Construction Journal

May 29, 2014

This pdf includes some note on what we have been building, what are the things that came out in reality (is it different or is it as expected?).

1 Notes on Vol. I

Construction of the dish began in the courtyard of HFA in Berkeley, CA. Some lessons that were learned from that construction I call Vol. I :

1. The size of the sono-tube is set by the distance between the center of the walls. In order to get the spacing correct of the 16 PVC pipes around the tube, make sure to measure the outer diameter and divide 16 for the arc. Since both inner and outer tubes were drilled with 16 holes the same way or measurement method before realizing the problem, the tubes fit in Vol. I.
2. Use less water in the concrete!
3. Special care of nails on fixing PVC sleeves while pouring concrete.
4. 14 meters of PVC is too droopy. Creating a perfect (or near perfect) may be hard by just anchoring the two ends. Support is needed. See Dave's new design (6/7/2013).
5. 3 Segments of all sizes of PVCs we have in hand were connecting using 2 couplers sitting in HFA

2 Notes on Vol. II

We are currently building the first actual thing in Carl's backyard, the first challenge with that is the slanted ground. So a lot of the distances, angles need to make use of the theodolite and some tools to be as accurate as possible.

As we started building, there are few things to note, such as distances, heights, angles, errors due to human mistakes... Ways to solve them..

1. 12 spokes + 12 supporting spars, not 16 as we previously designed with the 1st hub at HFA (vol. I)

2. sleeves length is 15” x 24 out of 2.5” PVC
3. Hub launch angle is 2.86 ° using 18” and 36”, see Equation 1
4. gave up the original supporting telephone pole design, now employed a equilateral traingle design; pole to pole distance : 14.6m = 574.8” = 47.9’, pole to center distance: 8.43m = 331.9” = 27.66’
5. made 12 spars of length 288.625”, correct length should be 291.3”, lost due to neglected built in coupler overlapping region
6. made 12 spokes of 218.5”, but half of them are plain on both ends, half of them have bell coupler at one end

Sono Tube	Measured Outer Circumference
36”	$114\frac{7}{8}$”
20”	$64\frac{2}{16}$”
18”	$58\frac{3}{16}$”

Table 1: The measured circumference (outer) of the sono tubes as we learned from Vol. I, it is bigger than simply $R_{listed} \times 2\pi$.

$$\theta = \arctan \frac{r}{2f} \tag{1}$$

where $r = 18 \pm 0.29$” since circumference of the 36” hub is greater than $36 * 2 * \pi$(overall hub radius) and $f = 4.5$m

2.1 Pole measurements and surveying

We surveyed 3 poles plus the center based on the 1st pivoted pole, we measured the angles from center to each pair of poles as listed in Table 2. Before the 2 poles were drilld, we measured the difference in height for pairs of poles and with the center using a theodolite, 2x4, and tape measure. These numbers came out to be very encouraging, the angles were close to 120° and the distance from each point to the other at the same horizonal level is approximately what we wanted, see Table 4 for how close is close.

After the two holes for the poles were drilled, in order for them to be easier to fit in the hole, they were drilled 16” in diameter and about 37” in depth. There were wider than the hole for the first pole, hence harder to keep it straight up, we will use more manpower and 2x4 / 2x6 to place it in position. One problem that arises with the bigger hole: the pole is now tilted to one side, as a result the center of the pole is not concentric on the surveryed center. We can try to shift the pole to match the surveyed center or we can work around with the error resulting from that.

A method that Zaki and I was using when we pivoted the first pole (these poles do not have same radius at all heights):

1. drill 2 screws on the pole separated by some "far" distances; these screws are centered independently by eyeballing only the width of the pole at that height
2. Check for centering of screws **Individually from far away**
3. fix a string connecting two screws
4. setup the theodolite pointing to the string and move the viewer vertically to check if string lines up with black vertical crosshair line
5. Jiggle the pole around and make the last step work

To deal with the slanted center for the hub, that part of the ground is craved / flattened. As a result, the center is now only an estimate to the previous surveyed rebarred point. What we can do perhaps is to figure the center after pivoting all 3 poles since the holes are drilled, there isn't a lot of room for adjustments at the poles.

The survey points in the table is defined as: Pole 1 = the very first pivot pole, hand drilled hole; Pole 2 = The highest pole near the fence; Pole 3 = the pole closes to the shed, near where our cars park.

Point	Angle
Pole 1	48°20'0"
Pole 2	286°21'41.5"
Pole 3	168°21'0"

Table 2: The table lists the azimuthal angle at each pole from true North. At this point, pole 2 and pole 3 were drilled, so we estimated where the rebars were surveyed previously. .

Point 1	Point 2	Δ angle
Pole 1	Pole 2	121°58'18.5"
Pole 2	Pole 3	118°41.5"
Pole 1	Pole 3	120°1'

Table 3: The difference between the azimuthal angles at each pole.

Point 1	Point 2	Distance
Pole 1	Pole 2	48'$\frac{1}{4}$"
Pole 1	Center	332"
Pole 1	Pole 3	47'$\frac{2}{3}$"

Table 4: The table lists the distances between poles and center before drilling the 2 holes after locating the point of same horion using a theodolite and 2X4s .

As we continue to pivoting the 2 poles, we shifted them to the center of the holes (as close as possible). The central point was re-surveyed using ratchets, strings and springs.

Point 1	Point 2	Height
Center	Pole 1	$22\frac{3}{4}$"
Center	Pole 2	$4\frac{1}{4}$"
Center	Pole 3	31"

Table 5: The table lists the height between poles and center before drilling the 2 holes, i.e. how slanted from pole to pole.

We measured the pole to pole distance after the center is finalized and the circumference of the poles at the same height that we measured using the theodolite (where strings were connected at during center re-surveying). The measurements are shown in Table 6 and 7 respectively, the pole names are defined at the beginning of this section.

Point 1	Point 2	Distance [Feet]
Pole 1	Pole 2	47.1
Pole 2	Pole 3	47.4
Pole 1	Pole 3	46.9

Table 6: The table lists the distances between poles after we finalized the center.

Pole	Circumference[Feet]
Pole 1	2.35
Pole 2	2.00
Pole 3	1.94

Table 7: The table lists the circumference of each pole at a specific height that we used to re-survey the center.

We also drilled holes on all the sleeves for the nails (used as a stopper to fix the PVC spokes), after putting in the nails, $\approx$ 2.5" of the sleeves are exposed on the exterior of the hub. Since the length of the spars were mistakenly cut previously, to accomodate that, we added one nail on each sleeve $3\frac{3}{4}$" from the exterior hub. The central hub is leveled using a jig, to preserve the launch angle designed on the hub, we learn that whole measurements should made with respect to the top of the hub.

2.2 Rim

After the rim is put up, we set up a theodolite and compared the top part of the horizontal 2x4s level-ness (2 on each pole / post). Table 8 (Below) is a table showing the motion (by approximation) each plate needs to go for consistency in all. Pole 1, 2, 3 are referring to the same poles mentioned in previous section, each 4x4 counting counter-clockwise from the corresponding rightmost telephone pole is named a,b,c.

Pole # / Post #	Right	Direction	Distance shift	Left	Direction	Distance shift
1a	R	up	1.0 * w	L	up	.75 * w
1b	R	up	.5 * w	L	up	.3 * w
1c	R	up	.75 * w	L	up	.5 * w
2	R	up	.5 * w	L	up	.3 * w
2a	R	up	1.5 * w	L	up	1.8 * w
2b	R	up	2.0 * w	L	up	2.0 * w
2c	R	up	.3 * w	L	up	.3 * w
3	R	up	1.0 * s	L	up	1.5 * s
3a	R	N/A	N/A	L	down	1.0 * s
3b	R	down	1.2 * w	L	down	1.2 * w
3c	R	down	.5 * w	L	down	.5 * w

Table 8: These motions are with respect to pole 1 which both the left and the right plates are aligned. 'w' is defined as the width of a 2x4; 's' is defined as the screw size.