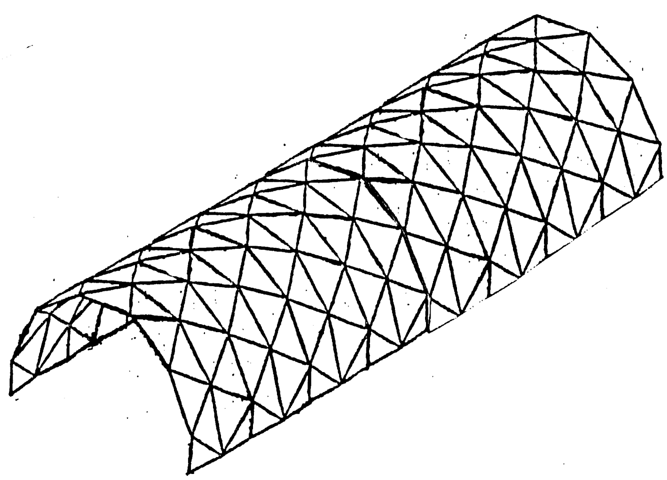
NEW TRICKS AND HINTS

November 2004 Edition of

THE GEODESIC QUONSET

BY

P.J. HAFER



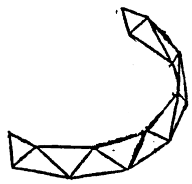
Experience obtained since 1986 by extending the original building and feedback from my readers, as well as a failed metal attempt, have lead to some observations which aid in faster and easier construction and better understanding.

NUMBER OF SECTIONS (1" X 6" X 48" HOOP STRUTS) / LENGTH (FT)

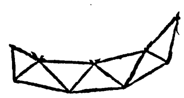
	2 / 7	4 / 14	6 / 21	8 / 28	10 / 35	12 / 42	14 / 49	16 / 55
BOARD FEET WOOD	102	186	270	354	438	522	606	690
POUNDS SCREWS	3.4	6.2	9.0	11.8	14.6	17.4	20.2	23
POUNDS NAILS	1.48	2.7	4.0	5.13	6.35	7.56	8.9	10
MAN HRS	13	23	34	44	54	65	76	85

HINT 1. Don't work on the ground while making hoops; you may not have a flat surface on site anyway. Make a table from one Type 1 and one Type 2 hoop joined by cross struts properly lined up. You create a true surface which is sturdy and easier on your back. Use complete hoops for work on site, or make a half-table for later transport of parts. The table will become part of the building. Use it as the " starter section ". Parts may be made male and female for later assembly on site. A half of a hoop strut will be denoted by 1/12 hoop so that a Type 1 hoop can be composed of a male 6/12 and a female 6/12. Similarly a Type 2 hoop can be composed of a male 5/12 and a female 7/12. We built our table from one female 6/12 hoop part and one female 7/12 hoop part. It required 7 cross struts. Use a nail first through all the wood; one person starts the screws with a hammer and the other drives them.

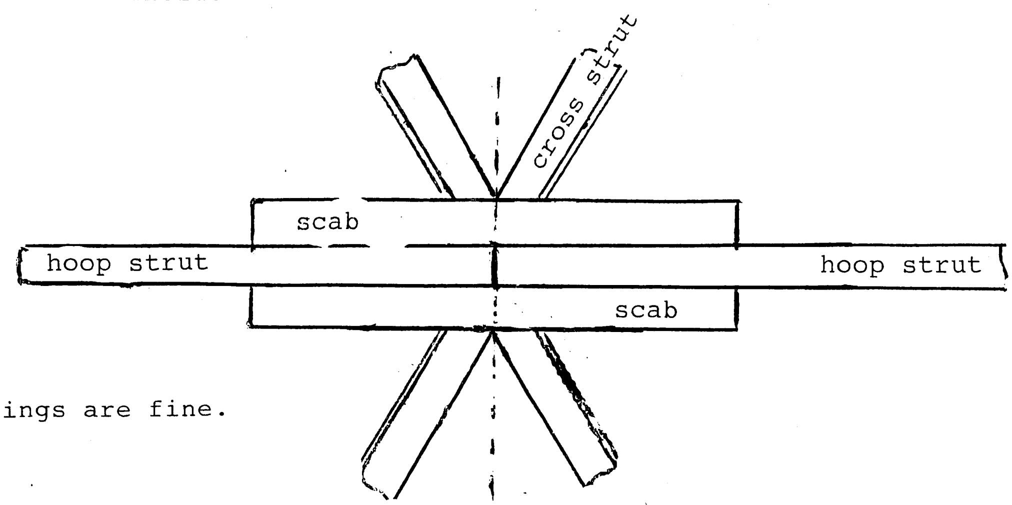
Full-table



Half-table



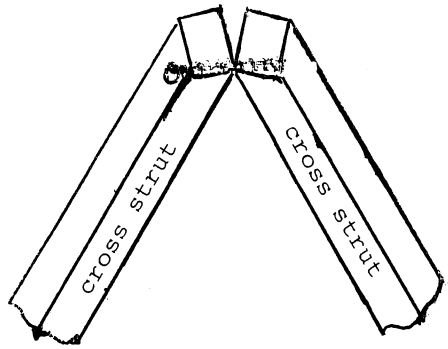
HINT 2. The ±7.5° marks are an aid in centering the scab patches and in attaching the cross struts to the hoop on the ground. The free ends are determined at this point in time, short of forcing a twist in them. For integrity, all that we need is a transverse between the two parallel scab planes. As long as the points of the V's line up with the hoop joint at each connection and look like this from inside:



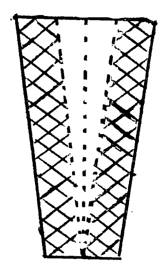
things are fine.

Small errors of ½ inch will probably cancel left to right without giving a twist to the building. Hang lower joints with a screw at any point of correct contact, but wait until then. Use a stable roller-jack and pole to lift new sections into place or get a case of beer for a gang. Work your way up each side and go back and fill in the rest of the screws. Remember: God is forgiving of amateur gardeners and carpenters.

HINT 3. When putting cross struts on hoops on the ground, tie them together at the top with a screw which will be left in place and hold them aligned until screwed to the building in place.Check the grain and flip boards so as not to split.

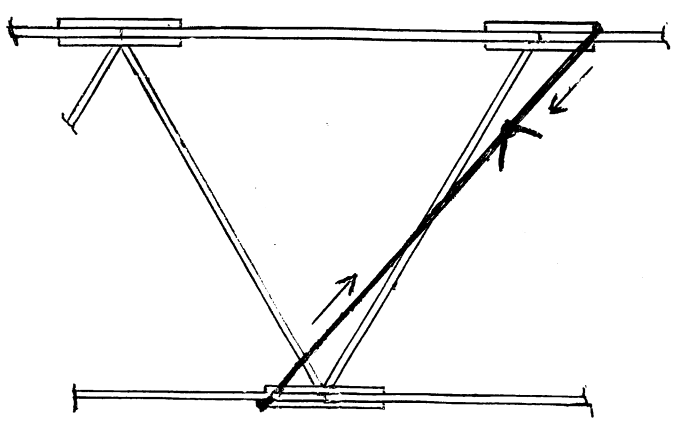


IDEA that I had but I did not try yet: Cut up soft plastic patches from milk jugs incorporating the ±7.5° marks,screw them to the ends of the cross struts instead. Staples in end grain pull out!



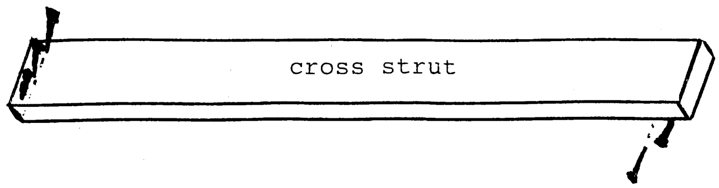
With heavy buildings, we may use these to attach pairs of cross struts to the structure and then hang a hoop.

HINT 4. Use a ratchet strap to draw parts together:



HINT 5. Use Type 1 hoops for propping up(not Type 2)and keep the working end well clear of terrain. Clear the area of brush, etc. before starting the project.

HINT 6. Set some screws in the cross struts



when desired and put some on the hoops and some on later. Whatever works, just line up those points and joints!

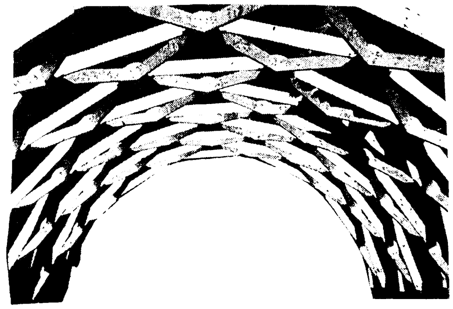
HINT 7. SECOND IDEA FOR YOU: We lacked manpower needed for 6" instead of 4" wood. Try attaching 6/12 , 5/12 , or 7/12 hoop parts onto the structure. Larger diameters and heavier lumber sizes may require this with an A-frame prop.

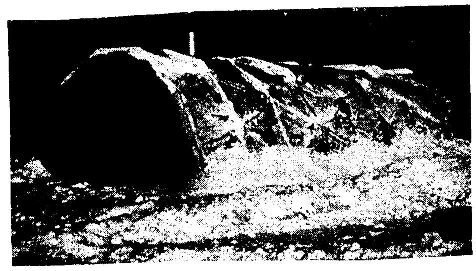
HINT 8. If you insist, use a big flat monkey wrench to twist the cross struts. Drill holes for wiring and hooks when you cut all the struts out, beats standing on a ladder with a drill.

HINT 9. It is much easier to build in " zero gravity " , i.e., in stacked tables on the ground and use a strong Type 1 hoop end to tip it 90° to the vertical position. Larger and heavier projects would exaggerate this.

HINT 10. As reported in PACIFIC ULTRALITES, March, 1995, I constructed a geodesic quonset using 5 foot long X 1.625 inch chain-link fence rail tubing, flattened at both ends, and joined with ½"diameter bolts. It formed the familiar rigid shape, but after a couple of winters with no heat to cause snow to slide off, some struts failed under their individual snowload and the structure collapsed. The adjoining wooden quonset held and has been extended to replace the metal one. I have sorted my tubing and plan to use it for a true dome which gets strength from curvature in all directions, rather than a cylinder which has no curvature along its axis. This "house of cards" failure mode is a tragic situation in many modern building structures. Roof and floor trusses may may save money and wood over older ways, but in a fire, they give no warning of a quick collapse costing firefighters' lives or making it impossible to safely fight the fire.

YOU CAN BUILD THIS!





Wood	269
Sills	103
Harsware	105
Tarp	100
	577

rea : 15.45 X 55.4 = 856 sq. ft..

nit cost 577 / 856 = 0.67 dollars / sq. ft.

OR SPEND FIVE TIMES AS MUCH FOR THIS!

ENCLOSED GARAGE CANOPIES

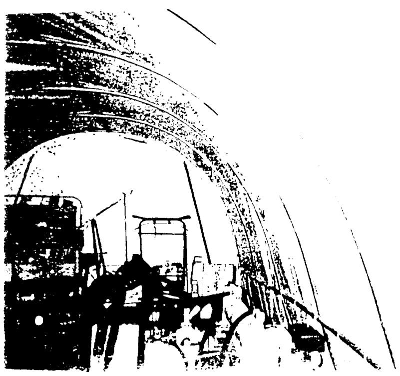
- The best vehicle/boat protection you can buy!
- This "garage" doubles as strong storage area for your lawn/garden equipment and other stuff that can't fit in your regular garage

er-colored polyethylene cover with its unique truss system increases overall
d capacity
ver is ultra resistant to sun's destructive UV rays
tom side & end walls (included) completely enclose the canopy to maximize
tection (one wall is zippered for easy entry/exit)
x 28" windows (one on each side) help you keep tabs on your valuables
ets commercial & California fire codes
set up using your wrench. Includes big 2" diam. galvanized steel frame, 8 legs
able, sturdy setup, side and back rails for extra stability, 8-pc. ground anchor kit
erchangeable corner brackets. Side height: 6'8". Center height: 9'9". Limited
warranty on cover. Shipped separately from factory. Not mailable—see
To Order Page (Shipping & Handling).

20' Garage Canopy. **$729.99**

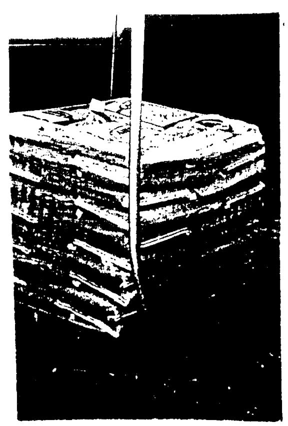
27' Garage Canopy. **$889.99**

COMPLETE WITH COVER & WALLS!



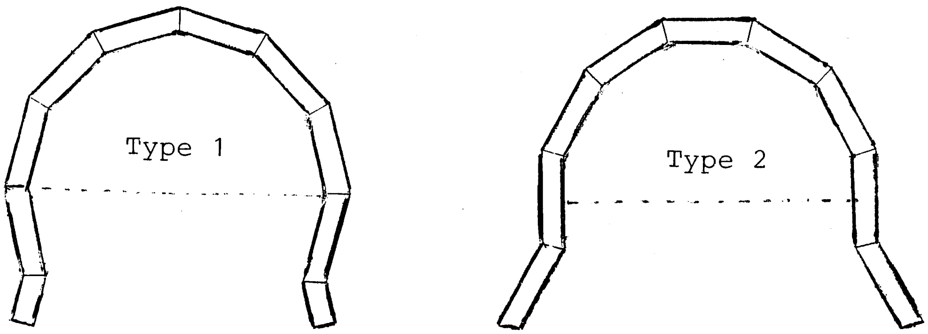
Plus frieght and tax = 3.26 dollars / sq. ft.

= 3.26 dollars / sq. ft.



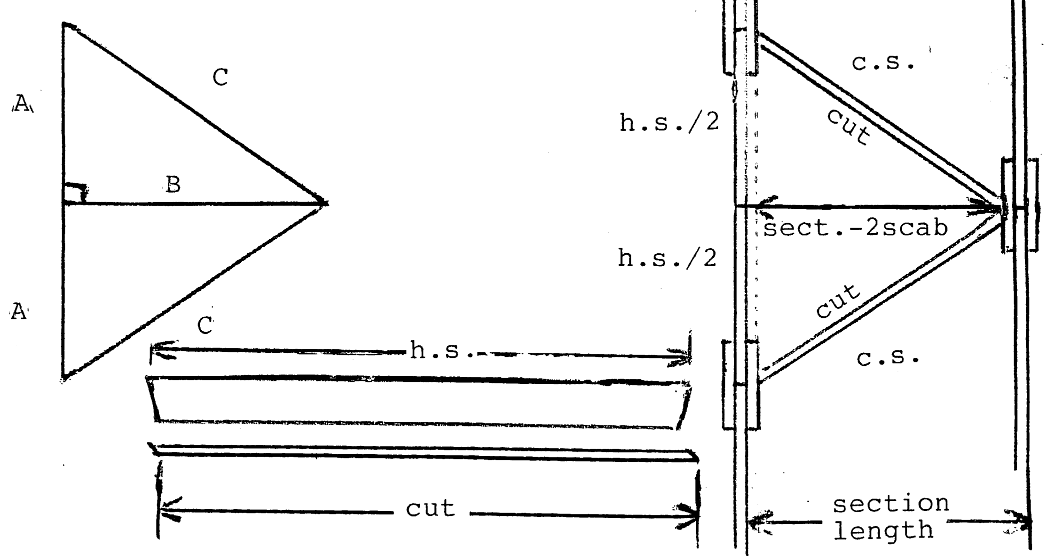
Your labor is worth atleast 3.26 - 0.67 = 2.59 dollars / sq.ft..
Since 85 man hours produced 856 sq.ft.,
this labor is worth
2.59) X (856) = 2217 dollars,
nd one man hour is worth 26.00 dollars.

HINT 11. Last May, Sally and I thought that we would need a camper top on our small truck. We took some 2" X 4" scrap wood from my brother's burn pile and ripped it into ½" widths and made a one-third scale quonset with 16" hoop struts. We added a nice riser wall by using reversed hoop struts:



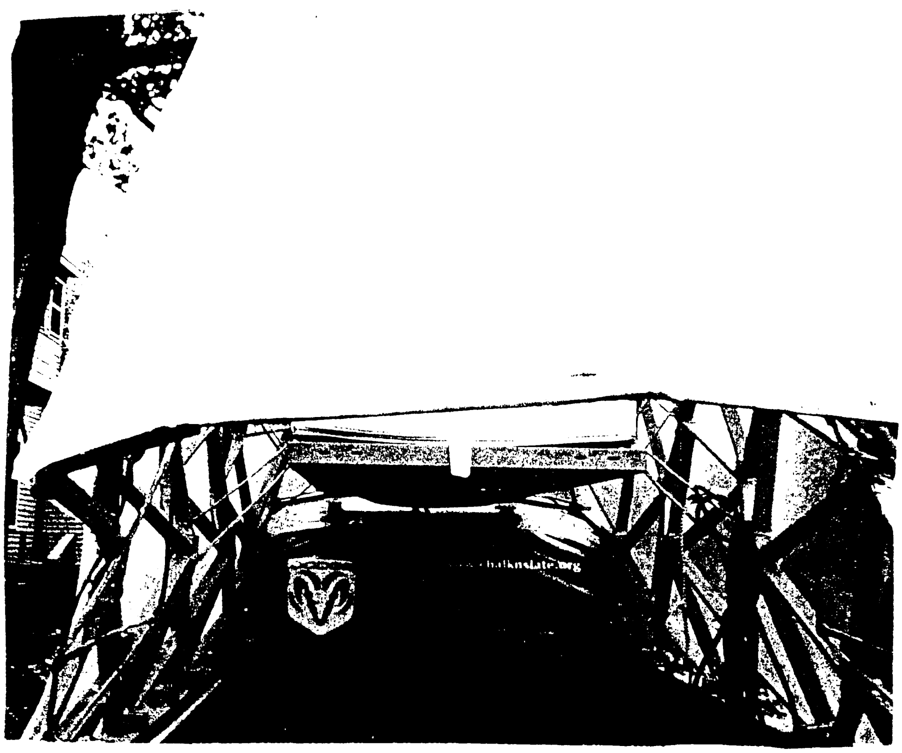
We obtained this hoop strut length from formula 7, page 15 and then sprung the hoops to the span using 2" X 4" for sills (strapped to the truck). Then we added the cross struts, thus fixing this dimension.
NOTE: The length of cross struts was found by choosing the number of sections and length of sills, using $A^2 + B^2 = C^2$ or trigonometry:

$$\text{cut} = \sqrt{(\text{sect.}-2\text{scab})^2 + (\text{h.s.}/2)^2}$$



Make a sample section and see how it comes out. Adjust the subsequent ones by changing cross strut as needed. I had fun here by using The Calculus to correct with a differential equation to find this " fudge factor". We used popsicle sticks to model quarter domes fitting the ends, streamlining it. The wood split with the screws, scabs were 6" long peices of similar wood. Pressure treated was better in this regard, but this was a worst case experiment so we used plenty of screws and gobbed all the joints with warm LIQUID NAILS to stop splitting and lock exposed threads in place. Plywood scabs would be easy to find as scrap next time. We strung up an old bed inside with fiberglass roving and polyester resin and painted it all bright orange. We covered it for winter with clear 3-year UV greenhouse plastic, stapling edges and drawing it in with fender washers.

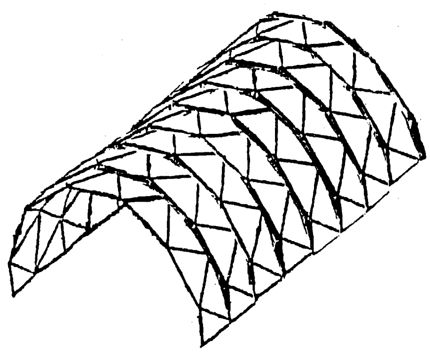
Geodesic SCRAPAHEDRON Camper and studio:



HINT 12. As I reported in the first edition of THE GEODESIC QUONSET,I was amazed by the rigidity obtained from such a relatively small amount of wood. Even the camper cap made from ½" X 1½" scrapwood supported me with only its first several sections complete.

"This material will not be on the test." Back when I taught classes, I would take note of how students reacted to that statement. One said "Then why cover it? ". This can be a factor whenever a student teeters between grades.

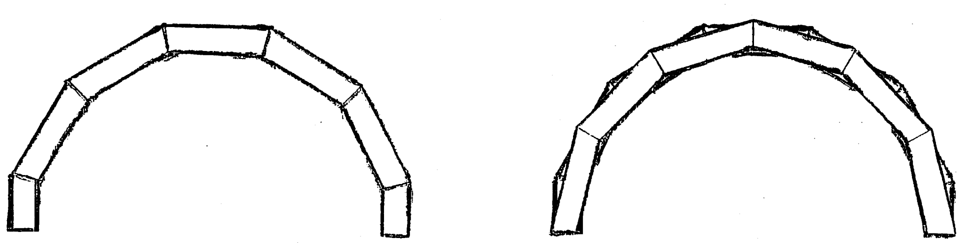
One local reader of mine built his quonset without alternating the hoop Types:



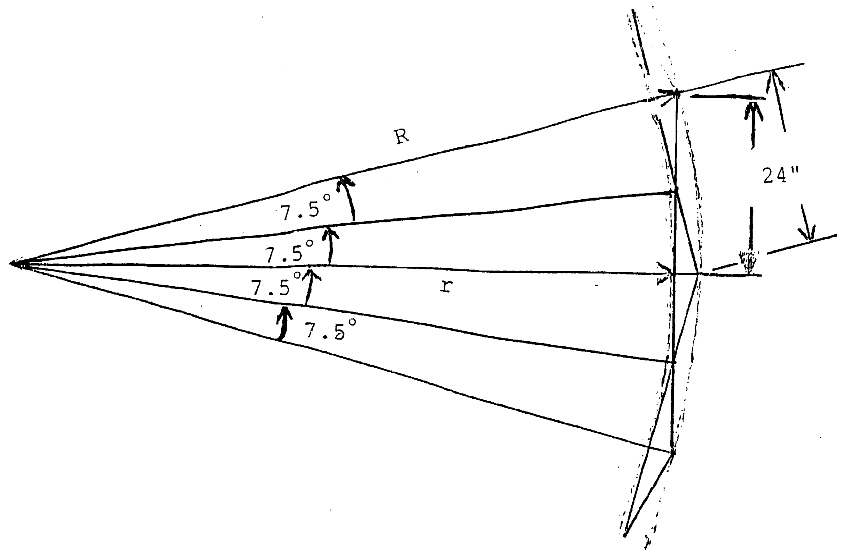
With pride, he showed it to me. I noticed his most original design. His subsequent buildings were erected correctly and have lasted. His first got wet vertices when the tarp got old and it came down. All tarps get old at these points first; don't neglect to add on a new one. I will show why alternating the hoop Types makes a difference.

Honestly, I worked one month reviewing college Physics and aircraft design (forces, moment arms, fiber stress, and modulae of elasticity), but I found it quite pleasurable. I was thrown out of a McDonalds restaurant for " loitering " while studying this.

Viewing both quonsets on end:



The poor quonset gives a uniform material depth of 4", while the other yields a depth varying linearly from 4" to about 7.1584 inches in 7.5° and then back down to 4" in the next 7.5°. To see this, we will use a " geodesic sanity " technique; think of the complete circle and polygons or sphere/dodecahedron for domes! We may consider a regular 12-sided polygon and find formulae for inscribed or circumscribed circles. I derive them for a double check on my understanding.



Let r and R represent the radii of the inscribed and the circumscribed circles, respectively. Then

$$\sin 15° = \frac{24"}{R} \quad \text{and} \quad \tan 15° = \frac{24"}{r}$$

So $$R = \frac{24"}{\sin 15°} \quad \text{and} \quad r = \frac{24"}{\tan 15°}$$

We are looking for $R - r = \left(\frac{24"}{\sin 15°} - \frac{24"}{\tan 15°} \right) 24"$

old four place tables!

$= (\csc 15° - \cot 15°) (24") = (3.8637 - 3.7321) (24")$

practice practice

$= (.1316) (24") = 3.1584$ inches.

```
 3.8637        24
-3.7321     X.1316    four decimal places
  .1316        144
               24
              72
           + 24
            31584
```

I am watching as computers choke out thousands of years of Mathematics, replacing intellect with stenography. Graphing calculators lead to a job hitting item keys in burgerking unable to figure change and twice telling me that $1 + $1 = $3.50 until the manager scolded me because it was the person's "second day".

The percent increase in depth is $\frac{3.1584}{4}$ X 100 = 77.5% With 6" deep lumber, the effect is less pronounced: $\frac{3.1584}{6}$ X 100 = 52.5%, Conversely, for one inch tubing, the increase is 316%. Paper can be taken from " zero " thickness and folded into origamy and even glide. The GEODESIC QUONSET has an earie resemblance to my 1972 high school box design project.

I digress, but I built my cottage from ½" strandboard sans frame by simply seaming the triangles inside and out with wet-layed waxfree polyester and fiberglass mat.
Tough lesson: Cover it 100% with glass like boats, paint fails and wood rots. I make as much cash fixing rot in my boats as I did on the original project. I sold paint over and over (planned obscolence). Opaque gelcoat can be tinted and waxfree resins may be ordered from Merton's Fiberglass Supply 1-800-888-8888 in MA.

I prefabricated most of the dome in " zero gravity " by hanging each triangle from a common overhead hook with light radius wires. They magically float together to be seamed. Next time, I will use wood/dow foam/wood sandwiches (epoxy won't melt dow) or simply dow with epoxy/glass outside and fire resistant texture paint inside. Liquid Nail might claim to be safe on foam, I made my floors and risers walls as sandwiches with no joists using it with many screws in the all wood perimeter. False for big gobs of the stuff, but totally insulated floor. Wet floor for a while means no floor! I learned. We are still tiling our 12 foot diameter dome and geodesic A-frame wings with scuffed dow and cans of polyurethane " shaving cream " and installing our solar electric and water systems.

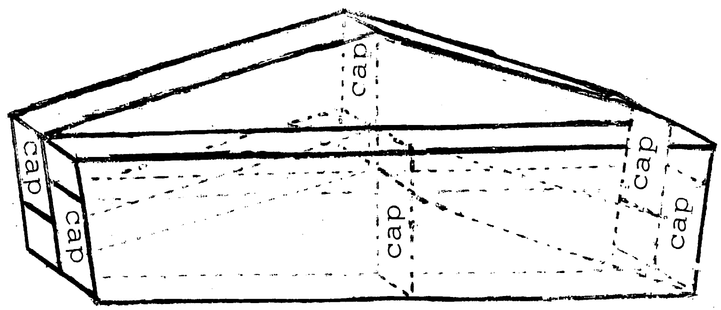
I cut out 27 portholes when I saw Burt Rutan's latest spaceship. WHOOPS! Frame any large opening in a dome before cutting. Do you remember flying butresses?

Returning to the original topic, a coarser division of the arc would give more variation in depth. To see this, consider that for n = 12,11,10,9,8,7,6,5,4,3,2, this table shows the story for any choice of hoop strut length. I included the degenerate case n=2 representing a diameter counted twice because we actually are looking at the distance from any chord midpoint to the circle. I visited my alma SPLATTER to find future high school teachers being trained but not educated on a geometer's sketchbook computer program which faithfully bisects angle ABC as long as the B-key is hit between A and C. Anybody want to buy a compass or straightedge? The new cybermath would likely consider AB and BA to represent two distinct line segments. Recall opposite vectors, but geometry is not physics and computers will always be just glorified shovels compared to Galois Theory.

n	$\frac{180°}{n}$	$\csc\frac{180°}{n}$	$\cot\frac{180°}{n}$	$\csc\frac{180°}{n} - \cot\frac{180°}{n}$
12	15°	3.8637	3.7321	.1316
11	16.36°	3.5488	3.4050	.1438
10	18°	3.2361	3.0777	.1584
9	20°	2.9238	2.7475	.1763
8	22.5°	2.6131	2.4142	.1989
7	25.71	2.3046	2.0763	.2283
6	30°	2.0000	1.7321	.2673
5	36°	1.7013	1.3764	.3249
4	45°	1.4142	1.0000	.4142
3	60°	1.1547	.57735	.5774
2	90°	1.0000	0	1.0000

After a long process, I can simply say that the strength and stiffness of the Geodesic Quonset is a result of the same phenomenum that occures when a cylinder is corrugated in order to form a culvert pipe or a vacume hose. Removing triangles from them could produce a Geodesic Quonset. Also, the vertex loads are all distributed outward by simple compression in its six struts.

The behavior of the poor quonset mimicks that of a simple wooden beam under shear and governed by a linear distribution of fiber stress ranging from a maximum in the outer surface to the opposite in the inner surface and vanishing along the midline.



The Geodesic Quonset surpasses this even at its narrowest points because it tends toward an I-beam construction with two caps separated by a web and overlapping ends which prevent slipage. Caps have uniform fiber stress throughout their cross section resulting in a much stronger and stiffer I-beam.

Platt Monfort has shown thousands how to build boats. A relatively small amount of wood is sawed into $\frac{1}{4}$" X $\frac{1}{4}$" lengths and formed with thin bent ribs then wrapped diagonally with Kevlar string and covered with waterproof fabric. By expanding the wood to become compression cap members he gets a canoe which weighs 11.5 pounds and supports 300 pounds.

A bundle of straw is floppy compared to a woven basket. Our sweat and toil raise the entropy to the material. The aircraft designer R.W. Hovey wrote:

<u>THERE ARE THREE KINDS OF PEOPLE</u>

1. The few who make things happen.

2. The many who watch things happens

3. The majority who have no idea of whats happening.

Thankyou and good luck,

Capt. P. J. Hafer

P.J. Hafer
Box 493
Potsdam, NY 13676 U.S.A.

www.chalknslate.org

STEVE SPENCE'S 1" X 6" X 55.4 foot PROJECT:

October 11,- November 10, 2004

HOOP STRUTS: 1" X 6" X 48"

NUMBER OF SECTIONS: 16 and HOOPS: 17

WIDTH: 15.45 feet and LENGTH: 55.4 feet, same as the plans except TWICE AS LONG.

BUILT BY HAFER, SALLY RUHL, AND SPENCE.

WOOD: 269 dollars for rough green 1" X 6" PINE FROM Lloyd BESAW, NORWOOD, NY.
708 board feet at 38¢/b.f. in 8,10,12 lengths.

HOOPS 204 b.f.
CROSS 384 b.f.
SCABS 102 b.f.

SILLS EXTRA 2" X 9" X 120feet=270 b.f. =103 DOLLARS.(omitted)

PERCENT WASTE: $\frac{708 - 690}{708}$ =2.5 %.

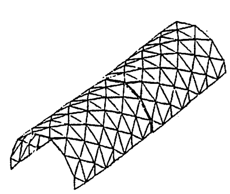
HARDWARE:	23 pounds 2" X 6 phillips head drywall screws	70 dollars.
	10 pounds 3" nails	9 dollars.
	10" CARBIDE SAW BLADE	19 dollarss.
	TOTAL plus 7% tax	105 dollars.

MATERIAL TOTAL: 374 DOLLARS.

LABOR: 85 man hours plus 20 additional for transportion.

DAILY REPORT FOR SPENCE PROJECT

Oct.11,04	Sally and PJ drove a small truck getting 242 board feet of 1" X 6" in 8', 10', or 12' lengths for 484 linear feet.	3 m.h.
Oct. 12	S and PJ cut 108 hoop struts for 17 hoops plus 1 extra for later rejecting. They went for 253 more board feet.	4 m.h. 3 m.h.
Oct. 13	S and PJ cut cross struts out of the last load getting 116 struts and delivered them to Spence (15 miles). Then they picked up the last 206 board feet.	4 m.h. 3 m.h.
Oct. 14	S and PJ cut 88 cross struts for a total of 204 or 16 sections plus 12 extra to reject later and delivered to site. Cut the scabs abd half-scabs.	4 m.h.
Oct. 15	S and PJ pointed all the scabs and half-scabs and built a 6/12 partial Type 1 hoop and a 7/12 Type 2 hoop with female ends.	8 m.h.
Oct. 16	S and PJ joined these with seven cross struts forming a table for correct assembling of 5/12 , 7/12 , and 6/12 hoops of male and female types at a convienient height and later transport to the site. Sally marked all the scabs and half-scabs with ±7.5 ° marks. They also made four female 7/12 hoops.	6 m.h.
Oct. 17	S and PJ used the table to make 3 more 7/12 female hoops and also made(8)5/12 male hoops, completing all 8 Type 2 hoops.	10 m.h.
Oct. 18	S and PJ used the table to make eight 6/12 female hoops and delivered most of them .	9 m.h.
Oct, 19	S and PJ made seven 6/12 male hoops on the table and bought four more struts as needed.	6 m.h.
Oct. 20	S and PJ finished the last two 6/12 male hoops and delivered them. This completes 9 Type 1 hoops and we assembled the full table on site.	3 m.h.
Oct. 22	S and PJ used full table to make two full hoops.	4 m.h.
Oct. 23	S,PJ, and Spence put up two sections over his generator.	6 m.h.
Oct. 24	S and PJ put up two more sections.	6 m.h.
Oct. 26	PJ put last six hoops together.	2 m.h.
Oct. 30	S, PJ, Spence, and friend put up 3 more sections.	6 m.h.
Nov. 6	S, PJ, and Spence put up two more sections and began tying the table to the building with cross struts.	6.m.h.
Nov. 7	S and PJ tied in the table and hung one more section.	5 m.h.
Nov. 8	PJ attached cross struts to the last four hoops on the ground.	2.5 m.h.
Nov. 9	PJ alone stood and attached two sections.	3 m.h.
Nov. 10	PJ hung last two sections, completing the structure.	2 m.h.



Total labor: 105.5 m.h.

-less travel time: 20.5 m.h.

Actual labor: 85 m.h.