GULF STATES UTILITIES COMPANY
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AREA CODE 713 838-6631

November 16, 1984
RBG-19365
File Nos. G9.5

Mr. Harold E. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Denton:

River Bend Station Unit 1
Docket No. 50-458

This letter is Gulf States Utilities (GSU) response to your October 17, 1984 request for additional information concerning River Bend Station shear reinforcement design. Please find enclosed forty (40) copies of GSU's response to items 1 through 4. These responses were discussed with your Mr. H. Polk on October 23, 1984. If you have any additional questions please contact us.

Sincerely,

J E Booker

J. E. Booker
Manager-Engineering,
Nuclear Fuels & Licensing
River Bend Nuclear Group

JEB/JAE/BEH/lp

Attachment

cc: D. G. Eisenhut

B001
1/1

RESPONSE TO QUESTIONS RAISED BY THE NRC
ON REACTOR SHIELD BUILDING SHEAR REINFORCEMENT

Item 1

The demand for shear reinforcing in the shield building was reduced, not as a result of the concrete fill in 1981, but because the thermal conditions were redefined in 1980.

The original design (performed in 1974) assumed the accident condition peak pool temperature, 185°F, as the temperature in the annulus between the containment and the shield building. The design assumed, conservatively, a straight line temperature gradient zone 185°F inside of the shield building to 68°F on the outside soil (below el 95 ft 0 in.). Also, the foundation mat surface temperature at the shield building was conservatively assumed to be 90°F.

A revision to this design, performed in 1980 (prior to the 1981 decision on placing concrete fill between the shield building and containment) was based on a revised annulus space temperature of 170°F (see Attachment 1). The design used a 24-hour gradient, 153°F to 68°F, as a governing case (see Attachment 1) for the shield building below el 95 ft 0 in. (exposed to soil). Also, the surface temperature of the foundation mat at the shield building was revised to 153°F. This increase in the foundation mat surface temperature, combined with the reduction in the inside face design temperature of the shield building resulted in shears near the base of the shield building (el 70 ft 0 in. to el 79 ft) which were lower than the capacity of concrete, thus requiring no shear reinforcement.

Calculation No. 201.120-067, Revision 1 (Attachment 2), shows that the shield building design (prior to the concrete fill) is adequate without the shear reinforcement shown, as required by the 1974 calculations.

Item 2

Calculation No. 201.120-067, Revision 0 (1976), calculated shear reinforcement at el 70 ft 0 in. prior to the addition of the concrete fill to be .569 sq in. (see Attachment 3). This calculation was updated to include the boundary conditions from Calculation No. 201.120-096. Calculation No. 201.120-067, Revision 1 (Attachment 2), shows that no shear reinforcement at el 70 ft 0 in. is required.

With the addition of the concrete fill, the shield building and containment act compositely with the fill. To resist shear forces in this section, shear bars were added to the concrete fill, assuming that the Z bars in the shield building do not contribute to the shear resistance. This was done in Calculation No. 210.120-126, Revision 0, and for an additional load case in Calculation No. 201.120-126, Revision 1 (see Attachment 4).

Item 3

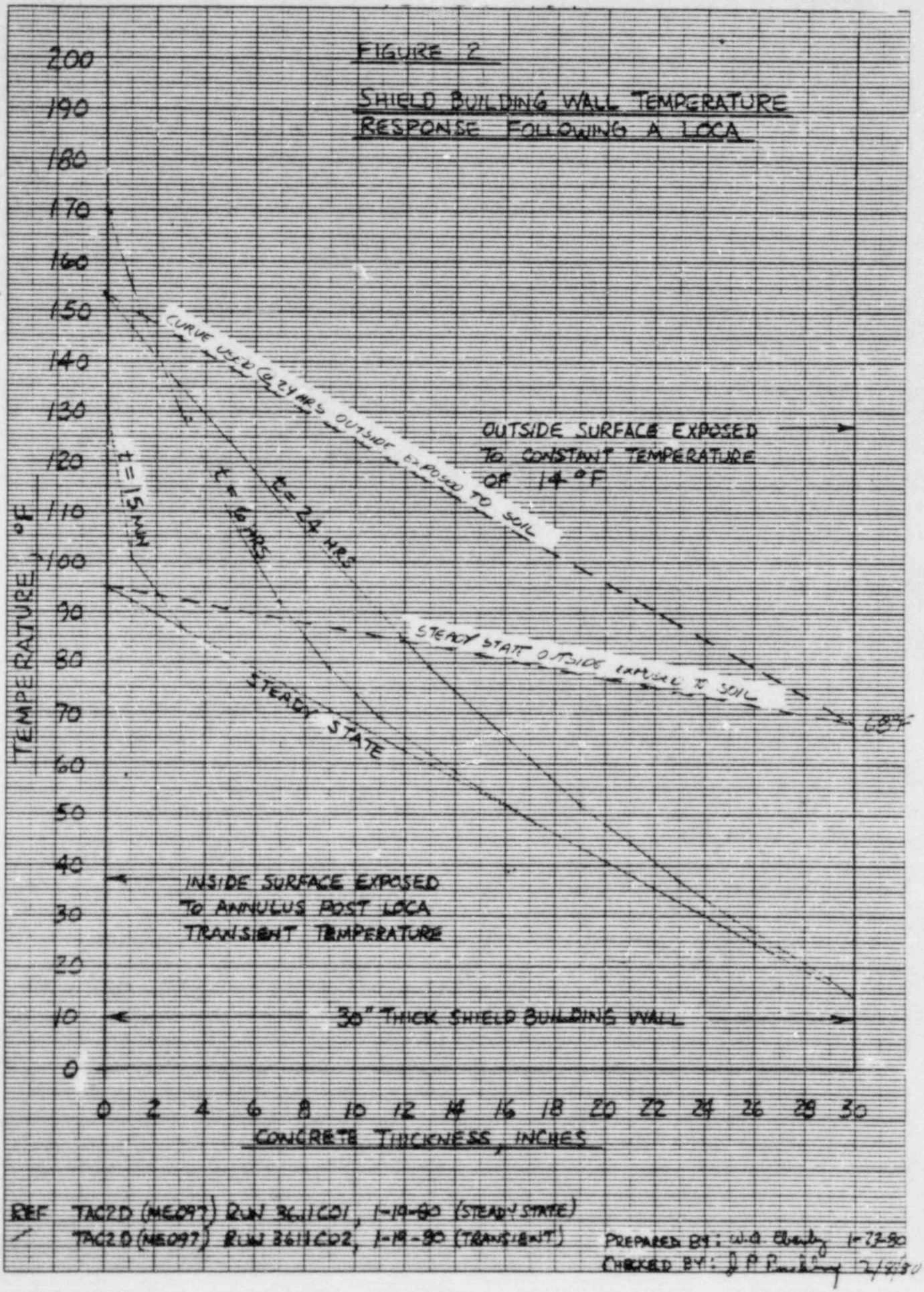
The out-of-plane shear forces in shell structures are the most critical at the structural and loading discontinuities. For the shield building, this occurred at the junction with the mat at el 70 ft 0 in. (before the concrete fill was added) and at the top of the annulus fill at el 95 ft 0 in. with the concrete fill in place.

The shield building is analyzed using the SHELL-1 computer code. The output of this analysis includes shear forces at approximately every 1 ft 0 in. elevation. This output is reviewed to ensure that the most critical sections are evaluated.

Item 4

Attachment 5 provides the results of the evaluation for loads at el 95 ft 0 in. from Calculation No. 201.120-126.

Attachments



REF TAC2D (ME097) RUN 3611C01, 1-19-90 (STEADY STATE)
TAC2D (ME097) RUN 3611C02, 1-19-90 (TRANSIENT)

PREPARED BY: W.A. Eberly 1-22-90
CHECKED BY: J.P. [illegible] 2/[illegible]/90

461510

K·E 10 X 10 TO THE CENTIMETER KEUFFEL & ESSER CO MADE IN U.S.A.

CALCULATION SHEET

STONE & WEBSTER ENGINEERING CORPORATION

ATTACHMENT 2 PLOF 3

A5010.01

J.O./W.O./CALCULATION NO.	REVISION	PAGE
12210.201.120-067	1	236

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
D Frowello / 5-29-84	A Paynter 5-29-84	A Paynter 5-29-84

SUBJECT/TITLE: SHIELD BUILDING - SHEAR @ BASE

QA CATEGORY/CODE CLASS: I

SHEAR - MAXIMUM AT BASE EL 70'-0"

FOR UNCRACKED CASE (REF. P 62)

LOAD CASE	N_i (K/Ft)	Q_i (K/Ft)	M_i (K-Ft/Ft)	
7 + SSE @ 0°	-20.22	16.75	+29.8	[CASE II]
10.2 - SSE @ 0°	+26.80	8.56	+66.8	
10.3 + SSE @ 0°	- 9.46	-14.23	+24.8	
10.3 + SSE @ 180°	-177.21	-28.79	-73.1	[CASE I]

FOR CRACKED CONCRETE (REF P. 134)

LOAD CASE	N_i (K/Ft)	Q_i (K/Ft)	M_i (K-Ft/Ft)	
10.2 - SSE @ 0°	16.49	4.59	+52.1	[CASE III]
10.3 + SSE @ 90°	-93.34	-10.5	+0.6	
10.3 + SSE @ 180°	-166.92	-14.39	-36.4	

NOTE: CRACKED CASES DO NOT INCLUDE SOIL PRESSURE - SOIL PRESSURE EXERTS A POSITIVE SHEAR AT THE BASE OF THE SHIELD BUILDING.

TO FIND SHEAR DUE TO SOIL PRESSURE ONLY, REF TO P. 111

10.2 (- SSE) WITH SOIL $Q_i = 15.65$ K/Ft

10.2 (- SSE) W/OUT SOIL $Q_i = 0.70$ K/Ft

DIFFERENCE $Q_s = 14.95$ K/Ft (SOIL ONLY)

CALCULATION SHEET

STONE & WEBSTER ENGINEERING CORPORATION

J.O./W.O./CALCULATION NO.	REVISION	PAGE
12210.201.120-067	1	237

A5010.61

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
DP Barnett / 5-29-84	A Paynter for 5-29-84	A Paynter for 5-29-84

SUBJECT/TITLE: SHIELD BUILDING - SHEAR @ BASE

QA CATEGORY/CODE CLASS: I

SHEAR - El 70'-0" (CONT)

CASE III BECOMES $Q_s = 4.59 + 14.95 = 19.54$ K/Ft

SRV LOADS (SEE ATTACH IV)

$N_s = \pm 18.6$ K/Ft $\quad Q_s = \pm 1.87$ K/Ft $\quad M_s = \pm 132$ K-Ft/Ft

LOCA LOADS (SEE ATTACH V)

$N_s = \pm 1.13$ K/Ft $\quad Q_s = \pm .08$ K/Ft $\quad M_s = \pm 0.5$ K-Ft/Ft

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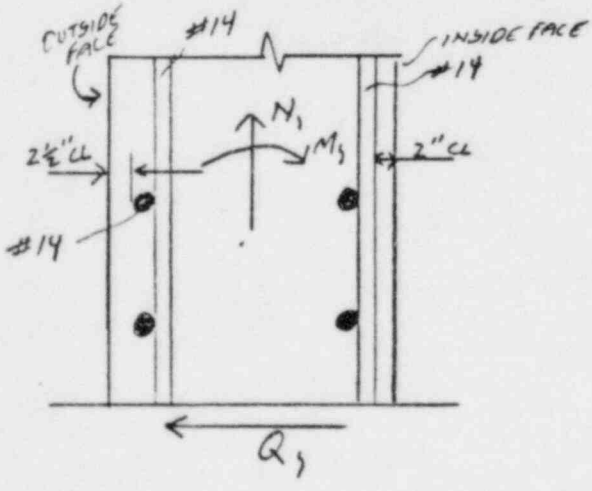
SHEAR STRESSES REF ACI 318-71 CHPT. 11



FOR M(+) $d = 25"$

FOR M(-) $d = 27"$

$b = 12"$

$f_c' = 3000$ PSI

CASE I $\quad N_s = -177.21 + 18.6 + 1.13 = -157.5$ K/Ft

$Q_s = -28.79 - 1.87 - .08 = 30.74$ K/Ft

$$v_u = \frac{V}{\phi b d} = \frac{30740}{.85(12)(27)} = 112 \text{ PSI}$$

ACI 318-71 EQ 11-6

$$v_c = 2\left(1 + .0005\frac{N_u}{A_g}\right)\sqrt{f_c'} = 2\left[1 + .0005\left(\frac{+157500}{12(30)}\right)\right]\sqrt{3000} = 133 \text{ PSI}$$

$v_c > v_u$ OK NO SHEAR REINF. REQ'D

CALCULATION SHEET

STONE & WEBSTER ENGINEERING CORPORATION

J.O./W.O./CALCULATION NO.	REVISION	PAGE
12210.201.120-067	1	238

A5010 61

PREPARER/DATE	REVIEWER/CHECKER/DATE	INDEPENDENT REVIEWER/DATE
DMcCulloch 5-29-84	A. Paynter for 5-29-84	A. Paynter for 5-29-84

SUBJECT/TITLE: SHIELD BUILDING - SHEAR @ BASE

QA CATEGORY/CODE CLASS: I

SHEAR - EL 70'-0" (CONT)

SHEAR STRESSES (CONT)

CASE II $N_1 = -20.22 + 18.6 + 1.13 = -0.49$

$Q_1 = 16.75 + 1.87 + .08 = 18.7^{K}/Ft$

$$N_u = \frac{18700}{.85(12)(25)} = 73.3 \text{ PSI}$$

$N_c = 2\sqrt{3000} = 109.5$ PSI

$N_c > N_u$ ∴ NO SHEAR REINF REQ'D

CASE III $N_1 = 16.49 + 18.6 + 1.13 = 36.22^{K}/Ft$

$Q_1 = 19.54 + 1.87 + .08 = 21.49^{K}/Ft$

$$N_u = \frac{21490}{.85(12)(25)} = 84.3 \text{ PSI}$$

ACI 318-71 EQ 11-8

$$N_c = 2\left(1 + .002\frac{N_u}{A_g}\right)\sqrt{F_c'}$$

$$= 2\left(1 + .002\left(\frac{-36220}{12(30)}\right)\right)\sqrt{3000} = 87.5 \text{ PSI}$$

$N_c > N_u$ ∴ NO SHEAR REINF REQ'D

A 5010.1D

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

Client G.S.U. Location RIVER BEND #1 Est. No. J.O. No. 12210

Subject ANALYSIS & DESIGN OF SHIELD BLDG. Date 7-26-76 By SLA

CHECK WALL FOR CONST. LOADS Checked 8-9-76 By MTS

Based on AT WALL - MAT JUNCTION. Revised By

TRY # 8 @ 1'-8" C/C (vertically)

$$A_v = 50\frac{b_w s}{f_y} = \frac{50 \times 12 \times 20}{40,000} = 0.3 \square''$$

$< 0.79 \square''/FT$ O.K.

(ACI 318-71, Eq. 11-1)

$$A_v = \frac{(v_u - v_c) b_w d}{f_y (\sin\alpha + \cos\alpha)}$$ (ACI 318-71, Eq. 11-14)

$$= \frac{(127.46 - 83.77) 12 \times 25.46}{40,000 \times \sqrt{2}}$$

$= 0.236 \square''$

$< 0.79 \square''$ (actual used) O.K.

Note - 1. Smaller size bars can be used but to maintain consistency use 6, # 8 @ 20" C/C (vertical spacing)

2. SEE SKETCH ON PAGE 26 of CALC. NO. 201.120-020

REV. 1

SUPERSEDED BY 236-238

A 2010 1D

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

Page No. 240
Preliminary 127
Item 201.120-067

Client G.S.U. Location R.R #1 Est No JO No 12210

Subject Analysis & Design of Shield Bldg Date 8-6-76 By [illegible]

Checked 8-9-76 By MJSheri

Based on LOADING 6 Revised By

+VE Radial Shear w/ SRV LOAD

$Q_E = 26.0^{K/FT}$

$N_E = 51.0^{K/FT}$

$V_c = 2\left(1 + \frac{.002(-51000)}{12 \times 30}\right)\sqrt{3000}$

$= 78.51$ psi

$V_u = \frac{26^K}{0.85 \times 12 \times 25.46} = 100.12$ psi.

$> V_c$

+VE Radial Shear w/o SRV

$Q_E = 23.0^{K/FT}$

$N_E = 37.2^{K/FT}$

$V_c = 2\left(1 + \frac{.002(-37.2)}{12 \times 30}\right)\sqrt{3000}$

$= 86.91$ psi

$V_u = \frac{23}{0.85 \times 12 \times 25.46} = 88.57$

$\simeq V_c$

O.K.

SUPERSEDED By 236-238 [REV. 1]

A 5010.1D

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

Page No. 241
Preliminary 128
Item 201.120-067

Client CECO Location R.P. #1 Est. No. J.O. No. 12212

Subject Loading Evaluation of Shield Bldg. Date 8-6-76 By JLA

Checked 8-9-76 By MJSeal

Based on LOADING 10 Revised By

Negative Radial Shear w/ SRV stuck open

$Q_\xi = -56.3^k/ft$

$N_\xi = 44.0^k/ft$

$V_c = 2\left(1 + \frac{.002(-44000)}{12 \times 30}\right)\sqrt{3000}$

$= 82.77$ psi.

$V_u = \frac{56.3^k}{0.85 \times 12 \times 25.46}$

$= 216.8$ psi

$V_u - V_c = 134.03$ psi.

$A_V = \frac{134.03 \times 12 \times 20}{40{,}000\sqrt{2}}$ — ACI 318-71 Eq. 11-15

$= \underline{0.569}\ \square''$

$< 0.79\ \square''$ provided.

O.K.

SUPERSEDED By 236-238 REV. 1

▲ 5010.65

JMF	1-5-82 CALCULATION IDENTIFICATION NUMBER API 1/22/82			
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST. M.	CALCULATION NO. 201.120-126	OPTIONAL TASK CODE	PAGE 302

8.6

SHEAR REINFORCING DESIGN

A 5010.66

7117 1-5-82 CALCULATION IDENTIFICATION NUMBER APE 1/22/82				
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST, M	CALCULATION NO. 201.120-126	OPTIONAL TASK CODE	PAGE 303

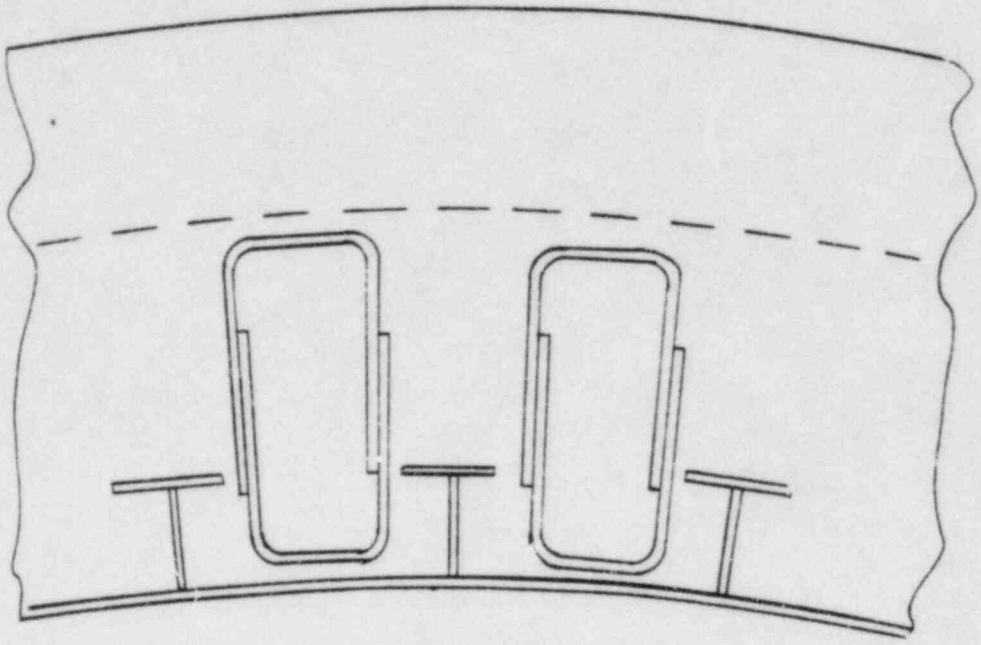
SHEAR FORCE SUMMARY

LOADING COMBINATION	ELEV.	M_{x1}	N_{x1}	Q_{x1}	COMMENTS
SERVICE LOADS (ASME 4)	70′	-1248.6	-250.8	-133.0	
	75′	-781.8	-221.8	-95.1	
	83′	-312.5	-198.4	-29.1	
10.1 SEA	70′	-1336.9	-292.4	-215.8	+SSE, SUMMER
		-996.0	-233.4	-184.5	-SSE, "
					", WINTER
	75′	-538.4	-260.4	-126.5	+SSE, SUM
		-324.0	-203.9	-104.2	-SSE, "
					", WINT
	83′	-81.4	-231.3	-16.3	+SSE, SUM
		+485.9	+102.8	+18.5	-SSE, "
					", WINT.
10.3 L.T. DBA	70′	-1439.3	-214.8	-191.4	6 HR
		-234.9	+43.4	-107.4	" "
		-1510.5	-214.8	-191.4	24 "
	75′	-663.4	-203.5	-114.1	6 HR
		+149.8	+47.5	-50.9	" "
		-422.7	-203.5	-118.9	24 HR
	83′	—	—	—	6 HR
		—	—	—	24 HR
11.3 L.T. D.BA. FACTORED LOADS	70′	-876.1	-25.4	-148.4	
	75′	-302.6	-19.1	-81.4	
	83′	+4.4	-9.2	-5.4	

▲ 5010.65

GMT 8/10/81 CALCULATION IDENTIFICATION NUMBER PPE 9/24/81				
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST.M.	CALCULATION NO. 201.120-126	OPTIONAL TASK CODE	PAGE 304

ASSUMED SHEAR REINFORCEMENT



PLAN

TRY:

#8's @ 6" c/c VERTICALLY	EL 40' TO EL 74'
#6's @ 12" c/c "	EL 74' TO EL 80'

GRADE 40 BARS

A 5010.85

JM7	1-5-82	CALCULATION IDENTIFICATION NUMBER API 1/22/82		
J.O. OR W.O. NO. 1221.0	DIVISION & GROUP ST/ST.M	CALCULATION NO. 201.120-176	OPTIONAL TASK CODE	PAGE 305

SERVICE LOAD SHEAR DESIGN

FOR SECTIONS IN COMPRESSION (CC-3431.3)

$$V_{c_1} \le \phi\left[1.9\sqrt{f'_c} + 2500\rho\left(V_u d/M'\right)\right]$$

$$V_{c_2} \le \phi\left[2\left(1 + .0005\,N_u/A_g\right)\sqrt{f'_c}\right] \quad \text{FOR } M' \ge 0$$

$$V_{c_3} \le \phi 3.5\sqrt{f'_c}\sqrt{1 + .002\,N_u/A_g} \quad \text{FOR } M' < 0$$

WHERE $\phi = 0.67$ WHEN THERMAL LOADS INCLUDED

$$M' = M_u - N_u\left[(4t - d)/8\right]$$

$t = 90"$

d = distance from compression fiber to tension centroid
$\approx 90" - 4" = 83" = 6.92'$
(4" = centroid of containment shell + stiffeners)

$$\therefore M' = M_u - N_u\left[(4(4.5) - 6.92)/8\right]$$

$$= M_u - 2.885\,N_u$$

$A_g \approx 90(12) = 1080\ in^2$

$$\epsilon \approx \frac{1\epsilon + 14.85}{1080} = .0304$$

$\therefore$ @ 40' $M' = 1248.6 - 2.885(250.8) = 525$ F-K

$$V_{c_1} = .67\left[(1.9)\sqrt{3000} + 2500(.0304)\left[(133)(6.92)/525\right]\right]$$

159.0 PSI

OR $V_{c_2} = .67(2)\left[1 + .0005\,\frac{250,800}{1080}\right]\sqrt{3000}$

$= 81.9$ PSI

BUT $V_{c_3} \le .67(3.5)\sqrt{3000}\sqrt{1 + .002\,\frac{250\,800}{1080}}$

$\le \underline{155.4}$ PSI ←

A 5010.66

JM7	1-5-82	CALCULATION IDENTIFICATION NUMBER API 1/22/82		
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST.M	CALCULATION NO. 201.120-126	OPTIONAL TASK CODE	PAGE 306

$v_u = V_u / bd$ (CC-3522)

HERE, ASSUME $d = 53''$, AS SHEAR REINF. CAN ONLY BE ADDED TO THE FIN REGION

$\therefore d = 60'' - 4'' = 53''$ (to stiff. + CTMT centroid)

$\therefore v_u = \frac{133{,}000}{12(53)} = \underline{209.1 \text{ PSI}}$

$v_u - v_c = 209.1 - 155.4 = 53.4 \text{ PSI}$

$A_v = 2(v_u - v_c)\, b\, s / f_y$ WHERE $s \leq .5d$

$b = 21''$
$s = 6''$

$A_v = 2(53.4)(21)(6)/40{,}000 = \underline{0.34 \text{ in}^2}$

$A_{\#8} = 0.79 \text{ in}^2 > 0.34 \text{ in}^2$ $\therefore$ OK

@ 45' $M' = 431.8 - 2.885(221.8) = 91.9$

$\therefore v_{c_1} = 434.4$

$v_{c_2} = 80.9$

$v_{c_3} = \underline{152.6 \text{ PSI}} \leftarrow$

$v_u = \underline{149.5 \text{ PSI}}$

$v_u - v_c < 0$ $\therefore$ NO ADD'L SHEAR REINF REQ'D

▲ 5010 85

JMF	1-5-82	CALCULATION IDENTIFICATION NUMBER API 1/22/82		
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST. M	CALCULATION NO. 201.120-126	OPTIONAL TASK CODE	PAGE 307

FACTORED LOAD SHEAR DESIGN

FOR SECTIONS IN COMPRESSION [CC-3421.4.1(b)]

$$v_{c_1} = 1.9\sqrt{f'_c} + 2500\,\rho\,(V_u d/M')$$

$$v_{c_2} = 2(1+.0005\,N_u/A_g)\sqrt{f'_c}$$

$$v_{c_3} = 3.5\sqrt{f'_c}\,\sqrt{1+.002\,N_u/A_g}$$

FOR SECTIONS IN TENSION

$$v_c = 2.0\sqrt{f'_c}\,(1+.002\,N_u/A_g) \qquad [CC-3421.4.1(c)]$$

N_u NEGATIVE

@ 40' CHECK THE FOLLOWING 2 COMBINATIONS

M_u	-1336.9	-876.1
N_u	-292.7	-25.4
V_u	-215.8	-148.4

(a) $M' = 1336.9 - (2.885)(292.7) = 492.5$

$v_{c_1} = 334.5$

$v_{c_2} = 124.4$

$v_{c_3} = \underline{\underline{238.1}}$ PSI ←

$v_u = V_u/.85\,bd$ (CC-3521.2.1)

$= \underline{\underline{399.2}}$ PSI

$v_u - v_c = \underline{161.1}$ PSI

▲ 5010.85

JMF 1-5-82	CALCULATION IDENTIFICATION NUMBER ADI 1/22/82			
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST.M	CALCULATION NO. 201.120-126	OPTIONAL TASK CODE	PAGE 308

(b) $M' = 876.1 - (2.885)(25.4) = 802.8$

$v_{c_1} = 201.3$

$v_{c_2} = 110.8$

$v_{c_3} = \underline{196.2 \text{ PSI}}$ ←

$v_u = \underline{274.5 \text{ PSI}}$

$v_u - v_c = \underline{78.3 \text{ PSI}}$

∴ USE $\underline{161.1 \text{ PSI}}$

$A_v = (v_u - v_c)\, b s / f_y$ (CC-3521.2.3)

$= (161.1)(21)(6)/40{,}000 = 0.51 \text{ in}^2$

#8 PROVIDED = $0.79 \text{ in}^2 > 0.51 \text{ in}^2$

∴ OK.

@ 75' CHECK THE FOLLOWING 2 COMBINATIONS

M_u	-538.4	+147.6
N_u	-260.4	+ 47.5
V_u	-126.5	- 50.9

(a) $M' = 538.4 - 2.885(260.4) = -212.9 < 0$

∴ $v_{c_3} = \underline{233.4 \text{ PSI}}$

$v_u = \underline{234.0 \text{ PSI}}$

▲ 5010 85

VRM	1-5-82	CALCULATION IDENTIFICATION NUMBER APT 1/22/32		
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST.M.	CALCULATION NO. 201.120-126	OPTIONAL TASK CODE	PAGE 209

$v_u - v_c = 0.6$

(b) $v_c = 2.0\sqrt{3000}\left(1 + .002\,\frac{-14{,}500}{1080}\right)$

$= \underline{99.9 \text{ PSI}}$

$v_u = \underline{94.2 \text{ PSI}}$

$v_u - v_c < 0$

$\therefore A_v = \frac{(0.6)(21)(12)}{40{,}000} = 0.004 \text{ in}^2$ (NEGLIGIBLE)

$\therefore$ #6's PROVIDED OK.

@ 83' - ALL OK BY INSPECTION

$\therefore$ SHEAR REINFORCING AS PROPOSED ON Pg 304 IS O.K.

SHEAR IN CONCRETE FILL @ EL 20'

N_{x_1} = -215.7 K/Ft
M_{x_1} = -1458.9 F-K/Ft
Q_{x_1} = -241.2 K/Ft

FROM Pgs 305 & 304

$$M' = M_u - 2.885 N_u = 1458.9 - (2.885)(215.7)$$
$$= 1136.6 \text{ F-K/Ft}$$

$$v_{c_1} = 1.9\sqrt{3000} + 2500(0.0304)\left(\frac{(241.2)(6.92)}{1136.6}\right)$$
$$= 215.7 \text{ PSI}$$ ←

$$v_{c_2} = 2\left(1 + .0005\,\frac{215.709}{1080}\right)\sqrt{3000}$$
$$= 120.5 \text{ PSI}$$

$$v_{c_3} = 3.5\sqrt{3000}\ \sqrt{1 + .002(215.709/1080)}$$
$$= \underline{226.8 \text{ PSI}}$$

$$v_u = \frac{241,200}{12(53)(.85)} = \underline{446.2 \text{ PSI}}$$ ①

$$v_u - v_c = 230.5 \text{ PSI}$$

$$A_v = (230.5)(21)(6)/40,000 = 0.73 \text{ in}^2$$

#8 PROVIDED = 0.79 in² > 0.73 in²

∴ OK

① CHECKER'S NOTE: ACTUALLY N_u WILL BE LESS AS D = 83", BUT D OF 53" IS USED SINCE ONLY THE STIRRUPS IN THE CONCRETE FILL ARE ACCOUNTED FOR D/F

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

ATTACHMENT 5
P1 OF 3

▲ 5010-65

9117	1-6-82 CALCULATION IDENTIFICATION NUMBER API 1/22/82			
J.O. OR W.O. NO. 12210	DIVISION & GROUP ST/ST.M	CALCULATION NO. 301.120-126	OPTIONAL TASK CODE	PAGE 310

CHECK SHEAR AT EL 95' ON SHIELD BUILDING

LOAD CASE	M_{x1}	N_{x1}	Q_{x1}	
10.2 6 HR	254.8	2.8	21.0	← TENSION ②
	250.4	-169.1	14.8	
24 HR	247.8	4.2	19.8	
	242.9	-188.2	16.2	
ASME 4	50.4	-10.8	5.8	← COMPRESSION SPECIAL
	-39.6	-112.2	3.2	CASE ④
	-35.0	-37.0	2.4	
	-24.2	-138.9	-0.2	
11.3	275.5	-65.8	21.4	← COMPRESSION ①
10.1 +SSE, SUMMER	234.7	16.9	19.8	← TENSION ③
	237.5	-156.3	17.6	
	219.3	-9.3	16.4	
	222.1	-182.5	14.2	

FOR SECTION IN COMPRESSION - CASE ①

$$V_{c_1} = 1.9\sqrt{f'_c} + 2500\rho_w \frac{V_u d}{M_m} \qquad \text{(ACI 11.4.2 \& 11.4.3)}$$

$$M_m = M_u - N_u\left(\frac{4h-d}{8}\right)$$

OR $$V_{c_2} = 2\left(1 + .0005\frac{N_u}{A_g}\right)\sqrt{f'_c}$$

BUT $$V_{c_3} \le 3.5\sqrt{f'_c}\sqrt{1 + .002\,N_u/A_g}$$

$d = 25'' = 2.083'$

$\rho_w = (4.50\,in^2)/(12)(25) = 0.0150$

$M_m = (275.5) - 65.8\left(\frac{4\times2.5 - 2.083}{8}\right) = 210.4$

▲ 5010.85

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$$\therefore v_{c_1} = 1.9\sqrt{3000} + 2500(.0150)\frac{(65.8)(2.083)}{10.4}$$

$$= 128.5 \text{ PSI}$$

$$v_{c_2} = 2\left(1 + .0005\frac{65,800}{(12)(30)}\right)\sqrt{3000}$$

$$= 119.6 \text{ PSI}$$

$$v_{c_3} = 3.5\sqrt{3000}\sqrt{1 + .002\frac{65,800}{12(30)}}$$

$$= 224.0 \text{ PSI}$$

$\therefore$ USE $v_c = 128.5$ PSI

$$v_u = V_u/\phi bd \qquad \text{(ACI 11.2.1)}$$

$$= \frac{21,400}{(.85)(12)(25)} = 83.9 \text{ PSI}$$

$v_u < v_c \quad \therefore$ OK.

FOR SECTIONS IN TENSION

$$v_c = 2\left(1 + .002\frac{N_u}{A_g}\right)\sqrt{f'_c} \qquad \text{(ACI 11.4.4)}$$

CASE ②

$$v_c = 2\left(1 + .002\frac{-3800}{12(30)}\right)\sqrt{3000} = 107.2 \text{ PSI}$$

$$v_u = 21,000/255 = 82.4 \text{ PSI}$$

$v_u < v_c \quad \therefore$ O.K.

A 5010.155

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CASE ③

$v_c = 99.3$ PSI

$v_u = 44.6$ PSI

$v_u < v_c$ ∴ O.K.

CASE ④ - SECTION IS SUBJECT TO COMPRESSION AND SHEAR, BUT WAS GENERATED VIA SERVICE LOADS, WITHOUT LOAD FACTORS. ∴ THIS CASE WILL BE ANALYSED USING THE "ALTERNATE DESIGN METHOD" AS GIVEN IN THE 1944 ACI CODE (ACI 318-44), APPENDIX B.

$$v = \frac{V}{bd} = \frac{5,800}{(12)(25)} \qquad (B.7.1)$$

$$= 19.3 \text{ PSI}$$

$$v_c = 1.1\left(1 + .0006\frac{N}{A_g}\right)\sqrt{f'_c} \qquad (B.7.4.5)$$

$$= 1.1\left(1 + .0006\left(\frac{10,800}{12(30)}\right)\right)\sqrt{3000}$$

$$61.3 \text{ PSI}$$

$v_u < v_c$ ∴ O.K.

NOTE - IN EACH CASE ABOVE MINIMUM SHEAR REINFORCEING, AS REQ'D BY ACI 318-71 SECTION 11.1.1 FOR $v_c > v_u > \frac{1}{2}v_c$, HAS NOT BEEN PROVIDED FOR THE FOLLOWING REASON: THE SHIELD BLDG. IS A SHELL, AND NOT A "CONCRETE FLEXURAL MEMBER". HOWEVER, IF ONE CONSIDERS IT AS A WALL, SECTION 11.16.6 SAYS TO DESIGN AS A SLAB. SLABS, THOUGH, ARE EXEMPT FROM THE MINIMUM REQUIRED SHEAR AREA PROVISION [SECTION 11.1.1(a)].