Interoffice

National Radio Astronomy Observatory

Green Bank, West Virginia
January 16, 1980

25 METER MILLIMETER WAVE TELESCOPE
MEMO No. 136

To: J. W. Findlay, L. King, W. Y. Wong

From: S. von Hoerner

Subject: SURFACE PLATES: GRAVITATIONAL DEFORMATION, 4-CORNER-TWIST.

Thanks for Lee King's data and plots about the plate deformation under loads. Please have a look at the enclosed 2 sheets. Here are some comments.

1. I have taken only those 25 points which are on complete lines of 5 points each (for an available program, doing also other calculations). But this should not make much difference. I used the "distributed load", divided by 3 for representing the <u>own</u> weight.

2. The center deformation can be compared with theoretical expectations via simple models. A rectangular solid plate should be between a beam and a square plate; with our longish plate (2:1) more close to the beam, say 60 to 70 μm. But the skin-rib combination is somewhat worse than the solid cross section of same thickness (worse means smaller radius of gyration), thus I would have expected 90 to 100 μm. The measured value of 86 μm then agrees quite well.

3. The rms $(z - \bar{z})$ of 26 μm agrees very well with the 24 μm of the 25-m Proposal, meaning the scaling was ok.

4. I have always claimed that subtracting $\bar{z}$ (when taking the rms) is alright for calculating the performance. But I do not know whether I ever really calculated it properly. This is now done on the enclosed second sheet; it <u>is</u> ok.

5. Regarding the factor 0.5 for the "average sky" in our 25-m Proposal (Vol. I, page III-44): this does not sound well and convincing. We might consider to make the ribs thicker (deeper), 4 inch instead of 3. This would give 14 μm for the <u>worst</u> case, which could enter the error budget without the factor 0.5.

   On the other side, the plates are made and measured in horizontal position, thus the gravitational deformation goes with 1 - sin(elevation); it is zero at zenith, and the worst case means pointing at the horizon. A factor 0.5 is obtained at 30° elevation. Therefore, one could still use the present plate, and the factor 0.5, too; but instead of "average" saying: "at 30° elevation, below which observations at the very shortest wavelengths are seldom done".

6. By the way, in November I did an experiment, with S. Smith, to find out whether both long sides of our bad plate deform under loads by different

or same amounts. We used a total load of 220 lb, with 110 lb on the middle of each long side. The "good" side deformed by 0.20 mm, the "bad" side by 0.17 mm, at their centers. Which means there are no cracks in the bad-side rib. The same result, of course, is also seen from Lee King's plots.

7. I am still working on the "Best-Fit of 4-Cornered Plates", using actual surface measurements. Preliminary results are the following:

   a. If one corner is lifted by 3 mm (strong internal twist), the surface shape follows equation (5) of my 25-m Memo 128 (Oct. 26, 1979) within 29 μm rms, which is only 1% of the corner lift. This means there is no problem in twisting a plate to its best-fit shape, using all 4 degrees of freedom. Has been done on only one plate, will be done on others, too.

   b. As a starting value, take the surface rms without any best-fit, all four corners at the nominal parabola. Using 1 degree of freedom, a parallel vertical lift by $\overline{\Delta z}$, the rms deviation from the parabola decreases by about 10%. Using the remaining 3 degrees yields about 15% of further improvement, with a total of 25%. These numbers are from four plates only, needing more data.

SvH/s

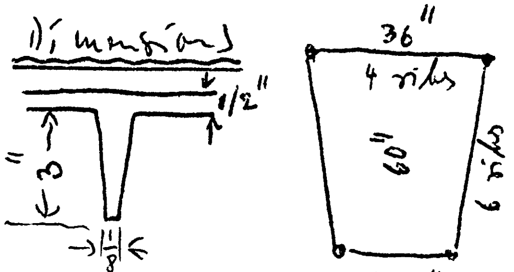
25-m plate, Cast-Alu : Gravity ① 1-15-80

1) **Measured**

own weight, 123.25 lb

- center deformation $\boxed{86\ \mu m}$ expected: $\left\{ \begin{array}{l} > \text{Beam} \\ \leq \text{Square} \end{array} \right\} \rightarrow$ ok
- average, $\bar{z}$ 54 µm
- rms (z) 59 µm
- rms $(z-\bar{z})$ $\boxed{26\ \mu m} \rightarrow$ ok

2) **Dimensions**

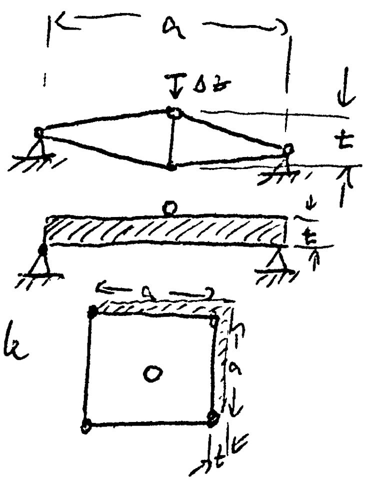


Aluminum:

$$\frac{\rho}{E} = 0.38 \frac{cm}{(100\ m)^2} = 3.8 \times 10^{-9} \frac{1}{cm} = 9.65 \times 10^{-9} \frac{1}{inch}$$

$$\frac{\rho}{E} \frac{60^4}{3^2} = 13.9 \times 10^{-3}\ inch$$

3) **Models**



		10^{-3} inch	µm
a) Lattice	$\Delta z = \frac{1}{8} \frac{\rho}{E} \frac{a^4}{t^2} = 0.125 \frac{\rho}{E} \frac{a^4}{t^2}$	= 1.738	44.1
b) Beam	$\Delta z = \frac{5}{32} \frac{\rho}{E} \frac{a^4}{t^2} = 0.156 \frac{\rho}{E} \frac{a^4}{t^2}$	= 2.168	$\boxed{55.1}$
c) Square plate	$\Delta z = 0.289 \frac{\rho}{E} \frac{a^4}{t^2} = 0.289 \frac{\rho}{E} \frac{a^4}{t^2}$	= 4.017	$\boxed{102.0}$

4) **25-m Proposal, Vol II**

page 38: Surface plates, gravity 12 µm (Total = 61 µm)

Vol I, page III-44:

a) measured plate; a = 1.8 m (71 inch): rms $(z-\bar{z})$ = 35 µm

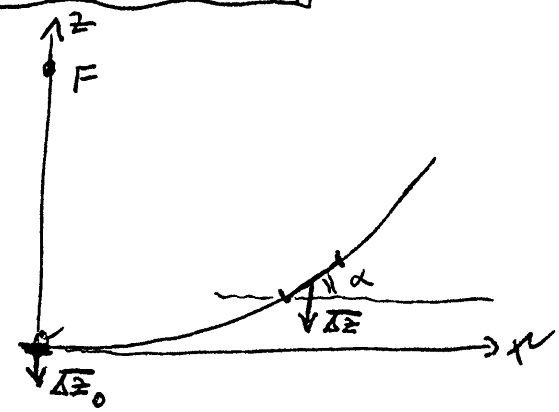
b) $\Delta z \sim a^2$ [if $\frac{a}{t}$ = const !]; a = 1.5 m (59 inch): $\boxed{= 24\ \mu m}$

c) This is the worst case. In the average, factor 0.5 = 12 µm

5) I would **prefer: 4"-ribs**

This would give rms $(z-\bar{z}) = 24\left(\frac{3}{4}\right)^2$ = 14 µm for worst case.

Plate-Average Gravit. Deform. $\overline{\Delta z}$ (2) 1-15-80



<u>parabola</u>

$$z = \frac{x^2}{4F}$$

$$z' = \frac{x}{2F} = \tan\alpha$$

<u>grav. Def.</u>

$$\overline{\Delta z} = \overline{\Delta z}_0 \cos\alpha$$

$$\cos\alpha = \frac{1}{\sqrt{1+\tan^2\alpha}}$$

	Exact	Approximation
$\overline{\Delta z}/\overline{\Delta z}_0$	$= \dfrac{1}{\sqrt{1+\left(\frac{x}{2F}\right)^2}}$	$\approx \underbrace{1-\frac{1}{2}\left(\frac{x}{2F}\right)^2}_{= \text{Parabola!}}$ Subtraction of this ↑ deformation parabola from original parabola gives again a <u>parabola</u>, with slightly smaller focal length.

<u>Worst case, at Rim:</u>

$$\frac{x}{2F} = \frac{1}{4F/D} = 0.5833$$

$$\overline{\Delta z}/\overline{\Delta z}_0 = \underbrace{0.8638 \;\Big|\; \approx 0.8299}_{\text{only 4\% difference, at worst}}$$

rms over surface
illumination taper } guess ≈ 2%. ok