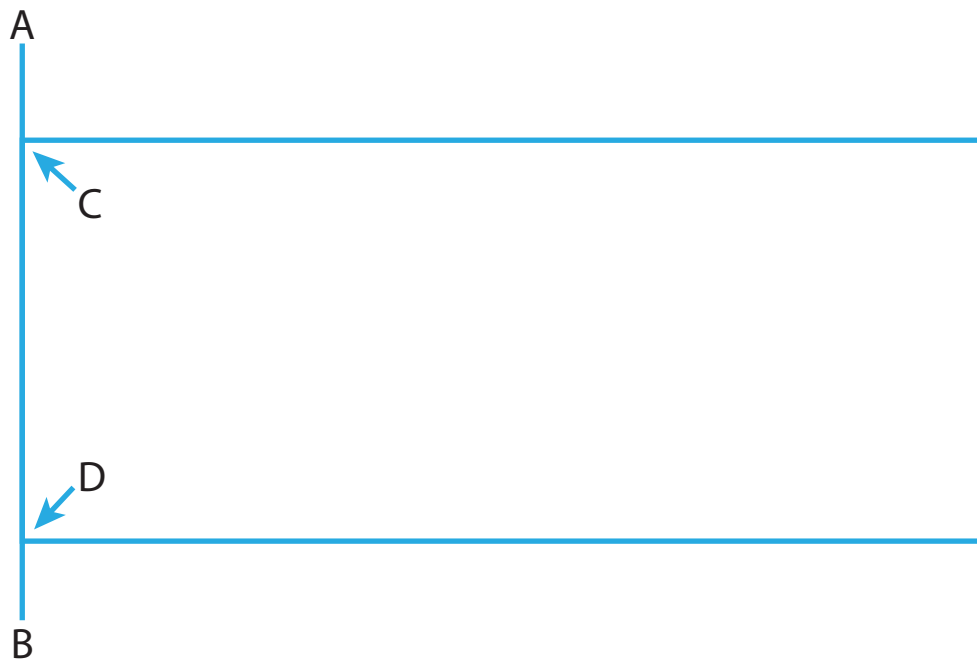
The following procedure can be used to establish the boundaries of a hoop house and the elevation of the ground posts.

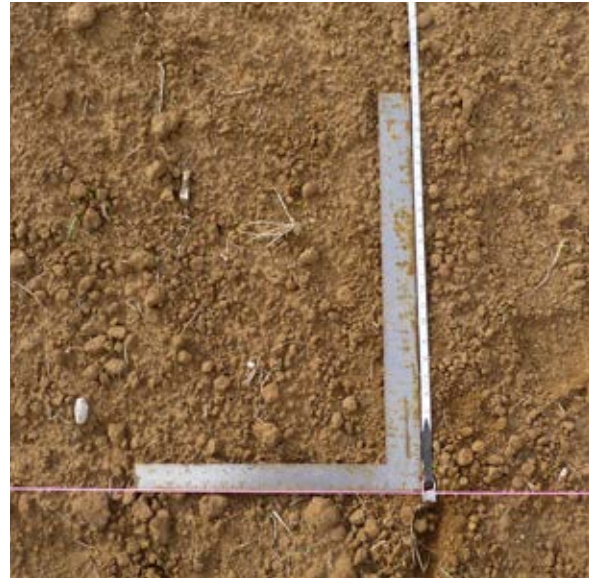
You will need the following tools to complete the job: sledge hammer, carpenter's square, plumb bob, six gutter nails, six wood screws, twine or heavy string, six rebar stakes, six wood stakes, a surveying instrument, measuring rod, two measuring tapes long enough to reach across the plot, and a permanent marker.

Begin by marking off one side of the plot. It is usually desirable to make this side parallel or perpendicular to the side of a nearby building, road or fence line. However, if the line of reference does not run true north-south or east-west, consider using a compass to establish the first side.

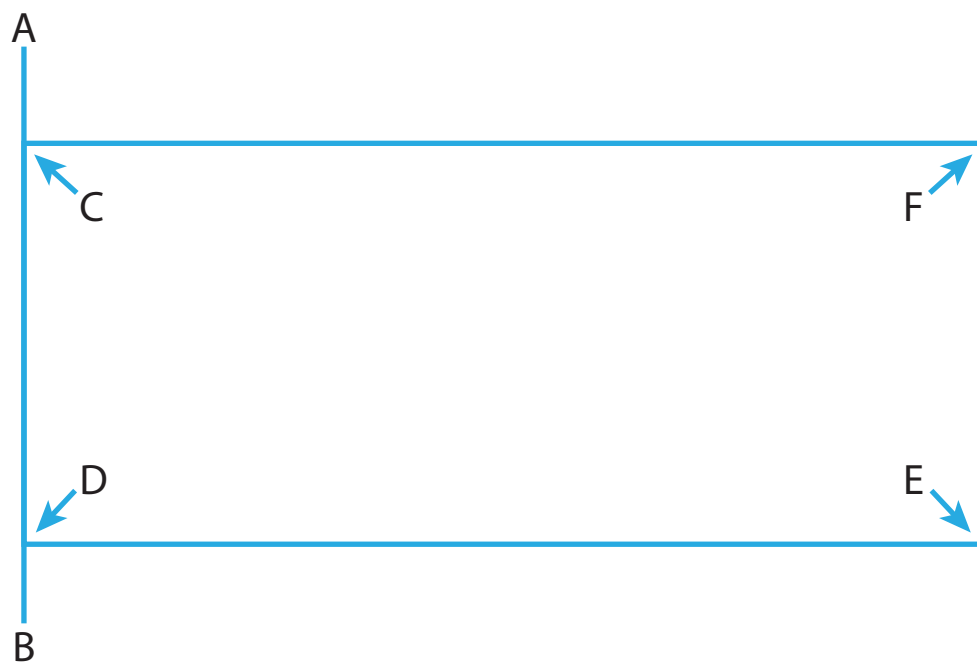
Drive two rebar stakes (points A and B) an equal distance from the line of reference or locate them based on compass headings. Make sure the distance between points A and B is greater by several feet than the actual structure measurement. String a line between points A and B.

Next, push a large nail (a gutter nail is best) into the soil directly under the string and at the point you designate to be one corner of the house (point C). Place another nail directly beneath the string at the point designating an adjacent corner of the house (point D). Line CD represents one end of the house.





Measure the distance to both corners on the opposite end of the house, designating their locations (points E and F) with nails. Use a framing square to make corners C and D as close to a 90-degree angle as possible.

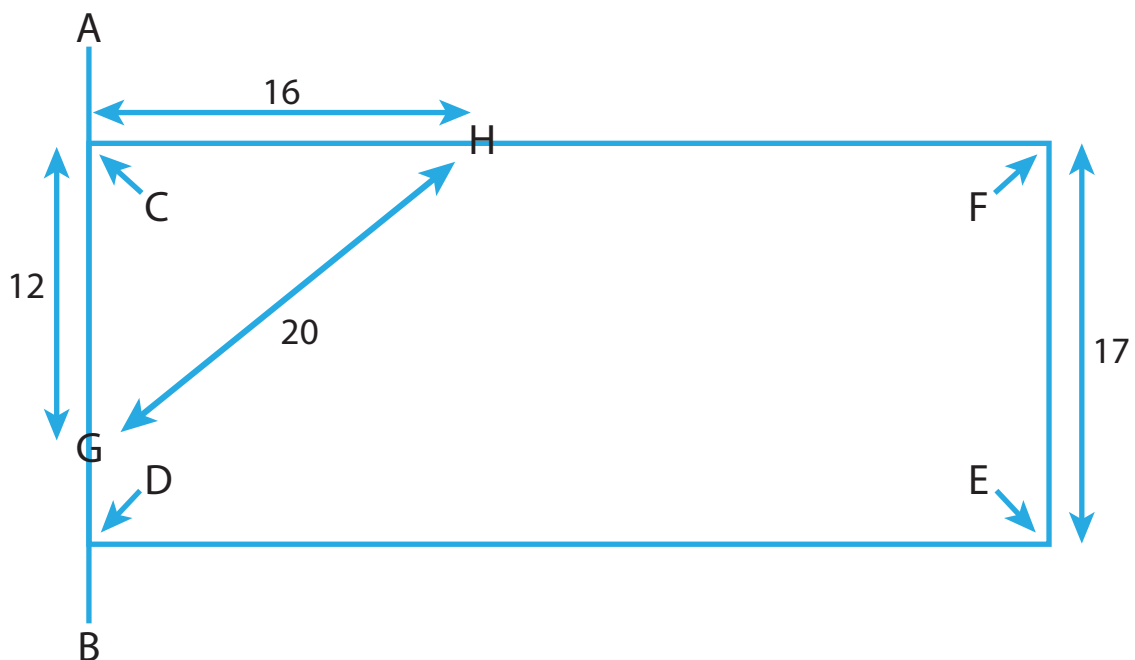


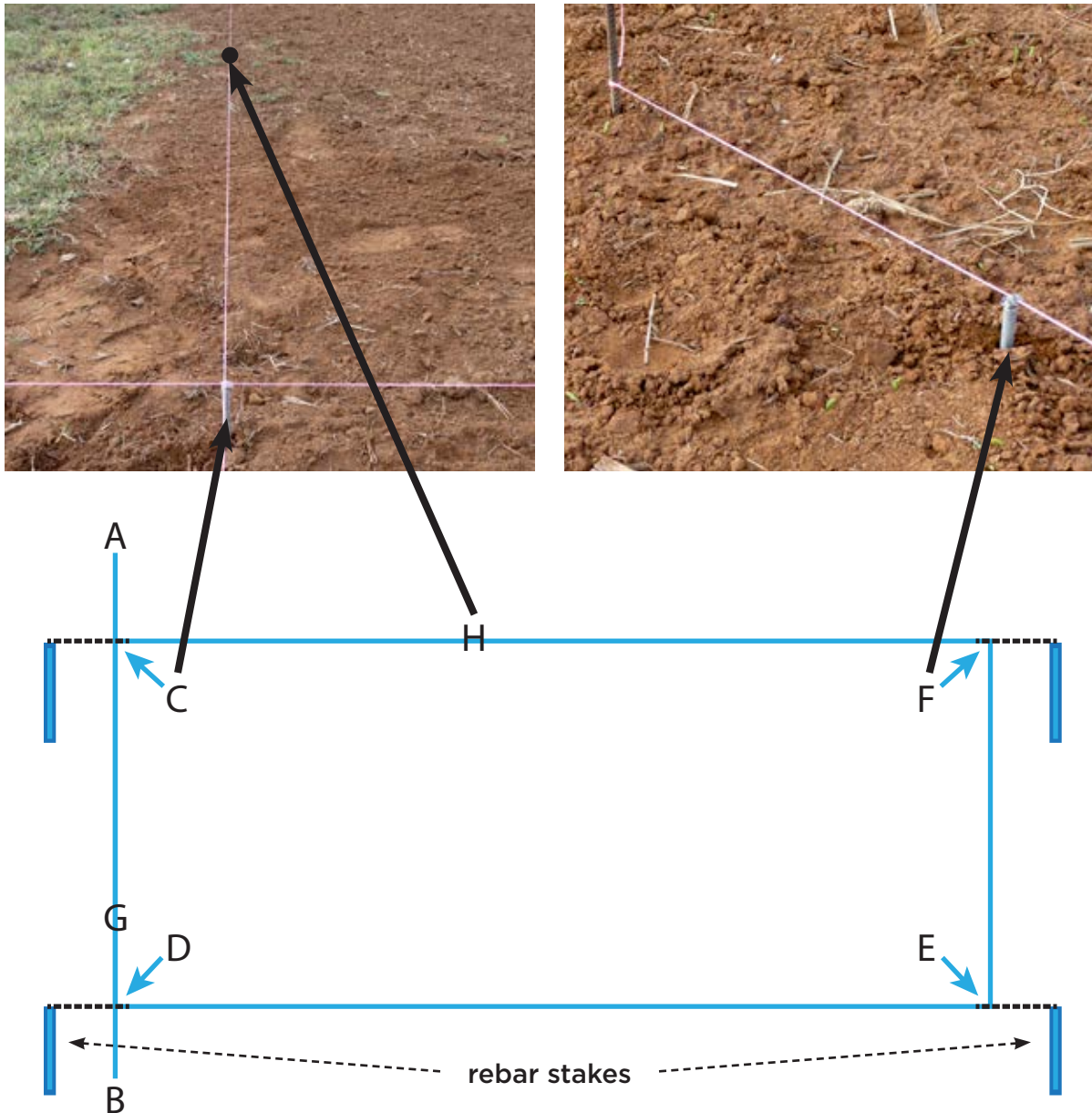
Now make sure corner C (angle FCD) forms a 90-degree angle. This is best accomplished by using the 3-4-5 triangle ratio (referring to lengths of the sides of a right-angled triangle). Any multiple of 3-4-5 will also work, such as 6-8-10 or 12-16-20. Using a larger multiple will help create an accurate 90-degree angle. The beauty of this procedure is that it enables you to square the entire plot using one corner set at 90 degrees.

In our example, the house is 17 feet wide so a 12-16-20 ratio is chosen. A 90-degree angle is established at corner C by first measuring 12 feet from point C and placing a nail directly under the string (point G).

Next, two measuring tapes are attached to the nails at points C and G. A nail is placed at the union (point H) where the 16-foot and 20-foot marks of the respective tapes converge.

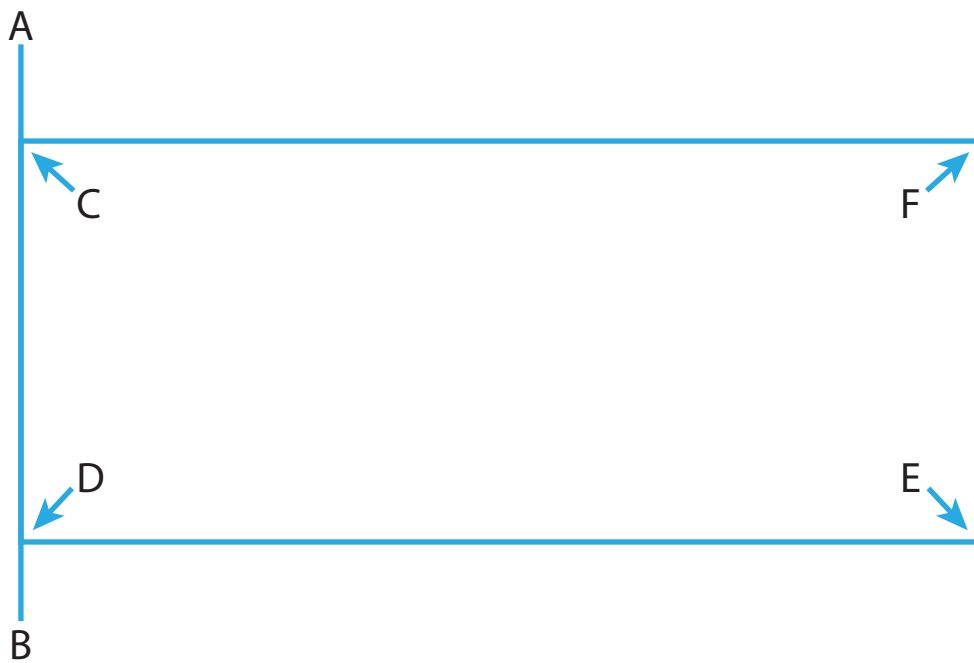
(Note: you may need to grind down the nail heads to accommodate the tape measures.)





After removing the measuring tapes, drive a set of rebar stakes at each end of the house in line with points C and F and another set of stakes in line with points D and E. Position the stakes a few feet outside of the house perimeter (similar to the stakes at points A and B). Attach a string to the stakes, and string a line between points C and F and points D and E. The string line between points C and F should be positioned directly above the nails at points C and H. If not, pull up the stake adjacent to point F and adjust the location of the line and the nail at point F. Corner C (angle FCD) should now be approximately 90 degrees.

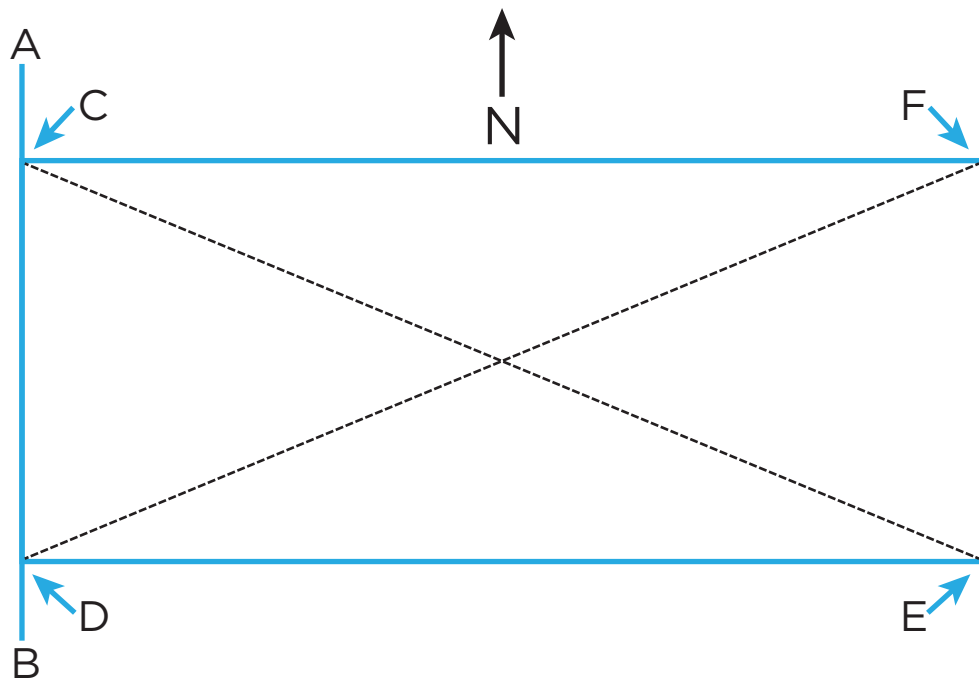
Next, check the distance between points F and E. The distance between points F and E should be the same as the distance between points C and D. If not, the nail at point E (not F) is adjusted accordingly. Corner D (angle EDC) should now be approximately 90 degrees.



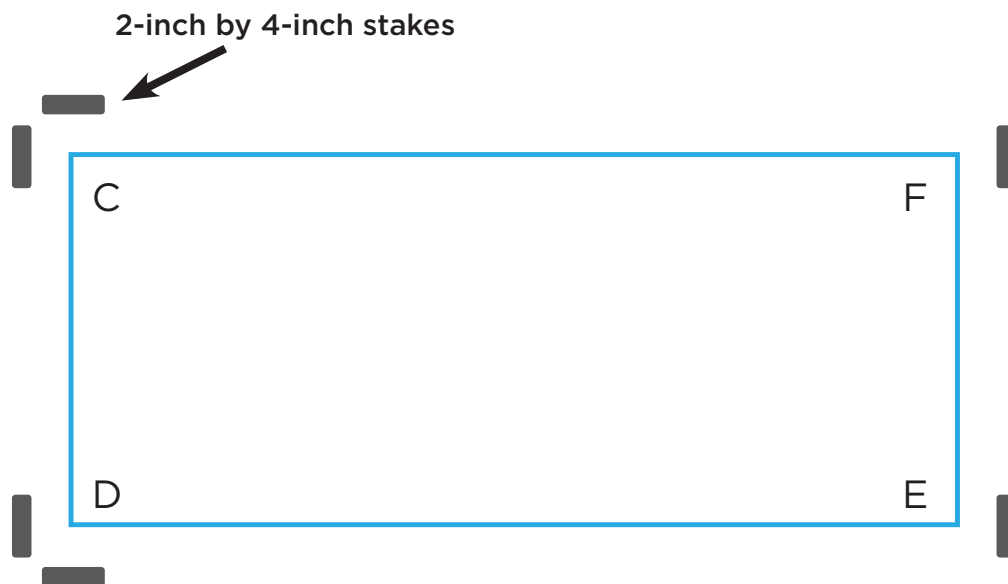
If you've followed these steps, your plot should be close to square. For the final proof, lines CE and DF must be of equal length. If the lengths are unequal, observe the following guidelines to square the plot:

1. Only adjust the location of points E and F.
2. Move the nails in only one direction along line EF, never towards or away from C or D.
3. When making an adjustment, always move nails in the same direction and at an equal distance.

For example, if line CE is found to be 4 inches longer than line DF, move both nails 2 inches to the north along line EF. Measure lines CE, DE and EF to make sure they are still the proper lengths. Next, measure CE and DF again. Repeat procedure until plot is square. Using two tapes simultaneously to take diagonal measurements will speed up the process. When lines CE and DF are the same length, the two tapes will cross each other at the same measurement.



Next, prepare six, 2-inch by 4-inch by 18-inch wood stakes. (Note: if the height of the ground posts extends greater than 6 inches above grade, you will need to prepare longer stakes). At corners C and D, drive the stakes 18 inches from the nail, centering them on each boundary line. Only one stake is required at points E and F. Drive the stakes into the ground only a few inches at this time.

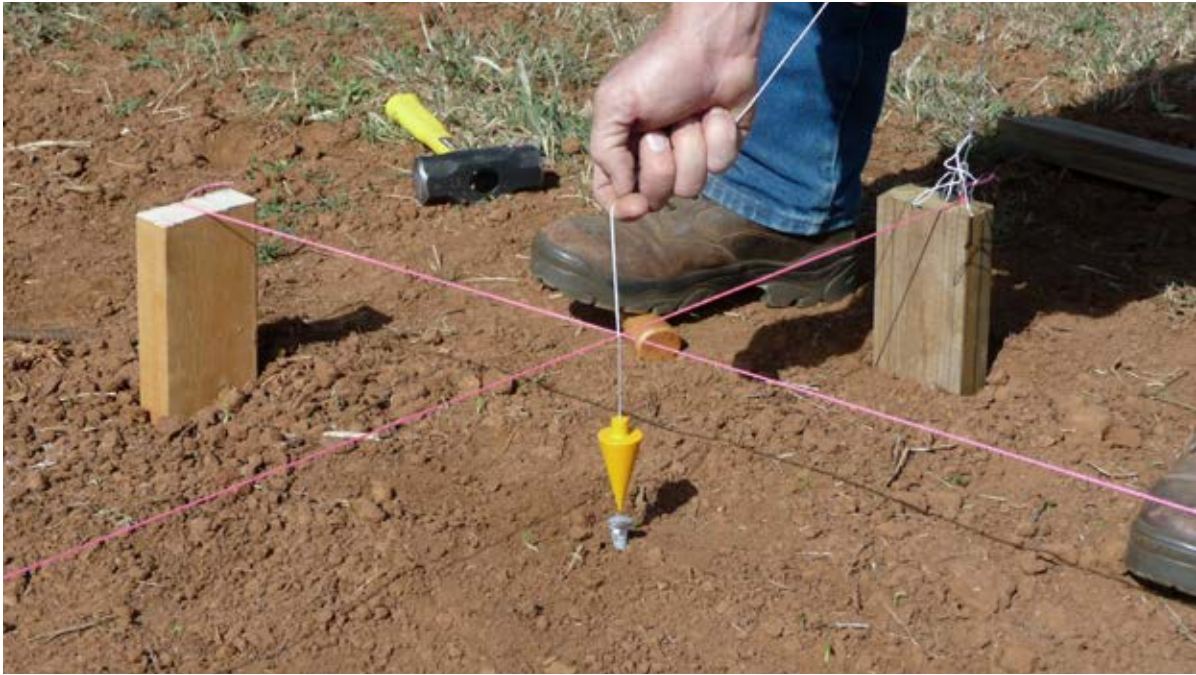




Select one stake and drive it to a height above the soil surface equivalent to the recommended height of the ground posts.

Use a surveying instrument and leveling rod to establish the remaining stakes at the same elevation as the first. An alternative method, although less accurate, is to use string lines and a line (bubble) level to set the other five stakes level with the first.

Insert a wood screw into the broad (4-inch) side of each stake, 4 inches from the top. Make sure the stakes are oriented with screws facing away from the house.



Next, establish the exact position of each boundary (perimeter). Attach strings to the nails on each stake, making sure strings run over the top of the stakes. Be sure each string line is taut.

Use a plumb bob to position each string line precisely above the nail points. Mark the position of each string line on the top of each stake with a permanent marker. Mark both sides of the string. If a string breaks or you need to remove the strings prior to completing ground post installation, they may be reattached to their exact location using the marks.

Congratulations! You have now defined the perimeter and ground post elevation of your hoop house.

Ground post installation

A typical ground post ranges in length from 30 to 40 inches and is larger in diameter than the post it will be supporting. When choosing a post, the length should be based on the soil type and the post height above ground. As a general rule, the sandier the soil, the longer the post should be to ensure adequate anchorage. With most commercial hoop house structures, ground posts should be driven to a minimum depth of 2 feet.

Begin construction by driving a ground post in one corner of the foundation perimeter. Position the post as close to both string lines as possible without touching the line. Unless the manufacturer specifies how the width of the house is defined, i.e., the distance between the inside of one ground post to the inside of the opposite ground post, it typically does not matter what side of the line you install the posts. To prevent flaring of the post while driving, insert a post driver or trailer ball hitch into the post. Stop occasionally while driving and use a carpenter's level to ensure the post is being driven vertically. Drive the post to where it is even with the string line. Repeat this procedure until all of the posts on both sides of the house are in place. The use of a template fashioned from a piece of 2-inch by 4-inch lumber is a quick and accurate method of spacing the posts.



House interior
A ground post being installed
on the outside of the string line





Accurate ground post installation minimizes complications that can arise during house construction.



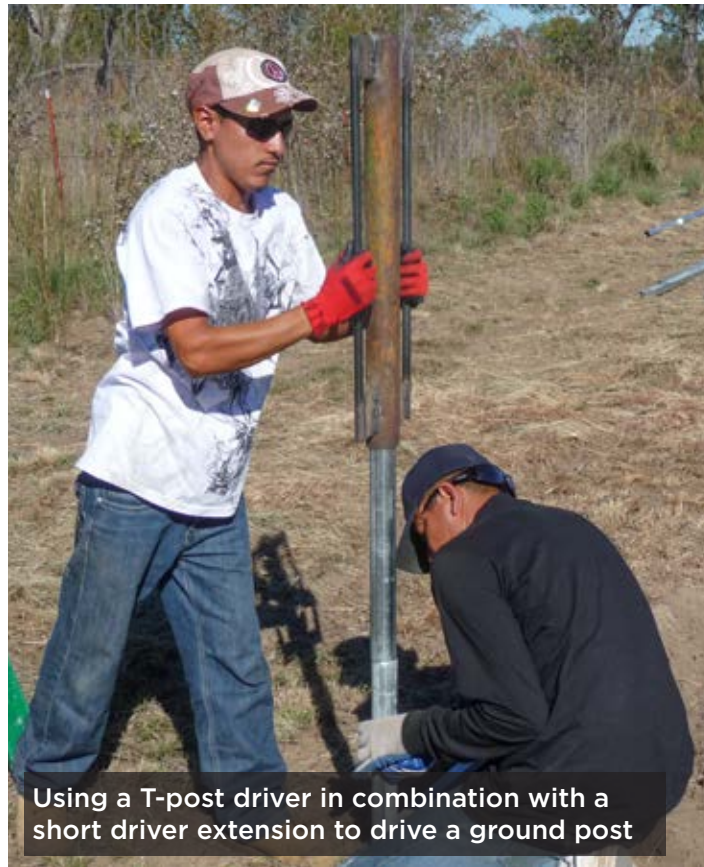
House interior

Ground posts installed on a 4-foot spacing using a template to ensure accurate post spacing

Installing ground posts can be a time consuming and exhausting experience. Professionals use a combination of tools and techniques to install ground posts. One such tool that can be fabricated by the grower is a driver extension. By raising and dropping the driver extension on a ground post, the post can be installed while standing in an upright position.

A driver extension consists of two parts, a larger diameter pipe handle and a smaller diameter pipe guide. The pipe selected for the handle should be a heavier gauge with the same outside diameter as the pipe used for the ground posts. The section of pipe used for the guide is identical to that used for the hoops. To fabricate a driver extension, insert a 3-foot section of pipe (the guide) into a 5-foot section of pipe (the handle). Make sure the guide extends beyond the handle by 2 feet. You may need to pound the smaller diameter guide into the larger diameter handle. Using a heavier gauge pipe for the handle ensures the guide fits tightly and increases the weight of the driver extension, improving its performance. In case of a loose fit, drill a 5/16-inch hole through the joined pipe and fasten with a bolt. A shorter version of the driver extension can be used in combination with a T-post driver to achieve greater impact.

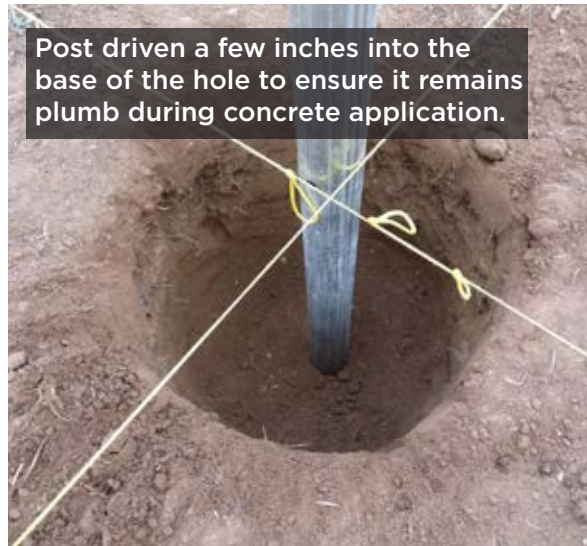




Using a T-post driver in combination with a short driver extension to drive a ground post



A pneumatic post driver makes post driving a breeze.



In situations where it is not possible to drive posts, use an auger to prepare the holes. Add concrete around the base of the posts before replacing excavated material. To avoid using your hands to keep the post plumb while adding concrete, drive the post into the soil several inches below the base of the hole. On some sites, it may be necessary to loosen the soil at the base of the hole prior to driving posts. Check to ensure the posts remain plumb following concrete application.



During storms, ground posts have been known to pull free of their concrete bases due to a lack of adhesion. To prevent slippage from occurring, insert a bolt through the post or flare the base using a sledge hammer prior to installation.

End wall construction



The end wall frame is typically the first component to install following ground post installation. If your house will be equipped with stationary end walls, the first item of business is post installation. Posts should be adequately sized and buried deep enough to bear the anticipated wind load. Embedding end wall posts in concrete is highly recommended. The number and spacing of end wall posts is dependent on the number and size of doors, vents, removable panels, etc. In many end walls, the end wall posts and door posts are one and the same.



Prior to constructing the end wall, install the end hoop. Position posts and adjust height of posts to link with hoop. Detach hoop and lay to the side. After posts are installed, reinstall hoop and connect with posts. (See next section for information on hoop assembly.)



Use a string line attached to opposite ground posts to align end wall posts. A carpenter's level is needed when setting posts to ensure they are installed plumb.



Two end wall center posts installed. Notice the use of braces to prevent movement of posts while concrete cures.



Lag Screw

A common method of attaching end hoops to posts is to cut a notch equivalent to the diameter of the hoop in the upper outside corner of each post and secure using a bolt or lag screw. A cutoff saw equipped with a hacksaw blade can be used to notch steel posts. To prevent tearing of the poly cover, use a wood rasp to round off the corners of wood posts or a grinder to round off corners on steel posts. You may also want to wrap the entire hoop/post union with heavy-weight duct (Gorilla) tape to reduce the chance of tearing.



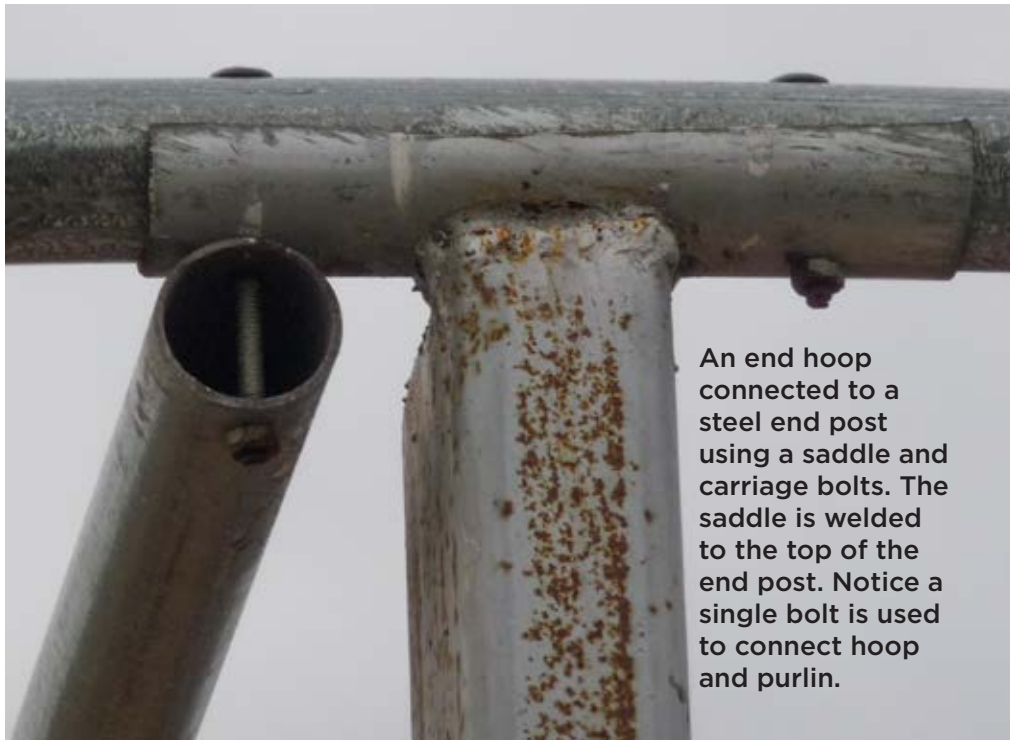
Drilling a bolt hole



A cutoff saw is ideal for notching posts.



Hoop installed in end wall post. Notice the rounded corners on the post.



An end hoop connected to a steel end post using a saddle and carriage bolts. The saddle is welded to the top of the end post. Notice a single bolt is used to connect hoop and purlin.



An end hoop connected to a steel end post using a piece of angle iron and a couple of tech screws. The angle iron is welded to the top of the end post.



End wall cross members connected to end wall posts using angle brackets and tech screws

After the end wall posts are installed, frame in the end walls. This will enable the installation of doors, baseboards, and any vents and removable panels you wish to add. The end wall frame also serves as a surface for attaching poly film, rigid polycarbonate or PVC sheeting. Installation of doors, vents and sheeting can wait until after the hoop house frame is assembled.

Hanger brackets make connecting 2-inch by 4-inch wood cross members to posts a quick and easy job. Steel angle brackets are commonly used for connecting square tubing cross members to posts. For a super strong end wall frame, consider welding cross members to posts.



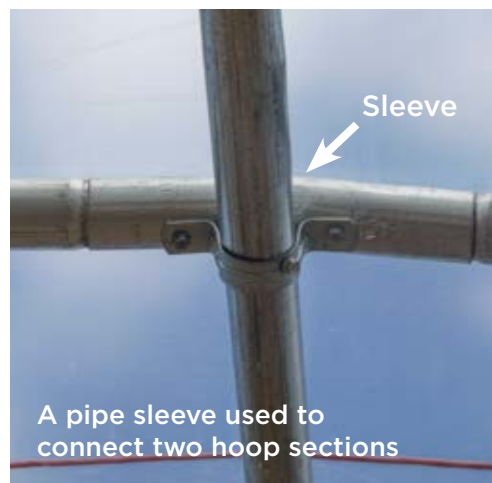
Hanger bracket

Hoop, purlin, baseboard and hip-board installation



A flat surface is ideal for hoop assembly.

Most hoops (bows) are composed of several sections requiring assembly prior to inserting into ground posts. Avoid forming a twisted hoop during assembly. This is best accomplished by assembling the hoops on a flat surface. A concrete driveway or parking lot is ideal for this task. Each hoop section should have a swaged and an unswaged end for easy assembly. Hoop sections without swaged ends can be connected using a sleeve. Once the sections are connected to form a hoop, secure each joint using a self-tapping tech screw.



A pipe sleeve used to connect two hoop sections



Insert the ends of each hoop into a set of ground posts and secure using a bolt or tech screw. Some ground posts have predrilled holes that correspond to holes in the hoops. When the holes are lined up and bolts installed, the hoop should be at the correct elevation (assuming the ground posts are at the same elevation). The only downside of using ground posts with predrilled holes is the need for precise installation to ensure holes align during hoop installation. If the holes don't line up, use a large pipe wrench to twist the ground post into the correct alignment. If the pipe wrench doesn't work or if the ground posts are embedded in concrete, drill another set of holes.



Drilling bolt hole to connect hoop with ground post. In this instance, the bolt is also used to connect the baseboard.

If the hoops do not have predrilled holes, you can drill them prior to erection or use a permanent marker to mark a set point on both ends of the hoop. The set point designates the depth at which the hoops are inserted into the ground posts. For commercial, prefabricated structures, the hoop set point will be designated in the assembly instructions. To ensure a strong connection, the minimum depth at which the hoops should be set into the ground posts is 6 inches. Inserting the hoops greater than 12 inches is a waste of time and money.

If the hoops form a snug fit when inserted into the ground posts, a tech screw can be used to secure the union. If, however, the hoops fit loosely, tech screws can be used to set the depth of the hoops in the posts, but should not be relied on to form a secure connection. Over time, movement of hoops in the ground posts can stress the screws, causing them to break. On loose-fitting hoops, connect hoops with posts using $\frac{1}{4}$ -inch bolts.



A hoop house equipped with a center purlin and two side purlins



Swaged tubing

Purlins are straight sections of pipe running the length of the house used to strengthen and stabilize the upper portion of the house. The same diameter of pipe used for the hoops is most commonly used for purlins. For ease of assembly, choose swaged tubing. Purlins should always be installed on the inner surface (underside) of the hoops. Every permanent hoop house needs, at minimum, one purlin. Typically, if only one purlin is used, it is installed in the center of the structure.

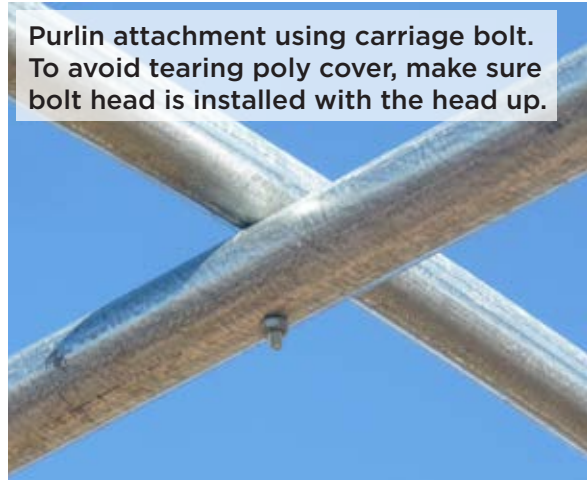


Carriage bolt

Purlins may be attached to hoops using carriage bolts, pipe hangers or cross connectors. Carriage bolts are the least preferred method due to the time required to drill the pipe. Cross connectors provide a strong union but are pricey. Pipe hangers are the connector of choice for experienced builders because they provide a secure union at a reasonable price and can be installed quickly using tech screws.

Prior to installation, use a chalked line to designate the exact location of each purlin. If ground posts are spaced accurately, a template, similar to what is used to space the ground posts, can be used to space the hoops during installation. If not, enlist the help of a friend standing off to the side of the house to ensure the hoops are plumb before fastening the purlin.

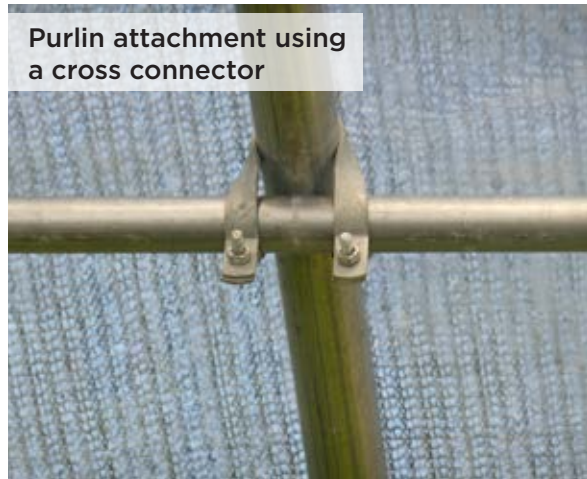
Purlin attachment using carriage bolt.
To avoid tearing poly cover, make sure bolt head is installed with the head up.



Purlin attachment using a pipe hanger



Purlin attachment using a cross connector





Baseboard installation using 2-inch by 6-inch treated lumber

Baseboards are used to seal the base of the hoop house and to form a level landing for roll-up side curtains. Because baseboards keep the curtains off the ground, they don't get as dirty. Several materials can be used to make baseboards, including pressure-treated lumber, rubber lumber or square steel tubing. Baseboards range in height from 4 to 6 inches and in width from 1 to 2 inches.

A chalked line drawn along each side of the house will ensure the baseboards are installed level or at least in a straight line. The preferred method of connecting baseboards to ground posts is with pipe hangers (a.k.a. brackets or clamps) and tech screws. Don't forget to attach the clamp to the post to prevent vertical movement of the baseboard. Depending on the material, baseboard sections can be connected on ends using ties, angles and plates of various kinds. Wood baseboard sections are typically spliced together using short pieces of wood.



A pipe hanger and tech screws. Use heavy-duty hangers to ensure a secure union.

Hardware for connecting wood and/or steel baseboard sections

Steel mending plate



Tie plate



Steel angle



Saddle rafter tie





Installing baseboard to end wall posts using wood screws



Recommended method of joining end wall and side wall baseboards



A hip-board fabricated using treated 1-inch by 6-inch lumber



Short sections of the 1-inch by 6-inch lumber used to connect individual boards

Hip-boards run the length of the house on both sides. Like purlins, they serve to stabilize the hoops. They also serve as the point of attachment for both the roof portion of poly film and the roll-up side curtains. The hip-boards are typically installed 4 to 6 feet above the ground. To ensure maximum cross ventilation when using roll-up side curtains, install hip-boards a minimum of 6 feet above the ground. At this height, the house is easily accessed from the sides when the curtains are fully retracted. Hip-boards can be constructed using wood, or round or square steel tubing. Pipe hangers are the preferred hardware for connecting hip-boards to hoops. The individual hip-board sections are connected end-to-end using the same hardware used in baseboard construction.



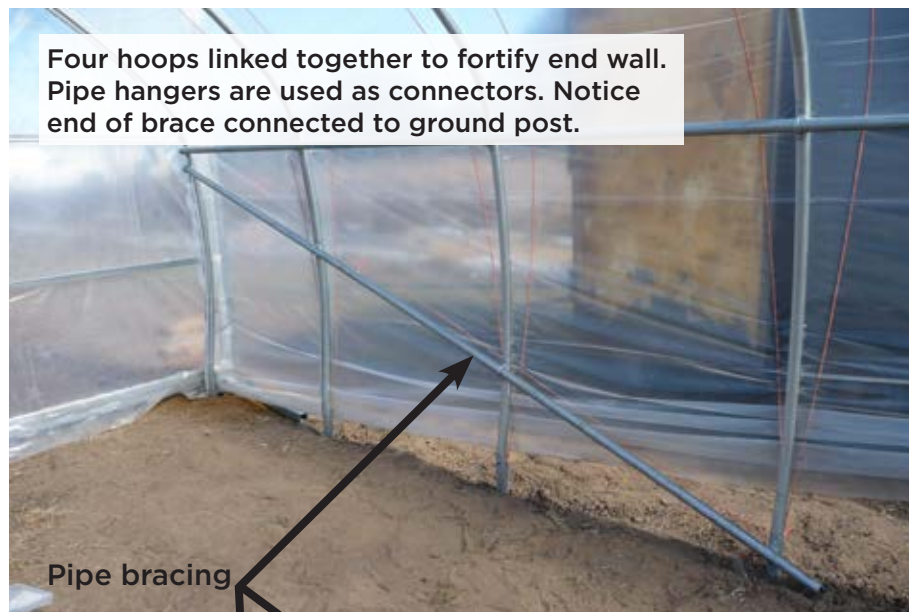
Hip-board fabricated using square steel tubing



A round tubing hip-board installed on the interior of a caterpillar tunnel

Hip-boards are typically installed on the exterior of the house to facilitate attachment of the poly film cover and roll-up curtains. Structures that rely on rope to secure the poly cover to the frame, commonly called caterpillar or Spanish tunnels, do not require hip-boards to maintain a tight poly cover. If hip-boards are used on caterpillar tunnels, they should be mounted on the interior of the structure so as not to impede water flow off the structure.

Brace for strength



Steel pipe bracing should be installed to add strength to the end wall.

On structures equipped with detachable end walls, interior posts are absent. By default, all of the wind load is transferred to the end hoop. In situations where no posts exist, bracing should be used to link the end hoop with as many hoops as possible.



Wind is not the only force of nature that can adversely affect hoop house structures. Snow and ice storms have been responsible for the collapse of many hoop houses over the years. Unlike greenhouses, snow and ice will accumulate on top of hoop houses because they are not heated. The risk of collapse from snow is one more reason why you shouldn't cut corners when it comes to house construction. Don't, however, assume that your house is collapse-proof. It's a good practice to remove snow or ice from the house before significant accumulation occurs. In an emergency, portable forced-air propane or kerosene heaters placed in the house can be used to slow or prevent the accumulation of ice. Also consider installing temporary bracing in the form of steel or wood posts under the center purlin during the winter months to provide extra support.



Optional retractable snow load posts. Each post is attached to the center purlin using a custom-made hanger fabricated from $\frac{1}{4}$ -inch by 1-inch steel strap and $\frac{1}{4}$ -inch bolts. For maximum effectiveness, locate the posts next to the hoops and space every other hoop.

Poly film cover attachment

There are two basic methods of attaching poly film to a hoop house; wood lath and aluminum poly fastener (Wiggle Wire). Wood lath is the least expensive of the two options. Wiggle Wire should be used in situations where the poly film will be removed on an annual basis such as when the film is removed and replaced by shade fabric.

As a fastening device, two pieces of lath, a permanent base and a removable piece, work much better than one. If lath will be used, install a permanent base of 1-inch by 2-inch treated lath the length of each hip-board. Locate the lath at the top, outer surface of the hip-board, and attach using wood screws. Drill pilot holes in the lath to prevent it from splitting when screws are inserted.

Attaching the poly film to the end walls can be the most difficult part of the process, depending on wind speed and direction at the time of film application. Consequently, it is important the film be attached to the end walls quickly. Wiggle Wire affords a much quicker method of attachment, thus the reason for using it on the end walls.

Wiggle Wire comes in two pieces – the wire and a base. Install the base to the top, outside surface of the hip-boards. If Wiggle Wire will be used to attach the poly cover to the end walls, the base can be installed on top of the end hoops or, if so equipped, on the end wall header boards. Use wood screws if the hip/header boards are wood and tech screws if they are steel tubing.



Permanently installed Wiggle Wire base



Permanently installed lath





When ordering poly film, be sure to over-size. Order a sheet long enough to reach the header boards on both end walls and wide enough to provide for the roll-up curtains. As a rule of thumb, order the plastic film 4 feet longer and wider than what the structure requires. This not only provides a safety factor but also ensures adequate plastic for grasping and stretching.

Ideally, the poly film should be applied on a calm, warm and sunny day. If you have no choice but to apply the film on a windy day, be sure to have plenty of help to keep a handle on the plastic. If applied on a cool, cloudy day, the plastic will relax when the temperature rises. Loose film is prone to flap in heavy winds, causing fatigue which can shorten the life of the film.

When you are ready to apply the poly film, roll it out along one side of the hoop house, preferably the windward side. Attach ropes to the long edge closest to the hoop house, one on each end and one in the middle. On very long pieces of film, use additional ropes.



An effective method of attaching a rope to the plastic is to form a wad of film and loop one end of the rope around it. Attach the free end of the rope to a half empty pint-size water bottle and throw the bottle over the top of the house to the other side. Pull the film over the house uniformly and position evenly on the structure. Do not rush this procedure. Take your time, being careful not to rip the film.





Poly film cover attachment



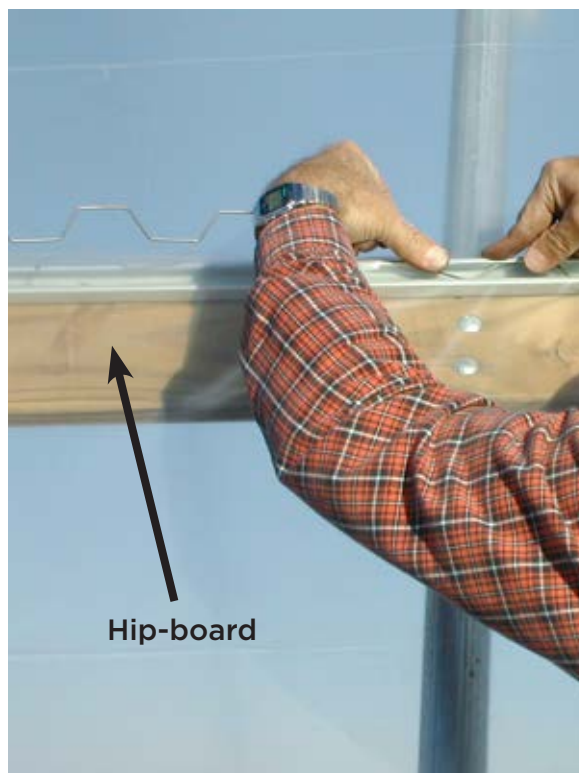
**Securing film to end hoop
using Wiggle Wire**

The poly film is at the mercy of the wind until you can get it attached to the structure. Start by fastening the plastic to both end hoops (or end walls if equipped with header boards) using Wiggle Wire.

Next, move to one side of the house. Beginning at one end, stretch the film down and towards the opposite end fastening it to the hip-board using either Wiggle Wire or 1-inch by 2-inch treated lath.

To fasten film to hip-boards using lath, place a removable piece of lath over the film and beneath the permanently installed lath on the hip-board. Push the removable piece against the permanent piece to lock the film between the two. Fasten the removable lath to the hip-boards using screws. Remember to drill pilot holes prior to inserting screws to prevent lath from splitting. Repeat the process on the other side of the house. To speed up fastening, limit the length of lath to 4 feet and preinstall the screws in the lath pieces.

Some growers choose to alternate from one side to the other, stretching and fastening film to the hip-board as they proceed to the opposite end of the house. Either way, the goal is the same – to center the film on the frame, remove any slack and fasten it to the frame. When finished with both sides, check the film for slack. In most situations, you will need to re-stretch the poly film as it has a tendency to relax over time. If required, remove the Wiggle Wire from the end walls, remove any remaining slack and reinstall the Wiggle Wire. Follow the same procedure when removing slack on the sides of the house. While 6-mil greenhouse film is extremely strong, it can be torn, so don't overstretch it.



A recent trend by growers is to replace hip-boards with rope as a means to secure the poly cover to the frame. One piece of rope is needed for each hoop. Eyebolts or custom-made brackets fastened to the ground posts at ground level anchor the rope to the base of the house. A common method used to connect the rope (and poly cover) to the frame consists of threading a single piece of rope through an eyebolt, over the top of the house, through the eyebolt at the other end of the hoop (opposite side of house) and back over the top of the house at which time a loop is tied in the lead end. Pulling the rope taut, the other (free) end of the rope is fed through the looped end and tied off using a half hitch. The use of a half hitch allows you to quickly untie the knot, readjust the tension on the rope and retie quickly.

When installed properly, one half of the rope should be located on one side of the hoop and the other half on the other side of the hoop. When tensioned properly, the rope does not allow movement of the poly cover.

When choosing rope, there are several options. Braided, 3/16-inch-diameter nylon rope is resistant to sunlight degradation and is not too abrasive on the poly cover. A less expensive option is heavyweight baling twine.

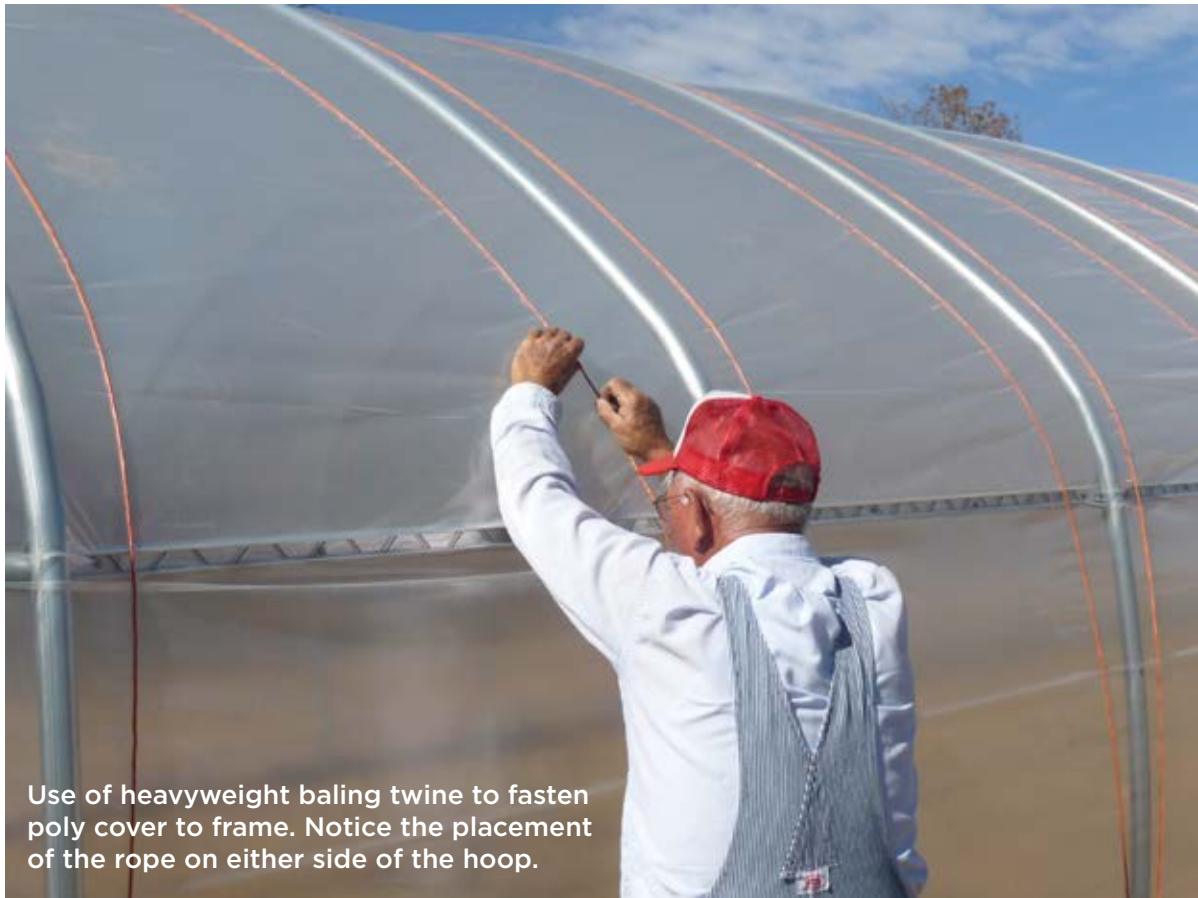


Eyebolt used to secure rope to ground posts

Rope strap tie-off procedure:

1. Form loop at one end of rope.
2. Draw free end through loop.
3. Tie off rope using a half hitch.







Roll-up side curtain (vent) construction

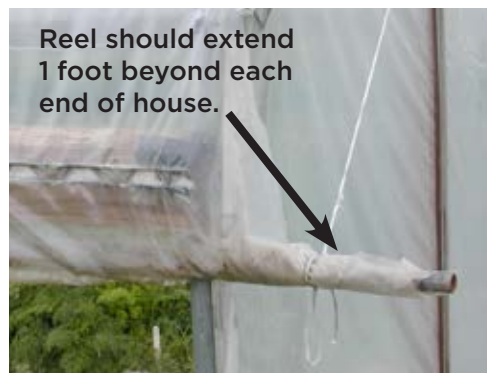


Raising side curtain with the help of a PVC tee handle. Use long handles to increase leverage.

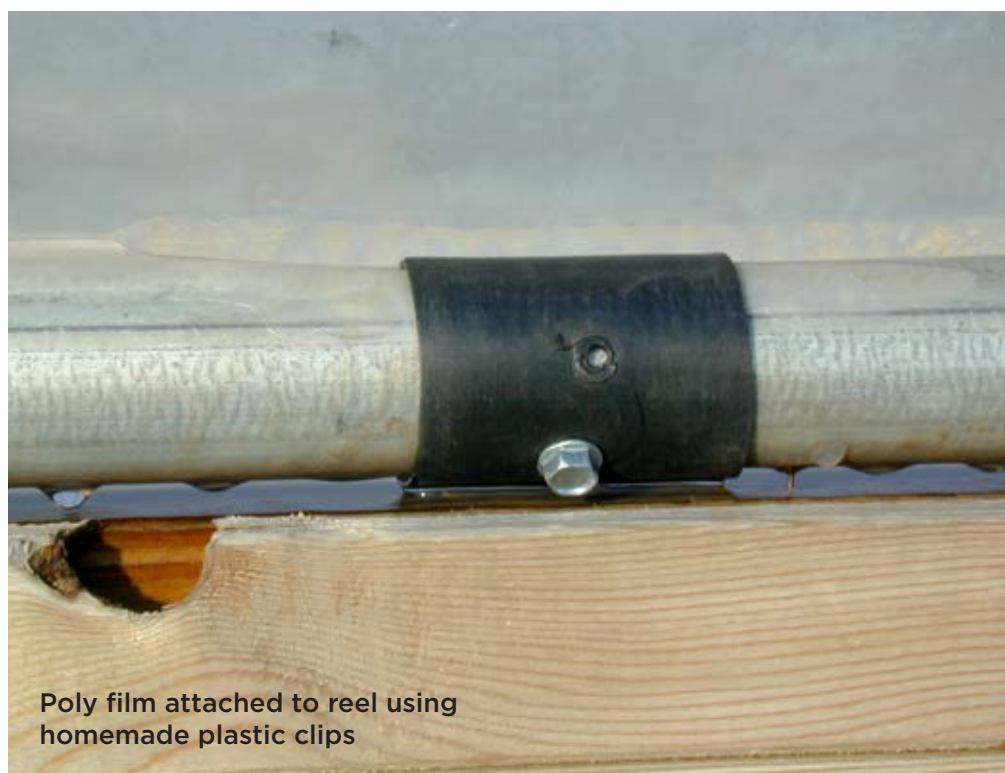
If you applied the correct size of film for your house, it should be hanging over the baseboards and extending beyond the ends of the house. This additional film is required to complete the roll-up side curtains.

A pipe reel is required to roll up each curtain. We recommend the use of lightweight steel tubing such as 'top rail' chain link fence tubing to construct the reel. We do not recommend the use of PVC pipe for reels because the PVC polymer is reported to react with the polyethylene film, causing it to degrade. Also, during hot summer days when the side curtains are completely rolled up, the heat trapped in the curtains softens the pipe. If there is any sag to the pipe while it is soft, it will permanently conform to the shape of the sag when it cools, preventing the curtain from rolling up and down uniformly.

Top rail fence tubing comes with swaged ends, making reel assembly easy. Connect the pieces of tubing using tech screws. Plan on making the reels about 2 feet longer than the house. Cut the reel to length using a hacksaw. One-inch PVC tee fittings attached to the ends of the reels make great handles. You can increase leverage by inserting short pieces of pipe into the tee fittings.



Reel should extend 1 foot beyond each end of house.



**Poly film attached to reel using
homemade plastic clips**

Before attaching the poly film to the reel, make sure the reel is centered on the baseboard with 1 foot of tubing exposed on each end. Make sure the reel is resting on top of the film. To ensure the reel remains on the baseboard during attachment, drive a few nails into the baseboard along the upper, outside edge.

The use of homemade plastic clips is the least expensive method of attaching the film to the reel. To manufacture clips, use a utility knife to cut 2-inch-long pieces of 1-inch-diameter, low-pressure, black poly tubing. Remove a 1/2-inch-wide strip of plastic from the side of each section of pipe. The number of clips required for both reels is equivalent to the length of the house in feet plus two.

Starting at one end of the house, wrap the film up and over the reel, and secure using a plastic clip. The clips hold tight enough to prevent the plastic from pulling off the reel, yet are loose enough to be adjusted by hand, if needed.

Locate the first clip next to the end wall, not at the end of the reel, and space every 2 feet along the reel. The portion of the roll-up curtain extending beyond the end wall needs to be free of the reel so it can be fastened to the end wall when the curtain is down.



Aluminum fabric clip

When all of the clips are attached, slowly roll up the curtains, looking for any sag that develops in the pipe reel. You'll notice the higher you raise the side, the more pronounced the sag. To eliminate sag, lower the curtains and reposition the film on the reel with the clips, concentrating on the areas that are out of alignment. Continue to adjust the sides until they open fairly uniformly. When you are satisfied with the performance of the roll-up sides, permanently secure the clips using tech screws.

Commercial aluminum and PVC clips (snap clamps) can also be used to attach poly film to reels. These clips require no screws once they are snapped into place. Because they cannot be easily adjusted, do not install them until the roll-up sides receive their final adjustment. Snap clamps come in various sizes and are available from greenhouse supply companies.



Aluminum fabric clip



PVC snap clamp



The side curtains can be rolled up by turning the pipe reel clockwise or counter-clockwise. Depending on the direction of turn (and the end of the house the pipe reel handle is located), the poly film will either wrap over the reel or under it. The curtains will shed water better if the film wraps over the reel.

Alternative methods of locking the position of roll-up curtain



Notice the locking bar made of steel pipe can be moved in and out of the locked position without removing the bar from the PVC tee handle.



Caterpillar tunnels are vented along each side by raising the poly film. This technique works great in dry weather but can present problems during rainy weather. When the film is lifted, folds are formed, which tend to trap water during a rain event. If the plastic is not lowered or folded up underneath itself prior to heavy precipitation, the structure may collapse due to the weight of the trapped water.



Restraining straps are required to prevent the roll-up curtains from flapping in the wind when closed. Two materials to consider for this purpose are 1-inch black poly pipe and commercial woven polypropylene restraining straps specifically designed for use on greenhouses. The restraining straps can be purchased from greenhouse supply companies. Attach the top of the restraining straps to the hip-board and the bottom to the baseboard using woodscrews and washers. Locate a strap at every other hoop.



Roll-up curtain restraining straps



Rigid panel shield



Poly film shield



Wiggle Wire used to seal edges of roll-up curtains

Install shields to prevent cold air intrusion at the corners of the house and reduce potential damage to the roll-up curtains during stormy weather. Some growers utilize cut-to-fit rigid PVC or polycarbonate panels for shields. The panels extend from the end hoop to the adjacent hoop and from the hip board to the baseboard at each corner of the structure and are typically attached to the exterior surface of the hoops. The curtains cover the shields when closed.

Poly film can also be used as shields. The poly film is typically wrapped around the hoops and attached to the inner surface of the hoops using Wiggle Wire.

To seal the corners of the house during the winter months, consider wrapping the ends of the curtains around the corners of the house and securing to the end walls using Wiggle Wire. Remember to remove the Wiggle Wire before rolling up the sides or the poly film will tear. Attach a sign to the tee handles as a reminder to detach the film before raising the curtains.

Windbreak curtain installation



Plan on installing windbreak curtains on the sides of your hoop house. Not only do the curtains reduce stress on plants as a result of wind, they also serve as sunscreens, protecting exposed fruit from sunburn on the west side of the house during the late afternoon hours of summer. The curtains also serve as a barrier to small animals such as dog, cat, skunk, coyote, raccoon and opossum. To make the house animal-proof, you'll want to secure the bottom of the curtains to the baseboards.

Fifty percent black shade fabric is an excellent choice for use in windbreak curtains. This material is porous enough to allow for cross ventilation and yet dense enough to negate the effects of strong winds.



Windbreak curtains can be mounted and operated in a roll-up fashion similar to the roll-up side curtains. They can also be woven between the hoops and attached to vertical curtain rods on both ends of the house. Weaving the fabric between the hoops is quicker to install and the less expensive of the two options.

When installing the curtains using the weave technique, be sure to stretch the curtains when attaching them to the rods to eliminate as much sag as possible. Because the curtains are under tension, the rods must be strong enough to avoid bending. Use a 5/8-inch piece of rebar or a thick-walled pipe for the curtain rods. Attach the rods to the back side of the hip-board and baseboard using pipe hangers, and locate as close to the end walls as possible. Attach the curtains to the rods using fabric clips and nylon ties or wire. “Clip-It” brand clips can be purchased from most greenhouse supply companies.

To be effective, it is not necessary to cover the entire side vent opening with a windbreak curtain. A 4-foot-high curtain is satisfactory for most situations. If your goal is to exclude birds and large insects, go ahead and cover the entire opening.

Considerations for growing in hot weather



In the United States, most hoop house growers cover their houses with clear, greenhouse grade, polyethylene film. This film, however, is not without its drawbacks. Clear film, which is used so effectively to produce a favorable growing environment during the fall, winter and spring, can also create an unfavorable condition for both plants and people on warm days.

The most obvious solution to this problem is to remove the cover from the house or, in the case of a movable structure, move to another location. Due to time and labor constraints involved with repeated application and removal of the covering, this option should only be used as a last resort.

Draping shade fabric over the house to reduce light intensity is a common practice among growers. Shade material ranging from 40-50 percent is recommended for use in the Southern Great Plains. As a general rule, shade fabric should be applied only when venting proves ineffective.



Several manufacturers offer light-diffusing and/or infrared-blocking greenhouse films that reduce the amount of radiation entering a hoop house. The reduction in radiation reduces the heat load in the house. When accompanied by adequate ventilation, a significant reduction in air temperature can be achieved. Films such as 'Kool-Lite' and 'Solar-Ice' have the unique ability to block more solar infrared radiation than conventional clear films. By blocking out more of this nonessential radiation, cooler house temperatures (up to 10 degrees Fahrenheit cooler) can be maintained during peak afternoon and evening hours. While these diffusing/infrared blocking films are more expensive than traditional greenhouse films, their use eliminates the need to install shade fabric.



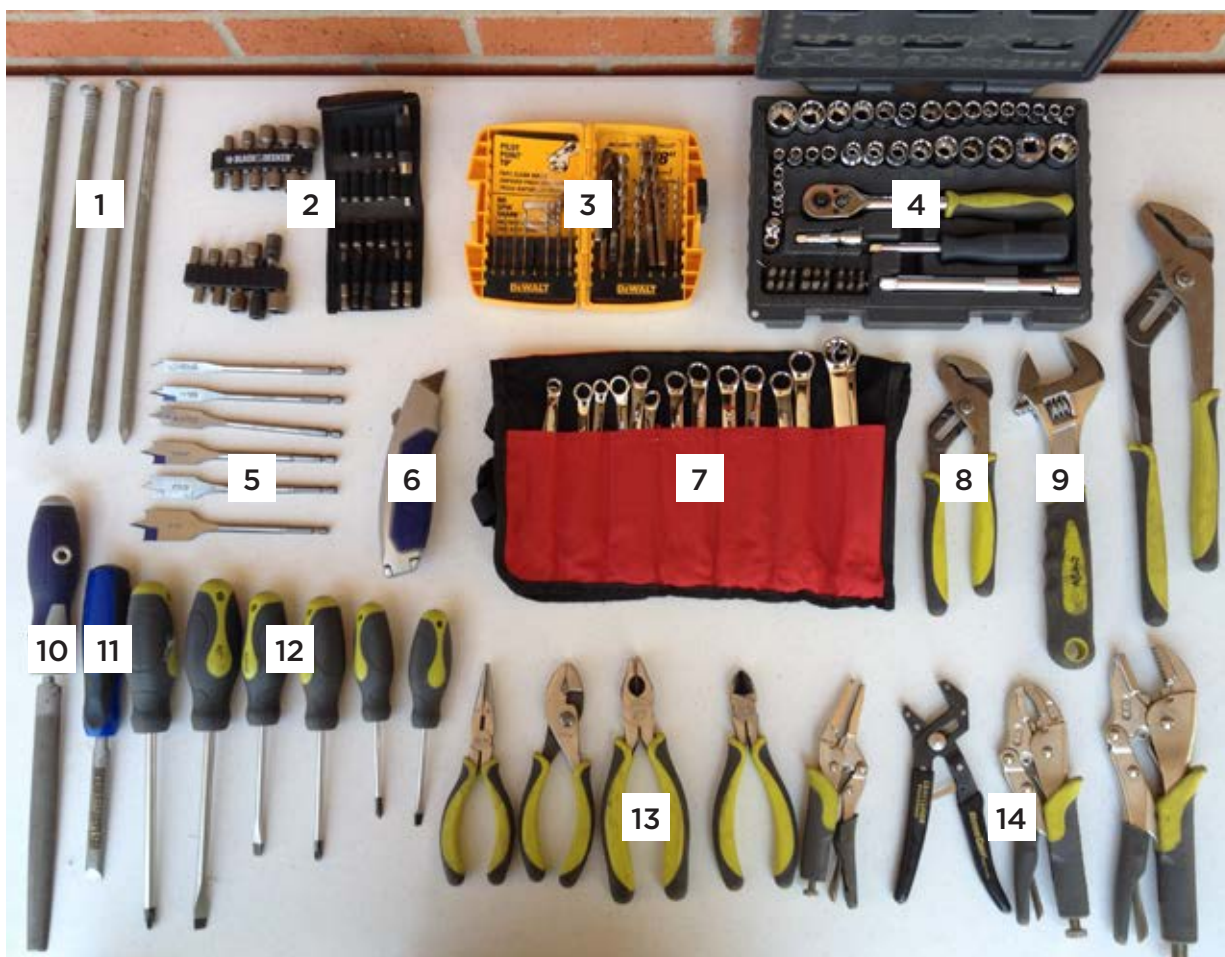
A hoop house ready to plant

For tips on managing hoop house crops, refer to the Noble Foundation horticulture publication website at: <http://www.noble.org/ag/horticulture> or visit the high tunnels website at: www.hightunnels.org.

Recommended tools and supplies



- | No. | Item |
|-----|--------------------------|
| 1 | Carpenter's level |
| 2 | Chalked line |
| 3 | Locking tape measure |
| 4 | Knee pads |
| 5 | Mason's string |
| 6 | Wood rasp/shaver |
| 7 | Measuring tape (100 ft.) |
| 8 | Safety glasses |
| 9 | Work gloves |
| 10 | Bolt cutters |
| 11 | Line level |
| 12 | Sledge hammer (3-4 lbs.) |
| 13 | Scissors |
| 14 | Permanent markers |
| 15 | Torpedo level (magnetic) |
| 16 | Adjustable clamps |
| 17 | Post driver |
| 18 | Framing square |



No. Item

- 1 Gutter nails
- 2 Assorted driver bits
- 3 Drill bit set
- 4 Socket set
- 5 Wood drill bit set
- 6 Utility knife
- 7 Wrench set

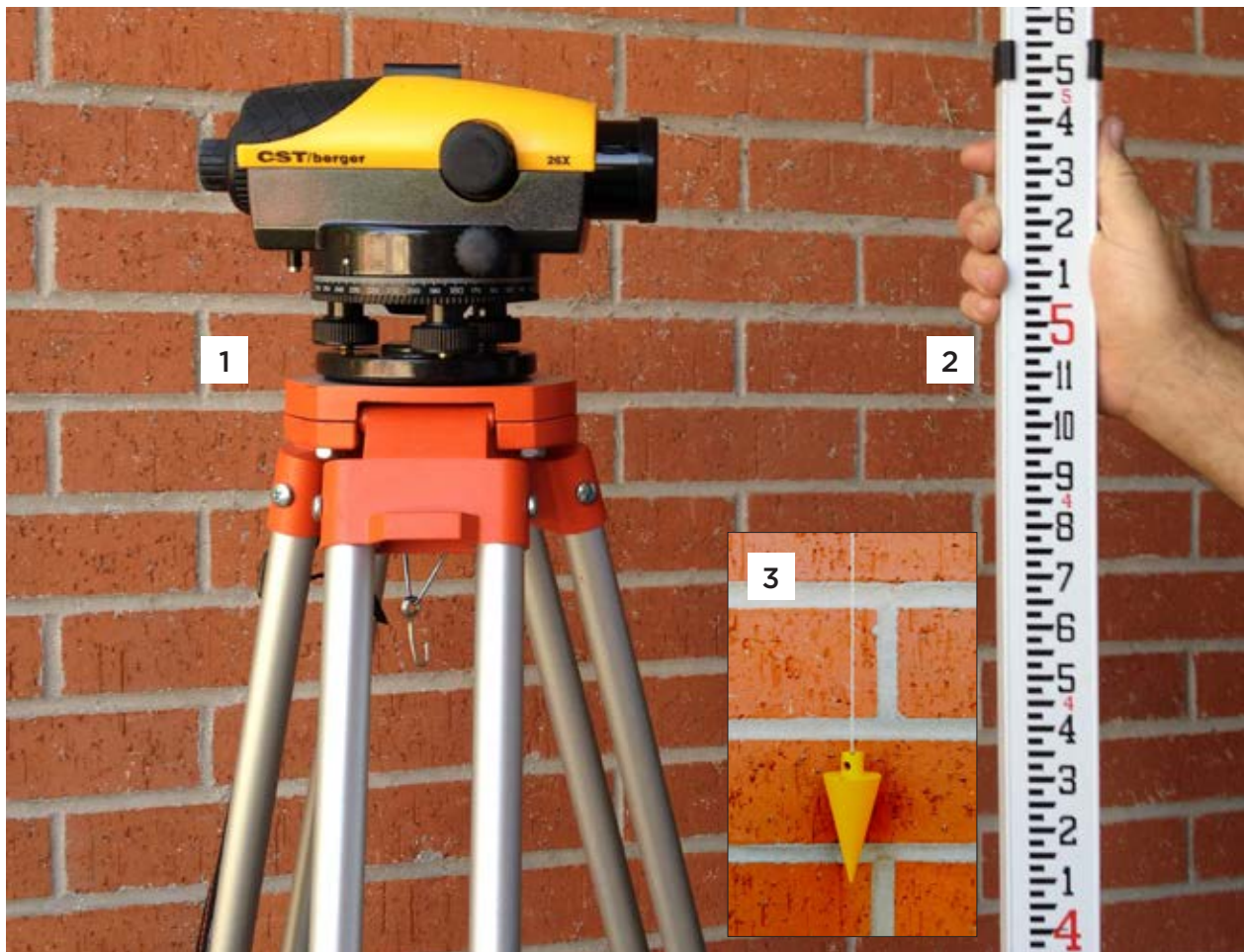
No. Item

- 8 Channel lock pliers
- 9 Wrench (adjustable)
- 10 File (half round metal)
- 11 Wood rasp/chisel
- 12 Assorted screwdriver set
- 13 Assorted cutting pliers
- 14 Assorted locking pliers



No. Item

- 1 Impact driver (cordless)
- 2 Drill (cordless)
- 3 Circular saw (cordless)
- 4 Reciprocating saw (cordless)



No. Item

- 1 Transit
- 2 Measuring rod
- 3 Plumb bob



No. Item

- 1 Stepladder
- 2 Sawhorse set (folding)



- No. Item
- 1 Rebar stakes
 - 2 Hoop spacing template
 - 3 Post driver extension

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