

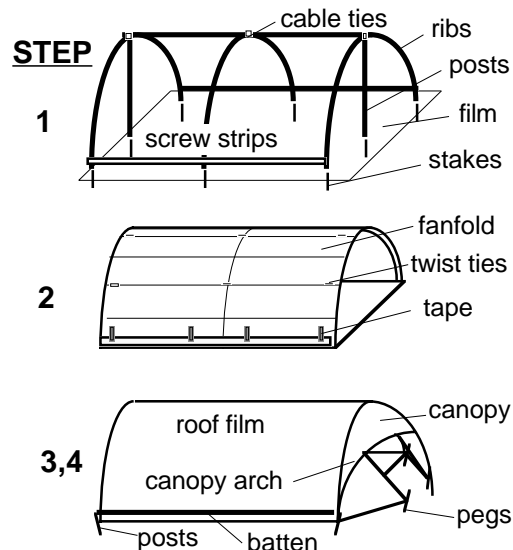
STORAGE AND DISASTER SHELTERS

10-05

A foldable "hard" tent, intermediate between tent and yard storage building.
Woven polyolefin film over fanfold insulation board on PVC pipe arch frame.
Not requiring a building permit or property tax.
Build yourself, fold and store.

4-STEP ASSEMBLY

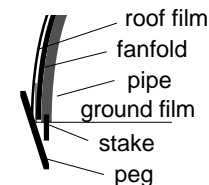
- 1. FRAME.** Drive garden stakes through the ground film perimeter holes. Set the PVC pipe ribs over the stakes. Tie the ridge pipe and two 1x2 screw strips to the ribs with cable ties. Insert and tighten the two telescoping end posts.
- 2. FANFOLD.** Pull the fanfold over the frame and attach to the ribs with the wire twist ties. Tape the ground film edges to the outside of the fanfold.
- 3. ROOF FILM.** Tension the film over the fanfold. Screw the battens through the film and fanfold to the screw strips.
- 4. ENDS.** Close the roof ends with drawstring through edge grommets and/or Velcro closures. Anchor the four corners with 2' fence posts.



Size	~ Bundled	~ Matl. cost *
8x10x6' high	2'x4'x6", 35 lb	\$ 90
12x15x7' high	2'x4'x1', 55 lb	\$190
16x20x8' high	2'x4'x2', 100 lb	\$280

* Matl. cost donated to 501c3 organizations by application. See "**FORM**" at www.airstrips.us.

SECTION



PARTS (12'x15' shelter)

Pipes

14-3/4" PVC-10' elec. conduit, for 5-20' quonset ribs plus a 20' entry canopy rib, & 15' ridge pipe.
(Drill 1/4" holes at crossings for cable ties and for post studs.)

1-1/2" CPVC-10' plus 2 caps with bolt studs and worm screw clamps for 2-5' telescoping post tops.

1-3/4" PVC-10' for 2-5' telescoping post bottoms.

Fanfold

4-4'x20'-1/4" fanfold insulation board (Tenneco, Owens Corning, or other)

(Cut from two 4'x50' bundles. Tape the two 10' remainders together for another shelter.)

Roof film: 1-20'x30' silver/black dense woven polyolefin. **Ground film:** 1-14'x15', any light woven polyolefin. (A grommet punch works well for making 1/2" holes for the rib and post stakes. Or use a knife or scissors.) **Film clamps:** 12, for roof ends, or add grommets.

Battens: 8-1x2-8'. **Stakes:** 12-3/8"x2' vinyl-coated steel or other sturdy garden stakes. **Pegs:** 4-1' plastic tent pegs. **Posts:** 4-2' steel fence posts. **Cord:** 60' braided nylon, or alternate for entry drawstring cord and end stays. **Velcro:** 2" wide- 3' adhesive-backed Velcro. Use as desired for end closures. **Tape:** 2" masking tape to attach ground film to fanfold.

20-9" nylon cable ties (or lash pipes with string). **20- #16 wire U ties** with pipe perf. strapping plates.

ASSEMBLY, 1 to 2 hours (See parts on assembly sketches.)

1. Frame

- a. Drive the stakes vertically through the ground film perimeter holes.
- b. Assemble the 20' PVC pipe ribs, closing the couplings tightly by hand or by tapping lightly with a hammer. Glue the pipes if preferred.
- c. Set the PVC pipe ribs over their stakes.
- d. Rotate the two end ribs to align the hole in the center coupling downward to receive the post cap stud.
- e. Set the telescoping end posts over their stakes, press their cap studs into the rib coupling holes, and tighten the worm screw clamps at the telescoping joints.
- f. Tie the ridge pipe and 1x2 screw strips to the ribs with the cable ties, looped through the holes at the pipe crossings, to prevent sliding. Add the canopy rib pipe over its stakes, adjacent to the quonset front rib.

2. Fanfold

- a. Lay the fanfold panels over the frame, lapped to the line marks at their folds, and attach through the laps to the ribs with the wire twist ties, installed at the X marks on the folds.
- b. Tape the ground film edges to the outside of the fanfold, to prevent water entry under the roof film.

3. Roof film

- a. Drag roof film over the fanfold, into the wind and with a tagline if needed, to lift it on the wind.
- b. Screw the 1x2 battens through the film and fanfold to the screw strips, to anchor the film.

4. End closures

- a. Close the ends with the drawstring lacing, top lapped over sides to shed water. Use any combination of drawstring lacing between film clamps and Velcro tape (provided) at back and front (over the canopy rib or not) suited to your need.

ASSEMBLY STEPS



1. Ground film and stakes.



2. Ribs & end posts over stakes.



3. Tie fanfold, tape ground film to it.



4. Pull roof film and drive pegs. Add canopy rib. Close ends with drawstring and/or Velcro.

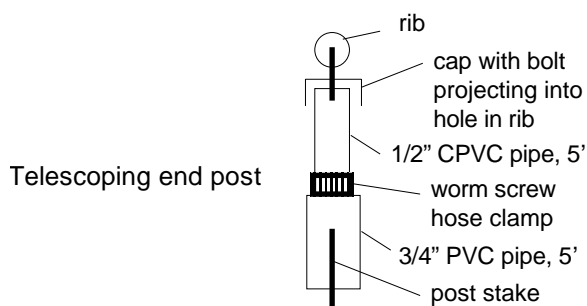
OPTIONS

- To lengthen, add fanfold and film sections. To shorten, remove sections.
- To increase insulation, lap more fanfold, and/or fanfold the two ends.
- To improve drainage and wind protection, berm with earth.
- To reuse, fold and re-bundle (cable ties are sacrificed).
- To repair, use patching tape or replace films or fanfold sections.
- Air drop as bundled, or use the roof film as a parachute, with shrouds to the four corners.

ASSEMBLY NOTES

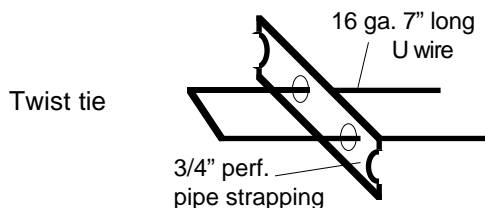
OPTIONAL EARTH SOCKETS. Ribs can be inserted into PVC pipe sockets instead of over the stakes. Use an earth bit to auger holes for the sockets. Choose the smallest size that the rib will nest into (1.5" PVC socket for 1" rib). Sockets are useful where a shelter may be used seasonally at the same site. They can be mowed over. You may wish to increase rib length in order to keep the same height.

TELESCOPING END POSTS. Insert the post over its stake and into the rib. Lift the upper portion to raise the rib, then tighten the worm screw clamp.

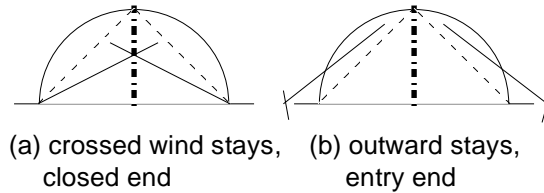


PLUMBING THE FRAME. To keep the frame plumb while tying the fanfold to it, use a back stay from the top of one end post to a tent peg, or from the end post to the stakes at the bottoms of the opposite end rib.

TWIST TIES. (To install at other than marked locations.) From inside at every alternate fold joint, poke nails adjacent to ribs through the lapped fanfold so the nails are visible from the outside. Using the nails as guides, push the bent wire ties through the perforated straps and two layers of fanfold over the ribs. A step stool may help for the highest ties. With pliers or vice grips, twist the two wire ends together over the rib, inside. These connections add some structural continuity.

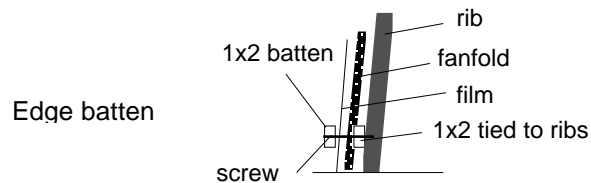


WIND STABILITY. The wire twist ties through the fanfold laps and around the ribs provide resistance to longitudinal racking. If winds loosen ties, re-tighten and/or add more ties. Stiffen against side sway, when needed, with diagonal guys from stakes under the end arches across the post tops (dashed) and/or with cross-lacing stays from the film clamps to the stakes under the arch at the closed end (a), and staking them outward (to avoid interference with entry) at the open end (b).



WIND ANCHORS. Drive 2' steel farm fence posts at each corner, tied to the rib and batten ends.

BATTENS. Before adding fanfold, cable-tie the 1x2 furring strips to the outside of the ribs near ground level, ends butted. Screw a second row of 1x2's through the film and fanfold to the first, with butt joints staggered. Rest it on nails pushed outward just below the inner 1x2's to position it for screwing. This anchors the film against wind, continuously along the two sides.



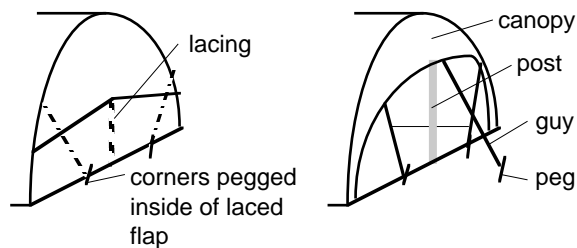
END CLOSURES. The roof film is long enough to hang to approximately ground level on each end.

At the back, lace the film closed with a drawstring between its film clamps, lapped outside over the film corners, pegged to the ground (a).

At the front, set the canopy rib adjacent to the quonset front rib (b).

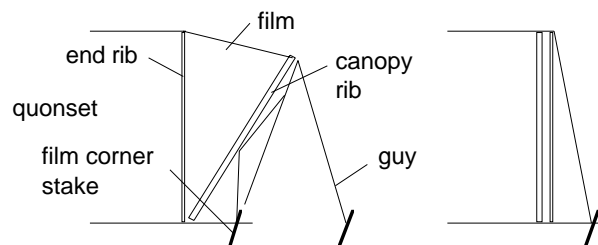
To open: bend the canopy rib outward and guy it. Tighten the film edge over the canopy rib with the perimeter cord.

To close, return the canopy rib upright against the quonset end rib, and lace the film, as for the back (a).



(a) Rib upright for laced closure. (b) Rib sloped for entry canopy.

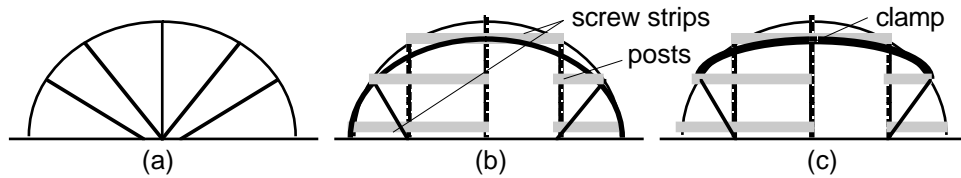
Canopy rib guy. For added support, you can guy to two points toward the sides of the canopy rib, instead of to a single point at its center.



Canopy rib guyed out, entry open Canopy rib returned upright, entry closed

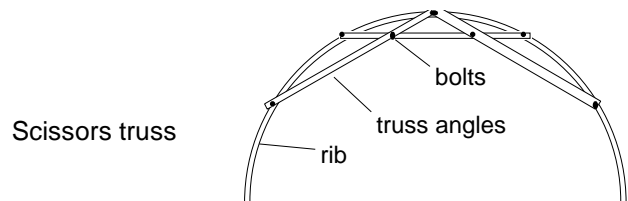
END WALLS. Back or front end walls can be added at any time with extra fanfold or other sheet board materials. Cable-tie or lash 1"x2" screw strips to additional telescoping posts placed under the end ribs. Screw the fanfold to the screw strips with screws and fender washers, lapping the

upper layer over the lower. Trim off excess fanfold above the rib with a knife. Leave an opening between two of the posts for an entry.



(a) roof film laced shut over end, (b) laced over canopy rib, or (c) rolled up and retained with a spring hand clamp.

SCISSORS TRUSSES. Add as time permits, or when wind and snow loads justify. They are useful for internal ribs, or for end ribs if the posts must be omitted to allow entry of wide loads. Three 3/4" angles 5' long with bolts near each end are included to make one rib truss. Bolt one angle to the side of the rib, horizontally, as high as possible, with the horizontal angle leg beneath the rib. Bolt the remaining two angles, back-to-back with the first angle, one end of each with a single bolt at the rib center, the other ends to the rib sides. Drill and bolt the angles together where they cross, to stiffen them.



GROUND FILM. Use any film. Tape patches can be added to one or both sides where holes are to be made for the rib and post stakes.

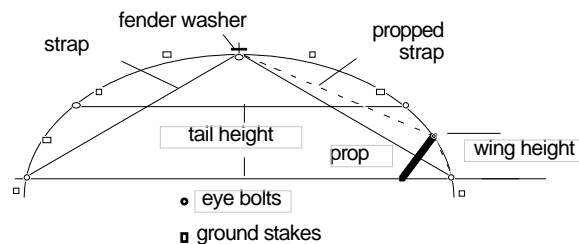
USES FOR EXTRA FANFOLD. End walls, increasing roof laps for added insulation, beds for disaster shelters, etc.

CONSTRUCTION ALTERNATIVES

Use where needed for large arches, to assemble from the ground without climbing.

A. TIE ARCHES BEFORE TILTING

Arches are wobbly until tied together. Bend large arches on the ground and pre-tie them before tilting up.



TIED ARCH SCHEMATIC

Steps. Bend the arch around ground stakes, tie straps between eyebolts, then tilt up.

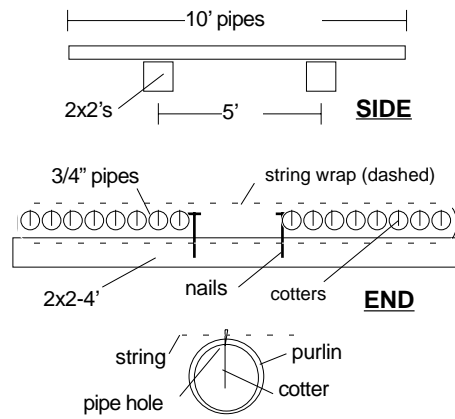
Four strap ties between eyebolts through the arch: a horizontal tie just above aircraft tail height, two diagonal ties from the arch top to eyebolts just above the socket tops, and a horizontal tie between the same two bottom eyebolts, to hold the arch ends together until tipped into the sockets, then removed.

1" & larger fender washers are easily bent with a vice & hammer into flat Vs to cup the pipe at eyebolts.

Put strap buckles just above the lower eyebolts, where easily adjusted after erection.

Prop any ties necessary to move a plane wing or tail in & out of the hangar. Or set eyebolts at wing height. Bottom eyebolts or spikes can rest on socket tops to keep all arches the same height.

B. TIE PURLINS TO DRAG OVER THE ARCHES



PURLIN & STRING ASSEMBLY

To avoid climbing a ladder to tie high purlins, tie purlins together at ground level and drag over the arches, similar to placing the fanfold.

1. Drill 1/16" holes 2.5' from each end of each 10' purlin (3/4" PVC or EMT conduit), aligned on the pipe print line.
2. Lay the pipes on two 4 ft. 2x2s, spaced 5', under the holes. Lay the pipes touching each other outside of 2 nails ~6" apart near each 2x2 center.
3. Set 3/4" cotter pins in the two holes drilled in each pipe.
4. Insert a knotted string end in the cotter pin in one of the two center pipes. Pinch the pin closed over the string and push it into (not through) the pipe hole.
5. Wrap the string successively around the pipes spaced farther apart on each side until the most distant pipes have been wrapped (dashed line). Insert the string in the cotter pins at the wrap point on each pipe, crimp the pins and push them into the holes as for the first pin in Step 4, by pressing the pins with a wide screw driver or tapping gently with a hammer.

The result is an assembly of 10' purlins spaced from ~1' to ~3', held together with two strings 5' apart.

Unwrap the bundle and lay on a bench or floor. When two such bundles are completed, tie the two purlins most closely spaced in each bundle together with string, using a spacer block for consistent spacing.

The result is an assembly of 10' purlins spaced ~1' at the center to ~3' at the edges, to provide closer purlin spacing at the top of arch, where needed to prevent water puddles due to tarp sagging.

Repeat the previous steps then glue PVC) or couple (EMT) the two purlin assemblies together, which would now cover some arch length (depending on the number of pipes used) by a 20' length of hangar. Repeat enough times to complete the hangar length.

Lay the complete purlin assembly on one side of the hangar and drag it over the top, similar to placing the fanfold insulation. Use the J pole (for tilting up arches) to assist sliding purlins up onto the arches as they are dragged over the top. A few arch nails, similar to those previously used to support purlins, are helpful to temporarily support purlins slid up on the arches with the J pole.

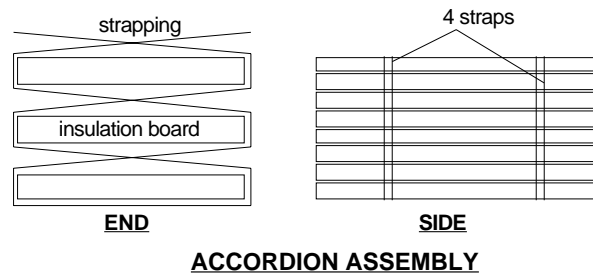
With the assembly approximately symmetrical on the arches, tie purlins to the arches as before, starting at ground level, but omitting some ties on upper purlins difficult to reach, since the strings hold them in place.

VARIATIONS

1. Purlin spacings can be increased by adding outer spacer nails to the 2x2's. If foam board is used under the tarp, purlin spacing can be greater. Increasing the central nail spacing from 6" to 9" can reduce the number of purlin lines by 4 to 6 on a 60' arch length. Experiment for your own structural need, time, and material constraints.
2. Cotter pin substitutions can include bent paper clips or a 19-gage wire roll cut to 1" lengths and one end bent 1/4" back. Any good quality packing string can be used. Test to confirm a convenient size pinhole to close the pin on the string as it is pressed into the pipe; i.e. 1/16" or 5/64".

C. OPTIONS WHEN FANFOLD IS UNAVAILABLE

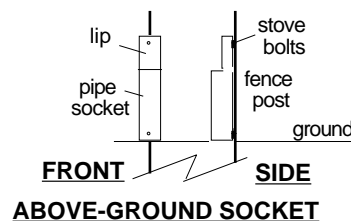
Pull the tarp directly over the purlins to omit insulation, or hinge insulation boards together with strapping, accordion fashion.



1. Lay strapping on the floor. Stack 2x8' insulation boards of any thickness over it, pulling the strapping snugly over each board as it is laid. Buckle the strapping together over the top board in the stack.
2. Drag the stack over the arch frame the same as for fanfold insulation, except butt these thicker boards instead of lapping them.
3. For spans less than about 20', hot wire or otherwise slice the board to 1' widths to conform better to the arch shape. Wider webbing, as for lawn chairs, can reduce cutting into foam edges.

D. SOCKETS ABOVE GROUND FOR HARD SOILS

Drive large fence posts instead of sockets. Bolt sockets with sawed lip extensions to the posts at ground level. Orient sockets so the bent arches push directly into the socket lips as the arches begin to tilt up.



E. SOLAR COVERS

If a remote hangar, like a weather or communications station, requires minimal electric power, cover part of it with thin film or foldable solar panels stretched or adhered over the sun-facing side (see www.iowathinfilm.com, for example). Compare the economics with your other options.

F. OTHER SHAPES - A YURT

PURPOSE: Initial emergency shelters for uav airdropping with drogue chutes (see www.airdrop.us), before tents or other relief shelters can be moved to the points of need.

- Assembles quickly with minimal skill.
- From cheap widely-available materials.
- Eliminates pre-manufacturing and storage costs.
- Add insulation, berming, etc. easily at any time.

For good yurts, see www.yurt.com (\$13 to \$36/sq.ft. of enclosed floor), or www.shelter-systems.com (\$2-\$3/sq.ft.). For emergency yurts that can be airdropped, use this (under \$1/sq.ft. for materials). It eliminates the pre-manufacturing and storage costs of sewn tents. Assemble partially before shipping, or after.

PARTS

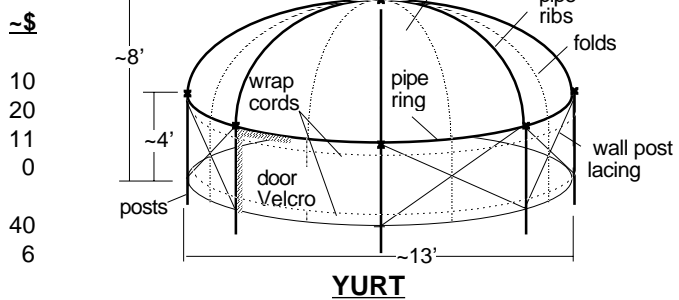
FRAME

40' of ½" PVC electric conduit, wall ring	10
65' of ¾" PVC electrical conduit, 4 ribs	20
9- ½"x5' EMT metal conduit posts	11
10- 8" 19 gage or garden wire ring/post ties	0

COVER

~25x25' cross ply or woven PE film	40
2~12" bungees or EMT rubber ties & 2~40' perimeter wrap cords	6
Adhesive Velcro tabs for door	2

TOTAL ~\$89



(89/127~70¢/sq.ft.)

TOOLS Saw or knife for flex pipe, pipe cutter for metal pipe, hand drill, sledge to drive posts.

ASSEMBLY

FRAME

1. Cut tie wires from the spool. Cut PVC ribs. Cut 10' EMT to 5' lengths and drill a ~5/32" hole 4" from the top of each post, loop a tie through it for attaching the pipe ring. Mark the desired embedment depth.
2. Mark the ring at 5' intervals, lay it on the ground and drive a 5' EMT post against the inside of the ring at each mark. Drive the 9th post at any perimeter location where a door less than the width between posts may be desired. Tie the ring to each post with a tie wire.
3. Insert the 4 pipe ribs over the 4" post projections above the ring and tie the ribs together at the center. Tying rib tops slightly off center allows only two ribs to cross at each point, smoothing the roof and improving rib-buckling stability.

COVER

1. Fasten the cover film to the frame with the 2 perimeter cords and bungees near the wall top and bottom. Add loops near the cord ends to adjust bungee tension. Make radial folds at posts to take up film slack. Let excess film at the wall bottom extend outward, stake and/or berm it with earth or snow for insulation and drainage. Leave a short section unbermed so it can be pulled from under the bottom perimeter cord and propped open as an entry. A short piece of polyethylene tubing bent like an inverted U provides a simple prop.

CONSTRUCTION OPTIONS

DIMENSIONS. Use any diameter, wall and center heights. Experiment full size or use a bench model with wood dowel posts in holes in a board, vinyl tubing ribs, and rubber bands for bungees, or use computer drawing software. ¾" flexible pipe is good to over 20' dia. Add intermediate posts and ribs plus a telescoping center post when needed, depending on roof pitch, and snow/wind loads. For larger yurts, rigid PVC electrical conduit in various diameters is inexpensive, light-weight, and easy to assemble without glue due to the long bell couplings. Use any even number of posts from 4 to about 16. An oval instead of circular wall can adapt to limited film width. Or use a 2-piece cover, one stretched around the wall and the other over the roof, lapping the wall by any amount. Cut the wall film to length and tape a dowel or pipe in each end to form a stretcher bar. Lace one bar to a door post, stretch the film around the perimeter and around the other door post. Then lace the remaining bar inside to the adjacent post.

Example. If film is available in 4x100' and 20x40' sizes, a 16x36' oval allows using the two films for wall and roof without having to join sections by heat sealing or taping. Since an oval needs different rib lengths, insert one end of the rib over its post, bend the rib and cut the other end to fit. If the wall film is wider than wall height cut the film lengthwise, or slit it at each rib and let it hang inside over the pipe ring. Infill framing can be added for larger yurts - smaller posts and ribs between main ones, or smaller rings too.

FRAME AND COVER MATERIALS. Use whatever frame and cover materials are available: lashed bamboo and greenhouse film, PVC electrical conduit and woven or cross-ply polyethylene film, CPVC pipe or costly carbon tube and rip-stop nylon to reduce weight.

Post and rib sizes can allow inserting ribs over the posts, into the posts, or lashed aside posts with wire or locking plastic ties. Observe actual sizes, they are rarely nominal size: for example a ½" ID CPVC fits snugly into a 1/2" OD EMT metal electric conduit.

Driving posts. If in hard soil, it may pay to sharpen bamboo tips, crimp metal pipe tips with a vice or hammer (also to prevent pipe filling with dirt), and/or use a capped driving head to protect post tops. For ½" metal conduit a ¾" galv. short nipple and cap driving head work well. If a post strikes a rock or root, move it a short distance along the ring; post spacing is not sacred.

If needed, add a telescoping center post for snow load (see the sketch for small hangar posts).

Grommets, film clamps, or ball bungees can also be used for film tensioning (www.creativeshelters.com, or www.gadgetbrothers.com/tarpclamp.html, for example). **Self-locking cable ties** can replace tie wires.

INSULATION. Add any available sheet insulation under the films - fanfold foam board for walls, bubble wrap packing or other blanket insulation for roof. See www.uline.com for 1/32 to 1/4" 6' wide polyethylene foam sheet rolls, 3 to 9¢/sq.ft. Use any number of layers. Add any **ground film** material available (see www.stocote.com).

WIND ANCHORING. Set self-tapping screws in the posts at ground level and cross-lace string between the post tops and bottoms to give wall stability (see schematic). Stake hold-down bungee/cords over the yurt top if needed.

AIR DROPPING. To ship, reverse assembly steps, wrap pipes in cover films and bundle with cable ties. 1 lb/5 sq.ft. of floor is a useful weight approximation, less for larger yurts. The weight may double with significant insulation, ground cover, and a heavier roof cover, or be halved by using lighter more costly framing and cover materials.



13' dia. yurt without insulation, ~\$89 for materials.