PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO

SUBJECT _____

FILE _____

ESTIMATE _____

COMPUTATION SHEET

PREPARED BY _____

DATE _____

CHECKED BY _____

DATE _____

CONTAINMENT BUILDING

SALEM NUCLEAR GENERATING STATION

STRUCTURAL ANALYSIS & DESIGN

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM G.E.N. STA.

SUBJECT

FILE

ESTIMATE

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DATE

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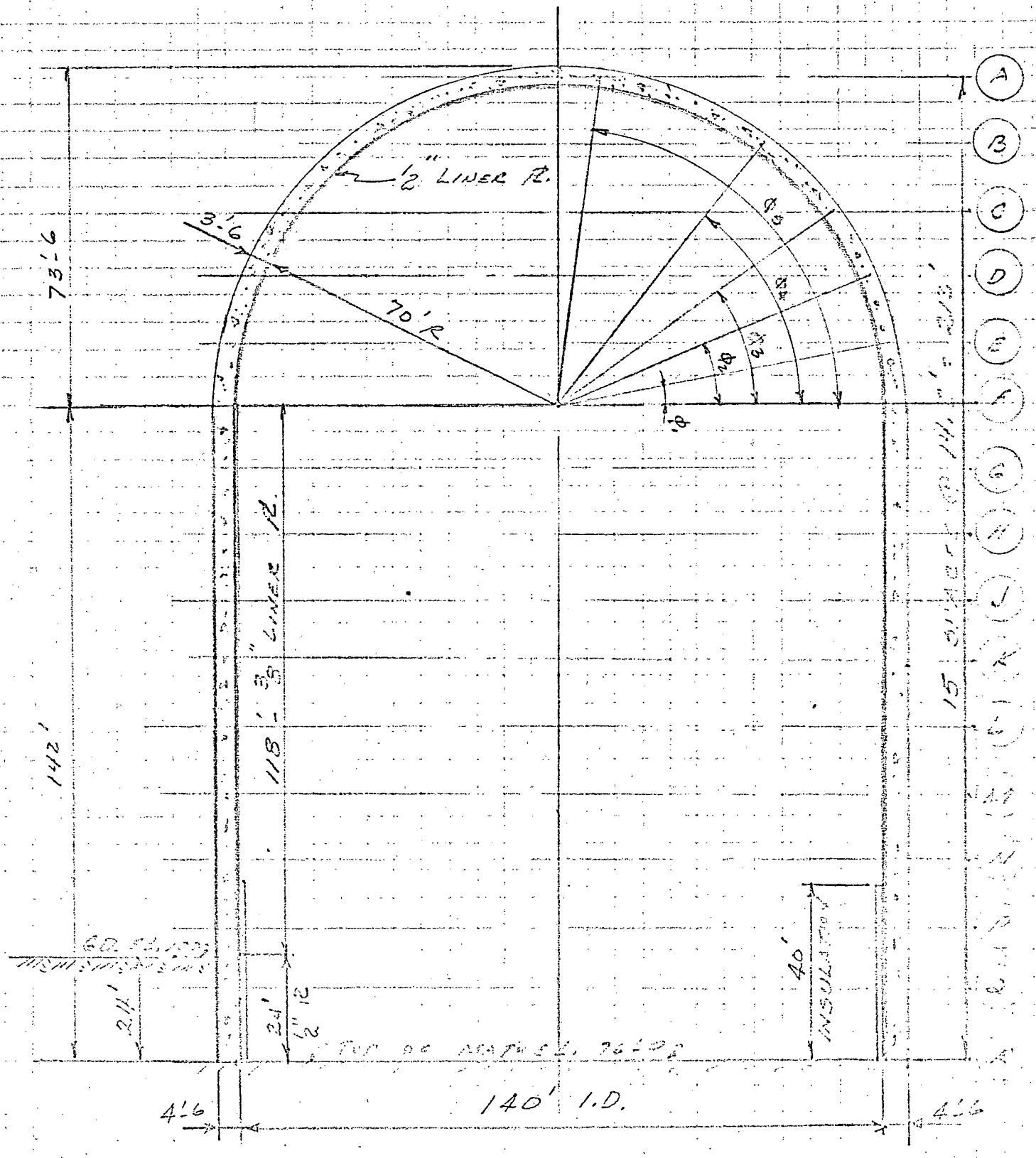
DATE



X SECTION THRU CONTAINMENT

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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CONCRETE $f_c' = 3500$ PSI, $n = 8.5$

AREA OF HOLLOW CIRCLE $= .785 (d_o^2 - d_i^2)$

Moment of Inertia of hollow circle $= .049 (d_o^4 - d_i^4)$

Rt. Circular Cylinder: $d_i = 140'$, $d_o = 149'$

Concrete area $= .785 (149^2 - 140^2) = .785 (22,201 - 19,600)$

$= .785 (2601) = 2040 ft^2$

Check: $\pi (144.5) 4.5 = 2040 ft^2$

Transformed area of $\frac{3}{8}$" R $= \frac{8.5 + 140\pi}{12} \times \frac{3}{8} = 116 ft^2$

Transformed area of $\frac{1}{2}$" R: $\frac{116 \times \frac{1}{2}}{\frac{3}{8}} = 155 ft^2$

$I_{conc.} = .049 (149^4 - 140^4) = .049 (494,000,000 - 384,000,000) =$

$5,400,000 ft^4$

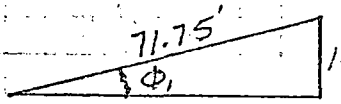
I of $\frac{3}{8}$" R = I of equiv. circle $\frac{8.5}{12} \times \frac{3}{8} = .266'$ thick

$= .049 (\overline{140.532}^4 - \overline{140}^4) = 294,000 ft^4$

I of $\frac{1}{2}$" R = I of equiv. circle $\frac{8.5}{12} \times \frac{1}{2} = .365'$ thick

$= .049 (\overline{140.73}^4 - \overline{140}^4) = 403,000 ft^4$

Hemisphere:



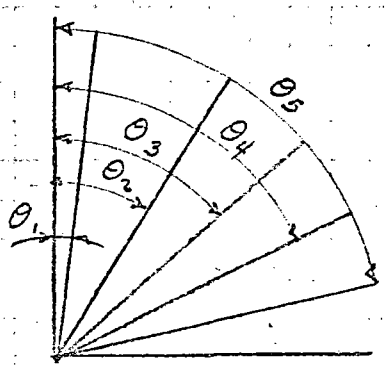
$\sin \phi_1 = 14.2/71.75 = .198$, $\phi_1 = 11°20'$

$\sin \phi_2 = 28.4/71.75 = .396$, $\phi_2 = 23°10'$

$\sin \phi_3 = 42.6/71.75 = .593$, $\phi_3 = 36°20'$

$\sin \phi_4 = 56.8/71.75 = .792$, $\phi_4 = 52°$

$\sin \phi_5 = 71/71.75 = .990$, $\phi_5 = 82°$



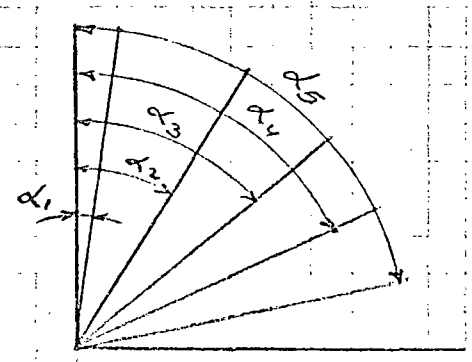
$\theta_1 = 90° - 82° = 8°$

$\theta_2 = 90° - 52° = 38°$

$\theta_3 = 90° - 36°20' = 53°40'$

$\theta_4 = 90° - 23°10' = 66°50'$

$\theta_5 = 90° - 11°20' = 78°40'$



surface area of a spherical arc $= 2\pi R^2 (\cos \alpha_1 - \cos \alpha_2$

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ESTIMATE ____ DATE ____

Spherical Arcs

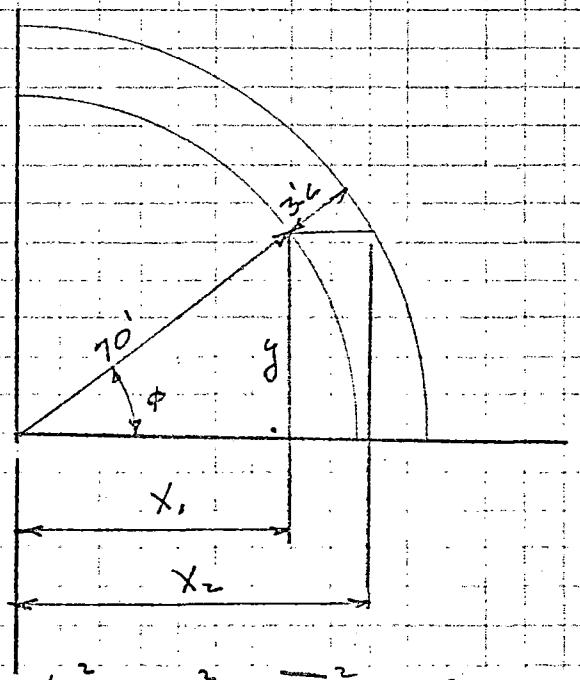
$\alpha_1 = \frac{8° + 38°}{2} = 23°$

$\alpha_2 = \frac{38° + 53°40'}{2} = 45°50'$

$\alpha_3 = \frac{53°40' + 66°50'}{2} = 60°15'$

$\alpha_4 = \frac{66°50' + 78°40'}{2} = 72°45'$

$\alpha_5 = \frac{78°40' + 90°}{2} = 84°20'$



φ	sin φ	× 70 =	y
φ1	.198	× 70 =	13.9
φ2	.396	× 70 =	27.
φ3	.593	× 70 =	41.4
φ4	.792	× 70 =	55.
φ5	.990	× 70 =	69.

① $X_1^2 + y^2 = \overline{70}^2 = 4900$

② $X_2^2 + y^2 = \overline{73.5}^2 = 5402$

$y = 13.8$: $X_1^2 = 4900 - 191 = 4709$, $X_1 = 68.5$ } $\Delta = 3.5$

$X_2^2 = 5402 - 191 = 5201$, $X_2 = 72.0$ }

$y = 27.7$: $X_1^2 = 4900 - 765 = 4135$, $X_1 = 64.3$ } $\Delta = 3.7$

$X_2^2 = 5402 - 765 = 4637$, $X_2 = 68.0$ }

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$y = 41.4$: $X_1^2 = 4900 - 1720 = 3180$, $X_1 = 56.2$ } $\Delta = 4.4$

$X_2^2 = 5402 - 1720 = 3682$, $X_2 = 60.6$ }

$y = 55.3$: $X_1^2 = 4900 - 3055 = 1845$, $X_1 = 42.8$ } $\Delta = 5.4$

$X_2^2 = 5402 - 3055 = 2347$, $X_2 = 48.2$ }

$y = 69.2$: $X_1^2 = 4900 - 4800 = 100$, $X_1 = 10$ } $\Delta = 14.5$

$X_2^2 = 5402 - 4800 = 602$, $X_2 = 24.5$ }

SECT.	Conc. Surface A X .15 h = Conc. WT. K	St. R. A" X F/A' = St. wt
A	$2\pi \overline{71.75}^2 (1.00 - .920) .15(3.5)$	1350	2460 x 20.4	50
B	$2\pi \overline{71.75}^2 (.92 - .697) .15(3.5)$	3780	6850 x 20.4	140
C	$2\pi \overline{71.75}^2 (.697 - .48) .15(3.5)$	3670	6660 x 20.4	136
D	$2\pi \overline{71.75}^2 (.48 - .296) .15(3.5)$	3120	5660 x 20.4	115
E	$2\pi (\overline{71.75})^2 (.296 - .099) .15(3.5)$	3340	6050 x 20.4	123
F	$2\pi \overline{71.75}^2 (.099) .15(3.5) =$	1680	3060 x 20.4	63
	$+ 2040 \times 7.1 \times .15$	2175	+ 3120 x 15.3	48
G	$2040 \times 14.2 \times .15$	4350	6240 x 15.3	96
H	do	4350	do	96
J	do	4350	do	96
K	do	4350	do	96
L	do	4350	do	96
M	do	4350	do	96
N	do	4350	do	96
P	do	4350	do	96
Q	do	4350	* 6240 x 20.4	127
R	$2040 \times 7.1 \times .15$	2150	* 3120 x 20.4	64

Example: Surface Area of spherical $\frac{1}{2}$ "R: $2\pi (70)^2 (\cos\theta_1 - \cos\theta_2)$

Surface Area of Cylindrical "R = $140\pi \times h$

* $\frac{1}{2}$" R.

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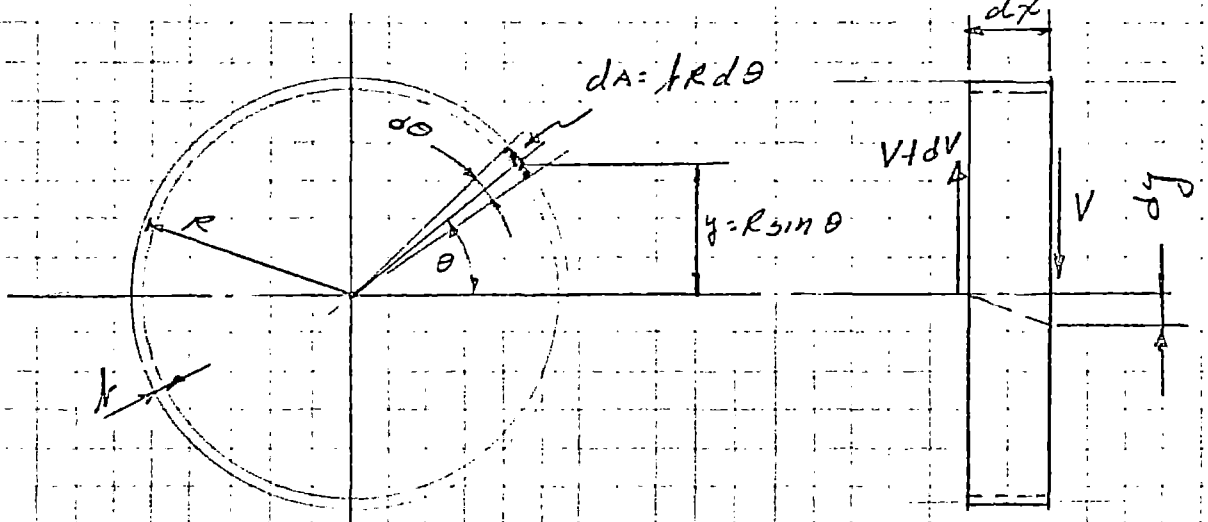
Sect.	X SECT. AREA CONC. - Ft²	Transf. Area R - Ft²	I CONC. Ft⁴	I R Ft⁴
A	$.785(\overline{49.0}^2-\overline{20.0}^2)=1565$	$\frac{8.5\times20\pi}{12\times2}=22$	$.049(\overline{49}^4-\overline{20}^4)=$ $=2,760,000$	$.049(\overline{20.706}^4-\overline{20}^4)$ $=1,150$
B	$.785(\overline{96.4}^2-\overline{85.6}^2)=1470$	$\frac{8.5\times85.6\pi}{12\times2}=95$	$.049(\overline{96.4}^4-\overline{85.6}^4)$ $=1,600,000$	$.049(\overline{86.306}^4-\overline{85.}^4)$ $=87,500$
C	$.785(\overline{121.2}^2-\overline{112.4}^2)=1610$	$\frac{8.5\times112.4\pi}{12\times2}=125$	$.049(\overline{121.2}^4-\overline{112.4}^4)$ $=2,690,000$	$.049(\overline{113.106}^4-\overline{112.4}^4)$ $=197,000$
D	$.785(\overline{136.0}^2-\overline{128.6}^2)=1565$	$\frac{8.5\times128.6\pi}{12\times2}=142$	$.049(\overline{136}^4-\overline{128.6}^4)$ $=3,360,000$	$.049(\overline{129.3}^4-\overline{128.6}^4)$ $=294,000$
E	$.785(\overline{144}^2-\overline{137}^2)=1500$	$\frac{8.5\times137\pi}{12\times2}=152$	$.049(\overline{144}^4-\overline{137}^4)$ $=3,810,000$	$.049(\overline{137.7}^4-\overline{137}^4)$ $=344,000$
F	2040	$\frac{8.5\times140\pi}{12\times2}=155$	5,400,000	$.049(\overline{140.}^4-\overline{140}^4)$ $=380,000$
G	do	$\phi\ 38''R=116$	5,400,000	294,000
H	do	116	5,400,000	294,000
J	do	116	5,400,000	294,000
K	do	116	5,400,000	294,000
L	do	116	5,400,000	294,000
M	do	116	5,400,000	294,000
N	do	116	5,400,000	294,000
P	do	116	5,400,000	294,000
Q	do	155	5,400,000	403,000
R	do	155	5,400,000	403,000

Determination of Shear Deflection Constant For a Beam of Thin Annular Cross Section



$$\frac{dy}{dx}=\varepsilon_s,\quad \frac{s_s}{\varepsilon_s}=G,\quad s_s=G\varepsilon_s=G\frac{dy}{dx}=\frac{KV}{A}$$

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$$\frac{KV}{A} = \frac{VQ}{Ib} \quad \text{where } b = 2h \quad \therefore \frac{K}{A} = \frac{Q}{Ib}$$

$$Q = 2\int_0^{\frac{\pi}{2}} h\,R\,d\theta\,(R\sin\theta) = \left[-2hR^2\cos\theta\right]_0^{\frac{\pi}{2}} = 2hR^2$$

$$I = 4\int_0^{\frac{\pi}{2}} h\,R\,d\theta\,(R\sin\theta)^2 = \left[4hR^3\left(\frac{\theta}{2} - \frac{\sin 2\theta}{4}\right)\right]_0^{\frac{\pi}{2}}$$

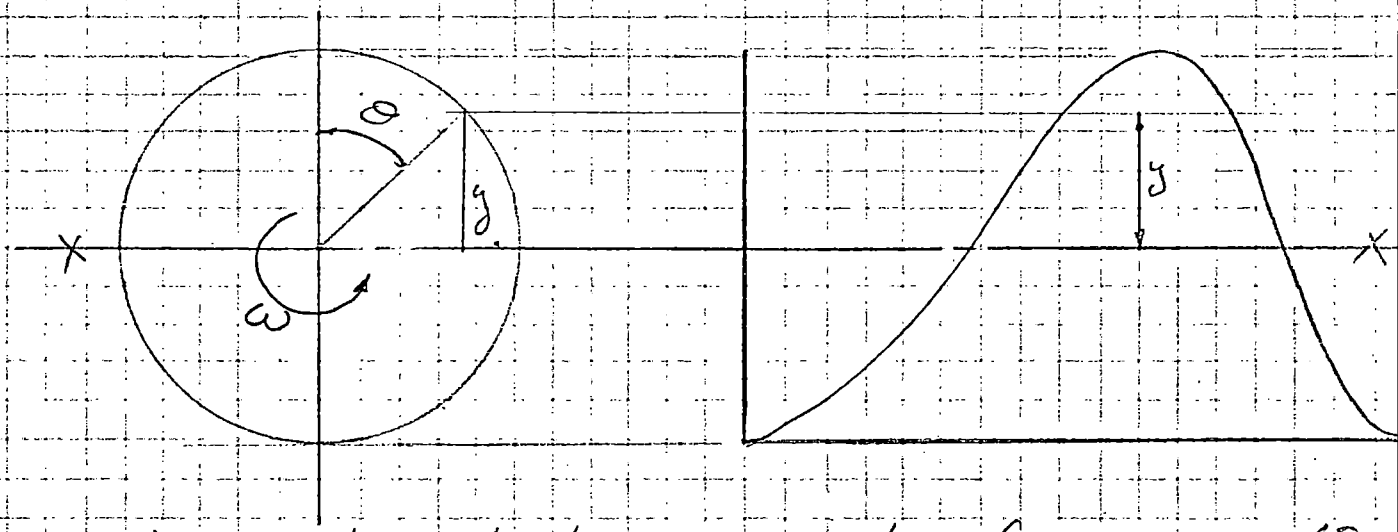
$$= \pi hR^3$$

$$A = 2\pi Rh$$

$$\therefore K = \frac{QA}{Ib} = \frac{2hR^2 \cdot 2\pi Rh}{\pi hR^3 \cdot 2h} = 2$$

$$\therefore \Delta = 2\frac{VL}{AG}$$

Rayleigh's Method Of Obtaining Natural Frequency



ω = angular velocity or circular frequency = $\frac{d\theta}{dt}$

2π radians = 1 cycle

f = cyclic frequency = $\frac{\omega}{2\pi}$

T = period = $\frac{1}{f}$

Rotational Kinetic Energy = $\frac{1}{2} MR^2\omega^2$

With respect to line x-x, K.E. = $\frac{1}{2} m y^2 \omega^2$

$= \frac{1}{2}\frac{W}{g} y^2 \omega^2$

Potential Energy = $\frac{1}{2} Wy$

Considering many masses involved: $\Sigma P.E. = \Sigma K.E.$

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ESTIMATE _____ DATE _____

$$\frac{1}{2}W_1 y_1 + \frac{1}{2}W_2 y_2 + \cdots \frac{1}{2}W_n y_n = \frac{1}{2}\frac{W_1}{g} y_1^2 \omega^2 + \frac{1}{2}\frac{W_2}{g} y_2^2 \omega^2 + \cdots \frac{1}{2}\frac{W_n}{g} y_n^2$$

$$\omega^2 = g \frac{[W_1 y_1 + W_2 y_2 + \cdots W_n y_n]}{[W_1 y_1^2 + W_2 y_2^2 + \cdots W_n y_n^2]}$$

If $W_1 = g\,dm_1$, $W_2 = g\,dm_2$ etc.

* y = max. deflection due to both moment and shear caused by lateral forces

If $\phi_1 = \frac{y_1}{y_1}$; $\phi_2 = \frac{y_2}{y_1}$; $\phi_n = \frac{y_n}{y_1}$

Then $\omega^2 = g \frac{[g\,dm_1 \phi_1 y_1 + g\,dm_2 \phi_2 y_1 + \cdots g\,dm_n \phi_n y_1]}{[g\,dm_1 \phi_1^2 y_1^2 + g\,dm_2 \phi_2^2 y_1^2 + \cdots g\,dm_n \phi_n^2 y_1^2]}$

$$\omega^2 = \frac{g\,y_1}{y_1^2} \frac{[dm_1 \phi_1 + dm_2 \phi_2 + \cdots dm_n \phi_n]}{[dm_1 \phi_1^2 + dm_2 \phi_2^2 + \cdots dm_n \phi_n^2]}$$

$$= \frac{g}{y_1} \frac{[\Sigma \phi\, dm]}{[\Sigma \phi^2 dm]}$$

$$T = \frac{2\pi}{\omega} = 2\pi \left[\frac{y_1 \Sigma \phi^2 dm}{g \Sigma \phi\, dm}\right]^{\frac{1}{2}}$$

* NOTE: FOR VERTICAL EARTHQUAKE FORCES

$$y = \frac{WL}{AE}$$

CALCULATIONS FOR TABLE (Pg 8) ARE SHOWN STARTING ON Pg. 9, FOR HORIZONTAL PERIOD T

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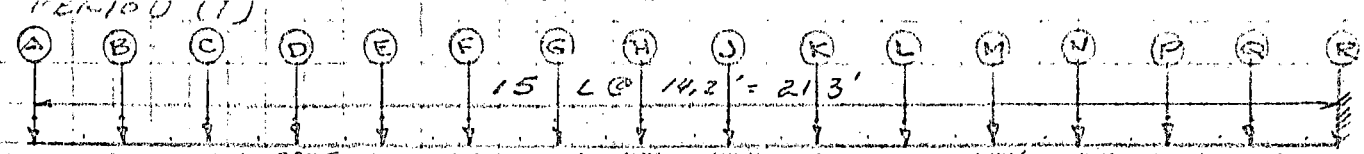
Pg 8

HORIZONTAL PERIOD (T)



$E = 3.4 \times 10^{}$
$G = 1.4 \times 10^{}$
$L = 14.2'$

	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	FACTOR	UNITS
Equiv. Bm. Ld.	1400	3920	3806	3235	3423	3966	4446	4446	4446	4446	4446	4446	4446	4446	4477	2214	$\times 10^{3}$	LBS
Bm shear (V)	14	53.2	91.3	123.6	158.2	197.9	242.4	286.8	331.3	375.7	420.2	464.7	509.1	553.6	598.4	620.5	$\times 10^{5}$	LBS
"X" sect. (A)	22.8	22.4	24.9	24.5	24.8	(31/31)	31	31	31	31	31	31	31	31	31.5	31.5	$\times 10^{4}$	IN^2
Avg. Area (A_o)		22.6	23.6	24.7	24.7	28.2	31	31	31	31	31	31	31	31	31.2	31.5	$\times 10^{4}$	IN^2
Incr. of shear		.15	.55	.89	1.25	1.37	1.56	1.91	2.26	2.60	2.92	3.32	3.65	4.0	4.32	4.65	$\times 10^{-2}$	IN
Defl. $= \frac{2VL}{A_o G}$																		
Shear defl. (Δ_v)	35.4	35.2	34.7	33.8	32.6	31.2	29.6	27.7	25.5	22.9	19.9	16.6	13.0	8.97	4.65	0	$\times 10^{-2}$	IN
I	5.72	3.5	5.97	7.55	8.6	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	12.0	12.0	$\times 10^{10}$	IN^4
Bm. Mom (M)	0	2.38	11.48	27.06	48.26	75.36	109.4	150.9	200.1	256.8	321.1	393	472.5	559.5	654.3	756.3	$\times 10^{8}$	IN^2
M/EI	0	.2	.565	1.05	1.65	1.86	2.74	3.75	4.95	6.36	7.93	9.7	11.65	13.8	16.0	18.5	$\times 10^{-8}$	$\frac{1}{IN}$
M/EI Diag.																		
Conj. Bm. Ld.	1057	.389	.997	1.822	2.694	3.331	4.636	6.872	8.130	10.64	13.42	16.47	19.81	23.36	27.23	15.03	$\times 10^{-6}$	—
Conj Bm (V)	154.7	154.3	153.3	151.5	148.8	145.5	140.9	134.0	126.0	115.3	101.9	85.5	65.6	42.3	15.0		$\times 10^{-6}$	—
Conj. Bm. M $= \Delta_M$	29.6	26.9	24.3	21.7	19.1	16.6	14.1	11.7	9.4	7.3	5.3	3.6	2.1	1.0	.3	0	$\times 10^{-2}$	IN
$\Delta M + \Delta V = Y_{1/2}$	65.0	62.1	59.0	55.5	51.7	47.7	43.7	39.4	34.9	30.2	25.2	20.2	15.1	10.0	5.0	0	$\times 10^{-2}$	IN
ϕ	1.0	.95	.90	.85	.79	.73	.66	.59	.53	.45	.38	.30	.22	.15	.07	0		
ϕdm	1400	3720	3420	2740	2740	2660	2940	2630	2360	2000	1690	1330	980	665	310	0	$\times 10^{3}$	
$\phi^2 dm$	1400	3520	3080	2320	2160	2100	1940	1550	1250	900	642	400	215	100	22	0	$\times 10^{3}$	

$\Sigma \phi dm = 31,605$

$\Sigma \phi^2 dm = 21599$

$$T_{(PERIOD)} = 2\pi \left[g' \frac{\Sigma \phi^2 dm}{g \Sigma \phi dm} \right]^{\frac{1}{2}}$$

$$= 2\pi \left[\frac{.678\,(21599)}{386\,(31605} \right]^{\frac{1}{2}}$$

$$= 2\pi \left[.001185 \right]^{\frac{1}{2}} = 2\pi\,(.0344) = .216 \text{ SEC.}$$

85-2068 (EG 65) 30M 7-67

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SAMPLE CALCULATIONS:

EQUIV. Bm LD. = $q\,dm$: @ SECT. A = $1350^K + 50^K = 1400^K$

Bm Shear (V) :

A-B	$= 1400^K$
B-C	$= 1400 + 3920 = 5320^K$
C-D	$= 5320 + 3806 = 9126$
D-E	$= 9126 + 3235 = 12361$
E-F	$= 12361 + 3463 = 15824$
F-G	$= 15824 + 3966 = 19790$
G-H	$= 19790 + 4446 = 24236$
H-J	$= 24236 + 4446 = 28682$
J-K	$= 28682 + 4446 = 33128$
K-L	$= 33,128 + 4446 = 37,574$
L-M	$= 37,574 + 4446 = 42020$
M-N	$= 42020 + 4446 = 46,466$
N-P	$= 46,466 + 4446 = 50,912$
P-Q	$= 50,912 + 4446 = 55358$
Q-R	$= 55,358 + 4477 = 59835$
R-O	$= 59,835 + 2214 = 62,049$

CROSS SECTIONAL AREA: @ G-P

$144\,(2040\,ft^2 + 116\,ft^2) = 2156 \times 144 = 310,000\,in^2$

Avg. Area = A_o : Sect. A-B : $\frac{(22.8 + 22.4)}{2} 10^4 = 22.6 \times 10^4\,in^4$

Increment of Shear defl. = $\frac{2VL}{A_o G}$:

Sect. A-B : $\frac{2 \times 14 \times 14.2 \times 12}{22.6 \times 1.4} \times \frac{10^5}{10^4 \times 10^6} = .15 \times$

Shear deflection : Δ_v : @ SECT. P

$10^{-2}(4.65 + 4.32) = 8.97 \times 10^{-2}$

Moment of Inertia I:

@ SECT. H:

$I = (5,400,000 + 294,500)\,12^4 = 11.9 \times 10^{10}\,in^4$

Bm Mom: @ SECT C:

$10^5 (14 \times 14.2 \times 12 \times 2 + 39.2 \times 14.2 \times 12) = 11.48 \times 10^8\,in\,\#$

$\frac{M}{EI}$: @ SECT. D: $\frac{27,08 \times 10^8}{3.4 \times 10^6 \times 7.55 \times 10^{10}} = 1.05 \times 10^{-8}$

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FILE ____ CHECKED BY A.J.

ESTIMATE ____ DATE ____

CONS BM. LOADS

SECTION:

A: $\frac{1}{3} \times .2 \times 14.2 \times 12 \times 10^{-8} \times \frac{1}{2} = .057 \times 10^{-6}$

B: $\frac{2}{3} \times .2 \times 14.2 \times 12 \times 10^{-8} \times \frac{1}{2} = .114 \times 10^{-6}$

$1 \times .2 \times 7.1 \times 12 \times 10^{-8} = .171 \times 10^{-6}$

$\frac{1}{3} \times \frac{1}{2}(.565 - .2) 14.2 \times 12 \times 10^{-8} = .104 \times 10^{-6}$

$.389 \times 10^{-6}$

C:

$.171 \times 10^{-6}$

$.208 \times 10^{-6}$

$\frac{1}{3} \times \frac{1}{2}(1.05 - .565) 14.2 \times 12 \times 10^{-8} = .138 \times 10^{-6}$

$1 \times .565 \times 7.1 \times 12 \times 10^{-8} = .480 \times 10^{-6}$

$.997 \times 10^{-6}$

D:

$.480 \times 10^{-6}$

$.276$

$1 \times 1.05 \times 7.1 \times 12 \times 10^{-8} = .895$

$\frac{1}{3} \times \frac{1}{2}(1.65 - 1.05) 14.2 \times 12 \times 10^{-8} = .171$

1.822×10^{-6}

E:

$.895 \times 10^{-6}$

$.342$

$1 \times 1.65 \times 7.1 \times 12 \times 10^{-8} = 1.400$

$\frac{1}{3} \times \frac{1}{2}(1.86 - 1.65) 14.2 \times 12 \times 10^{-8} = .057$

2.694×10^{-6}

F:

1.400×10^{-6}

$.113$

$1 \times 1.86 \times 7.1 \times 12 \times 10^{-8} = 1.580$

$\frac{1}{3} \times \frac{1}{2}(2.74 - 1.86) 14.2 \times 12 \times 10^{-8} = .238$

3.331×10^{-6}

G:

1.58×10^{-6}

$.476$

$1 \times 2.74 \times 7.1 \times 12 \times 10^{-8} = 2.290$

$\frac{1}{3} \times \frac{1}{2}(3.75 - 2.74) 14.2 \times 12 \times 10^{-8} = .290$

4.636×10^{-6}

H:

2.290×10^{-6}

$.58$

$1 \times 3.75 \times 7.1 \times 12 \times 10^{-8} = 3.16$

$\frac{1}{3} \times \frac{1}{2}(4.95 - 3.75) 14.2 \times 12 \times 10^{-8} = .842$

6.872×10^{-6}

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

SECTION I

J:

$1 \times 4.95 \times 7.1 \times 12 \times 10^{-8} = 4.170$

$1\frac{1}{2}(6.36 - 4.95) 14.2 \times 12 \times 10^{-8} = .115$

3.16×10^{-6}
$.685$
4.170
$.115$
8.130×10^{-6}

K:

$1 \times 6.36 \times 7.1 \times 12 \times 10^{-8} = 5.26$

$1\frac{1}{2}(7.93 - 6.36) 14.2 \times 12 \times 10^{-8} = .478$

4.170×10^{-6}
$.730$
5.26
$.478$
10.638×10^{-6}

L:

$1 \times 7.93 \times 7.1 \times 12 \times 10^{-8} = 6.70$

$1\frac{1}{2}(9.70 - 7.93) 14.2 \times 12 \times 10^{-8} = .505$

5.26×10^{-6}
$.955$
6.70
$.505$
13.42×10^{-6}

M:

$1 \times 9.70 \times 7.1 \times 12 \times 10^{-8} = 8.20$

$1\frac{1}{2}(11.65 - 9.70) 14.2 \times 12 \times 10^{-8} = .56$

6.70×10^{-6}
1.01
8.20
$.56$
16.47×10^{-6}

N:

$1 \times 11.65 \times 7.1 \times 12 \times 10^{-8} = 9.90$

$1\frac{1}{2}(13.8 - 11.65) 14.2 \times 12 \times 10^{-8} = .60$

8.20×10^{-6}
1.11
9.90
$.60$
19.81×10^{-6}

P:

$1 \times 13.8 \times 7.1 \times 12 \times 10^{-8} = 11.60$

$1\frac{1}{2}(16.0 - 13.8) 14.2 \times 12 \times 10^{-8} = .655$

9.90×10^{-6}
1.20
11.60
$.655$
23.355×10^{-6}

Q:

$1 \times 16 \times 7.1 \times 12 \times 10^{-8} = 13.60$

$1\frac{1}{2}(18.5 - 16.0) 14.2 \times 12 \times 10^{-8} = .715$

11.60×10^{-6}
1.31
13.60
$.715$
27.225×10^{-6}

R:

13.60×10^{-6}
1.43
15.03×10^{-6}

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

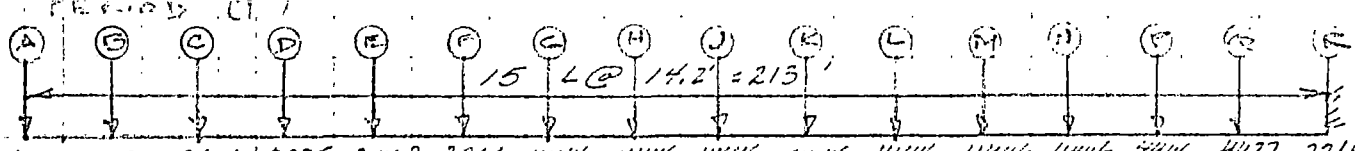
REFER TO SALEM GEN. STA. PREPARED BY 1.G DATE

SUBJECT VERTICAL PERIOD (T) COMPUTATION SHEET CHECKED BY A.J. DATE

FILE ESTIMATE

pg. 13

VERTICAL PERIOD (T)



$E = 3.4 \times 10^6$

$G = 1.4 \times 10^6$

	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	T	FACTOR	UNITS
W	1400	3920	3806	3235	3423	3966	4446	4446	4446	4446	4446	4446	4446	4446	4477	2214	$\times 10^3$	LBS
ΣW	14	53.2	91.3	123.6	158.2	197.9	242.4	286.8	331.3	375.7	420.2	464.7	509.1	553.6	598.4	620.6	$\times 10^5$	LBS
A_o	22.6	23.6	24.7	24.7	28.2	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.0	31.2	31.5		$\times 10^4$	IN^2
L	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171			IN
Incr. of Axial defl. = WL/AE	3.1	11.4	18.6	25.2	28.2	31.9	39.5	46.2	53.6	60.5	68.0	75.0	82.5	89.5	97		$\times 10^{-4}$	IN
$\Sigma \Delta$	7.29	7.26	7.15	6.96	6.71	6.43	6.11	5.71	5.25	4.71	4.11	3.43	2.68	1.86	.97	0	$\times 10^{-2}$	IN
ϕ	1.0	.995	.98	.94	.92	.88	.83	.78	.72	.65	.56	.47	.37	.25	.13	0		
ϕdm	1400	3900	3740	3320	3480	3470	3680	3460	3210	2900	2490	2090	1650	1100	590	0		
$\phi^2 dm$	1400	3880	3680	3150	2920	3060	3050	2700	2310	1880	1390	965	610	274	77	0		

$\Sigma \phi dm = 40,180$

$\Sigma \phi^2 dm = 31366$

$$T = 2\pi \left[\frac{.0729\,(31,366)}{386\,(40,180)} \right]^{\frac{1}{2}} = 2\pi [.000147]^{\frac{1}{2}}$$

$$= 2\pi\,[.0122] = .0765 \text{ SEC}$$

95-2006 (EG 651) 30M- 7-67

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT ROCKING PERIOD (T) COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

$$I_{2-2} = \frac{44,414 \times 10^3}{2g}\left(\overline{72}^2 + \frac{\overline{142}^2}{6}\right)$$

$$= \frac{44,414 \times 10^3}{2g}(5184 + 3370) = \frac{44,414 \times 10^3}{2g}(8554)$$

$$= \frac{190,000,000 \times 10^3}{g}$$

$$I_{3-3} = \frac{42,200 \times 10^3}{12g}\left(3 \times \overline{75}^2 + \overline{16}^2\right)$$

$$= \frac{42,200 \times 10^3}{12g}(16,800 + 256) = \frac{42200 \times 10^3}{12g}(17,056)$$

$$= \frac{60,000,000 \times 10^3}{g}$$

$$I_{4-4} = -\frac{43,700 \times 10^3}{12g}\left(3 \times \overline{75}^2 + 40^2\right)$$

$$= -\frac{3640 \times 10^3}{g}(\overbrace{16,800 + 1600}^{18,400}) = -\frac{67,000,000 \times 10^3}{g}$$

$$I_{C.G.} = \frac{38,000,000 \times 10^3}{g} + \frac{17,567 \times 10^3}{g} \times \overline{82.5}^2$$

$$+ \frac{190,000,000 \times 10^3}{g} + \frac{44,414 \times 10^3}{g} \times \overline{24.5}^2$$

$$+ \frac{60,000,000 \times 10^3}{g} + \frac{42,200 \times 10^3}{g} \times \overline{103.5}^2$$

$$- \frac{67,000,000 \times 10^3}{g} - \frac{43,700 \times 10^3}{g} \times \overline{91.5}^2$$

$$= (38,000,000 + 120,000,000 + 190,000,000 + 26,700,000 + 60,000,000 + 455,000,000 - 67,000,000 - 367,000,000)\frac{10^3}{g}$$

$$= \frac{455,700,000 \times 10^3}{g}$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN STA
SUBJECT ROCKING PERIOD (T) COMPUTATION SHEET
FILE
ESTIMATE

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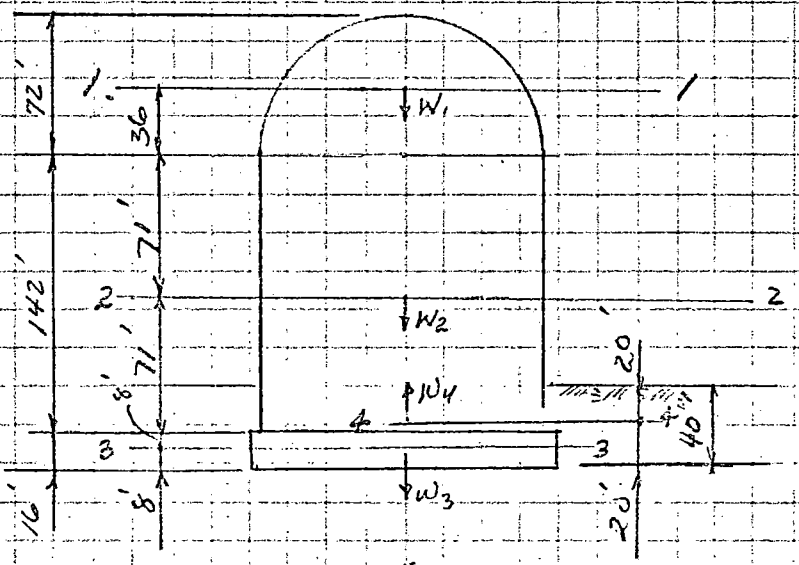

W_1 (see pg. 4) $= 1400 + 3920 + 3806 + 3235 + 3463 + 1743$ K
$= 17567$ K

W_2 (see pg. 4) $= 8 \times 446 + 2223 + 4477 + 2214 = 44,414$ K

$W_3 = \pi \overline{75}^2 \times 16 \times 150 = 42,200$ K

$W_4 = -(\pi \overline{75}^2 \times 16 \times 62.5 + \pi \overline{74.5}^2 \times 24 \times 62.5)$

$= -(17,600 + 26,100) = -43,700$ K

$$C.G. = \frac{17,567 \times 194 + 44,414 \times 87 + 42,200 \times 8 - 43,700 \times 20}{17,567 + 44,414 + 42,200 - 43,700}$$

$$= \frac{3,410,000 + 3,860,000 + 338,000 - 875,000}{60,481}$$

$$= \frac{6,733,000}{60,481} = 111.5'$$

MASS MOMENT OF INERTIA

$$I_{1-1} = \frac{17,567 \times 10^3}{g} \times \frac{5}{12} (72)^2 = \frac{38,009,000 \times 10^3}{g}$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA.
SUBJECT ROCKING PERIOD (T) COMPUTATION SHEET
FILE
ESTIMATE

PREPARED BY J.G.
DATE
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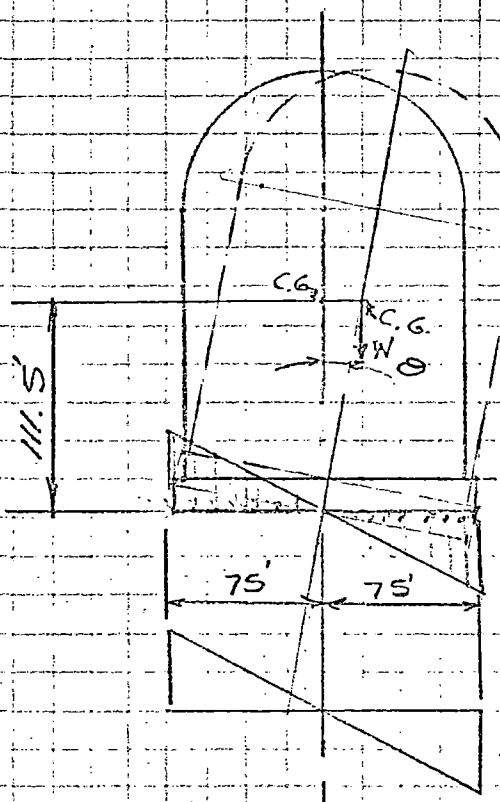
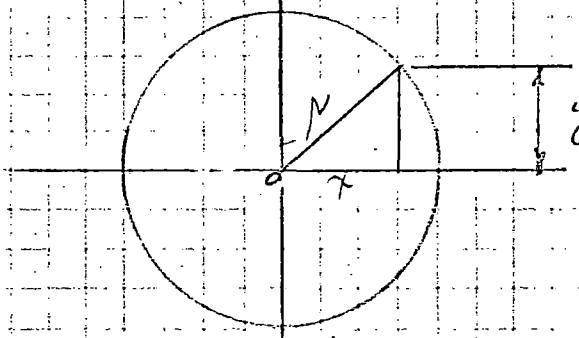


Overturning Couple:
$W \times 111.5 \sin\theta$
$= 60,481 \times 10^3 \times 111.5 \sin\theta$
$= 6,750,000 \times 10^3\ \theta$

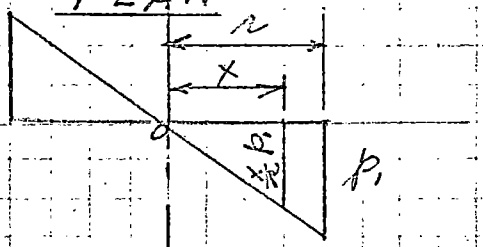
Restoring Couple Of subgrade reaction:

Let p_o = subgrade modulus in #/ft^2 needed to cause a depression of 1 ft.

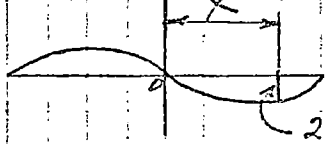
Subgrade pressure at any point = $p_o y$
$= p_o \rho\theta$
where ρ = radius to point



PLAN



PRESSURE



$2\frac{x}{r} p_1 \sqrt{r^2-x^2}$

FORCES

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY LG

SUBJECT ROCKING PERIOD (T) COMPUTATION SHEET DATE

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ESTIMATE DATE

Total force each side of pt. 0:

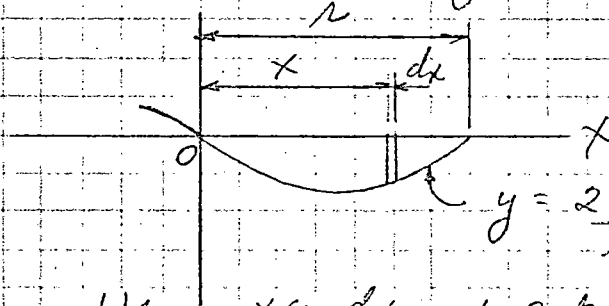
$$F = \int_0^r \frac{2p_1}{r} x\sqrt{r^2-x^2}\,dx$$

$$= \left[\frac{2p_1}{r}\left(-\frac{1}{3}\sqrt{(r^2-x^2)^3}\right)\right]_0^r$$

$$= \left[\frac{-2p_1}{3r}\sqrt{(r^2-r^2)^3}\right] - \left[-\frac{2}{3}\frac{p_1}{r}\sqrt{r^6}\right]$$

$$= \frac{2}{3}p_1 r^2$$

Finding C.G. of subgrade reactive forces:



$$dM_y = xy\,dx = x\cdot\frac{2p_1}{r}x\sqrt{r^2-x^2}\,dx$$

$$M_y = \int_0^r \frac{2p_1}{r}x^2\sqrt{r^2-x^2}\,dx$$

$$= \frac{2p_1}{r}\left[\frac{-x}{4}\sqrt{(r^2-x^2)^3} + \frac{r^2}{8}\left(x\sqrt{r^2-x^2} + r^2\sin^{-1}\frac{x}{r}\right)\right]_0^r$$

$$= \frac{2p_1}{r}\left[0 + \frac{r^2}{8}\left(0 + r^2\sin^{-1}1\right)\right] - \frac{2p_1}{r}[0+0+0]$$

$$= \frac{2p_1}{r}\cdot\frac{r^4}{8}\cdot\frac{\pi}{2} = \frac{\pi p_1 r^3}{8}$$

$$\bar{X} = \frac{M_y}{A} = \frac{\pi p_1 r^3}{8\times\frac{2}{3}p_1 r^2} = \frac{3\pi r}{16}$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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SUBJECT ROCKING PERIOD (T) COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

Restoring Couple of subgrade reaction:

$$\frac{2}{3} p_1 r^2 \cdot 2 \cdot \frac{3\pi r}{16} = \frac{\pi p_1 r^3}{4}$$

but $p_1 = p_o r \theta$

$$\therefore \text{Restoring Couple} = \frac{\pi p_o r^4 \theta}{4}$$

$$I\ddot{\theta} + \left(\frac{\pi p_o r^4}{4} - 6{,}750{,}000 \times 10^3\right)\theta = 0$$

$$I = \frac{455{,}700{,}000 \times 10^3}{g} \; ; \; r = 75',$$

Note: Containment mat is supported by 30' of lean concrete fill which in turn is supported by deep layer of cementatious type soil.

$\therefore p_o$ estimated at 700 #/in² /in of settlement

12 × 700 = 8400 #/in² gives a deflection of 1'

8400 × 144 = 1,210,000 #/ft² = p_o

$$\frac{455{,}700{,}000 \times 10^3}{32.2}\ddot{\theta} + \left(\frac{1{,}210{,}000\,\pi\, 75^4}{4} - 6{,}750{,}000 \times 10^3\right)\theta$$

$$14{,}150{,}000 \times 10^3 \ddot{\theta} + 30{,}000{,}000{,}000 \times 10^3 \theta = 0$$

$$\ddot{\theta} + 21200\theta = 0$$

$$T = 2\pi \sqrt{\frac{1}{2120}} = 2\pi \sqrt{.000047} = 2\pi(.0216)$$

$$= .136 \text{ SEC.}$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY J.G.

SUBJECT ROCKING PERIOD (T) COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

Restoring Couple of subgrade reaction:

$$\frac{2}{3} p_1 r^2 \cdot 2 \cdot \frac{3\pi r}{16} = \frac{\pi p_1 r^3}{4}$$

but $p_1 = p_0 r \theta$

$$\therefore \text{Restoring Couple} = \frac{\pi p_0 r^4 \theta}{4}$$

$$I\ddot{\theta} + \left(\frac{\pi p_0 r^4}{4} - 6{,}750{,}000 \times 10^3\right)\theta = 0$$

$$I = \frac{455{,}700{,}000 \times 10^3}{g}\ ;\ r = 75',$$

Note: Containment mat is supported by 30' of lean concrete fill which in turn is supported by deep layer of cementatious type soil.

$\therefore p_0$ estimated at 700 #/in² /in of settlement

12 × 700 = 8400 #/in² gives a deflection of 1'

8400 × 144 = 1,210,000 #/ft² = p_0

$$\frac{455{,}700{,}000 \times 10^3}{32.2}\ddot{\theta} + \left(\frac{1{,}210{,}000\,\pi\, 75^4}{4} - 6{,}750{,}000 \times 10^3\right)\theta$$

$$14{,}150{,}000 \times 10^3\ddot{\theta} + 30{,}000{,}000{,}000 \times 10^3\theta = 0$$

$$\ddot{\theta} + 21200\theta = 0$$

$$T = 2\pi\sqrt{\frac{1}{21200}} = 2\pi\sqrt{.000047} = 2\pi(.0216)$$

$$= .136 \text{ SEC.}$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA — PREPARED BY I.G.

SUBJECT E.Q. RESPONSE — COMPUTATION SHEET — DATE

FILE SPECTRUM — CHECKED BY A.J.

ESTIMATE — DATE

	.08g RESPONSE					.17g RESPONSE				
	0%	½%	1%	2%	5%	0%	½%	1%	2%	5%
T	g	g	g	g	g	g	g	g	g	g
.015	.08	.08	.08	.08	.08	.17	.17	.17	.17	.17
.02	.0815	.08	.08	.08	.08	.173	.17	.17	.17	.17
.03	.0928	.0865	.0833	.08	.08	.197	.183	.176	.17	.17
.04	.110	.099	.0928	.0833	.08	.235	.210	.197	.176	.17
.05	.136	.114	.101	.085	.08	.289	.242	.214	.180	.17
.06	.160	.136	.112	.0945	.08	.340	.288	.238	.200	.170
.07	.200	.152	.126	.098	.0815	.422	.322	.269	.207	.174
.08	.248	.176	.136	.104	.0833	.525	.374	.288	.221	.176
.09	.288	.192	.146	.112	.085	.610	.407	.310	.238	.180
.10	.320	.208	.160	.115	.088	.678	.442	.340	.245	.187
.15	.433	.272	.208	.144	.104	.915	.576	.443	.305	.220
.20	.465	.304	.240	.176	.120	.985	.645	.510	.374	.256
.30	.448	.304	.256	.192	.128	.950	.645	.545	.408	.271
.40	.400	.272	.224	.176	.120	.850	.576	.477	.374	.256
.50	.320	.232	.208	.160	.112	.680	.492	.445	.340	.238
.60	.272	.200	.176	.144	.104	.578	.425	.374	.308	.213
.70	.224	.176	.152	.127	.0875	.476	.374	.322	.272	.186
.80	.176	.159	.136	.111	.0815	.374	.327	.290	.238	.178
.90	.152	.136	.119	.095	.072	.322	.289	.255	.204	.153
1.00	.136	.126	.110	.088	.068	.289	.268	.235	.186	.144
1.50	.081	.08	.072	.0625	.049	.185	.170	.153	.138	.100
2.00	.064	.056	.056	.046	.040	.135	.119	.118	.098	.085

	.15g RESPONSE				
.015	.15	.15	.15	.15	.15
.02	.153	.15	.15	.15	.15
.03	.174	.162	.156	.15	.15
.04	.207	.186	.174	.156	.15
.05	.255	.213	.189	.165	.15
.06	.30	.255	.21	.177	.15
.07	.375	.285	.237	.183	.153
.08	.465	.33	.255	.195	.156
.09	.54	.36	.273	.21	.159
.10	.60	.39	.30	.216	.165
.15	.81	.51	.39	.27	.195
.20	.87	.57	.45	.33	.225
.30	.84	.57	.48	.36	.24
.40	.75	.51	.42	.33	.195
.50	.60	.435	.396	.30	.21
.60	.51	.375	.33	.27	.186
.70	.42	.33	.285	.24	.165
.80	.33	.297	.255	.21	.156
.90	.285	.255	.225	.18	.135
1.00	.255	.237	.207	.165	.126
1.5	.156	.15	.135	.117	.09
2.00	.12	.105	.105	.087	.075

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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SUBJECT E.Q. RESPONSE COMPUTATION SHEET DATE

FILE SPECTRUM CHECKED BY A.J.

ESTIMATE DATE

	.10 RESPONSE					.20 RESPONSE				
DAMP.	0%	1/2%	1%	2%	5%	0%	1/2%	1%	2%	5%
T	g	g	g	g	g	g	g	g	g	g
.015	.10	.10	.10	.10	.10	.20	.20	.20	.20	.20
.02	.102	.10	.10	.10	.10	.204	.20	.20	.20	.20
.03	.116	.108	.104	.10	.10	.232	.216	.208	.20	.20
.04	.138	.124	.116	.104	.10	.276	.248	.232	.208	.20
.05	.170	.142	.126	.106	.10	.34	.284	.252	.212	.20
.06	.20	.170	.140	.118	.10	.40	.34	.28	.236	.20
.07	.250	.190	.158	.122	.102	.50	.38	.216	.244	.204
.08	.310	.22	.170	.130	.104	.62	.44	.34	.26	.208
.09	.36	.24	.182	.140	.106	.72	.48	.364	.28	.212
.10	.40	.26	.20	.144	.110	.80	.52	.40	.288	.22
.15	.54	.34	.26	.18	.13	1.08	.68	.52	.36	.26
.20	.58	.38	.30	.22	.15	1.16	.76	.60	.44	.30
.30	.56	.38	.32	.24	.16	1.12	.76	.64	.48	.32
.40	.50	.34	.28	.22	.15	1.0	.68	.56	.44	.30
.50	.40	.29	.26	.20	.14	.80	.58	.52	.40	.28
.60	.34	.25	.22	.18	.12	.68	.50	.44	.36	.24
.70	.28	.22	.19	.16	.11	.56	.44	.38	.32	.22
.80	.22	.198	.170	.14	.10	.44	.296	.34	.28	.20
.90	.19	.17	.15	.12	.09	.38	.34	.30	.24	.18
1.00	.17	.158	.138	.11	.08	.34	.216	.276	.22	.16
1.50	.10	.10	.09	.078	.06	.20	.20	.18	.156	.12
2.00	.08	.07	.07	.058	.05	.16	.14	.14	.116	.10

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY A.J.

ESTIMATE _____ DATE _____

Formulae for required limiting capacity:

(a) $C = 1.0D \pm 0.05D + 1.5P + 1.0(T + TL) + 1.0B$

(b) $C = 1.0D \pm 0.05D + 1.25P + 1.0(T' + TL') + 1.25E + 1.0B$

(c) $C = 1.0D \pm 0.05D + 1.0P + 1.0(T'' + TL'') + 1.0E' + 1.0B$

(d) $C = 1.0D \pm 0.05D + 1.10N_t + 1.0P_b + 1.0B$

(e) $C = 1.0D \pm .05D + 1.15P + 1.0W + 1.0B$

(f) $C = 1.00 \pm .05D + P_{SEG} + 1.0E + 1.0TL''' + 1.0S.S.$

Where: C = Required load capacity of section.

D = Dead load of structure & equipment loads

P = Accident pressure load as shown on pressure-temperature transient curves

* T = Load due to max. temp. gradient thru concrete shell & mat based upon temp. associated with 1.5 times accident pressure.

TL = Load exerted by liner based upon temp. associated with 1.5 times accident pressure.

* T' = Load due to max. temp. gradient thru concrete shell & mat based upon temp. associated with 1.25 times accident pressure.

TL' = Load exerted by liner based upon temp. associated with 1.25 times accident pressure.

E = Load resulting from either design earthquake (.10g spectrum with 2% damping) or wind, whichever is greater.

* T'' = Load due to max. temp. gradient thru the concrete shell & mat based upon temp. associated with the accident pressure.

TL'' = Load exerted by the liner based upon temp. associated with the accident pressure.

E' = Load resulting from assumed hypothetical earthquake (.20g spectrum with 5% damping)

B = Load resulting from the buoyancy effect of ground water. For cases

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ESTIMATE DATE

@ thru' (f) the ground water level will be assumed to be ground level (EL. 100') for uplift analysis and design of mat with dead load only a flood condition at EL. 112.5' will be considered.

* There is no transmissibility of heat thru' 3'-6" to 4'-6" of concrete dome and wall during the short time of high accident temperature. See page 46 for analysis of stresses due to temp. gradient.

W_t = Wind load due to tornado

P_b = Bursting pressure loading associated with a tornado (3 psig)

$P_{NEG.}$ = An internal negative pressure = -3.5 psig

T_L''' = Load from a temperature drop = -70° F

S.S. = Load from saturated soil on cylinder walls.

Note: P = 47 PSIG
Wind load = 30 #/ft² on projected area
Tornado is considered to have 300 MPH winds tangential plus 60 MPH translation
Earthquake and wind loadings not to be coincident

HORIZONTAL EARTHQUAKE LOADING:

E condition (.10 g spectrum and 2% damping)

For T = .216 sec.:
acceleration = .224 g

E' condition (.20 g spectrum and 5% damping)

For T = .216 sec:
acceleration = .304 g

$$F_x = \frac{V w_x h_x}{\Sigma w h}$$

where: F_x = lateral force applied to a level designated as x.
V = total lateral load or shear at base

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SUBJECT
FILE
ESTIMATE

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W_x = that portion of the total load which is located at the level designated as X

h_x = height in feet above the base to the level designated as X

Σwh = summation of the products of all $w_x h_x$ for the structure

V for .10g and 2% damping = $\frac{62.05 \times 10^3}{g} \times .224g$

$= 13.9 \times 10^3$ KIPS

V for .20g and 5% damping = $\frac{62.05 \times 10^3}{g} \times .304g$

$= 18.9 \times 10^3$ KIPS

SECT.	W_x	h_x	$w_x h_x$	Σwh	$E = \frac{13.9 \times 10^3 w_x h_x}{62,725}$	1.25E	$E = \frac{18.9 \times 10^3 w_x h_x}{62725}$
A	14	213	2980	2980	660 K	825 K	900
B	39.2	198.8	7800	10780	1720	2150	2350
C	38.06	184.6	7020	17800	1550	1940	2120
D	32.35	170.4	5500	23300	1210	1510	1660
E	34.63	156.2	5420	28720	1200	1500	1630
F	39.66	142.0	5620	34340	1240	1550	1690
G	44.46	127.8	5680	40020	1250	1560	1710
H	44.46	113.6	5050	45070	1110	1390	1520
J	44.46	99.4	4420	49490	970	1210	1330
K	44.46	85.2	3780	53270	830	1040	1140
L	44.46	71.0	3150	56420	690	865	950
M	44.46	56.8	2520	58940	560	700	760
N	44.46	42.6	1890	60830	410	515	570
P	44.46	28.4	1260	62090	270	340	380
Q	44.77	14.2	635	62725	140	175	190
R	22.14	0	0	62725	0	0	0

(SEE P. 23a & P. 23b.)

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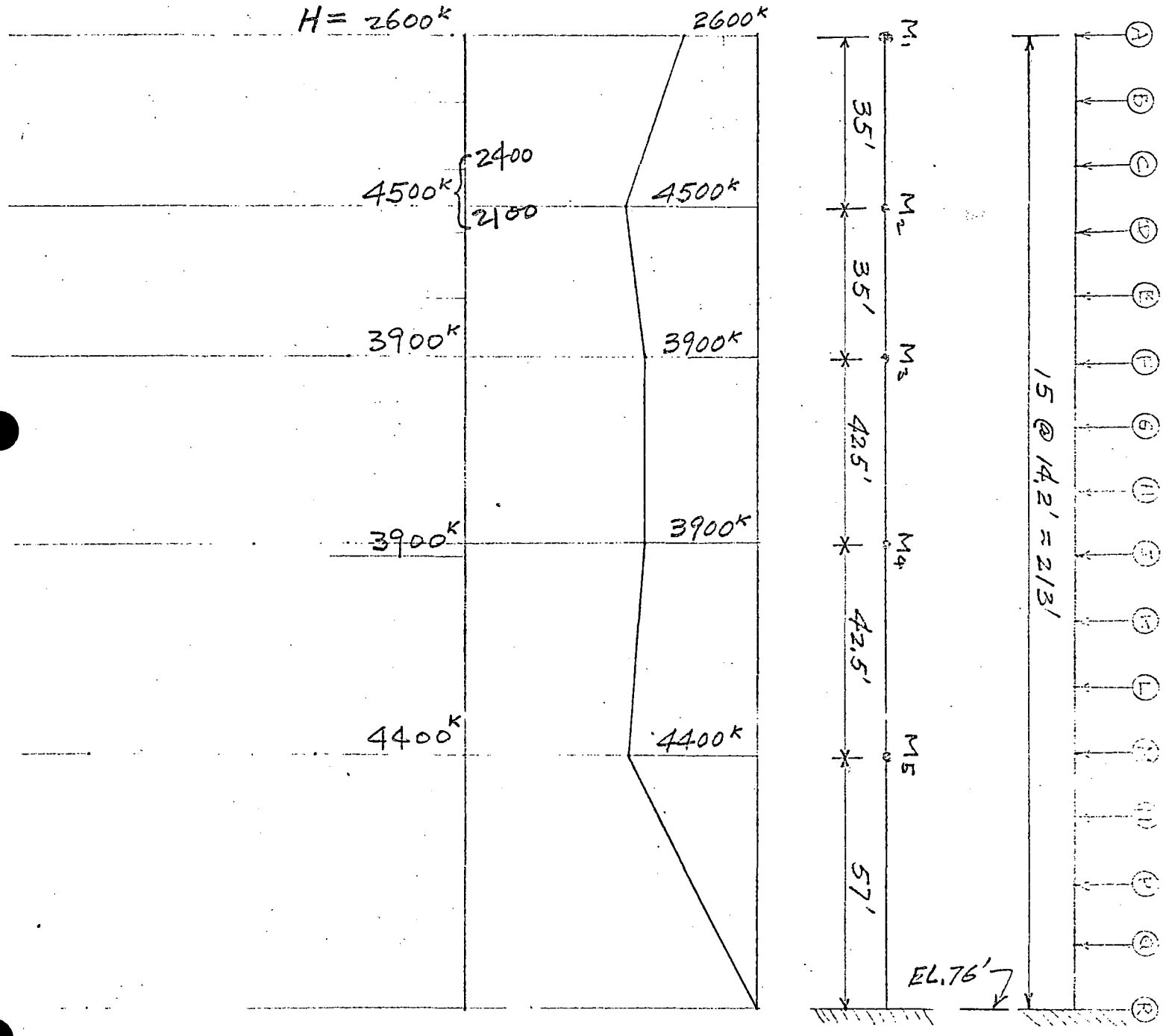
(SEE P. 264)

HORIZONTAL EARTHQUAKE .20g 5% DAMPING

1.0 E'



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(SEE P. 265)

HORIZONTAL EARTHQUAKE .10 g 2% DAMPING

1.25 E

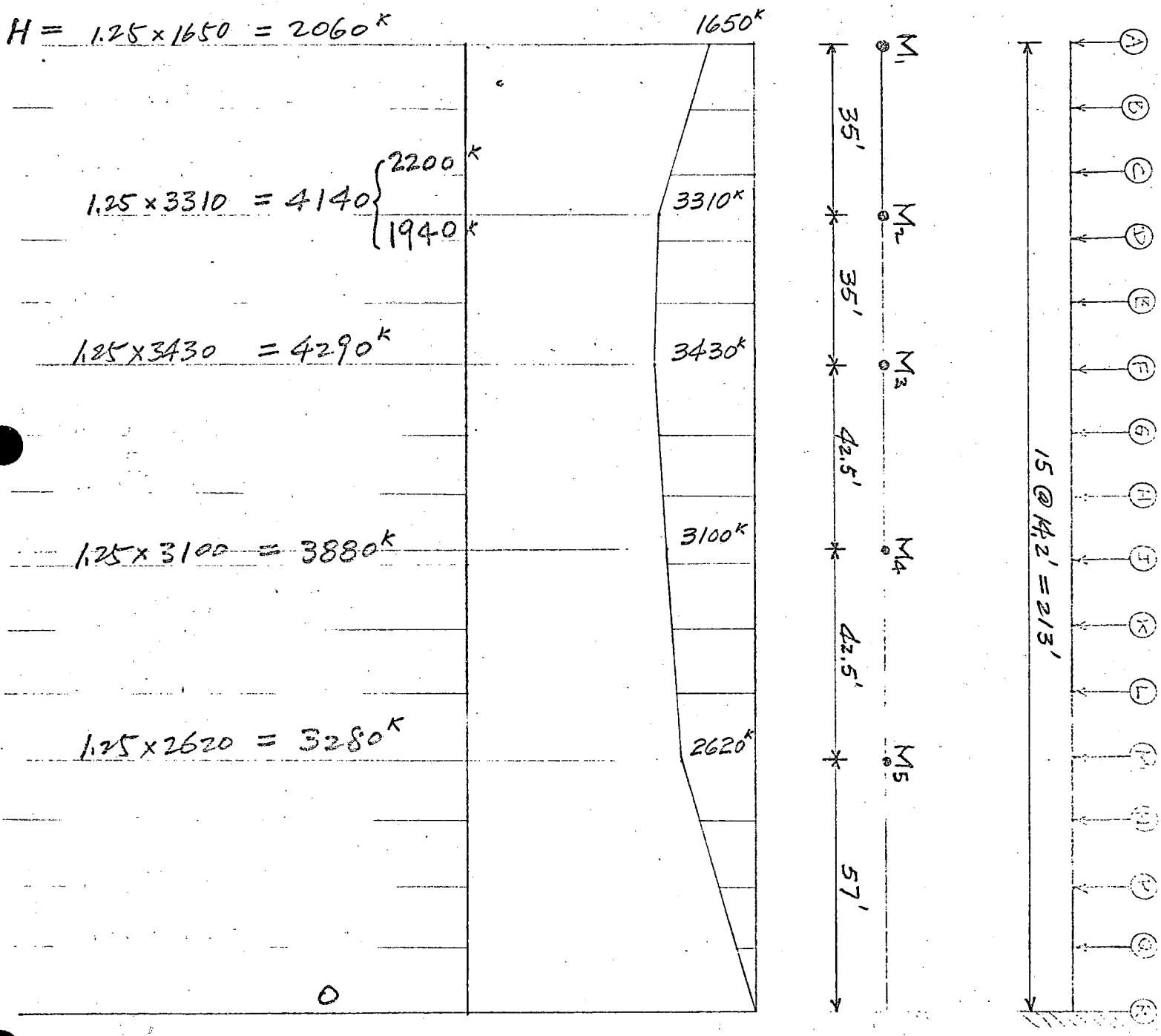
$H = 1.25 \times 1650 = 2060^k$

$1.25 \times 3310 = 4140 \begin{cases} 2200^k \\ 1940^k \end{cases}$

$1.25 \times 3430 = 4290^k$

$1.25 \times 3100 = 3880^k$

$1.25 \times 2620 = 3280^k$



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VERTICAL EARTHQUAKE LOADING

NOTE: Vertical acceleration shall be taken as 2/3 that value obtained from the response spectrum for the vertical period.

E condition (.10 g spectrum and 2% damping)

For T = .0765 sec:
acceleration = .129g × 2/3 = .086g

E' condition (.20 g spectrum and 5% damping)

For T = .0765 sec.:
acceleration = .207g × 2/3 = .138g

SECT.	W	× .086 = E	1.25E	W × .138 = E'
A	1400	120K	150K	193K
B	3920	340	425	542
C	3806	330	412	526
D	3235	250	360	456
E	3463	300	375	478
F	3966	342	427	548
G	4446	382	477	613
H	4446	382	477	613
J	4446	382	477	613
K	4446	382	477	613
L	4446	382	477	613
M	4446	382	477	613
N	4446	382	477	613
P	4446	382	477	613
Q	4477	386	482	620
R	2214	195	244	305
	62050	5349K		

62050K × .086 = 5350K
62050 × .086 × 1.25 = 6700K
62,050 × .138 = 8600K

(SEE P. 24a)

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SUBJECT CONTAINMENT BLDG. COMPUTATION SHEET
FILE
ESTIMATE

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VERTICAL EARTHQUAKE LOADING

SECT.	W	ACCELERATION/g	E	1.25 E	W x A/g = E'
A	1400	× 0.088	123 K	154 K	× .100 = 140 K
B	3920		345	431	392
C	3806		335	419	381
D	3235	× 0.099	320	400	× .229 = 741
E	3463		343	429	793
F	3956		393	491	908
G	4446	× 0.110	489	611	× .271 = 1205
H	4446		489	611	1205
J	4446		489	611	1205
K	4446	× 0.108	480	600	× .268 = 1192
L	4446		480	600	1192
M	4446		480	600	1192
N	4446	× 0.101	449	561	× .258 = 1147
P	4446		449	561	1147
Q	4477		452	565	1155
R	2214		224	280	571
			6340 K		14566 K

SEE CONRAD'S REPORT

FOR O.B.E. (.10 g)

VERT. FORCE = 6340 × 1.25 = 7925 K

FOR D.B.E. (.20 g)

VERT. FORCE = 14566 K

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FILE

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MEMBRANE STRESSES DUE TO HORIZONTAL FORCES

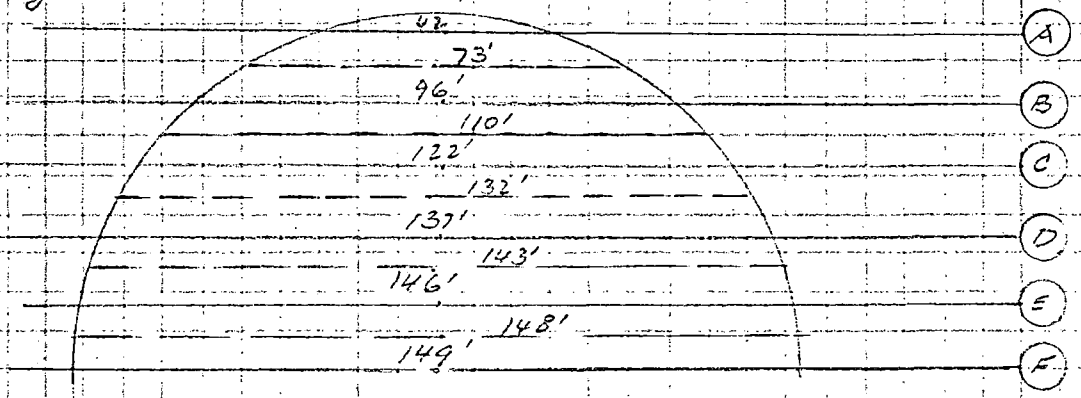
ALL MEMBRANE FORCES WILL BE SHOWN AS PRIME!

N_ϕ' = HOOP FORCE / FT

$N_y' = N_\phi'$ = MERIDIONAL FORCE / FT

$N_{\phi\theta} = N_{y\theta}'$ = SHEARING FORCE / FT.

} COMPRESSION IS −
TENSION IS +



PROJECTED AREA OF DOME

SECT	PROJ. AREA ft^2
A	$\frac{(73+42)}{2} \times 9.6 = 550$
B	$\frac{(110+4\times96+73)}{6} 14.2 = 1340$
C	$\frac{(132+4\times122+110)}{6} 14.2 = 1730$
D	$\frac{(143+4\times137+132)}{6} 14.2 = 1950$
E	$\frac{(148+4\times146+143)}{6} 14.2 = 2070$
F	$\frac{(149+4\times149+148)}{6} 14.2 = 2120$
G	$149 \times 14.2 = 2120$
H	do 2120
J	do 2120
K	do 2120
L	do 2120
M	do 2120
N	do 2120
P	do 2120
Q	do 2120
R	$149 \times 7.1 = 1060$

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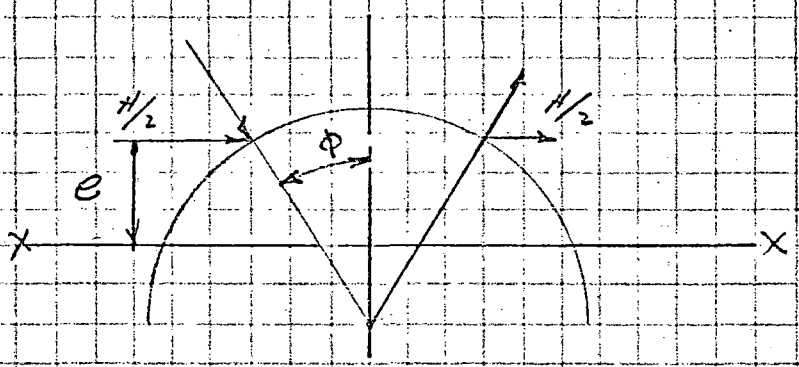
SUBJECT E.Q. LATERAL LOAD COMPUTATION SHEET DATE

FILE MEMBRANE STRESSES IN DOME CHECKED BY A.J.

ESTIMATE DATE



For loading Above Plane X-X':

$\Sigma M_x = 0$

$\Sigma H_x = 0$

$\Sigma Z = 0$ or $\frac{N'\theta}{r_2} + \frac{N'\phi}{r_1} + p_z = 0$ (for any surface of revolution)

It is convenient to express the distribution of membrane stress resultants as a function of the angle θ:

$N'\phi = S\phi \cos\theta$: Meridional force

$N'\phi\theta = N'\theta\phi = S\phi\theta \sin\theta$: Long. & trans. Shear

$N'\theta = S\theta \cos\theta$: Hoop force

$\Sigma M_x = 0$: Moment is produced by external load (M_e) and resisted by internal moment (M_i) which is the moment of the vertical component of $N'\phi$.

The vertical component of

$N'\phi = N'\phi \sin\phi = S\phi \cos\theta \sin\phi$

$S\phi \cos\theta \sin\phi \, r_o \, d\theta$ = increment on arc

Moment about line y-y:

$dM_i = - S\phi \cos\theta \sin\phi \, r_o \, d\theta \, r_o \cos\theta$

defined as positive when acting clockwise about line:

$M_i = -4 S\phi \sin\phi \, r_o^2 \int_0^{\pi/2} \cos^2\theta \, d\theta$

$M_i = - S\phi \, \pi \, r_o^2 \sin\phi$

$\Sigma M_x = 0 = M_e + M_i$

$S\phi = \frac{M_e}{\pi r_o^2 \sin\phi}$ $\therefore N'\phi = \frac{M_e \cos\theta}{\pi r_o^2 \sin\phi}$

$M_e = H e_t$

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$\Sigma H_x = 0$; The horizontal forces are produced by the external loads H_A, H_B etc and balanced by H_i.

H_i is made up of components contributed by N_ϕ and $N_{\phi\theta}$ (see page x-x)

$H_i = \int dH_{N'\phi} + \int dH_{N'\phi\theta}$

$dH_{N'_\phi} = -S_\phi \cos\theta \cos\phi \cos\theta r_o d\theta$

$dH_{N'\phi\theta} = S_{\phi\theta} \sin\theta \sin\theta r_o d\theta$

positive direction to right

$H_i = -4 S_\phi \cos\phi r_o \int_0^{\pi/2} \cos^2\theta d\theta + 4 S_{\phi\theta} r_o \int_0^{\pi/2} \sin^2\theta d\theta$

$H_i = -\pi r_o S_\phi \cos\phi + \pi r_o S_{\phi\theta}$

$H_e + H_i = 0$

$S_{\phi\theta} = -\frac{H_e}{r_o \pi} + S_\phi \cos\phi$

$N'_{\phi\theta_x} = -\left(\frac{H_e}{r_o \pi} - \frac{M_e \cos\phi}{\pi r_o^2 \sin\phi}\right) \sin\theta$

$\Sigma Z_x = 0$; $\frac{N'_\theta}{r_2} + \frac{N'_\phi}{r_1} + p_z = 0$ (general case)

For a sphere: $r_1 = r_2$

$r_o = r_1 \sin\phi$

$N'_\theta = -r_2\left(p_z + \frac{N'_\phi}{r_1}\right) = -r_2 p_z - N'_\phi$

$= -\frac{r_o p_z}{\sin\phi} - N'_\phi$; $p_z = p \sin\phi \cos\theta$

$N'_\theta = -\frac{r_o p \sin\phi \cos\theta}{\sin\phi} - N'_\phi = -r_o p \cos\theta - N'_\phi$

Note: p varies depending upon H_A, H_B etc

$p_A = H_A/2\times550$; $p_B = H_B/2\times1350$

$p_C = H_C/2\times730$; $p_D = H_D/2\times1950$

$p_E = H_E/2\times2070$; $p_F = H_F/2\times2120$

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SUBJECT E.S. SEISMIC LOAD COMPUTATION SHEET CHECKED BY AJ DATE ___

FILE HYDROGEN STRESSES IN DOME ESTIMATE ___

SECT.	ϕ	$\sin\phi$	R_o Ft.	R_o^2 Ft^2	H K	M_ϕ $(10)^3$ K	$\frac{M_\phi}{\pi R_o^2 \sin\phi} = \frac{N'_\phi}{\cos\theta}$ K/Ft	ΣH K	$-\frac{\Sigma H}{R_o\pi}$	$\cos\phi$	$\frac{N'_\theta \cos\phi}{\cos\theta}$ K/Ft	$\frac{-\Sigma H}{R_o\pi} + \frac{N'_\theta \cos\phi}{\cos\theta} = \frac{N'_{\phi\theta}}{\sin\theta}$ K/Ft	P #/Ft²	$-R_o P = -N'_1 = \frac{N'_\theta}{\cos\theta}$ K/Ft
A	8°	.139	10'	100	~~-825~~ 2060	0	0	~~825~~ 2060	~~-61.2~~ -65.6	.99	0	~~-26.3~~ -65.6	~~750~~ 1873	~~-7.5~~ -18.7
B	38°	.616	43.5	1900	2150	11.7	3.18	2975	-21.8	.788	+ 2.5	- 19.3	805	-58.14
C	53°40'	.806	56.8	3230	~~+940~~ 2200	~~53.95~~ 58.50	~~6.6~~ 7.2	~~4915~~ 4260	~~-27.6~~ -23.9	.592	+ ~~3.9~~ 4.3	~~-23.7~~ -19.6	~~560~~ 636	~~-58.4~~ -43.3
D	66°50'	.919	65.0	4220	~~+510~~ 1940	~~+22.95~~ 119.00	~~10.2~~ 9.8	~~6425~~ 6200	~~-31.5~~ -30.4	.393	+ ~~4.0~~ 3.9	~~-27.5~~ -26.5	~~387~~ 497	~~-35.4~~ -42.1
E	78°40'	.98	69.5	4830	1500	215.4	14.5	7925	-36.4	.196	+ 2.84	- 33.56	362	-34.7
F	90°	1.0	71.75	5150	4290 ~~7550~~	295.1 ~~328.2~~	18.2 ~~20.2~~	10490 ~~9475~~	-46.5 ~~-42.2~~	0	0	-46.5 ~~-42.2~~	1012 ~~365~~	-90.8 ~~-96.4~~

DOME MEMBRANE STRESSES FOR 1.25E (.10g)

							$N'_\phi/\cos\theta$					$N'_{\phi\theta}/\sin\theta$		$N'_\theta/\cos\theta$
A	8°	.139	10'	100	~~700~~ 2600	0	0	~~900~~ 2600	~~-28.8~~ -82.8	.99	0	~~-28.8~~ -82.8	~~816~~ 2364	~~-8.16~~ -23.6
B	38°	.616	43.5	1900	~~950~~	12.6	3.48	3250	-23.8	.788	+ 2.74	- 21.06	880	~~-41.6~~
C	53°40'	.806	56.8	3230	~~2120~~ 2400	~~59.0~~ 73.8	~~7.22~~ 9.02	~~5370~~ 5000	~~-30.2~~ -28.0	.592	+ ~~4.27~~ 5.34	~~-25.93~~ -22.66	~~610~~ 694	~~-41.6~~ -48.4
D	66°50'	.919	65.0	4220	~~+660~~ 2100	~~+35.5~~ 144.8	~~11.2~~ 11.9	~~7030~~ 7100	~~-34.4~~ -34.8	.393	+ ~~4.4~~ 4.7	- 30.0	~~422~~ 538	~~-38.6~~ -46.9
E	78°40'	.980	69.5	4830	1630	235.5	15.9	8660	-39.8	.196	+ 3.12	- 36.68	395	~~-43.3~~
F	90°	1.0	71.75	5150	~~1690~~ 3900	~~358.5~~ 346.5	~~22.3~~ 21.4	~~10350~~ 11,000	-46.2 -48.8	0	0	~~-50.2~~ -48.8	~~396~~ 920	~~-50.9~~ -87.4

DOME MEMBRANE STRESSES FOR 1.0E' (.20g)

SEE P.23a & P.23b.

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REFER TO SALEM GEN. STA
SUBJECT E.Q. LATERAL LOAD COMPUTATION SHEET
FILE MEMBRANE STRESSES IN CYL.
ESTIMATE

PREPARED BY I.G
DATE
CHECKED BY A.J
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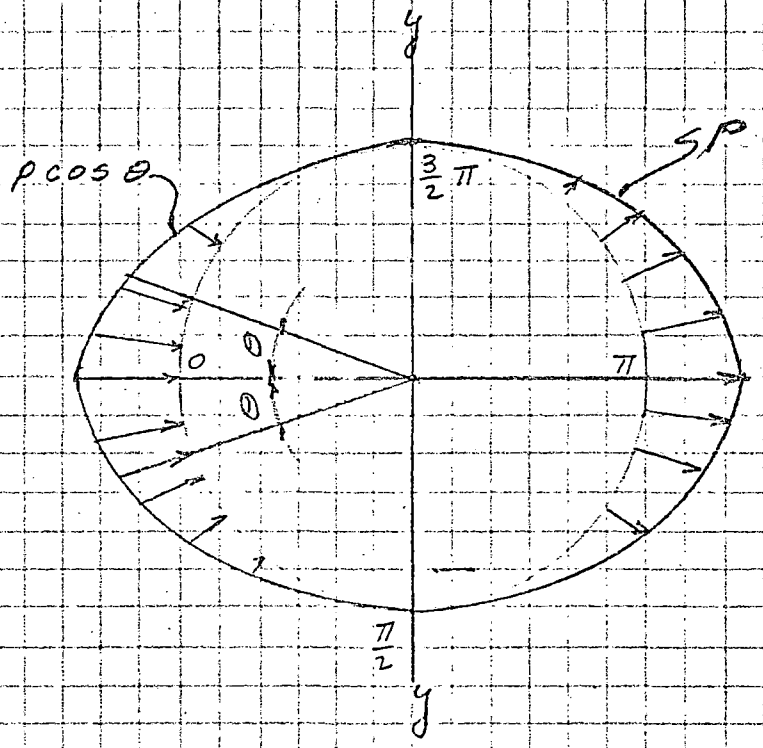
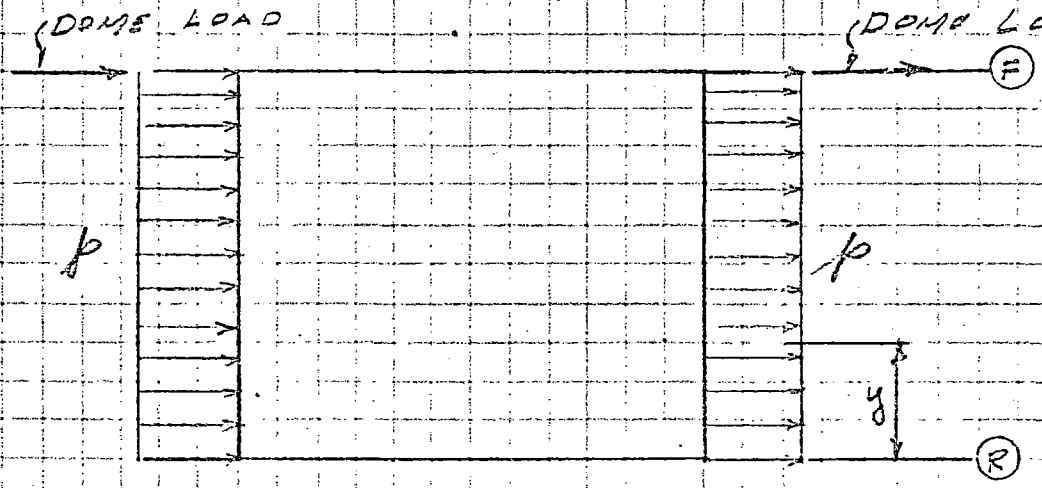


PLAN



ELEVATION

LOADING ON CYLINDER

$N'_\theta = -p_2 r = -p \cos\theta r$ Ref.

To find $N'_{y\theta} = N'_{\phi\theta}$; let $v = \frac{N'_{y\theta}}{h} = \frac{HQ}{Ib}$

H = total horizontal shear from either earthquake or wind (whichever applies)

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REFER TO Calc. Book 5th

SUBJECT [illegible] COMPUTATION SHEET

FILE Membrane Stresses in Cyl.

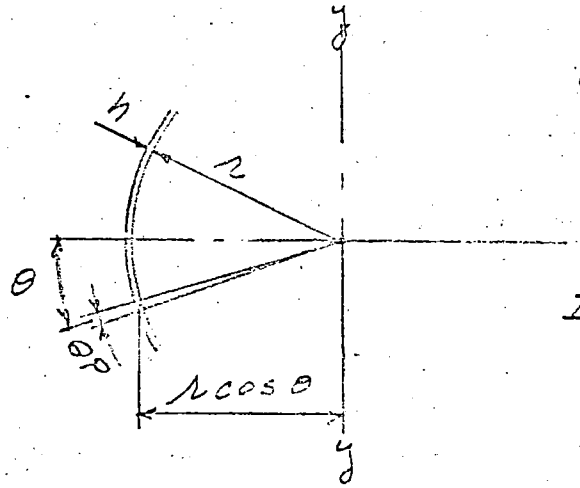
ESTIMATE

PREPARED BY L.C.

DATE

CHECKED BY A.J.

DATE



$$Q_y = 2\int_0^{\theta} h r\, d\theta\,(r\cos\theta)\, d\theta$$

$$= 2\int_0^{\theta} h r^2 \cos\theta\, d\theta$$

$$= 2hr^2 \sin\theta$$

$$I_y = \int x^2\, dA$$

$$= 4\int_0^{\frac{\pi}{2}} h r\, d\theta\,(r\cos\theta)^2$$

$$= 4\int_0^{\frac{\pi}{2}} h r^3 \cos^2\theta\, d\theta$$

$$= \pi h r^3$$

$$b = 2h$$

$$N'_{y\theta} = \frac{h\, Q_y}{I_y\, 2h} = \frac{2hr^2 \sin\theta}{\pi h r^3\, 2h} = \frac{\sin\theta}{\pi r}$$ K/Ft

To find $N'_y = N'_\phi$: let $f_y = \frac{N'_y}{h} = \frac{M_y x}{I}$

$x = r\cos\theta$

$M_y = H C_y$ $\therefore$ $N'_y = \frac{H C_y r\cos\theta}{\pi r^3} = \frac{H C_y \cos\theta}{\pi r^2}$ K/F

use $r = 75.5'$

Sect	1.25 E: ΣH	C	Hc	ΣHc	1.0 E: ΣH	C	Hc	ΣH
A	2060	14.2 x 2			2600	14.2 x 2		
B								
C	4260		58,500	58,500	5000		73,800	73,800
D	6200		60,500	119,000	7100		71,000	144,800
E								
F	10490		176,100	295,100	11,000		201,600	346,400
G								

SEE P.23a & P.23b

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SUBJECT C.O. LATERAL LOADS COMPUTATION SHEET
FILE MEMBRANE STRESSES IN CYL.
ESTIMATE

PREPARED BY J.G
DATE
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SECT.	1.25E ΣH	e	He	ΣH	1.0E' ΣH	e	He	ΣHe
G	11,135				13,060			
H	13,525				5,600		171,200	
J	14,370		446,900	742,000	14,900		468,600	815,000
K	14,775				16,060			
L	15,240				17,060			
M	17,650		612,200	1,354,200	19,300		634,700	1,449,700
N								
P	17,210				18,710			
Q								
R	17,650		1002,500	2356,700 2,394,700	19,300		1096,200	2545,90

SECT.	1.25E H/AREA = P	1.0E' H/AREA = P
F	4290 / 2×2120 = 1012 #/FT²	3900 / 2×2120 = 920 #/FT²
G		
H		
J	3880 / 4240 = 915	3900 / 4240 = 920
K		
L		
M	3280 / 4240 = 774	4400 / 4240 = 1040
N		
P		
Q		
R	0	0

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FILE MEMBRANE STRESSES IN CYL.
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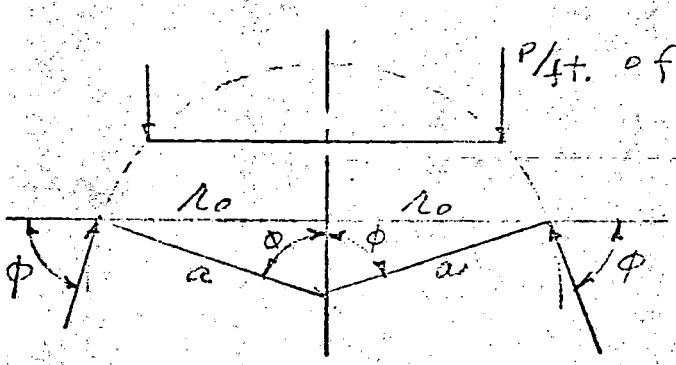
SECT.	1.25 E: $N'_y/\cos\theta$ (K/ft) $= \Sigma H_e / \pi(72.25)^2$	1.25 E: $N'_\theta = p r_{K/ft}$	1.25 E: $N'_{\phi\theta}/\cos\theta = \Sigma H / \pi 72.25$ K/ft	1.0 E': $N'_y/\cos\theta$ (K/ft) $= \Sigma H_e / \pi(72.25)^2$	1.0 E': $N'_\theta = p r_{K/ft}$	1.0 E': $N'_{\phi\theta}/\cos\theta = \Sigma H / \pi 72.25$ K/ft
F	295100 / 16220 = 18.2	1012/365 × 72.25 = 73.1	-46.2	346400 / 16220 = 21.4	920/365 × 72.25 = 66.5	-48.5
G	462,700 / 16,220 = 28.5	367 × 72.25 =	-49.4		407 × 72.25 = 29.0	-50.2
H	629,700 / 16220 = 38.7	326 × 72.25 =	-55.4		357 × 72.25 = 25.8	-60.0
J	742000 / 16220 = 45.7	915/365 × 72.25 = 66.1	-63.3	815000 / 16220 = 50.2	920/365 × 72.25 = 66.5	-65.6
K	995,700 / 16220 = 61.2	240 × 72.25 = 17.3	-65.5		264 × 72.25 = 19.5	-71.0
L	1,203,700 / 16,220 = 74.2	204 × 72.25 = 14.9	-69.1		223 × 72.25 = 16.1	-76.5
M	1354200 / 16,220 = 83.5	774/365 × 72.25 = 55.9	-77.8	1449700 / 16220 = 89.4	1040/365 × 72.25 = 75.1	-85.0
N	1,659,700 / 16220 = 102.3	121 × 72.25 = 8.7	-75.0		134 × 72.25 = 9.7	-81.0
P	1,910,700 / 16220 = 117.8	90 × 72.25 = 6.5	-76.5		90 × 72.25 = 6.5	-82.5
Q	2,165,700 / 16220 = 133.5	111 × 72.25 = 8.0	-77.3		65 × 72.25 = 4.7	-85.2
R	2356700 / 16,220 = 145.3	0	-77.8	2545900 / 16220 = 157	0	-85.0

E.Q. VERTICAL LOADS (SEE Pg. 24)

MEMBRANE STRESSES IN DOME AND CYLINDER:



Let $\Sigma P = R$

$$N'_\phi = -\frac{R}{2\pi r_0 \sin\phi}$$

$$\frac{N'_\phi}{r_1} + \frac{N'_\theta}{r_2} = -Z$$

For a sphere: $r_1 = r_2 = a$ and $Z = 0$

$$\therefore \frac{R}{2\pi r_0 \sin\phi} = N'_\theta \quad \text{but } r_0 = a\sin\phi$$

$$\therefore N'_\theta = R / 2\pi a \sin^2\phi$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA.

SUBJECT E.Q. VERTICAL LOAD COMPUTATION SHEET

FILE MEMBRANE STRESSES

ESTIMATE

PREPARED BY I.G.

DATE

CHECKED BY A.J.

DATE

FOR CYLINDER:

$N_\phi' = N_y' = \frac{1R}{2\pi a}$

$N_\theta' = 0$

SEE P.24a

			1.25 E				1.05			
Sect.	ϕ	$\sin^2\phi$	R / K	E R / K · 2π(71.75)sin²φ	E R / 2π(71.75)sin²φ	E R / 2π(72.25)	R	E R	E R / 2π(71.75)sin²φ	E R / 2π(72.25)
A	5°	.0193	~~150~~ 154 *	~~159~~ 154	~~7.2~~ 17.7 K1	—	~~193~~ 140	~~193~~ 140	~~22.2~~ 16.1 K1	—
B	38°	.378	~~431~~ 431	~~595~~ 585	3.4	—	~~511~~ 392	~~735~~ 532	~~4.2~~ 3.1	—
C	53°40'	.65	~~741~~ 419	~~1,062~~ 1,004	3.4	—	~~626~~ 381	~~1,061~~ 913	~~4.3~~ 3.1	—
D	66°50'	.846	~~266~~ 400	~~1,404~~ 1,404	~~3.5~~ 3.7	—	~~766~~ 741	~~1,717~~ 1,654	~~4.5~~ 4.3	—
E	78°40'	.96	~~2,212~~ 429	~~1,912~~ 1,833	~~4.8~~ 4.2	—	~~793~~ 793	~~2,447~~ 2,447	~~5.1~~ 5.7	—
F	90°	1.0	~~491~~ 491	~~2,324~~ 2,324	~~5.15~~ 5.16	~~5.12~~ 5.12	~~908~~ 908	~~3,355~~ 3,355	~~7.4~~ 7.4	~~7.4~~ 7.4
G			~~611~~ 611	~~2,935~~ 2,935	—	~~6.5~~ 6.5	~~1205~~ 1205	~~4,560~~ 4,560	—	~~10.0~~ 10.0
H			~~611~~ 611	~~3,546~~ 3,546	—	~~7.80~~ 7.80	~~1205~~ 1205	~~5,765~~ 5,765	—	~~12.7~~ 12.7
J			~~611~~ 611	~~4,157~~ 4,157	—	~~9.2~~ 9.2	~~1205~~ 1205	~~6,970~~ 6,970	—	~~15.4~~ 15.4
K			~~600~~ 600	~~4,757~~ 4,757	—	~~10.5~~ 10.5	~~1192~~ 1192	~~8,162~~ 8,162	—	~~18.0~~ 18.0
L			~~600~~ 600	~~5,524~~ 5,357	—	~~11.8~~ 11.8	~~1192~~ 1192	~~9,808~~ 9,354	—	~~20.6~~ 20.6
M			~~600~~ 600	~~5,957~~ 5,957	—	~~13.1~~ 13.1	~~1192~~ 1192	~~10,546~~ 10,546	—	~~23.2~~ 23.2
N			~~561~~ 561	~~6,518~~ 6,518	—	~~14.4~~ 14.4	~~1147~~ 1147	~~11,693~~ 11,693	—	~~25.8~~ 25.8
P			~~561~~ 561	~~7,079~~ 7,079	—	~~15.6~~ 15.6	~~1147~~ 1147	~~12,840~~ 12,840	—	~~28.3~~ 28.3
Q			~~565~~ 565	~~7,644~~ 7,644	—	~~16.8~~ 16.8	~~1155~~ 1155	~~13,995~~ 13,995	—	~~30.8~~ 30.8
R			~~280~~ 280	~~7,924~~ 7,924	—	~~14.8~~ 17.5	~~305~~ 571	~~15,572~~ 14,566	—	~~32.1~~
					N_θ	N_y'			N_ϕ or N_θ	N_y'

*(SEE P. 24a)

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY L.G

SUBJECT DESIGN WIND COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

$p = .00256 V^2 F^2$ = pressure on a flat surface

V = wind velocity in mph

F = gust factor

$p = .00256 (108)^2 (1)^2 = 30\ ^{\#}/ft^2$

In general: $p = c\,(.00256) V^2 F^2 C_h$

c = shape factor

C_h = height factor

for cylinder $c = .5$, $C_h = 1$

" dome $c = .4$, $C_h = 1.25$

$p_{design} = 30 \times .4 \times 1.25 = 15\ ^{\#}/ft^2$ (sphere)

$= 30 \times .5 \times 1.0 = 15\ ^{\#}/ft^2$ (cylinder)

$p = 15/2 = 7.5\ ^{\#}/ft^2$ on proj. area + $7.5\ ^{\#}/ft^2$ suction on projected area

SECT	Proj Area	× 15 =	Wind Force
A	550		8200 #
B	1341		20,100
C	1730		26,000
D	1950		24,250
E	2070		31,050
F	2120		31,750
G			
H			
J			
K			
L			
M			
N	2120		31,750
P	149+11.5 = 1720		25,800
GRADE @ EL. 24.			
			Σ = 389,450

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.C.

SUBJECT DESIGN WIND COMPUTATION SHEET DATE

FILE & TORNADO WIND CHECKED BY A.J.

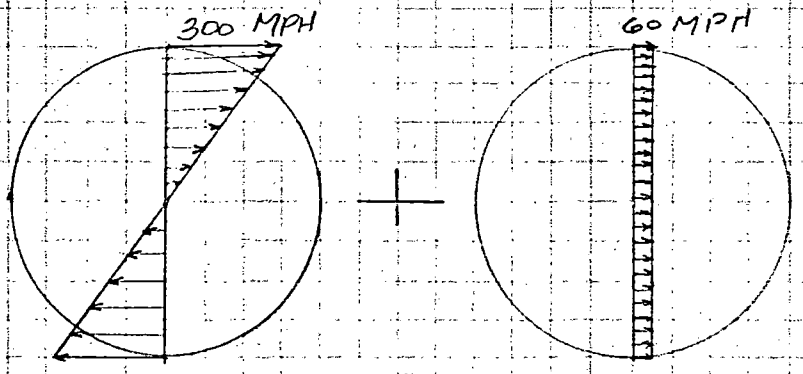
ESTIMATE DATE

SECT.	H	ΣH	e	He	ΣHe	p ± /FT²	pn = N'q/cosθ	ΣHe/πr² = N'y/cosθ
A	8.2	8.2	14.2			7.5	0	
B	20.1	28.3	14.2	116	116			
C	26.0	54.3	14.2	402	518			
D	24.3	78.6	14.2	770	1288			
E	31.1	109.7	14.2	1110	2398		K1	K1
F	31.8	141.5	14.2	1560	3958		7.5 K1 72.25 K1 55	.242
G		173.3	14.2	2010	5968			.366
H		205.1	14.2	2460	8428			.517
J		236.9	14.2	2910	11,338			.700
K		268.7	14.2	3360	14,698			.900
L		300.5	14.2	3820	18,518			1.13
M		332.3	14.2	4320	22,838			1.40
N	31.8	364.1	14.2	4810	27,648			1.70
P	25.8	389.9	28.4	6190	32,838	7.5		2.00
R	0	389.9		11,050	43,888	0	0	2.67

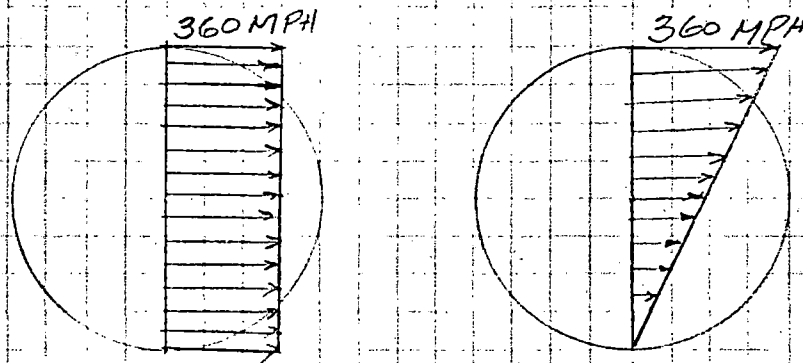
DESIGN WIND FORCES

TORNADO LOADING:

POSSIBLE LOADINGS:



CASE I



CASE II CASE III

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.C.

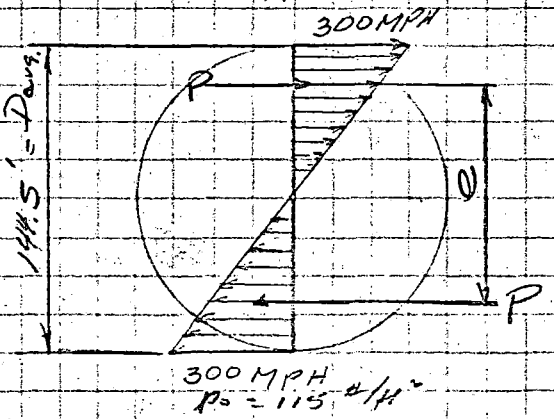
SUBJECT TORNADO WIND COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

CASE I:

$p_o = 115\ ^{\#}/_{ft^2}$



TORSION SHOWN ON CYL.

$p_o = .00256 \times \overline{300}^2 \times .5 = 115\ ^{\#}/_{ft^2}$

$P = \frac{1}{2} \times 72.25 \times 115 \times 17.2 = 59^K$

$e = \frac{2}{3} \times 144.5 = 96.5'$

$T = Pe = 59 \times 96.5 = 5700\ ^{1K}/_{SECT}$

SECT	Davg.	p_o	P	e	T 1K	ΣT
A	31 ±	24.5 #/ft²	½ × 15.5 × 24.5 × 9.6' = 1.8^K	20.6	37	37
B	91.5 ±	72.5	½ × 45.7 × 72.5 × 14.2 = 23.6^K	61	1440	1477
C	117.8 ±	94.0	½ × 58.5 × 94 × 14.2 = 39.2	76.5	3080	4557
D	133.5 ±	106.0	½ × 66.7 × 106 × 14.2 = 50.2	89.2	4480	9037
E	142.5 ±	113.0	½ × 71.2 × 113 × 14.2 = 57.0	95.0	5400	14,437
F	144.5'	115.0	59^K	96.5	5700	20,137
G						25,837
H						31,537
J						37,237
K						42,937
L						48,637
M						54,337
N			59^K		5700	60037
P	144.5'		½ × 72.25 × 115 × 11.5 = 47.7	96.5	4600	64,637
GRADE		115.0				
R						64,337

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA
SUBJECT TORNADO WIND COMPUTATION SHEET
FILE
ESTIMATE

PREPARED BY J.C
DATE
CHECKED BY A. J.
DATE

CASE I : CONT.

$$\frac{N'_{jo}}{h} = \frac{TR}{J} = \frac{16\,T\,D_{avg.}}{\pi(D_o^4 - D_i^4)} \quad \text{(for a hollow shaft)}$$

$$N'_{jo} = \frac{h\,(5.1)\,T\,D_{avg.}}{(D_o^4 - D_i^4)}$$ = shearing force/ft. of perimeter

SECT.	ET^K	$D_{avg.}$	D_o	D_i	D_o^4	D_i^4	h	N'_{jo}
A	37	31'	42'	20	3,111,700	160,000	11'	0
B	1477	91.5'	96'	87	84,930,000	57,250,000	4.5'	
C	4557	117.8	122	113.6	221,530,000	166,540,000	4.2	
D	9037	133.5	137	130	352,280,000	285,610,000	3.5	
E	14,437	142.5	146	139	454,370,000	373,300,000	3.5	
F	20,137	144.5	149	140	492,840,000	384,160,000	4.5	
G	25,837							
H	31,537							
J	37,237							
K	42,937							
L	48,637							
M	54,337							
N	60,037							
P	64,637							
GRADE	↓	↓	↓	↓			↓	↓
R	64,637	144.5	149	140	492,840,000	384,160,000	4.5	2^K/FT

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT TORNADO WIND COMPUTATION SHEET DATE

FILE CHECKED BY A. J.

ESTIMATE DATE

CASE II

DOME & CYLINDER USE .5 FOR SHAPE FACTOR.

$P = .00256(360)^2(.5) = 166\ \#/ft^2$

FOR SIMPLICITY AND CONSERVATISM ASSUME THIS PRESSURE ACTS ON THE PROJECTED AREA.

SECT.	AREA	$H = PA = 166A$	ΣH	e	HC	ΣHC	$\frac{\Sigma HC}{\pi(72.25)^2} = N'_j$	$\frac{72.25P}{2} = N'_\theta$	$\frac{\Sigma H}{72.25\pi} = N'_\theta$
A	550	91.0	91	14.2			—		—
B	1340	222.0	313		1290	1,290	—		—
C	1730	287.0	600		4450	5,740	—		—
D	1950	324.0	924		8530	14,270	—		—
E	2070	344.0	1268		13,100	27,370	—		—
F	2120	352.0	1620		18,000	45,370	2.77 K/	6 K/ (TYP)	7.1 K/
G	2120	352.0	1972		23,000	68,370	4.18		8.7
H	2120	352.0	2324		29,000	97,370	5.95		10.2
J	2120	352.0	2676		33,100	130,470	8.00		11.8
K	2120	352.0	3228		38,000	168,470	10.2		14.3
L	2120	352.0	3580		46,000	214,470	13.2		15.8
M	2120	352.0	3932		50,800	265,270	16.2		17.4
N	2120	352.0	4284		55,800	321,070	19.6		18.9
P	1720	286.0	4570		65,000	386,070	23.6		20.2
GRADE									
R									

A TORNADO THAT CREATES THE SAME STRESS AS .029 E.Q. IS. $N'_j = \frac{142.5}{23.6} \times 166 = 1040\ \#/ft^2$

$\frac{1040}{.00256 \times .5} = V^2 = 820{,}000$; $V = 905$ MPH

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY 1-6

SUBJECT TORNADO COMPUTATION SHEET DATE

FILE CHECKED BY A. J.

ESTIMATE DATE

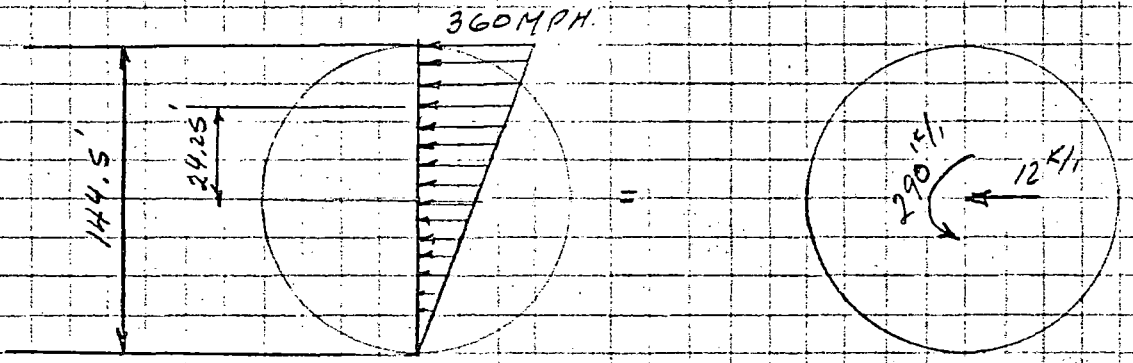
$N'_{yo} = \frac{83.3}{20.2} \times 166 = 685\ ^{\#}/_{ft^2}$

$\frac{685}{.00256 \times .5} = V^2 = 535{,}000$

$V = 733$ MPH ← This is critical as the seismic shear diagonal reinforcing is based on .029 acc.

CLASS III

$p_o = 166\ ^{\#}/_{ft^2}$



$P = 166 \times 144.5/2 = 12{,}000\ ^{\#}/_{L}$

$12^{K} \times 24.25 = 290\ ^{K}/_{L}$

FOR a 14.2 SECTION $M = 290 \times 14.2 = 4120\ ^{K}/_{SECT.}$

$H = 12 \times 14.2 = 171^{K}/_{SECT.}$

BY COMPARISON WITH CLASS I AND CLASS II, IT IS EVIDENT THAT CLASS II PREVAILS.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY L.G.

SUBJECT INTERACTION OF COMPUTATION SHEET DATE

FILE GROUND & CYLINDER WALL CHECKED BY A.J.

ESTIMATE DATE

There will be interaction forces developed between the portion of the structure below grade and the soil surrounding it, during an earthquake. The soil loading will be composed of the passive pressure plus a dynamic loading caused by the earthquake and will be as follows:

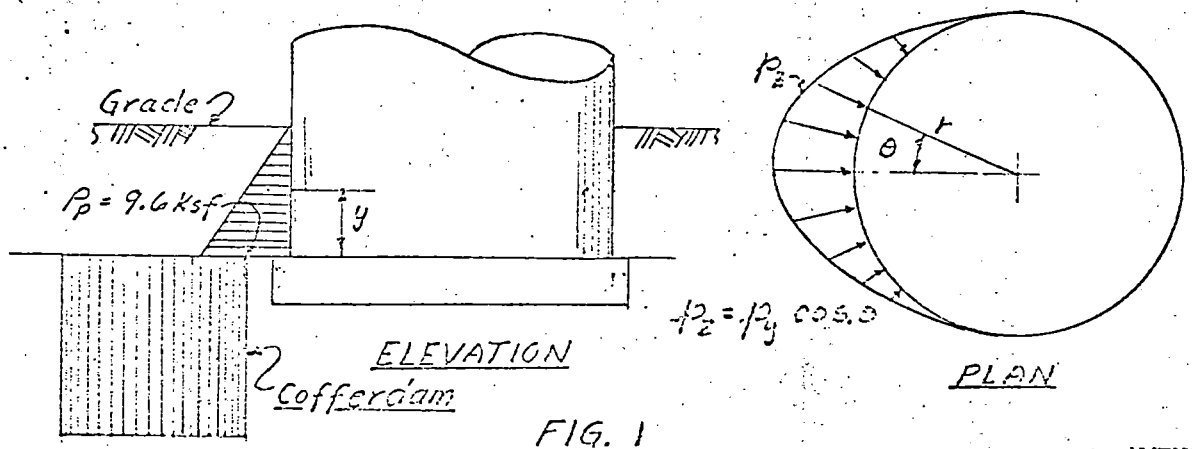


FIG. 1

AMENDMENT 8

Our preliminary calculations on the passive and dynamic pressures combined indicate that the equivalent hydrostatic pressure will be 400 pounds per cubic foot, which yields a maximum pressure of 9.6ksf at the top of the base mat.

We are interested in evaluating the effects of this loading on the cylindrical wall with respect to hoop stresses, meridonial stresses, shearing stresses and bending in the wall where it adjoins the base mat.

In Figure 1 we show the pressure distribution at any elevation on the containment.

The compressive nature of the loading indicates that the governing condition will be one where there is no internal pressure in the containment due to accident condition.

The hoop reinforcement was designed for a uniform internal pressure of 70.5psi which is equivalent to 10.2ksf. At the maximum, P_y would be 9.6ksf and the maximum hoop force would be 9.6 x r. This is a compressive force and the concrete as well as the reinforcing would be acting. In addition, the maximum pressure of 9.6ksf acts at the top of the mat where the movement of the cylinder is restricted and thus this maximum hoop force is not developed.

At any level y feet from the base,

$$V = 2\int_y^H \int_0^{\frac{\pi}{2}} p_z \cos.\theta\, r\, d\theta\, dy = \frac{\pi p_y r (H-y)}{2}$$

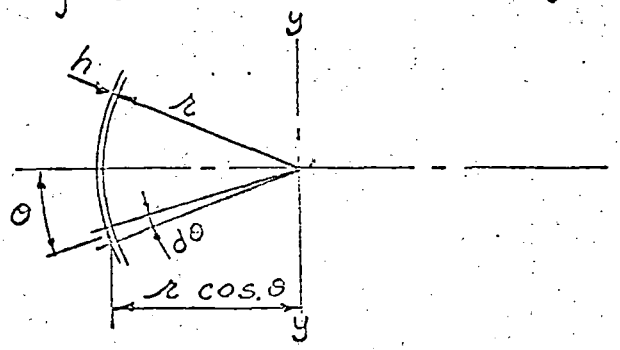


Fig. 2

AMENDMENT 8

$$Q_y = 2\int_0^{\theta} hr\, d\theta\, (r\cos.\theta)\, d\theta$$
$$= 2\int_0^{\theta} hr^2 \cos.\theta\, d\theta$$
$$= 2hr^2 \sin.\theta$$

$$I_y = \int x^2\, dA$$
$$= 4\int_0^{\frac{\pi}{2}} hr\, d\theta\, (r\cos.\theta)^2$$
$$= 4\int_0^{\frac{\pi}{2}} hr^3 \cos.^2\theta\, d\theta$$
$$= \pi h r^3$$

$$\frac{N'_{y\theta}}{h} = \frac{VQ}{Ib}$$

$b = 2h$

$$N'_{y\theta} = \text{Shearing force/ft.} = \frac{hV\,2hr^2 \sin.\theta}{\pi h r^3 \cdot 2h}$$
$$= \frac{V \sin.\theta}{\pi r}$$

$$\text{Total } V = \frac{9.6}{2}(24)\pi\,\frac{(72.25)}{2} = 13{,}000^{K}$$

$$N'_{y\theta\,(MAX.)} = \frac{13{,}000}{72.25\pi} = 57.5^{K}/FT.$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT INTERACTION OF GROUND & CYL. WALL COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

This will be taken by the seismic shear reinforcing and the concrete which is not cracked for this condition.

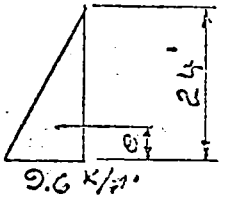
$$\frac{N_y'}{h} = \frac{M_x X}{I} \qquad \text{Where: } X = 2R\cos\theta$$

$$N_y' = \text{Meridional force/ft.} = \frac{h M_x R\cos\theta}{\pi h R^3} = \frac{M_y \cos\theta}{\pi R^2}$$

$$M_{y\,(MAX.)} = Ve$$

$$= 13{,}000^{K}(8') = 104{,}000^{IK}$$

$$N_{y\,(MAX.)}' = \frac{104{,}000}{\pi (72.25)^2} = 6.4^{K/FT.}$$



This is insignificant compared to the capacity of the wall.

There will be some bending moment at the intersection of the cylinder and the base. It will be maximum at $\theta = 0$, and zero at $\theta = \pi/2$ (Figure 1). However, even at its largest, it is evident by comparison of the design loads with the interaction forces that the reinforcement on the outside face of the wall (approximately 1/2 of that on the inside face) is much more than adequate to resist this bending.

In the final design, the actual stresses due to this loading will be computed.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY J. G.

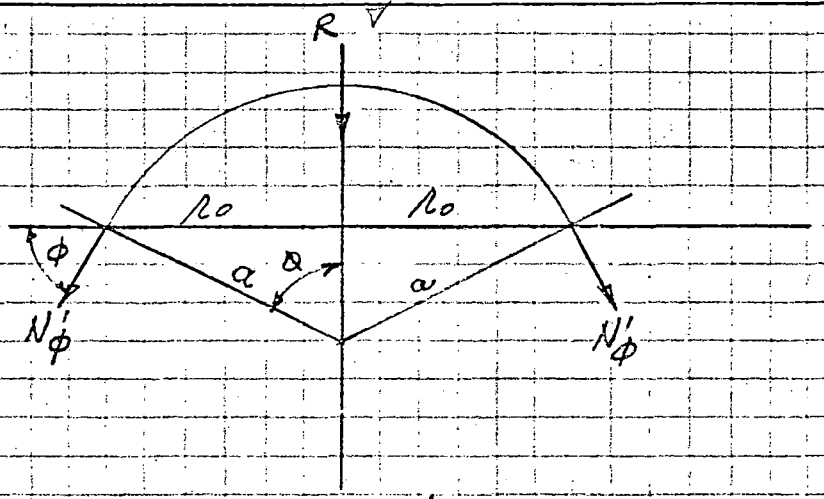
SUBJECT MEMBRANE STRESSES COMPUTATION SHEET DATE

FILE CHECKED BY A. J.

ESTIMATE DATE

MEMBRANE STRESSES - VARIOUS LOADS

General Dome Equations: For a Spherical Dome



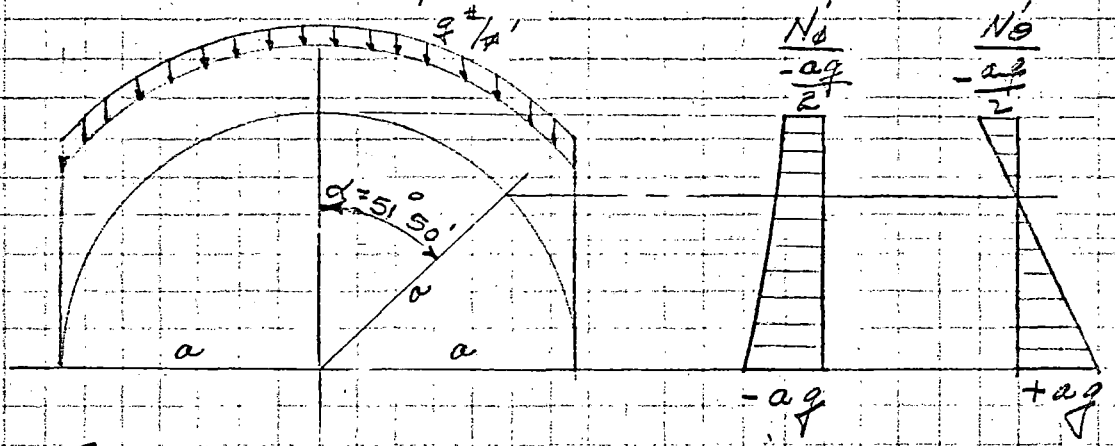
R is the total load obtained by multiplying q (uniform load) x effected area.

N'_ϕ = Meridional Force/l = $\dfrac{R}{2\pi r_o \sin\phi}$

N'_θ = Hoop Force/l = $\dfrac{R}{2\pi a \sin^2\phi} - p_2 \dfrac{r_o}{\sin\phi}$

p_2 is the pressure component of q directed toward the center of curvature.

Uniform Loading Over Dome Surface



$R = q^{\#}/ft^2 \times$ surface Area

$= 2q \int_0^\phi \pi a \sin\phi \cdot a\, d\phi = 2\pi a^2 q \int_0^\phi \sin\phi\, d\phi$

$= 2\pi a^2 q (1 - \cos\phi)$

$r_o = a \sin\phi$

$p_2 = q \cos\phi$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT MEMBRANE STRESSES COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

$$N_\phi' = -\frac{2\pi a^2 q (1-\cos\phi)}{2\pi a \sin^2\phi} = -\frac{a q (1-\cos\phi)}{\sin^2\phi}$$

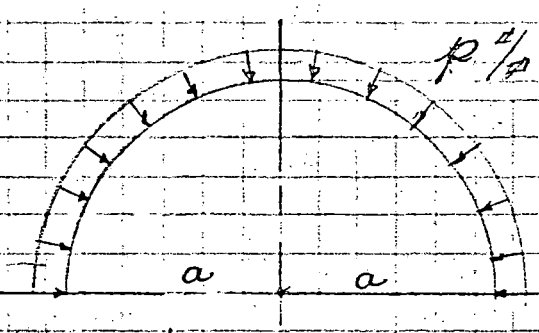
$$= -\frac{a q (1-\cos\phi)}{1-\cos^2\phi} = -\frac{a q (1-\cos\phi)}{(1-\cos\phi)(1+\cos\phi)}$$

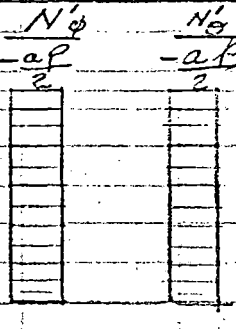
$$= -aq\left(\frac{1}{1+\cos\phi}\right)$$

$$N_\theta' = \frac{2\pi a^2 q (1-\cos\phi)}{2\pi a \sin^2\phi} - q\frac{\cos\phi \cdot a\sin\phi}{\sin\phi}$$

$$= aq\left(\frac{1}{1+\cos\phi} - \cos\phi\right)$$

Uniform External Pressure on Dome





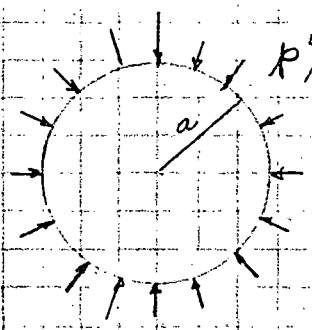
$$R = p_z \times \text{surface area} = p\,2\pi a^2 \int_0^\phi \sin\phi\cos\phi\,d\phi$$

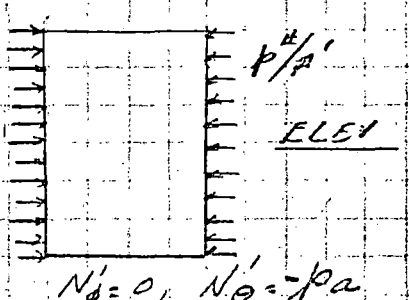
$$= \frac{\pi a^2 p}{2}\left[2\sin^2\phi\right]_0^\phi = \pi a^2 p \sin^2\phi$$

$$N_\phi' = -\frac{\pi a^2 p \sin^2\phi}{\pi\, 2a \sin^2\phi} = -\frac{ap}{2}$$

$$N_\theta' = \frac{\pi a^2 p \sin^2\phi}{2\pi a \sin^2\phi} - \frac{p\,a\sin\phi}{\sin\phi} = -\frac{ap}{2}$$

Uniform External Pressure on Cylinder





$N_\phi' = 0,\ N_\theta' = -pa$

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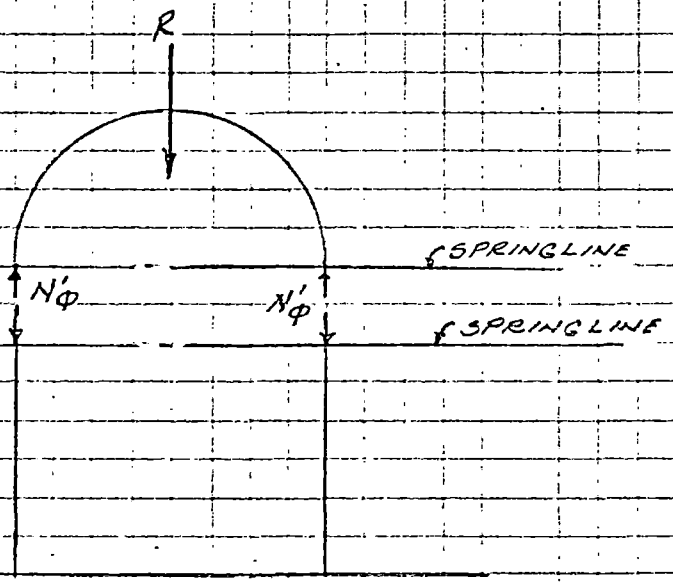
HOOP FORCE LOADINGS ON CYLINDER DUE TO DOME = 0.

MERIDIONAL FORCE LOADING ON CYLINDER DUE TO DOME:



REBAR STRESSES DUE TO WALL THERMAL GRADIENT

The stresses in the wall due to thermal gradient due not effect the capacity of the structure to carry load. This conclusion is based on the following rationale:

Temperature effects will induce stresses in the structure which are internal in nature. ie. The tension on the cold outside and the compression on the hot inside result in a net force equal to zero. Sketch 1 shows the physical section, either vertical or horizontal. Sketch 2 shows the initial stress distribution set up by a thermal gradient. Sketchs 3, 4 and 5 show how adding additional increments of axial tension causes the compression in the concrete to vanish and the tension in the steel to increase. When any fine of steel reaches yield, the additional load is transfered to the unyielded elements. This stress redistribution continues until in the condition shown in sketch 5, the magnitude of external final load resisted will be identical to that which would be carried

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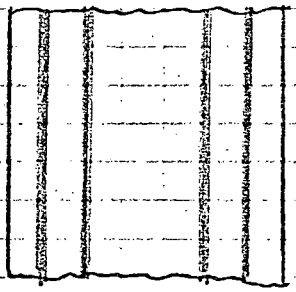
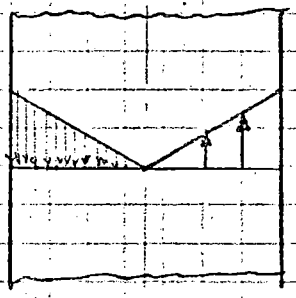
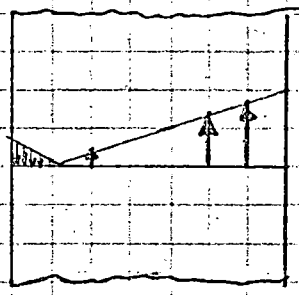
If the temperature effects were not considered. Ultimate strength design reinforces this argument because a basic assumption of ultimate strength design approach is that of transferring stresses THROUGH LOCAL REDISTRIBUTION AND EQUALIZATION.



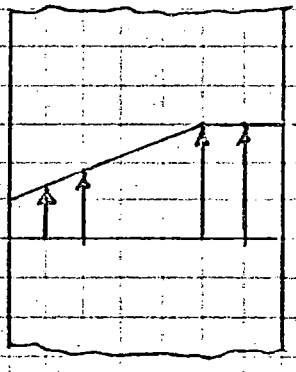
SK1



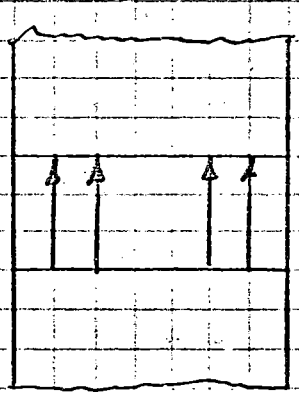
SK2



SK3



SK4



SK5

THERMAL LOAD FROM HEATING LINER

Expansion of the liner plate pushes against the concrete wall, thereby creating an interface pressure which adds tension to the rebars and an equal compression to the liner.

These pressures generate the forces TL, TL' and TL" on page 21.

If we assume erection temperature to be 60° F then the temperature rise for the different conditions are:

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1.5P & 1.0TL : $\Delta T = (306-60) = 246°$

1.25P & 1.0TL' : $\Delta T = (285-60) = 225°$

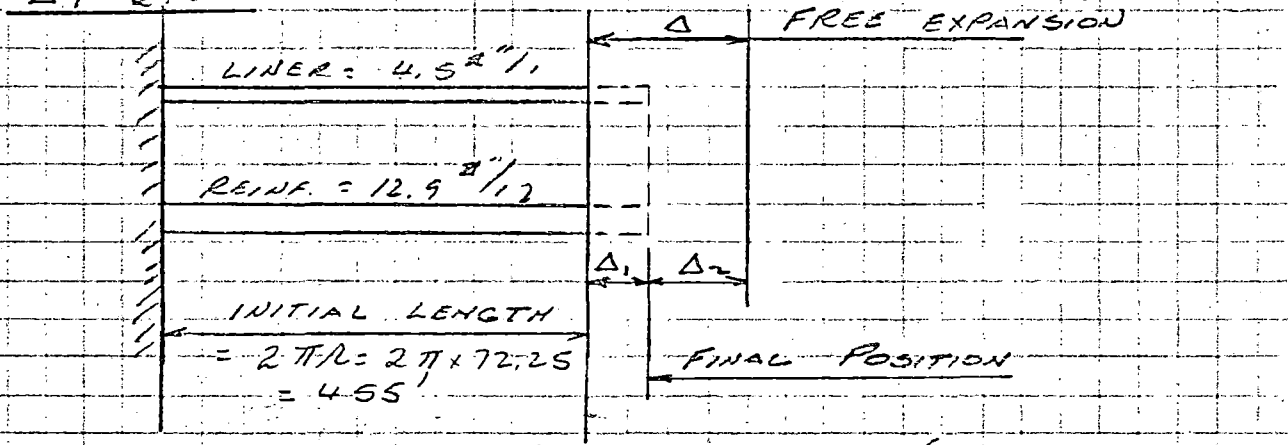
1.0P & 1.0TL'' : $\Delta T = (249-60) = 189°$

CYLINDER EQUIVALENT PRESSURE

Assume $\frac{3}{8}$" CYL. $R = 12 \times \frac{3}{8} = 4.5$ #/"

Assume horizontal reinf. @ 12.9 #/"

$\Delta T = 246°$



$\Delta_1 + \Delta_2 = \Delta = \alpha(\Delta T) L = 6.5 \times 10^{-6} \times 246 \times 455 \times 12 = 8.7"$

$\Delta_1 = \frac{P_R L}{A_R E}$; $\Delta_2 = \frac{P_L L}{A_L E}$

P_R = Force req'd. to stretch reinf.

A_R = Area of reinf.

P_L = Force req'd. to bring liner back from free expansion.

$P_L = P_R = P$

$\frac{12PL}{E}\left(\frac{1}{A_R} + \frac{1}{A_L}\right) = 8.7" = \frac{12PL}{E}\left(\frac{1}{4.5} + \frac{1}{12.9}\right) = \frac{3.61PL}{E}$

$P = \frac{8.7 \times 29 \times 10^6}{3.61 \times 455} = 153{,}000$ #/' $= N_\theta' = p \times 144 \times 72.25'$

p (interface) $= \frac{153{,}000}{144 \times 72.25} = 14.7$ psi

This pressure is independent of the length or circumference, the same answer is obtained for half the length, providing the areas of reinf. and liner are maintained.

N_θ for $\Delta T = 225° = 225/246 \times 153 = 140$ #/'

N_θ for $\Delta T = 189° = 189/246 \times 153 = 117$ #/'

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Checking the cylinder interface pressure by iteration process.

1. If the liner was free to expand, the increase in radius would be:

$W_1 = \alpha \Delta T a$

$= 6.5\times10^{-6}(246)\,72.25\times12 = 1.38"$

2. If the reinf. bars did not yield, the pressure due to the temperature increase would be; $PL/AE = \Delta = \alpha(\Delta T)L$ where $p_a = P$ and $A = h\times1$ $\therefore p = \dfrac{\alpha \Delta T E h}{a} = \dfrac{6.5\times10^{-6}(246)29\times10^{6}\times.375}{72.25\times12} = 20\text{ psi}$

3. Due to this pressure, the reinf. would give $W_2 = \dfrac{Pa}{A_s E}$ & $p_a = P$; $W_2 = \dfrac{pa^2}{A_s E} = \dfrac{20\times144\times72.25^2\times12}{12.9\times29\times10^6} = .48"$

4. The liner was prevented from moving $(1.38-.48) = W_3 = .9"$ which causes an interface pressure:

$W_3 = \dfrac{pa^2}{Eh}$ or $p = \dfrac{.9\times29\times10^6\times.375}{72.25^2\times144}$

$= 12.9\text{ psi}$

correction on reinf. yield $= \dfrac{12.9}{20}\times.48 = .31"$

correction on pressure $= \dfrac{(1.38-.31)}{.9}\times12.9 = 15.4\text{ psi}$

corr. on yield: $\dfrac{15.4}{20}\times.48 = .37"$

Corr. on $p = \dfrac{(1.38-.37)}{.9}\times12.9 = 14.5\text{ psi}$

Corr on yield: $\dfrac{14.5}{20}\times.48 = .35"$

Corr. on $p = \dfrac{(1.38-.35)}{.9}12.9 = 14.7\text{ psi}$

Corr on yield: $\dfrac{14.7}{20}\times.48 = .35"$

$\therefore$ no correction on p req'd. final $p = 14.7$ psi

N'_θ for $\Delta T = 225° = \dfrac{225}{246}\times153^{\#}/_{"} = 140^{\#}/_{"}$

N'_θ for $\Delta T = 169° = \dfrac{169}{246}\times153 = 117^{\#}/_{"}$

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DOME EQUIVALENT PRESSURE

Assume ½" dome plate = $12 \times \frac{1}{2} = 6^{\#}/_{1}$

Assume meridional and hoop reinf @ $6.25^{\#}/_{1}$

Investigation in hoop direction:

$\Delta T = 246°$

Since length is immaterial use $L = 100'$

$$\frac{12PL}{E}\left(\frac{1}{6.25} + \frac{1}{L}\right) = 6.5 \times 10^{-6} \times 246 \times 100 \times 12 = 1.93$$

$$\frac{12PL}{E}(.16 + .167) = \frac{3.92PL}{E} = 1.92"$$

$$P = \frac{1.92 \times 29 \times 10^{6}}{3.91 \times 100} = 144^{\#}/_{1} = N_{\theta} = N_{\phi}$$

$$144^{K} = P \times \frac{144 \times 71.75}{2}$$

$$\frac{2 \times 144 \times 1000}{144 \times 71.75} = 27.8 \text{ psi (interface pressure)}$$

$N_{\theta} = N_{\phi}$ for $\Delta T = 225° = \frac{225}{246} \times 144 = 132^{\#}/_{1}$

$N_{\theta} = N_{\phi}$ for $\Delta T = 189° = \frac{189}{246} \times 144 = 110^{\#}/_{1}$

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SHRINKAGE EFFECT:

Assume liner & reinf. steel to work together. The following calculations are based on literature from "Reinforced Concrete Structures" by Dean Peabody Jr., second Edition Pg. 187

① $\frac{f_s'}{E_s} = \varepsilon - \frac{f_c}{E_c}$

② $\Sigma F = 0$

$f_s' A_s = f_c A_c$

Where f_s' = compressive stress in steel

f_c = tensile stress in conc.

$E_c = 3.6 \times 10^6$

$E_s = 29 \times 10^6$

An avg. value of $\varepsilon = .0003$

Dome:

Peak: Circumferential & Meridional

A_s assumed: Hoop reinf. @ 6.25 #"/'

½" ℄ Liner steel @ 6.00 #"/'

12.25 #"/'

$A_c = 42" \times 12 - 6.25 = 498$ #"

① $\frac{f_s'}{29 \times 10^6} = .0003 - \frac{f_c}{3.6 \times 10^6}$

② $12.10 f_s' = 498 f_c$

$f_s' = \frac{498}{12.25} f_c = 40.8 f_c$

① $\frac{40.8 f_c}{29 \times 10^6} = .0003 - \frac{f_c}{3.6 \times 10^6}$

$40.8 f_c = 8700 - 8 f_c$

$48.8 f_c = 8700$

$f_c = +179$ psi tension * see Pg. 52

$f_s' = 40.8 \times 179 = -7300$ psi comp.

Springline: Circumferential & Meridional

Same as above.

Cylinder: Circumferential

A_s assumed: Hoop Reinf. @ 12.9 #"/'

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SUBJECT SHRINKAGE & COMPUTATION SHEET
FILE CREEP
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3/8" R Liner: = 4.5 #"/'

$\Sigma A_s = 12.9 + 4.5 = 17.4$ #"/'

$A_c = 54 \times 12 - 12.9 = 637$ #"/'

(1) $\frac{f_s'}{29\times10^6} = .0003 - \frac{f_c}{3.6\times10^6}$

(2) $17.4 f_s' = 637 f_c$

$f_s' = \frac{637}{17.4} f_c = 36.7 f_c$

(1) $\frac{36.7 f_c}{29\times10^6} = .0003 - \frac{f_c}{3.6\times10^6}$

$36.7 f_c = 8700 - 8 f_c$

$44.7 f_c = 8700$

$f_c = +194$ psi tension *

$f_s' = 36.7 f_c = 36.7 \times 194 = -7100$ psi.

Meridional:

$A_s = 5.9$ #" $\times 4.5 = 10.4$ #"

(2) $10.4 f_s' = 643 f_c$

$f_s' = \frac{643}{10.4} f_c = 62 f_c$

(1) $\frac{62 f_c}{29\times10^6} = .0003 - \frac{f_c}{3.6\times10^6}$

$62 f_c = 8700 - 8 f_c$

$70 f_c = 8700$

$f_c = +124$ PSI tension *

$f_s' = 62 f_c = 62 \times 124 = -7700$ psi

* Tensile strength determined by split cylinder tests are 6 to 7 times $\sqrt{f_c'}$

$= 6\sqrt{3500} = 350$

see "Design of Concrete Structures" Seventh Edition, by Winter, Urquhart, O'Rourke & Nilson ... pg. 19.

Effect of Creep By Dead Load

see "Reinforced Concrete Structures" by Peabody pg. 194.

Elastic stress in concrete $= \frac{N}{A_g + (n-1)A_s} = f_o$

$$b = \frac{1}{E_c}\left[\frac{1+(n-1)p}{np}\right]$$

c = plastic strain $= 100 \times 10^{-8}$ (avg.)

$f_c = \frac{f_o}{e^{c/b}}$ = stress in concrete due to plastic flow.

f_{is} = initial steel stress $= n f_o$

f_s^{Δ} = change in stress in steel due to plastic flow $= f_{is}\left(\frac{e^{c/b}-1}{e^{c/b}}\right)\left(\frac{1-p}{np}\right)$

In general there is no compressive stress in the circumferential direction due to dead load except in the dome from the peak to $\alpha = 51°50'$.

Dome: Peak: Meridional & Circumferential

q = 3.5' of conc $= 3.5 \times 150 = 525^{\#}/ft^2$

$\frac{1}{2}$" Liner $R = \frac{20}{545}$ a/a'

$$N_\theta = N_\phi = \frac{-aq}{2} = -\frac{545 \times 71.75}{2} = -19.6^{K}/_{1'}$$

$$p = \frac{12.25}{510} = .024$$

$$f_o = -\frac{19{,}600}{510 + 7 \times 12.25} = -32.6 \text{ psi}$$

$$b = \frac{1}{3.6 \times 10^6}\frac{[1+7(.024)]}{8(.024} = \frac{1.167}{3.6(.19)10^6} = 1.72 \times 10^{-6}$$

$$c/b = \frac{100 \times 10^{-8}}{1.72 \times 10^{-6}} = .582, \quad e^{c/b} = 1.79$$

$$f_c = -\frac{32.6}{1.79} = -18.2 \text{ psi}$$

$$f_{is} = n f_o = 8(-32.6) = -261$$

$$f_s^{\Delta} = -261\left(\frac{1.79-1}{1.79}\right)\left(\frac{1-.024}{8 \times .024}\right) = -595$$

-856 psi stress in steel

$= .86^{K}/_{in^2}$

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Spring Line Meridional

$N'_\phi = -q_g = -39.2^K/_{1'}$

Stress in steel due to creep $= -1.72^K/_{a''}$

Cylinder Base: Meridional

$N'_\phi = -4.5' \times 150^\#/_{ft^3} \times 142' - 39,200 = -135^K/_{1'}$

$p = \frac{10.4}{650} = .0159$

$f_o = -\frac{135,000}{650 + 7(10.4)} = -186 \text{ psi}$

$b = \frac{1}{3.6 \times 10^6}\left[\frac{1 + 7(.0159)}{8(.0159)}\right] =$

$= \frac{1}{3.6 \times 10^6}\frac{(1.111)}{.125} = 2.44 \times 10^{-6}$

$c/b = \frac{100 \times 10^{-8}}{2.44 \times 10^{-6}} = .412$

$e^{c/b} = 1.51$

$f_c = \frac{-186}{1.51} = -123$

$f'_{s_1} = n f_o = 8(-186) = -1480 \text{ psi}$

$f_s^\Delta = -1480 \frac{(.151)}{1.51}\frac{(.984)}{.127} = -3840$

-5320 psi creep in steel

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PS. 55

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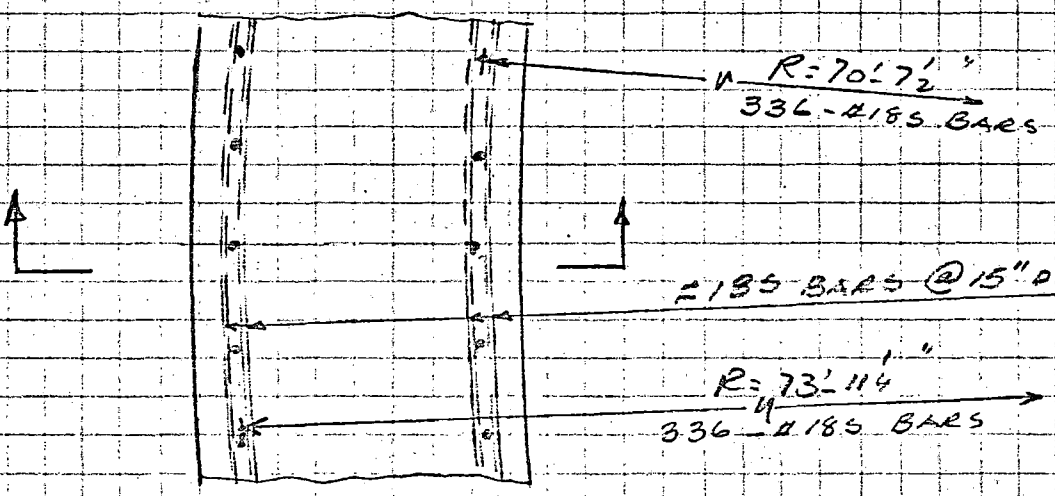
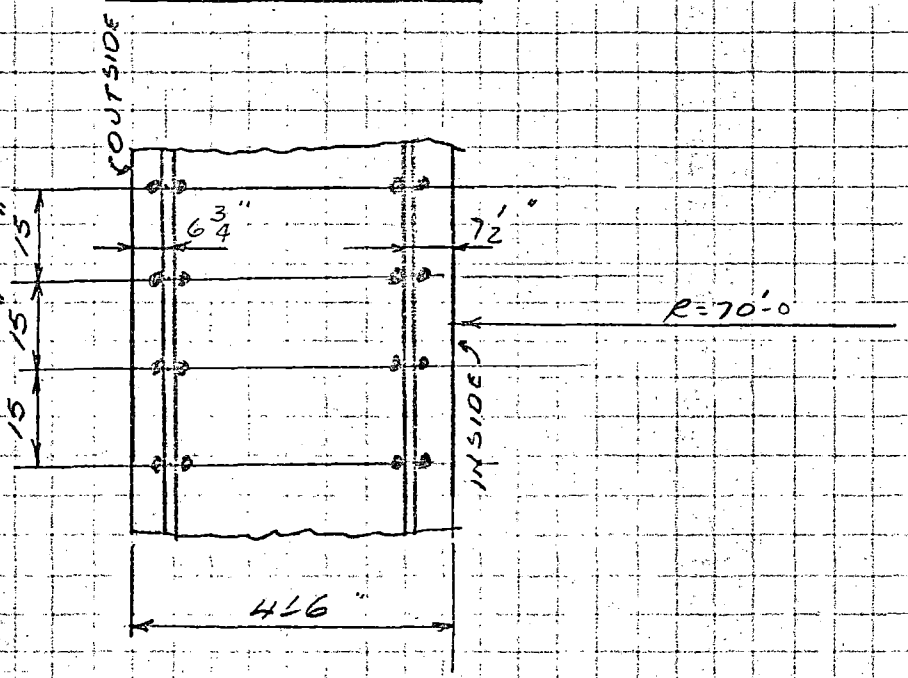
Basic reinforcing in Containment Cylinder:



PLAN SECTION



SECTIONAL ELEVATION

Meridional steel: Inner line: $\frac{2\pi \times 70.625 \times 12}{336} = 15.9"$ O.C

outer line: $\frac{2\pi \times 73.9375 \times 12}{336} = 16.6"$ O.C

$\frac{32.5}{2} = 16.25"$ avg.

$A_s = \frac{8" \times 12}{16.25} = 5.9 \#/'$

Hoop steel: $\frac{16 \times 12}{15} = 12.9 \#"$

Dome steel can only be estimated @ 6.25 #/' AVG. EA. WAY.

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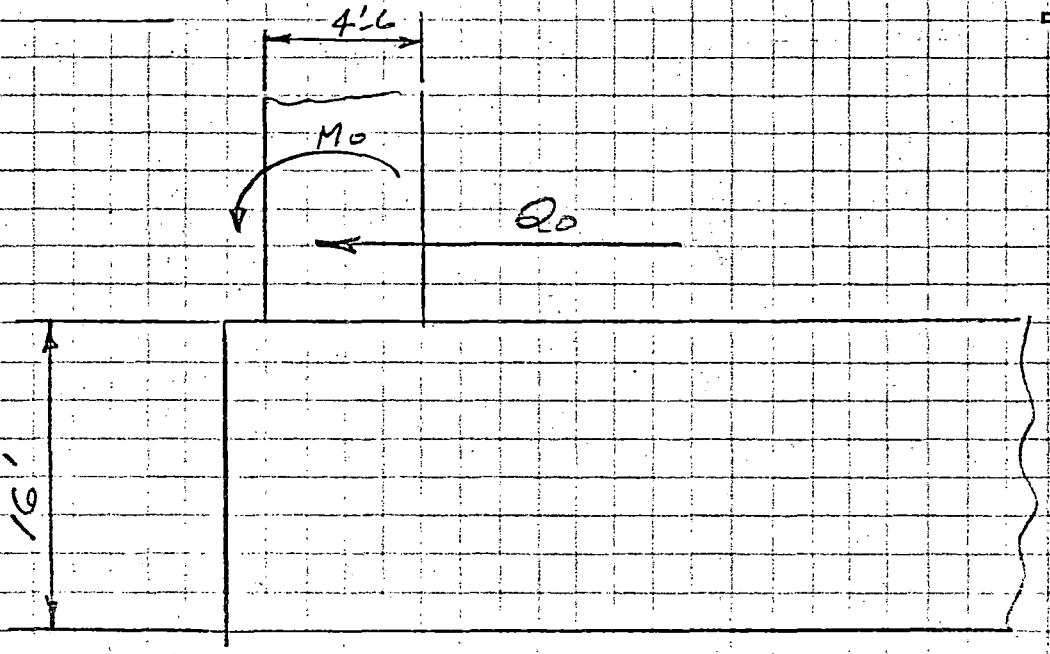

The mat is considered as offering complete fixity to the wall.
The following corrections are taken from Timoshenko & Woinowsky-Krieger "Theory of Plates and Shells" second edition pgs 468-470

If Mo and Qo are respectively, the external moment and shearing force per increment of cylinder perimeter which will force the cylinder to conform to the boundary conditions where the cylinder & mat meet; then for a fixed end condition:

$$(w)_{y=0} = -\frac{1}{2B^3D}(BM_o + Q_o) = \delta$$

$$\left(\frac{dw}{dy}\right)_{y=0} = \frac{1}{2B^2D}(2BM_o + Q_o) = 0$$

and for any other point y distance from the mat:

$$w = -\frac{1}{2B^3D}[BM_o\chi(By) + Q_o\theta(By)]$$

$$\frac{dw}{dy} = \frac{1}{2B^2D}[2BM_o\theta(By) + Q_o\phi(By)]$$

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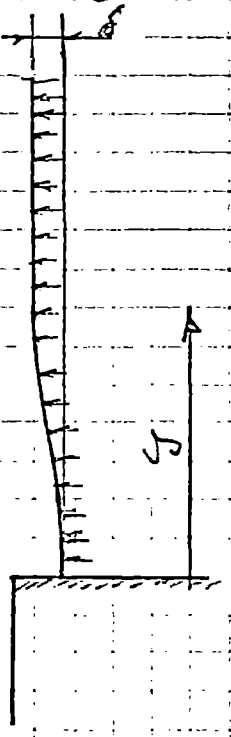
$$M''_y = \frac{1}{2\beta}\left[2\beta M_o \phi(\beta y) + 2Q_o \zeta(\beta y)\right]$$

$$Q''_y = -\left[2\beta M_o \zeta(\beta y) - Q_o \chi(\beta y)\right]$$

w is the radial deflection measured from the norm of the cylinder under the radial loading. For the containment, this will consist of pressure, temperature and shrinkage loading. δ is the max. value.



$\frac{dw}{dy}$ is the slope of the elastic curve.

M''_y & Q''_y are the moment and shear at any height y engendered by the fixity of the base with their maximum values M_o & Q_o at the base.

D is the flexural rigidity of the cracked wall section $= E_c I$ (E_c: Modulus of elasticity of concrete)

$$\beta = \sqrt[4]{\frac{E_s h}{4r^2 D}}$$

E_s is the modulus of elasticity of the reinf.
h is the area of hoop steel per unit height of wall
r is the mean radius of the wall

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$$\phi(\beta y) = e^{-\beta y}(\cos \beta y + \sin \beta y)$$

$$\chi(\beta y) = e^{-\beta y}(\cos \beta y - \sin \beta y)$$

$$\theta(\beta y) = e^{-\beta y}(\cos \beta y)$$

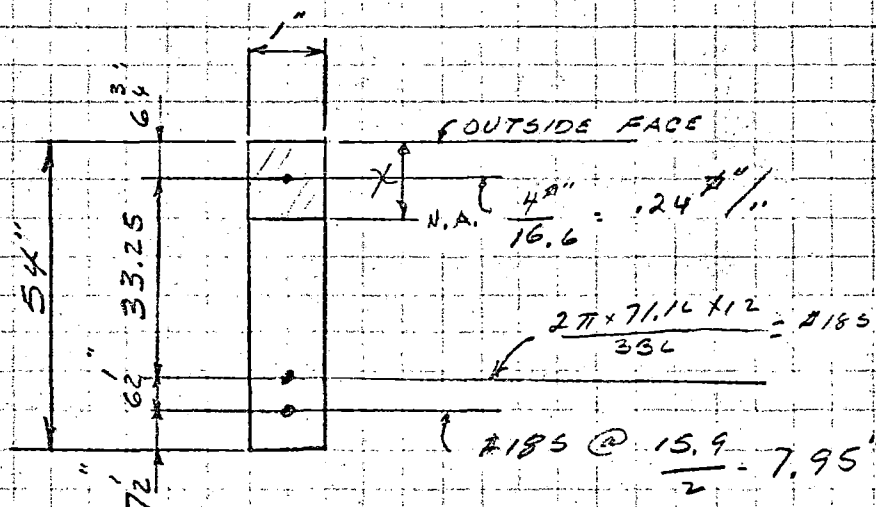
$$\psi(\beta y) = e^{-\beta y}(\sin \beta y)$$

On pages 472 & 473 of "Theory of Plates and Shells" by Timoshenko etc., the values of ϕ, χ, θ and ψ for values of βy are tabulated.

$$N_\theta'' = -\frac{Ehw}{r}$$

$$N_\theta'' + N_\theta' = N_\theta$$

Calculation of I of cracked section:



$\frac{4\#''}{16.6} = .24\#''/''$

$\frac{2\pi \times 71.14 \times 12}{336} = \#18s@16'' = \frac{4}{16} = .25\#''/''$

$\#18s @ \frac{15.9}{2} - 7.95'' = \frac{4}{7.95} = .503\#''/''$

$$7(.24)(x - 6.75) + \frac{x^2}{2} = 8(.503)(46.5 - x) + 4(.25)(40 - x)$$

$$1.68x - 11.4 + \frac{x^2}{2} = 187 - 4.02x + 80 - 2x$$

$$\frac{x^2}{2} + 7.7x - 278.4 = 0$$

$$x^2 + 15.4 - 556.8 = 0$$

$$x = \frac{-15.4 \pm \sqrt{(15.4)^2 + 4(556.8)}}{2} = \frac{-15.4 \pm \sqrt{237 + 2220}}{2}$$

$$= \frac{-15.4 + \sqrt{2457}}{2} = 17''$$

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SUBJECT RESTRAINT OF MAT COMPUTATION SHEET DATE

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$I = \frac{1}{3} \times 17 \times \overline{17}^3 + 1.68 \times 10.25 \times \overline{}^2 + 2 \times 23 \times \overline{}^2 + 4.02 \times 29.5 \times \overline{}^2$

$= 1630 + 177 + 1050 + 3440 = 6347$

1.5P + 1.0TL CONDITION:

"w" is the result of 3 forces acting on the cylinder:

1. Internal pressure seeking to expand cyl.
2. Shrinkage of concrete seeking to compress cylinder.
3. Heating of liner plate seeking to expand cylinder.

The cylinder is considered to be the hoop reinforcement.

$\frac{1.5 \times 47 \times 144 \times 72.25}{17.4} = 42,300$ psi (1.5P)

$\frac{14.7 \times 144 \times 72.25}{12.9} = \frac{11,950}{54,250}$ psi (1.0TL)

$- \frac{7100}{47,150}$ psi (S)

$"w" = \frac{47,150 \times 72.25 \times 12}{29 \times 10^6} = 1.41"$

$\beta^4 = \frac{Eh}{4r^2D}$

$D = EI = 3.4 \times 10^6 \times 6347 = 2.16 \times 10^{10}$

$r = 72.25 \times 12 = 867"$

$Eh = 29 \times 10^6 \times \frac{12.9}{12} = 31.2 \times 10^6$

$\beta^4 = \frac{31.2 \times 10^6}{4(867)^2 2.3 \times 10^{10}} = \frac{1}{22.2 \times 10^8}$

$\beta^2 = \frac{1}{4.71 \times 10^4}$; $\beta = \frac{1}{2.17 \times 10^2}$

$\beta^3 = \frac{1}{10.2 \times 10^6}$; $\beta^3 D = \frac{2.16 \times 10^{10}}{10.2 \times 10^6} = .212 \times 10^4$

$\beta^2 D = \frac{2.16 \times 10^{10}}{4.71 \times 10^4} = .458 \times 10^6$

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ESTIMATE DATE

(1) $(w)_{y=0} = 1.41 = -\frac{1}{2 \times .212 \times 10^4}\left(\frac{M_o}{217} + Q_o\right)$

(2) $\left(\frac{dw}{dy}\right)_{y=0} = 0 = \frac{1}{2 \times .458 \times 10^6}\left(\frac{2M_o}{217} + Q_o\right)$

(1) $5970 = -\frac{M_o}{217} - Q_o$

(1) $1{,}295{,}000 = -M_o - 217 Q_o$

(2) $0 = +M_o + 108.5 Q_o$

$1{,}295{,}000 = -108.5 Q_o$

$-11.95^{K}/_{''} = Q_o = 143^{K}/_{'}$

$M_o = -108.5(-11.95) = +1295^{''K}/_{''} = +12.95^{'K}/_{'}$

VERT. LOAD ON BASE SECTION /FT.

Condition @ C = 1.00 ±.05D +1.5P +1.0TL

The following conservative assumptions shall be made: 1. Shrinkage plus Creep will be included in loads on vertical rebars

2. The dead load shall be taken by the vertical rebars when in combination with pressure loads.

3. The pressure & E.Q. loads shall be resisted by both rebars and liner.

4. The vertical rebars shall be considered those that run full height of wall = 5.9 ft

5. The liner shall be assumed to be a 3" ℄ for entire height for the purpose of apportioning loads between rebars & liner.

		$^{K}/_{'}$
Dead Load:	$.95 \times 135^{K}/_{'}$ =	−128
SHRINKAGE:	$-7.7^{K}/_{a''} \times 5.9^{ft}/_{'}$ =	− 45.5
PRESSURE:	$\frac{70.5+144}{2} \times 71.25 \times \frac{5.9}{(5.9+4.5)}$ =	+ 207.0
TEMP.	=	+144
CREEP:	-5.32×5.9 =	− 31.5
		$+146.0 = N_y$

$\frac{146}{12} = 12.2^{K}/_{'}$

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SUBJECT RESTRAINT OF MAT COMPUTATION SHEET DATE

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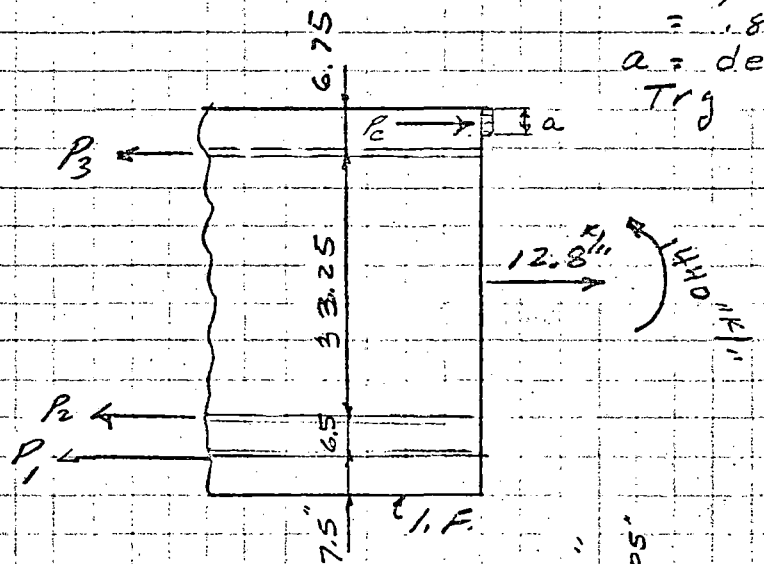
Checking base section out:
Since the capacity reduction factor for tension is .95 and that for bending is .90 we will increase the acting moment and tension load by dividing by .90 and .95 respectively instead of decreasing the allowable stresses by any particular amount. Therefore, design $M_u = \frac{1295}{.90} = 1440$ "K/",

design load $= \frac{12.2}{.95} = 12.8$ K/"

Design conc. capacity @ ultimate
$= .85 f'c = .85 \times 3500 = 2.97$ K/a"
a = depth of concrete in comp,
Try a = 4"; N.A. @ c = 4/.85 = 4.7"



$P_c = 4 \times 2.97 = 11.9$ K

If the outermost steel reaches yield,
$P_1 = .503 \times 60 = 30.2$ K
$P_2 = .25 \times 60 = 15.0$ K
$\varepsilon_1 = \varepsilon_2 = \frac{60{,}000}{29 \times 10^6} = .00207$

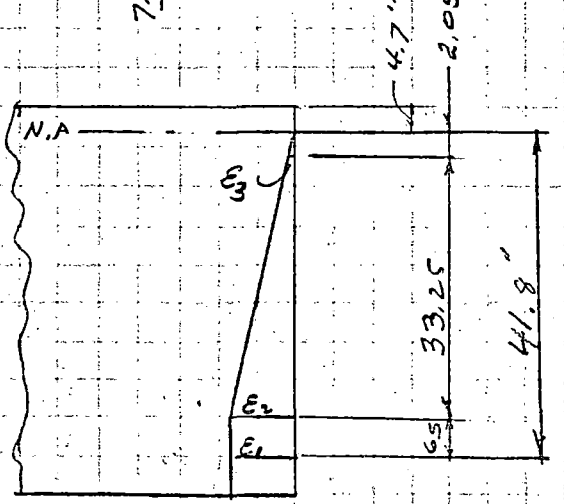
$\varepsilon_3 = \frac{2.05}{35.3} \times .00207 = .0001$

$f_3 = .00012 \times 29 \times 10^6 = 3.5$ K/"
$P_3 = 3.5 \times .24 = .85$

$12.9^K \rightarrow + 11.9^K \rightarrow = 24.7^K \leftarrow$

$30.2^K + 15 + .85 \leftarrow^K = 46.05^K \leftarrow$

Therefore no balance of loads.



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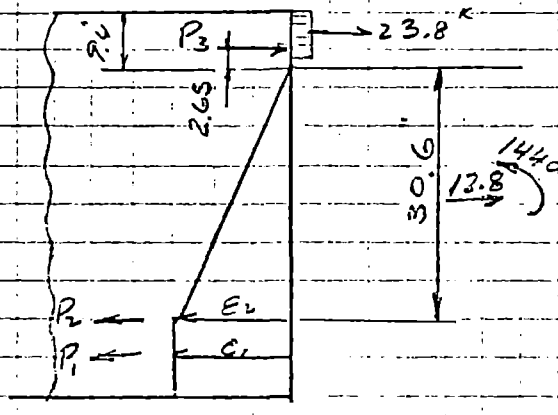
Try $a = 8"$, $c = \frac{8}{.85} = 9.4"$, $P_c = 8 \times 2.97 = 23.8^K$



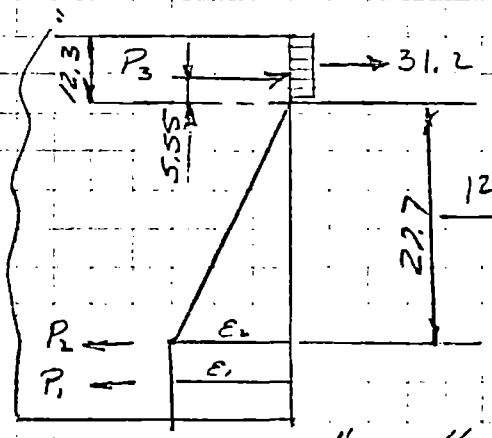
$\varepsilon_3 = \frac{2.65}{30.6} \times .00207 = .00018$

$P_3 = .00018 \times 29 \times 10^6 \times .24 = 1.25^K$

$12.8 + 23.8 + 1.25 = 37.85 \rightarrow$

$30.2 + 15 = 45.2^K \leftarrow$

Try $a = 10.5"$, $c = \frac{10.5}{.85} = 12.3"$, $P_c = 10.5 \times 2.97 = 31.2^K$



$\varepsilon_3 = \frac{5.55}{27.7} \times .00207 = .000415$

$P_3 = .000415 \times 29 \times 10^6 \times .24 = 2.9^K$

$12.8 + 31.2 + 2.9 = 46.9 \rightarrow$

$a = 10"$ will work ; $P_c = 10 \times 2.97 = 29.7^K$

$P_3 = 45.2 - 29.7 - 12.8 = 2.7^K$

Resisting Moment about ℄ wall:

$30.2\,(19.5) + 15\,(13) + 29.7\,(22) + 2.7\,(20.25)$

$= 590 + 195 + 655 + 56 = 1496 > 1440$ ∴ O.K.

1.2P + 1.0TL' + 1.25E CONDITION

$\frac{1.25 \times 47 \times 144 \times 72.25}{17.4^{Ft.}} = 35{,}000$ (1.25P)

$11{,}950 \times \frac{225}{246} = 10{,}900$ (1.0 TL')

$45{,}900$

$- 7{,}100$ (S)

$38{,}800$

$w = 38{,}800 \times 72.25 \times 12 / 29 \times 10^6 = 1.16"$

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VERT. LOAD ON BASE SECTION:

Condition ⑥ $C = 1.00 \pm .05D + 1.25P + 1.0TL' + 1.25E$

Dead Load = $-128^{K/'}$

Shrinkage = -45.5

Creep = -31.5

Pressure = $\frac{1.25 \times 47 \times 144 \times 71.75 \times 5.9}{2 \times 10.4} = +172.0$

Temp: $+132.0$

$1.25E: (147.5 + 14.8) \times \frac{5.9}{10.4}$ $+92.0$

$+191^{K/'} = N_y$

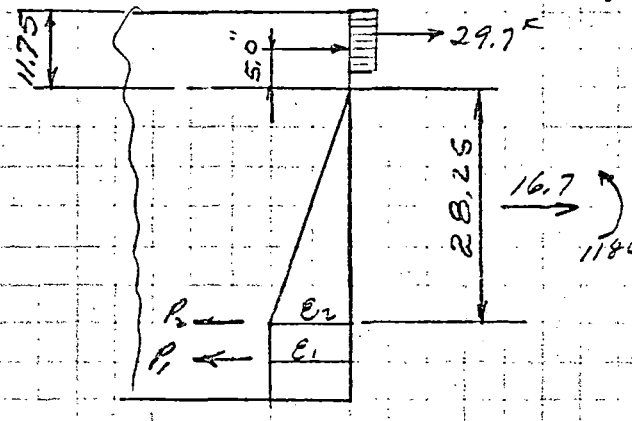
$\frac{191}{12} = 15.9^{K/''}$

$M_o = \frac{1.16}{1.41} \times 1295 = 1065^{''K/''}$

$Q_o = \frac{1.16}{1.41} \times 143^{K/'} = -117^{K/'}$

$M_u = \frac{1065}{.90} = 1180^{''K/''}$

$P = \frac{15.9}{.95} = 16.7^{K/''}$



Try $a = 10''$, $c = \frac{10}{.85} = 11.75''$

$P_c = 29.7^K$

$\varepsilon_3 = \frac{5.0}{28.25} \times .00207 = .000366$

$P_3 = .000366 \times 29 \times 10^6 \times .24$

$= 2.56^K$

$16.7^K \rightarrow + 29.7 \rightarrow + 2.56^K \rightarrow = 48.96$

$P_1 + P_2 = 45.2^K \leftarrow$

Try $a = 9''$, $c = \frac{9}{.85} = 10.6''$, $P_c = 9 \times 2.97 = 26.7^K$

$P_3 = \frac{3.85}{29.4} \times .00207 \times 25 \times 10^6 \times .24 = 1.9^K$

$16.7 + 26.7 + 1.9 = 45.3^K \rightarrow$

$P_1 + P_2 = 45.2 \leftarrow$

Resisting moment about E wall:

$30.2 \times 19.5 + 15 \times 13 + 26.7(22.5) + 1.9(20.25) > 1180^{''K/'}$

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1.0P + 1.0TL" + 1.0E' CONDITION

$\frac{47 \times 144 \times 72.25}{17.4} = 28000$ (1.0P)

$11,950 \times \frac{189}{246} = 9200$ (1.0TL")

37200

$-\ 7100$ (S)

$30,100$

$w'' = \frac{30,100 \times 72.25 \times 12}{29 \times 10^6} = .9''$

VERT LOAD ON BASE SECTION

Condition ⓒ C = 1.0D + .05D + 1.0P + 1.0TL" + 1.0E'

Dead Load = −128 K/'

Shrinkage = − 45.5

Creep = −31.5

Pressure = $\frac{47 \times 144 \times 71.75 \times 5.9}{2 \times 10.4} = +138.0$

Temp = 185.5 $+110$

1.0E': (166.5 + 19) $\frac{5.9}{10.4}$ $+105.0$

$+148$ K/' = N'y

$M_o = \frac{.9}{1.41} \times 1295 = 8.30$ "K/'

By comparison with conditions ⓐ and ⓑ it is evident that condition ⓒ is not critical.

y in.	B	B_y	M_y''	Q_y''	"w"	$N_o'' = -\frac{Ehw}{2}$
0	$\frac{1}{217}$	0	+1295 "K/'	−11.95 K/'	+1.41	−615
21.7		.1	+1050	−10.75	+1.40	−605
43.4		.2	+835	−9.6	+1.34	−580
65.1		.3	+630	−8.3	+1.30	−562
86.8		.4	+455	−7.4	+1.24	−535
108.5		.5	+314	−6.4	+1.16	−503
130.2		.6	+182	−5.4	+1.08	−468
152		.7	+76	−4.55	+.98	−422
173		.8	−10.8	−3.75	+.89	−384
195		.9	−87	−3.0	+.81	−350

PLOT FOR 1.5P CONDITION

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y_{in}	B	By	M_y "#/"	Q_y"	"w"	$N_\theta = \frac{-Ehw}{2}$
217	$\frac{1}{217}$	1.0	-149	-2.4	+.72	-310
261		1.2	-223	-1.3	+.55	-238
304		1.4	-258	-.5	+.40	-173
29.0' = 348		1.6	-268	0	+.27	-117
392		1.8	-256	+.5	+.18	-78
434		2.0	-230	+.7	+.09	-39
43.5' = 522		2.4	-157	+.8	0	0
610		2.8	-100	+.7	-.05	+22
58.0' = 695		3.2	-55	+.5	-.06	+26
785		3.6	-15	+.3	-.05	+22
870		4.0	0	+.14	-.037	+16
80'. = 960		4.4		0	-.02	+9
87' = 1040		4.8			0	0
1300		6.0				

PLOT FOR 1.15P CONDITION

All figures above are for (1.5P + 1.0TL) condition
To obtain figures for (1.25P + 1.0TL') and (1.0P + 1.0TL") conditions multiply by $\frac{1.16}{1.41}$ and $\frac{.9}{1.41}$ respectively.

"w" for test conditions @ 1.15P & 0°ΔT

$$f_s = \frac{47 \times 1.15 \times 144 \times 72.25}{12.4} - 7,100 = 25,200 \text{ psi}$$

$$"w" = \frac{25,200}{30,150} \times .9 = .75"$$

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ESTIMATE DATE

Bending at Junction of Cylinder and Dome

Note: The following analysis is based on text "Thin Shell Concrete Structures" by David P. Billington.

Dead load: $q = 3.5' \times .15^{K}/_{ft^3} = .525^{K}/_{ft'}$ (conc.)

$+ .020$ (liner)

$.545^{K}/_{ft'}$

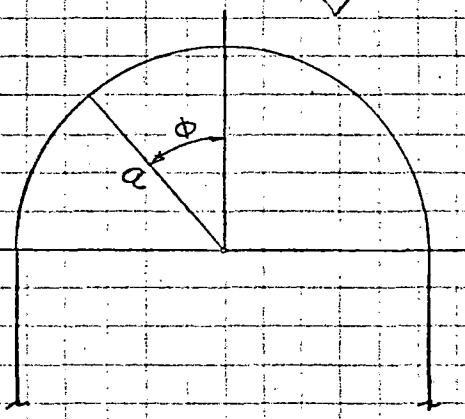
$$N_\phi' = -aq \frac{1}{1+\cos\phi}$$

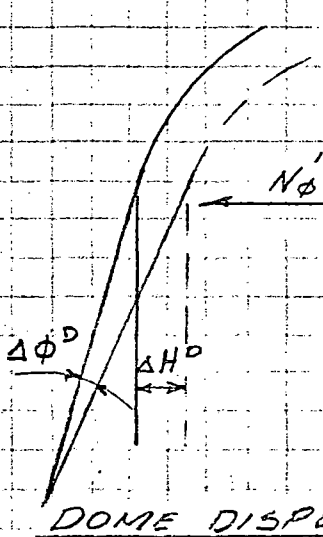
@ $\phi = 90°$

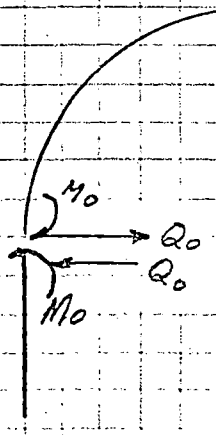
$N_\phi' = -aq$

$= -71.75 \times .545$

$= -39.2^{K}/_{'}$







CORRECTIONS

DOME DISPLACEMENTS

Based on membrane theory with top of wall free.

DISPLACEMENTS:

DOME:

$$\Delta H^D = a \sin\phi\, \varepsilon_\theta = \frac{1}{Eh}(N_\theta - \nu N_\phi')\, a \sin\phi$$

assuming $\nu = 0$: $\Delta H^D = \frac{a \sin\phi}{Eh} N_\theta' = \frac{a^2 q \sin\phi}{Eh}\left(\frac{1}{1+\cos\phi} - \cos\right)$

E will be E_{steel} and h will be based on equivalent width of hoop reinforcing steel plus liner steel.

$$\Delta\phi^D = \frac{\cot\phi}{aEh}\left[N_\phi'(a+\nu a) - N_\theta'(a+\nu a)\right] - \frac{d}{a\,d\phi}\left(\frac{\Delta H}{\sin\phi}\right)$$

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SUBJECT DISCONTINUITY @ COMPUTATION SHEET
FILE SPRING LINE
ESTIMATE

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For D.L. $\Delta\phi^D = -\frac{aq}{Eh}(2+\nu)\sin\phi$

If $\nu = 0$

$\Delta\phi^D = -\frac{2aq\sin\phi}{Eh}$

DISPLACEMENT OF WALL = 0

Hoop reinf. in Dome @ spring line = 6.25 #"/'
Liner R. = $\frac{1}{2}$" × 12" = 6.00
12.25 #"/'

Equiv. width of steel = $h = \frac{12.25}{12} = 1.03$"

Sign Convention For Displacements & Corrections

Dome: ΔH outward is +
Wall: ΔH inward is +
Dome and Wall: $\Delta\phi$ compression on outside face is +

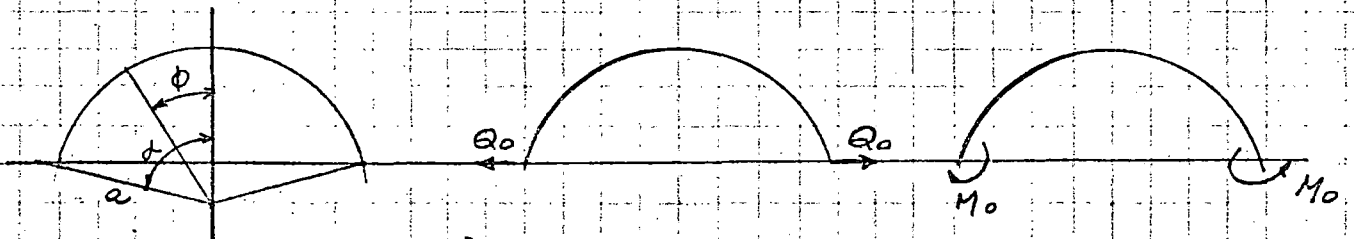
$$\Delta H^D = +\frac{(861)^2(.545)^{K/ft^2}}{29{,}000^{K/in^2}(1.03)(144)}\left(\frac{1}{1+0}-0\right) = +.094''$$

$$\Delta\phi^D = -\frac{2\times 861\times .545}{29{,}000\times 1.03\times 144} = -.000218$$

Corrections involve application of moments and shears to restore the shell to a condition of compatibility with M_o and Q_o existing at the springline. These moments and shears shall be taken by the reinforcement, not the liner:

CORRECTIONS: (see P 2-6 of "Thin Shell Conc. Struct.")

DOME:



$$\Delta H^D = \frac{2a\lambda\sin^2\alpha\, Q_o}{Eh} + \frac{2\lambda^2\sin\alpha\, M_o}{Eh}$$

$$\Delta\phi^D = \frac{2\lambda^2\sin\alpha\, Q_o}{Eh} + \frac{4\lambda^3 M_o}{Eah}$$

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REFER TO SALEM GEN. STA
SUBJECT DISCONTINUITY @ COMPUTATION SHEET
FILE SPRING LINE
ESTIMATE

PREPARED BY I.G
DATE
CHECKED BY A.J.
DATE

from pg 62 "Thin Shell Conc. Structures"

(m) $\frac{d^2 Q_\phi}{d\phi^2} = E h V$

(o) $\frac{d^2 V}{d\phi^2} = -\frac{a^2}{D} Q_\phi$

but $\frac{d^4 Q_\phi}{d\phi^4} = Eh \frac{d^2 V}{d\phi^2}$

and $\frac{d^4 Q_\phi}{d\phi^4} = -\frac{a^2 E h}{D} Q_\phi$

If $\frac{d^4 Q_\phi}{d\phi^4} + 4\lambda^4 Q_\phi = 0$ (Pg 63 "Thin Shell Conc. Struct.")

then: $\lambda^4 = \frac{a^2 E h}{4D}$

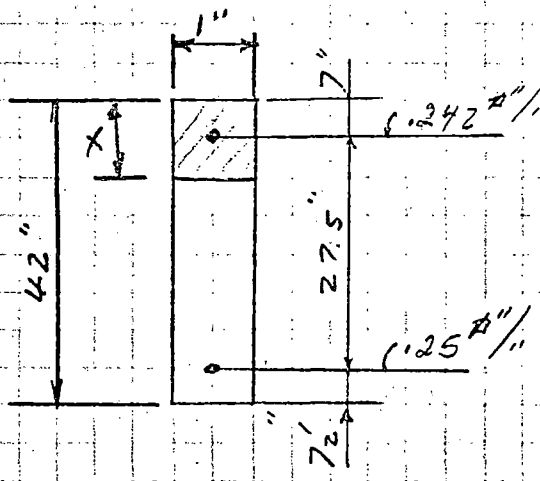
Wall:

$\Delta H^\omega = \frac{Q_o}{2\beta^3 D} - \frac{M_o}{2\beta^2 D}$ where $\beta^4 = \frac{Eh}{4a^2 D}$ and $D = EI$

$\Delta \phi^\omega = -\frac{Q_o}{2\beta^2 D} + \frac{M_o}{\beta D}$

I OF DOME @ SPRING LINE

Assume 42" section:



$\frac{X^2}{2} + 7(.242)(X-7) = 8(.25)(34.5-X)$

$\frac{X^2}{2} + 1.7X - 11.8 = 69 - 2X$

$\frac{X^2}{2} + 3.7X - 80.8 = 0$

$X^2 + 7.4X - 161.6 = 0$

$X = \frac{-7.4 \pm \sqrt{7.4^2 + 4(161.6)}}{2} =$

$X = 9.5"$

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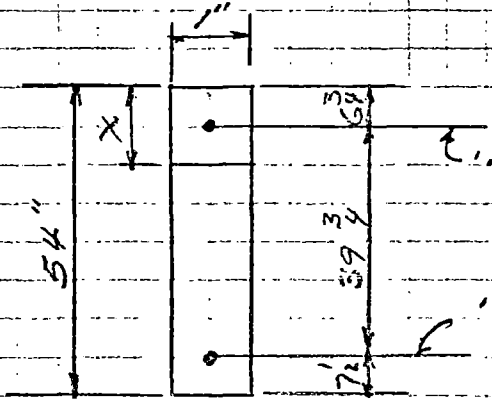
$$I = \frac{1}{3} \times \overline{9.5}^3 + 7(.242)\overline{2.5}^2 + 8(.25)\overline{2.5}^2$$

$$= 285 + 11 + 1250 = 1546$$

I WALL



$$\frac{X^2}{2} + 7(.24)(X - 6.75) = 8(.25)(46.5 - X)$$

$$\frac{X^2}{2} + 1.68X - 11.2 = 93 - 2X$$

$$\frac{X^2}{2} + 3.68X - 104.2 = 0$$

$$X^2 + 7.36X - 208.4 = 0$$

$$X = \frac{-7.36 \pm \sqrt{7.36^2 + 4(208.4)}}{2}$$

$X = 11.2$

$$I = \frac{1}{3} \times \overline{11.2}^3 + 7(.24)\overline{4.45}^2 + 8(.25)\overline{35.3}^2$$

$$= 468 + 33 + 2520 = 3021$$

CORRECTIONS DOME:

$$h = \frac{6.25\#"}{12"} = .520"$$

$$\lambda^4 = \frac{a^2 E h}{4D} = \frac{(861)^2 29\times10^6 (.520)}{4 \times 3.4\times10^6 \times 1546} = 530$$

$\lambda^2 = 22.9$

$\lambda = 4.45$

$\lambda^3 = 102$

$$\Delta H^D = \frac{2(861)4.45(1)Q_o}{29{,}000(.520)} + \frac{2(22.9)(1)M_o}{29{,}000(.520)}$$

$$= .505 Q_o + .00304 M_o$$

$$\Delta \phi^D = \frac{2(22.9)(1)Q_o}{29{,}000 \times .520} + \frac{4(102)M_o}{29{,}000 \times 861 \times .520}$$

$$= .00304 Q_o + .0000316 M_o$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G

SUBJECT DISCONTINUITY COMPUTATION SHEET DATE

FILE SPRING LINE CHECKED BY A.J.

ESTIMATE DATE

CORRECTIONS; WALL

$\beta^4 = \frac{Eh}{4a^2D}$; $h = \frac{12.9}{12} = 1.07$

$\beta^4 = \frac{29\times10^6 \times 1.07}{4(861)^2 \times 3.4\times10^6 \times 3021} = \frac{1}{9.9\times10^8}$

$\beta^2 = \frac{1}{3.15\times10^4}$; $\beta = \frac{1}{1.78\times10^2}$; $\beta^3 = \frac{1}{5.6\times10^6}$

$\Delta H^\omega = \frac{Q_o \times 5.6\times10^6 \times 1000}{2\times 3.4\times10^6 \times 3021} - \frac{M_o \times 3.15\times10^4 \times 1000}{2\times 3.4\times10^2 \times 3021}$

$= .272 Q_o - .00153 M_o$

$\Delta\phi^\omega = -.00153 Q_o + \frac{M_o \times 1.78\times10^2 \times 1000}{3.4\times10^6 \times 3021}$

$= -.00153 Q_o + .0000173 M_o$

DISPLACEMENTS OF DOME AND WALL DUE TO LOAD

from pgs. 66 & 67:

Dead Load: $\Delta H^D = +.088"$

$\Delta\phi^D = -.000204$

$\Delta H^\omega = 0$

$\Delta\phi^\omega = 0$

1.5P - SHRINKAGE:

$N'_\phi = +\frac{ap}{2}$ - shrinkage $= +\frac{861\times70.5}{2\times1000} - \frac{7300\times12.25}{1000\times12} = +22.95$ K/

$N'_\theta = +\frac{ap}{2}$ - shrinkage

$\Delta H^D = \frac{a \sin\phi}{Eh}(N'_\theta - \nu N'_\phi)$

If $\nu = 0$

$\Delta H^D = \frac{a \sin\phi}{Eh} N'_\theta = \frac{+861(1)\,22.95}{29{,}000\times1.03} = +.66"$

$\Delta\phi^D = \frac{\cot\phi}{aEh}[N'_\phi(a+\nu a) - N'_\theta(a+\nu a)] - \frac{d}{ad\phi}\left(\frac{\Delta H}{\sin\phi}\right)$

$= \frac{\cot\phi}{aEh}[N'_\phi a - N'_\theta a] - \frac{d}{ad\phi}\left(\frac{\Delta H}{\sin\phi}\right)$

$\Delta\phi^D = 0$

$\Delta H^\omega = -\frac{pa^2}{Eh}$ + shrinkage where $h = \frac{12.9 + 4.5}{12"} = 1.45$

$= -aN'_\theta/Eh$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY L.G

SUBJECT DISCONTINUITY @ COMPUTATION SHEET DATE

FILE SPRING LINE CHECKED BY A.J.

ESTIMATE DATE

$$N_o' = \frac{861 \times 70.5}{1000} - \frac{7100}{1000} \times \frac{17.4}{12} = 50.3^{K}/_{in}$$

$$\Delta H^{w} = -\frac{861 \times 50.3}{29000 \times 1.45} = -1.03''$$

$\Delta\phi^{w} = 0$ (uniform pressure entire length of cyl.)

Liner Temp. Displacement @ 1.5P

$\varepsilon = \frac{s}{E} = \frac{P}{AE}$ where A is area of hoop reinf.

$$\Delta H^{D} = \frac{144{,}000^{\#} \times 71.75 \times 12}{6.25^{D^{-}} \times 29 \times 10^{6}} = +.685''$$

$\Delta\phi^{D} = 0$

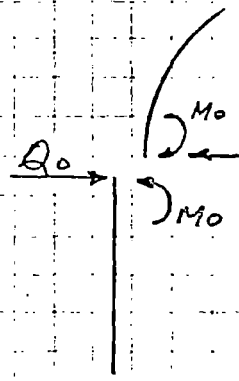
$$\Delta H^{w} = \frac{153000 \times 72.25 \times 12}{12.9 \times 29 \times 10^{6}} = -.36''$$

COMPATIBILITY OF DISPLACEMENTS

ΔH: $+.094 + .66 - 1.03 + .685 - .36 = +.049''$ (Net displ.)

$\Delta\phi$: $-.000218$

Assume following direction of corrections for positive Q_o and M_o



CORRECTIONS + DISPLACEMENTS = 0

ΔH: $+.049'' + .505 Q_o + .272 Q_o + .00304 M_o - .00153 M_o = 0$

$\Delta\phi$: $-.000218 + .00304 Q_o - .00153 Q_o + .0000316 M_o + .0000173 M_o = 0$

ΔH: $+.049'' + .777 Q_o + .00151 M_o = 0$

$\Delta\phi$: $-.000218 + .00151 Q_o + .0000469 M_o = 0$

$-30.9(\Delta\phi)$: $+.0064 - .0468 Q_o - .00151 M_o = 0$

ΔH: $+.0490 + .7770 Q_o + .00151 M_o = 0$

$+.0554 + .7302 Q_o = 0$

$Q_o = -.077^{K}/_{in}$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G

SUBJECT DISCONTINUITY @ COMPUTATION SHEET DATE

FILE SPRING LINE @ -M_g CHECKED BY A.J

ESTIMATE DATE

Substitute in ΔH:

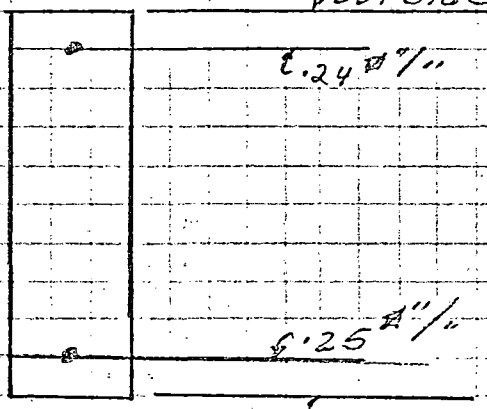
$+.049 - .777(.079) + .00151 M_o = 0$

$+.049 - .060 + .00151 M_o = 0$

$-.011 = -.00151 M_o$

$M_o = +\frac{.011}{.00151} = 7.3^{"K/"}$ NEGLECT FOR ALL LOADING CONDITIONS

Check Section @ 29' above base of cylinder for resistance to -M_g = 268 "K/"



Dead Load: $.95\left[39.2 + (135-39.2)\frac{113}{142}\right] = -110.0^{K/"}$

Shrinkage: $= -45.5$

Pressure $= +207.0$

Temp $= +144.0$

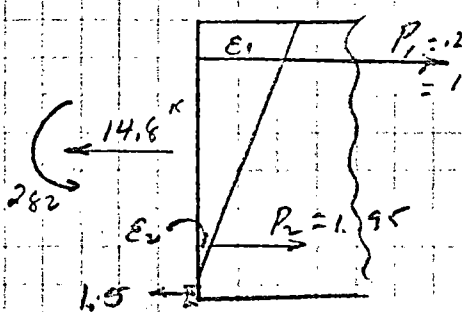
Creep: $\left(1.65 + (5.32-1.65)\frac{113}{142}\right) \times 5.9 = -27.0$

$+168.5^{K/"}$

$\frac{+168.5}{12} = 14^{K/"}$

$M_u = \frac{268}{.90} = 282^{"K/"}$

$P_u = \frac{14}{.95} = 14.8^{K/"}$



Trg $a = .5" \therefore P_c = .5 \times 2.97 = 1.5^{K}$

$c = \frac{.5}{.85} = .6"$

$\varepsilon_1 = .00207, \varepsilon_2 = \frac{6.9}{53.4} \times .00207 =$

$\varepsilon_2 = .00027$

$P_2 = .00027 \times 29 \times 10^6 \times .25^{"^2} = 1.95$

ΣH balances

ΣM_E ; $282 + 1.95 \times 19.5 \lessgtr 14.4 \times 20.5 + 1.5 \times 126.75$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
COMPUTATION SHEET
PREPARED BY L.G. DATE
CHECKED BY A.J. DATE
REFER TO SALEM GEN. STA.
SUBJECT LOAD FLOORS
FILE
ESTIMATE

HOOP FORCES *1/

POINT	D.L.	1.0P	1.15P	1.25P	1.5P	1.0TL	1.0TL'	1.0TL"	N_θ" (1.5P+TL)	N_θ" (1.0P+TL")	N_θ" (1.0P+TL")	1.25E	1.0E'	SHRINK.	CREEP
DOME												36.4	39.7		
Peak	-19.6	+244	+279	+305	+366	±144	±132	±110	—	—	—	±~~24.6~~	±~~30.4~~	-90	-10
γ=51°30'	0	↕	↕	↕	↕	↕	↕	↕	—	—	—	±~~11.6~~	±~~14.4~~	↕	0
S.L.	+39.2	+244	+279	+305	+366	±144	±132	±110	—	—	—	46.7 ±~~57.6~~	51.5 ±~~63.6~~	-90	0
												96.0	94.8		
CYL.															
S.L.	0	+490	+562	+615	+735	±153	±140	±117	—	—	—	±~~26.4~~ 73.1	±~~29.6~~ 66.5	-124	0
EL 87'		↕	↕	↕	↕	↕	↕	↕	0 ↕	0 ↕	0 ↕	±~~17.7~~	±~~19.6~~	↕	↕
EL. 58'									+26 ↓	+21 ↓	+17 ↓	±~~11.6~~	±~~13.6~~		
EL. 43.5						±153	±140	±117	0 ↓	0 ↓	0 ↓	↓	↓		
TOP OF INS.						(±153)(6)	(±140)(0)	(±117)(0)	↓	↓	↓	±~~5.8~~	±~~6.6~~	↓	↓
EL 0	0	+490	+562	+615	+735	0	0	0	-615	-502	-390	0	0	-124	0

conservative @ Base

MERIDIONAL FORCES *1/

POINT															
DOME												36.4	39.7		
Peak	-19.6	+244	+279	+305	+366	±144	±132	±110	—	—	—	±~~24.6~~	±~~30.4~~	-90	-10
S.L.	-39.2	↕	↕	↕	↕	↕	↕	↕				±~~25.9~~ 23.3	±~~32.1~~ 28.8	-90	-19
CYL.												23.3	28.8		
S.L.	-39.2											±~~25.9~~	±~~32.1~~	-60	-19
	↓											↓	↓	↕	↓
EL 0	-135	+244	+279	+305	+366	±144	±132	±110	—	—	—	±~~162.8~~	±~~189.1~~	0	-56

conservative @ Base — Thermal stress approach 0 @ base

Sample calculations: 1.5P @ Cyl. S.L. : $1.5 \times 47 \times 144 \text{ "}/\text{'} \times 72.25 = 735$ *1/ (Hoop)

1.5P @ Dome : $1.5 \times 47 \times 144 \times 71.75/2 = 366$ *1/ (Hoop & Mer.)

D.L. @ Dome Peak $-.545$ *1/' $\times 71.75'/2 = -19.6$ *1/

For TL, TL', TL" : see pgs. 48-50

For 1.25E & 1.0E' : see pgs. 29, 33 & 34

For N_θ (1.5P+TL) see pgs 64 & 65

For shrinkage & creep stresses see pgs 51-54

N_θ for shrinkage : Cyl @ S.L. : -7.1 *1/in $\times 17.4 = -124$ *1/ (Hoop)

× Sect. A in E.Q. calculations is not actually @ peak at the true peak $N_\theta = N_\phi$. Therefore use values shown for both.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

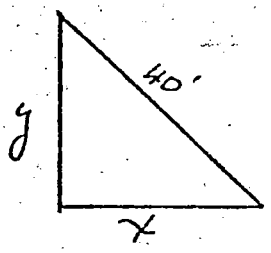
REFER TO SALEM GEN. STA. PREPARED BY I.G

SUBJECT Seismic Rebars. COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

Seismic bars run @ 45° with the central vertical axis of the containment. Bars are to run in two directions @ 90° to each other. If we allow these bars to be 40' in length, the height on the cylinder where the splices are to be made is as follows:



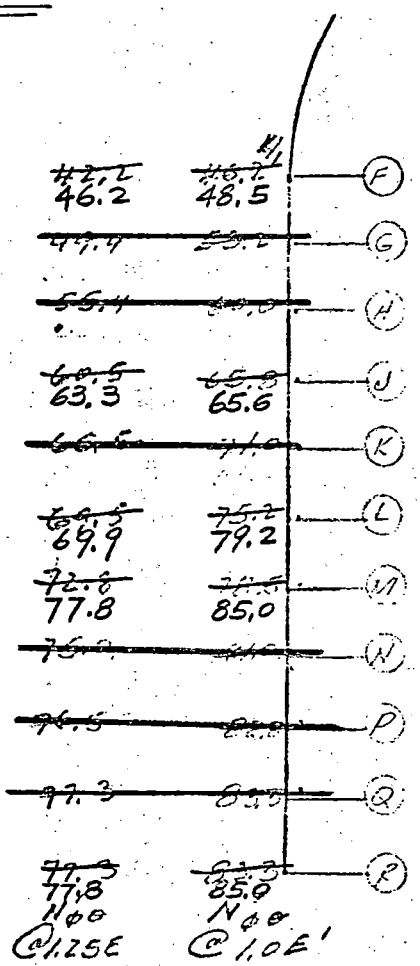
$$y = x$$

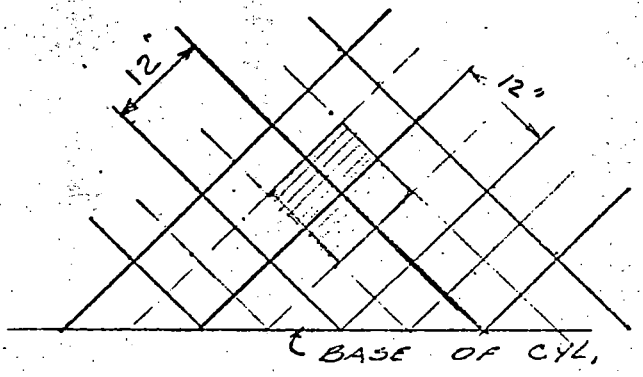
$$2y^2 = 40^2$$

$$y^2 = \frac{1600}{2} = 800$$

$$y = 28.2' \text{ sag } 28.4'$$

SEE P. 33





PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY [illegible]

SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY N.J.

ESTIMATE _____ DATE _____

ROCKING ACCELLERATION: see pg. 18

T = .136 sec., Response Spectrum = .19g, damp. = 2%

acc = .19g

COMBINING HORIZONTAL ACCELLERATION & ROCKING:

FOR E CONDITION:

$\sqrt{.224^2 + .19^2} = .294g$: acc.

RESPONSE SPECTRUM = .20g, damp = 5%

acc = .37g

FOR E' CONDITION:

$\sqrt{.304^2 + .27^2} = .406g$: acc.

SECT	1.25E (K1) N'_y	N'_θ	$N'_{y\theta}$	1.0E' (K1) N'_y	N'_θ	$N'_{\theta\theta}$
F	~~26.6~~ 18.2	~~33.1~~ ~~34.6~~	~~46.2~~	~~21.4~~	~~65.5~~ ~~58.2~~	~~48.5~~
G	~~37.3~~	~~34.8~~	~~65.0~~	~~50.0~~	~~38.6~~	~~24.0~~
H	~~50.2~~	~~31.2~~	~~73.~~	~~64.~~	34.3	0.0
J	~~64.5~~ 45.7	~~27.2~~ 66.1	~~76~~ 63.3	~~50.2~~	~~30.2~~ 66.5	~~2.6~~ 65.6
K	~~80.5~~	~~23.4~~	~~82~~		~~26.0~~	~~4.5~~
L	~~99.5~~	~~19.6~~	~~91.5~~	~~115.0~~	~~21.4~~	~~10.0~~
M	~~116.9~~ 83.5	~~15.1~~ 55.9	~~96.9~~ 77.8	~~135.0~~ 89.4	~~17.2~~ 75.1	~~15.0~~ 85.0
N	133.5	11.	~~98.6~~	~~135.0~~	12	~~19.5~~
P	~~154~~	~~7.5~~	~~101.0~~	~~177.0~~	~~8.7~~	~~14.0~~
Q	~~174~~	~~3.9~~	~~101.5~~	~~193.0~~	~~4.3~~	~~11.0~~
R	~~194~~ 145	0.	~~101.5~~ 77.8	~~201.0~~ 157	0	~~11.0~~ 85.0

SEE P 33

EV for 1.25E = $62.05 \times 10^3 \times .294 \times 1.25 = 22.8 \times 10^3$ kips

EV for 1.0E': $62.05 \times 10^3 + 406 = 25.2 \times 10^3$ kips

At base; Trg #145: $f_s = \frac{111}{.90 \times 2.2} = 55$ K/ø" O.K.

@ Sect H: Trg #11: $f_s = \frac{80}{.90 \times 1.5} = 57$ K/ø" -

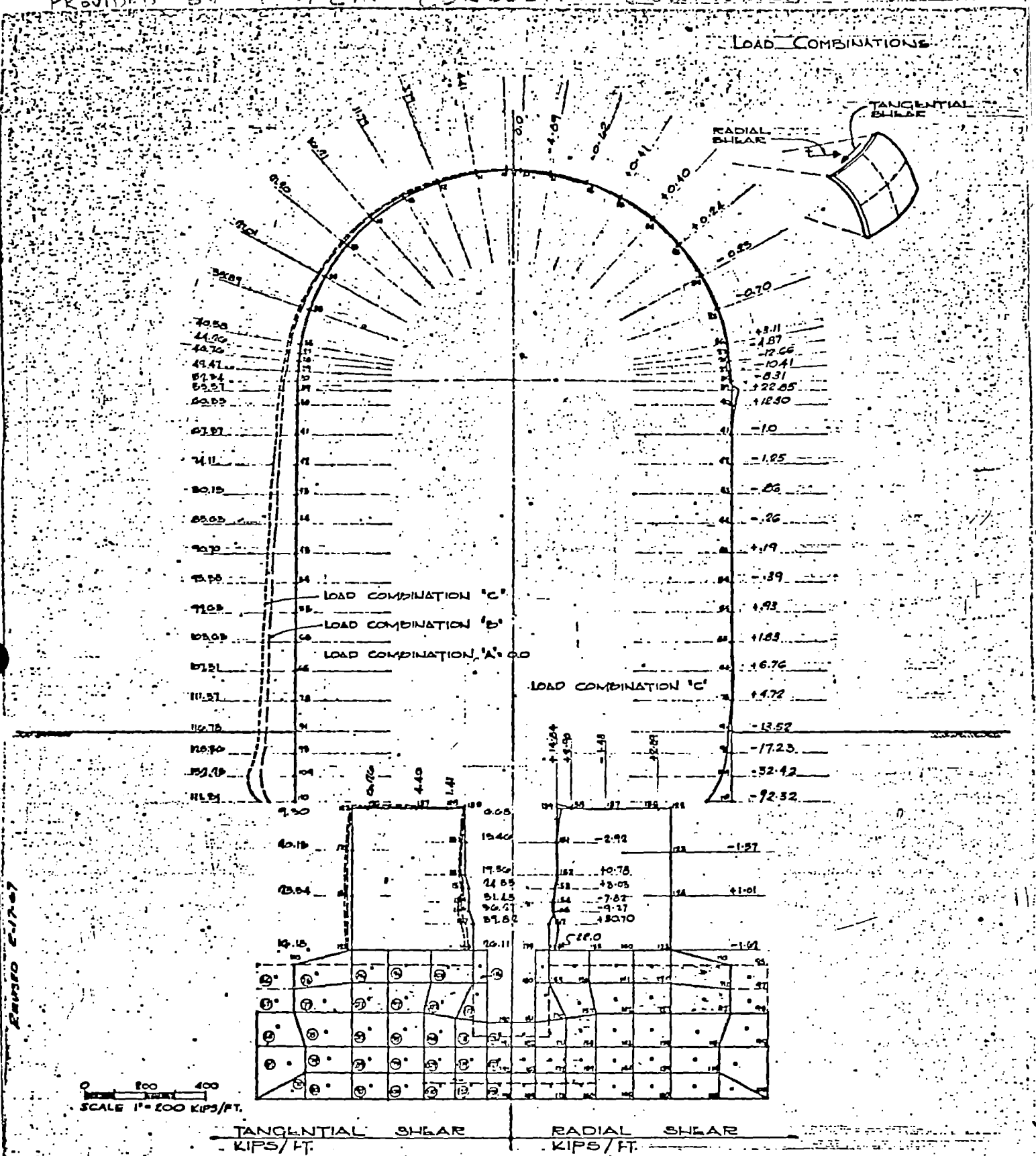
USE #11 UNTIL DISCONTINUED IN DONE

SEE PG. 75b

TANGENTIAL & RADIAL SHEARS BY FINITE ELEMENT

PROVIDED BY T.Y. LIN CONSULTING ENGINEERS

Pg 75b)



ENVELOPE OF PEAK TANGENTIAL & RADIAL FORCES IN SHELL FOR ULTIMATE LOAD COMBINATIONS A, B & C

CONTAINMENT VESSEL FOR UNITS NO. 1 & NO. 2
SALEM NUCLEAR GENERATING STATION

4

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA

SUBJECT

FILE

ESTIMATE

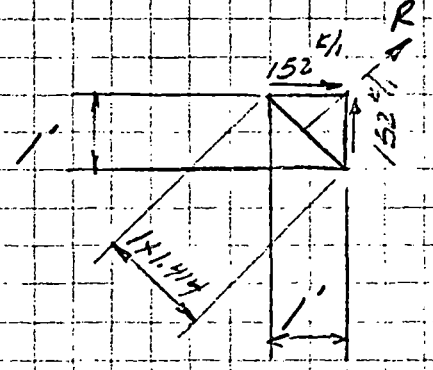
COMPUTATION SHEET

PREPARED BY I.C

DATE

CHECKED BY A.J.

DATE



$R = 152^{\#}/_{'} \times 1.414$

Force /ft on diagonal $= \frac{152 \times 1.414}{1 \times 1.414}$

$= 152^{\#}/_{'}$

$\frac{152^2}{.95 \times 60} = 2.66^{\#''}/_{'}$ req'd

Consider spacing 2-#5, 1-#8, 2-#5, 1-#8 c/c. at 11½" O.C.

$\frac{2 \times 2.25^{\#''} + 1 \times 4^{\#''}}{3 \times 11.5''/_{12}} = 2.96^{\#''}$ provided

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY 1.6

SUBJECT SEISMIC CAPACITY COMPUTATION SHEET DATE

FILE of Liner CHECKED BY A.J.

ESTIMATE DATE

The liner will be assumed to take the seismic shear from a point making an angle of 30° with the horizontal to the peak of the dome. To check the liners capacity let us conservatively check the combination of normal and shearing stresses in liner at springline under 1.0P + 1.0TL" + 1.0E' loading.

N_ϕ: 1.0P: $+244 \times \frac{6}{12.25} = +120$ K/I

TL": $= -110$

1.0E': $-28.4 \times \frac{6}{12.25} = -14$

S: $-82 \times \frac{6}{12.25} = -40$

C: $-19 \times \frac{6}{12.25} = -9.3$

-53.3 K/I

N_θ: 1.0P: $+244 \times \frac{6}{12.25} = +120$

TL": -110

1.0E': $-57 \times \frac{6}{12.25} = -28$

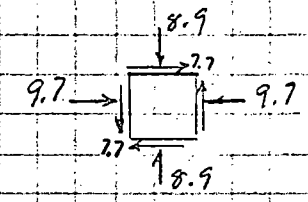
S: $-82 \times \frac{6}{12.25} = -40$

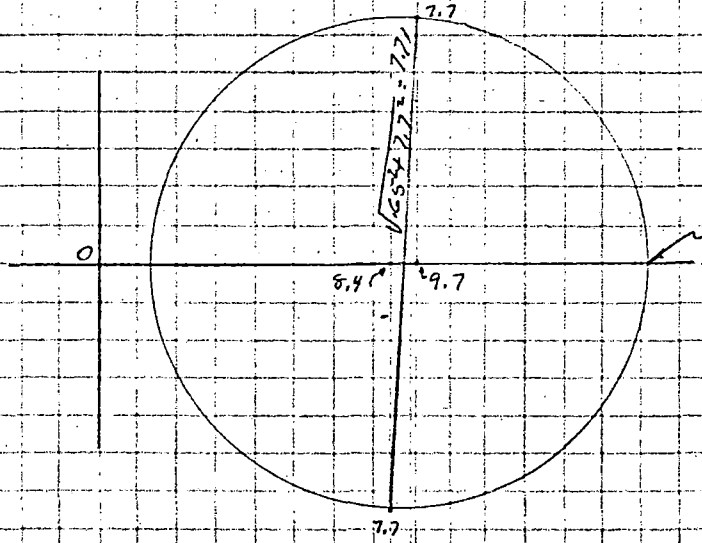
C: 0

-58 K/I

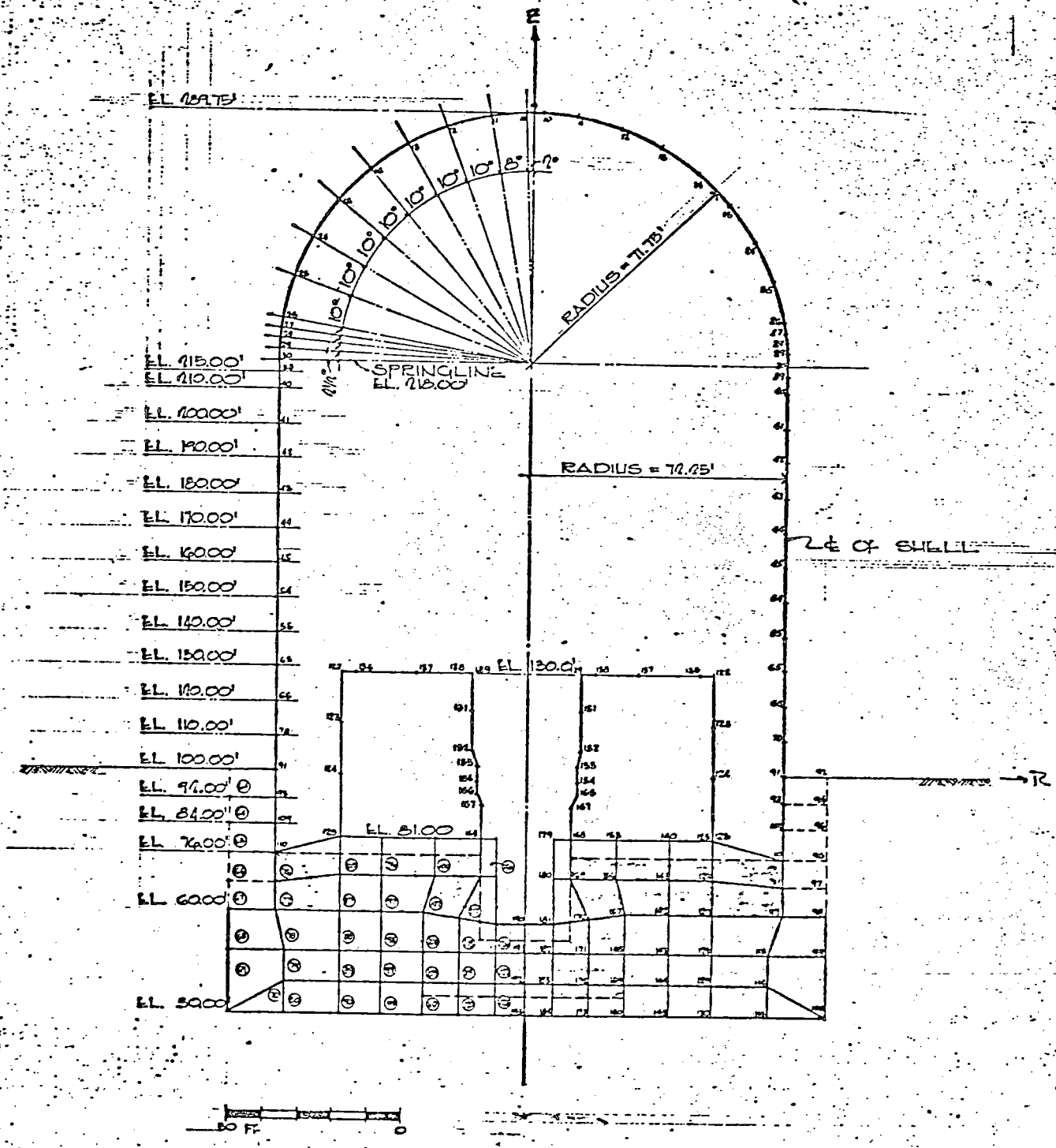
$\sigma_\phi = \frac{-53.3}{6} = -8.9$ K/A", $\sigma_\theta = \frac{-58}{6} = -9.7$ K/A"

$\sigma_{\phi\theta} = \frac{46.2}{6} = 7.7$ K/A"



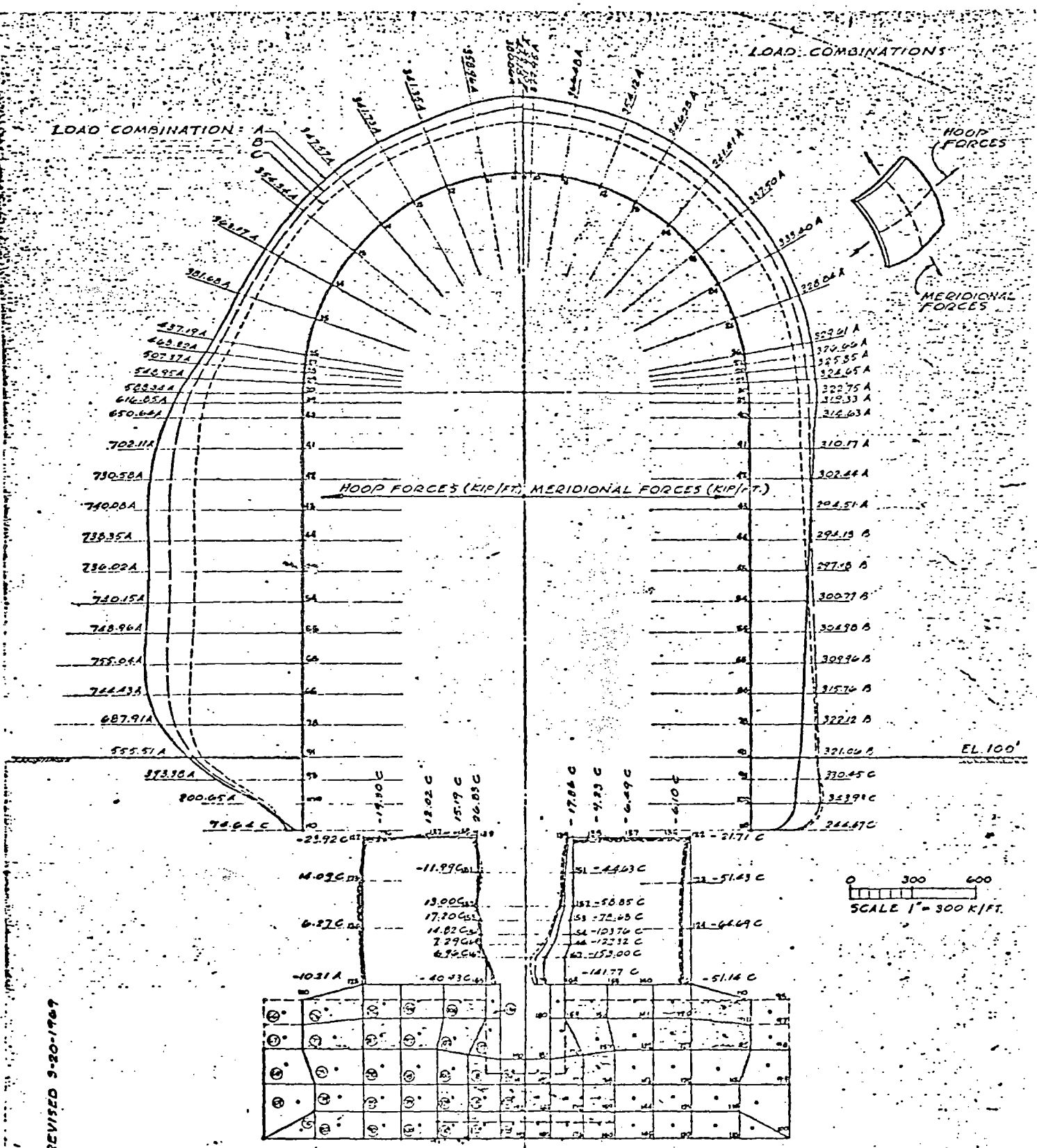


$8.9 + .65 + 7.7 = 17.25$ K/A" COMP. ⊙



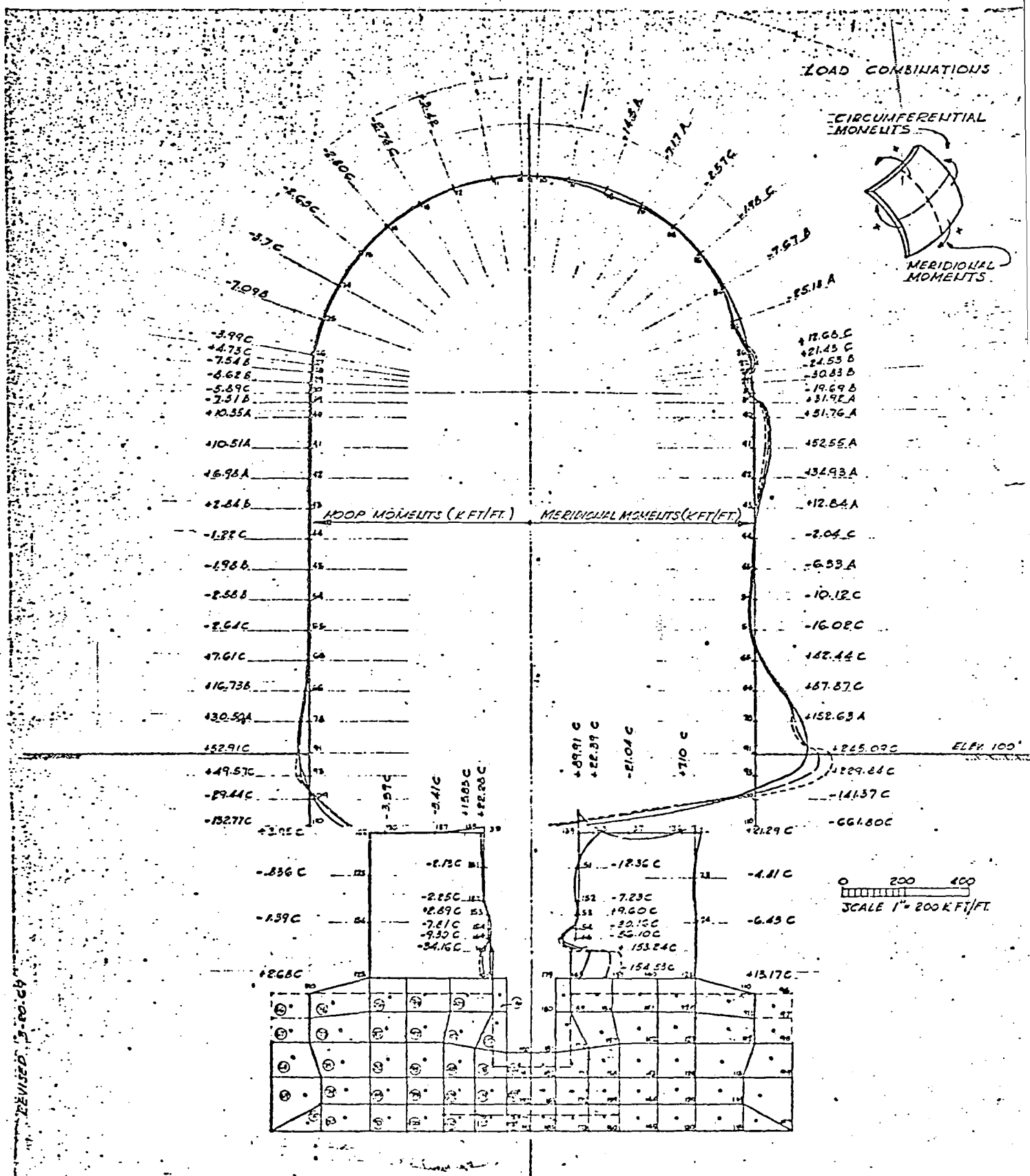
KEY CROSS-SECTION FOR LOCATION OF NODAL POINTS AND FINITE ELEMENTS

CONTAINMENT VESSEL FOR UNITS NO. 1 & NO. 2
SALEM NUCLEAR GENERATING STATION



ENVELOPE OF PEAK MERIDIONAL & HOOP FORCES IN SHELL FOR ULTIMATE LOAD COMBINATIONS A, B & C.

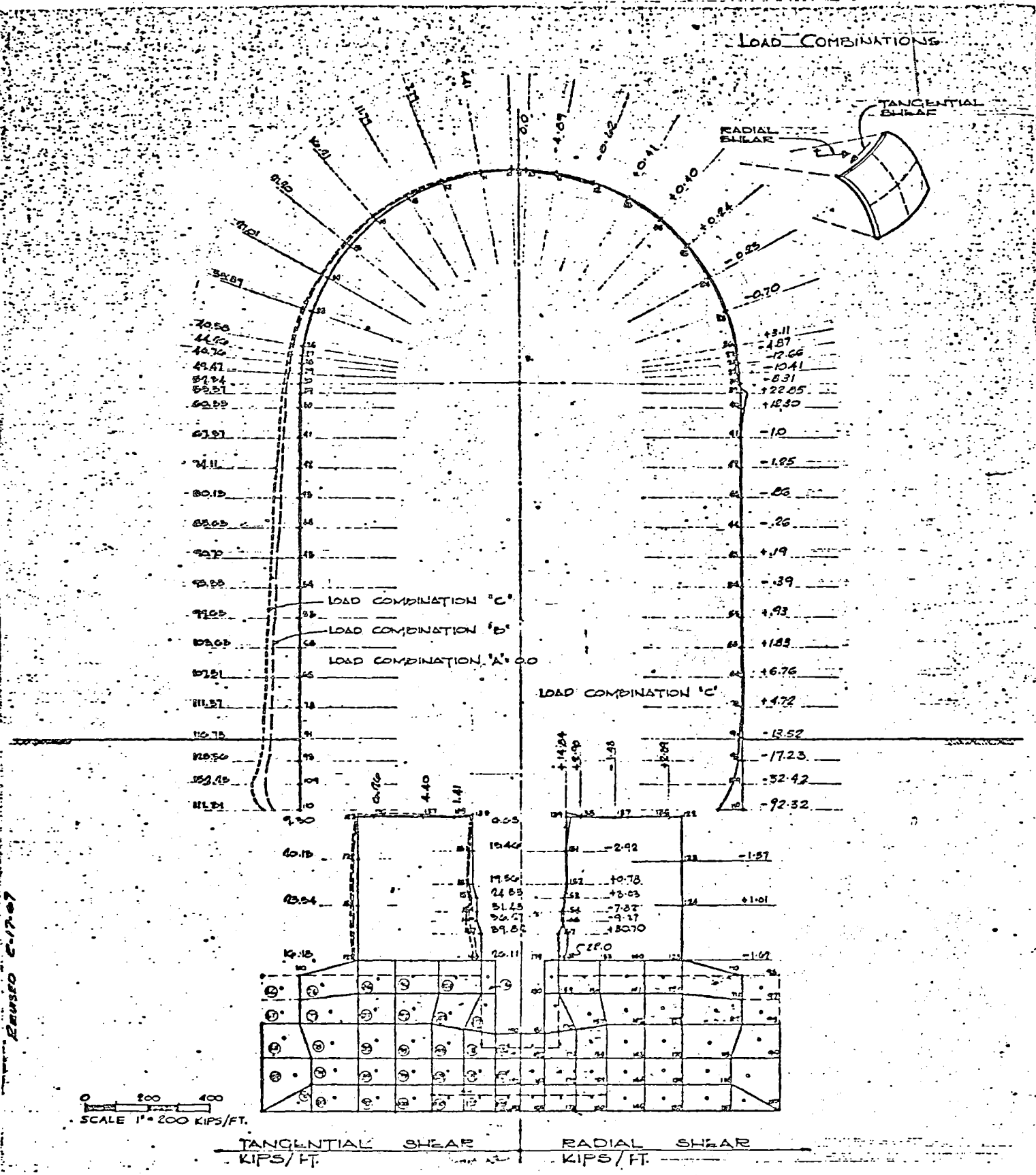
CONTAINMENT VESSEL FOR UNITS NO. 1 & NO. 2
SALEM NUCLEAR GENERATING STATION



MERIDIONAL AND CIRCUMFERENTIAL MOMENTS IN SHELL FOR ULTIMATE LOAD COMBINATIONS A B & C

CONTAINMENT VESSEL FOR UNITS NO. 1 & NO. 2
SALEM NUCLEAR GENERATING STATION

REVISED 3-20-69



ENVELOPE OF PEAK TANGENTIAL & RADIAL FORCES IN SHELL FOR ULTIMATE LOAD COMBINATIONS A, B & C -

CONTAINMENT VESSEL FOR UNITS NO. 1 & NO. 2
SALEM NUCLEAR GENERATING STATION

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY J.G.

SUBJECT REFIGURING STIRRUPS COMPUTATION SHEET DATE

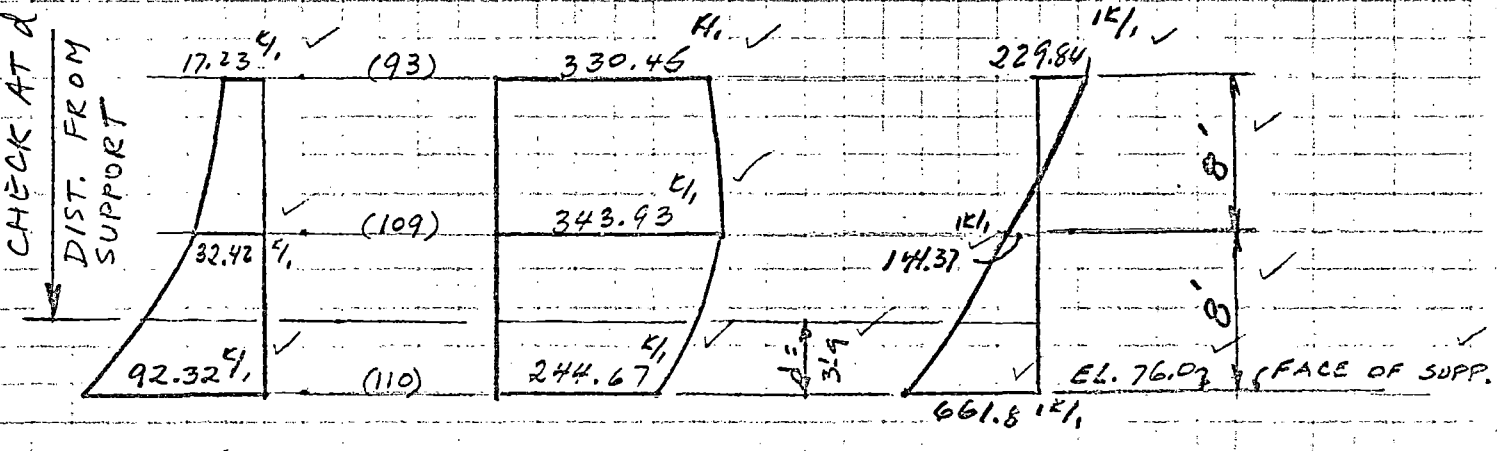
FILE BASED ON T.Y. LIN LOADS CHECKED BY P. CHIANG

ESTIMATE DATE

CHECKING RADIAL WALL STIRRUPS AT DISTANCE d FROM FACE OF SUPPORT AS PER ACI 1201 ✓

V_c ALLOWABLE $= \dfrac{\phi 2500 f_w V d}{M'}$ (SALEM PSAR 5.1.3.5)

THE FOLLOWING PLOTS ARE OBTAINED FROM T.Y. LIN SUBMISSIONS.



$V_d = 60.7$ K/L (SCALED FROM LARGE SCALE PRINT OF T.Y. LIN)

$N_d = \dfrac{3.75}{8.0}(343.5 - 244.67) + 244.67 = 291.18$ K/L ±

$M_d = \dfrac{4.25}{8.0}(661.8 - 141.37) + 141.37 = 417.85$ K/L ±

$f_w = \dfrac{A_s}{bd}$

A_s = 1-#8 @ 8.25" ± = 4 #8" @ 8.25" = .485 } .731 #8"/L
1-#8 @ 16.25" = 4 #8" @ 16.25 = .246 }

since b = 16.25" A_s TOTAL = .731 × 16.25" = 11.879 #8" ✓

$M' = M - N\left(\dfrac{4t - d}{8}\right)$ where N is negative for tension

$t = 4.5'$

$d = 3.75'$

$M' = 417.85 + 291.18\left(\dfrac{4 \times 4.5 - 3.75}{8}\right) = 936.5$ K/L

$\phi = .85$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT REFIGURING STIRRUPS COMPUTATION SHEET DATE

FILE BASED ON T.Y. LIN LOADS CHECKED BY P. CHIANG

ESTIMATE DATE

$$V_{c\ all.} = \frac{.85 \times 2500 \times \frac{11.879}{16.25 \times 45''} \times 60.67^{k/'} \times 3.75}{936.5^{k/'}}$$

$$= 8.4\ psi$$

$$\therefore V_c = 8.4 \times 45 \times 16.25 = 6.13^{k}$$

$$V_u' = \frac{60.67}{12} \times 16.25 - 6.13 = 76.0^{k}$$

SPACING OF $s = \frac{A_v \phi f_y d (\sin\alpha + \cos\alpha)}{V_u'}$ [17-6 ACI]

$\alpha = 45^{\circ}$

$A_v = 1.27\ \square''$ (#10 BAR)

$f_y = 60^{k/\square''}$

$\phi = .85$

$$S_{REQ'D} = \frac{1.27 \times .85 \times 60 \times 45 (1.414)}{76} = 54.23''$$

ACTUAL SPACING CONSIDERABLY LESS THAN THIS

CHECK PT. APPROX. 13' ABOVE BASE $A_v = 1.0\ \square''$

$$V = \frac{3}{8}(32.42 - 17.23) + 17.23^{k/'} = 22.926^{k/'}$$

Allowable stress @ $19^{k/\square''}$ (ACI 918(h))

$\alpha = 55^{\circ}$, $\cos\alpha + \sin\alpha = 1.4$

NOT CONSIDERING ANY $V_{c\ ALL.}$

$$s = \frac{1.0 \times 19 \times 45 (1.4)}{\frac{22.926}{12} \times 16.25} = 38.55''\ \text{O.K.}$$

CHECK PT. APPROX 18.5' ABOVE BASE: $A_v = .79\ \square''$

$$V = \frac{5.5}{8}(17.23 - 13.52) + 13.52 = 16.07$$

$\alpha = 45^{\circ}$ $s = \frac{.79 \times 19 \times 45 (1.414) \times 12}{16.07 \times 16.25} = 43.9''$ O.K.

CHECK PT. APPROX 22' ABOVE BASE: $A_v = .60\ \square''$

$\alpha = 55^{\circ}$ $V = \frac{2}{8}(17.23 - 13.52) + 13.52 = 14.447$

$s = \frac{.60 \times 19 \times 45 (1.4) 12}{14.447 \times 16.25} = 36.7''$ O.K.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM G.S. STA.

SUBJECT STRESSES IN REBARS COMPUTATION SHEET

FILE

ESTIMATE

PREPARED BY L. G.

DATE

CHECKED BY A. J.

DATE

MERIDIONAL : Rebars

1.5P + 1.0 TL' - .95D - S

Dome : Peak :	$+366 \times \frac{6.25}{12.25}$	$+186.5$ K/'	1.5P
		$+144.0$	1.0 TL
	$-19.6 \times .95$:	-18.5	.95D
	$-90 \times \frac{6.25}{12.25}$:	-46.0	S
		$+266$ K/'	

$266/6.25 = +42.5$ K/A"

Springline :

	$+186.5$	1.5P
	$+144.0$	1.0 TL
$-39.2 \times .95$:	-37.0	.95D
	-46.0	S
	$+248$ K/'	

$248/6.25 = +40.0$ K/A"

Cyl. Springline"

$+366 \times \frac{5.9}{10.4}$ =	$+208$ K/'	1.5P
	$+144$	1.0 TL
	-37	.95D
$-90 \times \frac{5.9}{10.4}$ =	-45	S
	$+270$ K/'	

$270/5.9 = +46$ K/A"

Base

	$+208$ K/'	1.5P
	$+144$	1.0 TL
$-.95 \times 135$ =	-128	.95D
	-45	S
	$+179$ K/'	

$179/5.9 = 30$ K/A"

1.25P + 1.0 TL' - .95D - S + 1.25E

Dome : Peak :

$+305 \times \frac{6.25}{12.25}$ =	$+156$ K/'	1.25P
	$+132$	1.0 TL'
	-19	.95D
	-46	S
$+243 \times \frac{6.25}{12.25}$ =	$+13$	1.25E
	$+236$ K/'	

$\frac{236}{6.25} = +38$ K/A"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY L.C

SUBJECT STRESSES IN REBARS COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

Dome: Springline

+156 K/I		1.25P
+132		1.0TL'
−37		.95D
−46		S
+13		1.25E
+218 K/I		

$\frac{218}{6.25} = +35$ K/I"

Cyl Springline:

$+305 \times \frac{5.9}{10.4}$	= +173 K/I	1.25P
	+132	1.0TL
	−37	.95D
	−45	S
$+25 \times \frac{5.9}{10.4}$	= +14	1.25E
	+237	

$\frac{237}{5.9} = +40.2$ K/I"

Base

+173 K/I		1.25P
+132		1.0TL'
−126		.95D
−45		S
$+1623 \times \frac{5.9}{10.4}$	= +93	1.25E
	+225 K/I	

$\frac{225 \text{ K/I}}{5.9} = +38$ K/I"

1.0P + 1.0TL" − .95D − S + 1.0E'

Dome: Peak

$+244 \times \frac{6.25}{12.25}$	= +125 K/I	1.0P
	+110	1.0TL"
	−19	.95D
	−46	S
$+30.4 \times \frac{6.25}{12.25}$	= +15	1.0E'
	+185	

$\frac{185}{6.25} = +29.6$ K/I"

Springline

	+125 K/I	1.0P
	+110	1.0TL"
	−37	.95D
	−46	S
$28.4 \times \frac{6.25}{12.25}$ =	+15	1.0E'
	+167	

$\frac{167}{6.25} = +26.7$ K/I"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN REBARS COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

Cyl. springline:

$+244 \times \frac{5.9}{10.4} =$	$+139^{K/'}$	1.0P
	$+110$	$1.0TL''$
	-45	S
$28.4 \times \frac{5.9}{10.4} =$	$+16$	$1.0E'$
	-37	.95D
	$+183^{K/'}$	

$+183/5.9 = +31^{K/\square''}$

Base

$+139^{K/'}$	1.0P
$+110$	$1.0TL''$
-128	.95D
-45	S
$185.5 \times \frac{5.9}{10.4} = +105$	$1.0E'$
$+181$	

$\frac{+181}{5.9} = +30.7^{K/\square''}$

TEST CONDITION: 1.15P − .95D − S

Dome: Peak

$279 \times \frac{6.25}{12.25} = +143^{K/'}$	1.15P
-19	.95D
-46	S
$+78^{K/'}$	

$78/6.25 = +12.5^{K/\square''}$

Springline:

$+143^{K/'}$	1.15P
-46	S
-37	.95D
$+60$	

$60/6.25 = +9.6^{K/\square''}$

Cyl. springline:

$279 \times \frac{5.9}{10.4} = +158^{K/'}$	1.15P
-45	S
-37	.95D
$+76^{K/'}$	

$76/5.9 = +12.9^{K/\square''}$

Base

$+158^{K/'}$	1.15P
-45	S
-128	.95D
-15	

$\frac{-15}{5.9} = -2.5^{K/\square''}$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN REBARS COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

CIRCUMFERENTIAL Rebars

1.5P + 1.0TL ± .05D ± 1.0D − S

Dome: Peak:

$N'_\theta = +266$ K/I

$S_\theta = +42.5$ K/□"

Springline:

	+186.5 K/I	1.5P
	+ 144.0	1.0TL
+1.05 × 39.2 =	+ 41.0	1.05D
	− 46.0	S
	+326 K/I	

+326/6.25 = +52 K/□"

Cyl. springline:

+735 × 12.9/17.4 =	+547 K/I	1.5P
	+ 153	1.0TL
−124 × 12.9/17.4 =	− 93	S
	+607 K/I	

607/12.9 = +46.8 K/□"

El. 82

N'_θ = +607 K/I

S_θ = +46.8 K/□"

El. 58:

	+607 K/I	
+26 × 12.9/17.4 =	+ 20	N''_θ
	627 K/I	

627/12.9 = 48.5 K/□"

El. 40': (ABOVE TOP OF INSULATION)

	+547 K/I	1.5P
	+ 153 K/I	1.0TL
	− 93 K/I	S
12.9/17.4 × 3.5/43.5 (.615) =	− 37 K/I	N'_θ
	+570 K/I	

570/12.9 = 44 K/□"

(BELOW TOP OF INSUL)

	+547 K/I	1.5P
	− 93	S
	− 37	N''_θ
	+417 K/I	

+417/12.9 = +32 K/□"

Base N_θ = 0

1.25P + 1.0TL' ± .05D ± 1.0D − S + 1.25E

Dome: Peak

N'_θ = +236 K/I

S_θ = +33 K/□"

Springline

	+156 K/I	1.25P
	+ 132	1.0TL'
	+ 41	1.05D
	− 46	S
+51.2 × 6.25/12.25 =	+ 26	1.25E
	+309 K/I	

+309/6.25 = +49.5 K/□"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN REBARS COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

CYL. Springline

$+615 + \frac{12.9}{17.4}$ = +455 K/, 1.25P

+140 1.0TL'

− 93 S

$+26.4 \times \frac{12.9}{17.4}$ = + 20 1.25E

+522 K/,

+522/12.9 = +40.5 K/#"

EL. 87

+455 K/, 1.25P

+140 1.0TL'

− 93 S

$+17.7 \times \frac{12.9}{17.4}$ = + 13 1.25E

+515

$\frac{+515}{12.9}$ = +40 K/#"

EL. 58 : +455 1.25P

+140 1.0TL'

− 93 S

$+21 \times \frac{12.9}{17.9}$ = + 15 N_θ"

$+11.9 \times \frac{12.9}{17.4}$ = + 9 1.25E

+526 K/,

+526/12.9 = 40.8 K/#"

EL. 40' : (ABOVE TOP OF INSUL)

+455 K/, (1.25P)

+140 (1.0TL)

− 93 S

$\frac{12.9}{17.4} \times \frac{3.5}{43.5} \times 502$ − 30 N_θ"

± 4 1.25E

$\frac{12.9}{17.4} \times 5.8$ = +476 = N_θ

476/12.9 = 37 K/#"

Base $N_\theta = 0$

(BELOW TOP OF INSUL)

+455 K/, (1.25P)

− 93 S

− 36 N_θ"

± 4 1.25E

+336 K/, = N_θ

$\frac{+336}{12.9}$ = 26.5 K/#"

1.0P + 1.0TL" ± .05D ± 1.0D − S + 1.0E'

Dome: Peak

N_θ = +185 K/,

G_θ = +29.6 K/#"

Springline

+125 K/, 1.0P

+110 1.0TL"

+ 41 1.05D

− 46 S

$+57 \times \frac{6.25}{12.25}$ = + 29 1.0E'

+259 K/,

$\frac{259}{6.25}$ = 41.5 K/#"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.C.

SUBJECT STRESSES IN REBARS COMPUTATION SHEET DATE

FILE CHECKED BY A J.

ESTIMATE DATE

Cyl. springline

$+450 \times \frac{12.9}{17.4} =$	$+364^K/_L$	1.0P
	$+117$	$1.0T_L$"
	-93	S
$+28.8 \times \frac{12.9}{17.4} =$	$+21$	$1.0E'$
	$+409$	

$409/12.9 = +31.7^K/_{\text{in}}$"

EL. 87

	$+364$	1.0P
	$+117$	$1.0T_L$"
	-93	S
$+19.5 \times \frac{12.5}{17.4} =$	$+14$	$1.0E'$
	$+402^K/_L$	

$402/12.9 = +31.2^K/_{\text{in}}$"

EL. 58

	$+364$	1.0P
	$+117$	$1.0T_L$"
	-93	S
$+117 \times \frac{12.9}{17.4} =$	$+13$	N_θ"
$+13 \times \frac{12.9}{17.4} =$	$+10$	$1.0E'$
	$+411$	

$\frac{411}{12.9} = +31.8^K/_{\text{in}}$"

EL 40: (ABOVE TOP OF INSUL)

	$+364^K/_L$	1.0P
	$+117$	$1.0T_L$"
	-93	S
$\frac{12.9}{17.4} \times \frac{3.5}{43.5} \times 39 =$	-23	N_θ"
$\frac{12.9}{17.4} \times 6.5 =$	$+5$	$1.0T_L$"
	$+370^K/_L$	

$370/12.9 = +27.6^K/_{\text{in}}$"

(BELOW TOP OF INSUL.)

$+364^K/_L$	(1.0P)
-93	S
-23	N_θ"
$+5$	$1.0E'$
$+253^K/_L$	$= N_\theta$

$+253/12.9 = 19.6^K/_{\text{in}}$"

Base

$N_\theta = 0$

TEST CONDITION: $1.15P \pm .05D \pm 1.0D\text{-}S$

Dome: Peak

$N_\theta = +78^K/_L$

$G_\theta = +12.5^K/_{\text{in}}$"

Springline

$+143^K/_L$	1.15P
$+41$	1.05D
-46	S
$+138^K/_L$	

$+138/6.25 = +22.1^K/_{\text{in}}$"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN REBARS COMPUTATION SHEET DATE

FILE 4 LINER CHECKED BY A.J.

ESTIMATE DATE

Cyl. SPRINGLINE

$+562 + 12.9 = +418^{K/'}$ 1.15P

$17.4 \quad -93$ S

$+325^{K/'}$

$\frac{325}{12.9} = +25.2^{K/\square''}$

EL. 87 $N_\theta = +325^{K/'}$

$\theta_\theta = +25.2^{K/\square''}$

EL. 58 $+418^{K/'}$ 1.15P

-93 S

$\frac{.75}{1.41} \times +20 = +11$ N_θ

$+336^{K/'}$

$\frac{336}{12.9} = +26.2^{K/\square''}$

EL. 40' (ABOVE TOP OF INSUL) (BELOW TOP OF INS)

$+418^{K/'}$ 1.15P $+418^{K/'}$ 1.15P

-93 S -93 S

$\frac{.75}{1.41} \times -37 = -20$ N_θ -20 N_θ

$+305$ $+305$

$305/12.9 = +23.6^{K/\square''}$ Base $N_\theta = 0$

LINER STRESSES

Meridional:

$+1.5P - 1.0TL - S - C$

Dome Peak

$+366 - 186.5 = +179.5^{K/'}$ 1.5P

-144.0 1.0TL

$-(90-46) \quad -44.0$ S

$-10 \times \frac{6.0}{12.25} = -5.0$ C

$-13.5^{K/'}$

$\frac{-13.5}{6.0} = -2.2^{K/\square''}$

Springline

$+179.5$ 1.5P

-144.0 1.0TL

-44.0 S

$-19 \times \frac{6.0}{12.25} = -9.3$ C

-17.8

$\frac{-17.8}{6.0} = -3.0^{K/\square''}$

Cyl. Springline

$+366 - 208 = +158^{K/'}$ 1.5P

-144 1.0TL

-35 S

$-19 \times \frac{4.5}{10.4} = -8$ C

$-29^{K/'}$

$-29/4.5 = -6.4^{K/\square''}$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN LINER COMPUTATION SHEET DATE

FILE CHECKED BY A.J

ESTIMATE DATE

EL. 24' ($\frac{3}{8}$"R)

	+158 K/I.	1.5P
	−144	1.0TL
	− 35	S
$-50 \times \frac{4.5}{10.4}$ =	− 22	C
	−43	

$\frac{-43}{4.5}$ = −9.5 K/A"

EL. 24' ($\frac{1}{2}$"R)

	+158 K/I.	1.5P
	−144	1.0TL
$-80 \times 6/11.5$ =	− 40	S
$-50 \times 6/11.5$ =	− 25	C
	−51 K/I.	

51/6 = −8.5 K/A"

Base

	+158 K/I.	1.5P
	−144	1.0TL
	− 40	S
$-56 \times \frac{6}{11.5}$ =	− 28	C
	−54 K/I.	

−54/6 = −9.0 K/A"

1.25P − 1.0TL' − S − C − 1.25E

Dome : Peak

+305 − 156 = +149 K/I. 1.25P

−132	1.0TL'
− 44	S
− 5	C
− 12	1.25E
−44 K/I.	

−44/6 = −7.4 K/A"

Springline

+149 K/I.	1.25P
−132	1.0TL'
− 44	S
− 9	C
− 12	1.25E
−48 K/I.	

−48/6 = −8.0 K/A"

Cyl. Springline

+305 − 173 = +132 K/I. 1.25P

−132	1.0TL
− 35	S
− 8	C
− 11	1.25E
−54 K/I.	

$\frac{-54}{4.5}$ = −12 K/A"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN LINER COMPUTATION SHEET DATE

FILE CHECKED BY A J.

ESTIMATE DATE

EL. 24' ($\frac{3}{8}$" R)

	−35 K/I	S
	−22	C
−139 × 4.5/10.4 =	−60	1.25E
	−117 K/I	

−117/4.5 = −26 K/I/in

EL. 24' ½" R.

	−40 K/I	S
	−25	C
−139 × 6/11.5 =	−70	1.25E
	−135 K/I	

−135/6 = −22.5 K/I/in

Base

	−40 K/I	S
	−28	C
−162.3 × 6/11.9 =	−82	1.25E
	−150 K/I	

−150/6 = −25 K/I/in

1.0P − 1.0 TL" − S − C − 1.0E'

Dome: Peak

+244 − 125 =	+119 K/I	1.0P
	−110	1.0TL"
	−44	S
	−5	C
	−15	1.0E'
	−55 K/I	

−55/6 = −9.2 K/I/in

Springline

	+119 K/I	1.0P
	−110	1.0TL"
	−44	S
	−9	C
	−13	1.0E'
	−57 K/I	

−57/6 = −9.5 K/I/in

Cyl. Springline

+244 − 139 =	+105 K/I	1.0P
	−110	1.0TL"
	−35	S
	−8	C
	−12	1.0E'
	−60	

−60/4.5 = −13.3 K/I/in

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.C.

SUBJECT STRESSES IN LINER COMPUTATION SHEET DATE

FILE CHECKED BY A. J

ESTIMATE DATE

EL. 24' ($\frac{3}{8}$"R.)

	+105 K/I	1.0P
	−110	1.0TL"
	−35	S
	−22	C
$-159 \times \frac{4.5}{10.4}$ =	−69	1.0E'
	−131 K/I	

$-131/4.5 = -29$ K/I"

EL. 24' ($\frac{1}{2}$"R)

	+105 K/I	1.0P
	−110	1.0TL"
	−40	S
	−25	C
$-159 \times \frac{6}{11.9}$ =	−80	1.0E'
	−150	

$-150/6 = -25$ K/I"

Base

	+105	1.0P
	−110	1.0TL"
	−40	S
	−28	C
$-185.5 \times \frac{6}{11.9}$ =	−94	1.0E'
	−167 K/I	

$-167/6 = -27.8$ K/I"

TEST CONDITION: 1.15P − S

Dome; Peak

+279 − 143 =	+136 K/I	1.15P
	−44	S
	+92 K/I	

$\frac{+92}{6} = +15.3$ K/I"

Springline

$N_\phi = +92$ K/I

$G_\phi = +15.3$ K/I"

CYL. Springline

+279 − 158 =	+121 K/I	1.15P
	−35	S
	+86	

$\frac{+86}{4.5} = +19.2$ K/I"

EL 24' ($\frac{3}{8}$"R)

$N_\phi = +86$ K/I

$G_\phi = +19.2$ K/I"

EL 24' ($\frac{1}{2}$"R)

	+121 K/I	1.15P
	−40	S
	+81 K/I	

$\frac{+81}{6} = +13.5$ K/I"

BASE $G_\phi = +13.5$ K/I"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN LINER COMPUTATION SHEET DATE

FILE CHECKED BY A J

ESTIMATE DATE

NORMAL OPERATION $\Delta T = +60°, P = 0$

Dome Peak

$-\frac{60}{246} \times 144 = -35^{K}/_{L} \quad \Delta T$

$-44 \quad S$

$-5 \quad C$

$-84^{K}/_{L}$

$\frac{-84}{6} = -14.0^{K}/_{\square''}$

Springline

$-35^{K}/_{L} \quad \Delta T$

$-44 \quad S$

$-9.3 \quad C$

-88.3

$\frac{-88.3}{6} = -14.7^{K}/_{\square''}$

CYL. Springline

$-35^{K}/_{L} \quad \Delta T$

$-35 \quad S$

$-8 \quad C$

-78

$\frac{-78}{4.5} = -17.3^{K}/_{\square''}$

EL. 24' ($\frac{3}{8}$ R)

$-35^{K}/_{L} \quad \Delta T$

$-35 \quad S$

$-22 \quad C$

-92

$\frac{-92}{4.5} = -20.4^{K}/_{\square''}$

EL 24' ($\frac{1}{2}$ R)

$-35^{K}/_{L} \quad \Delta T$

$-40 \quad S$

$-25 \quad C$

-100

$\frac{-100}{6} = -16.7^{K}/_{\square''}$

Base

$-35^{K}/_{L} \quad \Delta T$

$-40 \quad S$

$-28 \quad C$

-103

$\frac{-103}{6} = -17.2^{K}/_{\square''}$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT STRESSES IN LINER COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

CIRCUMFERENTIAL : LINER

1.5P – 1.0TL – S – C

Dome : Peak

$N_\theta = -13.5$ K/I

$G_\theta = -2.2$ K/in²

Springline

+179.0	1.5P
−144.0	1.0TL
−44.0	S
−8.0 K/I	

$-(90-46) = -8.0$

$\frac{-8.0}{6} = -1.3$ K/in²

Cyl. springline

$+735 - 547 = +188$ K/I 1.5P

-153 K/I 1.0TL

$-(124-93) = -31$ S

$+4$ K/I

$\frac{+4}{4.5} = +1.0$ K/in²

EL. 40' (ABOVE TOP OF INSUL)

+188 K/I	1.5P
−153	1.0TL
−31	S
−13	N"θ
−9 K/I	$= N_\theta$

$\frac{-9}{4.5} = -2.0$ K/in²

(BELOW TOP OF INSUL.)

+188 K/I	1.5P
−31 K/I	S
−13	N"θ
+144 K/I	$= -N_\theta$

$\frac{144}{4.5} = +32$ K/in²

Base $N_\theta = 0$

1.25P – 1.0TL' – S – C – 1.25E

Dome : Peak

$N_\theta = -44$ K/I

$G_\theta = -7.4$ K/in²

Springline

+149 K/I	1.25P
−132	1.0TL'
−44	S
−25	1.25E
−52	

$\frac{-52}{6} = -8.7$ K/in²

Cyl. springline

$+615 - 455 = +160$ K/I 1.25P

−140	1.0TL'
−31	S
−6	1.25E
−17 K/I	

$-17/4.5 = -3.8$ K/in²

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY 1.G

SUBJECT STRESSES IN LINER COMPUTATION SHEET DATE

FILE CHECKED BY A J.

ESTIMATE DATE

EL. 40' (ABOVE TOP OF INSUL)

615 - 455 = +160 K/' 1.25P

- 140 1.0TL'

- 31 S

- 11 N"θ

± 2 1.25E

-24 K/' = N_θ

$\frac{-24}{4.5} = -5.3$ K/in"

(BELOW TOP OF INSUL)

+160 K/' (1.25P)

- 31 S

- 11 N"θ

± 2 1.25E

+120 K/' = N_θ

$\frac{+120}{4.5} = 26.5$ K/in"

Base

$N_\theta = 0$, $G_\theta = 0$

1.0P - 1.0TL" - S - C - 1.0E'

Dome : Peak

$N_\theta = -55$ K/'

$G_\theta = -9.2$ K/in"

Springline

+119 K/' 1.0P

-110 1.0TL"

- 44 S

-28 1.0E'

-63 K/'

$\frac{-63}{6} = -10.5$ K/in"

Cyl Springline

+490 - 364 = +126 K/' 1.0P

- 117 1.0TL"

- 31 S

- 8 1.0E'

-30 K/'

$\frac{-30}{4.5} = -6.7$ K/in"

EL. 40' (ABOVE TOP OF INSUL)

+126 K/' 1.0P

- 117 1.0TL

- 31 S

- 8 N"θ

± 2 1.0E'

-32 K/' N_θ

$\frac{-32}{12.9} = -2.5$ K/in"

(BELOW TOP OF INSUL)

+126 K/' (1.0P)

- 31 S

- 8 N"θ

± 2 1.0E'

+89

$\frac{+89}{4.5} = +19.6$ K/in"

7-6-72 → Base → $\frac{-32}{4.5} = -7.1$ K/in"

$N_\theta = 0$, $G_\theta = 0$

TEST CONDITION: 1.15P - S

Dome : Peak:

$N_\theta = +92$ K/', $G_\theta = +15.3$ K/in"

Springline

$N_\theta = +92$ K/', $G_\theta = +15.3$ K/in"

Cyl. Springline

+562 - 418 = +144 K/' 1.15P

- 31 S

+113 K/'

+113/4.5 = +25.0 K/in"

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA PREPARED BY L.C

SUBJECT STRESSES IN LINER COMPUTATION SHEET DATE

FILE CHECKED BY A.J

ESTIMATE DATE

EL 40' (ABOVE TOP OF INSUL) (BELOW TOP OF INSUL)

+144 K/I 1.15P

- 31 S

- 7 No

+106 K/I

$\frac{106}{4.5}$ = +23.6 K/A"

$\frac{106}{4.5}$ = +23.6 K/A"

NORMAL OPERATION ΔT = 60°, P = 0

DOME: PEAK

N_θ = -84 K/I

6_θ = -14.0 K/A"

SPRINGLINE

-35 K/I ΔT

-44 S

-79 K/I

$\frac{-79}{6}$ = -13.2 K/A"

CYL. SPRINGLINE

$\frac{-60}{246} \times 153$: -37 K/I ΔT

-31 S

-68

$\frac{-68}{4.5}$ = -15.1 K/A"

"w": $\frac{11,950 \times 60}{246}$ = +2920 Psi (ΔT)

-7100 S

-4180 Psi

$w = \frac{-4180}{30,000} \times .9 = -.14"$

EL. 40' (ABOVE TOP OF INSUL)

-37 K/I ΔT

-31 S

$\frac{+.14}{1.41}(615)\frac{3.5}{43.8}$ = +5 No

-63 K/I = N_θ

$\frac{-63}{4.5}$ = -14 K/A"

(BELOW TOP OF INSUL)

-31 K/I S

+5 No

-26 K/I = N_θ

-26/4.5 = -5.8 K/A"

Base: C_θ = 0

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G

SUBJECT E.Q. MOTION COMPUTATION SHEET DATE

FILE CHECKED BY A.J

ESTIMATE DATE

HORIZONTAL DEFLECTION DUE TO LATERAL FORCES

$L = 14.2' \times 12 = 170''$

$G = 1.4 \times 10^6$

$E = 3.4 \times 10^6$

SECT	FORCE 10^3 K	Ao. 10^4 in^2	Bm. V 10^3 K	2VL/AoG 10^{-3} in	V_Δ 10^{-3} in	I_o 10^{10} in^4	V.L 10^5 in.K	M 10^8 in.#	M/EI 10^{-8} in^{-1}
A	.825		.825		134.93	5.72	0	0	0
		22.6		.89					
B	2.150		2.975		134.04	3.50	1.40	1.40	.127
		23.6		3.06					
C	1.940		4.915		130.98	5.97	5.05	6.45	.315
		24.7		4.93					
D	1.510		6.425		126.05	7.55	8.36	14.81	.575
		24.7		6.33					
E	1.500		7.925		119.72	8.60	10.90	25.71	.878
		28.2		6.80					
F	1.550		9.475		112.92	11.90	13.45	39.16	.965
		31.0		7.42					
G	1.560		11.035		105.50	11.90	16.10	55.26	1.36
		31.0		8.65					
H	1.390		12.425		96.85	11.90	18.80	74.06	1.83
		31.0		9.75					
J	1.210		13.635		87.10	11.90	21.20	95.26	2.35
		31.0		10.70					
K	1.040		14.675		76.40	11.90	23.20	118.46	2.92
		31.0		11.50					
L	.865		15.540		64.90	11.90	24.90	143.36	3.54
		31.0		12.10					
M	.700		16.240		52.80	11.90	26.40	169.76	4.20
		31.0		12.75					
N	.515		16.755		40.05	11.90	27.60	197.36	4.86
		31.0		13.15					
P	.340		17.095		26.90	11.90	28.50	225.86	5.55
		31.2		13.40					
Q	.175		17.270		13.50	12.0	29.00	254.86	6.25
		31.5		13.50					
R	0				0.00	12.0	29.30	284.16	6.95

1.25E CONDITION

.10g & 2% damping

Sample Calculations:

FORCE: see pg. 23

Ao: see pg. 8

Bm. V @ sect. B = .825 + 2.150 = 2.975

$\frac{2VL}{AoG}$ @ sect. B-C = $\frac{2 \times 2.975 \times 10^3 \times 170}{23.6 \times 10^4 \times 1.4 \times 10^6} = 3.06 \times 10^{-3}$

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SUBJECT E.Q Motion COMPUTATION SHEET DATE

FILE CHECKED BY A.J

ESTIMATE DATE

V_s @ sect. P = V_s @ sect. Q + 13.40 = 13.5 + 13.4 = 26.9

I_o : See pg. 8

VL @ sect. R = V @ sect. Q × L = $17.27 \times 170 \times 10^3 = 29.3 \times 10^5$

M @ sect. R = M @ sect. Q + VL @ sect. R = 254.86 + 29.3 = 284.16

$\frac{M}{EI}$ @ sect. R = $\frac{284.16 \times 10^8}{3.4 \times 10^6 \times 12 \times 10^{10}} = 6.95 \times 10^{-8}$

Moment Deflection for 1.25E Condition

Conjugate Bm. Method

Loads for $\frac{M}{EI}$: $\times 10^{-8}$

Sect

A: $\frac{1}{3} \times 14.2 \times 12 \times .127 =$ 7.2

B: $\frac{2}{3} \times 14.2 \times 12 \times .127 =$ 14.4

$+ 1 \times 7.1 \times 12 \times .127 =$ 10.8

$+ 1/3 \times 14.2 \times 12 (.315 - .127) =$ 10.6

.188 35.8

C: + 10.8

+ 21.2

$+ 1 \times 7.1 \times 12 \times .315 =$ 26.8

$+ 1/3 \times 14.2 \times 12 (.575 - .315) =$ 14.8

.260 73.6

D: + 26.8

+ 29.6

$+ 1 \times 7.1 \times 12 \times .575 =$ 49.0

$+ 1/3 \times 14.2 \times 12 (.878 - .575) =$ 17.2

.303 122.6

E: + 49.0

+ 34.4

$+ 1 \times 7.1 \times 12 (.878) =$ 74.5

$+ 1/3 \times 14.2 \times 12 (.965 - .878) =$ 4.9

.087 162.8

F: + 74.5

+ 9.8

$+ 1 \times 7.1 \times 12 (.965)$ 92.0

$+ 1/3 \times 14.2 \times 12 (1.360 - .965) =$ 22.4

.395 188.7

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SUBJECT E.Q. MOTION COMPUTATION SHEET DATE

FILE CHECKED BY A.J.

ESTIMATE DATE

G:

	+	82.0
	+	44.8
+1×7.1×12 (1.360)	=	116.0
+⅓×14.2×12 (1.83−1.36)	=	26.6
.47		269.4

H:

	+	116.0
	+	53.2
+1×7.1×12 (1.83)	=	+ 156.0
+⅓×14.2×12 (2.35−1.83)	=	+ 29.5
.52		354.7

J:

	+	156.0
	+	59.0
+1×7.1×12 (2.35)		200.0
+⅓×14.2×12 (2.52−2.35)		32.4
.57		447.4

K

	+	200.0
	+	64.8
+1×7.1×12 (2.92)	=	248.0
+⅓×14.2×12 (3.54−2.92)	=	35.2
.62		548.0

L:

	+	248.0
	+	70.4
+1×7.1×12 (3.54)	=	302.0
+⅓×14.2×12 (4.20−3.54)	=	37.4
.66		657.8

M:

	+	302.0
	+	74.8
1×7.1×12 (4.20)	=	358.0
⅓×14.2×12 (4.86−4.20)	=	37.4
.66		772.2

N:

	+	358.0
	+	74.8
1×7.1×12 (4.86)	=	415.0
⅓×14.2×12 (5.55−4.86)	=	39.2
.69		887.0

P:

	=	+ 415.0
		+ 78.4
1×7.1×12 (5.55)	=	473.0
⅓×14.2×12 (6.25−5.55)	=	39.6
.70		1006.0

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SUBJECT E.Q. MOTION COMPUTATION SHEET DATE

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ESTIMATE DATE

Q:

	473.0
	79.2
$+1 \times 7.1 \times 12\,(6.25)$	= 530.0
$+\frac{1}{3} \times 14.2 \times 12\,(6.95-6.25)$	= 39.6
.70	1121.8

R:

	530.0
	79.2
	609.2

SECT.	CONJ. BM. (V) 10^{-8}	CONJ. SH. (M) $= M_\Delta$ (10^{-3})	$V_\Delta + M_\Delta = E_\Delta$ 1.25E' in.	$V_\Delta + M_\Delta = E_\Delta$ 1.0E' in.
A		133.41	.268	.362
	7251.0			
B		121.06	.255	.346
	7221.2			
C		108.76	.240	.326
	7147.6			
D		96.56	.223	.303
	7025.0			
E		84.61	.204	.277
	6862.2			
F		72.91	.186	.252
	6693.5			
G		61.56	.167	.227
	6404.1			
H		50.66	.148	.201
	6049.4			
J		40.36	.127	.172
	5602.0			
K		30.81	.107	.145
	5054.0			
L		22.21	.087	.118
	4396.2			
M		14.75	.067	.091
	3624.0			
N		8.58	.048	.065
	2737.0			
P		3.93	.031	.042
	1731.0			
Q		1.04	.014	.019
	609.2			
R		0	0	0

Sample Calc: Conj. Bm (V) @ sect (P-N) = 609.2 + 1121.8 + 1006.0 = 2737.0

M_Δ @ sect. P = M_Δ @ sect. Q + 1731 × 14.2 × 12 = 1.04 + 2.89 = 3.93

$\Sigma\Delta$ (1.25E) @ sect. A = $(134.93 + 133.41)10^{-3}$ = .268 in.

$\Sigma\Delta$ (1.0E') @ sect. A = $.268 \times \frac{.3048}{.2249}$ = .362 in.

FILE 2-1-13-007

BY _____ DATE _____

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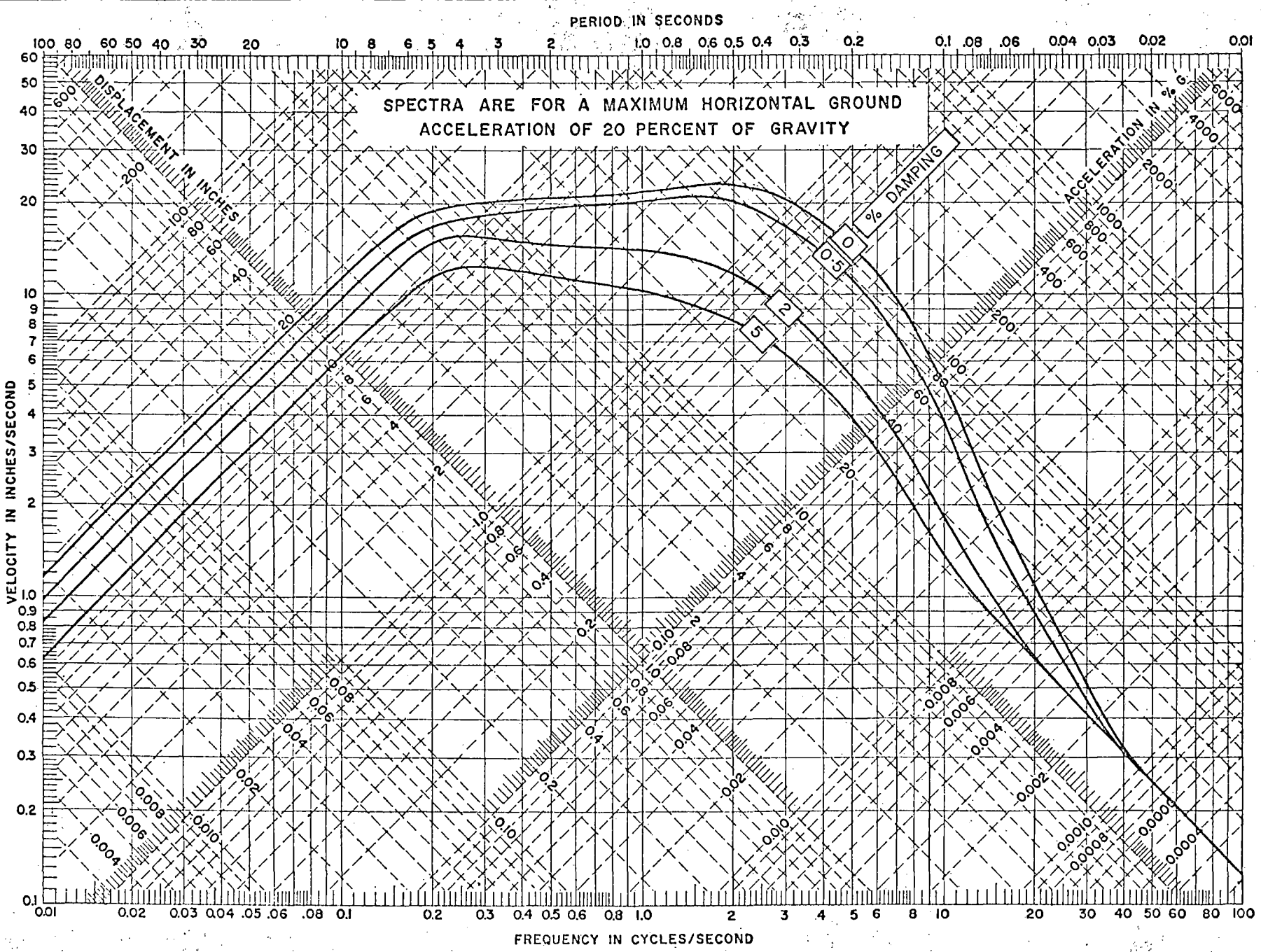
BY _____ DATE _____

BY _____ DATE _____

PLATE _____ OF _____

RECOMMENDED RESPONSE SPECTRA



BARNES & MOORE

FILE 4707-006-524-3-(B)

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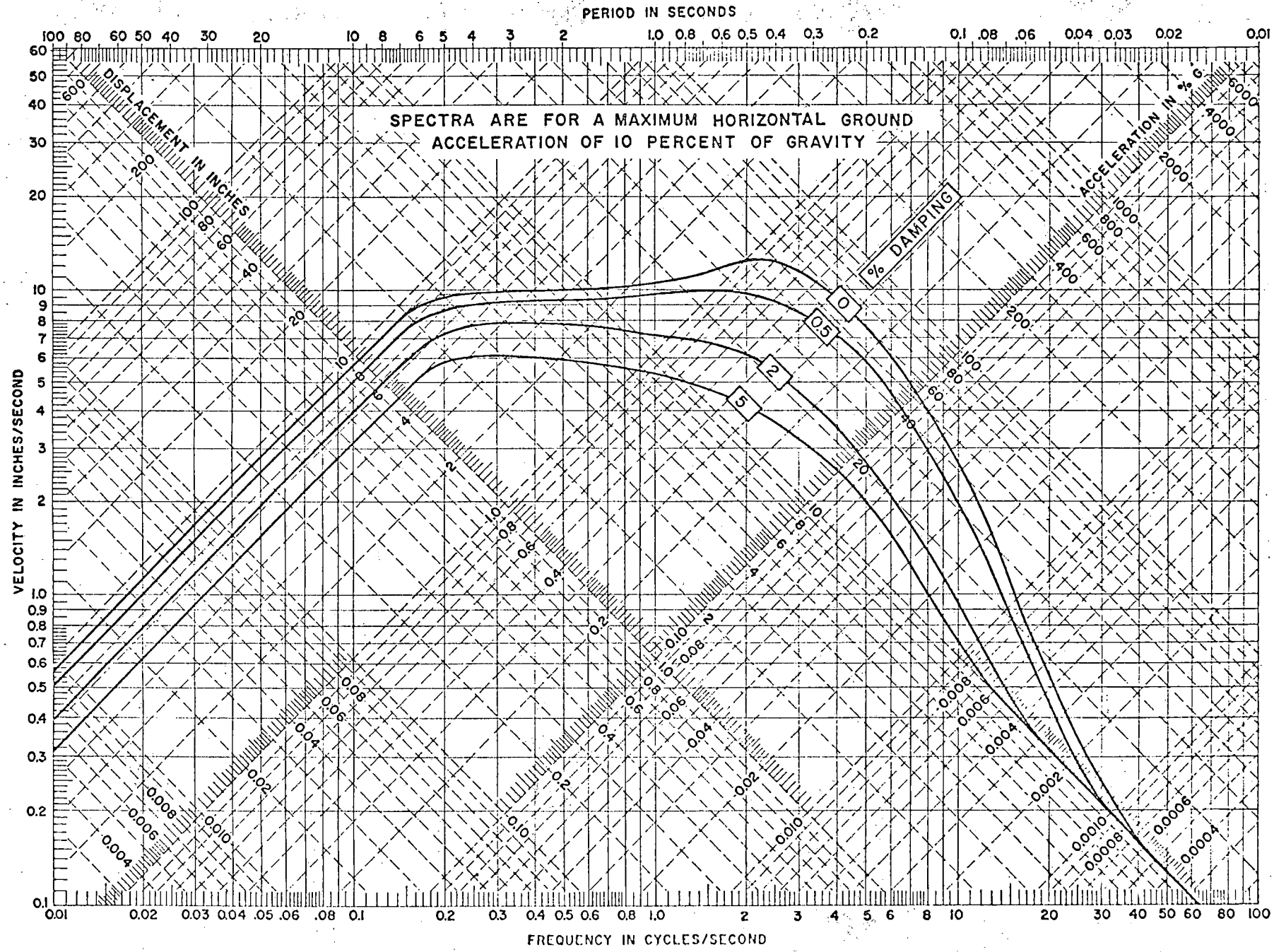
BY _____ DATE _____

PLATE _____ OF _____

RECOMMENDED RESPONSE SPECTRA



BAMES & MOORE

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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SUBJECT E.Q. ROCKING MOTION COMPUTATION SHEET DATE

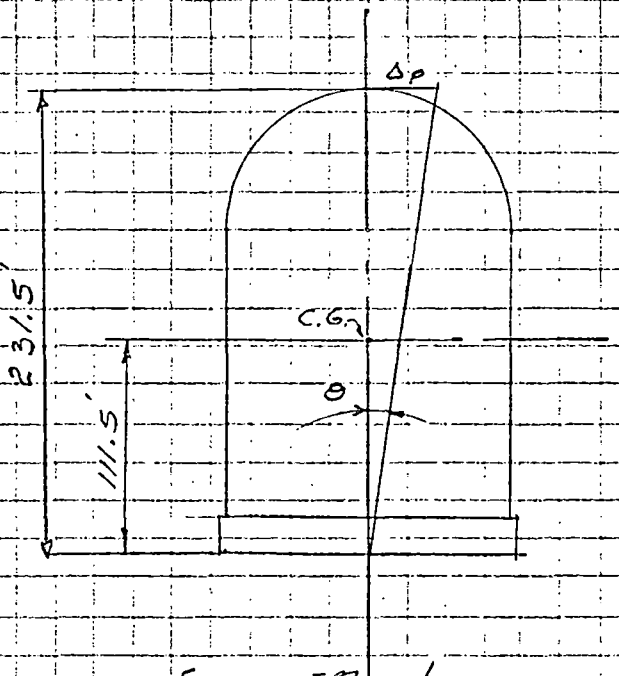
FILE CHECKED BY A.J

ESTIMATE DATE

HORIZONTAL DEFLECTION DUE TO ROCKING

ROCKING PERIOD T = .136 sec (see pg. 18)

For 2% damping and .10g acceleration spectrum, displacement of C.G. = .063" (see pg. 96)



$$\Delta_{PEAK} = \frac{231.5}{111.5} \times .063" = .131"$$

(VOID SEE PG 260-8)

For 5% damping and .20g acceleration spectrum, displacement of C.G. = .085" (see pg. 97)

$$\Delta_{peak} = \frac{231.5}{111.5} \times .085" = .175"$$

(VOID SEE PG 260)

REFER TO SALEM GEN. STA. PREPARED BY J.C

SUBJECT R. BUCKLING COMPUTATION SHEET DATE

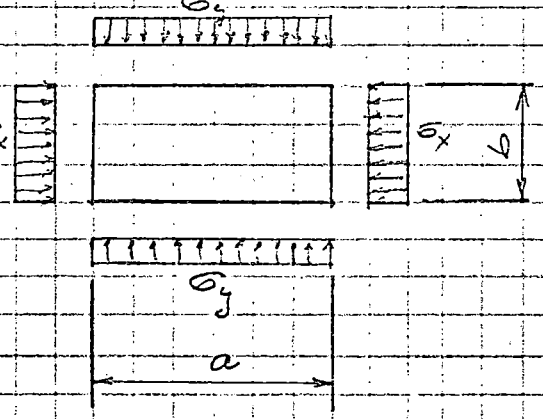
FILE CHECKED BY A.J

ESTIMATE DATE

LINER PLATE BUCKLING

The liner plate will be anchored to the wall by means of ½" stud anchors, normally spaced at 15" vertically and 16" horizontally. The dome liner is reinforced by Ts continuously welded to the liner in both circumferential and meridional directions at a maximum of 60" o.c. In addition, stud anchors will be placed with the grid of Ts so that the maximum unsupported length of the plate will be 20" in either direction.

If we conservatively consider the liner to be a series of simply supported plates, we obtain from "Theory of Elastic Stability by Timoshenko & Gere pg. 351, for the condition of a rectangular plate compressed in two perpendicular directions:



$$\left[\sigma_x m^2 + \sigma_y n^2 \frac{a^2}{b^2}\right]_c = \frac{\pi^2 D}{a^2 h}\left(m^2 + n^2 \frac{a^2}{b^2}\right)^2$$

Where: m and n are the number of half waves of buckling in each direction.

$$D = \frac{E h^3}{12(1-\nu^2)}$$

h = thickness of plate

ν = Poissons ratio = .3

The minimum value of the expression is obtained when m=n=1 or:

$$\left[\sigma_x + \sigma_y \frac{a^2}{b^2}\right]_c = \frac{\pi^2}{a^2 h} \cdot \frac{E h^3}{12(1-\nu^2)} \left(1 + \frac{a^2}{b^2}\right)^2$$

$$\left[\sigma_x + \sigma_y \frac{a^2}{b^2}\right]_c = \frac{\pi^2 E h^2}{12 a^2 (1-\nu^2)} \left(1 + \frac{a^2}{b^2}\right)^2$$

Our anchor pattern is basically a square. Consider 16"x16" spacing in cylinder and 20"x20" spacing in dome.

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SUBJECT R. BUCKLING COMPUTATION SHEET DATE

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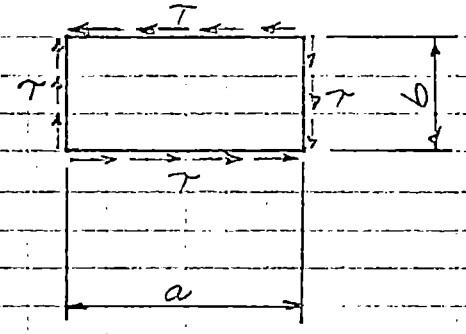
ESTIMATE DATE

If $a=b$

@ $[\sigma_x+\sigma_y]_c = \frac{\pi^2 E h^2}{12a^2(1-\nu^2)}(2) = \frac{\pi^2 E h^2}{3a^2(1-.09)} = \frac{\pi^2 E h^2}{2.73a^2}$

From "Theory of Elastic Stability" pg. 382 for a simply supported rectangular plate submitted to action of shearing forces:



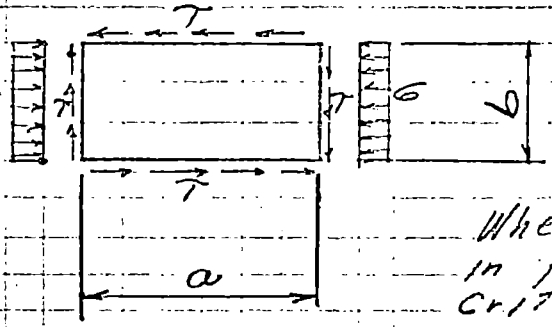
(b) $\tau_c = \frac{K\pi^2 D}{b^2 h} = \frac{K\pi^2}{b^2 h}\cdot\frac{Eh^3}{12(1-\nu^2)}$

$= \frac{K\pi^2 E h^2}{12b^2(.91)} = \frac{K\pi^2 E h^2}{10.9b^2}$

For $a=b$, $K=9.34$

CRITICAL COMBINATION OF SHEARING AND PURE COMPRESSIVE STRESSES IN THE LINER:

F. Bleich in his book "Buckling Strength of Metal Structures" states that S.B. Batdorf and M. Stein in their paper "Critical Combinations of Shear and Direct Stress for Simply Supported Rectangular Flat Plates NACA Tech. Note 1223, 1947, obtained the critical stress combinations for the case of shear and simultaneous longitudinal or transverse compressive stresses.



For $\frac{a}{b} \geq 1$

$$\left(\frac{\tau_c}{\tau_c^o}\right)^2 + \frac{\sigma_c}{\sigma_c^o} = 1$$

Where τ_c^o is the critical stress in pure shear and σ_c^o is the critical stress in pure compression. τ_c and σ_c are the critical stresses for the interaction condition.

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SUBJECT P. BUCKLING COMPUTATION SHEET DATE

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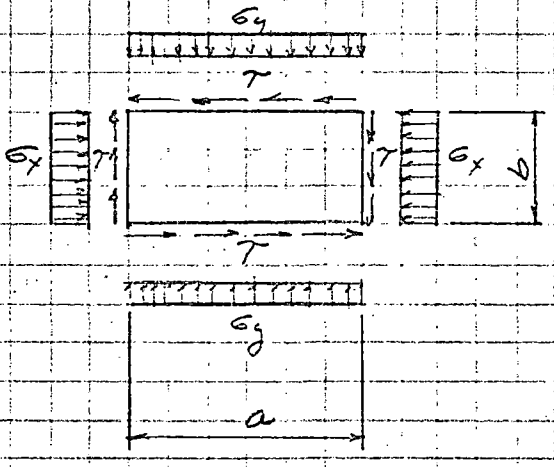
ESTIMATE DATE

Promoting the interaction formula to the case of biaxial compressive stresses...



$$\left(\frac{T}{T_c^\circ}\right)^2 + \frac{(\sigma_x + \sigma_y)}{(\sigma_x + \sigma_y)_c^\circ} \leq 1$$

Where T_c° is obtained from equation (6) and $(\sigma_x+\sigma_y)_c^\circ$ from equation @

T, σ_x and σ_y are actual stresses at particular points in the liner plate

Although, we are not dependent upon the liner to take seismic shear in the cylinder wall, we shall assume that the plate takes a proportionate part of the seismic shear with the diagonal seismic bars and check for buckling

MAX. COMPRESSION UNDER NO SHEAR CONDITION

NORMAL OPERATION

DOME: PEAK

$\sigma_x = \sigma_y = -14.0^K/_{in^2} = 6$

@ $[26]_c = \dfrac{\pi^2 \times 29\times10^6 (.5)^2}{2.73\times20^2}$

$\sigma_c = \dfrac{\pi^2\times29\times10^6(.5)^2}{2\times2.73\times20^2} = 32{,}800$ psi $>$ y.p. $= 32{,}000$

CYLINDER: $^3/_8$" P. @ 24' above base

$\sigma_y = -20.4^K/_{in^2}$

$\sigma_x = -15.1^K/_{in^2}$

@ $[\sigma_y+\sigma_x]_c = \dfrac{\pi^2\times29\times10^6(.375)^2}{2.73\times76^2} = 57{,}500$ psi

$[\sigma_y+\sigma_x]_{actual} = 20.4^K/_{in^2} + 15.1^K/_{in^2} = 35{,}500$ psi ✓

MAX. COMPRESSION PLUS MAX. SHEAR

1.0P − 1.0TL" − S − C − 1.0E'

DOME: PEAK (All shear taken by liner here)

$\sigma_y = -9.2^K/_{in^2} = \sigma_x = 6$

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SUBJECT R. BUCKLING COMPUTATION SHEET DATE

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ESTIMATE DATE

$T = \frac{28.8^{K}/_{1}}{6^{\square"}/_{1}} = 4.8^{K}/_{\square"}$

(Pg. 29)

$T_c^{\circ} = \frac{9.34\,\pi^2 \times 29\times10^6\,(.5)^2}{10.9\times20^2} > Y.P.$ ∴ use Y.P.

Y.P. in shear = .75 × 32 K/□" = 24 K/□"

G_c° = 32,000 PSI

$\frac{4.8^{K}/_{\square"}}{24^{K}/_{\square"}} + \frac{9.2^{K}/_{\square"}}{32^{K}/_{\square"}} = .2 + .29 = .49 < 1$

Dome @ S.L.

All bars used as diag. reinforcement. @12" o.c.

Equivalent vertical and horizontal

Area = $\frac{2\times.707\times1.56^{\square"}}{1.414\times12"} = 1.56^{\square"}/_{1}$

Liner plate takes $\frac{6.0}{6.0+1.56}$ × 46.3 (Pg. 29) = $36.7^{K}/_{1}$

$T = \frac{36.7}{6} = 6.1^{K}/_{\square"}$

$G_y = -9.5^{K}/_{\square"}$

$G_x = -10.5^{K}/_{\square"}$

$[G_x + G_y]_c^{\circ} = 64^{K}/_{\square"}$

$T_c^{\circ} = 24^{K}/_{\square"}$

$\frac{6.1}{24} + \frac{[9.5+10.5]}{64} = .25 + .31 = .56 < 1$ ✓

Cylinder: $\frac{3}{8}$" R @ 40' above base

$G_y = -\frac{102}{118}(29-13.3) - 13.3 = -26.9^{K}/_{\square"}$ comp.

$G_x = -11.3^{K}/_{\square"}$ ~~-11.3~~ -7.1 K/□" (SEE P. 90)

#18S bars used as diag reinf. @12"

Equiv. vertical and horizontal area = $4^{\square"}/_{1}$

Liner plate takes $\frac{4.5}{4.5+4.0}$ × 75 (Pg. 74) = $39.7^{K}/_{1}$

$T = \frac{39.7}{4.5} = 8.8^{K}/_{\square"}$

$T_c^{\circ} = \frac{9.34\,\pi^2\times29\times10^6\,(.375)^2}{10.9\,(16)^2} > Y.P.$ ∴ use Y.P.

$[G_x + G_y]_c^{\circ} = \frac{\pi^2\times29\times10^6\,(.375)^2}{2.73\times16^2} = 57{,}500$ PSI

$\frac{8.8}{24} + \frac{(26.9+7.1)}{57.5} = .356 + .66 = .59 < 1$ ∴ SPACE ANCHORS @12" EACH WAY

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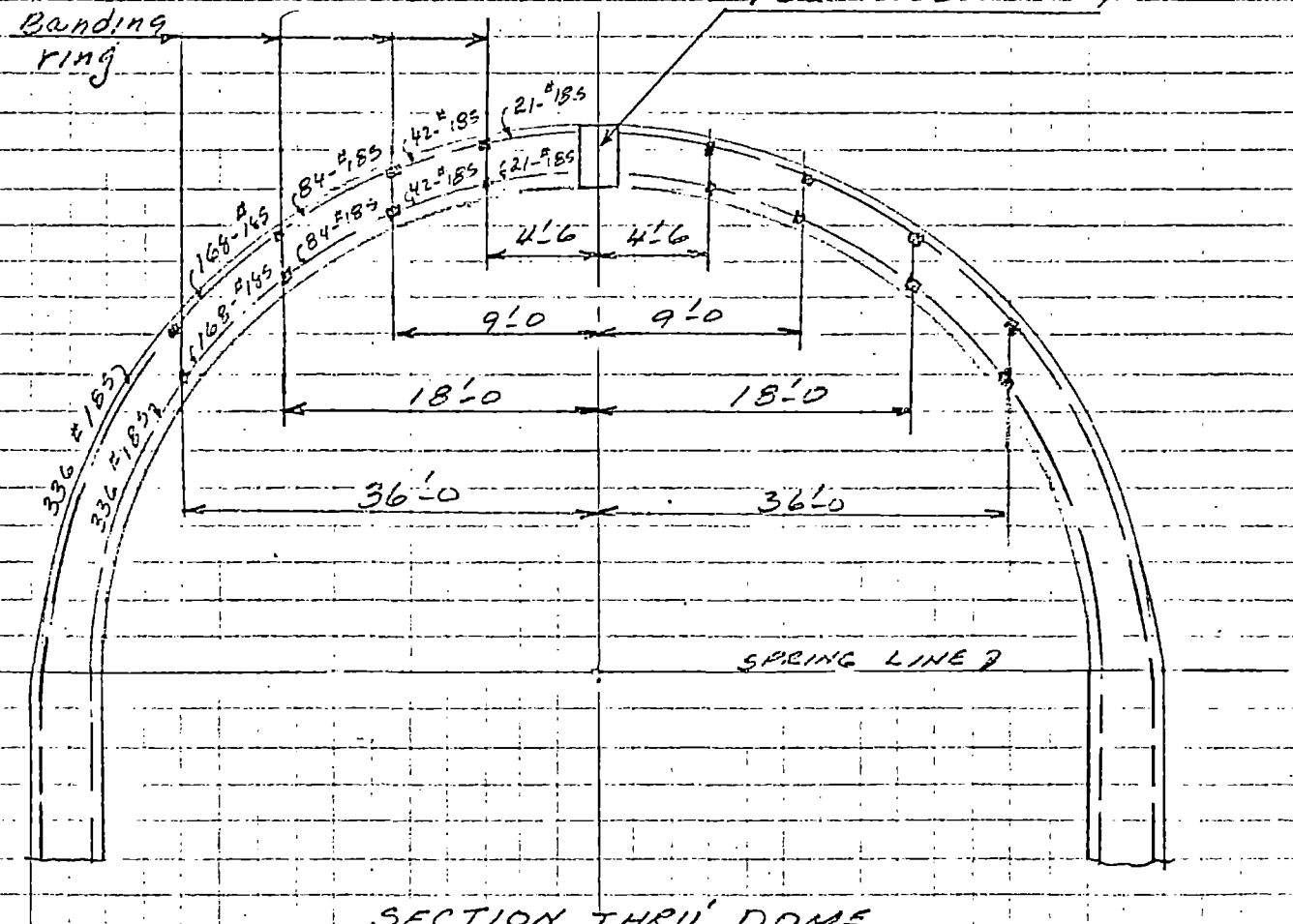
MERIDIONAL REINFORCING DOME

We start with two layers of #18S bars to match the bars in the cylinder wall. There will be a total of 336 bars in each layer. Because these bars are radial they will approach each other as they go toward the peak. Therefore, the area of steel per foot of perimeter increases as they approach the peak. In order to keep in the range of 6"/, and because the bars will get too close to each other, we must cut bars off. We do this by cutting half off at a time. Therefore, at successive cuts we go from 336 to 168 to 84 to 42 and finally to 21 bars near the peak (each layer). At each cut a banding ring will be used to distribute the load.



SECTION THRU' DOME
N.T.S.

As/, @ each cut off = 6 #"-
Viz: $\frac{2 \times 84 \times 4\#''}{2\pi \times 18'} = 5.95\#/'$

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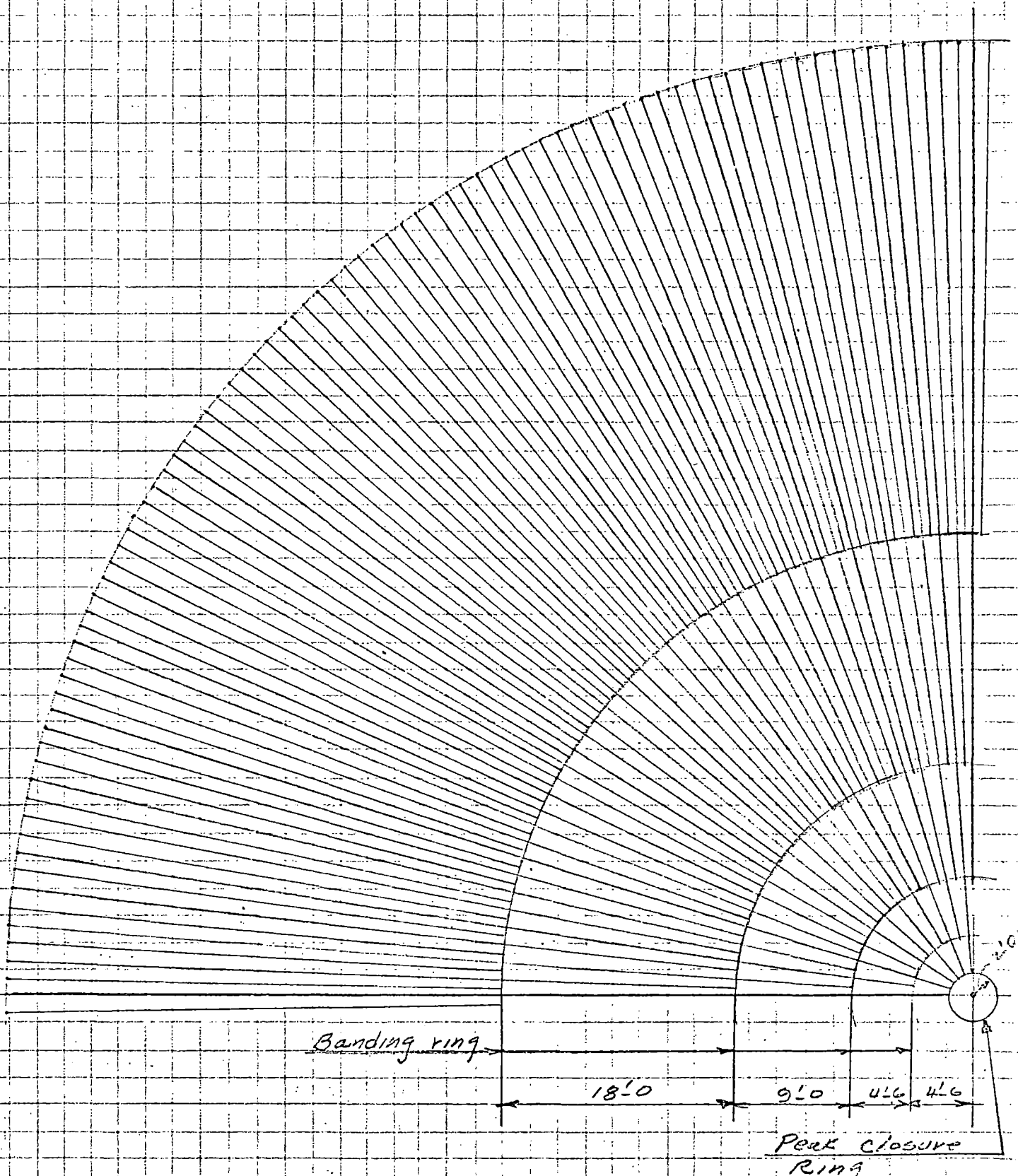

Partial Plan Meridional Reinforcement

3/32" = 1'-0"

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CIRCUMFERENTIAL REINFORCING DOME

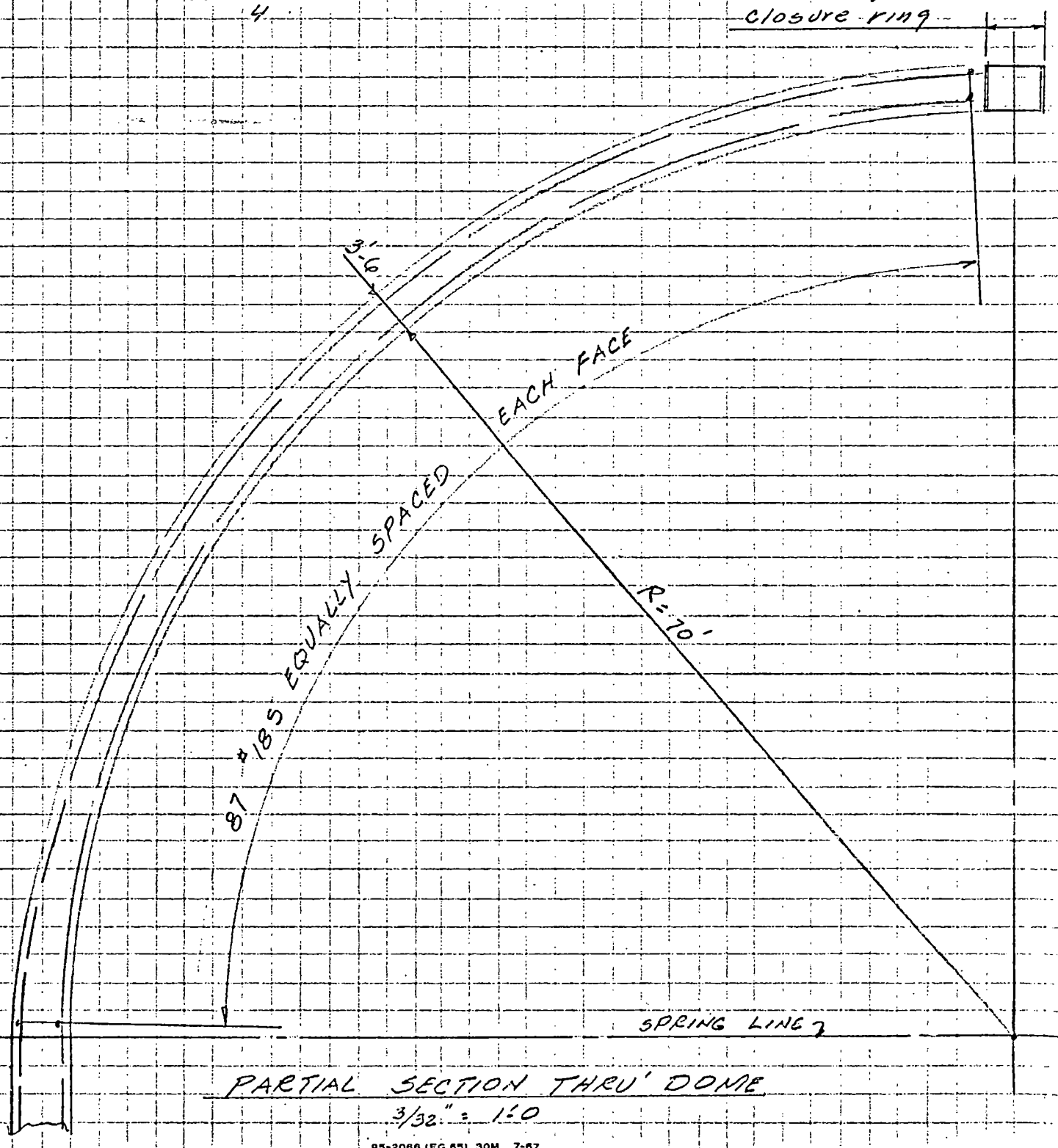
Radius to ℄ dome shell = 71.75'

Length of arc from springline to closure ring

$= \frac{\pi \times 71.75}{2} - 2' = 113' - 2' = 111'$

There is 6.25 #/' required and using #18 S bars ($A_s = 4$)

$\frac{111 \times 6.25}{4} = 174$ bars or 87 bars/layer.



PARTIAL SECTION THRU' DOME

3/32" = 1'-0"

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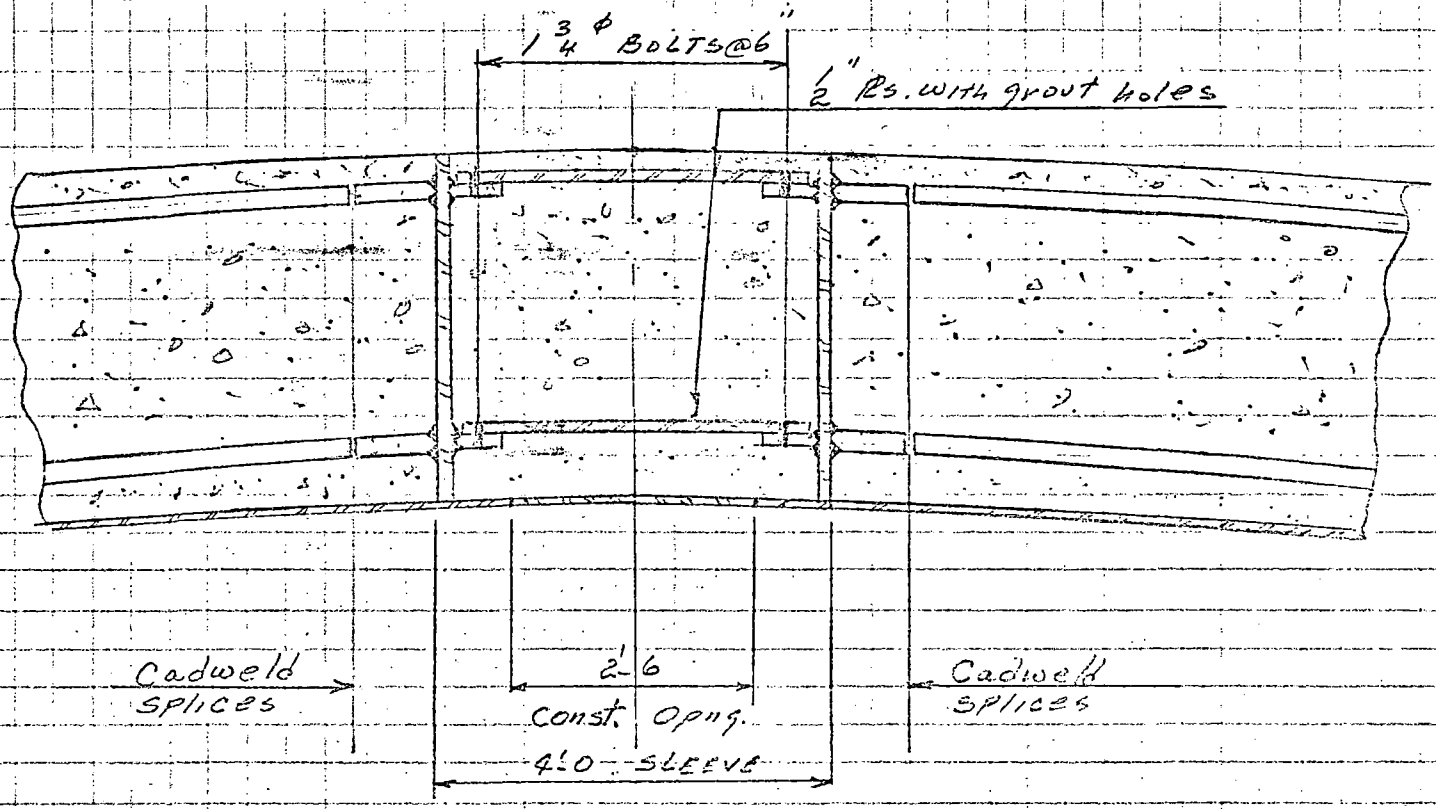
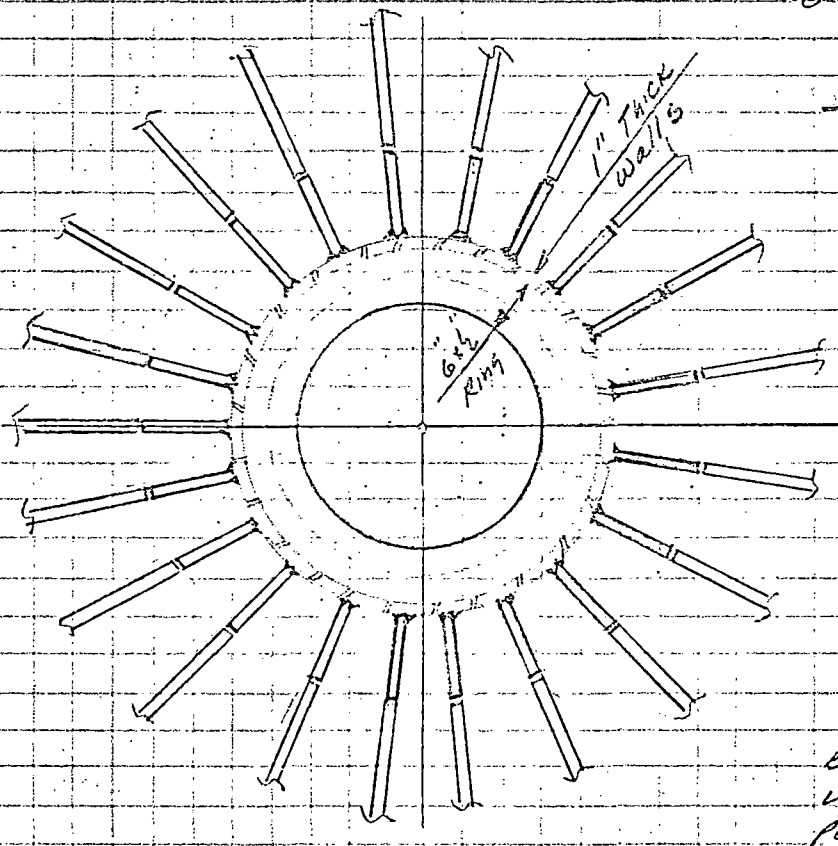
PEAK CLOSURE RING



SECTION AT PEAK



PLAN

No. $\frac{366 \times 6.25}{12.25} = +187^{K/'}$ I.S.P.

$+144$ I.O.T.

$-90 \times \frac{6.25}{12.25} = -46$ S

$285^{K/'}$

There are 2 rings

$285/2 = 142.5^{K/'}$

$\frac{142.5^{K/'} \times 2'}{.95 \times 60^{K/in^2}} = 5^{in^2}$ Req'd

Use rings 6x1/2

Thickness of circular plates req'd $= \frac{142.5^{K/'}}{.95 \times 60 \times 12''/'} = .21''$

USE 1/2" Pls.

Bolts: Ultimate strength in shear $= .75 \times 60 = 45^{K/in^2}$

B.C. $= 3.5''$; $\pi \times 3.5 \times 12 = 132''$

Use 6" spacing $\therefore$ 2 bolts per ft: $\frac{142.5}{2 \times 4.65 \times 45} = 1.65^{in^2}$/ft

USE 1 3/4 ϕ BOLTS

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FILE & Dome Liner Reinf. CHECKED BY A.J.

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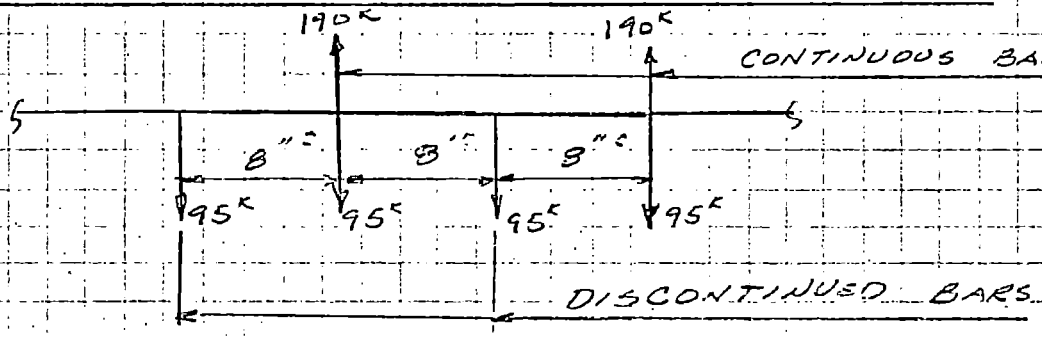
DESIGN OF BANDING RINGS IN DOME

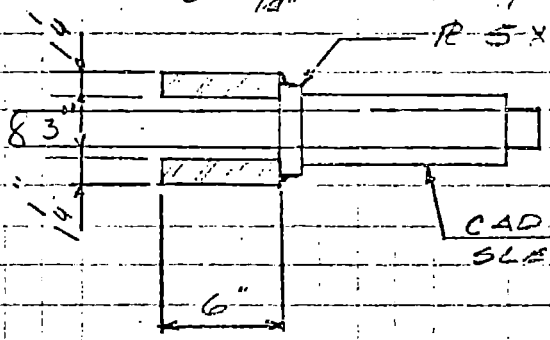


$\frac{142.5 \times 16}{12} = 190^K$

$M = \frac{95^K \times 16}{4} = 380^{"K}$

$\text{Design } K" = \frac{380}{.90} = 422^{"K}$

$\frac{422}{60^K/in^2} = 7.0 in^3$ Req'd S



$S \text{ supplied} = \frac{1}{6} \times 5.5 \times 6^2 = 33$

Bearing block: Area req'd: $\frac{95}{.90 \times 60} = 1.67^{in^2}$

Area supplied: $5 \times 1" = 5^{in^2}$

CHECKING ½" PL FOR BUCKLING UNDER WET CONCRETE LOAD

Dome Load @ critical peak:

D.L. ½" PL = 20.4 #/ft²

Conc. 3.5' x 150 = 525.0

Const. L.L. 50

595.4 #/ft² sag 600 #/ft²

If two cranes are working with 2 cu. yd. buckets, a pour rate of 42 cu. yds/hr. is feasible. If we assign 12 hours for initial set, there are 63 cu. yds. in loose condition.

$63 yd^3 = \frac{3.5' \times 2\pi r^2 (\cos\phi_0 - \cos\phi)}{27}$ where $r = 71.75'$

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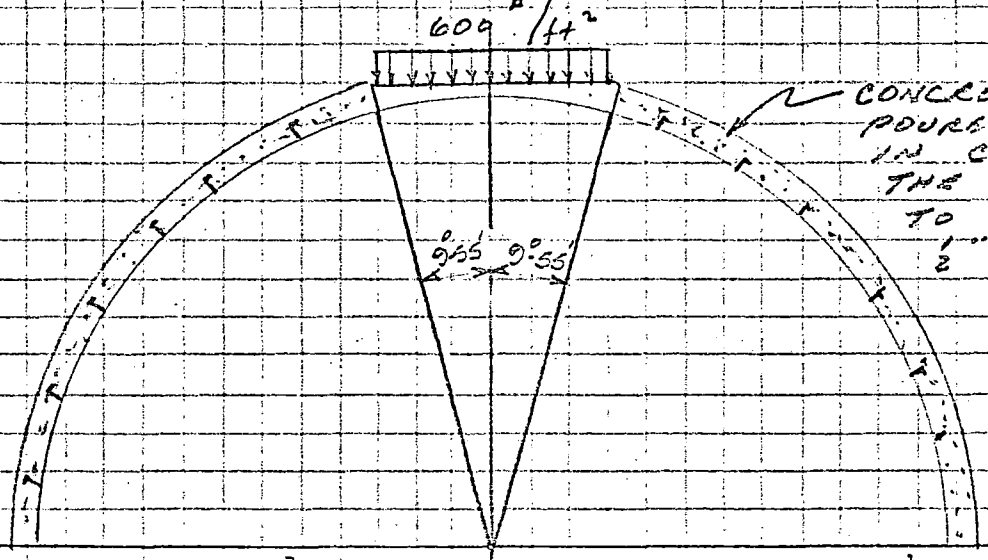
$$\frac{63\times 27}{3.5\times 2\pi (71.75)^2} = (\cos\phi_0 - \cos\phi_1) = .015$$

$\phi_0 = 0$; $\cos\phi_0 = 1$

$1 - \cos\phi_1 = .015$

$\cos\phi_1 = .985$

$\phi_1 = 9°55'$



CONCRETE PREVIOUSLY POURED AND ACTING IN CONCERT WITH THE LOWER LINER TO SUPPORT THE 1½" R. @ $\phi = 9°55'$

$R = 2\pi r^2 q (1 - \cos\phi) = 2\pi (71.75)^2 600 (.015)$

$= 292^K$

From peak to $\phi_1 = 9°55'$; $N'_\phi = -rq \frac{1}{1+\cos\phi}$

$N'_\theta = rq \left(\frac{1}{1+\cos\phi} - \cos\phi\right)$

Below $\phi_1 = 9°55'$; $N'_\phi = -\frac{R}{2\pi r \sin^2\phi} = \frac{2\pi r^2 \times .6 (.015)}{2\pi r \sin^2\phi}$

$N'_\theta = +\frac{R}{2\pi r \sin^2\phi} = \frac{.647^{K/}_{}}{\sin^2\phi}$

At peak; $N'_\phi = -\frac{71.75(.6)}{2} = -21.5^{K/}_{}$

$N'_\theta = -21.5^{K/}_{}$

At $\phi_1 = 9°55'$; $N'_\phi = -\frac{71.75 \times .6}{1+.985} = -21.7^{K/}_{}$

$N'_\theta = 71.75 \times .6 \left(\frac{1}{1.985} - .985\right)$

$= -20.7^{K/}_{}$

ϕ	$\sin\phi$	$\sin^2\phi$	N'_ϕ	N'_θ
20	.342	.117	$-5.55^{K/}_{}$	$+5.55^{K/}_{}$
40	.643	.412	Neglect	Neglect
60	.866	.750		
75	.966	.930		
90	1.0	1.0		

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At Peak; $G_\phi = G_\theta = \frac{-21,500}{.5 \times 12} = -3600$

From "Theory of Elastic Stability" by Timoshenko & Gere for an unreinforced sphere: Pg. 517

$$G_c = \frac{Eh}{R\sqrt{3(1-\nu^2)}} = \frac{29 \times 10^6 \times .5}{71.75 \times 12\sqrt{3(1-.3)^2}} = \frac{29 \times 10^6 \times .5}{71.75 \times 12\sqrt{2.72}}$$

$= 10,100$ psi

∴ Unreinforced R o.k. for construction loads

However since anchors are needed for resistance of liner to design loads, we will use Ts as reinforcements of liner in case of unusual construction loads. Maximum unbraced length of plate in hoop direction to be 5'-0.

$\frac{\pi \times 140}{5}$ = 88 spaces at edge, this can be broken down into 44 spaces at $R = \frac{44 \times 5}{2\pi} = 35'$ and into 22 spaces at $R = \frac{22 \times 5}{2\pi} = 17\frac{1}{2}$ and into 11 spaces at $R = 9'$.

(see page 110 for layout.

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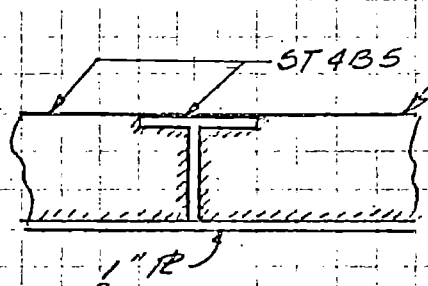

SECTS. A-A & B-B

PARTIAL PLAN OF DOME LINER REINF.

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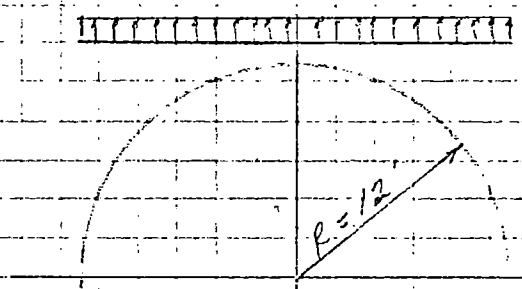
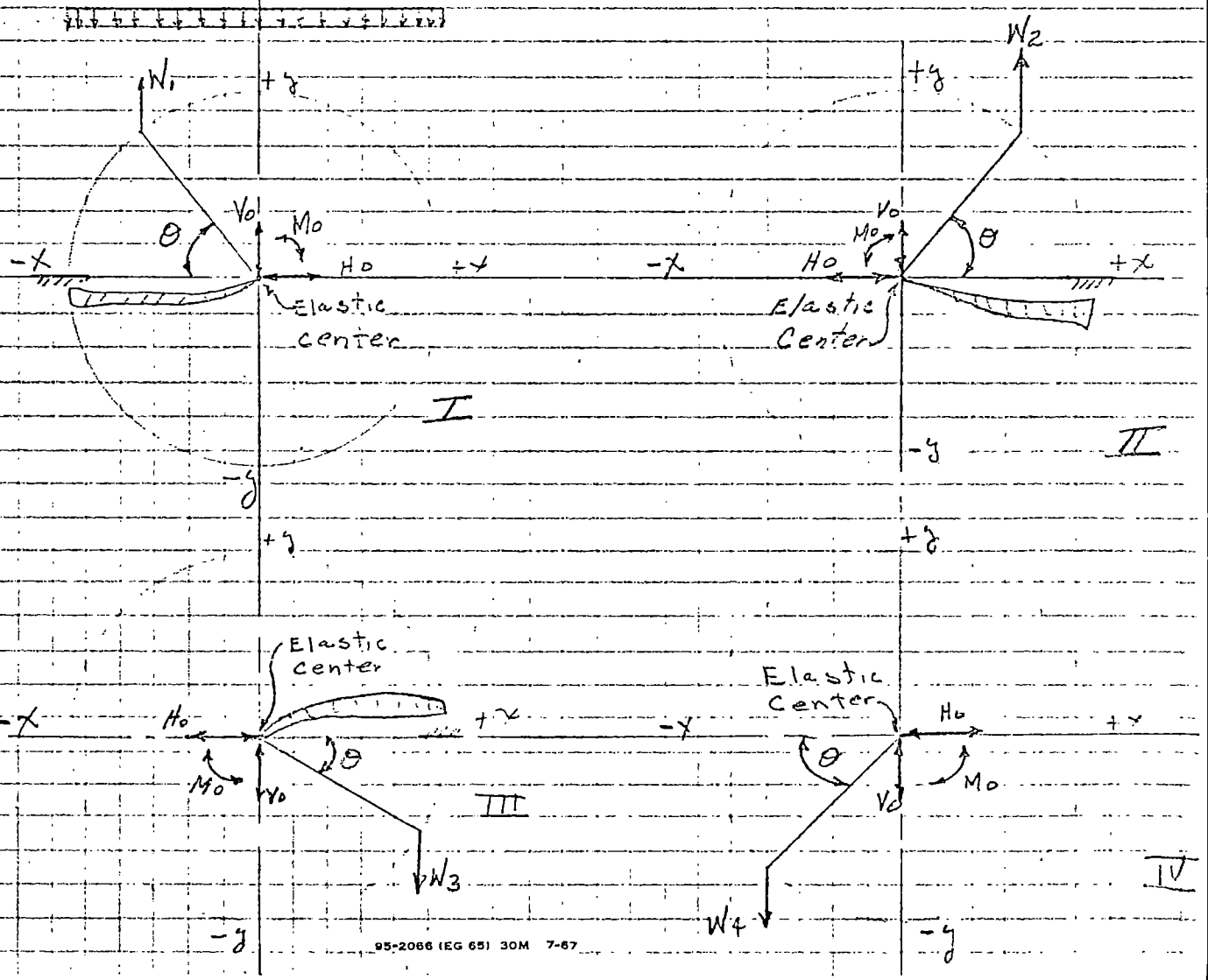
EQUIPMENT ACCESS HATCH ; 18'DIA. OPENING

ELASTIC CENTER ANALYSIS

UNIT LOAD BOTH VERTICAL AND HORIZONTAL TO BE 100 K/L
ASSUME DEPTH OF CIRCULAR RING TO BE 3'-0 AND WIDTH TO BE 7'-6

NOTE: Principal wall reinforcing will not terminate in ring but will sweep around opng. conservatively estimate the ring to take loading across the clear opn'g. plus 3' all around the clear opening. Therefore design diameter = 24'





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For a symmetrical structure, the following equations hold true: (see Portland Cement Assoc. Pamphlet 5453)

$$H_o = -\frac{\Sigma m a y}{\Sigma a y^2} \quad ; \quad V_o = -\frac{\Sigma m a x}{\Sigma a x^2} \quad ; \quad M_o = -\frac{\Sigma m a}{\Sigma a}$$

Where: (a) is the "elastic weight" of an arc of the structure $= \frac{ds}{EI}$

(y) and (x) are distances from the principal axese going thru' the elastic center.

(m) is the moment in the structure viewed as a statically determinate structure by removing some fixity and substituting the elastic center connected by an imaginary infinitely rigid arm to the point where the fixity was removed.

On the preceding page, the original ring will be replaced by the four rings shown below it, and a unit load $W_1 = W_2 = W_3 = W_4$ is shown placed at the same angle θ in each beam.

For I: $a_x = -$ For I: $a_y = +$

II: $a_x = +$ II: $a_y = +$

III: $a_x = +$ III: $a_y = -$

IV: $a_x = -$ IV: $a_y = -$

$\therefore V_{o_1} = -V_{o_2}$ $\therefore H_{o_1} = -H_{o_4}$

$V_{o_3} = -V_{o_4}$ $H_{o_2} = -H_{o_3}$

$V_{o_1} + V_{o_2} + V_{o_3} + V_{o_4} = 0 = V_o$ $H_{o_1} + H_{o_2} + H_{o_3} + H_{o_4} = 0 = H_o$

Final moment at any point $= M_o + H_o y + V_o x + m$

$= M_o + m$

If we consider compression on the outside face to be $-$ then m is negative at all times and M_o is positive.

Break circle up into 10° segments

$\therefore a_1 = a_2 = a_3 \ldots$

$$M_o = -\frac{\Sigma m a}{\Sigma a} = -\frac{a \Sigma m}{\Sigma a} = -\frac{ds \Sigma m}{\frac{1}{EI} \Sigma ds} = \frac{ds \Sigma m}{\Sigma ds}$$

Let $ds = 1$

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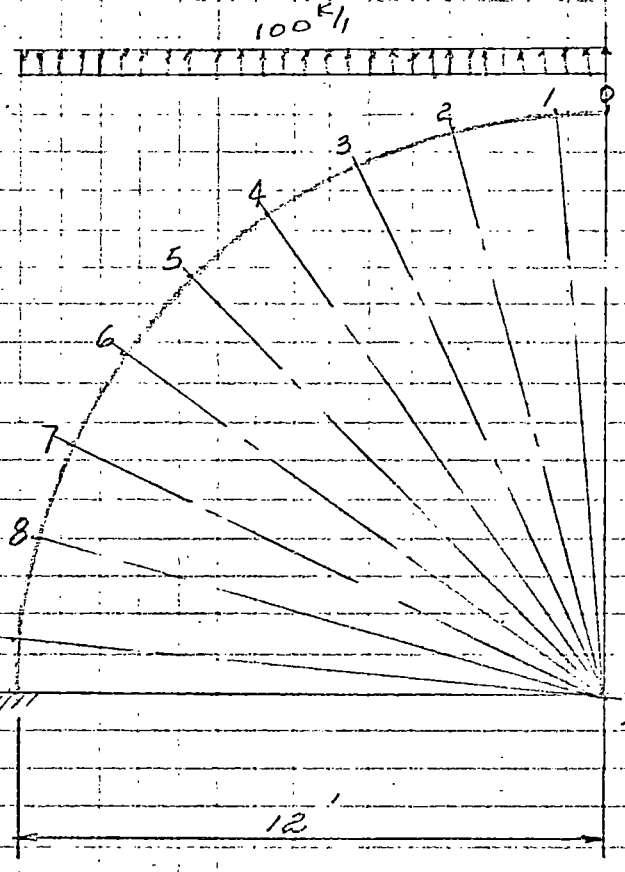

SECT	θ	$\sin\theta$	$R\sin\theta = X$	$m = \frac{wX^2}{2}$	$M_o = -\frac{1}{9}(-32470)$	$m + M_o$
1	5°	.08716	1.05	−55	+ 3600	+3545
2	15°	.25882	3.10	−465	+ 3600	+3135
3	25°	.42262	5.07	−1280	+ 3600	+2320
4	35°	.57358	6.88	−2370	+ 3600	+1230
5	45°	.70711	8.55	−3600	+ 3600	0
6	55°	.81915	9.85	−4830	+ 3600	−1230
7	65°	.90631	10.85	−5900	+ 3600	−2300
8	75°	.96593	11.60	−6750	+ 3600	−3150
9	85°	.99619	11.95	−7150	+ 3600	−3550

$\Sigma m = -32470$

Pt. 0: $m = 0$, $\therefore M = +3600$

Pt. 10: $m = -\frac{100}{2} \times 12^2 = -7200$, $M_o = +3600$ $\therefore M = -360$

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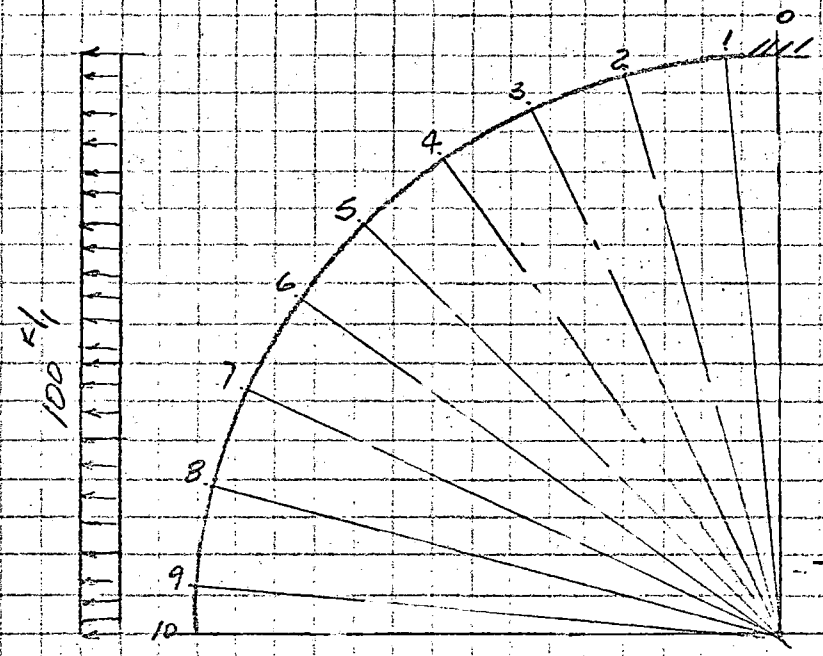

SECT.	M
0	-3600
1	-3550
2	-3150
3	-2300
4	-1230
5	0
6	+1230
7	+2300
8	+3150
9	+3545
10	+3600

CRITICAL LOADS

1.5P : VERT.

Σ ELEV. = 142 : $\left[\frac{-76}{142}(135-39)-39\right].95 =$

+366 K/1	1.5P
- 80	S
- 85	D
+201 K/1	

HOR.

+735 K/1	1.5P
- 124	S
+611 K/1	

1.25P : VERT.

+305 K/1	1.25P
- 85	D
- 80	S
+ 98	1.25E
+238 K/1	

HOR.

+615 K/1	1.25P
- 124	S
+ 14	1.25E
+505 K/1	

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1.0P: VERT.

+244 K/'	1.0P
+106	1.0E'
−85	D
−80	S
+185 K/'	

HOR

+490	1.0P
+15	1.0E'
−124	S
+381	

The critical combination of vertical plus horizontal loading is 1.5P condition.

Final Moments Due to Loading in 2 Directions

Sect.	Mom. due to vert. Ld.	Mom. due to hor. Ld.	M_y 'K
0	2.01 (+3600)	6.11 (−3600)	− 14,800
1	2.01 (+3550)	6.11 (−3550)	− 14,500
2	2.01 (+3150)	6.11 (−3150)	− 12,900
3	2.01 (+2300)	6.11 (−2300)	− 9,450
4	2.01 (+1230)	6.11 (−1230)	− 5050
5	2.01 (0) 0	6.11 (0) 0	C
6	2.01 (−1230)	6.11 (+1230)	+ 5,050
7	2.01 (−2300)	6.11 (+2350)	+ 9,450
8	2.01 (−3150)	6.11 (+3150)	+ 12,900
9	2.01 (−3550)	6.11 (+3550)	+ 14,500
10	2.01 (−3600)	6.11 (+3600)	+ 14,400

Axial Tension: T

Pt. 0: $611 \times 12' = 7,350^{K}$

Pt. 10: $201 \times 12' = 2,410^{K}$

Shear Load From 18' Door

$p = 70.5$ psi

Area $= \pi r^2 = \pi (9)^2 144 = 36,600\ in^2$

$P/_{ft} = \frac{36,600 \times 70.5}{\pi (18)} = 45.5\ ^{K}/_{'}$

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Secondary Stresses

If M_x is the torsional moment/ft about the centroid of the ring, it will generate the following M_z at any section normal to M_y and to M_x.

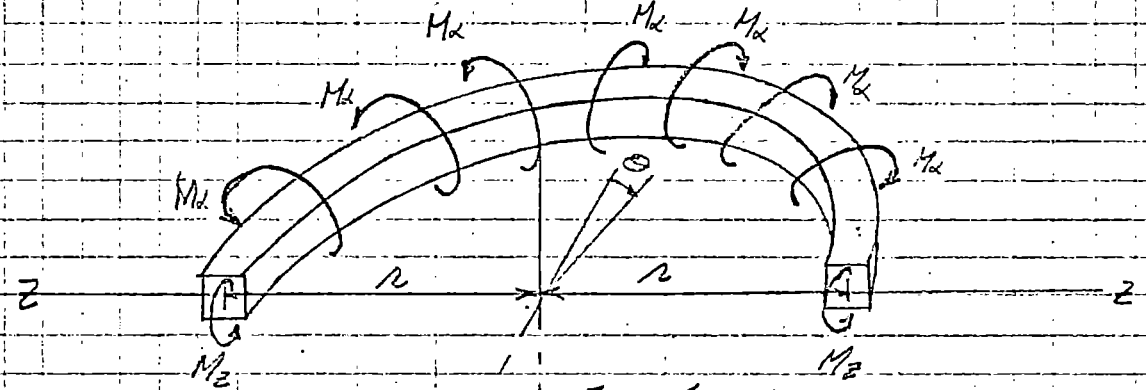

Fig. 1

Taking moments about z axis

$$2M_z = 2\int_0^{\frac{\pi}{2}} (M_x \cos\theta)(r\,d\theta)$$

$$2M_z = 2\int_0^{\frac{\pi}{2}} M_x r \cos\theta\, d\theta$$

$$M_z = M_x r [\sin\theta]_0^{\frac{\pi}{2}} = M_x r$$

We will consider that the ring girder around large openings is subject to loading from the vertical and circumferential reinforcing bars as shown in Figure # 2. In addition, the ring will be designed to support a shear loading along its inner edge caused by the peripheral reaction of the opening cover. In general, these loads will be carried primarily by the concrete ring reinforced with concentric reinforcing bar rings and radial stirrups.

For the purpose of analysis, the cover and ring will be considered as a disc and this disc cut into hypothetical strips, the same width as the reinforcing spacing, see Figure # 4. Since each strip is subject to the internal pressure of the containment, it will have an end reaction at the surface where the outer edge of the ring joins the shell. This reaction is shown as V' on Figure # 3. It can be proved that V' is equal and opposite to component V of the

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circumferential reinforcing bar tension T. The same relationship will hold for any other horizontal section through the ring. From this analysis, it can be seen that the peripheral shear forces around the outer edge of the ring are carried by the circumferential bars of the containment.

Again referring to Figure # 3, the ring will be subject to bending due to the eccentricity of the reinf. bars and liner loads. The component A of the circumferential reinf. tension T acting at the distance (e) from the centroid of the ring induces bending moments in the ring. The distance (e) is computed on the basis of both reinf. bars and liner R acting together. Similarly, the vertical bars and the liner plate have a centroid offset from the center of the ring by a distance (e') which will cause bending moments acting at right angles to those caused by the circumferential bar loads.

The shear loading on the inner edge of the ring in conjunction with the loading on the ring itself from the internal pressure causes torsion on the ring. The total torsional moment is resisted by both the ring itself and also by the main reinforcing bars in the shell. Figure # 5 shows three typical radial elements of the ring and how the deflection caused by torsion is resisted by the vertical or circumferential bars or by a combination of the two.

Under the influence of the torsional moment, a section through the ring rotates through an angle θ and the reinforcing bars in the shell changes in length by an amount Δ. (See Figure # 6) We will assume that since the concrete shell when subjected to internal pressure is cracked, that the total torsional moment is carried by the bars alone. The angle θ is dependent on the stiffness of the ring and the restraining action of the reinforcing bars at the outer edge of the ring. A process of iteration will be used so that the Δ of the wall bars and the θ of the ring will be compatible. (See Figure # 6). If necessary additional radial bars will be added to reinforce the wall reinforcement.

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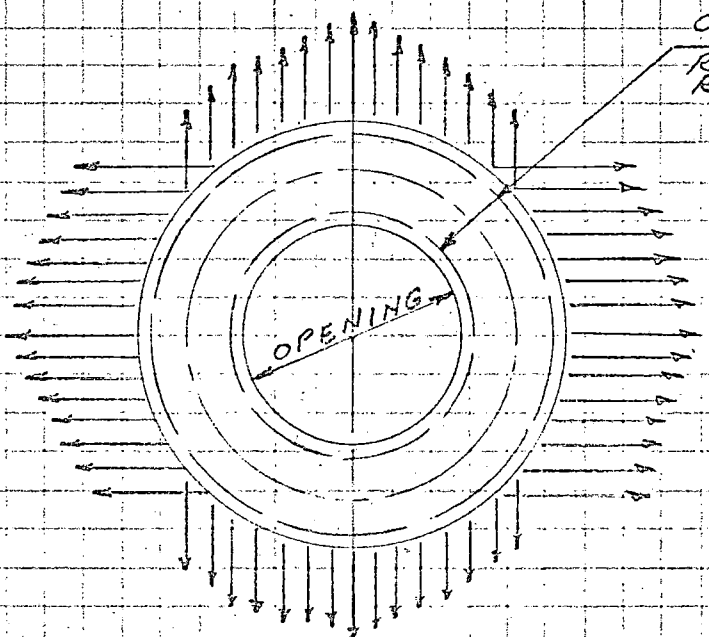
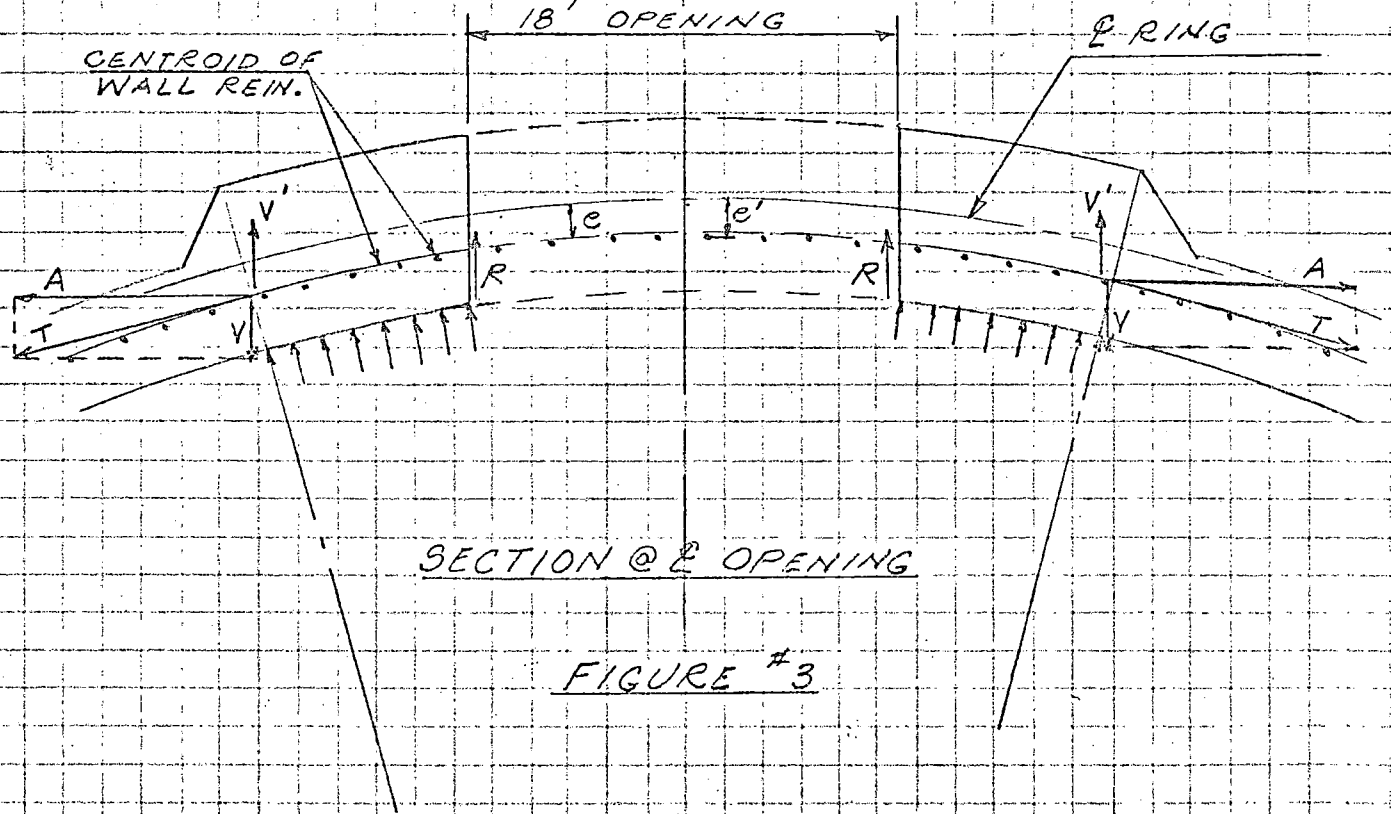


ELEVATION

FIGURE #2



SECTION @ ℄ OPENING

FIGURE #3

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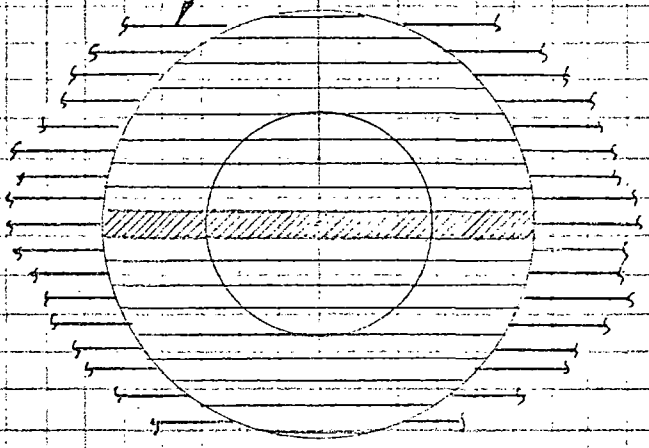


FIGURE # 4

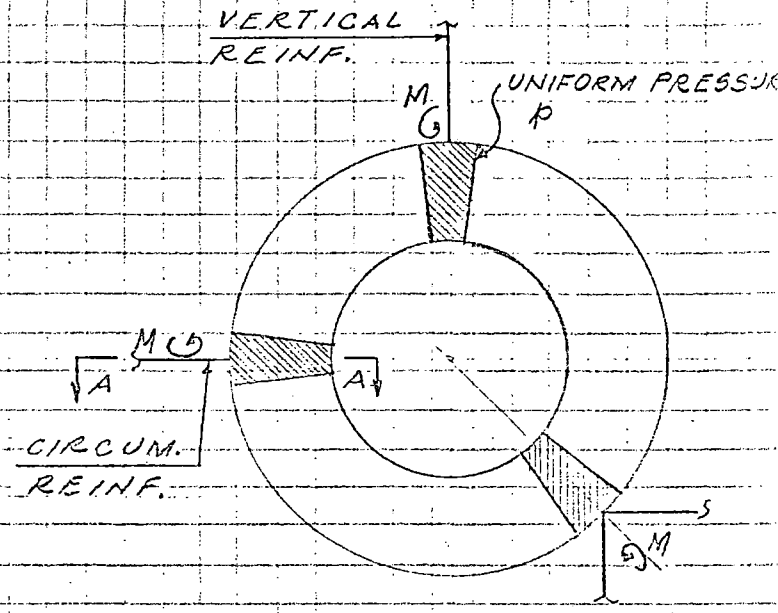
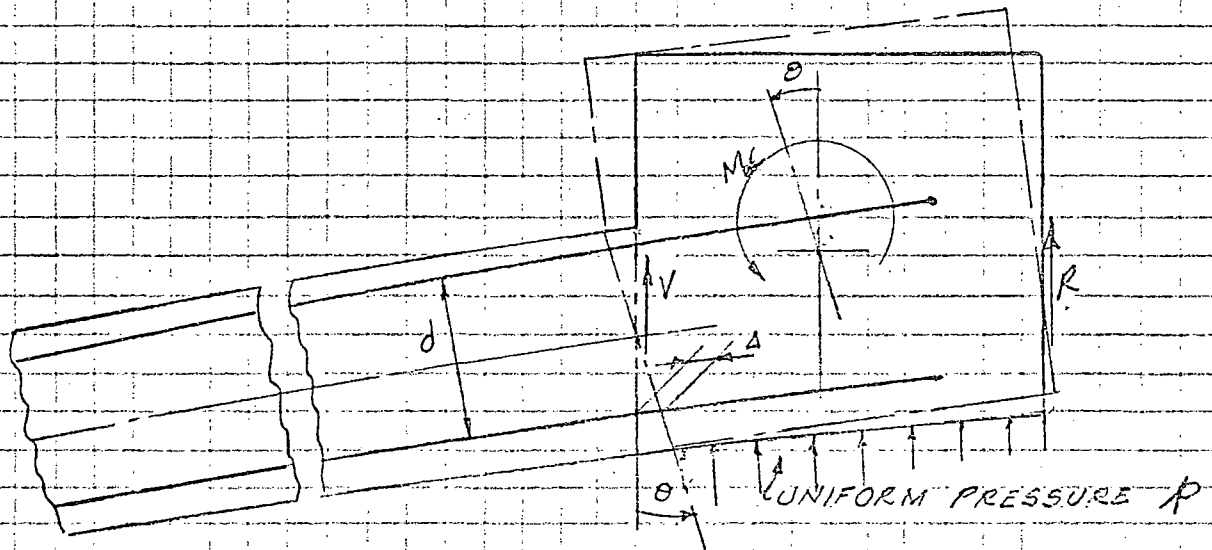


FIGURE # 5



SECTION A-A
IDEALIZED CONCEPTION OF ROTATION

FIGURE # 6

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SHEAR IN RING CAUSED BY NON UNIFORM LOADING AROUND PERIMETER

This will be maximum at point where the moment changes fastest. Therefore, pt. 5 of our typical ¼ quadrant is critical. Note that this shear is radial with respect to the center of the opening.

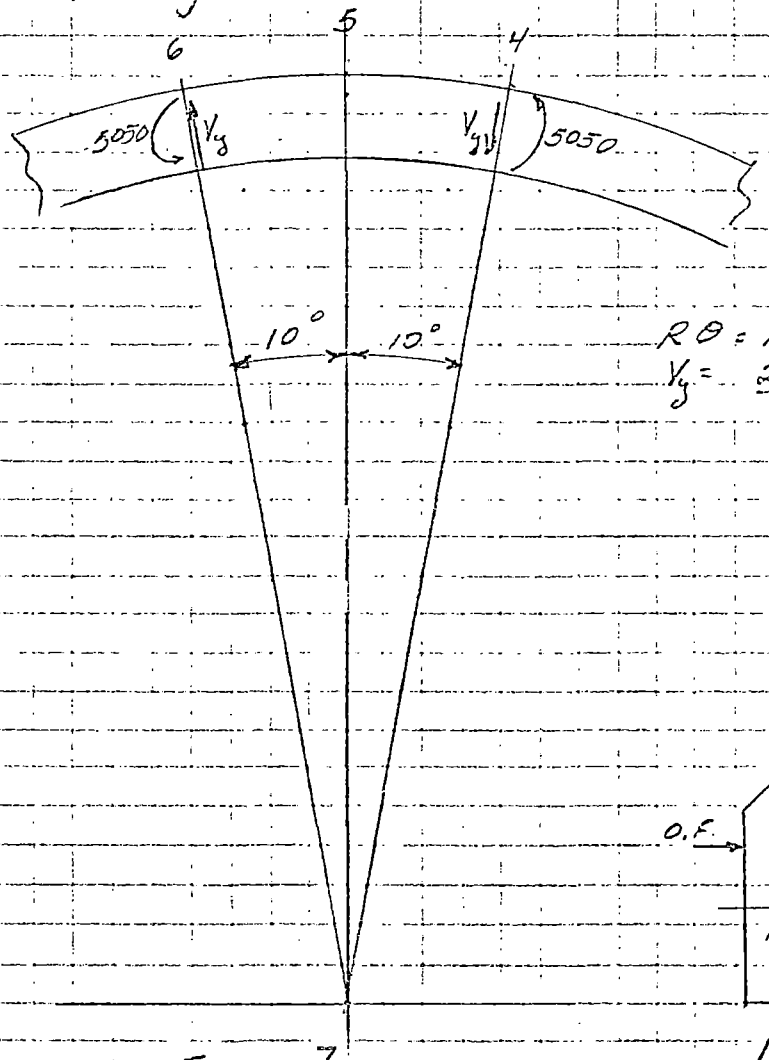

Fig. 7

$R\theta = 12' \times .349 = 4.2'$

$V_y = \frac{2 \times 505^0}{4.2} = 2400^K$

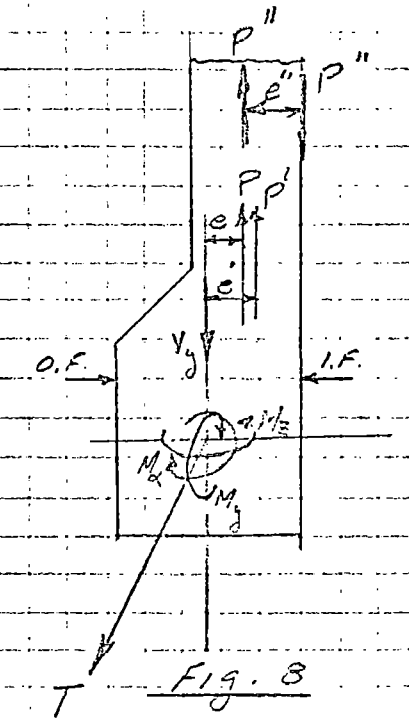

Fig. 8

Figure #8 shows the resultant normal load, moments and shear, to be taken by the ring. Pe is the effect of the eccentricity of the circumferential loading, Pe' is the effect of the eccentricity of the vertical loading.

"P"e" is the effect of couple produced by heating of the liner.

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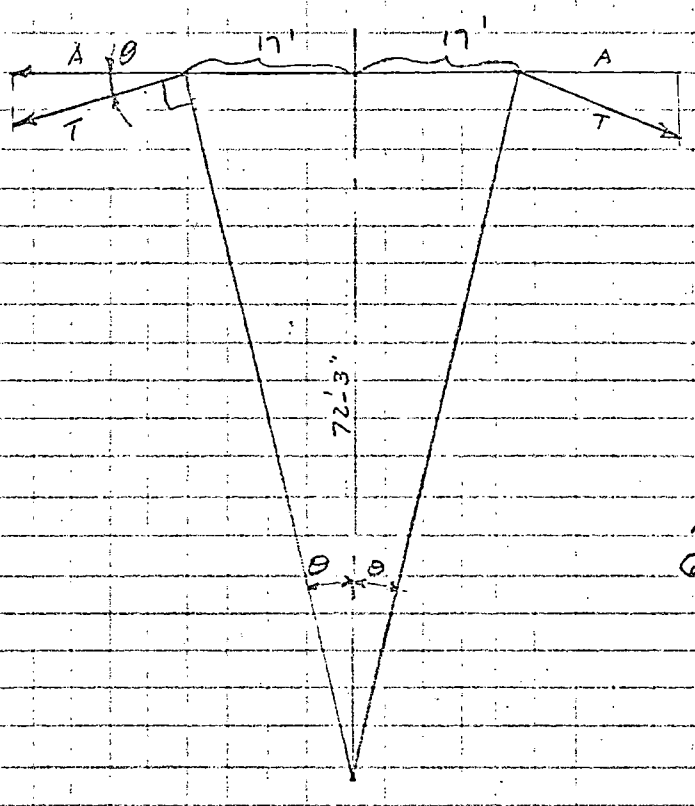
Secondary Moments Caused By Curvature of Wall

Assuming a 7'-6" wide bm. and a 4'-6" wall, $e = 45" \frac{12.9 \times 27}{17.4}$

$e = 25"$, $e' = 45 - 5.9 \times 27/10.4 = 29.5"$

CIRCUMFERENTIAL LOADING:

Loads vary from 0 at midheight of ring (Pt. 10) to max at top and bottom points of ring (Pt. 0)



PLAN @ Midheight

$\tan \theta$ @ midheight $= \frac{17}{72.25} = .235$

$\theta = 13°15'$

$A = T \cos \theta = .973T$

At pt. of max loading, $\theta = 0$ and $A = T$

Use $A = T$ thru' out.

Moment Pe @ Pt. 0:

$611 \times 12 + \frac{25}{12} = 15{,}300^{\#}$ Tension on I.F.

VERTICAL LOADING:

Loads vary from 0 at top and bot. points of ring (Pt. 0) to max at midheight of ring (Pt. 10)

Moment Pe @ Pt. 10:

$201^{\#}/_{1} \times 12' \times \frac{29.5}{12} = 5950^{\#}$ Tension on I.F.

Secondary Moments Caused By Heating of Liner

$e" = 2'-3"$

CIRCUMFERENTIAL LOADING

$P" = 153^{\#}/_{1}$; @ Pt. 0: $P"e" = 153 \times 2.25 \times 12 = 4{,}150^{\#}$ Comp. on I.F.

VERTICAL LOADING

$P" = 144^{\#}/_{1}$; @ Pt. 10; $P"e" = 144 \times 2.25 \times 12 = 3{,}900^{\#}$ Comp on I.F.

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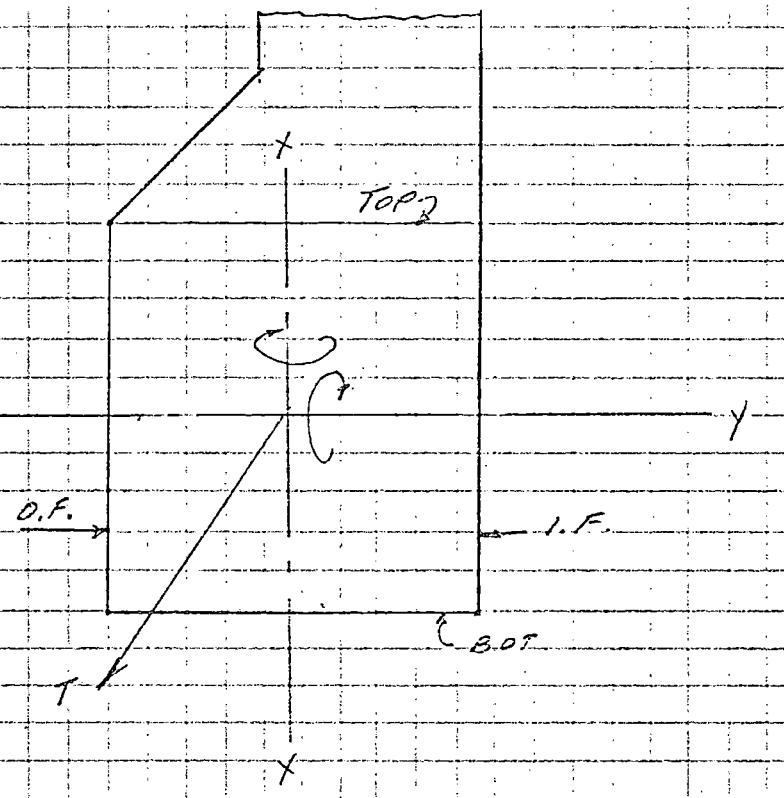
Secondary Moments Caused By Torsion

$M_z = 45.5^{K} \times 4' + 70.5^{\#}/_{A}" \times 144^{\#}/_{1}" \times \frac{4^2}{2}' = 263^{1K}/_{1}'$

M_z at any section $= 263^{1K}/_{1}' \times 13' = 3420^{1K}$ COMP. ON I.F.

DESIGN OF RING FOR BENDING ABOUT X-X AXIS, Y-Y AXIS AND AXIAL TENSION



Pt. 0:

$\frac{T}{\Phi} = \frac{7,350^{K}}{.95} = 7750^{K}$

$\frac{M_y}{\Phi} = -\frac{14,800}{.90} = -16,400^{1K}$ Tension on bot.

$\frac{M_x}{\Phi} = \frac{15300 - 4150 \cdot 3420}{.90} = \frac{7730}{.90} = 8600^{1K}$ Tension on I.F.

Pt. 10

$\frac{T}{\Phi} = \frac{2,410}{.95} = 2540^{K}$

$\frac{M_y}{\Phi} = +\frac{14,800}{.90} = +16,400^{1K}$ Tension on top

$\frac{M_x}{\Phi} = \frac{5950 - 3900 - 3420}{.90} = \frac{1370}{.90} = 1520^{1K}$ Tension on O.F.

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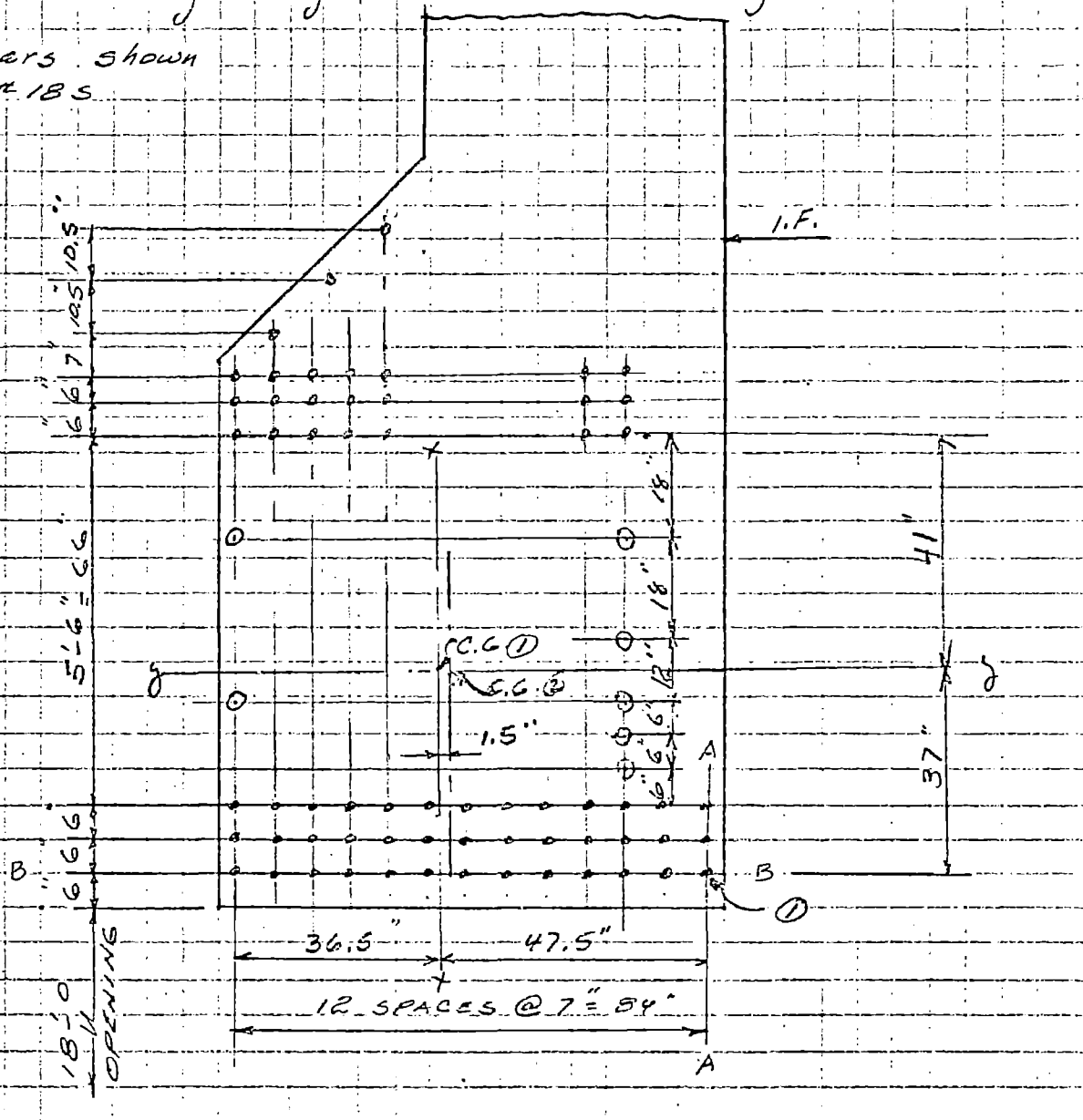
The following ring will be investigated

All bars shown are #18s



Finding c.c. EM about A-A:

$$\frac{3\times7+6\times14+6\times21+3\times26+3\times35+3\times42+3\times49+7\times56+6\times63+1\times64.5+6\times70+7\times77+6\times84}{63}$$

$$=\frac{21+84+126+84+105+126+147+392+378+66+420+539+504}{63}$$

$$=\frac{2992}{63}=47.5"$$

EM about B-B:

$$\frac{13\times6+13\times12+7\times78+7\times84+7\times90+1\times97+1\times107.5+1\times118}{63}$$

$$=\frac{78+156+546+588+630+97+107.5+118}{63}=\frac{2320}{63}=37"$$

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$I_{xx} = 4''(3\times47.5^2 + 3\times40.5^2 + 6\times33.5^2 + 6\times26.5^2 + 3\times19.5^2 + 3\times12.5^2 + 3\times5.5^2 + 6\times36.5^2 + 7\times29.5^2 + 6\times22.5^2 + 1\times19^2 + 6\times15.5^2 + 7\times8.5^2 + 3\times1.5^2) = 4(6800 + 4920 + 6740 + 4200 + 1140 + 470 + 90 + 8050 + 6150 + 3050 + 360 + 1450 + 500 + 10)$

$= 4(43,930) = 176,000\ in^4$

$I_{yy} = 4''(13\times37^2 + 13\times31^2 + 13\times25^2 + 7\times41^2 + 7\times47^2 + 7\times53^2 + 1\times60^2 + 1\times70.5^2 + 1\times81^2)$

$= 4(17,800 + 12,500 + 8150 + 11800 + 15,500 + 19,700 + 3,600 + 5000 + 6550) = 4(100,550) = 403,000\ in^4$

Checking stresses in steel

Pt 0:
Worst stressed bar is bar #1:

$f = \frac{P}{A} + \frac{M_y C_1}{I_{yy}} + \frac{M_x C_2}{I_{xx}}$

$\frac{7750}{63\times4} + \frac{16,400\times12\times37}{403,000} + \frac{8600\times12\times47.5}{176,000}$

$= 30.6^k/_{in^2} + 18.1^k/_{in^2} + 27.8 = 76.5^k/_{in^2}$ N.G.

Add bars shown THIS O

NEW C.G

ΣM_{A-A}: $\frac{2992 + 5\times14 + 2\times84}{70} = \frac{2992 + 70 + 168}{70} = \frac{3230}{70} = 46''$

ΣM_{B-B}: $\frac{2320 + 1\times18 + 1\times24 + 2\times30 + 1\times42 + 2\times60}{70}$

$= \frac{2584}{70} = 37''$

$I_{yy} = 4(100,550 + 1\times15^2 + 1\times13^2 + 2\times7^2 + 1\times5^2 + 2\times23^2)$

$= 4(100,550 + 360 + 170 + 100 + 25 + 1070) = 410,000\ in^4$

$I_{xx} = 4(3\times46^2 + 3\times39^2 + 11\times32^2 + 6\times25^2 + 3\times18^2 + 3\times11^2 + 3\times4^2 + 8\times38^2 + 7\times31^2 + 6\times24^2 + 1\times20.5^2 + 6\times17^2 + 7\times10^2 + 3\times3^2)$

$= 4(6350 + 4550 + 11,300 + 3750 + 980 + 360 + 50 + 11,600 + 6,750 + 3450 + 4200 + 1730 + 2000 + 30) = 4(52,020) = 208080$

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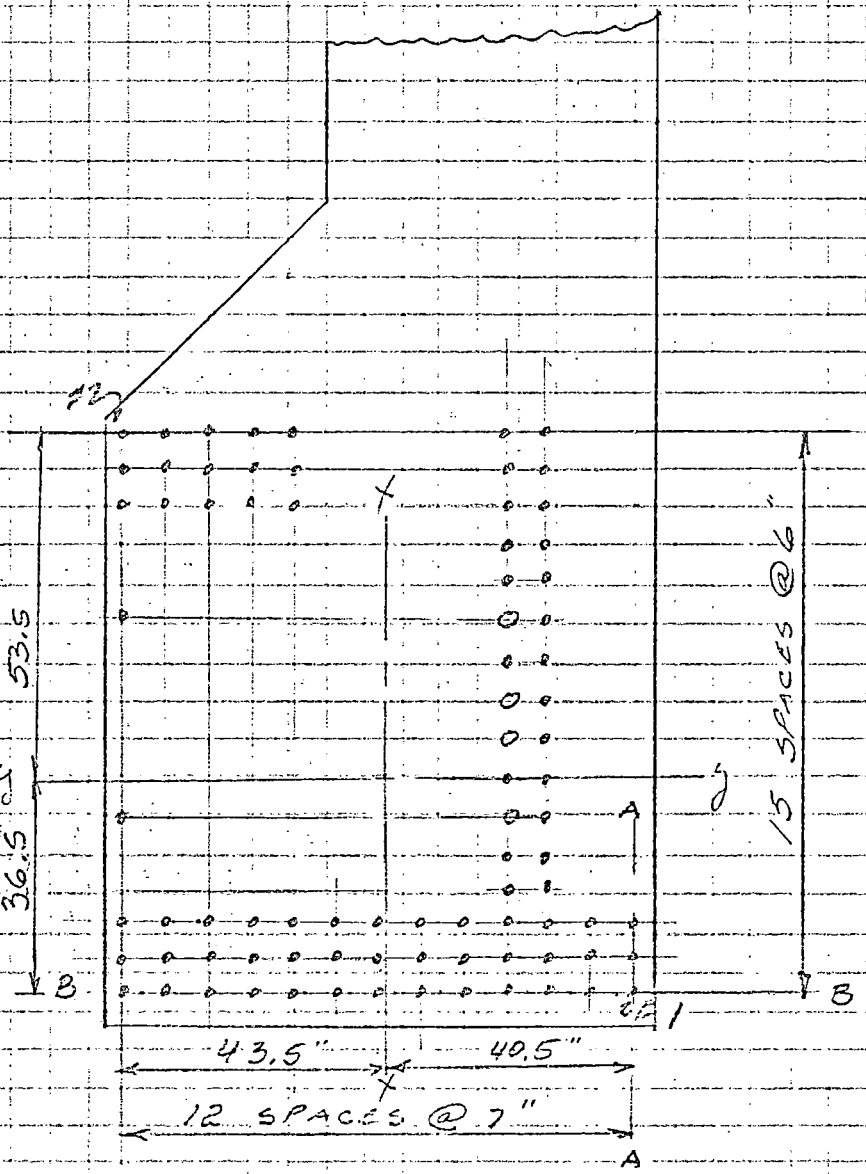
$$P = \frac{7750}{70\times4} + \frac{16450\times12\times3.7}{410,000} + \frac{8600\times12\times46}{208,000}$$

$$= 27.6^{K}/_{\square''} + 17.8 + 22.9^{K}/_{\square''} = 68.3^{K}/_{\square''} \text{ N.G.}$$

Try the following ring:



Finding C.G.

$$\Sigma M_{A-A}: \quad 3\times7+16\times14+12\times21+3\times28+3\times35+3\times42+3\times49+6\times56+6\times63+6\times70$$
$$+6\times77+8\times84 \div 78$$

$$\frac{21+224+252+84+105+126+147+336+378+420+462+672}{78}$$

$$= \frac{3227}{78} = 41.5"$$

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ΣM_{B-B}:

$13\times6 + 13\times12 + 2\times18 + 2\times24 + 2\times30 + 2\times36 + 1\times42 + 1\times48 + 2\times54 + 2\times60 + 2\times66 + 2\times72 + 7\times78 + 7\times84 + 7\times90 \div 78$

$$\frac{78+156+36+48+60+72+42+48+108+120+132+144+546+588+630}{78}$$

$$= \frac{2808}{78} = 36"$$

$$I_{xx} = 4(3\times41.5^2 + 3\times34.5^2 + 16\times27.5^2 + 12\times20.5^2 + 3\times13.5^2 + 3\times6.5^2 + 8\times42.5^2 + 6\times35.5^2 + 6\times28.5^2 + 6\times21.5^2 + 6\times14.5^2 + 3\times7.5^2)$$

$$= 4(5200 + 3600 + 12,200 + 5070 + 545 + 130 + 14,500 + 7,580 + 4900 + 2800 + 1260 + 170) = 4(57,955) = 232,000$$

$$I_{yy} = 4(13\times36^2 + 13\times30^2 + 13\times24^2 + 2\times18^2 + 2\times12^2 + 2\times6^2 + 7\times54^2 + 7\times48^2 + 7\times42^2 + 2\times36^2 + 2\times30^2 + 2\times24^2 + 2\times18^2 + 1\times12^2 + 1\times6^2)$$

$$= 4(16,900 + 11,700 + 7,500 + 650 + 288 + 72 + 20,400 + 16,200 + 12,400 + 2600 + 1800 + 1150 + 650 + 144 + 36)$$

$$= 4(92,490) = 370,000$$

$$A = \frac{7550}{78\times4} + \frac{16,400\times12\times36}{370,000} + \frac{9450\times12\times41.5}{232,000}$$

$$= 24.2^{k}/a" + 19.3^{k}/a" + 20.3 = 63.8^{k}/a"$$

Add bars marked O

C.G.: $\Sigma M_{A-A} = \frac{3227 + 4\times21}{82} = 40.5"$

$$\Sigma M_{B-B} = \frac{2808 + 1\times30 + 1\times42 + 1\times48 + 1\times60}{82} = \frac{2988}{82}$$

$$= 36.5"$$

$$I_{xx} = 4(3\times40.5^2 + 3\times33.5^2 + 16\times26.5^2 + 16\times19.5^2 + 8\times12.5^2 + 3\times5.5^2 + 8\times43.5^2 + 6\times36.5^2 + 6\times29.5^2 + 6\times22.5^2 + 6\times15.5^2 + 3\times8.5^2 + 3\times1.5^2)$$

$$= 4(4930 + 3400 + 11,300 + 6100 + 470 + 90 + 15,200 + 8,000 + 5250 + 3050 + 1450 + 220 + 7) = 4(59,467) = 238,000$$

$$I_{yy} = 4(13\times36.5^2 + 13\times30.5^2 + 13\times24.5^2 + 2\times16.5^2 + 2\times12.5^2 + 3\times6.5^2 + 7\times53.5^2 + 7\times47.5^2 + 7\times41.5^2 + 2\times35.5^2 + 2\times29.5^2 + 3\times23.5^2 + 2\times17.5^2 + 2\times11.5^2 + 2\times5.5^2)$$

$$= 4(17300 + 12200 + 7800 + 690 + 310 + 130 + 20,100 + 15,600 + 12,100 + 2520 + 1740 + 1660 + 610 + 270 + 60) = 4\times93,290 = 372,000$$

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$R = \frac{7550}{82\times4} + \frac{16,400\times12\times36.5}{372,000} + \frac{8600\times12\times40.5}{238,000}$

$= 22.9^{K/a"} + 19.2^{K/a"} + 17.6^{K/a"} = 59.7^{K/a"}$ —

Pt. 10

Worst stressed bar is bar # 2

$R = \frac{2540}{62\times4} + \frac{16,400\times12\times53.5}{372,000} + \frac{1520\times12\times43.5}{238,000}$

$= 7.75^{K/a"} + 28.2^{K/a"} + 3.33^{K/a"} = 39.28^{K/a"}$ —

DEFLECTION COMPATIBILITY AT INTERFACE OF CYLINDER WALL AND RING (see fig. #6 pg. 119)

An approximate value of θ for our ring can be obtained from Eq (126) Pg. 135 of "Strength of Materials" Part II by S. Timoshenko. Referring to our Fig. #1 (Pg. 116) for picture and terminology...

$$\theta = \frac{M_z r}{E I_z}$$

Checking pts 0 & 10: $I_z = I_x = 238,000\ in^4$

Ring: $\theta = \frac{3420\times12000\times13'\times12}{29,000,000\times238,000} = .00093$ radians

$\theta = 3'14"$

Wall: $\tan\theta = \frac{2\Delta}{d} = \frac{2\Delta}{40} = \frac{\Delta}{20} = .00093$

$\Delta = .00186"$

If this elongation were to take place in as little a distance as 12": $\varepsilon = \frac{.00186}{12} = .000155$

Pt. 0: R in vertical bar $= .000155\times29\times10^6 = 4.5^{K/a"}$

Stress in vertical bars @ pt. 0 before rotation of ring: $366\times\frac{5.9}{10.4} = +208^{K}$ 1.5P

$+144$ 1.0TL

$80\times\frac{5.9}{10.4} = -45$ S

-85 D

$+222^{K}/5.9 = 37.5^{K/a"}$

Therefore vertical bars have ample capacity to adjust to ring rotation.

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Pt. 10

Stress in horizontal bars @ pt. 10

before rotation of ring:

$735 + \frac{12.9}{17.4} = +545$ f/1.5P

$+153$ LOAD

$-124 + \frac{12.5}{17.4} = -92$

$+606^{K}/_{12.9} = 47^{K}/_{A}$

Therefore horizontal bars also have ample capacity to adjust to ring rotation

Shear Analysis

Torsional Shear: $M_t = 263^{K}/_{1}$

$$v_T = \frac{M_t}{ab^2}\left(3 + 1.8\frac{b}{a}\right)^{K}$$

$$= \frac{263\left(3 + 1.8 \times \frac{8}{7.5}\right)}{7.5^2 \times 8\ \mu^3} = \frac{263\,(4.93)}{7.5^2 \times 8} = 2.9^{K}/_{A}$$

$V_T = 2.9^{K}/_{1'} \times 3.75' \times 8' \times \frac{1}{2}$

$= 43.5^{K}$

FOR CONSERVATISM AND EASE OF CALCULATION ASSUME $\Sigma V = 2400^{K} + 87^{K}$

$= 2487^{K}$

$$A_v = \frac{V's}{\phi f_y d}$$

$$A_v/_{1'} = \frac{2487^{K} \times 12''}{.85 \times 50^{K}/_{\square''} \times 42''}$$

$= 6.35^{\square''}/_{1'}$

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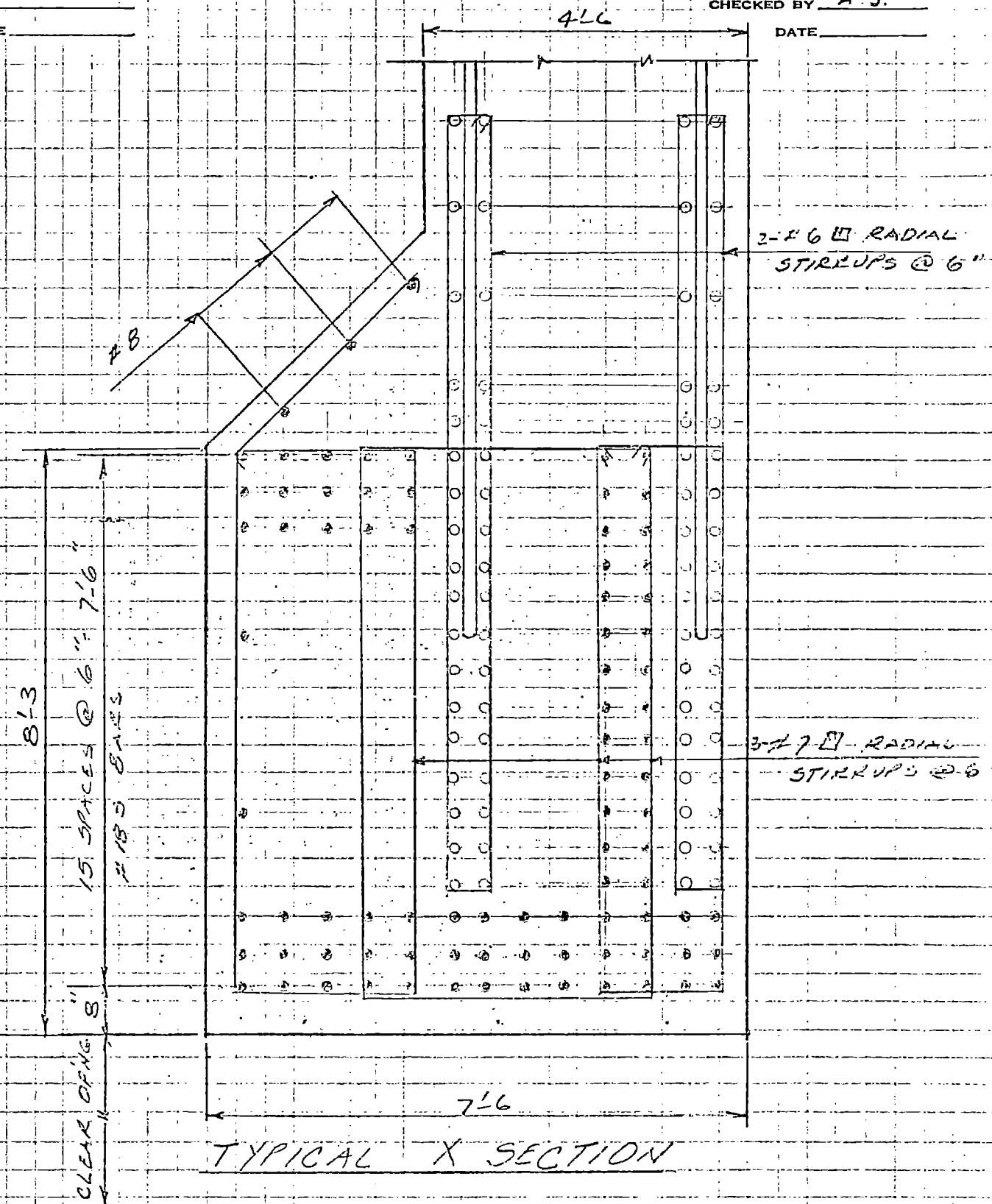

TYPICAL X SECTION

○ ADDITIONAL CIRCULAR BARS
● ORIGINAL WALL REINF.

NOTE: RADIAL STIRRUP SPACING OF 6" O.C. IS BASED ON PERIMETER AT EDGE OF OPENING
ALL BARS #18S UNLESS OTHERWISE NOTED

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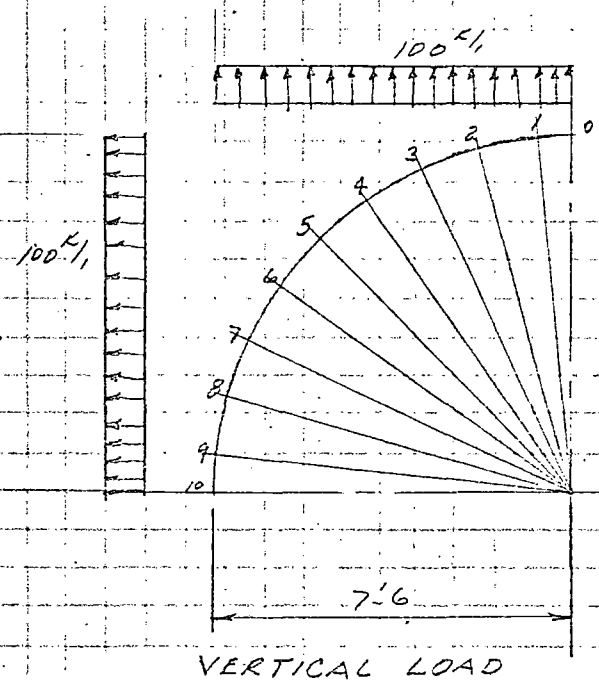
PERSONNEL ACCESS HATCH : 9'-0 OPNG.

ASSUME depth of circular ring to be 6'-0 and width to be 5'-6, radius to C.G. of beam to be 7'-6", and ℄ @ EL 134'



VERTICAL LOAD						HORIZONTAL LOAD
SECT.	θ	sin θ	2 sin θ = Y	$m = w\frac{x^2}{2}$	m + M₀ = M	M
1	5°	.08716	.655	-21.5	+1389	-1350
2	15°	.2588	1.94	-189.0	+1221	-1220
3	25°	.42262	3.17	-500.0	+910	-910
4	35°	.57358	4.30	-925.0	+485	-485
5	45°	.70711	5.30	-1410.0	0	0
6	55°	.81915	6.15	-1900.0	-490	+490
7	65°	.90631	6.80	-2320.0	-910	+910
8	75°	.96593	7.25	-2620.0	-1210	+1210
9	85°	.99619	7.45	-2780.0	-1370	+1370
				-12,665		

VERT. LD

$M_0 = -\frac{1}{9}(-12665) = +1410$ K

Pt. 0: m = 0, M = +1410

Pt 10: $m = -50 \times \overline{7.5}^2 = -2820$, $M_0 = +1410$; M = -1410

HOR LD.

Pt: 0; M = -1410

Pt. 10: M = +1410

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TOTAL VERT. LD

	+366 K/'	1.5P
	- 80	S
@EL. 134. $[-\frac{84}{142}(135-39)-39]\,.95 =$	- 95	D
	+191 K/'	

TOTAL HOR. LD

+611 K/'

FINAL MOMENTS DUE TO LOADING IN 2 DIRECTIONS

SECT	VERT. LD. MOM.	HOR. LD. MOM.	M_ϕ
0	1.91 (+1410)	6.11 (-1410)	- 5930
1	1.91 (+1390)	6.11 (-1390)	- 5850
2	1.91 (+1215)	6.11 (-1215)	- 5100
3	1.91 (+910)	6.11 (-910)	- 3820
4	1.91 (+490)	6.11 (-490)	- 2060
5	0	0	0
6	1.91 (-490)	6.11 (+490)	+ 2060
7	1.91 (-910)	6.11 (+910)	+ 3820
8	1.91 (-1215)	6.11 (+1215)	+ 5100
9	1.91 (-1390)	6.11 (+1390)	+ 5850
10	1.91 (-1410)	6.11 (+1410)	+ 5930

AXIAL TENSION: T

Pt. 0: $611 \times 7.5 = 4580^K$

Pt. 10: $191 \times 7.5 = 1430^K$

SHEAR FROM 9'-0 DOOR (RADIAL)

$p = 70.5$ psi

Area $= \pi(4.5)^2 144 = 9150\ in^2$

$$P/ft = \frac{9.150 \times 70.5}{\pi(9)} = 22.8^K/'$$

SHEAR IN RING CAUSED BY NON UNIFORM LOADING AROUND PERIMETER

$$V_j = \frac{2 \times 2060}{4.2} = 985^K$$

SECONDARY MOMENTS CAUSED BY CURVATURE OF WALL

$$e = \frac{66}{2} - \frac{12.9 \times 22}{17.4} = 33 - 20 = 13''$$

$$e' = 33 - \frac{5.9 \times 27}{10.4} = 17.5''$$

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ESTIMATE

PREPARED BY L.G.
DATE
CHECKED BY A.J.
DATE

CIRCUMFERENTIAL LOADING

Pt. 0: $P_e = 611 \times 7.5 \times \frac{13}{12} = 4950^{K}$ Tension on I.F.

VERTICAL LOADING

Pt. 10: $P'e' = 191 \times \frac{17.5}{12} \times 7.5 = 2080^{K}$ Tension on I.F.

SECONDARY MOMENTS CAUSED BY HEATING OF LINER

$e'' = 2'3''$

CIRCUMFERENTIAL LOADING

Pt. 0: $P''e'' = 153 \times 2.25 \times 7.5 = 2580^{K}$ COMP. ON I.F.

VERTICAL LOADING

Pt 10: $P''e'' = 144 \times 2.25 \times 7.5 = 2450^{K}$ COMP. ON I.F.

SECONDARY MOMENTS CAUSED BY TORSION

$M_2 = 22.8 \times 3 + 70.5 \times 144 \times \frac{3}{2} = 114^{K'}$

$M_3 = 114 \times 7.5 = 850^{K}$ COMP. ON I.F.

DESIGN OF RING FOR BENDING ABOUT X-X AXIS, Y-Y AXIS AND AXIAL TENSION

Pt. 0:

$\frac{T}{\phi} = \frac{4580}{.95} = 4820^{K}$

$\frac{M_4}{\phi} = \frac{-5930}{.90} = -6580^{K}$ Tension on bot.

$\frac{M_4}{\phi} = \frac{4950 - 2580 - 850}{.90} = \frac{1520}{.90} = 1690^{K}$ Tens. on I.F.

Pt. 10

$\frac{T}{\phi} = \frac{1430}{.95} = 1510^{K}$

$\frac{M_4}{\phi} = \frac{+5930}{.90} = +6590^{K}$ Tension on top

$\frac{M_4}{\phi} = \frac{2050 - 2450 - 850}{.90} = 1220^{K}$ Tension on I.F.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA
SUBJECT LARGE OPENINGS COMPUTATION SHEET
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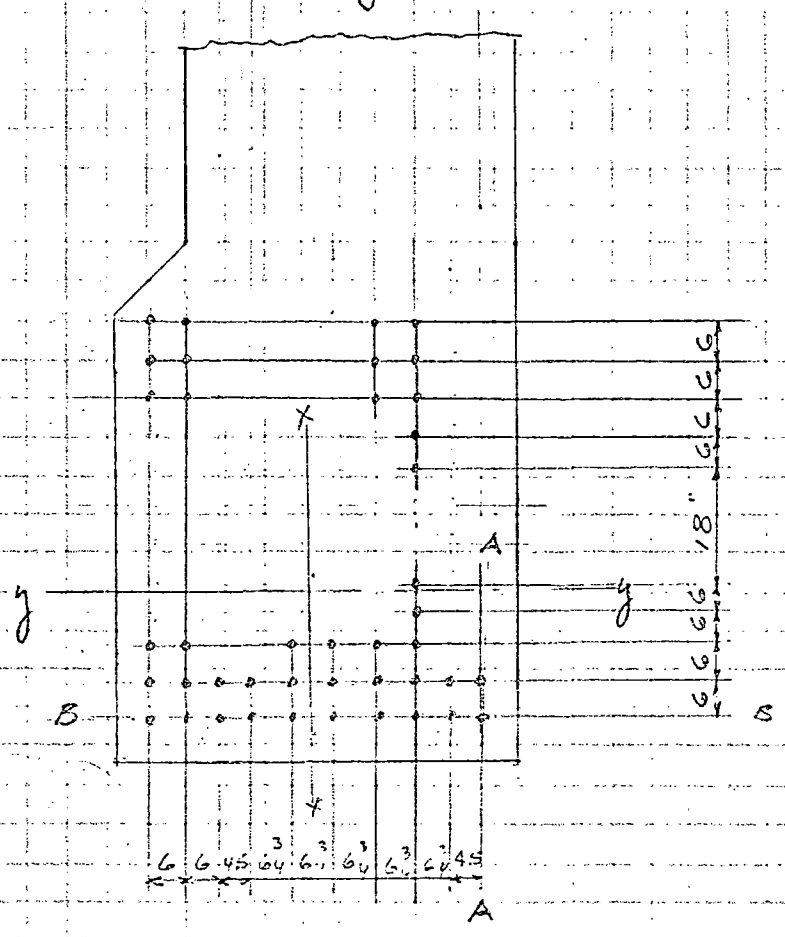
TRY the following ring, all bars are #18S.



Finding C.G.: ΣM_{A-A}

$2\times4.5 + 10\times11.25 + 6\times18.0 + 3\times24.75 + 3\times31.5 + 2\times38.25 + 2\times42.75 + 6\times48 + 6\times54.75 \div 42$

$= \frac{9.0 + 112.5 + 108 + 74.5 + 95 + 76.5 + 85.5 + 293 + 330}{42} = \frac{1184}{42} = 28.2"$

ΣM_{B-B}: $\frac{10\times6 + 6\times12 + 1\times18 + 1\times24 + 1\times42 + 1\times48 + 2\times54 + 2\times60 + 2\times66}{42}$

$= \frac{60 + 72 + 18 + 24 + 42 + 48 + 216 + 240 + 264}{42} = \frac{984}{42} = 23.4"$

$I_{gg} = 4[10\times23.4^2 + 10\times17.4^2 + 6\times11.4^2 + 1\times5.4^2 + 4\times42.6^2 + 4\times36.6^2 + 4\times30.6^2 + 1\times24.6^2 + 1\times18.6^2]$

$= 4[5500 + 3030 + 780 + 30 + 7290 + 5360 + 3760 + 605 + 346]$

$= 4[26681] = 107{,}000 \text{ in}^4$

$I_{yy} = 4[2\times26.2^2 + 2\times23.7^2 + 10\times16.95^2 + 6\times10.2^2 + 2\times3.45^2 + 6\times26.8^2 + 6\times20.8^2 + 2\times14.8^2 + 2\times10.3^2 + 3\times3.55^2]$

$= 4[1600 + 1120 + 2780 + 625 + 24 + 432 + 2600 + 440 + 212 + 25]$

$= 4[9858] = 39{,}400$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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SUBJECT LARGE OPENINGS COMPUTATION SHEET
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$$P = \frac{P}{A} + \frac{M_y c_1}{I_{yy}} + \frac{M_x c_2}{I_{xx}}$$

Pt. 8

$$S = \frac{4820}{4\times42} + \frac{6580\times12\times23.4}{107,500} + \frac{1690\times12\times26.2}{39,450}$$

$$= 28.6 + 17.2 + 14.5 \simeq 60^{K}/\text{in}^2$$

Pt. 10

$$P = \frac{1510}{4\times42} + \frac{6580\times12\times42.6}{107,500} + \frac{1220\times12\times26}{39,450}$$

$$= 9.0^{K}/\text{in}^2 + 31.4 + 9.7 = 50.1^{K}/\text{in}^2$$

DEFLECTION COMPATIBILITY AT INTERFACE OF CYLINDER WALL AND RING

$$\theta = \frac{M_2 R}{E I_2}$$

Ring: $\theta = \frac{850\times12000\times7.5\times12^2}{29,500\times35,450} = .0008$ radians

Wall: $\tan\theta = \frac{\Delta}{20} = .0008$

$\Delta = .0016$

Evidently additional stress in wall bars can be easily handled

SHEAR ANALYSIS

$$V_T = \frac{114\left(3+1.8\times\frac{6}{5.5}\right)}{5.5^2\times6} = \frac{114\times4.95}{5.5^2\times6} = 3.1^{K}/\text{in}^2$$

$$V_T = 3.1\times\frac{5.5}{2}\times6\times\frac{1}{2} = 34^{K}$$

Assume $2V = 985^{-} \times 2 \times 34 = 1053^{K}$

$$A_v/_1 = \frac{1053\times12}{.85\times60\times66} = 3.75\ \text{in}^2/_1$$

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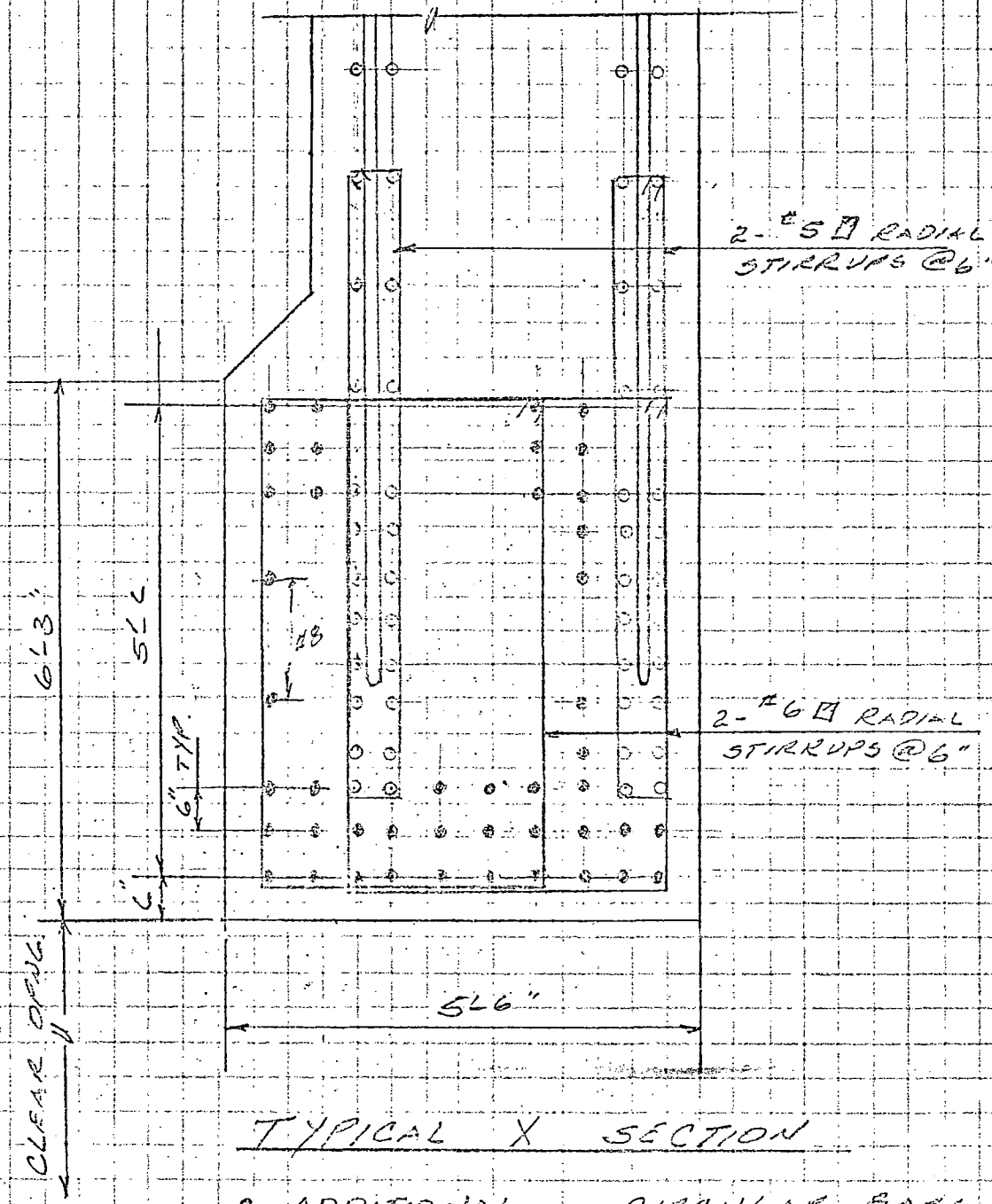

TYPICAL X SECTION

○ ADDITIONAL CIRCULAR BARS
○ ORIGINAL WALL REINF.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

P8.136

REFER TO SALEM GEN. STA.

SUBJECT FDN. MAT.

FILE

ESTIMATE

COMPUTATION SHEET

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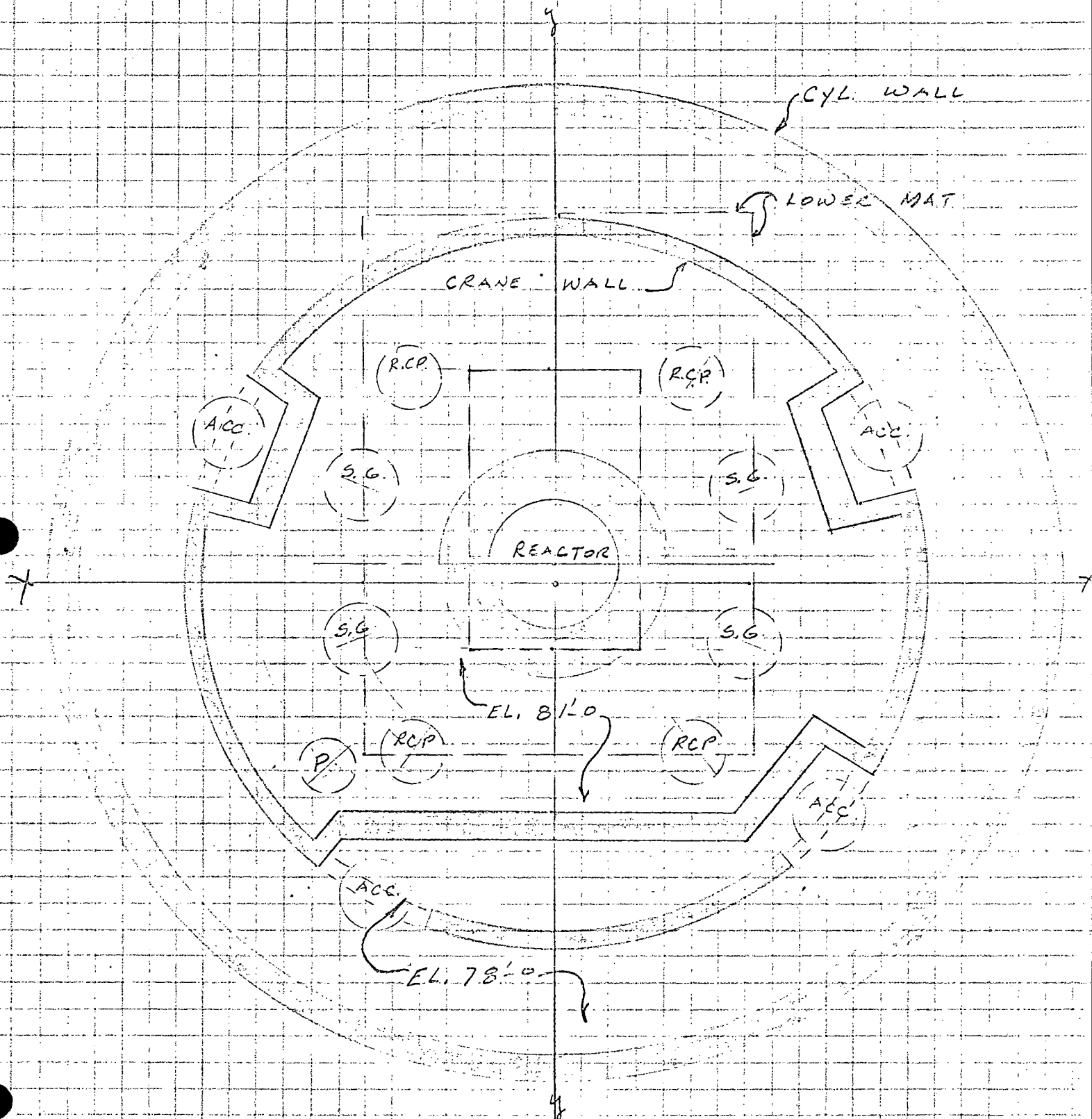

PLAN ABOVE FDN. MAT

ALL elevations given refer to Public Service Datum
TOP OF STRUCTURAL MAT @ EL. 76'

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM G.S. SPA. PREPARED BY I.C.

SUBJECT FOUN. MAT COMPUTATION SHEET DATE

FILE CHECKED BY P.C.

ESTIMATE DATE

S.G.: Steam generator @ 1055°F
R.C.P.: Reactor coolant pump @ 132.5°F
P = Pressurizer @ 348°F
Reactor @ 1087°F
ACC: Accumulator Tank @ 114.5°F

Basis For Design.

The major loading on the structural mat comes thru' the cylinder wall which is of course symmetrical about axes X-X and Y-Y. Another important load comes from the operating floor at Public service EL. 130'-0 in addition to the crane loading at EL. 130'-0, the floor loading at EL. 100'-0 and the weight of the crane wall. The load is also symmetrical about axes X-X and Y-Y.

The interior walls around the reactor pit, the reactor pit slabs and the major equipment are essentially symmetrical with the Y-Y axis and somewhat eccentric with respect to the X-X axis. The maximum soil pressures and moments in base slab occur under earthquake conditions. The only time we are concerned with potential hazard of radiation is after the equipment is in. Therefore, we will treat the equipment as dead load under earthquake conditions.

The base slab is considered to be a circular plate of constant thickness (t). The loads are imposed upon the slab by the exterior cylinder wall, the central circular crane wall and the interior walls and equipment acting acting around an assumed equivalent circle. The soil reaction pressures can be found in a conventional manner by treating the slab, which is sixteen feet thick, as a rigid mat.

The mat is then analyzed as a plate subjected to soil pressures and supported by a circular wall symmetrical with respect to the center of the mat. The supporting wall can be considered as simply supporting the mat, partially fixing or fully fixing. The exterior cylinder wall will be considered partially fixing the mat, the crane wall and exterior wall for interior walls and equipment will be simple supports. The

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SUBJECT FDN. MAT. COMPUTATION SHEET DATE

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Moments and shears obtained by considering at different times the cylinder wall, chase wall and equivalent equipment wall as supports are then superimposed. The following formulas and the basic analysis are obtained from a paper by Kuang-Han Chu and Omar F. Afandi for the A.C.I. "Title No. 63-63: "Analysis of Circular and Annular Slabs For Chimney Foundation".

The differential equation for a circular plate of constant thickness (t) is...

$$\left(\frac{\partial^2}{\partial r^2}+\frac{1}{r}\frac{\partial}{\partial r}+\frac{1}{r^2}\frac{\partial^2}{\partial \theta^2}\right)\left(\frac{\partial^2 w}{\partial r^2}+\frac{1}{r}\frac{\partial w}{\partial r}+\frac{1}{r^2}\frac{\partial^2 w}{\partial \theta^2}\right)=\frac{q}{D}$$

Where $D=\frac{Et^3}{12(1-\mu^2)}$

E = modulus of elasticity

μ = Poisson's ratio

q = intensity of load, ℔ per sq. ft. at any point, positive downward

r, θ = polar coordinates as shown in Fig. 5.1-15a

w = deflection of the plate, positive downward

The positive directions of the moments and shears in the slab are shown in Fig. 5.1-15b. The values of the moments, shears and reactions are given per unit length in all cases.

Bending moment in the radial direction, per unit length of circumferential direction is:

$$M_r=-D\left[\frac{\partial^2 w}{\partial r^2}+\mu\left(\frac{1}{r}\frac{\partial w}{\partial r}+\frac{1}{r^2}\frac{\partial^2 w}{\partial \theta^2}\right)\right]$$

Bending moment in the circumferential direction per unit length of radial direction is:

$$M_t=-D\left[\frac{1}{r}\frac{\partial w}{\partial r}+\frac{1}{r^2}\frac{\partial^2 w}{\partial \theta^2}+\frac{\partial^2 w}{\partial r^2}\right)$$

The shear in a radial strip, per unit length of circumference is:

$$Q_r=-D\frac{\partial}{\partial r}(\Delta w)=-D\frac{\partial}{\partial r}\left(\frac{\partial^2 w}{\partial r^2}+\frac{1}{r}\frac{\partial w}{\partial r}+\frac{1}{r^2}\frac{\partial^2 w}{\partial \theta^2}\right)$$

The shear in the circumferential direction, per unit length of radial direction, is:

$$Q_t = -D \frac{\partial}{r\,d\theta}(\Delta w)$$

The problem can be simplified by considering the soil pressure to be composed of uniform pressure & triangular pressure distribution. (See Fig's. 5.1-15c and 5.1-15d) Each condition is solved separately and results superimposed.

Annular slabs supported around a circle and subjected to a uniform upwards pressure (see Fig. 5.1-15c) yield the following results.

$$M_{r_I} = \frac{p_o a^2}{64}\left[4(3+\mu)\rho^2 - 16\alpha^2(1+\mu)\log\rho - 8\alpha^2(3+\mu) + 2(1+\mu)K_1 - 1(1-\mu)\rho^{-2}K_2\right]$$

$$M_{r_{II}} = -\frac{p_o a^2}{64}\left[4(3+\mu)\rho^2 - 16(1+\mu)\log\rho - 8(3+\mu) + 2(1+\mu)K_1' - (1-\mu)\rho^{-2}K_2'\right]$$

$$M_{t_I} = \frac{p_o a^2}{64}\left[4(1+3\mu)\rho^2 - 16\alpha^2(1+\mu)\log\rho - 8\alpha^2(1+3\mu) + 2(1+\mu)K_1 + (1-\mu)\rho^{-2}K_2\right]$$

$$M_{t_{II}} = \frac{p_o a^2}{64}\left[4(1+3\mu)\rho^2 - 16(1+\mu)\log\rho - 8(1+3\mu) + 2(1+\mu)K_1' + (1-\mu)\rho^{-2}K_2'\right]$$

$$Q_{r_I} = \frac{p_o a}{2}\left(\rho - \alpha^2\rho^{-1}\right)$$

$$Q_{r_{II}} = \frac{p_o a}{2}\left(\rho - \rho^{-1}\right)$$

$$\rho = \frac{r}{a}\ ;\ \left(\beta = \frac{b}{a}\ ;\ \alpha = \frac{c}{a}\right)$$

Annular slabs supported around a circle and subjected to an external moment (see fig. 5.1-15d) yield the following results.

$$M_{r_I} = \frac{p_o a^2}{152}\left[4(5+\mu)\rho^3 + 2(3+\mu)B\rho + 2(1-\mu)C\rho^{-1} + (1+\mu)D\rho^{-1}\right]\cos\theta$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN STA — COMPUTATION SHEET

SUBJECT EQ. 1/4 — PROJECT BY JG

FILE — DATE

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$$M_{r_2} = \frac{P a^2}{\pi^2} \left[\frac{\pi}{4}(3+\mu)\left(\frac{c}{a}\right)^3 + 2(3+\mu)\left(\frac{c}{a}\right)^2 \ln\frac{c}{a} + 2(1-\mu)\left(\frac{c}{a}\right) - (1+\mu)\left(\frac{a}{c}\right) \right] \cos\theta$$

$$M_{\theta_2} = \frac{P a^2}{\pi^2} \left[\frac{\pi}{4}(1-3\mu)\left(\frac{c}{a}\right)^3 + 2(1-3\mu)\left(\frac{c}{a}\right)^2 + 2(1-\mu)\left(\frac{c}{a}\right) \ln\frac{c}{a} - (1+\mu)\left(\frac{a}{c}\right) \right] \cos\theta$$

$$M_{r\theta_2} = -\frac{P a^2}{\pi^2} \left[\frac{\pi}{4}(1+3\mu)\left(\frac{c}{a}\right)^3 + 2(1+3\mu)\left(\frac{c}{a}\right)^2 + 2(1+\mu)\left(\frac{c}{a}\right) \ln\frac{c}{a} \right] \sin\theta$$

$$M_{z_2} = \mu(r_1+r_2)\frac{P a^2}{\pi^2} \left[\frac{\pi}{4}\left(\frac{c}{a}\right)^3 + 2\left(\frac{c}{a}\right)^2 + 2\left(\frac{c}{a}\right)\ln\frac{c}{a} \right] \cos\theta$$

$$V_{r_2} = \frac{P a^2}{\pi^2} \left[\frac{\pi}{4}\left(\frac{c}{a}\right)^3 + 2\left(\frac{c}{a}\right)^2 \right] \cos\theta$$

$$V_{\theta_2} = \frac{P a^2}{\pi^2} \left[\frac{\pi}{4}\left(\frac{c}{a}\right)^3 + 2\left(\frac{c}{a}\right)^2 \right] \sin\theta$$

In the following equations, the subscripts 1 and 2 refer to the loads 1 and 2 respectively. The primes on the variables denote the respective moments and forces. The constants $K_1, K_2, K_3, K_4, E, C, C_1, D$ are determined for the specific conditions of the shell and are determined by the boundary conditions.

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COMPUTATION SHEET

EVALUATION OF LOADS EXCEPT SEIS. TO INT.

EL. 150

EXTERIOR WALL: [illegible]

[illegible]

[illegible]

USE SEE TEXT FOR TO CALCULATE WALL AND CRANE WALL

[illegible]

[illegible]

ASSUME 1/2 WATER IN THE CRANE WELL CIRCLE AS EFFECTIVE LOADED SOILS FROM A 2ND CYCLE INCLUDING EFFECTS OF [illegible]

[illegible]

TOTAL WT. = EFF. SOIL + CONC. = 1500 KIPS

ASSUME 1/2 GOES TO CRANE WALL AND 1/2 TO INTERIOR WALLS AROUND REACTOR PIT

[illegible] = 3000 K/L OF CRANE WALL

USE 3000

EL. 100

EXTERIOR WALL [illegible] K.L. 225 K/F

[illegible] K.L. 450 ← INCLUDES OTHER ITEMS NOT EXPLICITLY STATED

USE FOR SEE TEXT TO CALCULATE WALL AND CRANE WALL

[illegible]

D.L. = 270 + 225 = 1550 K/L

T.L. = 450 + 225 = 3300 K/L

INTERIOR WALLS AROUND REACTOR PIT

ASSUME [illegible]

THICKNESS = [illegible]

PERIMETER = 280'

WT. = [illegible] = 2100 K/L

SIDE @ EL. 100 = 5'x2'x150 = 3450 K/L

SIDE @ EL. 85 = 5'x2'x150 = 3450 K/L

SIDE @ EL. 70 = [illegible]

[illegible] = 1650 K/L

USE 1650 FOR REACTOR [illegible]

= 8700 K/L

NET WT. = 1650 K/L (1.3) = 2100 + 3450 + 3450

= 8700 K/L

= 1650 K/L [illegible]

PIT OF REACTOR IS THE CENTER OF THE COMPARTMENT.

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PROJECT Salem Gen. Sta. PREPARED BY J.C.

SUBJECT Equipment COMPUTATION SHEET DATE

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ESTIMATE DATE

The major equipment, the exit walls and the pipe steel centerline loads are various distances from the center of the mat. Cut-outs in the symmetrical pattern about the center of equipment load areas can be ignored.

Item	Total load	Arm moment to center of mat	=
Salem Gen.	4200	3.25	13,650
R.C. Pumps	530	36.0	19,080
Pressurizer	235	43.0	10,105
Ejector	185	8.5	1,572.5
Structural Steel Exit Walls	1145	0	0
Mat walls	9350	20.0	187,000
Slab			
Total			

Slab = 29.5' Rad. 30' Equiv. Radius

Note: The structural mat is stepped down below the reactor pit. The side walls shown to this section are 20' deep and at least 16" thick and will be designed so that the entire unit acts as one unit.

Under the reactor cylinder wall and inner wall there is a two foot slab about the structural mat to be formed during the placing of this section. The reactor support and the shielding wall of cast steel as the base mat. Here is where is the unit slab. The structural mat to be effective of this. At the reactor pit there is full concrete which takes up most of the load. Using passed for forms and piles a unit pit slab has extra loading will be considered for this area.

Under the crane wall has been cut to permit accumulator tanks to install. There is a two foot cover plate and accumulator tanks have a weight load to store three feet on concrete over the

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PROJECT SALEM GEN. STA. PREPARED BY J.G.

SUBJECT EQM #1 COMPUTATION SHEET DATE

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Area: Between the Crane Wall and the Shielding Wall in addition there is a 2' post slab between the Crane Wall and the Shielding Wall. Crane Wall Loading (incl. Shielding Wall)

Height: 130'-7" = 52'

Thickness 3'

$2\pi \times 53' \times 52 \times 3 \times .15 = 7,300^K$

El. 130: Conc. Slab = 1250^K

Crane = 1000^K

Pipe: $155 \times 2\pi \times 53 = 130^K$

El. 100: $155 \times 2\pi \times 51 = 620^K$

Shielding Walls (Reinforcing)

Height: 100'-11" = 52'

Thickness: 4'

$116 \times 52 \times 4 \times .15 = 1550^K$

Holes in Crane Wall:

Perimeter: 12×4

Thickness: 3'

Height: El. 78'-20'

$12 \times 4 \times 20 \times 3 \times .15 = -600^K$

$\Sigma = 7,300 - 1250 - 1000 + 130 - 520 - 1550 - 620$

$= 11,610^K$

Cylinder and Dome

$\pi \times 53' \times 71.25' = 11,300^K$ (Includes Dia. Floor El. 130 & 178) Goes to Cols. next to Cyl. Wall

Fill Conc. in Reactor Pit

$\pi \times 53' \times 11' = 2,150^K$

Structural Steel

$16^K \times 150 \times 1.15 = 42,500$

$+ 3^K \times 20' \times 2\pi \times 53' \times .15 = 4,500$

$+ 5^K \times 2\pi \times 53' \times .15 = 5,300$

$+ 3^K \times 2\pi \times 53' \times .15 = 3,200$

$53,200^K$

Top Slab

2' within Shielding Walls Extended $= 4,600$

3' within Crane Walls: Excess $\times 3 \times .15 = 3,700$

Ground Water

Ground Water El. 100.0 $\Sigma = (\pi \times 53^2 \times 71 - 16 \times \pi \times 15^2 - 57 \text{ Cubic Ft.}) \times .062$

$= 50,550^K$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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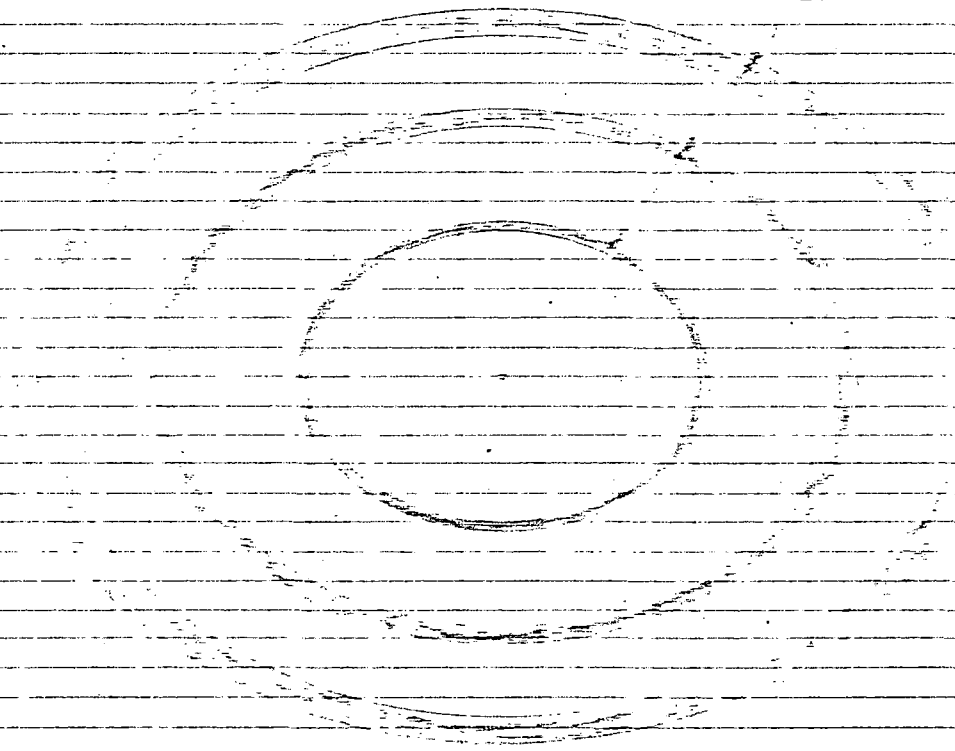
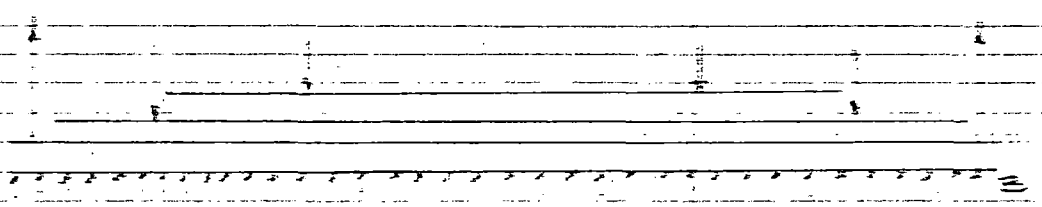
ENCLOSURE



PLAN



ELEVATION

DEF. ESC. LOCKINGS - PLAN & ELEVATION

PUBLIC SERVICE ELECTRIC AND GAS COMPANY — Pg [illegible]

COMPUTATION SHEET

REFERS TO: SALEM GEN STA [illegible]

SUBJECT: [illegible]

FILE:

ESTIMATE:

PREPARED BY: [illegible]

DATE:

CHECKED BY: [illegible]

DATE:

RESULTANT OF [illegible], MAT AND [illegible] LOADS

TOP SLAB [illegible] 4620 k @ EL 77'
+ [illegible] @ 3740 @ EL 79.5
FILL [illegible] [illegible] @ EL [illegible]
STRUCTURAL MAT [illegible] 42,500 k @ EL [illegible]
[illegible] @ EL [illegible]
[illegible] @ EL [illegible]
3220 @ EL [illegible]

BUOYANCY [illegible] 25,900 k @ EL [illegible]
− 17,800 k @ EL [illegible]
− 6,850 @ EL [illegible]

RESULTANT EL [illegible]

[illegible] × 24 − 7,900 × 4 − 25,900 × 44
− 17,800 × 24 − 6,850 [illegible] ÷ 4620 + 3740 + 2150 + 42,500
[illegible] + 3220 − 25,900 − 17,800 − 6,850

153,000 + 133,000 + 13,000 + 1,020,000 + 31,600 − 1,140,000
− 423,000 − 27,400 ÷ 13,520

$$\frac{214,000}{13,520} = 15.8' = \text{ELEV. } 59.8'$$

MOMENTS AND SHEARS FOR 1.25E CONDITION

[illegible]

CYL. & DOME:

SHEAR @ BASE OF CYL. (EL 76') = $\frac{14.2}{[illegible]} \times 10^3 \times 1.25 = \frac{17.8}{[illegible]} \times 10^3$

MOM @ BASE OF CYL. = $\frac{[illegible]}{2356} \times 10^{3\,k}$

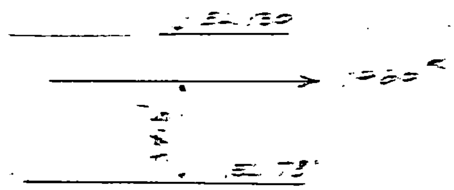
MOM. @ BASE OF MAT (EL 60') = $2356 \times 10^3 + 17.8 \times 10^3 \times 16$

$= \frac{[illegible]}{2640} \times 10^{3\,k}$

VERT. FORCE = ~~[illegible]~~ 7.25 k

CRANE WALL

SHEAR = 11,674 k × .10 × 1.25 = 1460 k.



MOM. @ BASE OF MAT = 1460 × 52.5
= 76,500 'k

VERT. FORCE = 11,674 × .10 × 1.25 × $\frac{2}{3}$
= 973 k

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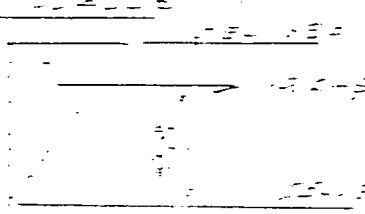

Mom @ Base of Wall = 1,000 + 55.5 = 1,055.5 ✓

Vert. Force = 10,200 x 1.10 x 1.25 x 1/3 = 5550 ✓

EQUIPMENT

ITEM	EST. EL OF C.G.				Mom @ Base of Wall
ST. GEN	120	69	4120	530	36,600
	115	55	530	66	3640
	91	31	235	30	930
	90	30	1987	245	7450
			6872	871	48,620 ✓

Vert. Force = 871 x 1.10 x 1.25 x 1/3

= 550 ✓

SLAB AND MATS INCLUDING BUOYANCY

Slab = 13,580 ✓

Spear = 13,580 x .10 x 1.25 = 1700 ✓

Mom @ Base of Mat = 1700 x -.2 = -340

Vert. Force = 13580 x .10 x 1.25 x 1/3 = 1130 ✓

MOMENTS AND SHEARS FOR 10% CONDITION

CYL AND DOME

Shear @ Base of Cyl = 220 x 10^3 ✓

Mom @ Base of Cyl = 2.566 x 10^3 ✓

Mom @ Base of Mat = 2.566 x 10^3 + 220 x 10^3 x 13

= 2866.000 ✓

Vert. Force = 14566 ✓

CRANE WALL

Shear = 11,670 x .20 = 2330 ✓

Mom @ Base of Mat = 2330 x 51.5 = 122,500 ✓

Vert. Force = 11,670 x .20 x 1/3 = 1550 ✓

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REFER TO _____ SHEET NO. _____

SUBJECT _____ COMPUTATION SHEET

FILE _____

ESTIMATE _____

PREPARED BY _____ DATE _____

CHECKED BY _____ DATE _____

[illegible]

[illegible]

[illegible]

SLAB AND MATS INCLUDING BUOYANCY

[illegible]

FACTORS OF SAFETY

	D.L.	VERT. E.Q.	MOM. @ BASE
CYL AND DOME	62,000	-12,556	2,866,000
CRANE WALL	11,674	-1550	221,500
INT. WALLS	19,245	-1360	109,500
E.S.V.P.	6,972	-930	77,500
SLABS & MAT	64,130	-7910	—
	155,021	-24,216	3,175,500

$$F.S.\ (UPLIFT) = \frac{155,021}{50,550 + 20,216} = \frac{155,021}{70,766} = 2.19$$

$$F.S.\ (OVERTURNING) = \frac{155.02 \times 5}{70,766 \times 5 - 3,175,500} = \frac{775,000}{5,353,830 - 3,175,500} = \frac{11,350,000}{2,453,000} = 4.37$$

SOIL PRESSURE

The following cases will be investigated

A.) D.L. + 1.5P + B

B.) D.L + 1.25 P + 1.25E + B

C) D.L. + 1.0P + 1.0E' + B

D) D.L. + 1.0E' + B

E) D.L + 1.15P + B

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

COMPUTATION SHEET

PREPARED BY: _____ DATE: _____ CHECKED BY: _____ DATE: _____

REFER TO: _____ SUBJECT: _____ FILE: _____ ESTIMATE: _____

A) _____

ITEM	

$$R = \frac{\quad}{\quad} = \frac{\quad}{\quad} = \quad \text{@ EL. 60}$$

$$P = \frac{F}{A} = \frac{\quad}{\pi\,(75)^2} = \quad \text{@ EL. 60}$$

B) _____

ITEM	WEIGHT (K)	MOMENT ARM (FT)
C.I. - FLOOR	7925	
CONC. WALLS		
INT. WALLS EQUIP. SLABS ETC.		
	11,465 K	2,645,095
		2933,620 K

$$M = 109,471 + \frac{2933,620}{11,465} = 115,939$$

$$P = \frac{F}{A} \pm \frac{M}{S} = \frac{115,939}{\pi\,(75)^2} \pm \frac{2933,620}{.785 \times (75)^3}$$

$$= 6.55 \pm 5.55$$

This shows uplift over a small part of base

Approximate Max. pressure = 6.55 + 2.66 = 5.89 T/F

Exact pressure can be found by use of Fig. 3 from Publication Title No. 61-3 "Estimated Foundations" by John W. Smith etc

$$\text{Max Eccentricity } e = \frac{M}{W} = \frac{2933620}{115,939} = 24.4'$$

$$\frac{e}{D} = \frac{22.4}{150} = .16 \qquad F_{max}/F = 2.35$$

$P_{max} = 2.35 \times 6.55 =$ [illegible] acceptable

However, to this we must add pressure due to rocking of containment. (See Page 11 of 25)

$$P_r = P_o \frac{FS}{A} = \frac{1,210 \times 75' \times .063''}{\pi \times 75^2 \times 12} = 4.28 \text{ T/F}$$

∴ Max pressure = 15.24 + 4.28 = 19.52 T/F @ EL. 60

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO _____ PREPARED BY _____

SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY _____

ESTIMATE _____ DATE _____

c) D.L. + 1.0E' + S

ITEM	WEIGHT K	MOMENT @ EL =
S.I. CONC.	14566 K	2,866,000
CRANE WALL	1500	122,500
INT. WALL + SLAB	2200	187,000
SURCH. - INT.	7316	
	25216 K	3,175,500

$M' = 125,000 + 122,500 = 247,500$

$e = \frac{M}{P} = \frac{M'}{S} = \frac{247,500}{3,175,500} = 3,175,500$

$= \frac{7.06}{12.5} = 0.53'$

Approximate Max. pressure = 15.3 K/S.F.

Exact max. pressure from ACI Title No. 64-3

$E = \frac{P}{M'} = \frac{3,175,500}{247,500} = 25.5'$

$\frac{E}{L} = \frac{25.5}{150} = .170$

$F_{max}/F = 2.54$

$\therefore F_{max} = 2.54 \times 5.7 = 17 K/S.F.$

The comparison of approximate to exact values shows negligible error, therefore use of equations derived by Portland Cement Assoc. all right.

b) due to rocking $= \frac{.125 \times 75 \times .095}{17.5 \times 1.2} = 5.75 K/S.F.$

$\therefore$ Max. pressure $= 17 + 5.75 = 22.75 K/S.F. @ EL. 60$

d) D.L. + 1.0E' + S

Soil pressure same as case c.

e) D.L. + 1.15E' + S same as case c.

Note: By the time the pressures calculated above reach EL 30' (bottom of lean concrete) they will decrease in intensity by spreading out over a greater area. However they will gain by the submerged wt. of lean concrete $= (144 - 62.5) 30' = 2.4 K/S.F.$

$\therefore$ Max. point pressure at EL 30 = 20 K/S.F. (minus)

Normal avg. pressure at EL 30 = 17 K/S.F. (minus)

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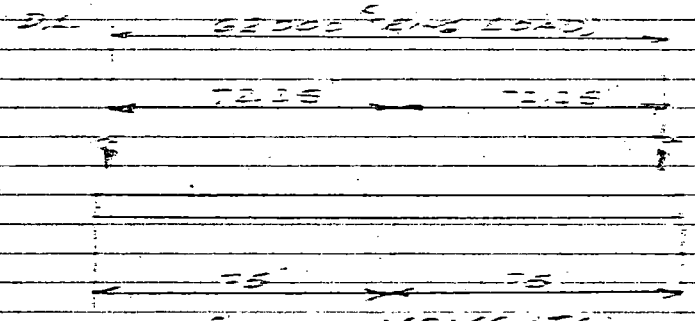
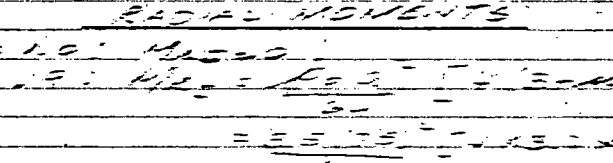
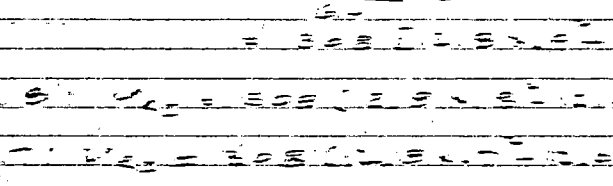
SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY _____

ESTIMATE _____ DATE _____







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REFER TO SALEM - 2 - 4 STA.

SUBJECT [illegible]

FILE

ESTIMATE

COMPUTATION SHEET

PREPARED BY

DATE

CHECKED BY

DATE

$\rho = .5$: $M_{R_2} = 305(12.5 \times .5^2 - 12.03) = 305(-9.53) = -2720$

$\rho = .4$: $M_{R_2} = 305(12.5 \times .4^2 - 12.03) = 305(-9.55) = -3050$

$\rho = .3$ $M_{R_2} = 305(12.5 \times .3^2 - 12.03) = 305(-10.98) = -3350$

$\rho = .2$ $M_{R_2} = 305(12.5 \times .2^2 - 12.03) = 305(-11.52) = -3510$

$\rho = .1$ $M_{R_2} = 305(12.5 \times .1^2 - 12.03) = 305(-11.90) = -3630$

$\rho = 0$: $M_{R_2} = 305(0 - 12.03) = -3670$

For pressure loading, obtain moments by proportion:

$1.5P$: $-366^k/_{ft} = -156,500^k$ (ring load) $\frac{-156,500}{61,000} = -2.57$

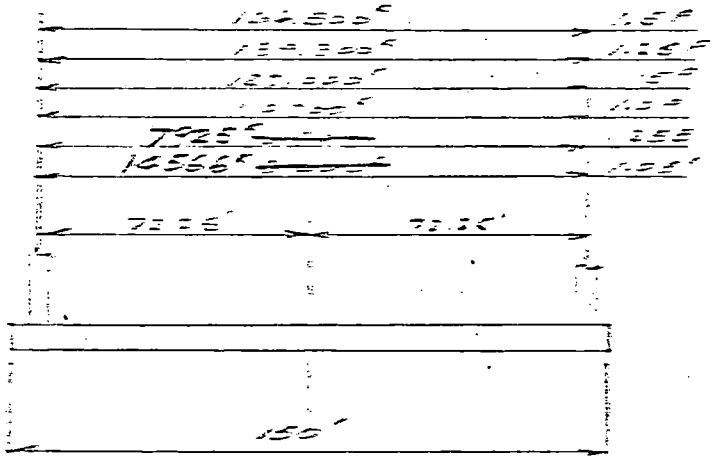
$1.25P$: $-305^k/_{ft} = -130,500^k$ (ring load) $\frac{-130,500}{61,000} = -2.14$

$1.15P$: $-281^k/_{ft} = -120,000^k$ (ring load) $\frac{-120,000}{61,000} = -1.97$

$1.0P$: $-244^k/_{ft} = -104,300^k$ (ring load) $\frac{-104,300}{61,000} = -1.71$

$1.25E$: $\frac{.7925}{6.272} = \frac{.126}{\rho}$

$1.0E$: $\frac{14569}{62,272} = \frac{.234}{\rho}$



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COMPUTATION SHEET

1.0					= 65	= 120
.9					= 151	= 277
.8					= 227	= 415
.7					= 292	= 536
.6					= 348	= 639
.5					= 394	= 724
.4					= 429	= 787
.3					= 456	= 837
.2					= 470	= 862
0					= 475	= 872

* ARBITRARY CONSTANTS FOR EXTERNAL MOMENTS

$$C = \frac{E}{\quad} = -3 \times .9633^2 \left(\frac{\quad}{\quad}\right) - 3(\quad)\left(\frac{\quad}{\quad}\right)$$

$$= 3.1\ldots - .\ldots - 5.5 = -2.\ldots$$

$$E' = 3 - .\ldots - 5.5 = -\ldots$$

$$C' = 3 \times .9633^2 = 2.784$$

$$D = 0 \quad , \quad D' = 1/2$$

EXTERNAL MOM FOR 125 = 2,575,000 "K"

$$f_c = \frac{\quad}{E^3} = \frac{\quad}{\quad} = 3.05 \text{ K/in}^2$$

Due To Rocking: $f_c = 4.25$

$$f_c = 7.30 - 1.25 = 12.55 \text{ K/in}^2$$

$$= \ldots - 2.22 = 10.33$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

COMPUTATION SHEET

REFER TO

SUBJECT

FILE

ESTIMATE

PREPARED BY

DATE

CHECKED BY

DATE

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO

SUBJECT COMPUTATION SHEET

FILE

ESTIMATE

PREPARED BY

DATE

CHECKED BY

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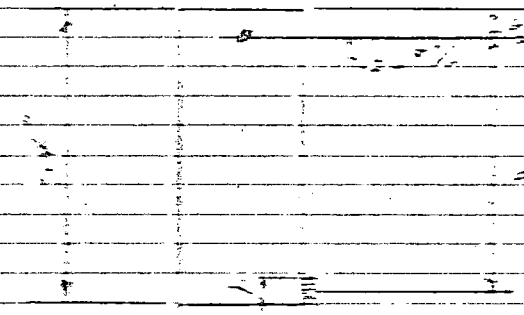

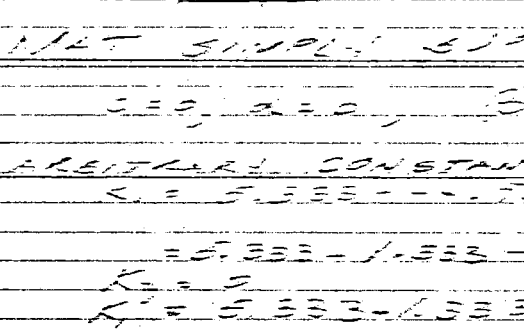

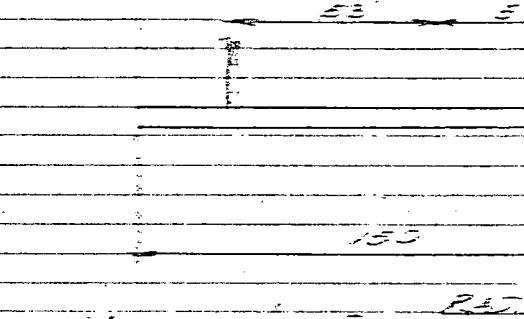

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SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY _____

ESTIMATE _____ DATE _____

$x = 1.0$: $M_{FE} = 0$

$x = 0.9$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.1)\right) = -2.76$

$x = 0.8$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.2)\right) = -5.52$

$x = 0.7$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.3)\right) = -8.28$

$x = 0.6$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.4)\right) = -11.04$

$x = 0.5$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.5)\right) = -13.80$

$x = 0.4$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.6)\right) = -16.56$

$x = 0.3$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.7)\right) = -19.32$

$x = 0.2$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.8)\right) = -22.08$

$x = 0.1$: $M_{FE} = -55.2 \left(\frac{1}{2}(0.9)\right) = -24.84$

$x = 0$: $M_{FE} = -55.2 \left(\frac{1}{2}(1.0)\right) = -27.60$

Reaction $= 55.2 + 27.6 = 82.8$

$V_{FE} = \frac{82.8}{1550} = .053$

$1.0 - .053 = \frac{1550}{1550} = .947$

x	M_{FE} (1550)	M_{FE} (1.0 x)
1.0	0	0
.9	-82	-83
.8	-165	-166
.7	-248	-249
.6	-331	-332
.5	-414	-415
.4	-496	-498
.3	-579	-581
.2	-662	-664
.1	-745	-747
0	-828	-830

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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SUBJECT COMPUTATION SHEET

FILE

ESTIMATE

PREPARED BY

DATE

CHECKED BY

DATE

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO _____ COMPUTATION SHEET

SUBJECT _____

FILE _____

ESTIMATE _____

PREPARED BY _____ DATE _____

CHECKED BY _____ DATE _____

$\theta = .1$; $M_L = 0$

$\theta = 0$; $M_{end} = 0$

EXTERNAL MOM FOR 1.0E-12 SEC

$\theta = 1.0$; $M_L = 0$

$\theta = .9$; $M_L = 0$

$\theta = .8$; $M_L = +3J \cos\theta$

$\theta = .7$; $M_L = +2J \cos\theta$

$\theta = .6$; $M_L = +1J \cos\theta$

$\theta = .5$; $M_L = +3 \cos\theta$

$\theta = .4$; $M_L = +1 \cos\theta$

$\theta = .3$; $M_L = +1 \cos\theta$

$\theta = .2$; $M_L = 0$

$\theta = .1$; $M_L = 0$

$\theta = 0$; $M_L = 0$

FIXED ENDED MOMENTS EQUIVALENT CIRCLE OF INTERNAL MOMENTS AND REQUIREMENT

$\cos\theta$; $\theta = 0$; $\theta = \frac{\pi}{3} = .4$

ARBITRARY CO-STARTS FOR UNIFORM LOADED TRUSS CB

$K_1 = 5.333 - \frac{1}{3} - \frac{1}{3} \cdot \frac{1}{1.667} = 5.333 - .33 - .6 = 4.333$

$= 4.333$

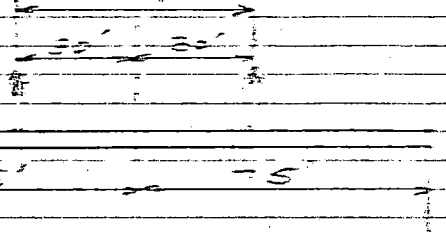
$K_2 = 5$

$K_3 = 5.333 - .2 - 2 = 4.133$

$K_4 = -\frac{64.0}{5.6} = -11.43$

$R_2 = \frac{(10)(2)}{7.75} = 2.58^k$

$R_{0-2} = .775 \cdot 15^k = 11.6^k$



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SUBJECT _____

FILE _____

ESTIMATE _____

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DATE _____

CHECKED BY _____

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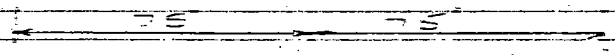
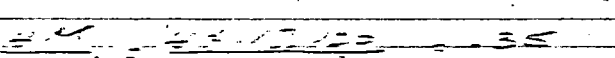
PUBLIC SERVICE ELECTRIC AND GAS COMPANY

SUBJECT SALEM GEN STA — COMPUTATION SHEET





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SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY _____

ESTIMATE _____ DATE _____

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN STA

SUBJECT [illegible] COMPUTATION SHEET

FILE

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PREPARED BY [illegible]

DATE

CHECKED BY [illegible]

DATE

[illegible]

[illegible]

$\theta = 0$, $M_L = 0$

PROJECTION FOR LOCI

$\frac{M_L}{M_{LO}}$	θ
1.0	0
.5	± 3
.6	± 21
.7	± 27
.8	± 111
.9	± 322
1.0	± 573
.3	± 210
.2	± 278
.1	± 336
0	0

COLATAL MOMENTS DUE TO PRESSURE LOADING

[illegible]

[illegible]

[illegible] ELECTRIC AND GAS COMPANY

REFER TO [illegible]
SUBJECT [illegible]
FILE [illegible]
ESTIMATE [illegible]

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PREPARED BY [illegible]
DATE [illegible]
CHECKED BY [illegible]
DATE [illegible]

COMBINED EXTERNAL [illegible] FOR [illegible]

[illegible]											
[illegible]											
[illegible]											
[illegible]											

COMBINED EXTERNAL MOMENTS FOR [illegible]

[illegible]											
[illegible]											
[illegible]											
[illegible]											

NOTE: THESE MOMENTS CAUSE [illegible] DEPENDING ON DIRECTION OF [illegible].

SUMMATION OF [illegible] MOMENTS

[illegible]

[illegible]											
[illegible]											
[illegible]											
[illegible]											
[illegible]											
[illegible]											

[illegible] FOR [illegible]

[illegible]											
[illegible]											
[illegible]											
[illegible]											
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SUBJECT MISC. STR.

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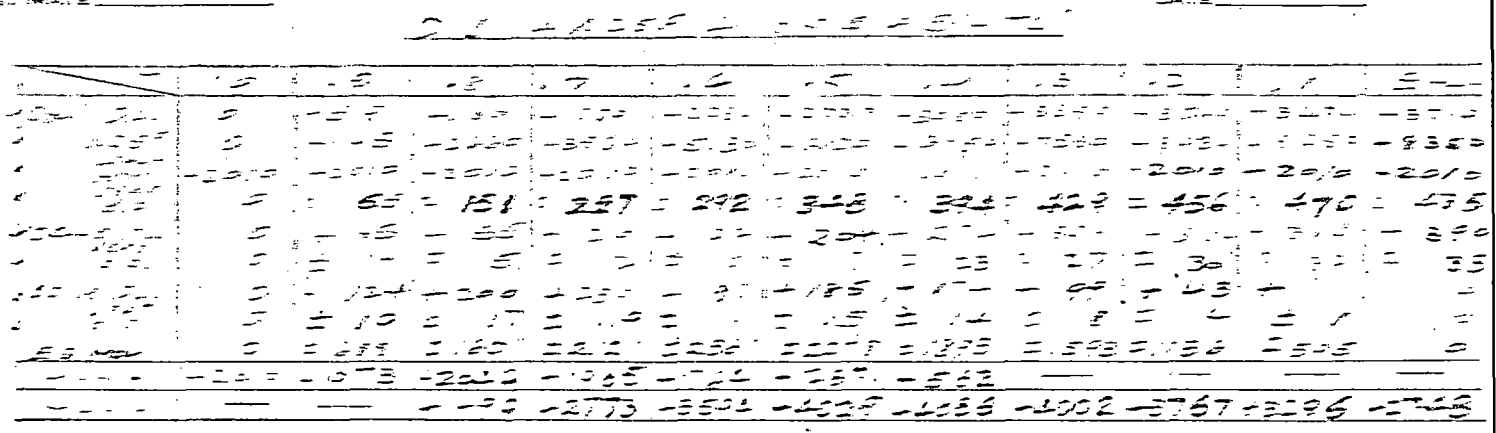

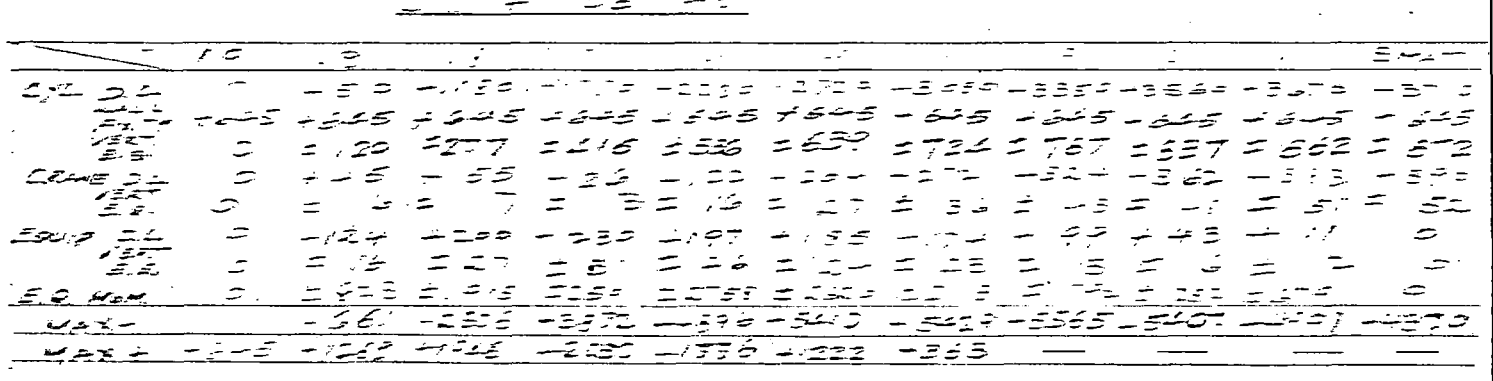

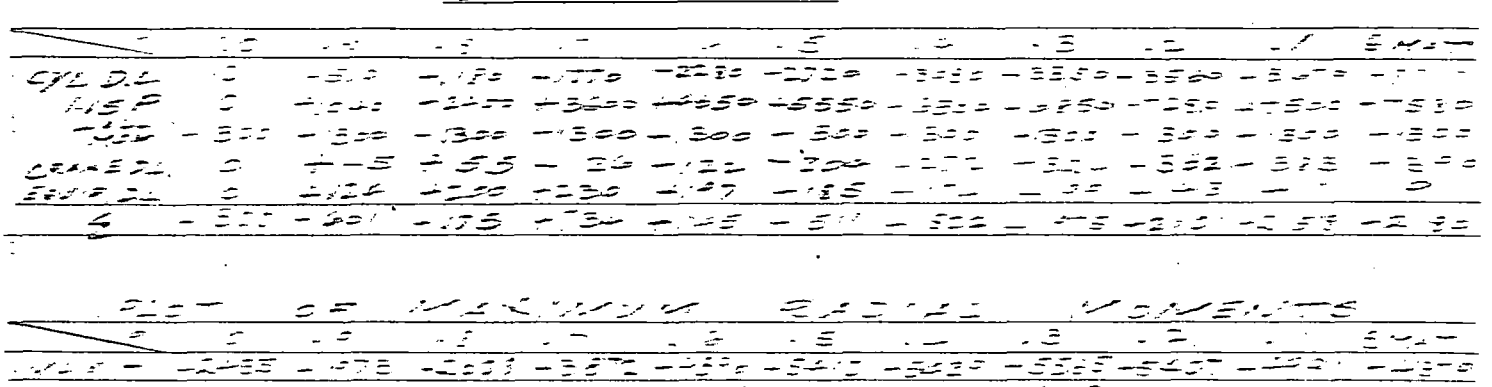

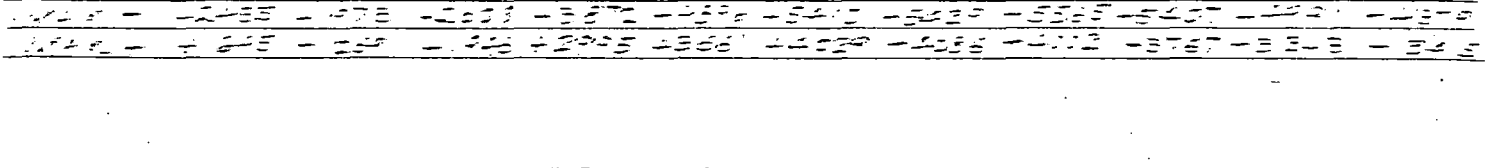

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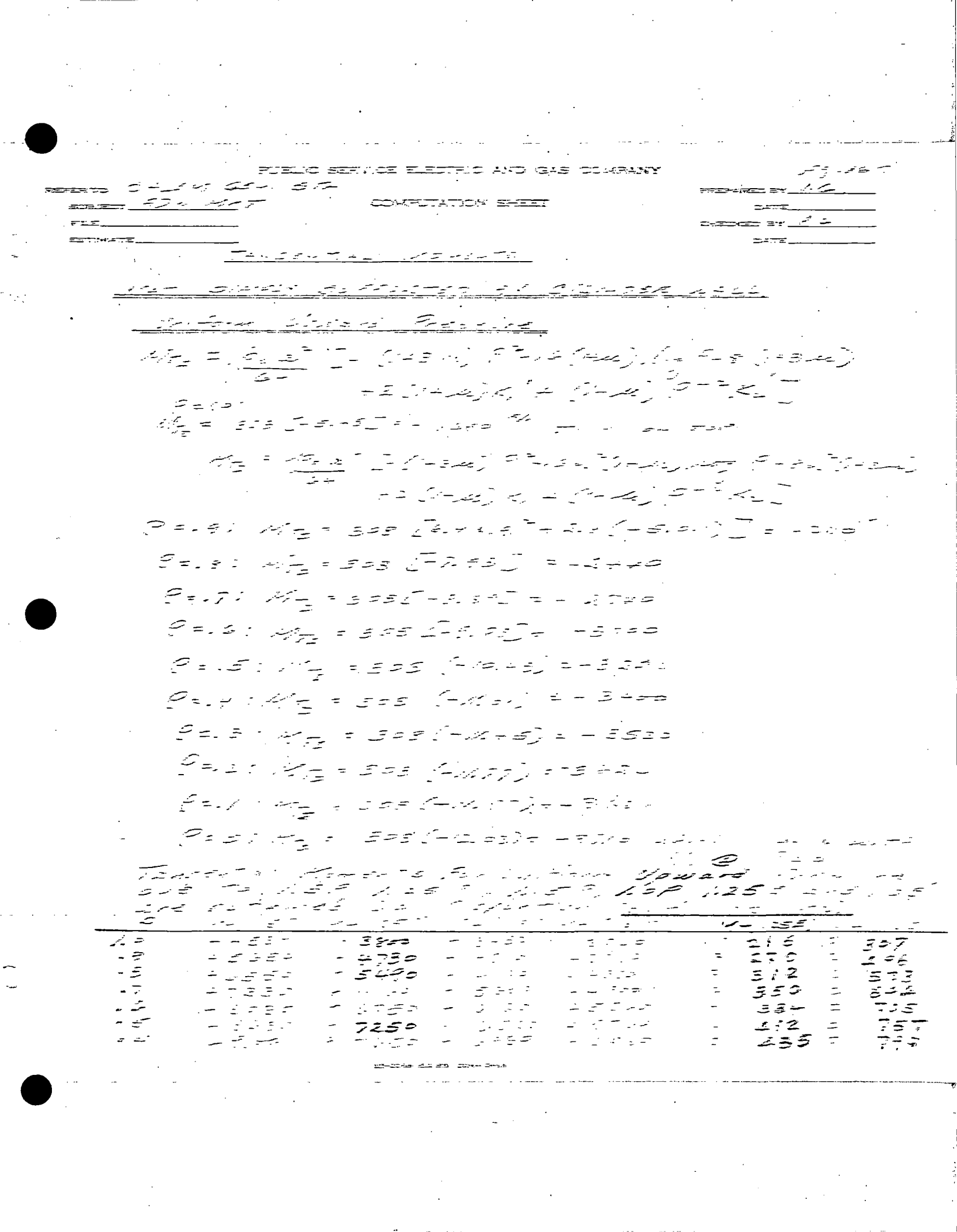
PREPARED BY _____ DATE _____

CHECKED BY _____ DATE _____

SUBJECT _____ FILE _____ ESTIMATE _____



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COMPUTATION SHEET

REFER TO: SALEM GEN. STA.

SUBJECT: [illegible] MAT

FILE:

ESTIMATE:

PREPARED BY: [illegible]

DATE:

CHECKED BY: [illegible]

DATE:

ρ	M (1.50)	M ([illegible])	M (1.0)	M (1.00)	M ([illegible])	M ([illegible])
.3	− [illegible]	− 7910	+ 7250	+ 6300	= 559	= 820
.2	− 4370	+ 4150	+ 7570	+ 6470	= 563	= 554
.1	+ 4190	+ 3270	+ 7570	+ 6570	= 471	= 865
0	+ 4450	+ 7350	+ 7590	+ 6650	= 475	= 872

Tangential Moments due to [illegible] Cyl. Wall

$M_T = \frac{P a^2}{192}$ [illegible]

ρ = 1.0 : 381 [−1.88] = − 680 [illegible]

$M_T = \frac{P a^2}{192}$ [illegible]

ρ = .9 : M_T = 381 (−2.7) = − 975

.8 : M_T = 381 (−3.04) = − 1255

.75 : M_T = 381 (−3.50) = − 1350

.65 : M_T = 381 (−3.46) = − 1430

.5 : M_T = 381 (−3.74) = − 1425

.4 : M_T = 381 (−3.[illegible]) = − [illegible]

.3 : M_T = 381 (−2.[illegible]) = − 915

.2 : M_T = 381 (−1.73) = − 660

.1 : M_T = 381 (−.89) = − 338

0 : M_T = 0   0

Tangential Moments due to [illegible] Cyl. Wall

Proportion = [illegible] = 1.[illegible]

ρ	M_T
1.0	− 815
.9	− 1170
.8	− 1535
.7	− 1633
.6	− 1724
.5	− 1610
.4	− 1420
.3	− 1.33
.2	− 783
.1	− 405
0	0

[illegible] Simply Supported by [illegible] Wall

Uniform Pressure

$M_T = \frac{P a^2}{[illegible]}$ [illegible]

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SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY _____

LOCATION _____ DATE _____

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO _____ PREPARED BY _____ DATE _____

SUBJECT _____ COMPUTATION SHEET CHECKED BY _____ DATE _____

FILE _____

$\theta = 0 \quad M_{T_2} = 6.28\left[6(.6)^3 - 18.85(.6) - \frac{-2.4}{.6^3} - \frac{18.2}{.6}\right]\cos\theta$

$= 6.28\left[5.4 - 16.95 - 3.3 - 30.3\right]\cos\theta = 6.28(-41.15)\cos\theta$

$= -258\cos\theta$

$\theta = .1 \quad M_{T_2} = 6.28\left[6(.1)^3 - 18.85(.1) - \frac{-2.4}{.1^3} - \frac{18.2}{.1}\right]\cos\theta$

$= 6.28\left[.006 - 1.885 + 240 - 182\right]\cos\theta = 6.28(56.121)\cos\theta$

$= 352\cos\theta$

$\theta = .2 \quad M_{T_2} = 6.28\left[6(.2)^3 - 18.85(.2) - \frac{-2.4}{.2^3} - \frac{18.2}{.2}\right]\cos\theta$

$= 6.28\left[.048 - 3.77 + 30 - 91\right]\cos\theta = 6.28(-64.722)\cos\theta$

$= -406\cos\theta$

$\theta = .3 \quad M_{T_2} = 6.28\left[6(.3)^3 - 3.2(.18)\right]\cos\theta$

$= 6.28\left(.162 - .576\right)\cos\theta = -2.6\cos\theta$

$\theta = .4 \quad M_{T_2} = 6.28\left[6(.4)^3 - 3.2(.16)\right]\cos\theta$

$= 6.28\left(.384 - .512\right)\cos\theta = -.8\cos\theta$

$\theta = .5 \quad M_{T_2} = 6.28\left[6(.5)^3 - 3.2(.125)\right]\cos\theta$

$= 6.28\left(.75 - .4\right)\cos\theta = +2.2\cos\theta$

$\theta = .6 \quad M_{T_2} = 6.28\left[6(.6)^3 - 3.2(.216)\right]\cos\theta$

$= 6.28\left(1.296 - .691\right)\cos\theta = +3.8\cos\theta$

$\theta = .7 \quad M_{T_2} = 6.28\left[6(.7)^3 - 3.2(.343)\right]\cos\theta$

$= 6.28\left(2.058 - 1.098\right)\cos\theta = +6.0\cos\theta$

$\theta = .8 \quad M_{T_2} = 6.28\left[6(.8)^3 - 3.2(.512)\right]\cos\theta$

$= 6.28\left(3.072 - 1.638\right)\cos\theta = +9.0\cos\theta$

$\theta = .9 \quad M_{T_2} = 6.28\left[6(.9)^3 - 3.2(.729)\right]\cos\theta$

$= 6.28\left(4.374 - 2.333\right)\cos\theta = +12.8\cos\theta$

$\theta = 1.0 \quad M_{T_2} = 6.28\left[6(1.0)^3 - 3.2(1.0)\right]\cos\theta$

$= 6.28\left(6 - 3.2\right)\cos\theta = +17.6\cos\theta$

$\theta = 0 \quad M_T = 0$

TANGENTIAL MOMENTS DUE TO 1.05' ECCENTRICITY

$\theta = 1.0 \quad M_T = -15$

$.9 \quad = -21$

$.8 \quad = -26$

$.7 \quad = -32$

$.6 \quad = -27$

$.5 \quad = -15$

$.4 \quad = -6$

$.3 \quad = +3$

$.2 \quad = +7$

$.1 \quad = +1$

$0 \quad 0$

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COMPUTATION SHEET

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SUBJECT _____ DATE _____

FILE _____ CHECKED BY _____

ESTIMATE _____ DATE _____

$x = 0$: $M_{FE} = 55.5\left[6.4(0) - 19.2\frac{(0)^2}{2} - 12.8 + 11.6 - 1.02(0)^3\right] = +3.58$

$x = .5$: $M_{FE} = 55.5\left[6.4(.5) - 19.2\frac{(.5)^2}{2} - 12.8 + 11.6 - 1.02(.5)^3\right] = +3.06$

$x = .6$: $M_{FE} = 55.5\left[6.4(.6) - 19.2\frac{(.6)^2}{2} - 12.8 + 11.6 - 1.02(.6)^3\right] = +2.70$

$x = .7$: $M_{FE} = 55.5\left[6.4(.7) - 19.2\frac{(.7)^2}{2} - 12.8 + 11.6 - 1.02(.7)^3\right] = +2.20$

$x = .8$: $M_{FE} = 55.5\left[6.4(.8) - 19.2\frac{(.8)^2}{2} - 12.8 + 11.6 - 1.02(.8)^3\right] = +1.58$

$x = .9$: $M_{FE} = 55.5\left[6.4(.9) - 19.2\frac{(.9)^2}{2} - 12.8 + 11.6 - 1.02(.9)^3\right] = +.832$

$x = .5$: $M_{FE} = 55.5\left[6.4(.5) - 19.2\frac{(.5)^2}{2} - 12.8 + 11.6 - 1.02(.5)^3\right] = +1.20$

$x = .4$: $M_{FE} = 55.5\left[6.4(.4) - 19.2\frac{(.4)^2}{2}\right] = +.44$

$x = .3$: $M_{FE} = 55.5\left[6.4(.3) - 19.2\frac{(.3)^2}{2}\right] = +.22$

$x = .2$: $M_{FE} = 55.5\left[6.4(.2) - 19.2\frac{(.2)^2}{2}\right] = +.22$

$x = .1$: $M_{FE} = 55.5\left[6.4(.1) - 19.2\frac{(.1)^2}{2}\right] = -5$

$x = 0$: $M_{FE} = 0$

TANGENTIAL DEVIATIONS FOR UNIFORM LOAD OF [illegible] PER [illegible] FOR [illegible] CURVE

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PROJECT SALEM GEN. STA.
SUBJECT
FILE
ESTIMATE

COMPUTATION SHEET

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DATE

0		
.3		
.2		
.1		
0		

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COMPUTATION SHEET

$\theta = 1.5$: $M_\theta = 10.2 [+4.7 \times 3^2 + 4.7 \times 3^2] \cos\theta$

$= 10.2 [+42.3 + 42.3] \cos\theta = 10.2 [+12.72] \cos\theta$

$= +130^{K} \cos\theta$

$\theta = 1.0$: $M_\theta = 10.2 [+4.7 \times 2^2 + 4.7 \times 2^2] \cos\theta$

$= 10.2 (+9.4 + 9.35) \cos\theta = 10.2 (+18.7) \cos\theta$

$= +191 \cos\theta$

$\theta = .1$: $M_\theta = 10.2 [+4.7 \times 1] \cos\theta = +48 \cos\theta$

$\theta = 0$: $M_\theta = 0$

TANGENTIAL MOMENTS DUE TO DEAD LOAD NON-UNIFORM PRESSURE FROM DEAD LOAD

θ	M_θ
1.0	$+191 \cos\theta$
.9	$+175$
.8	$+154$
.7	$+134$
.6	$+115$
.5	$+ 93$
.4	$+ 71$
.3	$+ 49$
.2	$+ 27$
.1	$+ 8$
0	0

CONSTANT MOMENTS DUE TO PRESSURE LOADING

[illegible]	$M_\theta = -2435$
[illegible]	$M_\theta = -2010$
[illegible]	$M_\theta = -1570$
[illegible]	$M_\theta = -1300$

COMBINING EXTERNAL MOMENTS FOR BASE CONDITIONS

θ	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

NOTE: THESE MOMENTS CAN BE + OR - DEPENDING ON DIRECTION OF E.Q.

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REFER TO: SALEM GEN STA — COMPUTATION SHEET

SUBJECT: FDN. MAT

FILE:

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DATE:

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DATE:

Pg- 132

Combined Horizontal Moments for Load Combination

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	Elev.
Col. Line	-515	-1135	-1555	-1850	-2130	-2340	-2480	-2530	-2485	-2405	0
Grade Beam	-13	-27	-36	-39	-41	-43	-45	-46	-47	-48	2
Mat	-54	-75	-102	-138	-185	-238	-279	-297	-286	-226	5
Soil	-743	-1237	-1693	-2027	-2356	-2621	-2804	-2873	-2818	-2679	5

Note: These moments can be combined to obtain moments for other combinations of E.Q.

Summation of Transverse Moments

E.L. 115.5 - Mat

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	Elev.
Col. Line	-1610	-2210	-2770	-3250	-3620	-3870	-4020	-4080	-4050	-3940	0
Soil	+1830	+2540	+3200	+3760	+4190	+4480	+4660	+4730	+4700	+4570	0
Mat	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	0
Grade Beam	-	-	-	-130	-256	-247	-330	-356	-375	-396	-340
Col. Line	-	-	-	-	-	-	-	-	-	-	0
Soil	-348	-485	-629	+739	+822	+792	+1023	+1132	+1146	+1135	+545

E.L. 115.5 - Longitudinal

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	Elev.
Col. Line	-1610	-2210	-2770	-3250	-3620	-3870	-4020	-4080	-4050	-3940	0
Soil	+1830	+2540	+3200	+3760	+4190	+4480	+4660	+4730	+4700	+4570	0
Mat	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	0
Grade Beam	-	-	-	-130	-256	-247	-330	-356	-375	-396	-340
Col. Line	-	-	-	-	-	-	-	-	-	-	0
Soil	-348	-485	-629	+739	+822	+792	+1023	+1132	+1146	+1135	+545

E.L. 115.5 - Longitudinal

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	Elev.
Col. Line	-1610	-2210	-2770	-3250	-3620	-3870	-4020	-4080	-4050	-3940	0
Soil	+1830	+2540	+3200	+3760	+4190	+4480	+4660	+4730	+4700	+4570	0
Mat	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	-2435	0
Grade Beam	-	-	-	-130	-256	-247	-330	-356	-375	-396	-340
Col. Line	-	-	-	-	-	-	-	-	-	-	0
Soil	-348	-485	-629	+739	+822	+792	+1023	+1132	+1146	+1135	+545

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

COMPUTATION SHEET

Fig 473

REFER TO Salem GS

SUBJECT [illegible]

FILE

ESTIMATE

PREPARED BY [illegible]

DATE

CHECKED BY [illegible]

DATE

[illegible]

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	SPR L
CYL. DL	-1890	-2110	-2440	-2740	-3000	-3220	-3400	-3520	-3620	-3680	-3710
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-1570	-1570	-1570	-1570	-1570	-1570	-1570	-1570	-1570	-1570	-1570
[illegible]	±397	±446	±573	±644	±705	±757	±799	±827	±850	±865	±872
[illegible]	0	-64	-130	-209	-250	-297	-330	-356	-375	-386	-390
[illegible]	0	±10	±17	±23	±34	±40	±44	±47	±50	±51	±52
[illegible]	+358	+306	+270	+240	+232	+180	+89	+44	+22	+5	0
[illegible]	±49	±41	±36	±32	±31	±24	[illegible]	±7	±3	±1	0
[illegible]	±743	[illegible]	[illegible]	±1500	[illegible]	±357	[illegible]	[illegible]	±654	±385	0
[illegible]	-360	-275	-505	[illegible]	[illegible]	[illegible]	-23	-247	-630	—	—
[illegible]	[illegible]	-762	-2503	-3555	[illegible]	-3933	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	SPR L
CYL. DL	-1890	-2110	-2440	-2740	-3000	-3220	-3400	-3520	-3620	-3680	-3710
[illegible]	+645	+645	+645	+645	+645	+645	+645	+645	+645	+645	+645
[illegible]	±397	±476	±573	±644	±705	±757	±799	±827	±850	±865	±872
[illegible]	0	-64	-130	-209	-250	-297	-330	-356	-375	-386	-390
[illegible]	0	±10	±17	±23	±34	±40	±44	±47	±50	±51	±52
[illegible]	+358	+306	+270	+240	+232	+180	+89	+44	+22	+5	0
[illegible]	±49	±41	±36	±32	±31	±24	[illegible]	±7	±3	±1	0
[illegible]	±743	[illegible]	[illegible]	±1500	±514	±357	[illegible]	[illegible]	±654	±385	0
MAX	-1575	-2545	-3658	-4276	-4663	-4572	-4155	-4082	-3855	-4068	-4370
MIN	—	—	—	—	—	—	—	—	—	—	—

[illegible]

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	SPR L
CYL. DL	-1890	-2110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-3450	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6950	7200	[illegible]	-7500	[illegible]
[illegible]	-1500	-1500	-1500	[illegible]	[illegible]	[illegible]	[illegible]	-1500	-1500	-1500	[illegible]
[illegible]	0	-64	-130	[illegible]	-250	[illegible]	[illegible]	[illegible]	[illegible]	-386	-390
[illegible]	-358	-306	-270	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-3/5	[illegible]	-1385	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PLOT OF MAXIMUM TANGENTIAL MOMENTS

	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	SPR L
MAX	-1575	-2545	-3658	-4276	-4663	-4572	-4155	-4082	-3855	-4068	-4370
MIN	+339	+2067	+2701	+3122	+3444	+3543	+3570	+3370	+3172	+3384	+3415

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

COMPUTATION SHEET

REFERS TO Salem Gen. Sta. [illegible]
SUBJECT Fdn. Mat

FILE ____________
ESTIMATE ____________

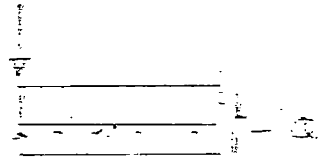
PREPARED BY [illegible]
DATE [illegible]
CHECKED BY [illegible]
DATE ____________

SHEAR CALCULATIONS

UNIFORM PRESSURE

$Q = \frac{[illegible]}{2}([illegible]) = \frac{[illegible]}{2}[illegible]$

$Q = \frac{[illegible]}{2}([illegible])$



CYL. WALL — D.L.

[illegible] = 3.5 [illegible] ; β = [illegible]

$\frac{[illegible]}{2} = \frac{[illegible]}{2} = .31$ [illegible]

x = 1.0	Q = [illegible]	= 0
0.9	Q = .31 × [illegible]	= −112 [illegible]
0.8	= [illegible]	= −10[illegible]
0.7	= [illegible]	= −9[illegible]
0.6	= [illegible]	= −7[illegible]
0.5	= [illegible]	= −6[illegible]
0.4	= [illegible]	= −[illegible]
0.3	= [illegible]	= +3[illegible]
0.2	= [illegible]	= +2[illegible]
0.1	= [illegible]	= +[illegible]
0	= [illegible]	= 0

CYL. WALL — PRESSURE [illegible]

$\frac{[illegible]}{D.L.} = \frac{[illegible]}{[illegible]} \ldots = \frac{[illegible]}{0.128} = \frac{[illegible]}{0.235}$

[illegible]

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN STA.

SUBJECT FEA. ANAL.

FILE

ESTIMATE

COMPUTATION SHEET

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DATE

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DATE

					= 15	= 28
					= 13	= 25
					= 12	= 21
					= 10	= 19
					= 8	= 16
					= 7	= 12
					= 5	= 9
					= 3	= 6
					= 2	= 3
					0	0

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REPORT Salem Gen. Sta. PREPARED BY DC

SUBJECT Dil. Mat COMPUTATION SHEET DATE 6-10-75

FILE CHECKED BY J.G.

ESTIMATE DATE

P = 2.0 Δ_{22} = 2.0 × 2.5 = -5.0 K

0.3 Δ_{22} = 2.0 × 0.3 = -0.6 K

0.2 Δ_{22} = 2.0 × 0.2 = -0.4 K

0.1 Δ_{22} = 2.0 × 0.1 = -0.2 K

0 Δ_{22} = 2.0 × 0 = 0

CRUSH WALL - E.I. (Refer to P.L.-5)

P	Δ_{22} (INCHES)	Δ_{22} (INCHES)
1.0	0	0
0.9	= 0.5 K	= 0.5 K
0.8	= 0.9	= 0.9
0.7	= 1.2	= 1.2
0.6	= 1.3	= 1.3
0.5	= 1.3	= 1.3
0.4	= 1.2	= 1.2
0.3	= 0.9	= 0.9
0.2	= 0.5	= 0.5
0.1	= 0.2	= 0.2
0	0	0

INTERPOLATE TO FIND [illegible]

P_{cr} = 0.07 E_c (Eq. E-3) = 0.07 × 3.3 × 10^6 = 231,000 psi

$\frac{P_{cr}}{f'_c}$ = $\frac{231,000}{4,000}$ = 57.75 > 0.5 SEE SEC. 3.1.2.1

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY PC

SUBJECT FDN. MAT COMPUTATION SHEET DATE 6-13-68

FILE CHECKED BY L.G

ESTIMATE DATE

$\rho = 1.0$	$Q_{RII} = 0$ K/,	
0.9	$Q_{RII} = 36.5\ (-.225)$	$= -8.3$ K/,
0.8	$Q_{RII} = 36.5\ (-0.45)$	$= -16.4$ K/,
0.7	$Q_{RII} = 36.5\ (-0.73)$	$= -26.6$
0.6	$Q_{RII} = 36.5\ (-1.07)$	$= -39.0$
0.5	$Q_{RII} = 36.5\ (-1.5)$	$= -54.6$
0.4	$Q_{RII} = 36.5\ (-2.1)$	$= -77.0$
0.4	$Q_{RI} = 36.5 \times 0.4$	$= +14.5$
0.3	$Q_{RI} = 36.5 \times 0.3$	$= +10.9$
0.2	$Q_{RI} = 36.5 \times 0.2$	$= +7.2$
0.1	$Q_{RI} = 36.5 \times 0.1$	$= +3.6$ K/,
0	$Q_{RI} = 0$ K/,	

INT. WALL & EQUIP'T — E.Q. (Refer to P. 159)

ρ	Q_R (1.2 E)	Q_R (1.0 E')
1.0	0	0
0.9	$\mp$ 0.7	$\mp$ 1.1
0.8	$\mp$ 1.4	$\mp$ 2.2
0.7	$\mp$ 2.2	$\mp$ 3.5
0.6	$\mp$ 3.3	$\mp$ 5.2
0.5	$\mp$ 4.6	$\mp$ 7.3
0.4	$\mp$ 6.4	$\mp$ 10.2
0.4	$\pm$ 1.2	$\pm$ 1.9
0.3	$\pm$ 0.9	$\pm$ 1.5
0.2	$\pm$ 0.6	$\pm$ 1.0
0.1	$\pm$ 0.3	$\pm$ 0.5
0	0	0

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SUBJECT FDN. MAT COMPUTATION SHEET DATE 6-13-68

FILE CHECKED BY J.G.

ESTIMATE DATE

EXT. MOMENT

$$Q_{RI} = \frac{\rho a}{192}\left[72\rho^2 + 8B - 2D\rho^{-2}\right]\cos\theta$$

$$Q_{RII} = \frac{\rho a}{192}\left[72\rho^2 + 8B' - 2D'\rho^{-2}\right]\cos\theta$$

CYL. WALL — 1.25E (INCLUDING ROCKING)

$\rho = 12.33^{K}/_{\square'}$ P. 153

$$\frac{\rho a}{192} = \frac{12.33 \times 75}{192} = 4.81^{K}/_{'}$$

$B = -2.963$ $D = 0$ $B' = -6.196$ $D' = 12$

$\rho = 1.0$ $Q_{RII} = 4.81\left[72(1)^2 - 8(6.196) - 2(12)\right]\cos\theta$

$= 4.81[72 - 49.3 - 24]\cos\theta = 0$

$\rho = 0.9$ $Q_{RI} = 4.81\left[72\times.9^2 - 8(2.963) - 0\right]\cos\theta$

$= 4.81[58.3 - 23.6]\cos\theta = \pm 168\cos\theta$

$\rho = 0.8$ $Q_{RI} = 4.81\left[72\times.8^2 - 23.6\right]\cos\theta = \pm 109\cos\theta$

$\rho = 0.7$ $Q_{RI} = 4.81\left[72\times.7^2 - 23.6\right]\cos\theta = \pm 56\cos\theta$

$\rho = 0.6$ $Q_{RI} = 4.81\left[72\times.6^2 - 23.6\right]\cos\theta = \pm 11\cos\theta$

$\rho = 0.5$ $Q_{RI} = 4.81\left[72\times.5^2 - 23.6\right]\cos\theta = \mp 27\cos\theta$

$\rho = 0.4$ $Q_{RI} = 4.81\left[72\times.4^2 - 23.6\right]\cos\theta = \mp 59\cos\theta$

$\rho = 0.3$ $Q_{RI} = 4.81\left[72\times.3^2 - 23.6\right]\cos\theta = \mp 82\cos\theta$

$\rho = 0.2$ $Q_{RI} = 4.81\left[72\times.2^2 - 23.6\right]\cos\theta = \mp 100\cos\theta$

$\rho = 0.1$ $Q_{RI} = 4.81\left[72\times.1^2 - 23.6\right]\cos\theta = \mp 110\cos\theta$

$\rho = 0$ $Q_{RI} = 4.81\left[-23.6\right]\cos\theta = \mp 114\cos\theta$

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REFER TO SALEM GEN. STA. PREPARED BY PC

SUBJECT FDN. MAT. COMPUTATION SHEET DATE 6-13-68

FILE CHECKED BY L.G

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CYL. WALL – 1.0E' (INCLUDING ROCKING)

ϕ (1.0E') = 14.80 , ϕ (1.25E) = 12.33

$\frac{14.80}{12.33} = 1.2$

ρ = 1.0	$Q_{RII} = 0$
0.9	$Q_{RI} = \pm 202 \cos\theta$
0.8	$Q_{RI} = \pm 131 \cos\theta$
0.7	$Q_{RI} = \pm 67 \cos\theta$
0.6	$Q_{RI} = \pm 13 \cos\theta$
0.5	$Q_{RI} = \mp 32 \cos\theta$
0.4	$Q_{RI} = \mp 71 \cos\theta$
0.3	$Q_{RI} = \mp 98 \cos\theta$
0.2	$Q_{RI} = \mp 120 \cos\theta$
0.1	$Q_{RI} = \mp 132 \cos\theta$
0	$Q_{RI} = \mp 137 \cos\theta$

CRANE WALL – 1.25E (CROCKING NEGLIGIBLE)

$\phi = 0.231$ K/□' P.157

$\frac{\phi a}{192} = \frac{0.231 \times 75}{192} = 0.09$

B = 0 APPROX. B' = -5.875

D = 0 D' = 12

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SUBJECT FDN. MAT
FILE
ESTIMATE

COMPUTATION SHEET

PREPARED BY PC
DATE 6-13-68
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DATE

$\rho = 1.0$ $\quad Q_{RII} = 0.09\left[72(1)^2 - 8(5.875) - \frac{24}{1}\right]\cos\theta$

$= 0.09[72 - 47 - 24]\cos\theta = 0$

$\rho = 0.9$ $\quad Q_{RII} = 0.09\left[72\times.9^2 - 47 - \frac{24}{.9^2}\right]\cos\theta = \mp 1.1\cos\theta$

$\rho = 0.8$ $\quad Q_{RII} = 0.09\left[72\times.8^2 - 47 - \frac{24}{.8^2}\right]\cos\theta = \mp 3.5\cos\theta$

$\rho = 0.7$ $\quad Q_{RII} = 0.09\left[72\times.7^2 - 47 - \frac{24}{.7^2}\right]\cos\theta = \mp 5.5\cos\theta$

$\rho = 0.7$ $\quad Q_{RI} = 0.09\times 72\times.7^2\cos\theta = \pm 3.1\cos\theta$

$\rho = 0.6$ $\quad Q_{RI} = 0.09\times 72\times.6^2\cos\theta = \pm 2.3\cos\theta$

$\rho = 0.5$ $\quad Q_{RI} = 0.09\times 72\times.5^2\cos\theta = \pm 1.6\cos\theta$

$\rho = 0.4$ $\quad Q_{RI} = 0.09\times 72\times.4^2\cos\theta = \pm 1.0\cos\theta$

$\rho = 0.3$ $\quad Q_{RI} = 0.09\times 72\times.3^2\cos\theta = \pm 0.6\cos\theta$

$\rho = 0.2$ $\quad Q_{RI} = 0.09\times 72\times.2^2\cos\theta = 0$

$\rho = 0.1$ $\quad Q_{RI} = 0.09\times 72\times.1^2\cos\theta = 0$

$\rho = 0$ $\quad Q_{RI} = 0.09\times 72\times 0\cos\theta = 0$

CRANE WALL — 1.0 (E)

$\frac{122500}{76500} = 1.6$

(refer to P. 157 & 158)

$\rho = 1.0$	$Q_{RII} = 0$	$\rho = 0.4$	$Q_{RI} = \pm 1.6\cos\theta$
0.9	$Q_{RII} = \mp 1.8\cos\theta$	0.3	$Q_{RI} = \pm 1.0\cos\theta$
0.8	$Q_{RII} = \mp 5.6\cos\theta$	0.2	$Q_{RI} = 0$
0.7	$Q_{RII} = \mp 8.8\cos\theta$	0.1	$Q_{RI} = 0$
0.7	$Q_{RI} = \pm 5.0\cos\theta$	0	$Q_{RI} = 0$
0.6	$Q_{RI} = \pm 3.7\cos\theta$		
0.5	$Q_{RI} = \pm 2.6\cos\theta$		

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SUBJECT FDN. MAT. COMPUTATION SHEET DATE 6-13-68

FILE CHECKED BY L.G.

ESTIMATE DATE

INT. WALL & EQUIP'T — 1.25 E

$\rho = 0.35$ (P.160)

$B = 13.08$ $B' = -5.62$ $D = 0$ $D' = 12$

$$\frac{pa}{192} = \frac{0.35 \times 75}{192} = 0.137$$

$\rho = 1.0$	$Q_{RII} = 0.137\left[72 \times 1^{72}{}^2 - 8 \times 5.62^{45} - \frac{24}{1^2}\right]\cos\theta$	$= 0$ k/
$\rho = 0.9$	$Q_{RII} = 0.137\left[72 \times .9^{58.3}{}^2 - 8 \times 5.62 - \frac{24}{.9^2}\right]\cos\theta$	$= \mp 2.2 \cos\theta$
$\rho = 0.8$	$Q_{RII} = 0.137\left[72 \times .8^{46.1}{}^2 - 8 \times 5.62 - \frac{24}{.8^2}\right]\cos\theta$	$= \mp 5.0 \cos\theta$
0.7	$Q_{RII} = 0.137\left[72 \times .7^{35.3}{}^2 - 8 \times 5.62 - \frac{24}{.7^2}\right]\cos\theta$	$= \mp 8.1 \cos\theta$
0.6	$Q_{RII} = 0.137\left[72 \times .6^{25.9}{}^2 - 8 \times 5.62 - \frac{24}{.6^2}\right]\cos\theta$	$= \mp 11.8 \cos\theta$
0.5	$Q_{RII} = 0.137\left[72 \times .5^{18.0}{}^2 - 8 \times 5.62 - \frac{24}{.5^2}\right]\cos\theta$	$= \mp 16.9 \cos\theta$
0.4	$Q_{RII} = 0.137\left[72 \times .4^{11.5}{}^2 - 8 \times 5.62 - \frac{24}{.4^2}\right]\cos\theta$	$= \mp 25.1 \cos\theta$
0.4	$Q_{RI} = 0.137\left[72 \times .4^{11.5}{}^2 + 8 \times 13.08^{104.5}\right]\cos\theta$	$= \pm 15.8 \cos\theta$
0.3	$Q_{RI} = 0.137\left[72 \times .3^{6.5}{}^2 + 8 \times 13.08\right]\cos\theta$	$= \pm 15.2 \cos\theta$
0.2	$Q_{RI} = 0.137\left[72 \times .2^{2.9}{}^2 + 8 \times 13.08\right]\cos\theta$	$= \pm 14.7 \cos\theta$
0.1	$Q_{RI} = 0.137\left[72 \times .1^{0.7}{}^2 + 8 \times 13.08\right]\cos\theta$	$= \pm 14.4 \cos\theta$
0	$Q_{RI} = 0.137\left[72 \times 0 + 8 \times 13.08\right]\cos\theta$	$= \pm 14.3 \cos\theta$

INT. WALL & EQUIP'T — 1.0 E' (CRACKING NEGLIGIBLE)

$1.0E' = 1.6 \times 1.25E$ (Refer to P. 162)

$\rho = 1.0$	$Q_{RII} = 0$	$\rho = 0.4$	$Q_{RII} = \mp 40.2 \cos\theta$
$\rho = 0.9$	$Q_{RII} = \mp 3.5 \cos\theta$	$\rho = 0.4$	$Q_{RI} = \pm 25.2 \cos\theta$
$\rho = 0.8$	$Q_{RII} = \mp 8.0 \cos\theta$	$\rho = 0.3$	$Q_{RI} = \pm 24.1 \cos\theta$
$\rho = 0.7$	$Q_{RII} = \mp 13.0 \cos\theta$	$\rho = 0.2$	$Q_{RI} = \pm 23.5 \cos\theta$
$\rho = 0.6$	$Q_{RII} = \mp 18.9 \cos\theta$	$\rho = 0.1$	$Q_{RI} = \pm 23.0 \cos\theta$
$\rho = 0.5$	$Q_{RII} = \mp 27.0 \cos\theta$	$\rho = 0$	$Q_{RI} = \pm 22.8 \cos\theta$

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Pg 182

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SUBJECT FDN. MAT COMPUTATION SHEET DATE

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ESTIMATE DATE

SUMMARY OF RADIAL SHEAR

EXT. MOMENT FOR 1.25E

C /	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	ΣMA
CYL. E.Q. MOM.	0	+165	+109	+56	+11	-27	-59	-82	-100	-110	-114
CRANE E.Q. MOM	0	- 1	- 4	+ 3	+ 2	+ 2	+ 1	+ 1	0	0	0
ERVIP E.Q. MOM	0	- 2	- 5	- 8	-12	-17	-25	+15	+15	+14	+14
Σ	0	+165	+100	+51	+ 1	-42	-83	-66	-85	-96	-10

NOTE; ABOVE FINAL MOMENTS CAN BE ± DEPENDING ON DIRECTION OF E.Q.

C /	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	ΣM
CYL. E.Q. MOM	0	+202	+131	+67	+13	-32	-71	-98	-120	-132	-13
CRANE E.Q. MOM	0	- 2	- 6	+ 5	+ 4	+ 3	+ 2	+ 1	0	0	0
ERVIP E.Q. MOM	0	- 4	- 8	-13	-19	-27	-40	+24	+24	+23	±2
Σ	0	+196	+117	+59	- 2	-56	-109	+73	-96	-109	-11

NOTE; ABOVE FINAL MOMENTS CAN BE ± DEPENDING ON DIRECTION OF E.Q.

D.L. +1.5P +TL +S

C /	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	ΣM
CYL. D.L.	0	+118	+105	+91	+79	+66	+53	+39	+26	+13	0
1.5P	0	-316	-282	-244	-212	-175	-141	-106	-70	-35	0
CRANE D.L	0	- 6	- 11	- 18	+15	+12	+10	+ 7	+ 5	+ 3	0
ERVIP D.L	0	- 8	-16	-27	-39	-55	-77	+11	+ 7	+ 4	0
Σ	0	-212	-204	-198	-57	-152	-155	-49	-32	-15	0

D.L. +1.0P +1.0E' +TL' +S

C /	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	ΣMA
CYL. D.L.	0	+118	+105	+91	+79	+66	+53	+39	+26	+13	0
1.0P	0	-211	-189	-163	-141	-117	- 94	- 71	- 47	- 24	0
VERT E.Q	0	± 28	± 25	± 21	± 19	± 16	± 12	± 9	± 6	± 3	0
CRANE D.L	0	- 6	- 11	- 18	+15	+12	+10	+ 7	+ 5	+ 3	0
VERT E.Q	0	± 1	± 2	± 2	± 2	± 2	± 1	± 1	± 1	0	
ERVIP D.L.	0	- 8	- 16	- 27	- 39	- 55	- 77	+11	+ 7	+ 4	0
VERT E.Q	0	0	± 1	± 2	± 4	± 5	± 7	±10	± 2	± 1	0
E.Q. MOM	0	± 196	± 117	± 59	± 2	± 56	± 109	± 73	± 96	± 109	±11
MAX -	0	-332	-256	-201	-113	-173	-237	-107	-114	-117	-11
MAX +	0	+118	+ 34	—	—	—	—	+ 79	+ 96	+109	+114

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REFER TO SALEM GEN. STA

SUBJECT FDN. MAT

COMPUTATION SHEET

FILE

ESTIMATE

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D.L. ± 1.25P ± T.L. + 1.25E + B

ρ	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	ΣM₂
CYL. D.L.	0	+118	+105	+ 91	+ 79	+ 66	+53	+39	+26	+13	0
1.25P	0	-264	-236	-205	-175	-148	-118	- 89	- 59	- 30	0
VERT. EQ.	0	± 15	± 13	± 12	± 10	± 8	± 7	± 5	± 3	± 2	0
CRANE D.L.	0	- 6	- 11	- 18	+15	+12	+10	+ 7	+ 5	+ 3	0
VERT. E.Q.	0	0	± 1	± 2	± 1	± 1	± 1	± 1	0	0	0
EQUIP. D.L.	0	- 8	-16	-27	-39	-55	-77	+11	+ 7	+ 4	0
VERT. E.Q.	0	± 1	± 1	± 2	± 3	± 5	± 6	± 1	± 1	0	0
E.Q. MOM	0	±165	±100	± 51	± 1	± 42	±83	±66	±85	±96	±10
MAX. -	0	-341	-273	-226	-138	-181	-229	-105	-110	-108	-10
MAX. +	0	+ 21	—	—	—	—	—	+41	+68	+ 88	+10

D.L. + 1.0E' + B

ρ	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	ΣM₂
CYL. D.L.	0	+118	+105	+ 91	+79	+66	+ 53	+39	+26	+13	0
VERT. EQ.	0	± 28	± 25	± 21	± 19	± 16	± 12	± 9	± 6	± 3	0
CRANE D.L.	0	- 6	- 11	[illegible]	+15	+ 12	+10	+ 7	+ 5	+ 3	0
VERT. E.Q.	0	± 1	± 2	± 2	± 2	± 2	± 1	± 1	± 1	0	0
EQUIP. D.L.	0	- 8	-16	- 27	- 39	- 55	- 77	+11	+7	+ 4	0
VERT. E.Q.	0	± 1	± 2	± 4	± 5	± 7	± 10	± 2	± 1	± 1	0
E.Q. MOM	0	±196	±117	± 59	± 2	± 56	±109	±73	±96	±109	±114
MAX -	0	-122	-68	-40	—	-58	-146	-28	-66	- 93	-114
MAX +	0	+330	+224	+167	+83	+104	+118	+142	+142	+133	+114

PLOT OF MAX. RADIAL SHEAR

ρ	1.0	.9	.8	.7	.6	.5	.4	.3	.2	.1	ΣM₂T
MAX -	0	-341	-273	-226	-157.	-181	-237	-107	-114	-117	-114
MAX +	0	+330	+224	+167	+83	+104	+118	+142	+142	+133	+114

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SUBJECT EDN. MAT COMPUTATION SHEET DATE

FILE CHECKED BY P.C.

ESTIMATE DATE

A_s REQUIRED FOR MAT

$-M_r$ (TENSION ON TOP)

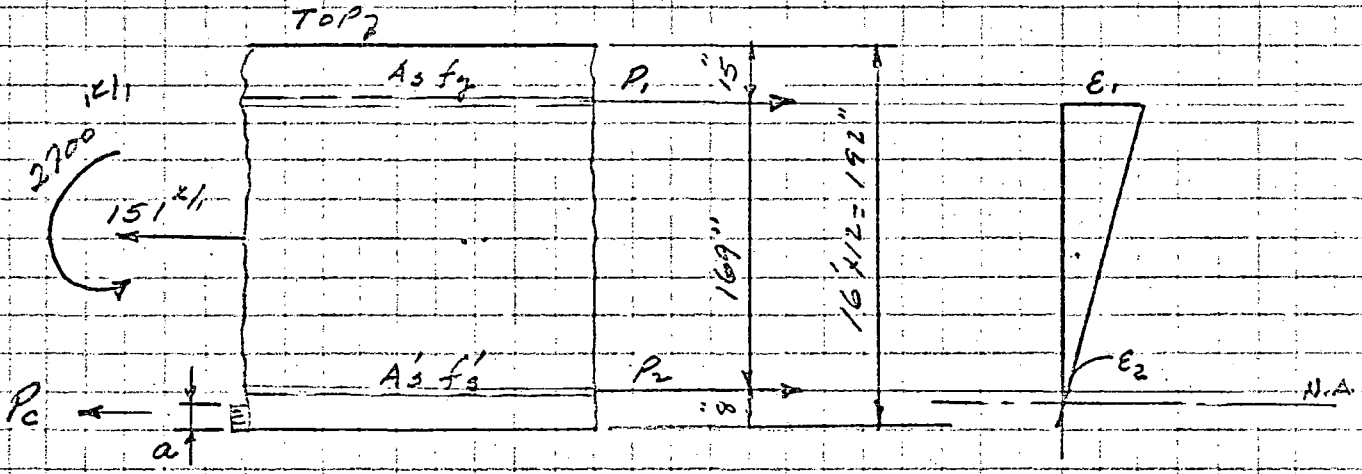
$P = 1.0$; $R = 75'$

$M_r = -2435^{K'}$; Hor. $Q = 143^{K}$

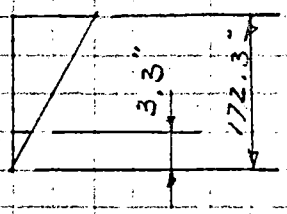
Design $M_r = \frac{-2435}{.90} = -2700$

Design $Q = \frac{143}{.95} = 151^{K}$

Assume bot. steel to be 336 - #14's around perimeter $= \frac{336 \times 2.25}{2\pi(75)} = 1.6''$



TRY $a = 4''$; $\frac{4}{.85} = 4.7'' = N.A.$



$\varepsilon_1 = \frac{60{,}000}{29 \times 10^6} = .00207$

$\varepsilon_2 = \frac{3.3}{172.3} \times .00207 = .0000396$

$f'_s = .0000396 \times 29 \times 10^6 = 1150 PSI$, $P_2 = 1.6 \times 1.15 = 1.84^{K}$

$P_c = 2.91^{K}/a'' \times 4'' \times 12'' = 143^{K}$

$P_1 = 151 + 143 - 1.84 = 292.2^{K}$

CAPACITY OF SECTION $= 292.2 \times \frac{81}{12} + 143 \times \frac{94}{12} - 1.84 \times \frac{88}{12}$

$= 1970 + 1115 - 13 = 3072^{K'}$

$3072 > 2700$

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SUBJECT _____ COMPUTATION SHEET DATE _____

FILE _____ CHECKED BY _____

ESTIMATE _____ DATE _____

Try $a = 3.5"$, $\frac{3.5}{.85} = 4.1"$

$\epsilon_2 = \frac{3.9}{172.9} \times .00207 = .0000467$

$f_s' = .0000467 \times 29 \times 10^2 = 1.355^{K/in^2}$; $P_2 = 1.6 \times 1.355 = 2.16^K$

$P_c = 2.97 \times 3.5" \times 12 = 125^K$

$P_1 = 151 + 125 - 2^{\pm} = 274^K$

Cap. of section $= 274 \times \frac{81}{12} + 125 \times \frac{94.25}{12} - 2.16 \times \frac{88}{12}$

$= 1855 + 980 - 16 = 2819 > 2700$

$\therefore$ As req'd $= \frac{274}{60} = 4.5^{in^2}$ @ cyl. wall.

Use 336-18s & 336-14s alternately

$\rho = .9$, $R = 67.5'$

$M_n = -1973^{K'}$; $Q = 118^K$

By comparison; 336-18s & 336-14s more than adequate ✓

$\rho = .8$; $R = 60'$

$M_n = -2601$; $Q = 92^K$

Design $M_n = -\frac{2601}{.90} = -\frac{2890}{2773}{}^{K'}$

Design $Q = \frac{92}{.95} = 97^K$

Assume bot steel to be 336-14s around perimeter $= \frac{336 \times 2.25}{2\pi(60)} = 2^{in^2}$

Try $a = 3.5"$; N.A. @ $4.1"$

$P_2 = 1.355 \times 2 = 2.7^K$

$P_c = 125^K$

$P_1 = 97 + 125 - 2.7 = 219.3^K$

Capacity of section $= 219.3 \times \frac{81}{12} + 125 \times \frac{94.25}{12} - 2.7 \times \frac{88}{12}$

$= 1490 + 980 - 20 = 2440 < \frac{2740}{2890}$

Try $a = 4"$; N.A. @ $4.7"$

$P_2 = 1.15 \times 2 = 2.3^K$

$P_c = 143^K$

$P_1 = 97 + 143 - 2.3 = 237.7^K$

Cap. of section $= 237.7 \times \frac{81}{12} + 143 \times \frac{94}{12} - 2.3 \times \frac{88}{12}$

$= 1600 + 1120 - 17 = 2703 \simeq 2890$

A_s req'd $= \frac{240^{\square''}}{60} = 4^{\square''}/_{'}$

use 336-#14s & 336-#18s a/f.

A_s provided $= \frac{336 \times 6.25}{2\pi(60)} = 5.58^{\square''}/_{'}$

$\rho = .7, K = 52.5'$

$M_2 = -\frac{3706}{3872}, Q = 0$ Case I

$M_2 = -\frac{2736}{2907}, Q = 92^K/_{'}$ Case II

Case I: Design $M_2 = \frac{3872}{.90} = \frac{4300^{IK}}{\#11\square}/_{'}$

Assume bot steel to be $4.1^{\square''}$

Try $a = 4''$; $P_2 = 143^K$, $P_2 = 4.1 \times 1.15 = 4.7^K$

$P_1 = 143^K - 4.7 = 138.3^K$ N.G.

Try $a = 8''$ $\therefore P_2 = 0$; $P_c = 8 \times 2.97 \times 12 = 284^K = P_1$

Capacity of section: $284^K \times \frac{173}{12} = 4100^{IK}/_{'}$ OK.

$\frac{\frac{4300}{\#11\square} \times 12}{173} = \frac{298}{285^K} = P_1 = P_c$

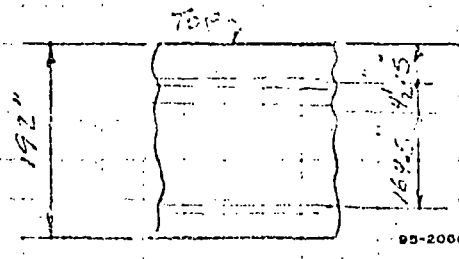
$\frac{298}{60} = \frac{285}{4.75}^{\square''}/_{'}$ Req'd.

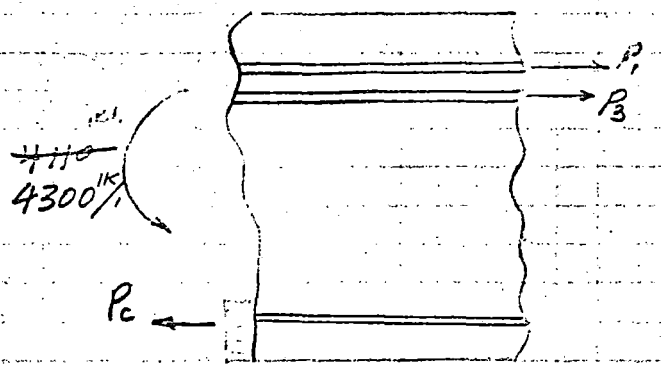
336-#18 provided $\frac{336 \times 4}{2\pi(52.5)} = 4.1^{\square''}$ O.C.

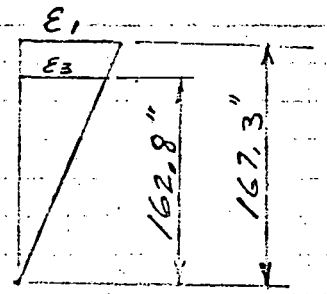
If we had 672 bars, spacing would be

$\frac{2\pi \times 52.5 \times 12}{672} = 5.9''$ o.c.

This space would decrease as we brought the bars closer to center to develope them. Therefore, go to two rows of radial bars.







Try $a = 8.25$

$\frac{8.25}{.85} = 9.7"$ N.A.

$\varepsilon_1 = .00207$

$\varepsilon_3 = \frac{162.8}{167.3} \times .00207 = .1002$, $f_s = .002 \times 29 \times 10^6 = 58\ ^K/_{in^2}$

$P_1 = 4.1 \times 60 = 246^K$

$P_c = 8.25 \times 2.97 \times 12 = 293^K$

$P_3 = 293 - 246 = 47^K$

Cap. of section $= 246 \times \frac{61}{12} + 47 \times \frac{76.5}{12} + \frac{293 \times 92}{12}$

$= 1660 + \frac{2700}{300} + 2246 = 4496 > 4206 \approx 4300$

$A_{s_3} = \frac{47}{58} = .81\ in^2/_1$

Case II: Design $M_u = \frac{2907}{.90} = \frac{3230}{3040}\ ^{K'}/_1$

Design $Q = \frac{92}{.95} = 97\ ^K/_1$

Try $a = 4"$ $P_c = 143^K$

$P_2 = 4.1 \times 1.15 = 4.7^K$

$P_1 = 4.1 \times 60 = 246^K$

$P_1 + P_2 + P_3 > 143^K + 97^K$

$\therefore$ Try $a = 6.75"$; $\frac{6.75}{.85} = 8" \therefore P_2 = 0$

$\varepsilon_3 = \frac{164.5}{169} \times .00207 = .00202$; $f_3 = .00202 \times 29 \times 10^6 = 58.5\ ^K/_{in^2}$

$P_3 = 58.5 \times .81 = 47.5^K$

$P_c = 6.75 \times 2.97 \times 12 = 240^K$

$240 + 97 = 337 > 246 + 47.5 = 293.5$

Try $a = 5.75"$; N.A. $= \frac{5.75}{.85} = 6.75"$

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FILE CHECKED BY P.C

ESTIMATE DATE

Neglect P_2

$\varepsilon_3 = \frac{165.75}{179.25} \times .00207 = .00202$

$P_3 = .00202 \times .81 \times 29 \times 10^6 = 47.5^K$

$P_1 + P_3 = 246 + 48 = 294^K$

$P_c + 97 = 5.75 \times 2.97 \times 12 + 97 = 303^K$ CLOSE ENOUGH

Cap. of Sect. $= 246 + \frac{81}{12} + 47.5 \times \frac{76.5}{12} + 206 \times \frac{93}{12}$

$= 1660 + 302 + 1600 > 3230^{(K)}$

$C = .6; R = 45'$

$M_r = -4896$; $Q = 0$

Design $M_r = \frac{-4896}{.90} = \frac{5440}{-5200}$

2 rows of radial steel req'd

$P_1 = \frac{336 \times 4^{\square''}}{2\pi(45)} \times 60^{K/\square''} = 285^K$

Trg $a = 9.5"$; $\frac{9.5}{.85} = 11.2" = N.A.$

$f_3 = \frac{161.3}{165.8} \times .00207 \times 29 \times 10^3 = 58.5^{K/\square''}$

$P_c = 9.5 \times 2.97 \times 12 = 338^K$

$P_3 = 338 - 285 = 53^K$

Cap of section $= 285 + \frac{81}{12} + 53 + \frac{76.5}{12} + 338 \times \frac{91.25}{12}$

$= 1930 + 340 + 2580 = 4850$

Trg $a = 10.5"$, $\frac{10.5}{.85} = 12.3"$; $f_3 = 58.5^{K/\square''}$

$P_c = 10.5 \times 2.97 \times 12 = 374^K$

$P_3 = 374 - 285 = 89^K$

Cap. of section $= 285 \times \frac{81}{12} + 89 \times \frac{76.5}{12} + 374 \times \frac{90.75}{12}$

$= 1930 + 590 + 2820 = 5330 > \frac{5200}{5440}$

$A_{s_3} = \frac{89}{58.5} = 1.52^{\square''}/1$

(SEE P.188-a)

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO S.N.S.S. | PREPARED BY Y.C.

SUBJECT | DATE

COMPUTATION SHEET

FILE | CHECKED BY

ESTIMATE | DATE

FOR $f=.6$, $R=45'$

TRY $a=11.0"$ $\quad 11.0/.85=12.9"$ $\quad f_3=58.5$ K/□"

$P_c = 11.0 \times 2.97 \times 12 = 392^K$

$P_3 = 392 - P_1 = 392 - 285 = 107^K$

$$\text{Cap. of section} = 285 \times \frac{81}{12} + 107 \times \frac{76.5}{12} + 392 \times \frac{90.25}{12}$$

$$= 1920 + 680 + 2950 = 5550 > 5440$$

$A_{S_3} = 107/58.5 = 1.83$ □"/'

FOR $f=.5$, $R=37.5'$ (See P. 189)

TRY $a=12$ $\quad f_3 = 58.5$ K/□"

$P_c = 12 \times 2.97 \times 12 = 428$

$P_3 = 428 - 342 = 86^K$

$$\text{Cap. of section} = 342 \times \frac{81}{12} + 86 \times \frac{76.5}{12} + \frac{428 \times 90.25}{12}$$

$$= 2310 + 550 + 3210 = 6070 > 6010$$

$A_{S_3} = \frac{86}{58.5} = 1.47$ □"/'

$\rho = .5$, $R = 37.5$

$M_r = -\frac{5410}{5411}$; $Q = 0$

Design $M_r = -\frac{5410}{.90} = -\frac{6010}{6011}$ IK/'

$P_1 = \frac{336 \times 4}{2\pi(37.5)} \times 60 = 342^K$

Trg $a = 10.5''$, $f_3 = 58.5^K/a''$

$P_c = 374^K$

$P_3 = 374 - 342 = 32^K$

Cap. of section $= 342 \times \frac{81}{12} + 32 \times \frac{76.5}{12} + \frac{374 \times 90.75}{12}$

$= 2310 + 204 + 2820 = 5334$

Trg $a = 11.5''$; $f_c = 58.5^K/a''$

$P_c = 11.5 \times 2.91^K \times 12 = 410^K$

$P_3 = 410 - 342 = 68^K$

Cap. $= 2310 + 68 \times \frac{76.5}{12} + \frac{410 \times 90.25}{12} = 2310 + 433 + 3080$

$= 5823 < \frac{6010}{5700}$ (SEE P.188-a)

$A_{s_3} = \frac{68}{58.5} = 1.16^{\#}/'$ needed but $1.52 \times \frac{45}{37.5} = 1.82^{\#}/'$ provid

$\rho = .4$ $R = 30$

$M_r = -\frac{5429}{5132}$, $Q = 0$

Design $M_r = -\frac{5429}{.9} = -\frac{6030}{6031}$ IK/'

Reactor Pit Mat: Assume #18S bars @ 7

$A_{s/'} = \frac{4 \times 12}{7} = 6.85^{\#}/'$

$P_1 = 6.85 \times 60 = 410^K = F_c$

$\frac{410}{2.91 \times 12} = 11.5''$; Cap of conc. $= 410 \times \frac{171}{12}$

$= 5850$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA.
SUBJECT FDN. MAT
FILE
ESTIMATE

COMPUTATION SHEET

PREPARED BY I.G.
DATE
CHECKED BY P.C.
DATE

Top Mat

$P_1 = \frac{336 \times 4}{2\pi(30)}$ $60 = 425^K$

∴ No A_{s_3} needed.

P=.3 R=22.5

$M_r = -\overset{5565}{5241}^{IK'}$, Q=0

Design $M_r = -\frac{\overset{5565}{5241}}{.9} = -\overset{6180}{5850}^{IK}$ #18s @7" Reg'd

P=.2

Design $M_r = \frac{\overset{5407}{5063}}{.9} = \overset{6010}{5650}^{IK'}$ #18s @7½" Reg'd

P=.1

Design $M_r = -\frac{\overset{4991}{4637}}{.9} = -\overset{5550}{5150}^{IK'}$ #18s @8" Reg'd

P=0

Design $M_r = -\frac{\overset{4379}{4020}}{.9} = -4500^{IK'}$ #18s @9" Reg'd.

$+M_r$ (Tension on Bot.) $\overset{4870}{}$

P=1.0 R=75'

$M_r = +645^{FK'}$, Q=0

Design $M_r = \frac{+645}{.9} = +720^{IK'}$

Checking $A_s = 1.6^{\square''}$

$\phi P = 1.6 \times 60 = 96^K = P_c$

$\frac{96}{2.97 \times 12} = 2.7''$

Capacity of section $= 96 \times \frac{182.7}{12} = 1460^K$ ✓

336-#14s ok

P=.9 R=67.5

$M_r = +1265$ Q=0

Design $M_r = \frac{1265}{.9} = \overset{1410}{+350}^K$ ∴ 336-#14s $= 1.78^{\square''}$ ok

P=.8 R=60'

$M_r = + \overset{+418}{1946}^{IK'}$ Q=0 Case I

$= + \overset{+723}{1851}^{IK'}$ Q=92$^{K'}$ Case II

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT FDN. MAT COMPUTATION SHEET DATE

FILE CHECKED BY P.C.

ESTIMATE DATE

Case I: Design M_r: $\frac{1946}{.9} = 2160$ $\quad \frac{1845}{.9} = 2020$

$P = 2 \times 60 = 120^K = P_2$

Capacity of sect. $= 120 \times \frac{182.3}{12} = 1820^K$ N.G.

Change from #5 to #8

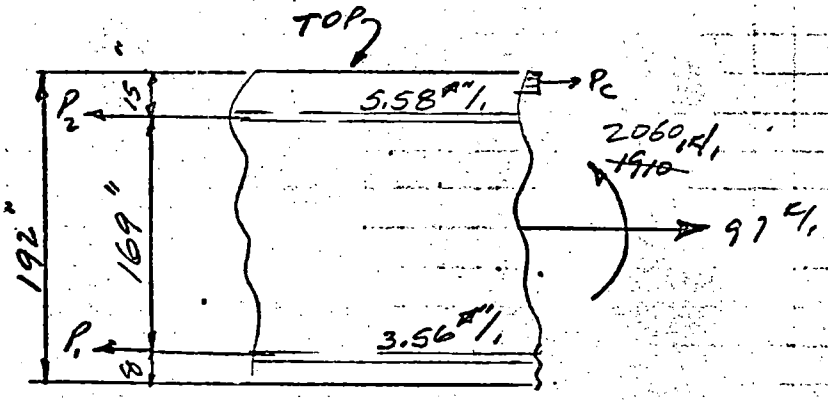
$A_s = \frac{336 \times 4}{2\pi(60)} = 3.56^{\#}/_{"}$

$\frac{3.56}{2} \times 1820 = 3250^{K}/_{'}$ O.K.

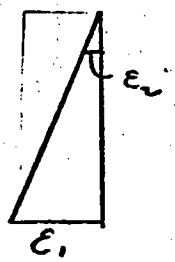
Case II:

Design M_r: $\frac{1851}{.9} = 2060^{K}/_{'}$ $\quad \frac{1723}{.9} = 1910$

Design $Q = \frac{92}{.95} = 97^{K}/_{'}$



TRY $a = 3"$, $P_c = 3 \times 2.97 \times 12 = 107^K$, $\frac{3}{.85} = 3.5"$



$\varepsilon_1 = .00207$

$\varepsilon_2 = \frac{165}{180.5} \times .00207 = .000133$

$f_2 = .000133 \times 29 \times 10^6 = 3.85^{K}/_{\#"}$

$P_2 = 3.85 \times 5.58 = 21.5^K$

$P_1 = 3.56 \times 60 = 214^K$

$214 + 21.5 = 235.5^K$

$97 + 107 = 204^K$

$a = 3.75"^c$ will balance forces $P_c = 3.75 \times 12 \times 2.97 = 13$

$P_2 = \frac{10.0}{179.6} \times .00207 \times 29 \times 10^6 \times 5.58 = 18.8^K$

$214 + 18.8 = 232.8^K$

$97 + 134 = 231^K$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY L.G.

SUBJECT FDN. MAT. COMPUTATION SHEET DATE

FILE CHECKED BY P.C

ESTIMATE DATE

Cap. of section: $214 \times \frac{66}{12} + 134 \times \frac{94}{12} - 18.6 \times \frac{81}{12}$

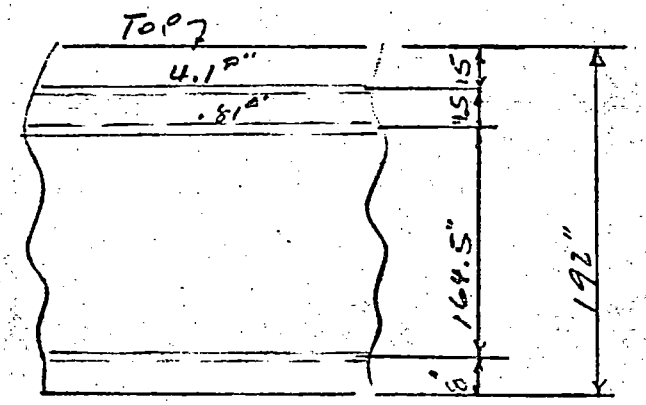
$= 1570 + 1050 - 127 \rightarrow$ ~~1570~~ 2060 −

$\phi = .7 \quad R = 52.5$

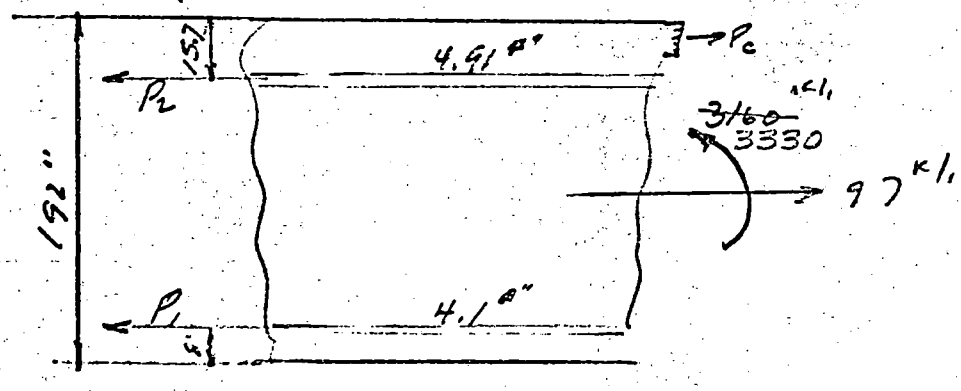
$M_r = +\frac{2824}{2995}$,$^{K'}$ $\quad Q = 92^{K'}$

Design $M_r = +\frac{2824}{.9} = \frac{2995}{3160}$ $^{K'}$

Design $Q = \frac{92}{.95} = 97^{K'}$



$$\frac{15.4 \quad 61.5}{.81 \times 19.5 + 4.1 \times 15} = 15.7"$$
$$4.91$$



Try $a = 5"$; $P_c = 5 \times 2.97 \times 12 = 178^{K}$

$\frac{5}{.85} = 5.9"$ $\quad P_1 = 4.1 \times 60 = 246^{K}$

$P_2 = \frac{9.8}{176.1} \times .00207 \times 29 \times 10^6 \times 4.91 = 16.4$

$178 + 97 = 275^{K}$

$246 + 16.4 = 262.4^{K}$

$a = 4.75"$ will work $\therefore P_c = 2.97 \times 16 \times 4.75 = 169^{K}$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO: SALEM GEN STA.
SUBJECT: FDN. MAT
FILE:
ESTIMATE:

COMPUTATION SHEET

PREPARED BY: I.G.
DATE:
CHECKED BY: P.C.
DATE:

$P_2 = 169 + 97 - 246 = 20^{K} \pm$

Capacity of sect. $= 246 \times \frac{88}{12} + 169 \times \frac{93.5}{12} - 20 \times \frac{80.3}{12}$

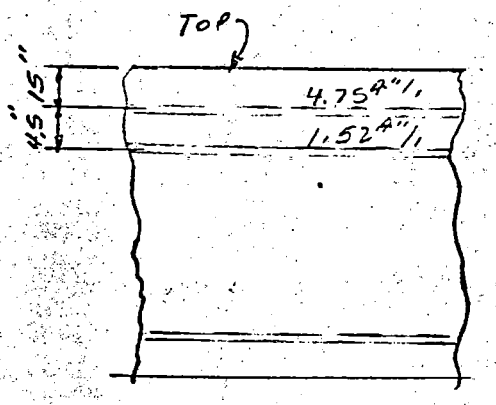
$= 1810 + 1320 - 133 = 3000 \simeq \cancel{3160}\ 3330$

$\rho = .6; R = 45'$

$M_r = +\cancel{3548}\ 3661 \qquad Q = 118^{K/'}$

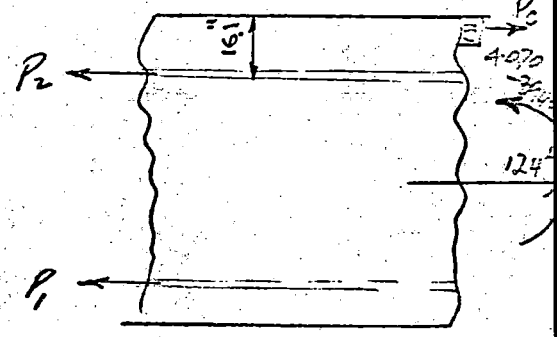
Design $M_r = \frac{3661}{.90} = \cancel{3940}\ 4070^{iK/'}$

Design $Q = \frac{118}{.95} = 124^{K/'}$



$\frac{29.6}{1.52 \times 19.5} + \frac{71.5}{4.75 \times 15} = 16.1"$

$=$



For As, Try 336-#8 @ 336-#9 $= \frac{336 \times 5}{2\pi(45)} = 5.95^{\#/'}$

Try $a = 6"$; $\frac{6}{.85} = 7"$

$P_c = 6 \times 2.97 \times 12 = 214^{K}$; $P_1 = 5.95 \times 60 = 356^{K}$

$P_2 = \frac{9.1}{177} \times .00207 \times 29 \times 10^6 \times 6.27 = 19.4^{K}$

$214 + 124 = 338^{K}$

$356 + 19.4 = 375.4^{K}$

Try $a = 7"$; $\frac{7}{.85} = 8.2"$

$P_c = 7 \times 2.97 \times 12 = 249^{K}$

$P_2 = \frac{7.9}{175.4} \times .00207 \times 29 \times 10^6 \times 6.27 = 17^{K}$

$249 + 124 = 373^{K}$

$356 + 17 = 373^{K}$ ✓

Cap of section $= 356 \times \frac{88}{12} + 249 \times \frac{92}{12} - 17 \times \frac{80}{12}$

$= 2620 + 1900 - 113 = 4407$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY L.C.

SUBJECT FDN MAT COMPUTATION SHEET DATE

FILE CHECKED BY P.C

ESTIMATE DATE

TRY A_{s_1} : 336-#8 & 336-#8 = $336 \times \frac{4.79}{2\pi(45)} = 5.7^{\#}/_{'}$

$P_1 = 5.7 \times 60 = 342^{K}$

TRY $a = 6.5"$, $P_2 = 6.5 \times 12 \times 2.51 = 232^{K}$

$c = \frac{6.5}{.85} = 7.6"$

$P_2 = \frac{8.5}{176.4} \times .00207 \times 29 \times 10^6 \times 6.27 = 18.2^{K}$

$232 + 124 = 356^{K}$

$342 + 18 = 360^{K}$ OK.

Cap. of sect. $= 342 \times \frac{85}{12} + 232 \times \frac{92.25}{12} - 18.2 \times \frac{80}{12}$

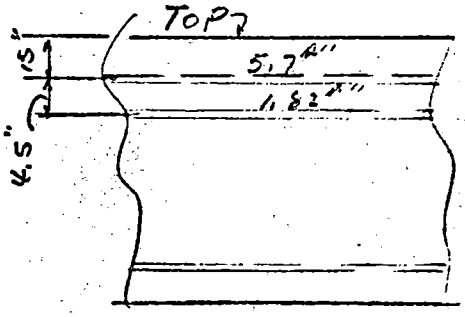
$= 2510 + 1780 - 121 = 4169 > \cancel{3940}\ 4070$

$\phi = .5 \quad R = 37.5$

$M_r = +\cancel{3975}\ 4029^{K'}/_{'}$; $Q = 118^{K}/_{'}$

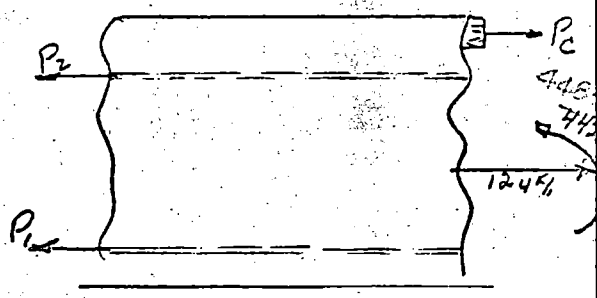
Design $M_r = \frac{\cancel{3975}\ 4029}{.90} = +\cancel{4420}\ 4480^{K}/_{'}$

Design $Q = \frac{118}{.95} = 124^{K}/_{'}$



$\frac{35.6 \quad 55.5}{1.82 \times 19.5 + 5.7 \times 15} = 7.52$

$16.1" =$



$A_{s_1} = \frac{336 \times 4.79}{2\pi(37.5)} = 6.85^{\#}$

$P_1 = 6.85 \times 60 = 412^{K}$

TRY $a = 7.5"$, $P_c = 7.5 \times 12 \times 2.97 = 268^{K}$; $\frac{7.5}{.85} = 8.8"$

$P_2 = \frac{7.3}{175.2} \times .00207 \times 29 \times 10^6 \times 7.52 = 18.9^{K}$

$268 + 124 = 392^{K}$

$412 + 19 = 431^{K}$

TRY $a = 8.75"$, $P_c = 8.75 \times 12 \times 2.97 = 311^{K}$, $\frac{8.75}{.85} = 10.2"$

$P_2 = \frac{5.9}{173.8} \times .00207 \times 29 \times 10^6 \times 7.52 = 15.4^{K}$

$412 + 15.4 = 427.4^{K}$; $311 + 124 = 435^{K}$ O.K.

Cap of Sect.

$$412 + \frac{84}{12} + 311 \times \frac{90.5}{12} - 15.4 \times \frac{80}{12}$$

$$= 3020 + 2340 - 103 = 5257 > 4480$$

$P = .4 \quad R = 30$

$M_r = \frac{4086}{4025}$ K'/'; $Q = 118^{K}/_{'}$

Design $M_r = \frac{4086}{.90} = 4540$ K'/' $\quad$ ~~4480~~

Design $Q = \frac{118}{.95} = 124^{K}/_{'}$

Top Mat

A_s Provided $= \frac{336 \times 4}{2\pi(30)} = 7.1^{\square''}$

This is adequate

Reactor P.T Mat

Trg $A_s = 6^{\square''} = \#18$ s @ 8"

$P_1 = 6 \times 60 = 360^{K}$

Trg $a = 7''$, $P_c = 7 \times 12 \times 2.97 = 250^{K}$, $N.A = \frac{7}{.85} = 8.3''$

$P_2 = \frac{6.7}{1254} \times .00207 \times 29 \times 10^{6} \times 6^{\square''} = 13^{K}$

$250^{K} + 124^{K} = 374^{K}$

$P_1 + P_2 = 360 + 13 = 373^{K}$ —

Cap. of sect. $= 360 \times \frac{88}{12} + \frac{250 \times 92.5}{12} - \frac{13 \times 81}{12}$

$= 2640 + 1930 - 88 = 4482$ K'/' —

$P = .3 \; P = .2, \; P = .1, \; P = 0$

By comparison #18 s @ 8" more than adequate

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA.
SUBJECT FDN. MAT
FILE
ESTIMATE

COMPUTATION SHEET

PREPARED BY I.G.
DATE
CHECKED BY P.C.
DATE

As REQ'D FOR $-M_f$ (Tension On Top)

NOTE: AXIAL FORCE FOR A SOLID MAT = σ_r (RADIAL) and σ_t (TANGENTIAL)

$\sigma_r = \sigma_t = p_o$ where p_o = uniform external pressure

$$\sigma_r = \frac{p_o b^2}{b^2 - a^2}\left(1 - \frac{a^2}{r^2}\right)$$

Singer - "Strength of Materials" Pg. 508

$$\sigma_t = \frac{p_o b^2}{b^2 - a^2}\left(1 + \frac{a^2}{r^2}\right)$$

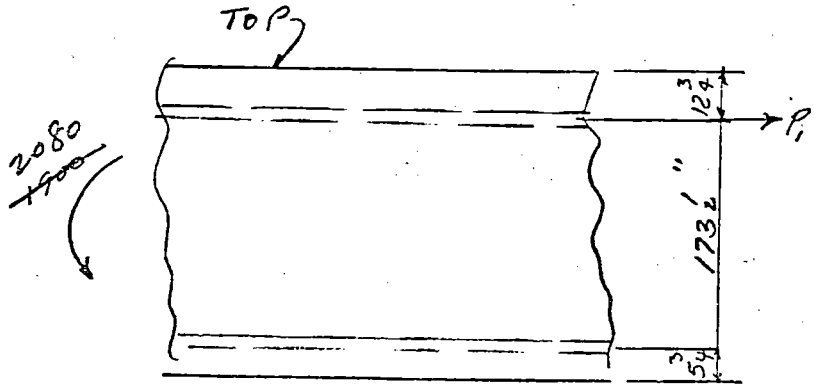
Where: r = radius at any point
a = radius of inner hole
b = radius of outside

If $a = 0$: $\sigma_r = \sigma_t = p_o$

$\phi = 1.0$

$M_t = -1712$; $Q = 0$

Design M_t: $\frac{-1712}{.90} = \frac{1875}{} = -1900$ ~~-2080~~ IK/'



TRY A_{s_1} = #14S @ 12" = 2.25 $^{\#}/_{'}$

$P_1 = 60 \times 2.25 = 135^{K}$

$\frac{135}{2.97^{K}/_{\#} \times 12} = 3.78" = a$

Cap. of sect.: $135 \times \frac{177.75}{12} = 2000^{IK} > 1900 \approx 2080$

$\phi = .9$

$M_t = -2638$; $Q = 0$

Design M_t: $\frac{-2638}{.90} = \frac{2843}{} = -2920$ ~~-3160~~ IK/'

Try $A_{s_1} = 3.12^{\#}/_{'}$ = avg of #14S @ 12" & #18S @ 12"

$P_1 = 3.12 \times 60 = 187^{K}$

$\frac{187}{2.97 \times 12} = 5.25" = a$

Cap. of Sect. $= 187 \times \frac{176.6}{12} = 2740^{IK}$, N.G. Use #18S @ 12

REFER TO SALEM GEN. STA. PREPARED BY I.G.
SUBJECT FDN. MAT COMPUTATION SHEET DATE
FILE CHECKED BY P.C.
ESTIMATE DATE

$\rho = .8$

$M_+ = -\frac{3658}{3422}$; $Q = 0$

Design $M_+ = -\frac{3658}{.9} = -\frac{4060}{3800}$ IK/'

Try #8's @ 12" = 4 #"/'

$P_1 = 4 \times 60 = 240^K$

$\frac{240}{2.97 \times 12} = 6.75" = a$

Cap. of Sect. $= .240 \times \frac{175.9}{12} = -3520$ IK/' N.G.

Try 2-Rows of #8's @12" = 4.5 #"/'

$P_1 = 4.5 \times 60 = 270^K$

$\frac{270}{2.97 \times 12} = 7.5" = a$

Cap. of Sect $= 270 \times \frac{173.25}{12} = -3900^K > \frac{3800}{\approx 4060}$

$\rho = .7$

$M_+ = -\frac{4276}{4010}$; $Q = 0$

Design $M_+ = -\frac{4276}{.90} = -\frac{4750}{4470}$ IK/'

Try 2 Rows of 1-#8's & 1-#11 @12" = 5.56 #"

$P_1 = 5.56 \times 60 = 333^K$, $\frac{333}{2.97 \times 12} = 9.4" = a$

Cap. of Sect. $= 333 \times \frac{172.3}{12} = 4780$ IK/' $> \frac{4470}{4750}$

$\rho = .6$

$M_+ = -\frac{4663}{4375}$; $Q = 0$

Design $M_+ = -\frac{4663}{.90} = -\frac{5180}{4850}$ IK/'

Try #8's @ 9" = 5.35 #"

$P_1 = 5.35 \times 60 = 322^K$; $\frac{322}{2.97 \times 12} = 9" = a$

Cap. of sect. $= 322 \times \frac{174.75}{12} = 4700$ IK/'

Use #8's & #7 @ 9" = 6.15 #"

$\rho = .5$

$M_+ = -\frac{4872}{4560}$, $Q = 0$

Design $M_+ = -\frac{4872}{.90} = -\frac{5070}{5410}$ IK/'

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT FDN. MAT. COMPUTATION SHEET DATE

FILE CHECKED BY P.C.

ESTIMATE DATE

Try #18's @ 9" ¢ #7 @ 5" = 6.15 #"/'

$P_1 = 6.15 \times 60 = 369^{K/'}$; $\frac{369}{2.97 \times 12} = 10.4" = a$

Cap. of sect. $= 369 \times \frac{1.73^{\pm}}{12} = 5320^{'K/'} > \cancel{5070} \approx 5410$

$P = .4$

$M_+ = -\frac{4988}{\cancel{4657}}$, $Q = 0$

Design $M_+ = \frac{4988}{\cancel{4659}} = \cancel{5180}^{'K/'}$ TOP MAT USE #18's @ 7 @ 5

$\frac{.90}{5540}$

Reactor Pit Mat

#18's @ 8" O.K.

$P = .3$

$M_+ = -\frac{\cancel{4644}}{4982}$ $Q = 0$

Design $M_+ = \frac{4982}{\cancel{4644}} = -\frac{5540}{\cancel{5140}}$

$.9$

TOP MAT

Depth of section is some 40' developed by vertical reinforcement thru' horizontal construction joints.

A_s req'd: $\frac{M}{60d} = \frac{\cancel{5190}\ 5540}{60 \times 38.5'^{\pm}} = \cancel{2.22}\ 2.40\ ^{\#"/'}$

Use #14's @ 12"

Reactor Pit Mat

Try #18's @ 8" = 6 #"/'

$P_1 = 6 \times 60 = 360^{K/'}$; $\frac{360}{2.97 \times 12} = 10" = a$

Cap. of sect. $= 360 \times \frac{174.25}{12} = 5230 > \cancel{5140} \approx 5540$

$P = .2$

Design $M_+ = \frac{4885}{\cancel{4525}} = \frac{}{.9} = \cancel{5030}^{'K/'} = 5430$ ∴ #18 @ 8" O.C.

$P = .1$

Design $M_+ = \frac{4668}{\cancel{4371}}$: $\frac{5190^{'K/'}}{\cancel{4800}}$

Try #18's @ $8\frac{1}{2}$" = 5.65 #"

Cap. of sect: $5.65 \times 60 \times 14.5'^{\pm} = 4920 > \cancel{4800}$ ≈5190

$P = 0$

Design $M_+ = \frac{4379}{\cancel{4020}/.9} = \frac{}{4870} = \cancel{4470}^{'K}$; ∴ #18's @ 9" O.K

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO SALEM GEN. STA. PREPARED BY I.G.

SUBJECT FDN. MAT COMPUTATION SHEET DATE

FILE CHECKED BY P.C.

ESTIMATE DATE

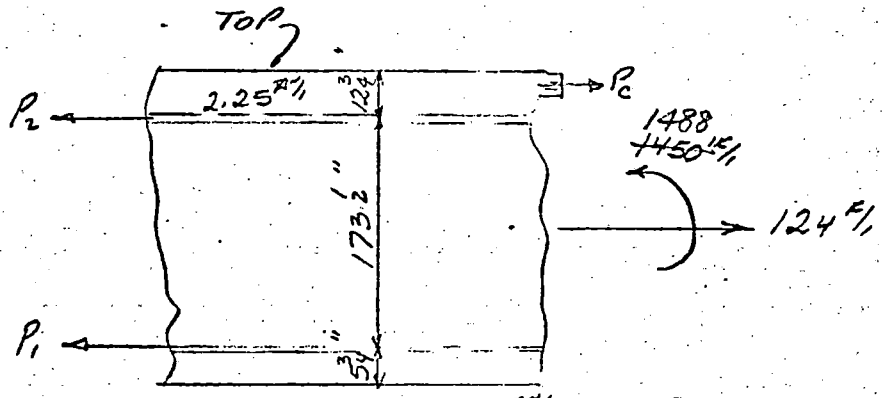
As REQ'D FOR +M (Tension on Bot.)

P=1.0

$M_+ = \overset{1339}{+306}$ K', Q = 118 K'

Design $M_+ = \frac{\overset{1339}{+306}}{.9} = \overset{1488}{+450}$ K'

Design $Q = \frac{118}{.95} = 124$ K'



Try $As_1 = 2.25 A''$; $P_1 = 2.25 \times 60 = 135$ K'

Try a = 3" ; $P_c = 12 \times 3 \times 2.97 = 107$ K ; $\frac{3}{.85} = 3.5$"

$P_2 = \frac{9.25}{182.75} \times .00207 \times 29 \times 10^6 \times 2.25 A'' = 6.9$ K

$P_1 + P_2 = 135 + 7 = 142$ K

$P_c + 124 = 107 + 124 = 231$ K N.G.

Try a = 1.5" ; $P_c = 12 \times 1.5 \times 2.97 = 53.5$ K TOO HIGH

Try a = .5" ; $P_c = 12 \times .5 \times 2.97 = 18$ K

$P_2 = \frac{11.75}{185.25} \times .00207 \times 29 \times 10^6 \times 2.25 = 8.5$ K

$P_1 + P_2 = 135 + 8.5 = 143.5$ K

$P_c + 124 = 18 + 124 = 142.0$ K ✓

Cap. of Sect. $= 18 \times \frac{96}{12} + 135 \times \frac{90.25}{12} - 8.5 \times \frac{83.25}{12}$

$= 143 + 1020 - 59 = 1104 < \overset{1488}{1450}$ N.G.

Try As_1 = #14S @ 12" & #7 @ 12" = 2.85 A", 1488

Try a = 1" ; $P_c = 1 \times 12 \times 2.97 = 35.6$ K

$P_2 = 8.5$ K

$P_1 = 2.85 \times 60 = 171$ K

$P_1 + P_2 = 179.5$ K

$P_c + 124 = 35.6 + 124 = 159.6$ K O.K.

a = 1.5" O.K. Cap of Sect. $= 54 \frac{K}{12} + 171 \times \frac{90.25}{12} - 8.5 \times \frac{83.25}{12}$

Cap. of Sect. = 433 + 1280 − 59 = 1654 K/' > ~~1750~~ 1488 K/' ✓

$\rho = .9$

$M_u = +\frac{2067}{\cancel{2025}}$ K/', $Q = 118$ K/'

Design $M_u = \frac{2067}{.90} = \frac{2290}{\cancel{2250}}$ K/'

Design $Q = 124$ K/' $A'_s = 4$ #" ✓

Try $A_{s_1} = 4$ #"/' = #18's @ 12"

$P_1 = 4 \times 60 = 240$ K

Try $a = 4$", $P_c = 4 \times 12 \times 2.97 = 142$ K, $\frac{4}{.85} = 4.7$"

$P_2 = \frac{8}{181.50} \times .00207 \times 29 \times 10^6 \times 4 = 10.6$ K

$P_1 + P_2 = 240 + 10.6 = 250.6$ K

$P_c + 124 = 142 + 124 = 266$ K

Try $a = 3.5$", $P_c = 3.5 \times 12 \times 2.97 = 125$ K;

$P_2 = 10.3$ K

$P_c + 124 = 125 + 124 = 249$ K OK

CAP. OF SECT $= 125 \times \frac{94}{12} + 240 \times \frac{90.25}{12} - 10.6 \frac{83.25}{12}$

$= 975 + 1810 - 71 = 2714$ TOO HIGH

Try #14's ¢ #10 @ 12" = 3.52 #"/'

$P_1 = 3.52 \times 60 = 210$ K

Try $a = 2.75$", $P_c = 2.75 \times 12 \times 2.97 = 98$ K

$P_2 = \frac{9.50}{183} \times .00207 \times 29 \times 10^6 \times 4 = 12$ K

$P_1 + P_2 = 222$ K

$P_c + 124 = 222$ K

Cap. of Sect. $= 210 \times \frac{90.25}{12} + 98 \times \frac{94.5}{12} - 12 \times \frac{83.25}{12}$

$= 1580 + 770 - 83 = 2267 > \cancel{2210} \approx 2290$

$\rho = .8$

$M_u = \cancel{2663}^{2701}$ K/', $Q = 118$ K/'

Design $M_u = \frac{\cancel{2663}^{2701}}{.90} = \frac{\cancel{2960}}{3000}$ K/', Design $Q = 124$ K/'

Try $A_{s_1} = 18$'s @ 12" ¢ # 7 @ 12" = 4.6 #"/'

$P_1 = 4.6 \times 60 = 276$ K

Try $a = 4.5$"/', $A'_s = 4.5$ #"/', $P_c = 4.5 \times 12 \times 2.97 = 160$ K; $\frac{4.5}{.85} = 5.3$"

$P_2 = \frac{7.5}{1.81} \times .00207 \times 29 \times 10^6 \times 4.5 = 11$ K

$P_1 + P_2 = 276 + 11 = 287$ K, $P_c + 124$ K $= 160 + 124 = 284$ K O.K

Cap. of sect. $= 276 \times \frac{90.25}{12} + 160 \times \frac{93.75}{12} - 11 \times \frac{83.25}{12}$

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SUBJECT FDN. MAT COMPUTATION SHEET DATE
FILE CHECKED BY P.C.
ESTIMATE DATE

Cap. of Sect. = 2080 + 1250 − 76 = 3254 > ~~2960~~ 3000 ✓

$\rho = .7$

$M_u = 1306\text{g}^{3122}$ $^{K'}$, $Q = 118^{K'}$

Design $M_u = \frac{3066}{.9} = \frac{3122}{.9} = \frac{3470}{3420}$ $^{K'}$; Design $Q = 124^{K'}$

Try 1-#18S & 1-# 8 @ 12" = 4.79 $^{\#"}/'$

$P_1 = 4.79 \times 60 = 288^K$; $A'_s = 5.56^{\#"}$

Try a = 5"; $P_c = 2.97 \times 12 \times 5 = 178^K$; $\frac{5}{.85} = 5.9"$

$P_2 = \frac{6.85}{180.35} \times .00207 \times 29 \times 10^6 \times 5.56 = 12.3^K$

$P_1 + P_2 = 288 + 12 = 300^K$

$P_c + 124 = 178 + 124 = 302^K$ ✓

Cap. of sect. $= 288 \times \frac{90.25}{12} + 178 \times \frac{93.5}{12} - 12.3 \times \frac{83.25}{12}$

$= 2160 + 1380 - 85 = 3455 > \sim\!\!3420$ ✓
≈ 3470

$\rho = .6$

$M_u = \frac{3441}{3381}$ $^{K'}$, $Q = 118^{K'}$

$M_u = \frac{3441}{.9} = \frac{3760}{3820}$ $^{K'}$, $Q = \frac{118}{.195} = 124^{K'}$

$A'_s = 6.15^{\#"}$.

Try A_{s_1} = #18S @ 9": $5.35^{\#"}/'$

$P_1 = 5.35 \times 60 = 320^K$

Try a = 5.75", $P_c = 5.75 \times 12 \times 2.97 = 205^K$; $\frac{5.75}{.85} = 6.8$

$P_2 = \frac{6}{179.5} \times .00207 \times 29 \times 10^6 \times 6.15 = 12^K$

$P_1 + P_2 = 332^K$, $P_c + 124 = 205 + 124 = 329^K$ ok

Use $P_c = 208^K$

Cap. of Sect. $= 320 \times \frac{90.25}{12} + 204 \times \frac{93}{12} - 12 \times \frac{83.25}{12}$

$= 2400 + 1620 - 83 = 3937 > \frac{3760}{3820}$ ✓

$\rho = .5$

$M_u = \frac{3474}{3543}$ $^{K'}$, $Q = 118^{K'}$

Design $M_u = \frac{3543}{.90} = \frac{3937}{3960}$ $^{K'}$, Design $Q = 124^{K'}$

∴ #18S @ 9" O.K.

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ESTIMATE DATE

C = .4

$M_u = +\cancel{3402}^{3470}$ K', Q = 118 K'

Design $M_u = \frac{+\cancel{3402}^{3470}}{.90} = +\cancel{3780}^{3860}$ K', Design Q = 124 K'

TOP MAT

#18 S @ 9" O.K

REACTOR PIT MAT

#18 S @ 9" O.K.

C = .3

$M_u = +\cancel{3302}^{3370}$ K', Q = 118 K'

Design $M_u = \frac{+\cancel{3302}^{3370}}{.90} = \cancel{3670}^{3740}$ K', Design Q = 124 K'

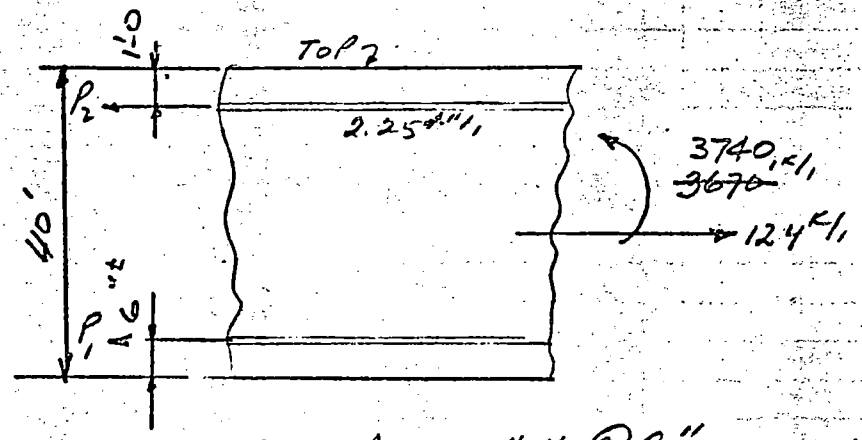
Reactor Pit MAT

16' thick area

#18 S @ 9" more than adequate

40' thick area

$A_s' = 2.25$ #"/'



Try A_{s_1} = #11 @ 9" = 2.1 #"/'

$P_1 = 2.1 \times 60 = 126^K$

Try a = .5", $P_c = .5 + 2.97 \times 12 = 18^K$

$P_2 = \frac{1.0}{39.5} \times .00207 \times 29 \times 10^6 \times 2.25^{\#"} = 3.5^K$

$a \approx 0$ O.K.

Cap. of Sect. = 126 × 19.5' = 2450 K' N-6.

Try #14 S @ 9" = 3 #"

$P_1 = 3 \times 60 = 180^K$ Try a = 1.75", $P_c = 1.75 \times 12 \times 2.97 = 6$

$P_2 = 4^K$

$P_1 + P_2 = 184^K$, $P_c + 124 = 186^K$ O.K.

Cap. of Sect. = 180^K × 19.5 + 62 × 20' − 4 × 15' = 3500 + 1240 − 76

= 4664 K'

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ESTIMATE DATE

$\rho = .2$

$M_u = 3292^{IK'}$, $Q = 143^{K'}$

Design $M_u = \frac{3292}{.90} = 3640^{IK'}$

Design $Q = \frac{143}{.95} = 151^{K'}$

Reactor Pit Mat

16' Thick area

Assume A's: #18's @ 8" = 6"²/'

Try $A_s = 6"^2/'$

$P_1 = 6 \times 60 = 360^K$

Try $a = 6.25"$, $\frac{6.25}{.85} = 7.3"$, $P_c = 6.25 \times 2.97 \times 12 = 223^K$

$P_2 = \frac{5.5}{17.9} \times .00207 \times 29 \times 10^6 \times 6 = 11^K$

$P_1 + P_2 = 371^K$

$P_c + 151 = 223 + 151 = 374^K$ O.K

Cap. of Sect. $= 360 \times \frac{90.25}{12} + 223 \times \frac{93}{12} - 11 \times \frac{83.25}{12}$

$= 2720 + 1730 - 76 = 4374^{IK'} > 3640^{IK'}$

#18's @ 9" would be O.K.

40' Thick Mat

By inspection #14's @ 9" O.K.

$\rho = .1$

$M_u = 3384$; $Q = 143^{K'}$

Design $M_u = \frac{3384}{.9} = 3740^{IK'}$

Design $Q = 151^{K'}$

16' Mat

#18's @ 9" O.K

40' MAT

#14's @ 9" O.K.

$\rho = 0$

$M_u = 3415^{IK'}$; $Q = 143^{K'}$

Design $M_u = \frac{3415}{.9} = 3790^{IK'}$; Design $Q = 151^{K'}$

#18's @ 9" O.K

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FILE FDN. MAT

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DATE 6-25-68

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DATE

WEB REINFORCEMENT IN MAT

Since the compressive - stress - area in concrete is relatively small, it is advisable that all shear be carried by reinforcing steel

try #9 Stirrup $A_v = 1.0" \times 2 \text{ legs} = 2.0"$ per stirrup

$\phi = .85$ $f_y = 60.^{k}/_{\square"}$ $d = 178"$ $\frac{1}{2}d = 89"$

S_c — Spcg. along Ring (ft.)

S_r — Spcg. along radial direction (ft.)

$$S_c \text{ req'd.} = \frac{A_v \phi f_y d}{12 S_r V_u}$$

$$= \frac{2 \times 0.85 \times 60 \times 178}{12 S_r V_u} = \frac{1515'}{S_r V_u}$$

P		0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	℄ MAT
V_u	k/.	~~339~~ 341	278	226	157	180	236	~~134~~ 142	~~140~~ 142	132	114
S_r given	ft.	3.0	4.0	4.0	4.0	3.75	3.75	3.5	3.5	3.5	3.5
S_c req'd	ft.	1.49	1.37	1.69	2.41	2.24	1.71	3.11	3.10	3.29	3.79

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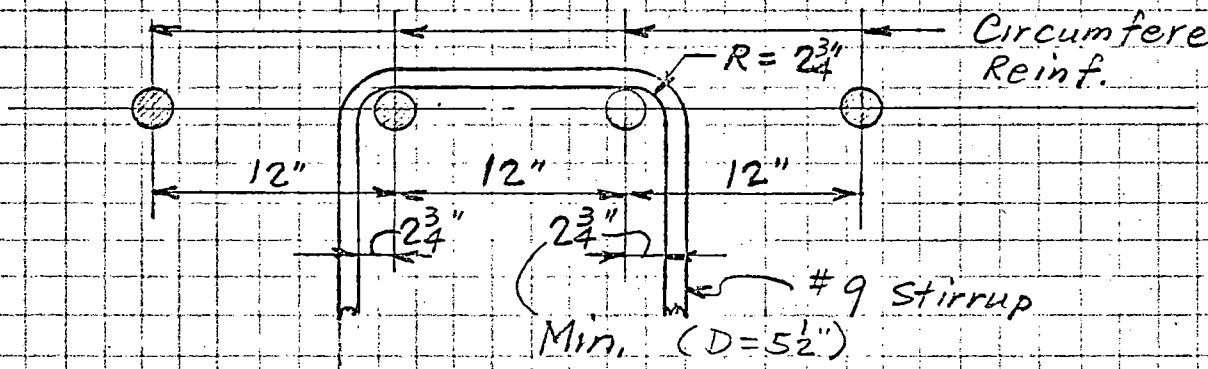

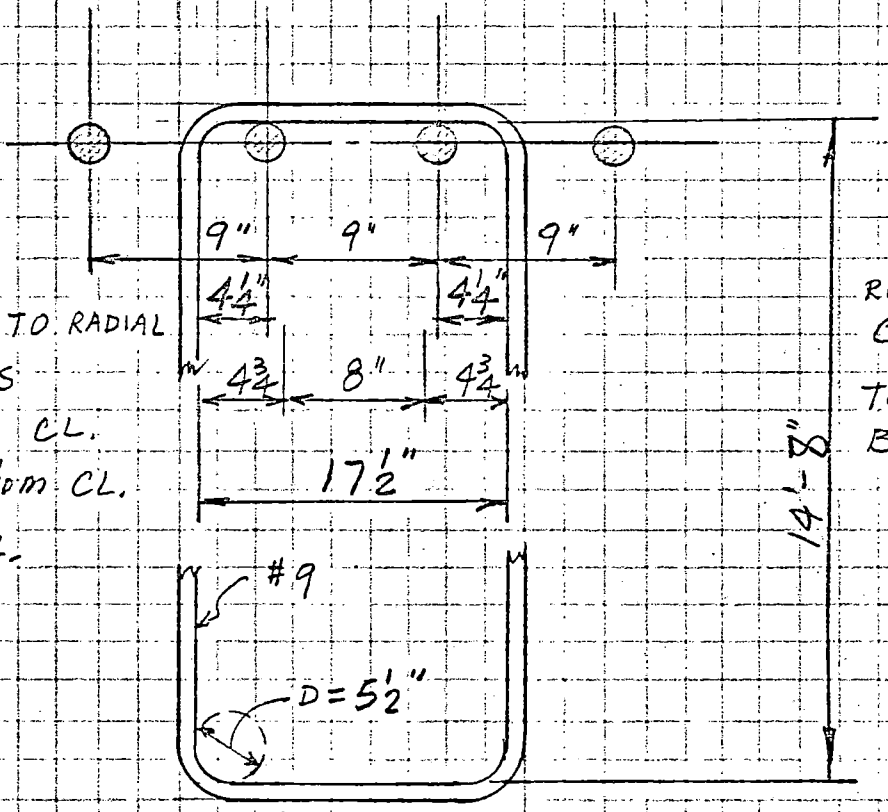

TOP MAT

1'-1 3/4"	CL. TO RADIAL
2 1/4"	#18S
11 1/2"	TOP CL.
4 1/2	Bottom CL.
16"	Σ CL.
16'-0"	
14'-8"	

LOWER MAT

ROUGH CONC.	6"
CL.	5 1/2"
TOP CL.	11 1/2"
BOT. CL.	4 1/2
Σ CL.	16"
	16'-0"
	14'-8"

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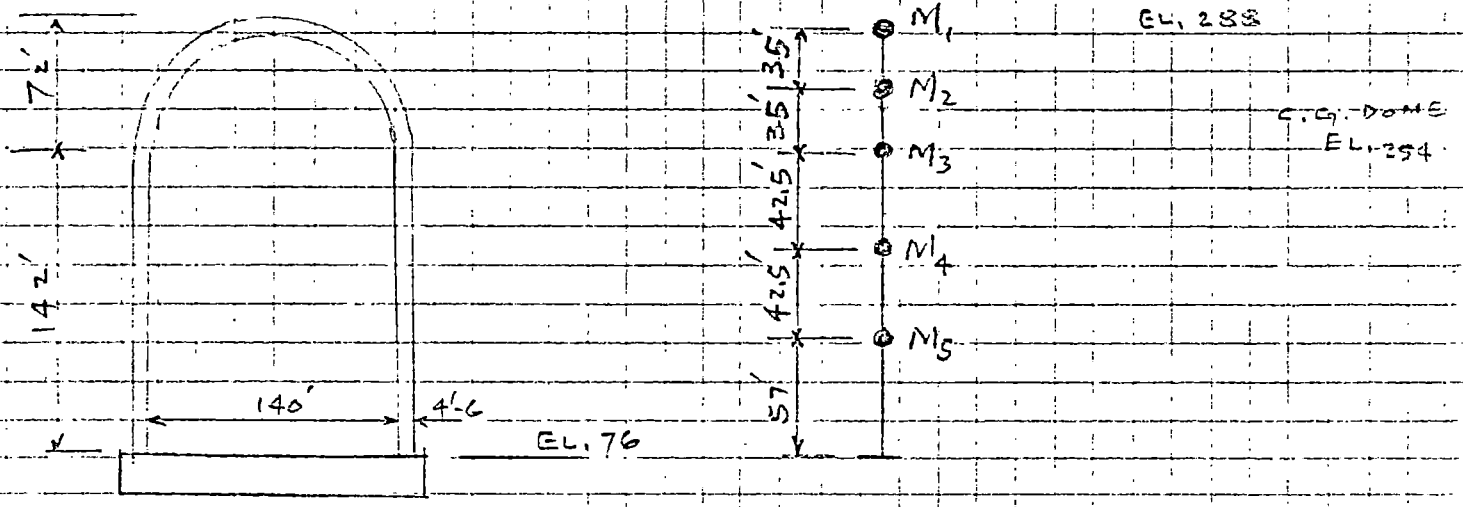
SEISMIC ANALYSIS

RIGID BASE



$W_1 = 1400^K + 2900 = 4300^K$

$M_1 = 13+ \ K\,sec^2/FT$

$W_2 = (3920 - 2900) + 3806 + 3235 + \frac{1}{4} \times 3463 = 8827^K$

$M_2 = 278$

$W_3 = \frac{3}{4} \times 3463^K + 3966^K + 1146^K = 11{,}009^K$

$M_3 = 353$

$W_4 = 4446 \times 3 = 13{,}338^K$

$M_4 = 413$

$W_5 = 4446 \times 3.5 = 15{,}600^K$

$M_5 = 484$

$W_6 = 4446 \times 2 = 8{,}892^K$

$M_6 = 276$

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FILE CONTAINMENT
ESTIMATE

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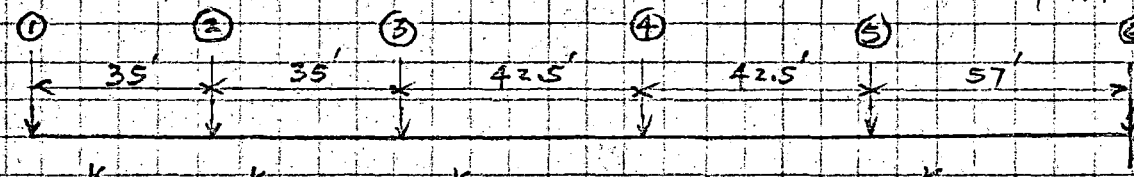
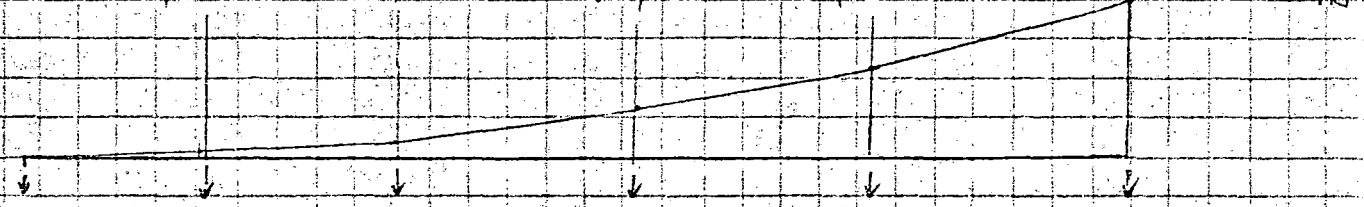
$E = 3.4 \times 10^6$ #/IN²
$G = 1.4 \times 10^6$ #/IN²



BM. WT.	4300 K	8927 K	11,009 K	13,338 K	15,600 K	8892 K
V	4300 K	13,227 K	24,236 K	37,574 K	53,174 K	
AREA	228000 IN²	247,000 IN²	310,000 IN²	310,000	310,000	315,000 IN²
AV. A		237500	288500	310,000	310,000	312,500
INCRE. OF SHEAR $\Delta_V = \frac{2VL}{AG}$		.0099"	.0322"	.0569"	.088"	0.167"
SHEAR Δ	.354"	.3441"	.3119"	.255"	0.167"	0
I	5.72×10^{10}	6.8×10^{10}	11.9×10^{10}	11.9×10^{10}	11.9×10^{10}	12.0×10^{10} IN⁴
M	0	-1.18×10^9 IN-lb	7.34×10^9 IN-lb	19.7×10^9	38.9×10^9	75.1×10^9 IN-lb
M/EI	0	$.78 \times 10^{-8}$	1.81×10^{-8}	4.87×10^{-8}	9.6×10^{-8}	18.4×10^{-8} 1/IN



Panel loads	$.55 \times 10^{-6}$	3.48×10^{-6}	10.33×10^{-6}	26.28×10^{-6}	63.16×10^{-6}	52.74×10^{-6}
CONJ. BM V	155.99×10^{-6}	152.51×10^{-6}	142.18×10^{-6}	115.9×10^{-6}	52.74×10^{-6}	
CONJ. BM MOMENT $= \Delta_M$	.2968"	.2315"	.1675"	.095"	.036"	0
$\Delta_V + \Delta_M$	.6518"	.5791"	.4784"	.35"	.203"	
ϕ	3.21	2.85	2.35	1.72	1.0	

M 11.15 23.1 28.5 34.6 40.5 23.0

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PANEL LOADS @ CONJ. BM.

at ①

$.78\times10^{-8}\times35'\times12''\times\frac{1}{2}\times\frac{1}{3}=.55\times10^{-6}$

at ②

$.78\times10^{-8}\times35'\times12''\times\frac{1}{2}\times\frac{2}{3}=1.1\times10^{-6}$

$.78\times10^{-8}\times35'\times12''\times\frac{1}{2}=1.65\times10^{-6}$

$1.03\times10^{-8}\times35'\times12''\times\frac{1}{2}\times\frac{1}{3}=.73\times10^{-6}$

3.48×10^{-6}

at ③

1.65×10^{-6}

$.73\times10^{-6}\times2=1.46\times10^{-6}$

$(4.87-1.81)\times10^{-8}\times42.5\times12\times\frac{1}{2}\times\frac{1}{3}=2.6\times10^{-6}$

$1.81\times10^{-8}\times42.5\times12\times\frac{1}{2}=4.62\times10^{-6}$

10.33×10^{-6}

at ④

4.62×10^{-6}

$2.6\times10^{-6}\times2=5.2\times10^{-6}$

$(9.6-4.87)\times10^{-8}\times42.5\times12\times\frac{1}{2}\times\frac{1}{3}=4.02\times10^{-6}$

$4.87\times10^{-8}\times42.5\times12\times\frac{1}{2}=12.4\times10^{-6}$

26.28×10^{-6}

at ⑤

12.4×10^{-6}

$4.02\times10^{-6}\times2=8.04\times10^{-6}$

$(18.4-9.6)\times10^{-8}\times57\times12\times\frac{1}{2}\times\frac{1}{3}=10.02\times10^{-6}$

$9.6\times10^{-8}\times57\times12\times\frac{1}{2}=32.7\times10^{-6}$

63.16×10^{-6}

at ⑥

32.7×10^{-6}

$10.02\times10^{-6}\times2=20.04\times10^{-6}$

52.74×10^{-6}

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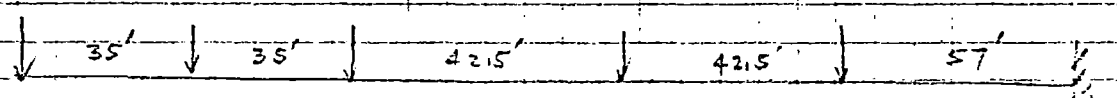
MODIFIED RAYLEIGH METHOD FOR FUNDAMENTAL MODE :

MASS POINT	ASSUMED SHAPE ϕ_r'	$F_{r_i} = M_r \phi_r'$	COMPUTED Δ	COMPUTED SHAPE ϕ_r''	$F_{r_i} \phi_r''$	$M_r(\phi_r'')^2$
1	3.21	$\frac{4300}{386}$ K sec²/IN × 3.21 = 35.8	.00397	3.71	133	154
2	2.85	8927/g × 2.85 = 65.7	.00346	3.25	213	245
3	2.35	11047/g × 2.35 = 67.2	.00284	2.67	180	203
4	1.72	13328/g × 1.72 = 59.4	.001975	1.85	110	118
5	1.0	15600/g = 40.3	.001069	1.00	-40	40
					676	760



F_{r_i}	35.8	65.7	67.2	59.4	40.3	
V	35.8	101.5	168.7	228.1	268.4	
INCRE. OF SHEAR $\Delta = \frac{2VL}{AG}$	.00009	.000213	.000395	.000535	.00085	
SHEAR Δ	.00209	.00200	.00179	.001385	.00085	
M	0	1.5×10^{7}	5.77×10^{7}	14.35×10^{7}	26×10^{7}	44.4×10^{7}
M/EI		$.65 \times 10^{-10}$	1.42×10^{-10}	3.55×10^{-10}	6.4×10^{-10}	10.9×10^{-10}
PANEL LOADS (SEE NEXT PG.)	$.454 \times 10^{-8}$	2.813×10^{-8}	7.81×10^{-8}	17.3×10^{-8}	40.84×10^{-8}	32×10^{-8}
CONJ BM V		100.82×10^{-8}	98.01×10^{-8}	90.14×10^{-8}	72.84×10^{-8}	32×10^{-8}
MOMENT Δ	.00188	.00146	.00105	.00059	.000219	
$\Delta_V + \Delta_M$	.00397	.00346	.00284	.001975	.001069	
ϕ	3.71	3.25	2.67	1.85	1.00	

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PANEL LOADS @ CONJ. BM

at ① $.165 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{1}{3} = .454 \times 10^{-8}$

at ② $.165 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{2}{3} = .908 \times 10^{-8}$

$.165 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} = 1.365 \times 10^{-8}$

$.77 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{1}{3} = .154 \times 10^{-8}$

2.813×10^{-8}

at ③ 1.365×10^{-8}

$.54 \times 10^{-8} \times 2 = 1.08 \times 10^{-8}$

$(3.55 - 1.42) \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} \times \frac{1}{3} = 1.805 \times 10^{-8}$

$1.42 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} = 3.62 \times 10^{-8}$

7.870×10^{-8}

at ④ 3.62×10^{-8}

$1.08 \times 10^{-8} \times 2 = 2.16 \times 10^{-8}$

$(6.4 - 3.55) \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} \times \frac{1}{3} = 2.42 \times 10^{-8}$

$3.55 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} = 9.10 \times 10^{-8}$

17.30×10^{-8}

at ⑤ 9.10×10^{-8}

$2.42 \times 10^{-8} \times 2 = 4.84 \times 10^{-8}$

$(10.9 - 6.4) \times 10^{-8} \times 57 \times 12 \times \frac{1}{2} \times \frac{1}{3} = 5.1 \times 10^{-8}$

$6.4 \times 10^{-8} \times 57 \times 12 \times \frac{1}{2} = 21.8 \times 10^{-8}$

40.84×10^{-6}

at ⑥ 21.8×10^{-8}

$5.1 \times 10^{-8} \times 2 = 10.2 \times 10^{-8}$

32.10×10^{-8}

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FILE CONTAINMENT — DATE

ESTIMATE — CHECKED BY

DATE

$E = 3.4 \times 10^3$ ksi

$G = 1.4 \times 10^3$

2ND TRIAL FOR FUNDAMENTAL MODE :

(3RD TIME ACCTUALLY)

MASS PT.	ASSUMED SHAPE ϕ_r'	$F_{ri} = M \phi_r'$ (Ksec²/IN)	COMPUTED Δ	COMPUTED SHAPE ϕ_r''	$F_{ri}\phi_r''$	$M_r(\phi_r'')^2$
1	3.71	$\frac{4300}{386} \times 3.71 = 41.4$	.004487	3.77	156	158.5
2	3.25	$8927/g \times 3.25 = 75.0$	.003895	3.29	247	250.0
3	2.67	$11009/g \times 2.67 = 76.2$	.003179	2.68	204	205.0
4	1.85	$13328/g \times 1.85 = 64$	.002206	1.86	119	123.0
5	1.00	$15600/g \times 1.0 = 40.3$	.001186	1.00	40	40.5
					766	777.0

35' 35' 42.5' 42.5' 57'

F_{ri}	41.4	75.0	76.2	64	40.3	
V	41.4	116.4	192.6	256.6	296.9	
INCRE. OF SHEAR $\Delta = \frac{2VL}{AG}$	.000104	.000244	.00045	.0006	.00094	
SHEAR Δ	.002338	.002234	.00199	.00154	.00094	
M''	0	1.74×10^7	6.62×10^7	16.42×10^7	29.52×10^7	49.8×10^7
M/EI		$.754 \times 10^{-10}$	1.62×10^{-10}	4.05×10^{-6}	7.28×10^{-10}	12.2×10^{-10}
PANEL LOADS (SEE NEXT PG.)	$.526 \times 10^{-8}$	3.746×10^{-8}	8.93×10^{-8}	21.29×10^{-8}	46.32×10^{-8}	36.12×10^{-8}
CONJ. BM V		116.41×10^{-8}	112.66×10^{-3}	103.73×10^{-8}	82.44×10^{-8}	36.12×10^{-8}
CONJ. BM MOMENT $= \Delta_M$	.002149	.001661	.001189	.000666	.000246	
$\Delta_V + \Delta_M$	.004487	.003895	.003179	.002206	.001186	

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ESTIMATE

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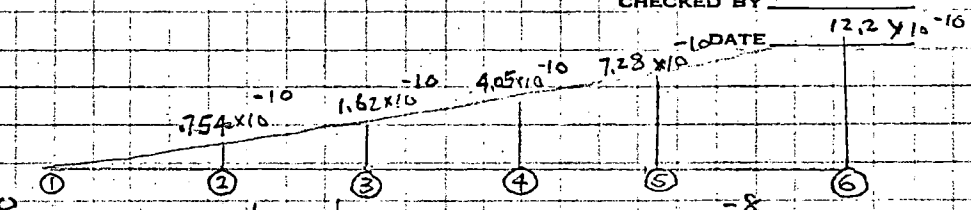
PANEL LOADS



@ (1) $.754 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{1}{3} = 0.526 \times 10^{-8}$

@ (2) $.754 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{2}{3} = 1.05 \times 10^{-8}$

$.754 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} = 1.58 \times 10^{-8}$

$.866 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{1}{3} = .59 \times 10^{-8}$

3.746×10^{-8}

@ (3)

1.58×10^{-8}

$.59 \times 10^{-8} \times 2 = 1.18 \times 10^{-8}$

$1.62 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} = 4.11 \times 10^{-8}$

$(4.05 - 1.62) \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} \times \frac{1}{3} = 2.06 \times 10^{-8}$

8.93×10^{-8}

@ (4)

4.11×10^{-8}

$2.06 \times 10^{-8} \times 2 = 4.12 \times 10^{-8}$

$4.05 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} = 10.32 \times 10^{-8}$

$(7.28 - 4.05) \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} \times \frac{1}{3} = 2.74 \times 10^{-8}$

21.29×10^{-8}

@ (5)

10.32×10^{-8}

$2.74 \times 10^{-8} \times 2 = 5.48 \times 10^{-8}$

$7.28 \times 10^{-10} \times 57 \times 12 \times \frac{1}{2} = 24.92 \times 10^{-8}$

$(12.2 - 7.28) \times 10^{-10} \times 57 \times 12 \times \frac{1}{2} \times \frac{1}{3} = 5.60 \times 10^{-8}$

46.32×10^{-8}

@ (6)

24.92×10^{-8}

$5.6 \times 10^{-8} \times 2 = 11.20 \times 10^{-8}$

36.12×10^{-8}

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FUNDAMENTAL MODE

$$\omega^2 = \frac{\sum_1^{n} F_{ri}\,\phi_r''}{A''\sum_1^{n} M_r(\phi_r'')^2}$$

$$= \frac{766}{.001185 \times 777} = 825$$

$$\omega = 28.7$$

$$T_1 = \frac{2\pi}{\omega} = .218 \text{ sec}$$

MODIFIED RAYLEIGH METHOD FOR SECOND MODE

ϕ_{r1} – first mode shape

$\sum_{1}^{5} M_r \phi_{r1}^2 = 7.77$

Mass Pt	ϕ_{r1}	Assumed shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r1}$	$\psi_1 \phi_{r1}$	$\phi_{ras} = \phi_{ra} - \psi_1 \phi_{r1}$	$F_{r1} = M_r \phi_{ras}$	Computed Deflection $A'' \phi_r''$ (SEE NEXT PG)	COMPUTED SHAPE	$F_{r2} \phi_r''$	$M_r (\phi_r'')^2$
11.15	1	3.77	-1.5	- 63.1	.117	-1.617	- 18.0	-.0004854	-7.8	
23.1	2	3.29	-0.8	- 60.7	.103	-0.903	- 20.8	-.0003534	-5.67	
28.5	3	2.68	+0.1	+ 7.63	.084	+ .016	+ 0.46	-.0001832	-2.94	
34.6	4	1.86	+0.8	+ 51.4	.058	+ .742	+ 25.7	-.0000917	-2.72	
40.5	5	1.00	+1.0	+ 40.5	.031	+ .969	+ 39.3	+.0000622	+1.0	
				-24.27						

$\psi_1 = \frac{24.27}{7.77} = .0312$

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FILE CONTAINMENT

ESTIMATE

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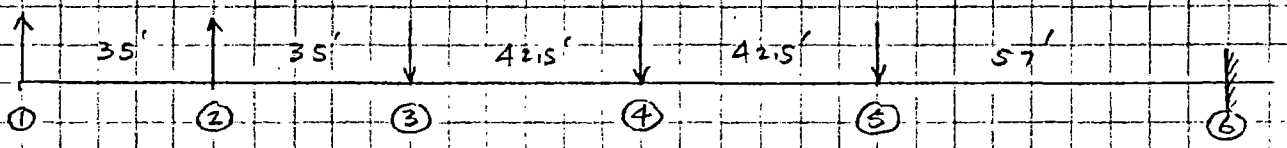

F_i	-18.0	-20.8	+0.46	+25.7	+39.3	
V	-18.0	-38.8	-38.34	-12.64	+26.66	
Inc. of $\Delta_V = \frac{2VL}{AG}$	-.000051	-.000095	-.000090	-.000029	+.000084	
SHEAR Δ	-.000181	-.000130	-.000035	+.000055	+.000084	0
M	0	$-.757 \times 10^{7}$	-2.387×10^{7}	-4.34×10^{7}	-4.985×10^{7}	-3.165×10^{7}
$\frac{M}{EI}$		$-.334 \times 10^{-10}$	$-.59 \times 10^{-10}$	-1.07×10^{-10}	-1.123×10^{-10}	$-.775 \times 10^{-10}$
PANEL LOAD (SEE NEXT PG.)	$-.234 \times 10^{-8}$	-1.348×10^{-8}	-2.966×10^{-8}	-5.18×10^{-8}	-6.682×10^{-8}	-3.165×10^{-8}
CONJ. BM V	-19.575×10^{-8}	-19.343×10^{-8}	-17.933×10^{-8}	-15.027×10^{-8}	-9.847×10^{-8}	-3.165×10^{-8}
Δ_M	-.0003044	-.0002234	-.0001482	-.000072	-.000218	
$\Delta_V - \Delta_M$	-.0004854	-.0003534	-.0001832	-.000017	+.0000622	

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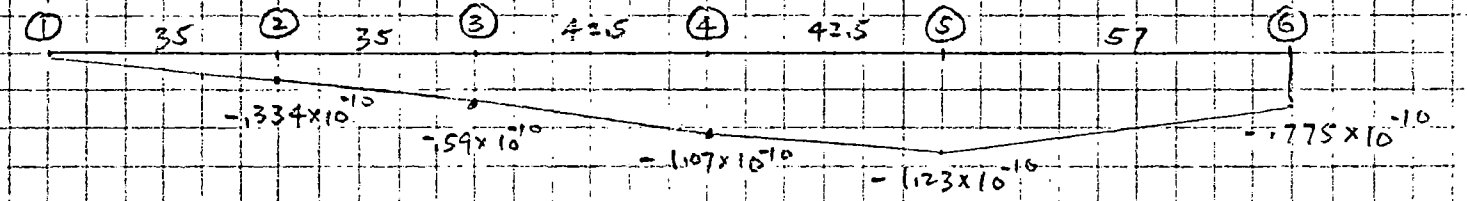
EL DIAGRAM FOR PANEL LOADS



at ① $-.334\times10^{-10}\times35'\times12\times\frac{1}{2}\times\frac{1}{3}$ = $-.234\times10^{-8}$

at ②

$2\times(-.234\times10^{-8})$ = $-.468\times10^{-8}$

$-.334\times10^{-10}\times35\times12\times\frac{1}{2}$ = $-.701\times10^{-8}$

$-(.59-.334)\times10^{-10}\times35\times12\times\frac{1}{2}\times\frac{1}{3}$ = $-.179\times10^{-8}$

-1.348×10^{-8}

at ③

$-.701\times10^{-8}$

$2\times(-.179\times10^{-8})$ = $-.358\times10^{-8}$

$-.59\times10^{-10}\times42.5\times12\times\frac{1}{2}$ = -1.5×10^{-8}

$-(1.07-.59)\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{1}{3}$ = $-.407\times10^{-8}$

-2.966×10^{-8}

at ④

$2\times(-.407\times10^{-8})$ = $-.814\times10^{-8}$

-1.5×10^{-8}

$-1.07\times10^{-10}\times42.5\times12\times\frac{1}{2}$ = -2.73×10^{-8}

$-(1.23-1.07)\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{1}{3}$ = $-.136\times10^{-8}$

5.180×10^{-8}

at ⑤

-2.73×10^{-8}

$2\times(-.136\times10^{-8})$ = $-.272\times10^{-8}$

$-.775\times10^{-10}\times57\times12\times\frac{1}{2}$ = -2.65×10^{-8}

$-(1.23-.775)\times10^{-10}\times57\times12\times\frac{1}{2}\times\frac{2}{3}$ = -1.03×10^{-8}

-6.682×10^{-8}

at ⑥

-2.65×10^{-8}

$\frac{1}{2}\times(1.03\times10^{-8})$ = -0.515

-3.165×10^{-9}

SECOND MODE (SECOND TRY)

ϕ_{r1} – first mode shape

$\sum_1^5 M_r \phi_{r1}^2 = 777$

Mass Pt	ϕ_{r1}	Assumed shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r1}$	$\psi_1 \phi_{r1}$	$\phi_{ras} = \phi_{ra} - \psi_1 \phi_{r1}$	$F_{ri} = M_r \phi_{ras}$	Computed Deflection	Computed slope ϕ_r'	$F_{ri} \phi_r''$	$M_r(\phi_r'')^2$
1 1.5	1	3.77	-4.0	-168	-1.66	-2.34	-26.9	-.0003546	-1.74	+46.9	33.7
23.1	2	3.29	-2.5	-190	-1.45	-1.05	-24.2	-.0003256	-1.60	+38.7	59.2
28.5	3	2.68	-1.0	-76.5	-1.18	+0.18	+5.2	+.0000084	+0.04	+0.2	—
34.6	4	1.86	+0.8	+51.4	-0.82	+1.62	+56.0	+.0001864	+0.92	+51.5	29.4
40.5	5	1.00	+1.0	+40.5	-0.44	+1.44	+58.3	+.0002036	+1.00	+58.3	40.5
				-342.6						+195.6	162.8

$$\psi_1 = \frac{-342.6}{777} = -0.44$$

$$\omega_2^2 = \frac{195.6}{.0002036 \times 162.8} = 5880 \qquad \omega_2 = 76.8$$

$$T_2 = .0818$$

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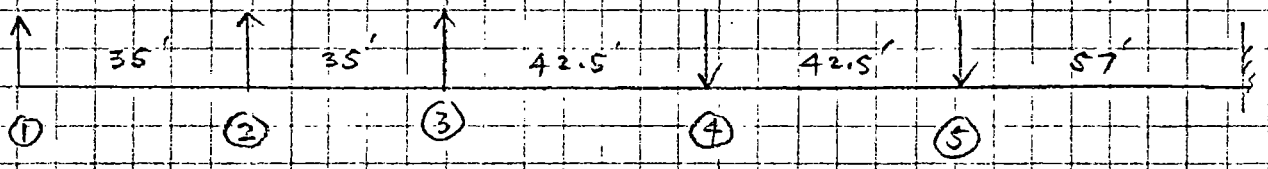

	1	2	3	4	5	
F_{ri}	-26.9	-24.2	+5.2	+56.0	+58.3	
V	-26.9	-51.1	-45.9	+10.1	+68.4	
Inc. of $\Delta_V = \frac{2VL}{AG}$	-.0000765	-.000124	-.000105	+.000023	+.000215	
SHEAR Δ	-.0000675	+.000009	+.000133	+.000238	+.000215	
M	0	-1.13×10^{7}	-3.27×10^{7}	-5.61×10^{7}	-5.09×10^{7}	-0.41×10^{7}
M/EI		$-.498\times10^{-10}$	$-.808\times10^{-10}$	-1.38×10^{-10}	-1.26×10^{-10}	-0.1×10^{-10}
PANEL LOAD (SEE NEXT PG.)	$-.35\times10^{-8}$	-1.97×10^{-8}	-4.027×10^{-8}	-6.38×10^{-8}	-6.28×10^{-8}	-1.67×10^{-8}
CONJ. BM. V	-20.68×10^{-8}	-20.33×10^{-8}	-18.36×10^{-8}	-14.33×10^{-8}	-7.95×10^{-8}	-1.67×10^{-8}
Δ_M	-.0002871	-.0002016	-.0001246	-.0000516	-.0000114	
$\Delta_M + \Delta_V$	-.0003546	-.0003256	+.0000084	+.0001864	+.0002036	

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FILE CONTAINMENT

ESTIMATE

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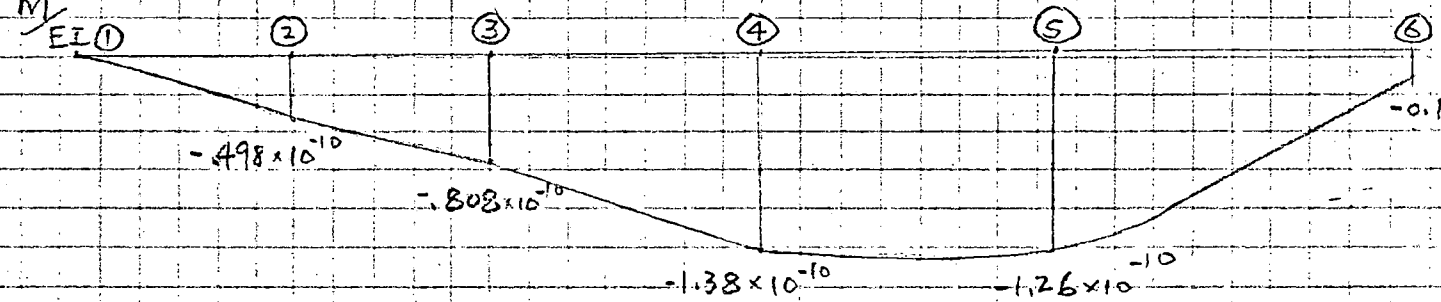
PANEL LOAD



at ① $-.498\times10^{-10}\times35\times12\times\frac{1}{2}\times\frac{1}{3} = -.35\times10^{-8}$

at ② $-.35\times10^{-8}\times2 = -.70\times10^{-8}$

$-.498\times10^{-10}\times35\times12\times\frac{1}{2} = -1.053\times10^{-8}$

$-(.808-.498)\times10^{-10}\times35\times12\times\frac{1}{2}\times\frac{1}{3} = -.217\times10^{-8}$

-1.970×10^{-8}

at ③ $2\times(-.217\times10^{-8}) = -.434\times10^{-8}$

-1.053×10^{-8}

$-.808\times10^{-10}\times42.5\times12\times\frac{1}{2} = -2.06\times10^{-8}$

$-(1.38-.808)\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{1}{3} = -.48\times10^{-8}$

-4.027×10^{-8}

at ④ -2.06×10^{-8}

$-.48\times10^{-8}\times2 = -0.96\times10^{-8}$

$-1.26\times10^{-10}\times42.5\times12\times\frac{1}{2} = -3.22\times10^{-8}$

$-.08\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{2}{3} = -0.14\times10^{-8}$

-6.38×10^{-8}

@ ⑤ -3.22×10^{-8}

$-0.14\times10^{-8}\times\frac{1}{2} = -0.07\times10^{-8}$

$-(1.26-.10)\times10^{-10}\times57\times12\times\frac{1}{2}\times\frac{2}{3} = -2.65\times10^{-8}$

$-.10\cdot10^{-10}\times10^{-10}\times57\times12\times\frac{1}{2} = -0.34\times10^{-8}$

-6.28×10^{-8}

@ ⑥ -0.34×10^{-8}

$-2.65\times10^{-8}\times\frac{1}{2} = -1.33\times10^{-8}$

-1.67×10^{-8}

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SUBJECT SALEM

FILE CONTAINMENT

ESTIMATE

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PREPARED BY F. S

DATE

CHECKED BY

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SECOND MODE (3RD TRIAL)

ϕ_{r1} = first Mode shape $\sum_1^5 M_r \phi_{r1}^2 = 777$

Mass Pt.	ϕ_{r1}	Assumed shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r1}$	$\psi_1 \phi_{r1}$	$\phi_{ras} = \phi_{ra} - \psi_1 \phi_{r1}$	$F_{ri} = M_r \phi_{ras}$	Computed Deflection	Computed shape ϕ_r	$F_{ri} \phi_r$	$M_r(\phi$
1	3.77	-1.74	-73.2	-.445	-1.295	-14.4	-.0002018	-1.28	+18.4	+18.3
2	3.29	-1.60	-121.5	-.388	-1.212	-28.0	-.0001401	-6.89	+24.9	+12.4
3	2.68	+0.04	+ 3.0	-.317	+0.357	+10.2	+.0000256	+0.16	+1.6	-
4	1.86	+0.92	+ 59.2	-.220	+1.14	+39.4	+.000146	+0.92	+36.2	+39.5
5	1.00	+1.00	+40.5	-.118	+1.118	+45.3	+.000158	+1.00	+45.3	+40.5
			-92.0						126.4	36.7

$$\psi_1 = \frac{-92}{777} = -0.118$$

$$w^2 = \frac{126.4}{.000158 \times 106.7} = 7500 \qquad w = 86.5$$

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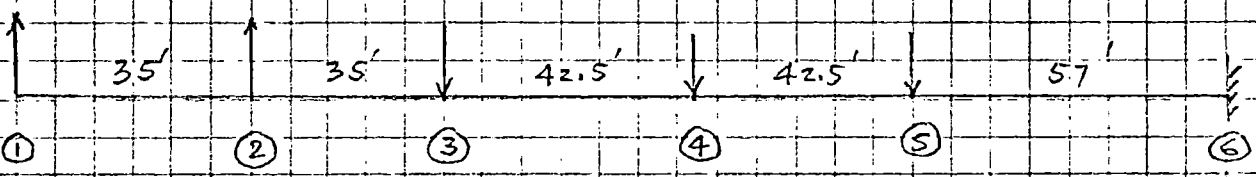

	1	2	3	4	5	6
F_{vi}	-14.4	-28.0	+10.2	+39.4	+45.3	
V	-14.4	-42.4	-32.2	+7.2	+52.5	
INC. OF $\Delta_V = \frac{2VL}{AG}$	-.000037	-.000103	-.000076	+.000017	+.000165	
SHEAR Δ	-.000034	+.000003	+.000106	+.000182	+.000165	
M"#	0	$-.604\times10^{7}$	-2.384×10^{7}	-4.024×10^{7}	-3.656×10^{7}	$-.08\times10^{7}$
$\frac{M}{EI}$		$-.26\times10^{-10}$	$-.59\times10^{-10}$	-1.00×10^{-10}	-0.9×10^{-10}	$-.02\times10^{-10}$
PANEL LOAD (SEE NEXT PG.)	$-.174\times10^{-8}$	-1.12×10^{-8}	-2.86×10^{-8}	-4.93×10^{-8}	-4.67×10^{-8}	-1.04×10^{-8}
CONJ. BM V	-14.794×10^{-8}	-14.62×10^{-8}	-13.5×10^{-8}	-10.64×10^{-8}	-5.71×10^{-8}	-1.04×10^{-8}
Δ_M	-.000198	-.000137	-.0000804	-.0000361	-.0000071	
$\Delta_V + \Delta_M$	-.0002018	-.0001401	+.0000256	+.0001459	+.000158	

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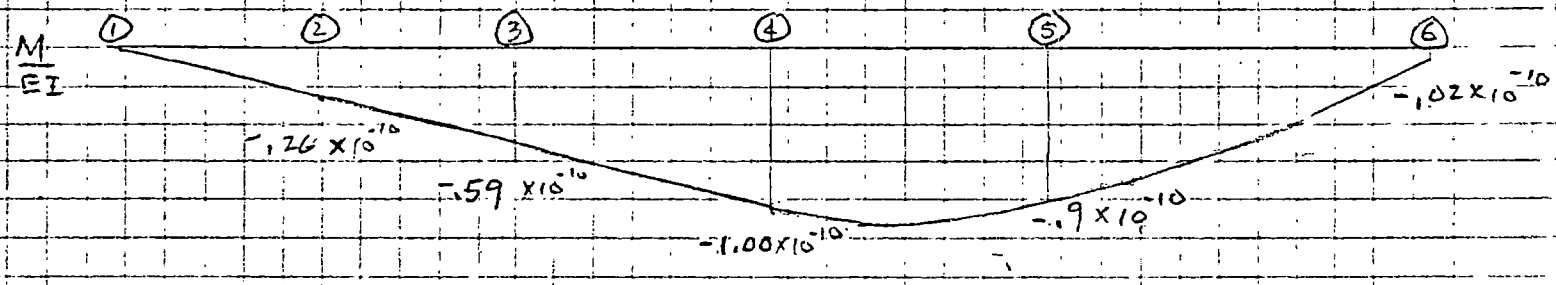
PANEL LOAD



at (1) $-.26 \times 10^{-10} \times 35' \times 12 \times 12 \times \frac{1}{2} \times \frac{1}{3}$ $= -.174 \times 10^{-8}$

at (2) $-.174 \times 10^{-8} \times 2$ $= -.348 \times 10^{-8}$

$-.26 \times 10^{-10} \times 35' \times 12 \times \frac{1}{2}$ $= -.542 \times 10^{-3}$

$-(.59 - .26) \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{1}{3}$ $= -.23 \times 10^{-3}$

-1.120×10^{-3}

at (3) $2 \times (-.23 \times 10^{-3})$ $= -.46 \times 10^{-3}$

$-.59 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2}$ $= -1.51 \times 10^{-3}$

$-(1.00 - .59) \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} \times \frac{1}{3}$ $= -.35 \times 10^{-3}$

$-.54 \times 10^{-3}$

-2.86×10^{-3}

at (4) -1.51×10^{-3}

$-.35 \times 10^{-8} \times 2$ $= -.70 \times 10^{-8}$

$-0.9 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2}$ $= -2.55 \times 10^{-3}$

$-(1.00 - .9) \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} \times \frac{2}{3}$ $= -0.17 \times 10^{-3}$

-4.93×10^{-3}

at (5) -2.55×10^{-8}

$-.17 \times 10^{-8} \times \frac{1}{2}$ $= -0.08 \times 10^{-8}$

$-(.9 - .02) \times 10^{-10} \times 57 \times 12 \times \frac{1}{2} \times \frac{2}{3}$ $= -2.00 \times 10^{-3}$

$-.02 \times 10^{-10} \times 57 \times 12 \times \frac{1}{2}$ $= -0.04 \times 10^{-3}$

-4.67×10^{-8}

@ (6) -0.04×10^{-8}

$2.00 \times 10^{-8} \times \frac{1}{2}$ $= -1.00 \times 10^{-8}$

-1.04×10^{-8}

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SECOND MODE (4TH TRIAL)

$\sum_{1}^{5} M_r \phi_{r1}^2 = 461.2$

Mass PT	ϕ_{r1}	Assumed Shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r1}$	$\psi_1 \phi_{r1}$	$\phi_{ras} = \phi_{ra} - \psi \phi_{r1}$	$F_{r1} = M_r \phi_{ras}$	Computed Deflection	Computed shape ϕ''_r	$F_{ra} \phi''_r$	$M_r (\phi''_r)^2$
M_r										
11.15	1	3.77	-1.28	-53.9	-.0475	-1.23	-13.7	-.0001935	-1.32	+18.1	+19.5
23.1	2	3.29	-0.89	-67.7	-.0413	-0.85	-19.6	-.0001075	-0.74	+14.5	+12.7
28.5	3	2.68	+0.16	+12.2	-.0337	+0.19	+5.4	+.000015	+0.10	+0.5	—
34.6	4	1.86	+0.92	+59.1	-.0234	+0.94	+32.4	+.000131	+0.90	+29.0	+28.0
40.5	5	1.00	+1.00	+40.5	-.0126	+1.01	+40.8	+.000146	+1.00	+40.8	+40.5
				-9.8						+102.9	100.7

$\psi_1 = \frac{-9.8}{777} = -.0126$

$\omega^2 = \frac{102.9}{.000146 \times 100.7} = 7.00$ $\quad \omega_2 = 83.7$

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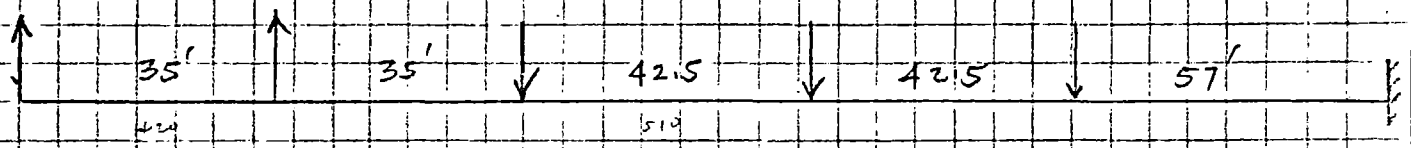

	1	2	3	4	5	
F_{rn}'	-13.7	-19.6	+5.4	+32.4	+40.8	
V	-13.7	-33.3	-27.9	+4.5	+45.3	
INC. of $\Delta_V = \frac{2VL}{AG}$	-.000035	-.000081	-.000066	+.000010	+.000152	
SHEAR Δ	-.00002	+.000015	+.000096	+.000162	+.000152	
M"#	0	$-.575\times10^{7}$	-1.973×10^{7}	-3.393×10^{7}	-3.164×10^{7}	$-.064\times10^{7}$
$\frac{M}{EI}$		$-.25\times10^{-10}$	$-.49\times10^{-10}$	$-.84\times10^{-10}$	$-.78\times10^{-10}$	$-.016\times10^{-10}$
PANEL LOAD (SEE NEXT PG)	$-.175\times10^{-8}$	-1.043×10^{-8}	-2.405×10^{-8}	-3.954×10^{-8}	-3.86×10^{-8}	$-.093\times10^{-8}$
CONJ. BM V	-12.37×10^{-8}	-12.195×10^{-8}	-11.152×10^{-8}	-8.744×10^{-8}	-4.79×10^{-8}	$-.093\times10^{-8}$
Δ_M	-.0001725	-.0001225	-.0000755	-.0000308	-.0000063	
$\Delta_V + \Delta_M$	-.0001925	-.0001075	+.0000115	+.000131	+.000146	

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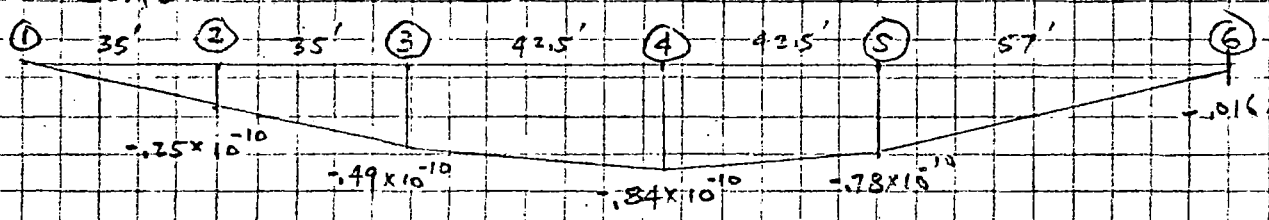
PANEL LOADS



at ① $-.25\times10^{-10}\times35\times12\times\frac{1}{2}\times\frac{1}{3} = -.175\times10^{-8}$

at ② $-.175\times2\times10^{-8} = -.35\times10^{-8}$

$-.25\times10^{-10}\times35\times12\times\frac{1}{2} = -.525\times10^{-8}$

$-(.49-.25)\times10^{-10}\times35\times12\times\frac{1}{2}\times\frac{1}{3} = -.168\times10^{-8}$

-1.043×10^{-8}

at ③ $2\times(-.168\times10^{-8}) = -.336\times10^{-8}$

$-.49\times10^{-10}\times42.5\times12\times\frac{1}{2} = -1.25\times10^{-8}$

$-.525\times10^{-8}$

$-(.84-.49)\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{1}{3} = -.297\times10^{-8}$

-2.408×10^{-8}

at ④ -1.25×10^{-8}

$2\times(-.297\times10^{-8}) = -.594\times10^{-8}$

$-.79\times10^{-10}\times42.5\times12\times\frac{1}{2} = -2.01\times10^{-8}$

$-(.84-.78)\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{2}{3} = -0.1\times10^{-8}$

-3.954×10^{-8}

at ⑤ -2.01×10^{-8}

-0.05×10^{-8}

$-(.78-.016)\times10^{-10}\times57\times12\times\frac{1}{2}\times\frac{2}{3} = -1.74\times10^{-8}$

$-.016\times10^{-10}\times57\times12\times\frac{1}{2} = -.06\times10^{-8}$

-3.86×10^{-8}

at ⑥ $\frac{1}{2}\times(-1.74\times10^{-8}) = -0.87\times10^{-8}$

-0.06

-0.93×10^{-8}

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THIRD MODE

ϕ_{r_2} – 2nd MODE $\quad \Sigma M_r \phi_r^2 = 106.7$

Mass Pt	Mass	ϕ_{r_2}	Assumed Shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r_2}$	$\psi_2 \phi_{r_2}$	$\phi_{ras} = \phi_{ra} - \psi_2 \phi_{r_2}$	$F_{ra} = M_r \phi_{ras}$	Computed Deflection $A'' \phi_r''$	Computed shape ϕ_r''	$F_{ra} \phi_r''$ $M_r(\phi_r'')$
1	11.15	-1.32	+0.5	-7.4	-.41	+0.91	+10.2	+.00059	+1.68	
2	23.1	-0.74	-0.1	+1.7	-.23	+0.13	+3.0	+.000020	+0.57	
3	28.5	+0.10	-0.7	-2.0	+.03	-0.73	-20.9	-.000019	-0.54	
4	34.6	+0.90	+0	0	+.28	-0.28	-9.7	+.000008	+0.23	
5	40.5	+1.90	+1.0	+40.5	+.31	+0.69	+28	+.000035	+1.00	
				+32.8						

$$\psi_2 = \frac{+32.8}{106.7} = .307$$

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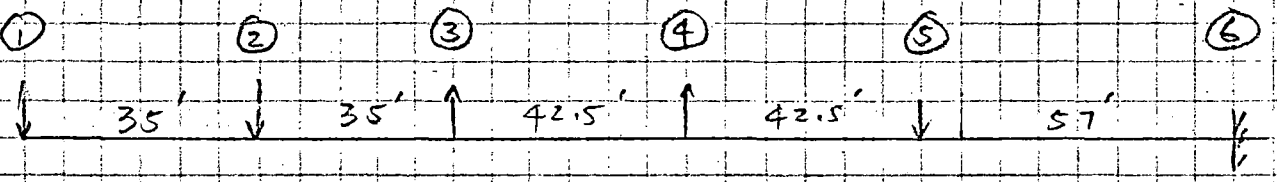

F_{vi}	+10.2	+3.0	-20.9	-9.7	+28
V	+10.2	+13.2	-7.7	-17.4	+10.6
INC. of $\Delta_S = \frac{2VL}{AG}$	+.000029	+.000032	-.0000 18	-.000040	+.000034
SHEAR Δ	+.000037	+.000008	-.000024	-.000006	+.000034
M	0	$+0.43 \times 10^{7}$	$+.98 \times 10^{7}$	$+.59 \times 10^{7}$	$-.30 \times 10^{7}$	$+.42 \times 10^{7}$
$\frac{M}{EI}$		$+.19 \times 10^{-10}$	$+.24 \times 10^{-10}$	$+.145 \times 10^{-10}$	$-.074 \times 10^{-10}$	$+.10 \times 10^{-10}$
PANEL LOAD (SEE NEXT PG.)	$+.133 \times 10^{-8}$	$+0.70 \times 10^{-8}$	$+1.00 \times 10^{-8}$	$+.63 \times 10^{-8}$	$-.06 \times 10^{-8}$	$+.14 \times 10^{-8}$
CONJ. BM. V	$+2.54 \times 10^{-8}$	$+2.41 \times 10^{-8}$	$+1.71 \times 10^{-8}$	$+.71 \times 10^{-8}$	$+.08 \times 10^{-8}$	$+.14 \times 10^{-8}$
Δ_M	+.000022	+.0000121	+.000005	+.0000014	+.000001	
$\Delta_V + \Delta_M$	+.00059	+.000020	-.000019	+.000008	+.000035	

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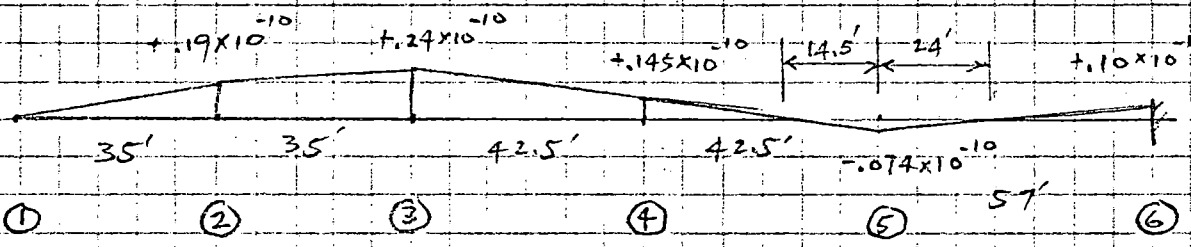
PANEL PT. LOADS



at ① $+.19\times10^{-10} \times 35' \times 12'' \times \frac{1}{2} \times \frac{1}{3} = +.133\times10^{-8}$

at ②

$+.19\times10^{-10} \times 35' \times 12 \times \frac{1}{2} = +.266\times10^{-8}$

$+.05\times10^{-10} \times 35' \times 12 \times \frac{1}{2} \times \frac{1}{3} = +.034\times10^{-8}$

$+.40\times10^{-8}$

$.70\times10^{-8}$

at ③

$+.145\times10^{-10} \times 42.5\times12 \times \frac{1}{2} = +.07\times10^{-8}$

$+.095\times10^{-10} \times 42.5\times12\times\frac{1}{2}\times\frac{2}{3} = +.40\times10^{-8}$

$+.37\times10^{-8}$

$+.16\times10^{-8}$

1.00×10^{-8}

at ④

$.145\times10^{-10} \times 28\times12\times\frac{1}{2}\times\frac{33.17}{42.5} = +.37\times10^{-8}$

$-.074\times10^{-10}\times145\times12\times\frac{1}{2}\times\frac{4.8}{42.5} = +.08\times10^{-8}$

$+.19\times10^{-8}$

$-.01\times10^{-8}$

0.63×10^{-8}

at ⑤

$+.145\times10^{-10} \times 28\times12\times\frac{1}{2}\times\frac{9.33}{42.5} = +.05\times10^{-8}$

$-.074\times10^{-10}\times14.5\times12\times\frac{1}{2}\times\frac{36.17}{42.5} = -.06\times10^{-8}$

$+.10\times10^{-10}\times33\times12\times\frac{1}{2}\times\frac{11}{57} = +.04\times10^{-8}$

$-.074\times10^{-10}\times24\times12\times\frac{1}{2}\times\frac{49}{57} = -.09\times10^{-8}$

$-.06\times10^{-8}$

at ⑥

$-.074\times10^{-10}\times24\times12\times\frac{1}{2}\times\frac{8}{57} = -.02\times10^{-8}$

$+.10\times10^{-10}\times33\times12\times\frac{1}{2}\times\frac{46}{57} = +.16\times10^{-8}$

$+.14\times10^{-8}$

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THIRD MODE (2ND TRIAL)

ϕ_{r2} - 2ND MODE $\quad \Sigma M_r \phi_r^2 = 106.7$

Mass Pt	Mass	ϕ_{r2}	Assumed Shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r2}$	$\psi_2 \phi_{r2}$	$\phi_{ras} = \phi_{ra} - \psi_2 \phi_{r2}$	$F_{ri} = M_r \phi_{ras}$	Computed Deflection $A'' \phi_r''$	Computed Shape ϕ_r''	$F_{ri} \cdot \phi_r''$	$M_r (\phi_r'')^2$
1	11.15	-1.32	+0.6	-8.9	-0.38	+0.98	+10.9	+.0000332	+1.15		
2	23.1	-.74	-0.1	+1.7	-0.21	+0.11	+2.6	-.0000056	-0.19		
3	28.5	+.10	-0.8	-2.3	+0.03	-0.83	-23.6	-.0000403	-1.40		
4	34.6	+.90	0	0	+0.27	-0.27	-9.3	-.0000177	-0.60		
5	40.5	+1.00	+1.0	+40.5	+.29	+0.70	+28.4	+.0000029	+1.00		
				+31.0							

$$\psi_2 = \frac{+31.0}{106.7} = .29$$

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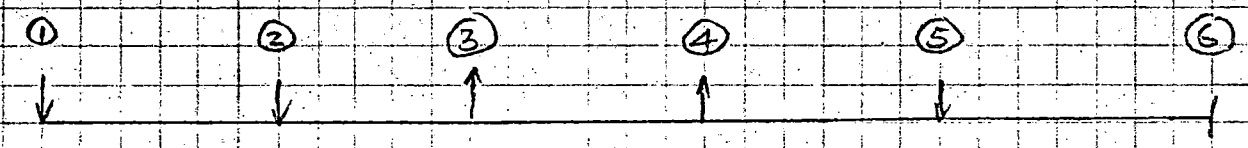

Fri	+10.9	+2.6	-23.6	=9.3	+28.4
V	+10.9	+14.5	-9.1	-18.4	+10.0
(Nc. of $\Delta_s = \frac{2VL}{AG}$	+.000031	+.000033	-.000023	-.000044	+.000029
SHEAR Δ	+.000023	-.000008	-.000038	-.000015	+.000029
M	0	$+.46\times10^{7}$	$+1.03\times10^{7}$	$+.51\times10^{7}$	$-.48\times10^{7}$	$+.13\times10^{7}$
$\frac{M}{EI}$		$+.20\times10^{-10}$	$+.25\times10^{-10}$	$+.126\times10^{-10}$	$-.12\times10^{-10}$	$+.03\times10^{-10}$
PANEL LOAD	$+.14\times10^{-8}$	$+.74\times10^{-8}$	$+1.02\times10^{-8}$	$+.52\times10^{-8}$	$-.34\times10^{-8}$	$-.08\times10^{-8}$
CONJ. BM V	$+2.00\times10^{-8}$	$+1.86\times10^{-8}$	$+1.12\times10^{-8}$	$+.10\times10^{-8}$	$-.42\times10^{-8}$	$-.08\times10^{-8}$
Δ_M	+.0000102	+.0000024	-.0000023	-.0000027	-.0000006	
$\Delta_M + \Delta_V$	+.0000332	-.0000056	-.0000403	-.0000177	+.000029	

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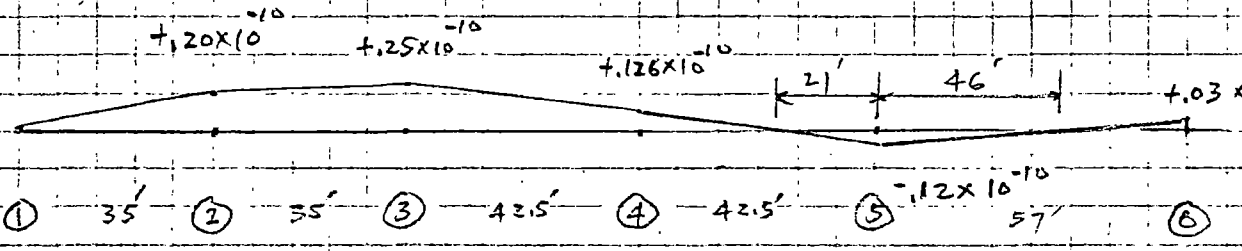
PANEL LOAD



at ① $+.20\times10^{-10}\times35'\times12\times\frac{1}{2}\times\frac{1}{3}$ = $+.14\times10^{-8}$

at ② $+.20\times10^{-10}\times35'\times12\times\frac{1}{2}$ = $+.28\times10^{-8}$

$+.05\times10^{-10}\times35'\times12\times\frac{1}{2}\times\frac{1}{3}$ = $+.04\times10^{-8}$

$+.74\times10^{-8}$

at ③ $+.42\times10^{-8}$

$+.126\times10^{-10}\times42.5\times12\times\frac{1}{2}$ = $+.07\times10^{-8}$

$+.124\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{2}{3}$ = $+.32\times10^{-8}$

$+.121\times10^{-8}$

$+1.02\times10^{-8}$

at ④ $+.32\times10^{-8}$

$+.126\times10^{-10}\times21.5'\times12\times\frac{1}{2}\times\frac{35.5}{42.5}$ = $+.10\times10^{-8}$

$-.12\times10^{-10}\times21\times12\times\frac{1}{2}\times\frac{7}{42.5}$ = $+.13\times10^{-8}$

$-.03\times10^{-8}$

$+.52\times10^{-8}$

at ⑤ $+.126\times10^{-10}\times21.5'\times12\times\frac{1}{2}\times\frac{7.2}{42.5}$ = $+.03\times10^{-8}$

$-.12\times10^{-10}\times21\times12\times\frac{1}{2}\times\frac{35.5}{42.5}$ = $-.13\times10^{-8}$

$-.12\times10^{-10}\times46\times12\times\frac{1}{2}\times\frac{41.7}{57}$ = $-.24\times10^{-8}$

$+.03\times10^{-10}\times11\times12\times\frac{1}{2}\times\frac{3.7}{57}$ = $\_\times10^{-8}$

$-.34\times10^{-8}$

at ⑥ $+.01\times10^{-8}$

$-.09\times10^{-8}$

$-.08\times10^{-8}$

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THIRD MODE (THIRD TRIAL)

ϕ_{r2} – 2nd MODE $\quad \Sigma M_r \phi_r^2 = 106.7$

MASS PT	Mass	ϕ_{r2}	Assumed shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r2}$	$\psi_2 \phi_{r2}$	$\phi_{ras} = \phi_{ra} - \psi_2 \phi_{r2}$	$F_{ri} = M_r \phi_{ras}$	Computed Deflection $A''\phi_r''$	computed shape ϕ_r''	$F_{ri}\phi_r''$	$A_{lr}(\phi_r'')^2$
1	11.15	-1.32	+1.0	-14.7	-.25	+1.25	+14	+.000063	+1.8		
2	23.1	-.74	-0	0	-.14	+.14	+3.2	+.000147	+0.4		
3	28.5	+.10	-1.0	-2.85	+.02	-1.02	-29.1	-.000039	-1.1		
4	34.6	+.90	-0.1	-3.1	+.17	-0.27	-9.3	-.000015	-0.4		
5	40.5	+1.00	+1.0	+40.5	+.19	+.81	+32.8	+.000035	+1.0		
				+19.85							

$$\psi_2 = \frac{+19.85}{106.7} = .185$$

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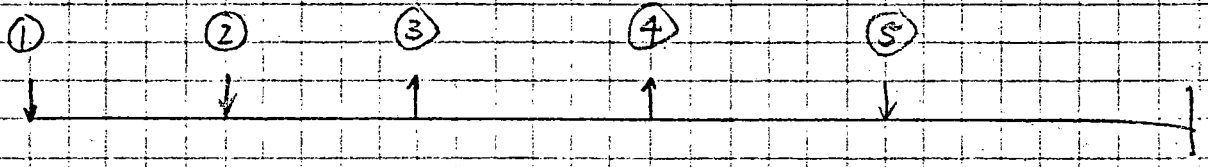

	1	2	3	4	5
F_{ri}	+14	+3.2	-29.1	-9.3	+32.8
V	+14	+17.2	-11.9	-21.2	+11.6
(No. of $\Delta_s = \frac{2VL}{AG}$	+.000036	+.000041	-.000028	-.000050	+.000036
Δ_s	+.000037	+.000021	-.000042	-.000014	+.000036
M	0	$+.59\times10^{7}$	$+1.31\times10^{7}$	$+.70\times10^{7}$	$-.39\times10^{7}$	$+.43\times10^{7}$
$\frac{M}{EI}$		$+.26\times10^{-10}$	$+.32\times10^{-10}$	$+.17\times10^{-10}$	$-.10\times10^{-10}$	$+.11\times10^{-10}$
PANEL LOAD	$+.18\times10^{-8}$	$+.97\times10^{-10}$	$+1.36\times10^{-8}$	$+.77\times10^{-8}$	$-.13\times10^{-8}$	$+.13\times10^{-8}$
CONJ. $\frac{BM}{V}$	$+3.28\times10^{-8}$	$+3.1\times10^{-10}$	$+2.13\times10^{-8}$	$+.77\times10^{-8}$	$+0\times10^{-8}$	$-.13\times10^{-8}$
Δ_M	+.000026	+.0000137	+.0000029	-.0000001	-.0000001
$\Delta_M+\Delta_V$	+.000063	+.0000147	-.000039	-.000015	+.000035

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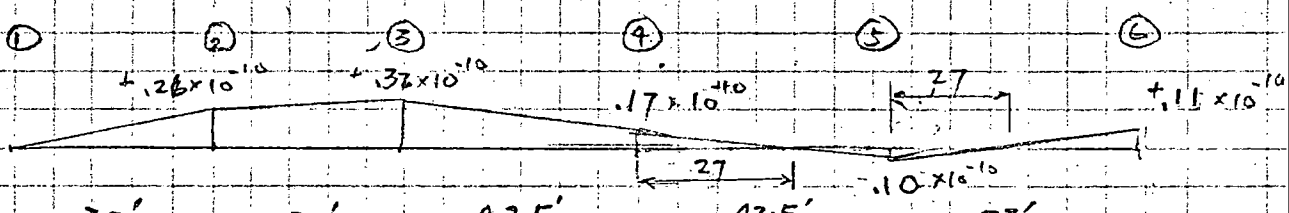

at ① $.26\times10^{-10}\times35'\times12\times\frac{1}{2}\times\frac{1}{3}$ = $+.18\times10^{-8}$

at ②

$.26\times10^{-10}\times35'\times12\times\frac{1}{2}$ = $+.36\times10^{-8}$

$+.06\times10^{-10}\times35'\times12\times\frac{1}{2}\times\frac{1}{3}$ = $+.55\times10^{-8}$

$+.06\times10^{-8}$

$+.97\times10^{-8}$

at ③ $+.55\times10^{-8}$

$+.12\times10^{-8}$

$+.17\times10^{-10}\times42.5\times12\times\frac{1}{2}$ = $+.44\times10^{-8}$

$+.15\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{27}{3}$ = $+.25\times10^{-8}$

$+1.36\times10^{-8}$

at ④ $+.17\times10^{-10}\times27\times12\times\frac{1}{2}\times\frac{33.5}{42.5}$ $+.22\times10^{-8}$

$-.10\times10^{-10}\times15.5\times12\times\frac{1}{2}\times\frac{27}{42.5}$ $-.01\times10^{-8}$

see ③ above = $+.44\times10^{-8}$

= $+.12\times10^{-8}$

$+1.77\times10^{-8}$

at ⑤ $\times\frac{9}{42.5}$ = $+.06\times10^{-8}$

$\times\frac{37}{42.5}$ = $-.08\times10^{-8}$

$-.10\times10^{-10}\times27\times12\times\frac{1}{2}\times\frac{28}{57}$ = $-.14\times10^{-8}$

$+.17\times10^{-10}\times30\times12\times\frac{1}{2}\times\frac{10}{57}$ = $+.03\times10^{-8}$

$-.13\times10^{-8}$

at ⑥ $\times\frac{9}{57}$ $-.03\times10^{-8}$

$\times\frac{47}{57}$ $+.16\times10^{-8}$

$+.13\times10^{-8}$

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THIRD MODE (4TH TRIAL)

MASS PT	ϕ_{r2}	Assumed shape	$M_r\phi_{ra}\phi_{ra}$	$\psi_2\phi_{r2}$	$\phi_{ras} = \phi_{ra} - \psi_2\phi_{r2}$	$M_r\phi_{ras}$	$F_{ri} =$ computed deflection	computed shape	$F_{ri}\phi_r''$	$M_r(\phi_r'')$
1	-1.32	+1.4	-20.6	-.008	+1.408	+15.7	+.000053	+1.4		
2	-.74	+0.2	-3.4	-.004	+.204	-4.7	0	0		
3	+.10	-1.2	-3.4	—	-1.200	-34.2	-.000057	-1.5		
4	+.90	-.4	-12.4	+.005	-.405	-14.0	-.0000298	-0.80		
5	+1.00	+1.0	+40.5	+.006	+.994	+40.2	+.0000398	+1.00		

$$\psi_2 = \frac{+0.7}{1067} = .006$$

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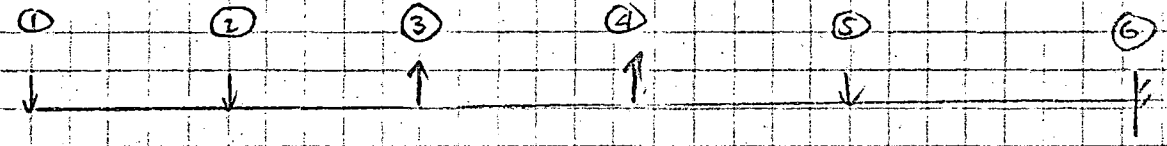
ESTIMATE



F_{VN}'	+15.7	+4.7	-34.2	-14.0	+40.2
V	+15.7	+20.4	-13.8	-27.8	+12.4
Inc. of $\Delta_S = \frac{2VL}{AG}$	+.000041	+.000049	-.000028	-.000065	+.000038
Δ_S	+.000034	-.000007	-.000056	-.000027	+.000038
M	0	$+.66\times10^{7}$	$+1.51\times10^{7}$	$+0.80\times10^{7}$	$-.62\times10^{7}$	$+.23\times10^{7}$
$\frac{M}{EI}$		$+.29\times10^{-10}$	$+.37\times10^{-10}$	$+.19\times10^{-10}$	$-.16\times10^{-10}$	$+.06\times10^{-10}$
Panel Load (see Next Pg)	$+.20\times10^{-8}$	$+1.06\times10^{-8}$	$+1.51\times10^{-8}$	$+.83\times10^{-8}$	$-.42\times10^{-8}$	$-.05\times10^{-8}$
Conj. BM V	$+3.13\times10^{-8}$	$+2.93\times10^{-8}$	$+1.87\times10^{-8}$	$+.36\times10^{-8}$	$-.47\times10^{-8}$	$-.05\times10^{-8}$
Δ_M	+.000019	+.000007	-.000001	-.0000028	-.0000004	
$\Delta_M + \Delta_V$	+.000053	———	-.000057	-.0000298	+.0000376	

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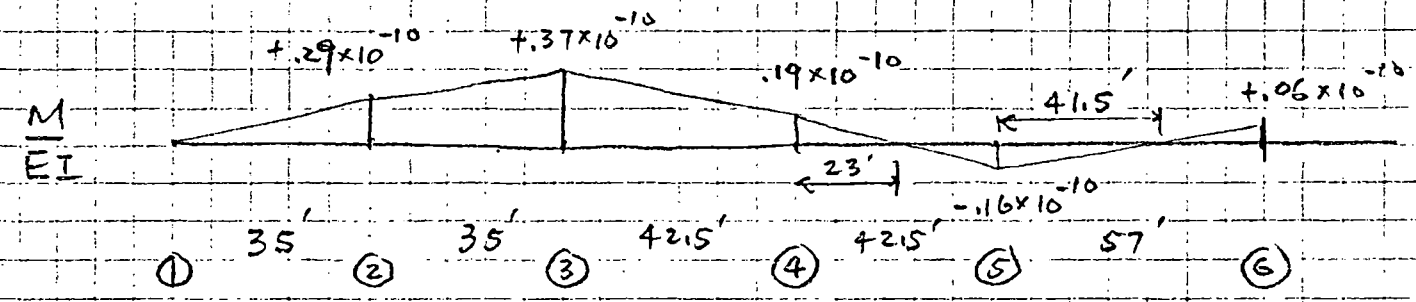
PANEL LOADS



at ① $+.29 \times 10^{-10} \times 35' \times 12 \times \frac{1}{2} \times \frac{1}{3} = +.120 \times 10^{-8}$

at ②

$+.29 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} = +.140 \times 10^{-8}$

$+.08 \times 10^{-10} \times 35 \times 12 \times \frac{1}{2} \times \frac{1}{3} = +.060 \times 10^{-8}$

$+.106 \times 10^{-8}$

at ③

$+.060 \times 10^{-8}$

$.19 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} = +.12 \times 10^{-8}$

$.18 \times 10^{-10} \times 42.5 \times 12 \times \frac{1}{2} \times \frac{2}{3} = +.49 \times 10^{-8}$

$+.130 \times 10^{-8}$

$+.151 \times 10^{-8}$

at ④

$+.49 \times 10^{-8}$

$+.19 \times 10^{-10} \times 23 \times 12 \times \frac{1}{2} \times \frac{34.8}{42.5} = +.15 \times 10^{-8}$

$-.16 \times 10^{-10} \times 19.5 \times 12 \times \frac{1}{2} \times \frac{6.5}{42.5} = +.22 \times 10^{-8}$

$-.03 \times 10^{-8}$

$+.83 \times 10^{-8}$

at ⑤

$\times \frac{7.7}{42.5} = +.05 \times 10^{-8}$

$\times \frac{36}{42.5} = -.17 \times 10^{-8}$

$-.16 \times 10^{-10} \times 41.5 \times 12 \times \frac{1}{2} \times \frac{43.2}{57} = -.31 \times 10^{-8}$

$+.06 \times 10^{-10} \times 15.5 \times 12 \times \frac{1}{2} \times \frac{5.2}{57} = +.01 \times 10^{-8}$

$-.142 \times 10^{-8}$

at ⑥

$\times \frac{13.8}{57} = -.10 \times 10^{-8}$

$\times \frac{51.8}{57} = +.05 \times 10^{-8}$

$-.05 \times 10^{-8}$

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SUBJECT Salem

FILE Containment

ESTIMATE

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THIRD MODE (4TH TRIAL)

Mass Pt	Mass	ϕ_{r2}	Assumed shape ϕ_{ra}	$M_r \phi_{ra} \phi_{r2}$	$\psi_2 \phi_{r2}$	$\phi_{ras} = \phi_{ra} - \psi_2 \phi_{ras}$	$F_{ri} = M_r \phi_{ras}$	Computed Deflection $A''\phi''_r$	ϕ'_r	$F_{ri}\phi''_r$	$M_r(\phi''_r$
1	11.15	-1.32	+1.120	-17.7	-.120	+1.320	+14.7	+.000050	+.124	+18.2	17.2
2	23.1	-.74	+0.20	-3.4	-.067	+.267	+6.2	+.000005	+.13	+0.8	.4
3	28.5	+.10	-1.25	-3.6	+.009	-1.259	-36.0	-.000051	-1.27	+45.8	45.6
4	34.6	+.90	-0.20	-6.2	+.081	-.281	-9.7	-.000018	-.45	+4.4	7.0
5	40.5	+1.00	+1.00	+40.5	+.092	+.908	+36.5	+.000042	+1.00	+36.5	40.5
				+9.6						105.7	110.7

$$\psi_2 = \frac{+9.6}{106.7} = +.09$$

$$\omega^2 = \frac{105.7}{.0000402 \times 110.7} = 23800$$

$$\omega = 158$$

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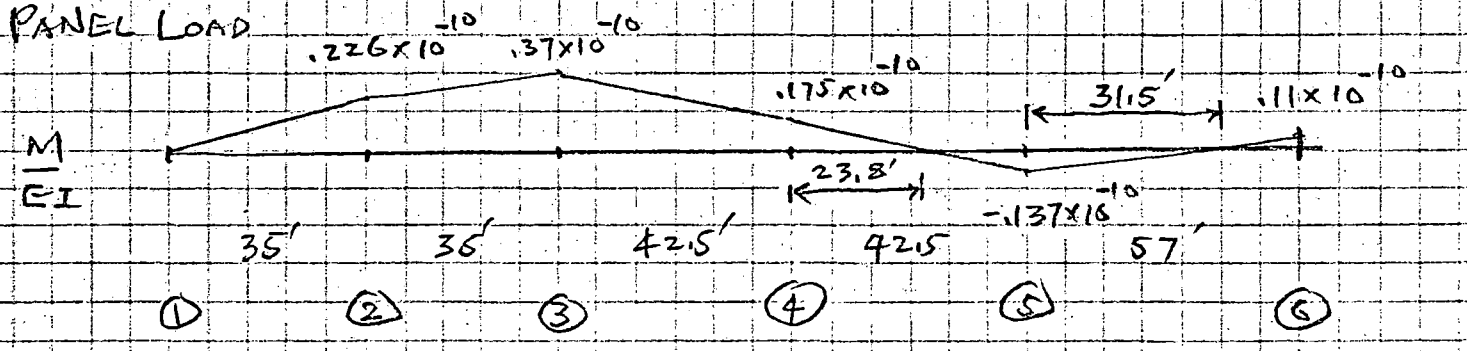
PANEL LOAD



at ① $.226\times10^{-10}\times35\times12\times\frac{1}{2}\times\frac{1}{3}$ $= 1.16\times10^{-8}$

at ②

$.226\times10^{-10}\times35\times12\times\frac{1}{2}$ $= .32\times10^{-8}$

$.144\times10^{-10}\times35\times12\times\frac{1}{2}\times\frac{1}{3}$ $= .47\times10^{-8}$

$= .10\times10^{-8}$

$+ .89\times10^{-8}$

at ③

$= .47\times10^{-8}$

$.175\times10^{-10}\times42.5\times12\times\frac{1}{2}$ $= .20\times10^{-8}$

$.195\times10^{-10}\times42.5\times12\times\frac{1}{2}\times\frac{2}{3}$ $= .45\times10^{-8}$

$= .33\times10^{-8}$

$+ 1.45\times10^{-8}$

at ④

$+ .45\times10^{-8}$

$+ .175\times10^{-10}\times23.8\times12\times\frac{1}{2}\times\frac{34.6}{42.5}$ $= + .16$

$= + .195$

$-.137\times10^{-10}\times18.7\times12\times\frac{1}{2}\times\frac{6.2}{42.5}$ $= - .102$

$+ .78\times10^{-8}$

at ⑤

$\times\frac{7.9}{42.5}$ $= +.04\times10^{-8}$

$\times\frac{36.3}{42.5}$ $= -.13\times10^{-8}$

$-.137\times10^{-10}\times31.5\times12\times\frac{1}{2}\times\frac{46.5}{57}$ $= -.21\times10^{-8}$

$+.11\times10^{-10}\times25.5\times12\times\frac{1}{2}\times\frac{8.5}{57}$ $= +.03\times10^{-8}$

$-.27\times10^{-8}$

$\times\frac{10.5}{57}$ $= -.04\times10^{-8}$

$\times\frac{48.5}{57}$ $= +.22\times10^{-8}$

$+ .18\times10^{-8}$

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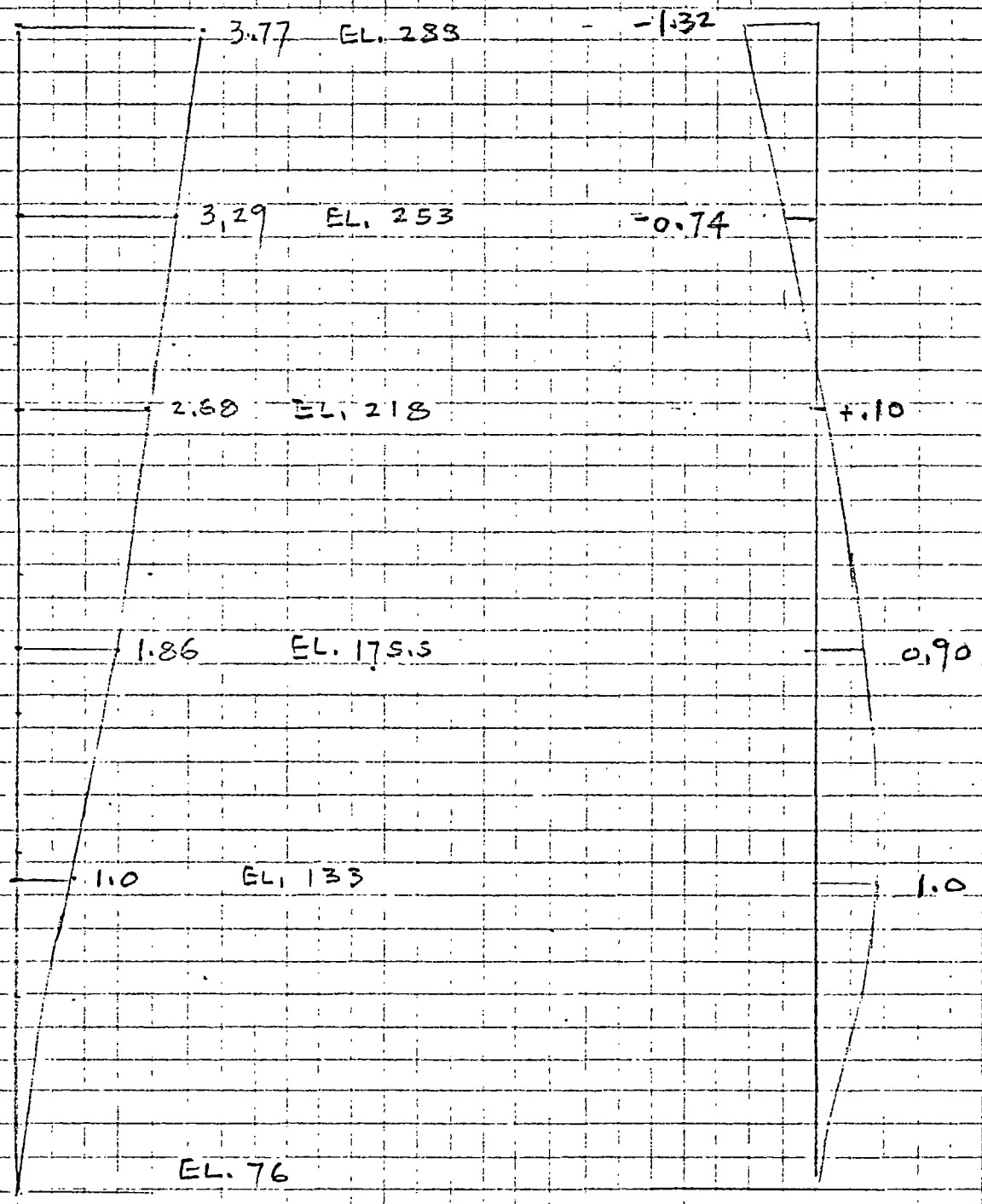
FILE CONTAINMENT
ESTIMATE

PREPARED BY F.S.
DATE
CHECKED BY
DATE



1ST MODE
w = 28.7
f = 4.57

2ND MODE
w = 83.7
f = 13.3

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FILE

ESTIMATE

COMPUTATION SHEET

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DATE

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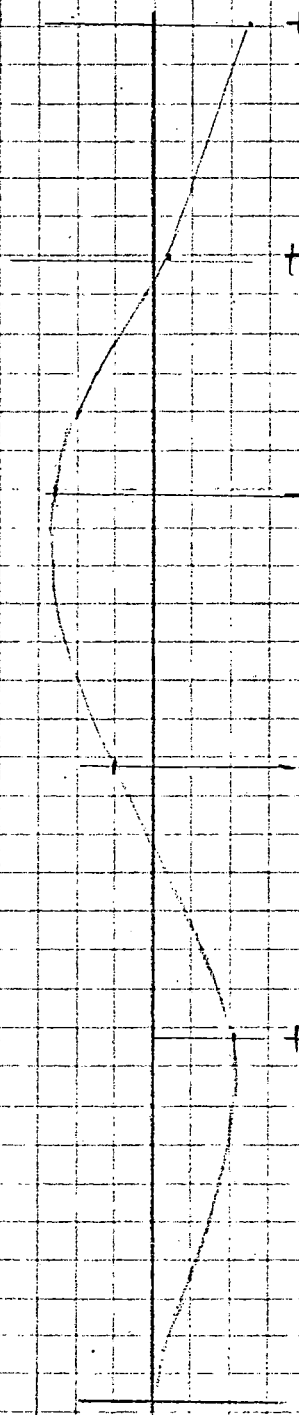
DATE



3RD MODE

w = 158

f = 25.2

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PARTICIPATION FACTORS

1ST MODE

$$\Gamma_1 = \frac{\Sigma M \phi}{\Sigma M \phi^2}$$

$$\Gamma_1 = \frac{11.15 \times 3.77 + 23.1 \times 3.29 + 28.5 \times 2.68 + 34.5 \times 1.86 + 40.5 \times 1.0}{11.15 \times 3.77^2 + 23.1 \times 3.29^2 + 28.5 \times 2.68^2 + 34.5 \times 1.86^2 + 40.5 \times 1.0}$$

$$= \frac{42.1 + 75.7 + 76.3 + 64.2 + 40.5}{159 + 249 + 205 + 119 + 40.5}$$

$$= \frac{298.8}{772.5} = .387$$

2ND MODE

$$\Gamma_2 = \frac{11.15 \times (-1.32) + 23.1 \times (-.74) + 28.5 \times .10 + 34.5 \times .9 + 40.5 \times 1.0}{11.15 \times 1.32^2 + 23.1 \times .74^2 + 28.5 \times .10^2 + 34.5 \times .9^2 + 40.5 \times 1}$$

$$= \frac{-14.7 - 17.1 + 2.85 + 31 + 40.5}{19.4 + 12.7 + 0.3 + 27.9 + 40.5}$$

$$= \frac{42.55}{100.8} = .42$$

3RD MODE

$$\Gamma_3 = \frac{11.15 \times 1.24 + 23.1 \times .13 + 28.5 \times (-1.27) + 34.5 \times (-.45) + 40.5 \times 1}{11.15 \times 1.24^2 + 23.1 \times .13^2 + 28.5 \times 1.27^2 + 34.5 \times .45^2 + 40.5}$$

$$= \frac{13.8 + 3.0 - 36.2 - 15.5 + 40.5}{17.1 + 0.39 + 46.1 + 7.0 + 40.5}$$

$$= \frac{5.6}{111.1} = .051$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

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SUBJECT Salem COMPUTATION SHEET DATE ____
FILE Containment CHECKED BY ____
ESTIMATE ____ DATE ____

ACCELERATIONS (RIGID BASE)

1ST MODE

S_a = .32g FOR .20g 5% Damping
S_a = .22g FOR .10g 2% Damping

		$\ddot{Y}$ for .20g 5% D.	$\ddot{Y}$ for .10g 2% D.
EL. 288	.32g x .387	x 3.77 = .467g	.22g x .387 x 3.77 = .321g
253		x 3.29 = .408g	x 3.29 = .280g
218		x 2.68 = .332g	x 2.68 = .229g
175.5		x 1.86 = .230g	x 1.86 = .158g
133		x 1.00 = .124g	x 1.00 = .085g

2ND MODE

S_a = .21g for .20g 5% D.
S_a = .10g for .10g 2% D.

		$\ddot{Y}$ for .20g 5% D	$\ddot{Y}$ for .10g 2% D.
EL. 288	.21g x .42	x 1.32 = .116g	.10g x .42 x 1.32 = .056g
253		x 0.74 = .066g	x 0.74 = .031g
218		x .010 = .009g	x .010 = .004g
175.5		x 0.90 = .079g	x 0.90 = .038g
133		x 1.00 = .088g	x 1.00 = .042g

3RD MODE

S_a = .20g for .20g 5% D.
S_a = .10g for .10g 2% D.

EL. 288	.20g x .051	x 1.24 = .013g	.10g x .051 x 1.24 = .006g
253		x 0.13 = .001g	x 0.13 = .001g
218		x 1.27 = .013g	x 1.27 = .006g
175.5		x 0.45 = .005g	x 0.45 = .002g
133		x 1.00 = .010g	x 1.00 = .005g

ONLY 2 CONTRIBUTING MODES, USE ABSOLUTE SUM

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Rocking ROTATIONAL AXIS EL. 30

WEIGHT :

DOME	17567 K
CYLINDER	44414 (FROM PG. 14 BY I.G.)
BASE MAT	42200
LEAD CONC.	75000
EL. 130 & WALLS UNDER	16000
EQMT:	6000 K
	201,200

p_s = SOIL BEARING PRESSURE

$$= \frac{201200 - 51600}{\pi \times 75^2} = 8.5\ ^{k}/_{ft^2}$$ (WITH BUOYANCY)

(11.4 WITHOUT B.)

$$I_M = \frac{1}{g}\left[38{,}000{,}000 + 17567 \times 224^2 + 190{,}000{,}000 + 4441 \times 117^2 + 60{,}000{,}000 + 42{,}200 \times 38^2 + \frac{75000}{12}(3 \times 7.5^2 + 30^2) + 9{,}000 \times (129-30)^2 + 7000 \times (89-36)^2 + 75000 \times 15^2\right]$$

$$= \frac{1}{g}\left[38 \times 10^6 + 870 \times 10^6 + 190 \times 10^6 + 606 \times 10^6 + 60 \times 10^6 + 61 \times 10^6 + 92 \times 10^6 + 89 \times 10^6 + 24.5 \times 10^6 + 17 \times 10^6\right]$$

$$= \frac{1}{g}\left[2038 \times 10^6\right]$$

$$r = \sqrt{\frac{2038 \times 10^6 \times \frac{1}{g}}{201.2 \times 10^3 \times \frac{1}{g}}} = \sqrt{10.15 \times 10^3}$$

$$T\ (.10g) = 9.5\sqrt{\frac{8.5 \times 10150}{15000 \times 32.2 \times 66.5}} = .49 \text{ sec}$$

(.57 sec W.O.B.)

$$T\ (.20g) = 9.5\sqrt{\frac{8.5 \times 10150}{8000 \times 32.2 \times 66.5}} = .67 \text{ sec}$$

(.78 sec W.O.B.)

WITH BUOYANCY MORE CRITICAL

(SEE RESP. SP.)

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DATE

ROCKING

ROTATIONAL AXIS EL. 45 CT. (LID)

WEIGHT :

DOME	17567 k
CYLINDER	44414
BASE MAT	42200
LEAN CONC.	75000
FL. EL. 130 & WALLS UNDER EQUIPMTS	16,000
	6,000
	201,200 k

(FROM PG. 14 BY I.G.)

p_s = SOIL BEARING PRESSURE

$$= \frac{201200 - 51600}{\pi \times 75^2} = 8.5 \ ^{k}/_{FT^2}$$ WITH BUOYANCY

(11.4 $^{k}/_{FT^2}$ WITHOUT B.)

$$I_M = \frac{1}{g}\left[38{,}000{,}000 + 17567 \times 209^2 + 190{,}000{,}000 + 44414 \times 102^2 + 60{,}000{,}000 + 42{,}200 \times 23^2 + \frac{75000}{12}(3 \times 75^2 + 30^2) + 9{,}000 \times (129-45)^2 + 7000 \times (89-45)^2\right]$$

$$= \frac{1}{g}\left[38 \times 10^6 + 768 \times 10^6 + 190 \times 10^6 + 473 \times 10^6 + 60 \times 10^6 + 22.5 \times 10^6 + 9213 \times 10^6 + 64 \times 10^6 + 13.6 \times 10^6\right]$$

$$= \frac{1}{g}\left[1722 \times 10^6\right]$$

$$r = \sqrt{\frac{1722 \times 10^6 \times \frac{1}{g}}{(201.2 - 6.0) \times 10^3 \times \frac{1}{g}}} = \sqrt{8.8 \times 10^3}$$

$$T(.10\,g) = 9.5\sqrt{\frac{8.5 \times 8800}{15000 \times 32.2 \times 66.5}} = .456 \text{ sec.}$$

(.528 W.O. B.)

$$T_{(.20\,g)} = 9.5\sqrt{\frac{8.5 \times 8800}{8000 \times 32.2 \times 66.5}} = .627 \text{ sec.}$$

(.725 W.O. B.)

WITH B. MORE CRITICAL

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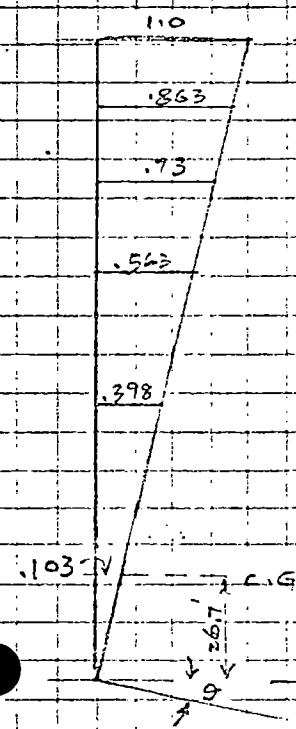
ROCKING (CONTINUED)



C.G. OF MAT, LEAN CONC. & WALL BETWEEN EL. 76 & EL. 104.5

$\bar{Y}$ (FROM EL. 30) APPROX.

$$= \left[\frac{(104.5-76)\times 44414^{K}}{142'} \times 60.25' + 42200^{K}\times 38' + 75000\times 15'\right] \div (8900 + 75000 + 42200)$$

$$= [535{,}000 + 1{,}600{,}000 + 1{,}125{,}000] \div 126{,}100 = 26.7'$$

$$M \text{ @ EL. } 56.7 = \frac{126{,}100}{386} = 326$$

I_M FOR MATS (PG. 14 I.G.)

$$= \frac{42200 + 75000 - 43700}{12g}(3\times 75^2 + 46^2) + \frac{73500}{g}\times 26.7^2$$

$$= 5.25 \times 10^6 \ K\,SEC^2$$

$$2\pi \times 258 = 1620 \qquad \theta = \frac{2\pi}{1620} = .00385$$

$$\Gamma = \frac{\Sigma M \phi}{\Sigma M \phi^2 + I\theta^2}$$

$$\Sigma M\phi = 134\times 1 + 278\times .863 + 353\times .73 + 413\times .563 + 434\times .398 + 326\times 12\times .103$$
$$= 134 + 240 + 258 + 233 + 193 + 402 = 1460$$

$$\Sigma M\phi^2 + I\theta^2 = 134 + 240\times .863 + 258\times .73 + 233\times .563 + 193\times .398 + 402\times .103 + 5.25\times 10^6 \times .00385^2$$
$$= 134 + 207 + 168 + 131 + 76 + 42 + 78 = 836$$

$$\Gamma = \frac{1460}{836} = 1.78$$

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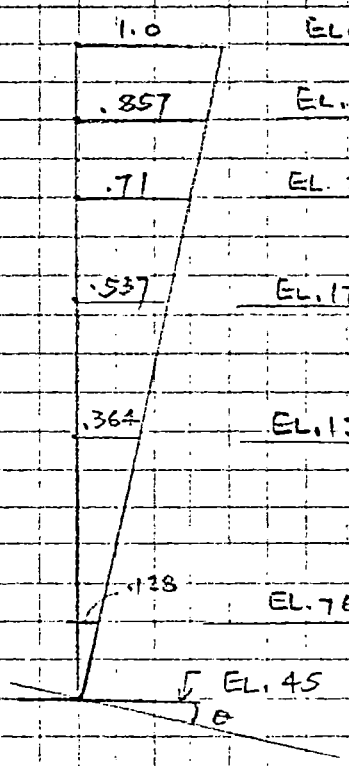
SUBJECT Salem N.G.S. COMPUTATION SHEET DATE 10, 2, 69

FILE CONTAINMENT CHECKED BY _____

ESTIMATE _____ DATE _____

ROCKING (CONTINUED)



M @ EL. 76

$$= \left[\frac{57'}{2} \times \frac{44414^{k}}{142'} + 42{,}200\right] \times \frac{1}{386}$$

$$= 132$$

I_M FOR BASE MATS

$$= \frac{42{,}200 + 75000 - 43700}{12g}\left(3 \times 75^2 + 46^2\right)$$

$$+ \frac{73500}{g} \times 8^2$$

$$= 3.76 \times 10^6 \ ^{K}\!\!\diagup_{SEC^2}$$

$2\pi \times 243' \times = 1525$

$1 : 1525 = \theta : 2\pi$

$$\theta = \frac{2\pi}{1525} = .00413$$

$$\Gamma = \frac{\Sigma M \phi}{\Sigma M \phi^2 + I\theta^2}$$

$\Sigma M\phi = (11.15 \times 1 + 23.1 \times .857 + 28.5 \times .71 + 34.6 \times .537 + 40.5 \times .364$
$+ 132 \times .128) \times 12$
$= (11.15 + 19.85 + 20.2 + 18.6 + 14.7 + 16.9) \times 12$
$= 101.40 \times 12 = 1218$

$\Sigma M\phi^2 + I\theta^2 = (11.15 + 17 + 14.35 + 10 + 5.35 + 2.15) \times 12$
$+ 3.76 \times 10^6 \times .00413^2$
$= 784$

$$\Gamma = \frac{1218}{784} = 1.55$$

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FILE Containment
ESTIMATE

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DATE
CHECKED BY
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Rocking

Accelerations due to Rocking

For .20g 5% D. T = .67 S_a = .23 g

For .10g 2% D. T = .49 S_a = .20 g

	$\ddot{Y}$ for .20g 5% D.	$\ddot{Y}$ for .10g 2% D.
El. 288	.23g × 1.78 × 1.0 = .41g ;	.20g × 1.78 × 1.0 = .357g ;
253	× .863 = .355g ;	× .863 = .31g ;
218	× .73 = .30g ;	× .73 = .262g ;
175.5	× .563 = .23g ;	× .563 = .201g ;
133	× .398 = .163g ;	× .398 = .143g ;
76	× .178 = .073g ;	× .178 = .064g ;

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DATE 10, 2, 69
CHECKED BY
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ROCKING

ACCELERATIONS DUE TO ROCKING

S_a = .23 g FOR .20 g 5% D

S_a = .15 g FOR .10 g 2% D

	$\ddot{X}$ for .20 g 5% D	$\ddot{X}$ for .10 g 2% D.
EL. 288	$.23^g \times 1.55 \times 1.0 = .357\ g$	$.20^g \times 1.55 \times 1.0 = .31\ g$
253	$\times .857 = .306$	$\times .857 = .264\ g$
218	$\times .71 = .253$	$\times .71 = .22\ g$
175.5	$\times .537 = .192$	$\times .537 = .167\ g$
133	$\times .364 = .130$	$\times .364 = .113\ g$
75	$\times .128 = .046$	$\times .128 = .04\ g$

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$S_a = .20g$

COMBINATION OF ROCKING & SHEAR MODES BY COMPLIMENTARY SYSTEMS

Rocking

$\Sigma M_i \phi_i^2 = 1$

$\phi_A = \dfrac{L_i}{\sqrt{\Sigma M_i L_i^2 + I}}$

.20g 5% DAMPING

.10g 2% "

C. of ROTATION EL. 30

Coordinate		L_i	M_i	$M_i L_i^2$	ϕ_A
1	EL. 288	258	134	8.92×10^6	.0341
2	EL. 253	223	278	13.55×10^6	.0294
3	EL. 218	188	353	12.58×10^6	.0248
4	EL. 175.5	145.5	413	8.72×10^6	.0192
5	EL. 133	103	484	5.12×10^6	.0136
6	EL. 56.7	26.7	3900	2.78×10^6	.0035
7				$I = 5.38 \times 10^6$	
				57.35×10^6	

$\phi_A = \dfrac{L_i}{\sqrt{57.35 \times 10^6}} = \dfrac{L_i}{7560}$

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REFER TO
SUBJECT Salem
FILE Containment
ESTIMATE

COMPUTATION SHEET

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COMBINE FIXED BASE MODES WITH ROCKING MODE ACCORING TO SALVADORI'S PROCEDU

FIXED BASE MODES RENORMALIZED

1ST MODE

Coord.		M_i	ϕ_1	$M\phi_1^2$	$M\phi_1'^2$	$\phi_1'^2$	ϕ_1'
1	EL 288	134	3.77	1910	0.203	.00151	.0388
2	253	278	3.29	3030	0.323	.00116	.0341
3	218	353	2.68	2540	0.270	.000763	.0276
4	175	413	1.86	1435	0.153	.000371	.0193
5	133	484	1.00	480	0.051	.000105	.0103
6	76						
				9395	1.000		

2ND MODE

Coord.		M_i	ϕ_2	$M\phi_2^2$	$M\phi_2'^2$	$\phi_2'^2$	ϕ_2'
1	EL 288	134	-1.32	233	0.193	.00144	-.0380
2	253	278	-0.74	152	0.126	.000452	-.0213
3	218	353	+.10	4	0.003	.000009	+.0030
4	175	413	+.90	334	0.277	.000672	+.0259
5	133	484	+1.00	484	0.401	.000827	+.0287
6	76						
				1207	1.000		

3RD MODE

Coord.		M_i	ϕ_3	$M\phi_3^2$	$M\phi_3'^2$	$\phi_3'^2$	ϕ_3'
1	EL 288	134	+1.24	207	0.153	.00114	+.0337
2	253	278	+0.13	5	0.004	.000014	+.0037
3	218	353	-1.27	572	0.424	.00120	-.0345
4	175	413	-0.45	84	0.062	.00015	-.0123
5	133	484	+1.00	484	0.357	.00074	+.0270
6	76						
				1352	1.000		

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REFER TO

SUBJECT Salem

FILE containment

ESTIMATE

COMPUTATION SHEET

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DATE

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DATE

$$b_j = \sum_{j=1}^{n} M_i \phi_A(i) \phi_j(i)$$

$b_1 = 134 \times .0341 \times .0388 + 278 \times .0294 \times .0341$
$+353 \times .0248 \times .0276 + 413 \times .0192 \times .0196$
$+484 \times .0136 \times .0103$

$= .177 + .278 + .242 + .155 + .068$

$= .92$

$b_2 = 134 \times .0341 \times (-.038) + 278 \times .0294 \times (-.0213)$
$+353 \times .0248 \times .0030 + 413 \times .0192 \times .0259$
$+484 \times .0136 \times .0287$

$= -.173 - .174 + .026 + .203 + .189$

$= +.071$

$b_3 = 134 \times .0341 \times .0337 + 278 \times .0294 \times .0037$
$+353 \times .0248 \times (-.0345) + 413 \times .0194 \times (-.0123)$
$+484 \times .0136 \times .0027$

$= .154 + .0302 - .302 - .098 + .18$

$= -.036$

.208

$\omega_A = \frac{2\pi}{T} = \frac{6.2832}{.67} = 9.35$ (pg 245)

$\omega_1 = 28.7$

$\omega_2 = 83.7$

$\omega_3 = 158$

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REFER TO
SUBJECT Salem
FILE Containment
ESTIMATE

COMPUTATION SHEET

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DATE
CHECKED BY
DATE

$$\frac{\omega_A^2}{\Omega_K^2} - 1 = \sum_{j=1}^{N} \frac{b_j^2}{\frac{\omega_j^2}{\Omega_K^2} - 1}$$

$$\frac{9.135^2}{\Omega_K^2} - 1 = \frac{.92^2}{\frac{28.7^2}{\Omega_K^2} - 1} + \frac{.071^2}{\frac{83.7^2}{\Omega_K^2} - 1} + \frac{.036^2}{\frac{158^2}{\Omega_K^2} - 1}$$

$$\frac{87.5}{\Omega_K^2} - 1 = \frac{.85}{\frac{825}{\Omega_K^2} - 1} + \frac{.00505}{\frac{7000}{\Omega_K^2} - 1} + \frac{.0013}{\frac{25000}{\Omega_K^2} - 1}$$

$\Omega_1^2 = 80$ $\Omega_2^2 = 5380$ $\Omega_3^2 = 25300$

$\Omega_1 = 8.96$ $\Omega_2 = 73.2$ $\Omega_3 = 159.2$

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REFER TO
SUBJECT Salem — COMPUTATION SHEET — PREPARED BY F. S. — DATE
FILE Containment — CHECKED BY — DATE
ESTIMATE

$$C_{kj} = \frac{b_j}{\frac{\omega_j^2}{\Omega_k^2} - 1} C_k$$

$$C_{11} = \frac{.92}{\frac{825}{80} - 1} C_1 = .0987\ C_1$$

$$C_{12} = \frac{.071}{\frac{7000}{80} - 1} C_1 = .00082\ C_1$$

$$C_{13} = \frac{-.036}{\frac{25000}{80} - 1} C_1 = -.000115\ C_1$$

$$87.5\ C_1^2 + 825 \times (.0987\ C_1)^2 + 7000 \times (.00082 C_1)^2 + 25000 \times (.000115 C_1)^2 = 80$$

$$87.5\ C_1^2 + 8\ C_1^2 + .0047\ C_1^2 + .00033\ C_1^2 = 80$$

$$C_1^2 = .84 \qquad C_1 = .917$$

$$C_{11} = .0905 \qquad C_{12} = .00075 \qquad C_{13} = -.000105$$

$$C_{21} = \frac{.92}{\frac{825}{5380} - 1} C_2 = -1.085\ C_2$$

$$C_{22} = \frac{.071}{\frac{7000}{5380} - 1} C_2 = -.237\ C_2$$

$$C_{23} = \frac{-.036}{\frac{25000}{5380} - 1} C_2 = -.00986 C_2$$

$$87.5\ C_2^2 + 825 \times (-1.085\ C_2)^2 + 7000 \times (.237\ C_2)^2 + 25000 (.00986 C_2)^2 = 5380$$

$$87.5\ C_2^2 + 970\ C_2^2 + 393\ C_2^2 + 2.4\ C_2^2 = 5380$$

$$C_2^2 = 3.7 \qquad C_2 = 1.93$$

$$C_{21} = -2.1 \qquad C_{22} = .458 \qquad C_{23} = -.019$$

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REFER TO

SUBJECT Salem

FILE Containment

ESTIMATE

COMPUTATION SHEET

PREPARED BY F. S.

DATE

CHECKED BY

DATE

$$C_{31} = \frac{.92}{\frac{825}{25300} - 1} C_3 = -.95\, C_3$$

$$C_{32} = \frac{.071}{\frac{7000}{25300} - 1} C_3 = -.098\, C_3$$

$$C_{33} = \frac{-.036}{\frac{25000}{25300} - 1} C_3 = +2.57\, C_3$$

$$87.5\, C_3^2 + 825 \times (-.95\, C_3)^2 + 7000\,(-.098\, C_3)^2 + 25000(+2.57\, C_3)^2 = 25300$$

$$87.5\, C_3^2 + 745\, C_3^2 + 67.3\, C_3^2 + 165000\, C_3^2 = 37000$$

$$C_3^2 = .153 \qquad C_3 = .39$$

$C_{31} = -0.371$

$C_{32} = -0.038$

$C_{33} = +1.01$

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REFER TO
SUBJECT Salem
FILE Containment
ESTIMATE

COMPUTATION SHEET

PREPARED BY F.S.
DATE
CHECKED BY
DATE

1ST COMBINED MODE

ψ_{11} = .917 x .0341 + .0905 x .0388 + .00075 x (-.038) - .000105 x .0337
= .0313 + .00351 = +.0348

ψ_{12} = .917 x .0294 + .0905 x .0341 + .00075 x (-.0213) - .000105 x .0037
= .0270 + .00309 = +.0301

ψ_{13} = .917 x .0248 + .0905 x .0276 + .00075 x .0030 - .000105 x (-.0345)
= .0228 + .0025 = +.0253

ψ_{14} = .917 x .0192 + .0905 x .0193 + .00075 x .0259 - .000105 x (-.0123)
= .0177 + .00175 = +.0195

ψ_{15} = .917 x .0136 + .0905 x .0103 + .00075 x .0287 = .000105 x .027
= .0125 + .00093 = +.0135

ψ_{16} = .917 x .0035 = +.0035

2ND COMBINED MODE

ψ_{21} = 1.93 x .0341 - 2.1 x .0388 + 0.458 x (-.038) - .019 x .0337
= .0658 - .082 - .0174 - .00064 = -.0342

ψ_{22} = 1.93 x .0294 - 2.1 x .0341 + .458 x (-.0213) - .019 x .0037
= .0567 - .072 - .0098 - .00007 = -.0252

ψ_{23} = 1.93 x .0248 - 2.1 x .0276 + .458 x .0030 - .019 x (-.0345
= .0478 - .058 + .00137 + .00066 = -.008

ψ_{24} = 1.93 x .0192 - 2.1 x .0193 + 0.458 x .0259 - .019 x (-.0123)
= .037 - .041 + .0119 + .00024 = +.008

ψ_{25} = 1.93 x .0136 - 2.1 x .0103 + .458 x .0287 - .019 x .027
= .0263 - .0216 + .0131 - .0005 = +.0193

ψ_{26} = 1.93 x .0035 = .0068

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REFER TO

SUBJECT Salem

FILE Containment

ESTIMATE

COMPUTATION SHEET

PREPARED BY F.S.

DATE

CHECKED BY

DATE

3RD COMBINED MODE

ψ_{31} = .39 x .0341 - .38 x .0388 - .038 x (-.038) + 1.01 x .0337

= .0133 - .0148 + .00144 + .0341 = +.0339

ψ_{32} = .39 x .0294 - .38 x .0341 - 0.038 x (-.0213) + 1.01 x .0037

= .0115 - .013 + .00081 + .0037 = +.0020

ψ_{33} = .39 x .0248 - .38 x .0276 - 0.038 x .0030 + 1.01 x (-.0345)

= .0097 - .0105 - .000114 - .035 = -.0357

ψ_{34} = .39 x .0192 - .38 x .0193 - 0.038 x .0259 + 1.01 x (-.0123)

= .0075 - .0074 - .00098 - .0124 = -.0133

ψ_{35} = .39 x .0136 - .38 x .0103 - 0.038 x .0287 + 1.01 x .027

= .0053 - .0039 - 0.00109 + .0273 = +.0276

ψ_{36} = .39 x .0035

= .00136

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FILE

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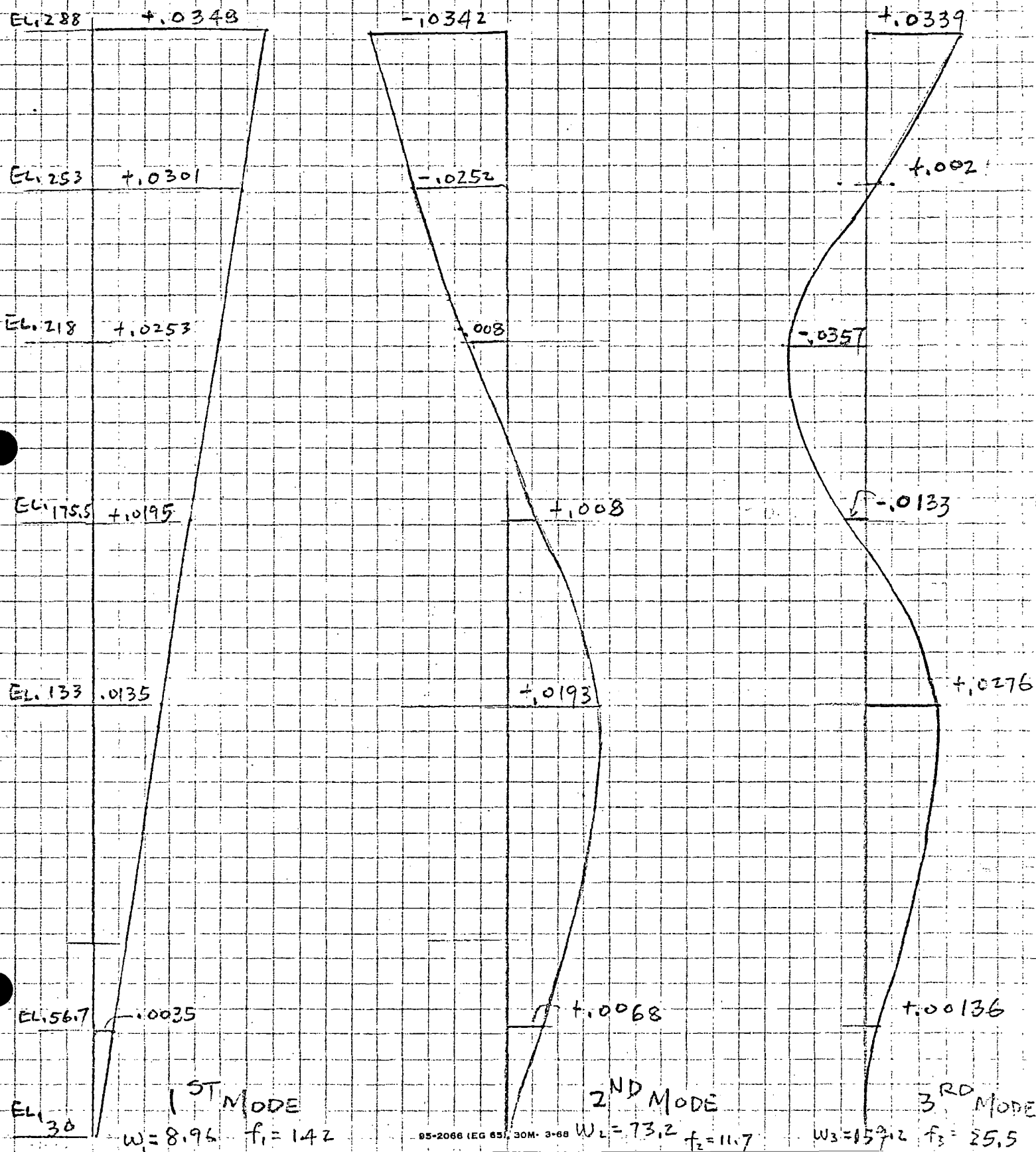
COMBINE MODE SHAPES (.20g & 5% D)



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REFER TO
SUBJECT Salem Containment COMPUTATION SHEET
FILE
ESTIMATE

PREPARED BY F.S.
DATE
CHECKED BY
DATE

.20g 5% D.

1st Combined Mode

Coord.		M_i	ψ_{i1}	$M_i\psi$	$\ddot{X}$
1	El. 288	134	+0.0348	4.69	.405 g
2	253	278	+0.0301	8.38	.350 g
3	218	353	+0.0253	8.93	.293 g
4	175	413	+0.0195	8.07	.226 g
5	133	484	+0.0135	6.55	.156 g
6	56.7	3900	+0.0035	13.70	.041 g
				50.32	

$f_1 = 1.42$ $S_a = .23g$

$\Gamma = 50.32$

$\ddot{X} = \psi_{i1} \times \Gamma \times S_a = 50.32 \times .23g \times \psi_{i1} = 11.6g\ \psi_{i1}$

2nd Combined Mode

Coord.		M_i	ψ_{i2}	$M_i\psi$	$\ddot{X}$
1	El. 288	134	-.0342	-4.60	.185 g
2	253	278	-.0252	-7.03	.136 g
3	218	353	-.008	-2.82	.043 g
4	175	413	+.008	+3.32	.043 g
5	133	484	+.0193	+9.38	.104 g
6	56.7	3900	+.00068	+26.50	.037 g
				24.75	

$f_2 = 11.7$ $S_a = .22g$

$\ddot{X} = \psi_{i2} \times 24.75 \times .22g = 5.4g\ \psi_{i2}$

3rd Combined Mode

Coord.		M_i	ψ_{i3}	$M_i\psi$	$\ddot{X}$
1	El. 288	134	+.0339	+4.55	.040 g
2	253	278	+.002	+0.55	.002 g
3	218	353	-.0357	-12.60	.042 g
4	175	413	-.0133	-5.50	.016 g
5	133	484	+.0276	+13.40	.032 g
6	56.7	3900	+.00136	+5.42	.002 g
				5.82	

$f_3 = 25.5$ $S_a = .20g$

$\ddot{X} = \psi_{i3} \times 5.82 \times .20g = 1.17g\ \psi_{i3}$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO

SUBJECT SALEM N.G.S. COMPUTATION SHEET

FILE

ESTIMATE

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DATE

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DATE

.20g 5% Damping

MAX. PROBABLE ACCELERATION

EL. 288 $\ddot{X} = \sqrt{.405^2 + .185^2 + .04^2}\ g = .45\ g$

or $\ddot{X} = .405 + .185 = .59\ g$ (.60g Conrad)

EL. 253 $\ddot{X} = \sqrt{.350^2 + .136^2 + .002^2 + \left(\frac{35}{214} \times .2\right)^2} = .38g$

or $\ddot{X} = \sqrt{(.350 + .136)^2 + .033^2} = .49\ g$

EL. 218 $\ddot{X} = \sqrt{.293^2 + .043^2 + .042^2 + \left(\frac{70}{214} \times .2\right)^2} = .296g$

or $\ddot{X} = \sqrt{.336^2 + .066^2} = .34g$

EL. 175 $\ddot{X} = \sqrt{.226^2 + .043^2 + .016^2 + \left(\frac{112.5}{214} \times .2\right)^2} = .253\ g$

or $\ddot{X} = \sqrt{.269^2 + .11^2} = .29\ g$

EL. 133 $\ddot{X} = \sqrt{.156^2 + .104^2 + .032^2 + \left(\frac{155}{214} \times .2\right)^2} = .239\ g$

or $\ddot{X} = \sqrt{.260^2 + .145^2} = .295\ g$

SHELL @ EL. 130 $\approx .29\ g$ (.28g Conrad)

SEISMIC SHEAR

@ EL.	WEIGHT (K)	SEISMIC COEF.	SHEAR	CUMMULATIVE SHEAR
EL. 288-0	4300	.59	2537 K	2537 K
253-0	8927	.49	4374	6911
218-0	11,009	.34	3743	10654
175-0	13,338	.29	3868	14522
133-0	15,600	.295	4602	19124
BASE EL. 76'-0	8,892	.20	1778	20902

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO
SUBJECT Salem
FILE
ESTIMATE

COMPUTATION SHEET

PREPARED BY F.S.
DATE
CHECKED BY
DATE

CONTAINMENT BLDG.

DEFLECTION @ Top .20 g 5% DAMPING

	1ST COMBINED MODE	2ND COMBINED MODE	3RD COMBINED MODE	
w RAD/SEC	8.96	73.2	159.2	
a IN/SEC²	.405 × 386 = 157	.185 × 386 = 71.5	.04 × 386 = 15.4	
U (IN.)	1.95"	.0133"	.00061"	

$$U = \frac{a}{w^2}$$

MAX. DEFL. at Top of DOME

$$= \sqrt{1.95^2 + .0133^2 + .00061^2} = 1.96"$$

@ El. 130

$$U \text{ 1st Mode} = \frac{.152 \times 386}{8.96^2} = .69$$

$$U \text{ 2nd Mode} = \frac{.100 \times 386}{73.2^2} = .007"$$

$$U \text{ 3rd Mode} = \frac{.030 \times 386}{159.2} = .0004$$

$$U = \sqrt{.69^2 + .007^2 + .00048^2} = .69$$

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FILE CHECKED BY

ESTIMATE DATE

(SEE P245) $T = .49$ SEC.

.10 g

$$W_A = \frac{2\pi}{T} = \frac{6.2832}{.49} = 12.82 \quad \text{(SEE P. 251)}$$

$W_1 = 28.7$

$W_2 = 83.7$

$W_3 = 158.0$

$$\frac{W_A^2}{\Omega_K^2} - 1 = \sum_{j=1}^{N} \frac{b_j^2}{\frac{W_j^2}{\Omega_K^2} - 1}$$

$$\frac{12.82^2}{\Omega_K^2} - 1 = \frac{.92^2}{\frac{28.7^2}{\Omega_K^2} - 1} + \frac{.071^2}{\frac{83.7^2}{\Omega_K^2} - 1} + \frac{.036^2}{\frac{158^2}{\Omega_K^2} - 1}$$

$$\frac{164.35}{\Omega_K^2} - 1 = \frac{.8464}{\frac{824}{\Omega_K^2} - 1} + \frac{.00504}{\frac{7006}{\Omega_K^2} - 1} + \frac{.0013}{\frac{24970}{\Omega_K^2} - 1}$$

$\Omega_1^2 = 140.05$ $\Omega_2^2 = 5625$ $\Omega_3^2 = 8080$

$\Omega_1 = 11.83$ $\Omega_2 = 75$ $\Omega_3 = 89.9$

$$C_{Kj} = \frac{b_j}{\frac{W_j^2}{\Omega_K^2} - 1} C_K$$

$$C_{11} = \frac{.92}{\frac{824}{140.05} - 1} C_1 = .1884\, C_1$$

$$C_{12} = \frac{.071}{\frac{7006}{140.05} - 1} C_1 = .00145\, C_1$$

$$C_{13} = \frac{-.036}{\frac{24970}{140.05} - 1} C_1 = -.000203\, C_1$$

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REFER TO S.N.G.S. PREPARED BY Y.C.

SUBJECT DATE

COMPUTATION SHEET

FILE CHECKED BY

ESTIMATE DATE

$$164.35\,C_1^2 + 824 \times (.1884\,C_1)^2 + 7006 \times (.00145\,C_1)^2 + 24970 \times (-.000203\,C_1)^2 = 140.05$$

$$164.35\,C_1^2 + 29.2475\,C_1^2 + 0.0147\,C_1^2 + 0.0010\,C_1^2 = 140.05$$

$$C_1^2 = 0.7233 \rightarrow C_1 = 0.8505$$

$C_{11} = 0.1602$ $C_{12} = 0.0012$ $C_{13} = -.000173$

$$C_{21} = \frac{.92}{\frac{824}{5625} - 1} C_2 = -1.0779\,C_2$$

$$C_{22} = \frac{.071}{\frac{7006}{5625} - 1} C_2 = 0.2892\,C_2$$

$$C_{23} = \frac{-.036}{\frac{24970}{5625} - 1} C_2 = -0.01047\,C_2$$

$$164.35\,C_2^2 + 824 \times (-1.0779\,C_2)^2 + 7006 \times (0.2892\,C_2)^2 + 24970 \times (-0.01047\,C_2)^2 = 5625$$

$$164.35\,C_2^2 + 957.3796\,C_2^2 + 585.9583\,C_2^2 + 3.7372\,C_2^2 = 5625$$

$$C_2^2 = 3.2887 \rightarrow C_2 = 1.8135$$

$C_{21} = -1.9548$ $C_{22} = 0.5245$ $C_{23} = -0.01899$

$$C_{31} = \frac{.92}{\frac{824}{8080} - 1} C_3 = -1.0245\,C_3$$

$$C_{32} = \frac{.071}{\frac{7006}{8080} - 1} C_3 = -0.5342\,C_3$$

$$C_{33} = \frac{-.036}{\frac{24970}{8080} - 1} C_3 = -0.0172\,C_3$$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO S.N.G.S. | PREPARED BY Y.C.

SUBJECT | COMPUTATION SHEET | DATE

FILE | CHECKED BY

ESTIMATE | DATE

$$164.35\,C_3^2 + 824 \times (-1.0245\,C_3)^2 + 7006 \times (-0.5342\,C_3)^2 + 24970 \times (-0.0172\,C_3)^2 = 8080$$

$$164.35\,C_3^2 + 864.8706\,C_3^2 + 1999.2997\,C_3^2 + 7.3871\,C_3^2 = 8080$$

$$C_3^2 = 2.5766 \longrightarrow C_3 = 1.6052$$

$C_{31} = -1.6445$ $\quad C_{32} = -0.8575$ $\quad C_{33} = -0.0276$

1st. COMBINED MODE

$\psi_{11} = 0.8505 \times .0341 + 0.1602 \times 0.0388 + 0.0012 \times (-0.0380) - 0.000173 \times 0.0337$

$= 0.0290 + 0.0062 = 0.0352$

$\psi_{12} = 0.8505 \times .0294 + 0.1602 \times 0.0341 + 0.0012 \times (-0.0213) - 0.000173 \times 0.0037$

$= 0.0250 + 0.0055 = 0.0305$

$\psi_{13} = 0.8505 \times .0248 + 0.1602 \times 0.0276 + 0.0012 \times 0.0030 - 0.000173 \times (-.0345)$

$= 0.0211 + 0.0044 = 0.0255$

$\psi_{14} = 0.8505 \times .0192 + 0.1602 \times 0.0193 + 0.0012 \times 0.0259 - 0.000173 \times (-.0123)$

$= 0.0163 + 0.0031 = 0.0194$

$\psi_{15} = 0.8505 \times .0136 + 0.1602 \times 0.0103 + 0.0012 \times 0.0287 - 0.000173 \times 0.0270$

$= 0.0116 + 0.0017 = 0.0133$

$\psi_{16} = 0.8505 \times .0035 = 0.0030$

2nd. COMBINED MODE

$\psi_{21} = 1.8135 \times .0341 + (-1.9548) \times 0.0388 + 0.5245 \times (-.038) - 0.01899 \times 0.0337$

$= 0.0618 - 0.0758 - 0.0199 - 0.0006 = -0.0345$

$\psi_{22} = 1.8135 \times .0294 + (-1.9548) \times 0.0341 + 0.5245 \times (-.0213) - 0.01899 \times 0.0037$

$= 0.0533 - 0.0667 - 0.0112 - 0.0001 = -0.0247$

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO S.N.G.S. | PREPARED BY Y.C.

SUBJECT | COMPUTATION SHEET | DATE

FILE | CHECKED BY

ESTIMATE | DATE

$\psi_{23} = 1.8135 \times .0248 + (-1.9548) \times 0.0276 + 0.5245 \times 0.0030 - 0.01899 \times (-.0345)$

$= 0.0450 - 0.0540 + 0.0016 + 0.0007 \quad = -0.0067$

$\psi_{24} = 1.8135 \times .0192 + (-1.9548) \times 0.0193 + 0.5245 \times 0.0259 - 0.01899 \times (-.0123)$

$= 0.0348 - 0.0377 + 0.0136 + 0.0002 \quad = 0.0109$

$\psi_{25} = 1.8135 \times .0136 + (-1.9548) \times 0.0103 + 0.5245 \times 0.028) - 0.01899 \times .027) 0$

$= 0.0247 - 0.0201 + 0.0151 - 0.0005 \quad = 0.0192$

$\psi_{26} = 1.8135 \times .0035 + 0 \quad = 0.0063$

3rd. COMBINED MODE

$\psi_{31} = 1.6052 \times .0341 - 1.6445 \times 0.0388 - 0.8575 \times (-.038) - 0.0276 \times 0.033)$

$= 0.0547 - 0.0638 + 0.0326 - 0.0009 \quad = 0.0226$

$\psi_{32} = 1.6052 \times .0294 - 1.6445 \times 0.0341 - 0.8575 \times (-.0213) - 0.0276 \times 0.003)$

$= 0.0472 - 0.0561 + 0.0183 - 0.0001 \quad = 0.0093$

$\psi_{33} = 1.6052 \times .0248 - 1.6445 \times 0.0276 - 0.8575 \times 0.0030 - 0.0276 \times (-.0345)$

$= 0.0398 - 0.0454 - 0.0026 + 0.0010 \quad = -0.0072$

$\psi_{34} = 1.6052 \times .0192 - 1.6445 \times 0.0193 - 0.8575 \times 0.0259 - 0.0276 \times (-.0123)$

$= 0.0308 - 0.0317 - 0.0222 + 0.0003 \quad = -0.0228$

$\psi_{35} = 1.6052 \times .0136 - 1.6445 \times 0.0103 - 0.8575 \times 0.028) - 0.0276 \times 0.027) 0$

$= 0.0218 - 0.0169 - 0.0246 - 0.0007) \quad = -0.0204$

$\psi_{36} = 1.6052 \times .0035 \quad = 0.0056$

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SUBJECT
FILE
ESTIMATE

COMPUTATION SHEET

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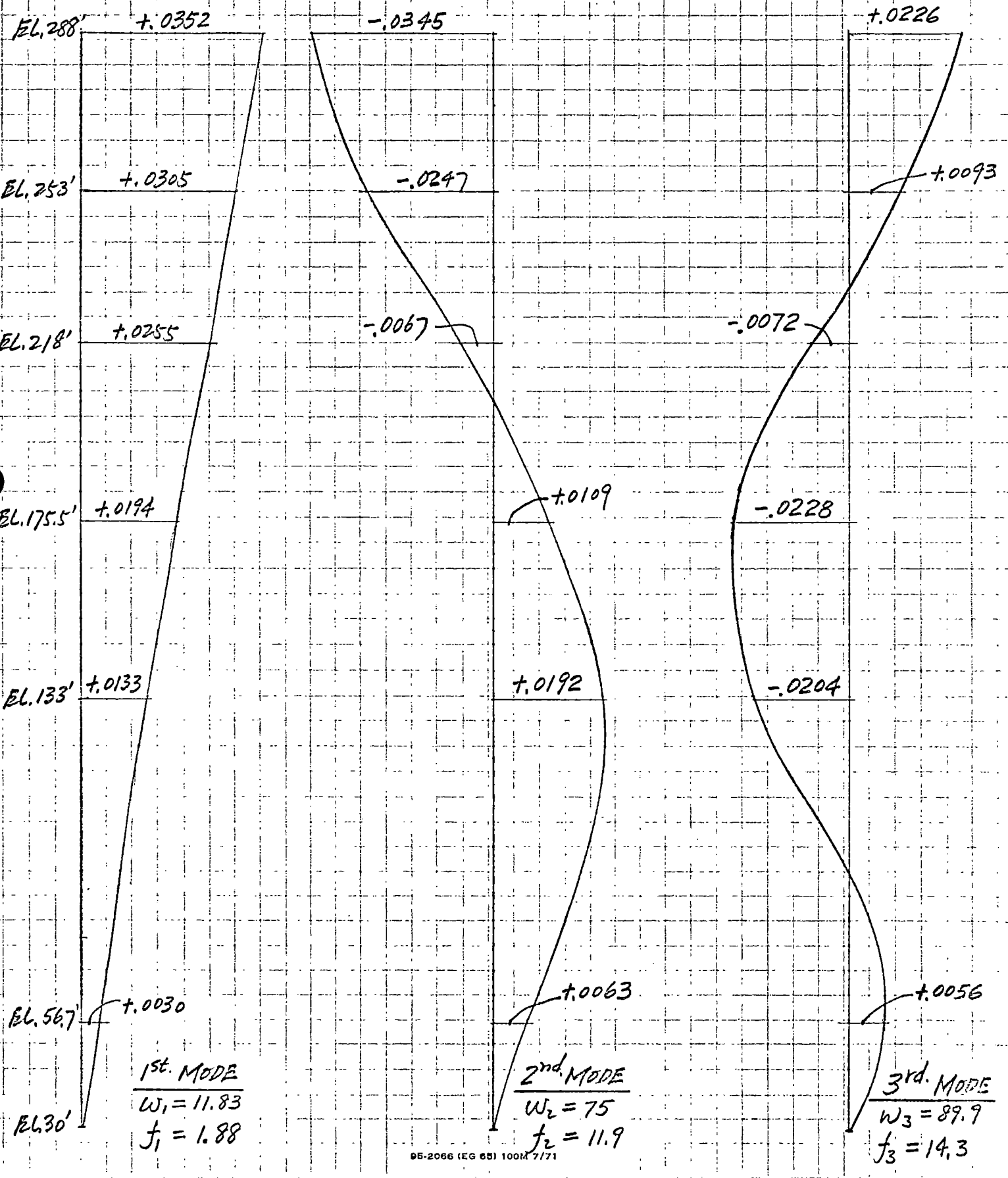
COMBINED MODE SHAPES (.10g & 2% D)



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ESTIMATE _____ DATE _____

.10 g 2 % D

1st. COMBINED MODE

COORD.		M_i	ψ_{i1}	$M_i\psi$	$\ddot{X}$
1	EL. 288	134	+.0352	4.72	.323 g
2	253	278	+.0305	8.48	.280 g
3	218	353	+.0255	9.00	.234 g
4	175	413	+.0194	8.01	.178 g
5	133	484	+.0133	6.44	.122 g
6	56.7	3900	+.0030	11.70	.028 g
				48.35	

$f_1 = 1.88$ $S_a = .19\,g$

$\ddot{X} = \psi_{i1} \times \Gamma \times S_a = 48.35 \times .19\,g \times \psi_{i1} = 9.19\,\psi_{i1}\,g.$

2nd. COMBINED MODE

COORD.		M_i	ψ_{i2}	$M_i\psi$	$\ddot{X}$
1	EL. 288	134	-.0345	-4.62	.110 g
2	253	278	-.0247	-6.87	.079 g
3	218	353	-.0067	-2.37	.021 g
4	175	413	+.0109	+4.50	.035 g
5	133	484	+.0192	+9.29	.061 g
6	56.7	3900	+.0063	+24.57	.020 g
				24.50	

$f_2 = 11.9$ $S_a = .13\,g$

$\ddot{X} = 24.50 \times .13\,g \times \psi_{i2} = 3.19\,\psi_{i2}\,g.$

3rd COMBINED MODE

COORD.		M_i	ψ_{i3}	$M_i\psi$	$\ddot{X}$
1	EL. 288	134	+.0226	3.03	.015 g
2	253	278	+.0093	2.59	.006 g
3	218	353	-.0072	-2.54	.005 g
4	175	413	-.0228	-9.42	.015 g
5	133	484	-.0204	-9.87	.014 g
6	56.7	3900	+.0056	21.84	.004 g
				5.63	

$f_3 = 14.3$ $S_a = .12\,g$

$\ddot{X} = 5.63 \times .12\,g \times \psi_{i3} = 0.676\,\psi_{i3}\,g.$

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SUBJECT | COMPUTATION SHEET | DATE

FILE | CHECKED BY

ESTIMATE | DATE

.10 g 2% DAMPING

MAX. PROBABLE ACCELERATION

EL. 288 $\ddot{X} = \sqrt{.323^2 + .110^2 + .015^2}\ g = .34\ g$

OR $\ddot{X} = .323 + .110 = .43\ g$

EL. 253 $\ddot{X} = \sqrt{.280^2 + .079^2 + .006^2 + \left(\frac{35}{214} \times .10\right)^2} = .29\ g$

OR $\ddot{X} = \sqrt{(.280 + .079)^2 + (.016)^2} = .36\ g$

EL. 218 $\ddot{X} = \sqrt{.234^2 + .021^2 + .005^2 + \left(\frac{70}{214} \times .10\right)^2} = .24\ g$

OR $\ddot{X} = \sqrt{(.234 + .021)^2 + (.033)^2} = .26\ g$

EL. 175 $\ddot{X} = \sqrt{.178^2 + .035^2 + .015^2 + \left(\frac{112.5}{214} \times .10\right)^2} = .19\ g$

OR $\ddot{X} = \sqrt{(.178 + .035)^2 + (.053)^2} = .22\ g$

EL. 133 $\ddot{X} = \sqrt{.122^2 + .061^2 + .014^2 + \left(\frac{155}{214} \times .10\right)^2} = .16\ g$

$\ddot{X} = \sqrt{(.122 + .061)^2 + (.072)^2} = .20\ g$

SEISMIC SHEAR

@ EL.	WEIGHT (K)	SEISMIC COEF.	SHEAR	CUMULATIVE SHEAR
EL. 288'-0	4,300 K	.43	1849 K	1849 K
EL. 253'-0	8,927	.36	3214	5063
EL. 218'-0	11,009	.26	2862	7925
EL. 175'-0	13,338	.22	2934	10859
EL. 133'-0	15,600	.20	3120	13979
BASE EL. 76'-0	8,892	.10	889	14868

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

REFER TO S.N.G.S. PREPARED BY Y.C.

SUBJECT DATE

COMPUTATION SHEET

FILE CHECKED BY

ESTIMATE DATE

.10 g 2% DAMPING

DEFLECTION @ TOP OF CONTAINMENT BLDG.

	1ST. COMBINED MODE	2nd. COMBINED MODE	3rd COMBINED MODE
w RAD/SEC	11.83	75	89.9
a IN/SEC^2	$0.323 \times 386 = 124.68$	$0.110 \times 386 = 42.46$	$0.015 \times 386 = 5.79$
u (IN.)	0.89"	0.0075"	0.00072"

$$u = \frac{a}{w^2}$$

MAX. DEFL. AT TOP OF DOME

$$= \sqrt{0.89^2 + 0.0075^2 + 0.00072^2} = 0.89"$$

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SUBJECT DATE

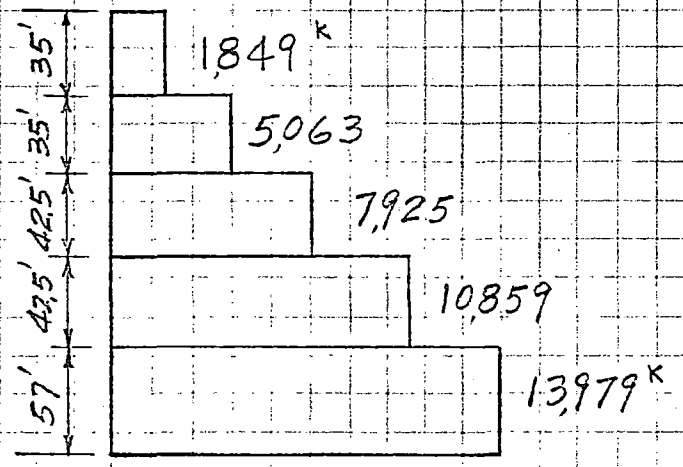
COMPUTATION SHEET

FILE CHECKED BY

ESTIMATE DATE

(SEE P. 260-7)

.10 & & 2% D.



SHEAR FOR 1.25 E = 1.25 × 13,979 K = 17,474 K

1,849 × 35 = 64,715 IK

5,063 × 35 + 64,715 = 241,920

7,925 × 42.5 + 241,920 = 578,733

10,859 × 42.5 + 578,733 = 1,040,241

13,979 × 57.0 + 1,040,241 = 1,837,044 IK

MOMENT FOR 1.25 E = 1.25 × 1,837,044 = 2,296,305 IK

2,296,305 IK < 2,356,700 IK (SEE P. 32)

< 2,357,600 IK (SEE P. 274)

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SUBJECT
FILE
ESTIMATE

COMPUTATION SHEET

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DATE
CHECKED BY
DATE

PREL. MODAL ANALYSIS

OVERTURNING MOMENT:

(a) .10g

$$M = 7900^{k} \times 178' + 1550^{k} \times 135' + 2530 \times 113.5 + 2120 \times 85' + 1720 \times 56.5' + 1330 \times 28$$

$$= 1,406,000 + 209,000 + 287,000 + 180,000 + 97,000 + 37,300 = 2,216,300 \text{ FT-k}$$

(2,380,000 T.Y. Lin)

(b) .20g

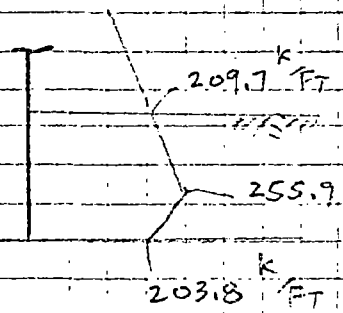
$$M = 11,250 \times 178 + 2220 \times 135 + 3640 \times 113.5 + 2990 \times 85' + 2540 \times 56.5 + 2040 \times 28$$

$$= 2,010,000 + 300,000 + 412,000 + 255,000 + 143,000 + 57,200 = 3,177,200 \text{ FT-k}$$

(3,940,000 T.Y. Lin)

$$f = \frac{3,177,200^{k} \times 74.5'}{5,400,000 \text{ FT}^4} = 44 \text{ k/FT}^2$$

$$F = 44 \text{ k/FT}^2 \times 4.5' = 198 \text{ k/FT}$$



← peak meridional force

Conrad DIAGRAM Fig 2-61

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SUBJECT S.N.G.S. COMPUTATION SHEET | DATE
FILE CONTAINMENT BLDG | CHECKED BY
ESTIMATE | DATE

FLOOR EL. 130

FLEXURE DEFLECTION

$$\Delta = \frac{\ell^3}{12EI} = \frac{54^3}{12\times3.4\times10^3\times144\times5.4\times10^6} = \frac{157000}{31.6\times10^{12}}$$

$$= 4.96\times10^{-9}\ \text{FT/K}$$

SHEAR DEFLECTION — SHEAR A (N-S) APPROX. $= 35\times3\times2 + 27\times3\times4 = 534\ \text{FT}^2$

$$\Delta = \frac{1.2H}{GA} = \frac{1.2\times5.2'}{.4\times3.4\times10^3\times144\times534} = 6.0\times10^{-7}\ \text{FT/K}$$

$K_F = 2.02\times10^8$ $\quad K_S = 1.66\times10^6$

$$\frac{1}{K_c} = \frac{1}{4.96\times10^{-9} + 6.0\times10^{-7}} = \frac{1}{6.05\times10^{-7}}$$

$K_c = 1.65\times10^6\ \text{K/FT}$

A OF SLAB $= \pi\times54.5^2 - 22\times65 - 4\times17\times15 - 4\times11\times11$

$= 9300 - 1430 - 1020 - 484 = 6366$

$$M = \frac{1}{32.2}\left[6366^{\square'}\times2'\times.15 + \pi\times109\times3\times26'\times.15 + 4\times100'\times26'\times.15\times2\right]$$

$= 280\ \text{K-SEC}^2/\text{FT}$

$$T = 2\pi\sqrt{\frac{M}{K}} = 2\pi\sqrt{\frac{280}{1.65\times10^6}} = .082\ \text{SEC.}$$

$S_a = .21g$

ROCKING $T = .627$ SEC FROM PG 12A

$S_a = .24g$ $\quad \ddot{Y}$ SIMILAR AS @ 4% PG 14A $= .157g$

TOTAL ABSOLUTE $\ddot{Y} = .21g + .157g = .367g$

" R.M.S. $\ddot{Y} = \sqrt{.21g^2 + .157^2} = .26g$

$.27g$ GIVEN BY T.Y. LIN

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SEISMIC REINFORCING STEEL

SEISMIC SHEAR TO BE TAKEN BY DIAGONAL BARS ONLY WITHOUT RELYING ON LINER PL & CONCRETE

MAX. BASE SEISMIC SHEAR (DBE) = 24000 K ± (PRELIM.)

TO FIND MAX UNIT SHEAR @ PERIMETER

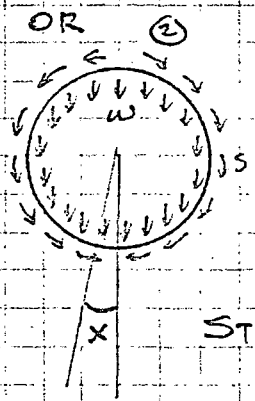
① $\text{MAX. } v = \frac{VQ}{Ib}$

$$= \frac{24000 \times (\frac{1}{2} \times \pi \times 74.5^2 \times .4244 \times 74.5 - \frac{1}{2} \times \pi \times 70^2 \times .424 \times 70}{5{,}400{,}000 \times 9'}$$

$$= \frac{24000 \times (276{,}000 - 227{,}000)}{48{,}600{,}000} = 24.4 \text{ K/FT}^2$$

$24.4 \times 4.5' = 110 \text{ K/FT}$

OR ②



$W = \frac{V}{\pi D} = \frac{24000}{\pi \times 149} = 51.5 \text{ K/FT}$

$S = 2W \sin X \qquad X = 90°$

$S_{max} = 2W = 2 \times 51.5 = 103 \text{ K/FT}$

STRESS IN DIAG. BARS 45° WITH HORIZ. PL.

1 #18 Alternate with 2 - #14 @ 16" (HORIZ.)

$A = \frac{4 + 2 \times 2.25}{3} = 2.83 \square''$ PER 16" (HORIZ.)

$110 \text{ K/FT} \times 1.33 = 147 \text{ K/FT}$

$147 \div (2 \times \sin 45°) = 104 \text{ K/PER 16"}$

$104 \div 2.83 = 36.7 \text{ K/}\square''$

TO TAKE ACCOUNT ON TORSIONAL EFFECT OF GROUND MOTION REF. "TORSION IN SYMMETRICAL BLDG. BY N. M. NEWMARK

$e/a = .24$ allow $e = \frac{1}{4} \times 149 = 37.25'$

$T = 24000 \times 37.25 = 894000 \text{ ft-k}$

$S = \frac{2 \times T r_1}{\pi (r_1^4 - r_0^4)} = \frac{2 \times 894000 \times 74.5}{\pi (74.5^4 - 70^4)} = \frac{133{,}200{,}000}{21{,}300{,}000}$

$= 6.25 \text{ K/FT}^2 = 43.4 \text{ PSI}$

$43.4 \times 54 \times 12 = 28123 \text{ \#/FT} = 28.1 \text{ K/FT}$

COMBINED STRESS IN DIAG. BARS

$\frac{147 + 28.1}{2 \times \sin 45°} \times \frac{1}{2.83} = 43.8 \text{ K/}\square''$

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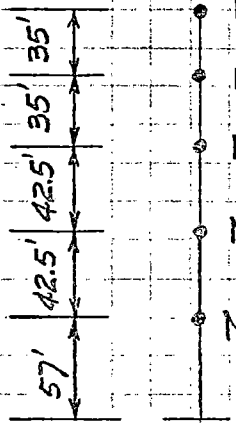
HORIZONTAL EARTHQUAKE

.20g 5% DAMPING (SEE P.259)



M_1 = 134 KSEC²/FT.	EL. 288'	.59 × 32.2 = 19.0	= $\ddot{X}_1$
M_2 = 278	EL. 253	.49 × 32.2 = 15.8	= $\ddot{X}_2$
M_3 = 353	EL. 218	.34 × 32.2 = 10.9	= $\ddot{X}_3$
M_4 = 413	EL. 175.5	.29 × 32.2 = 9.3	= $\ddot{X}_4$
M_5 = 484	EL. 133.0	.26 × 32.2 = 8.4	= $\ddot{X}_5$
	EL. 76.0'		

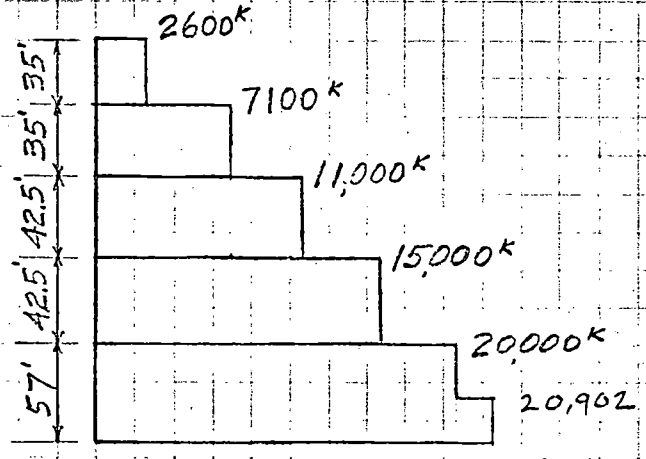
$M_1\ddot{X}_1 = 19.0 \times 134 = 2600^K$

$M_2\ddot{X}_2 = 16.0 \times 278 = 4500^K$

$M_3\ddot{X}_3 = 11.0 \times 353 = 3900^K$

$M_4\ddot{X}_4 = 9.3 \times 413 = 3900^K$

$M_5\ddot{X}_5 = 9.0 \times 484 = 4400^K$



SHEAR

(FOR SHEAR, 25660K WAS USED.)

$2600 \times 35 = 91{,}000^{IK}$

$7100 \times 35 + 91{,}000 = 340{,}000^{IK}$

$11{,}000 \times 42.5 + 340{,}000 = 808{,}000^{IK}$

$15{,}000 \times 42.5 + 808{,}000 = 1{,}446{,}000^{IK}$

$20{,}000 \times 57.0 + 1{,}446{,}000 = 2{,}586{,}000^{IK}$

MOMENT

(FOR MOMENT, 3,177,200 IK WAS USED. SEE P.270)

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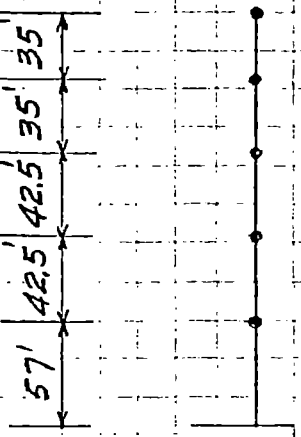
HORIZONTAL EARTHQUAKE



$M_1 = 134$ K SEC²/FT	EL. 288'	$.383 \times 32.2 = 12.3 = \ddot{X}_1$
$M_2 = 278$	EL. 253'	$.370 \times 32.2 = 11.9 = \ddot{X}_2$
$M_3 = 353$	EL. 218'	$.300 \times 32.2 = 9.7 = \ddot{X}_3$
$M_4 = 413$	EL. 175.5'	$.233 \times 32.2 = 7.5 = \ddot{X}_4$
$M_5 = 484$	EL. 133.0'	$.167 \times 32.2 = 5.4 = \ddot{X}_5$
	EL. 76.0'	

.10 & 2% DAMPING

(SEE CONRAD ASSO. P 2-77)

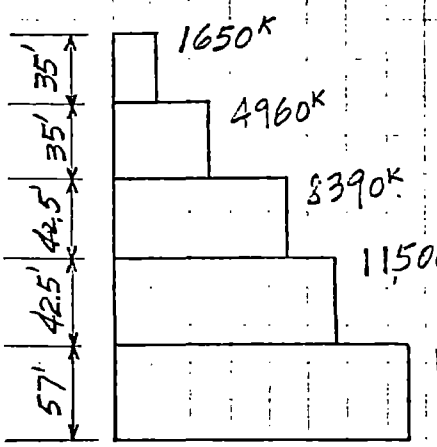
$12.3 \times 134 = M_1\ddot{X}_1 = 1650^K$

$11.9 \times 278 = M_2\ddot{X}_2 = 3310^K$

$9.7 \times 353 = M_3\ddot{X}_3 = 3430^K$

$7.5 \times 413 = M_4\ddot{X}_4 = 3100^K$

$5.4 \times 484 = M_5\ddot{X}_5 = 2620^K$



SHEAR

FOR 1.25E → $1.25 \times 14{,}200 = 17{,}750^K$

(SEE P. 32)

$1650 \times 35 = 57{,}750^{IK}$

$4960 \times 35 + 57750 = 231{,}350$

$8390 \times 42.5 + 231350 = 587{,}925$

$11500 \times 42.5 + 587{,}925 = 1{,}076{,}675$

$14200 \times 57.0 + 1{,}076{,}675 = 1{,}886{,}100^{IK}$

MOMENT

$1.25 \times 1{,}886{,}100 = 2{,}357{,}600^{IK}$

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SUBJECT
FILE
ESTIMATE

COMPUTATION SHEET

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DATE
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VERTICAL EARTHQUAKE (SEE CONRAD ASSO. P.2-76 & P.2-77)

.20 g 5% DAMPING

EL. 288'	.100 × 32.2	$= 3.22 = \ddot{X}_1$	$M_1\ddot{X}_1 = 134 \times 3.22 = 432^K$
EL. 253'	.229 × 32.2	$= 7.37 = \ddot{X}_2$	$M_2\ddot{X}_2 = 278 \times 7.37 = 2050^K$
EL. 218'	.271 × 32.2	$= 8.73 = \ddot{X}_3$	$M_3\ddot{X}_3 = 353 \times 8.73 = 3090^K$
EL. 175.5'	.268 × 32.2	$= 8.63 = \ddot{X}_4$	$M_4\ddot{X}_4 = 413 \times 8.63 = 3570^K$
EL. 133.0'	.258 × 32.2	$= 8.31 = \ddot{X}_5$	$M_5\ddot{X}_5 = 484 \times 8.31 = 4030^K$
EL. 76.0'			

.10 g 2% DAMPING

EL. 288'	.088 × 32.2	$= 2.84 = \ddot{X}_1$	$M_1\ddot{X}_1 = 134 \times 2.84 = 381^K$
EL. 253'	.099 × 32.2	$= 3.19 = \ddot{X}_2$	$M_2\ddot{X}_2 = 278 \times 3.19 = 887$
EL. 218'	.110 × 32.2	$= 3.55 = \ddot{X}_3$	$M_3\ddot{X}_3 = 353 \times 3.55 = 1254$
EL. 175.5'	.108 × 32.2	$= 3.48 = \ddot{X}_4$	$M_4\ddot{X}_4 = 413 \times 3.48 = 1438$
EL. 133'	.101 × 32.2	$= 3.26 = \ddot{X}_5$	$M_5\ddot{X}_5 = 484 \times 3.26 = 1578^K$