Client: Wisconsin Public Service Corporation Calculation No. C-007

Title: Seismic Capacity of Diesel Generator Day Tank Block Wall

Project: Kewaunee A46

Method: CDFM analysis to produce a HCLPF seismic level.

Acceptance Criteria: N/A

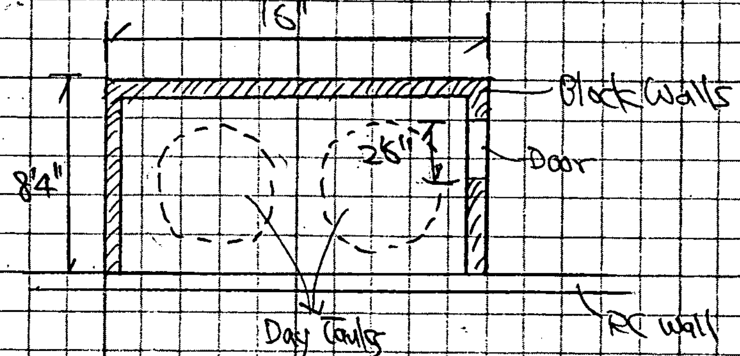
Remarks:

REVISIONS							
No.	Description	By	Date	Chk.	Date	App.	Date
0	Initial Issue	MSLi	11/1/93	TMT	11/24/93		

S&A Stevenson and Associates	CALCULATION COVER SHEET FIGURE 1.3	CONTRACT NO. 91C2683

Seismic Analysis of Block Wall

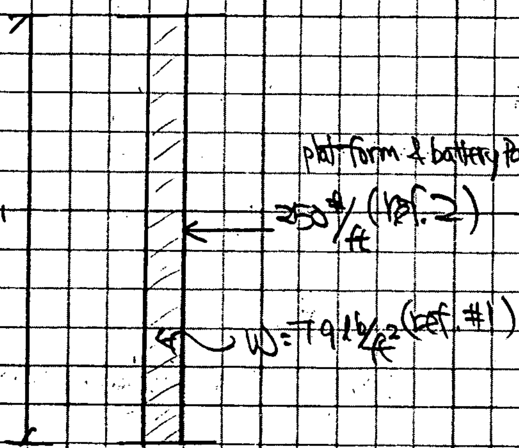
The Diesel Generator Day Tanks are enclosed by three lightly reinforced non-load bearing block wall and one RC wall as shown below.

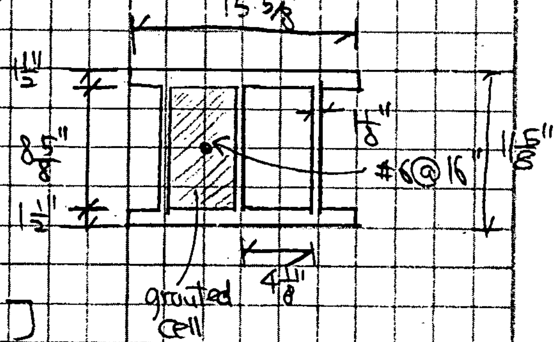


A HCLPF analysis of the block walls is performed here. The HCLPF will be defined in terms of a Peak Ground Acceleration (PGA) associated with a LLNL 0.306 G motion. This motion was used to generate the existing FRS at Mass Point 27 as shown in page 6 & 7.

The walls have been re-analyzed previously, documented in Refs. 1 & 2 and have been deemed of adequate strength. The previous analysis was considered the walls as unreinforced non-load bearing block walls. The calculation here is considered that the walls are non-loaded bearing but reinforced.

Ref: ① Calculation No. S-B01-BLD-001, IE Bulletin 80-11, Masonry Walls, Response to NRC Inquiry, Feb 22, 1983, Project No. 834708 by Flour Power Service Inc.
② "Block Wall Re-evaluation for DCR-1432" Project # 834734 Jan 29, 1985 by Fluor Engineers, Inc. Power Division.
③ Drawing No. S510.
④ "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)" EPRI NP-6041-SL, Appendix R, Aug. 1991





[Ref. #1]
Hori. Reinforcement
Extra Heavy weight Dur-O-wall @ 24" on center
Vertical Reinforcement
6 @ 16" on center ASTM A-615 Grade 60
Masonry Wall
$f_m' = 1350$ psi per. UBC-67

(A) Ultimate Moment Capacity

The wall is assumed to span vertically and is simply supported at top and bottom

Nominal ultimate moment capacity M_u

$$M_u = A_s f_y \left[d - \frac{a}{2}\right] \quad \text{where } a = \frac{A_s f_y}{0.85 f_m'}$$

For the DG Day Tank wall

$$A_s = \frac{0.44\,in^2}{16\,in} = 0.0275\,in^2/in, \quad d = \frac{15.625}{2} = 7.8125\,in$$

Thus

$$a = \frac{0.0275 \times 60 \times 10^3}{0.85 \times 1350} = 1.438\,in, \quad c = \frac{a}{0.85} = \frac{1.438}{0.85} = 1.69" > 1.5"$$

Use $c = 1.5"$, $a = 0.85c = 1.275"$, $f_s = \frac{a\,0.85 f_m'}{A_s} = 53.2$ ksi

$$M_u = 0.0275 \times 53.2 \times \left[7.8125 - \frac{1.275}{2}\right] = 10.50\ \frac{kip\text{-}in}{in}$$

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Seismic Capacity of Diesel Generator Day Tanks Block Wall

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REVISIONS: 0 — MSL 11/1/93, TMT 11/20/93

$M_{CDFM} = \Phi_{CDFM} M_u$

Using $\Phi_{CDFM} = 0.8$ (Note: ACI code $\Phi = 0.9$ for flexural)

$M_{CDFM} = 0.8 \times 10.50 \frac{kip\text{-}in}{in} = 8.40 \frac{kip\text{-}in}{in}$

(B) Elastic Frequency: (Ref. #1)

$f_w = \frac{1}{2\pi}\sqrt{\frac{384(E_m I_e)g}{(0.78)\,5 W L^4}}$ and $f_p = \frac{1}{2\pi}\sqrt{\frac{48(E_m I_e)g}{P L^3}}$

$E_m = 750 f_m'$ (Ref. #4)

and

$I_e = I_T + \left(\frac{M_{CR}}{M_{CDFM}}\right)^3 (I_g - I_T) \le I_g$

where $M_{CR} = f_T S_g$

$S_g = I_g/(D/2)$

$f_T = 2.5\sqrt{f_m'}$

thus

$I_{g_{16''}} = \frac{1}{12} 15.625 \times (11.625)^3 - \frac{1}{12} 8.25 \times (8.625)^3 = 1611 \text{ in}^4 \rightarrow I_g = \frac{1611}{15.625} = 103 \text{ in}^4/\text{in}$

$S_g = \frac{103}{15.625/2} = 13.2 \frac{in^3}{in}$

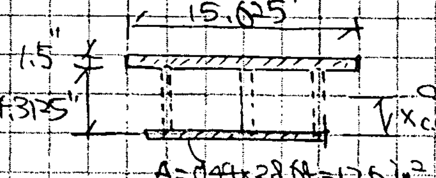
$E_m = 750 f_m' = 1.0125 \times 10^6$ psi, $n = \frac{E_s}{E_m} = \frac{29 \times 10^6}{1.0125 \times 10^6} = 28.64$

$f_T = 2.5\sqrt{1350} = 91.856$ psi

$M_{CR} = 91.856 \times 13.2 = 1212.\ lb\text{-}in/in = 1.212 \frac{kip\text{-}in}{in}$

$I_{T_{16''}} = 15.625 \times 1.5 \times \left[4.3125 + \frac{1.5}{2} - 3.292\right]^2 + 12.6 \times 3.292^2$

$= 210 \text{ in}^4$



$I_T = \frac{I_{T16''}}{15.625} = \frac{210}{15.625} = 13.44 \frac{in^4}{in}$

$X_{cg} = \frac{15.625 \times 1.5 \times (4.3125 + 1.5/2)}{15.625 \times 1.5 + 12.6}$

$= 3.292$ in

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$$I_e = 13.44 + \left(\frac{1212}{8.40}\right)^3 (103 - 13.44) = 13.710 \ \text{in}^4/\text{in}$$

$$f_w = \frac{1}{2\pi}\sqrt{\frac{384 \times 1.0125\times10^6 \times 13.710 \times 386}{0.78 \times 5 \times 79 \times 15^4 \times 144}} = 4.81 \text{Hz}$$

$$f_p = \frac{1}{2\pi}\sqrt{\frac{48 \times 1.0125\times10^6 \times 13.710 \times 386}{250 \times 15^3 \times 144}} = 7.32 \text{Hz}$$

Using Southwell–Dunkerley's method

$$\frac{1}{f^2} = \frac{1}{f_w^2} + \frac{1}{f_p^2} = \frac{1}{4.81^2} + \frac{1}{7.32^2} \Rightarrow f = 4 \text{ Hz}$$

(c) Limit on permissible Drift

CDFM permissible Drift Limit:

$$\left(\frac{\Delta u}{L}\right)_{CDFM} = \frac{0.005}{(c/d)} F_c(L/d) \leq 0.04$$

$$F_c(L/d) = \frac{(L/d)}{30} \leq 1.0$$

For Day Tank Block Wall

$c = 1.5''$

$L = 15 \times 12 = 180$ in

$d = D/2 = 5.8125$ in

$$F_c(L/d) = \frac{180/5.8125}{30} = 1.03 \geq 1 \quad \text{Thus } F_c(L/d) = 1$$

$$\left(\frac{\Delta u}{L}\right) = \frac{0.005}{(1.50/5.8125)} \times 1 = 0.019 < 0.04$$

$$\Delta u = 0.019 \times 180 = 3.42 \text{ in}$$

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(D) Seismic Capacity

$$\frac{S_{AC}}{g} = \frac{M_{CDFM} - M_{P\Delta}}{\frac{WL^2}{8} + \frac{PL}{4}}$$

$$M_{P\Delta} = \frac{WL^2}{2}\left(\frac{\Delta_u}{L}\right) = \frac{79 \times 15^2}{2}(0.019) = 169 \frac{lb\text{-}in}{in} = 0.17 \frac{kip\text{-}in}{in}$$

$$\frac{S_{AC}}{g} = \frac{(8.40 - 0.17) \times 10^3}{\frac{79 \times 15^2}{8} + \frac{250 \times 15}{4}} = 2.605$$

$S_{AC} = 2.605 g$

(E) Secant Frequency

$$f_s = \frac{1}{2\pi}\sqrt{\frac{1.5 S_{AC}}{\Delta u}} = \frac{1}{2\pi}\sqrt{\frac{1.5 \times 2.605 \times 386}{3.42}} = 3.34 \text{ Hz}$$

(F) Effective Nonlinear Demand

$S_{AD} = S_A(\pm 15\% f_s \text{ or } \pm 15\% f, 5\%)$

IPEEE PRA FRS at Mass Point 2T (X and Y direction) Page 6 & 7

(G) CDFM Capacity

Drift Ratio $\Delta u/L$	Δu (inches)	Frequency (Hz) f	f_s	±15% Range	Ref. Demand S_{ADR} (f_s, 5%) (g)	Capacity S_{AC} (g)	$FSI = \frac{S_{AC}}{S_{ADR}}$
Elastic	0.677	4	—	3.4 ~ 4.6	0.53 (X)	2.66 *	5.02
1.9%	3.42	—	4.11	2.84 ~ 3.84	0.65 (X)	2.605	4.01

$$* \quad \frac{S_{AC}}{g} = \frac{M_{CDFM}}{\frac{WL^2}{8} + \frac{PL}{4}}$$

Thus, the CDFM Capacity is

CDFM = 5.02 × 0.306 g = 1.536 g (PGA)

The median Capacity ($\beta = 0.4$) is

Median Capacity = 2.1 × 1.536 g = 3.22 g (PGA) *

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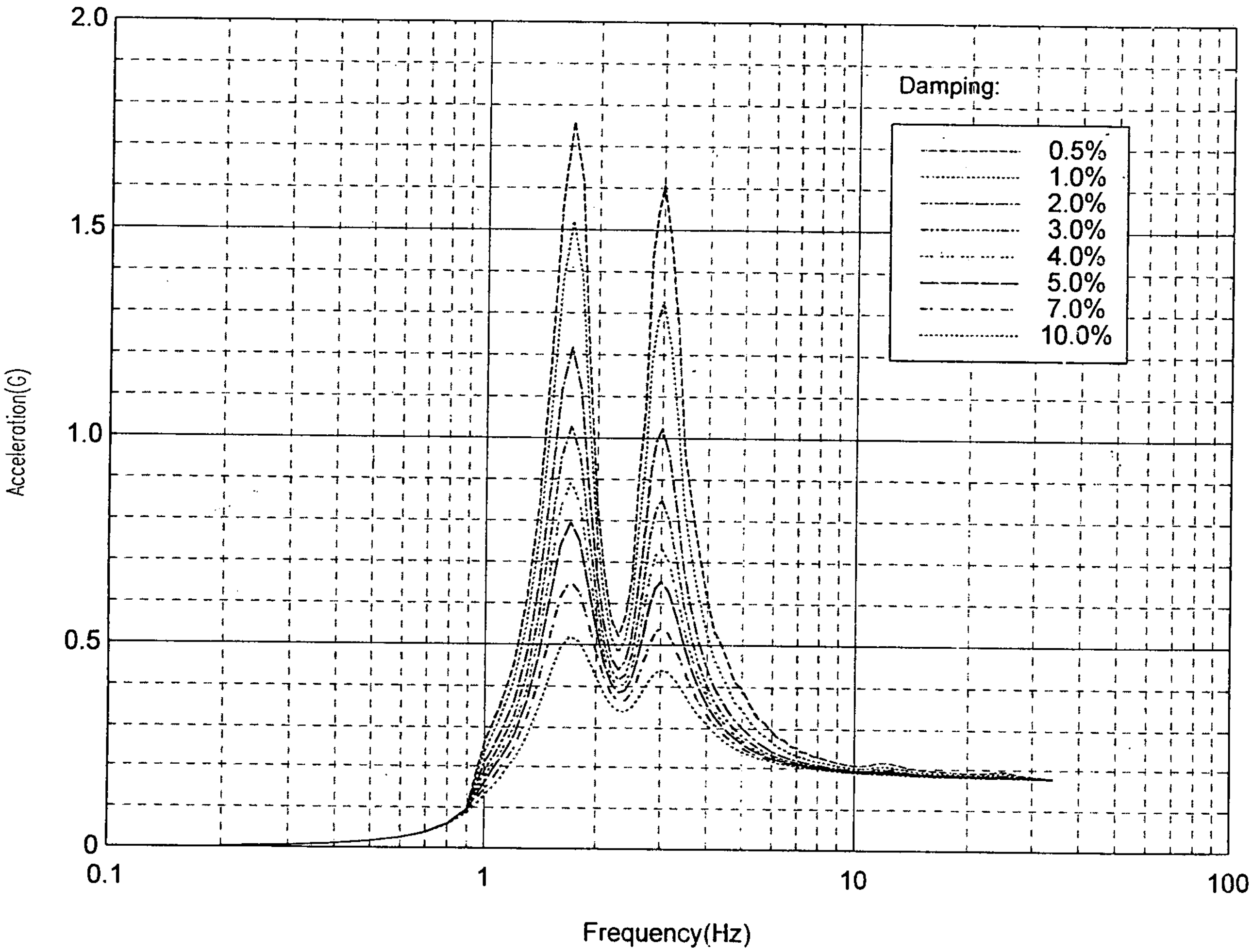
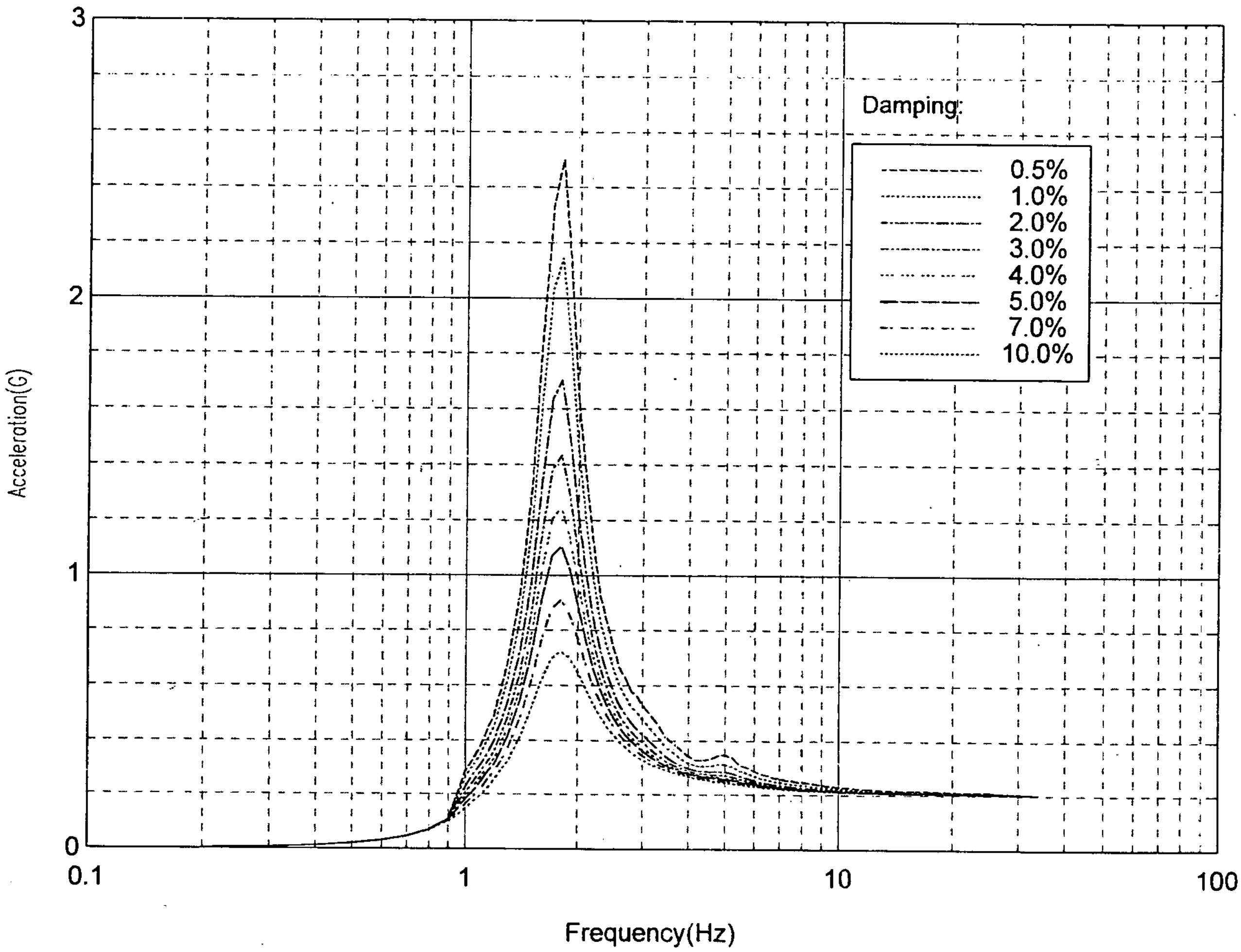
Wisconsin Public Service Corporation
Kewaunee Nuclear Power Plant
Amplified Floor Response Spectra
IPEEE

LOCATION : Node 27
DIRECTION : X
BASE EXCITE : LLNL 0.306
MODEL : $KEWAU_H$



Wisconsin Public Service Corporation
Kewaunee Nuclear Power Plant
Amplified Floor Response Spectra
IPEEE

LOCATION : Node 27
DIRECTION : Y
BASE EXCITE : LLNL 0.306
MODEL : $KEWAU_H$



APPENDIX B

SUPPORTING INFORMATION

FOR

SEISMIC INDUCED FIRE QUESTIONS

QUESTION SI.1(a)

SCREENING EVALUATION WORK SHEET (SEWS)		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 1 of 2
ID : 148-011 (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : Turbine Oil Reservoir		
Building : TURB	Floor El. : 586.00	Room, Row/Col : 7.5/D.0
Manufacturer, Model, Etc. :		

BASIS : External analysis

1. The buckling capacity of the shell of a large, flat-bottom, vertical tank is equal to or greater than the demand.	N/A
2. The capacity of the anchor bolts and their embedments is equal to or greater than the demand.	Yes
3. The capacity of connections between the anchor bolts and the tank shell is equal to or greater than the demand.	Yes
4. Attached piping has adequate flexibility to accommodate the motion of a large, flat-bottom, vertical tank.	N/A
5. A ring-type foundation is not used to support a large, flat-bottom, vertical tank.	N/A

IS EQUIPMENT SEISMICALLY ADEQUATE? **Yes**

COMMENTS

Anchorage shown on drawings S511, S509, S512 & XK100-14.

Evaluated for both seismic and fire interactions.

For tank analysis, see S&A calculation # C-018 Appendix L.

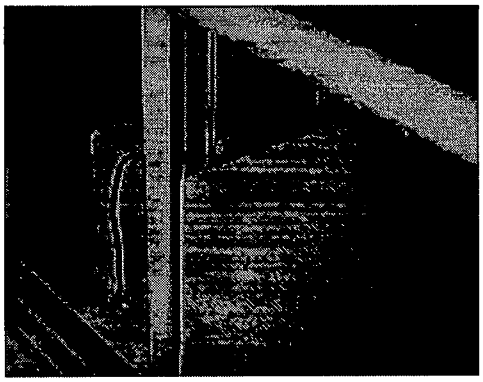
Evaluated by: ______________________ Date: __________

______________________ __________

Attachment: Pictures

SCREENING EVALUATION WORK SHEET (SEWS)		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 2 of 2
ID : 148-011 (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : Turbine Oil Reservoir		
Building : TURB	Floor El. : 586.00	Room, Row/Col : 7.5/D.0
Manufacturer, Model, Etc. :		

PICTURES



Anchorage for 148-011