Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

September 10, 1982

Mr. Darrell G. Eisenhut, Director
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Zion Station Units 1 and 2
I.E. Bulletin 80-11, Masonry Walls
NRC Docket Nos. 50-295 and 50-304

Reference (a): July 12, 1982, letter from
S. A. Varga to L. O. DelGeorge.

Dear Mr. Eisenhut:

In response to NRC's request of reference (a), this is to provide additional information regarding masonry walls at Zion Station. The Attachment to this letter provides the information requested.

Please address questions regarding this matter to this office.

Very truly yours,

E. Douglas Swartz
for F. G. Lentine
Nuclear Licensing Administrator

lm

Attachment

A001

cc: J. G. Keppler
D. L. Wigginton
Region III Inspector - Zion

4973N

ATTACHMENT

COMMONWEALTH EDISON COMPANY

ZION STATION UNITS 1 and 2

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
ON
MASONRY WALLS

4973N

1. The SEB Criteria (8) indicate that for operating plants the load combinations provided in the plant FSAR should be used in re-evaluation of masonry walls. Explain and justify the difference (if any) between the load combinations provided in the plant FSAR and the load combinations given in Table 5-1 of Reference 1.

   Response

   As pointed out in Section 5 of Reference 1, Masonry Walls at Zion are not subjected to loads such as wind, tornado, tornado missile, thermal loads, loads generated by a postulated pipe break, and loads due to presssure differential. Therefore, the combinations in Table 5-1 of Reference 1 are consistent with those provided in the Zion FSAR Volumes 2 and 8.

2. Provide the boundary conditions and modeling techniques used in the re-evaluation of masonry walls at Zion plant.

   Response

   The Boundary conditions and modeling techquies used in the re-evaluation of masonry walls at Zion are discussed in Section 6.0 of Reference 1.

3. Indicate how earthquake forces in three directions were considered in the seismic analysis of masonry walls.

   Response

   The Masonry Walls at Zion Units 1 and 2 are non-load bearing, interior partition walls which are not part of the shear wall system. All concrete masonry walls have been designed for out-of-plane seismic loadings. Vertical seismic acceleration is less than 1.0g for all these walls, thus causing no net tension on the walls. In-plane inertial loads have also been considered in the design for each wall.

   In accordance with the Zion FSAR, one horizontal earthquake component is combined with the vertical component. Any effects of combined horizontal and vertical excitation were summed using SRSS techniques.

4. Provide the number of unreinforced walls and a sample calculation illustrating the analytical approach used for single-wythe and multiple-wythe wall.

   Response

   There are a total of 130 safety-related walls at Zion, 100 of which are single-wythe construction. Of these, 86 walls are unreinforced. A sample calculation illustrating the analytical approach is attached for your reference.

5. With reference to Section 4.1 of Reference 1, justify the increase factor of 1.67 applied to allowable stresses for abnormal/extreme environmental loading combinations involving DBE. The SEB criteria (5) allow increase factors of 1.5 for tension parallel to the bed joint and shear in the reinforcement, and 1.3 for tension normal to bed joint and masonry shear. If the Licensee intends to use any existing test data to justify this increase factor, the Licensee is required to discuss the applicability of these tests to the masonry walls at the plant with particular emphasis on the following areas: boundary condition, type of load, size of walls, and type of masonry construction (block type, grouted, or ungrouted).

Response

The Zion plant masonry wall criteria in Reference 1 were established prior to the existence of the SEB criteria. Table A (attached) provides a comparison of the Zion and SEB interim criteria allowable stresses for unreinforced concete masonry design.

A survey of all safety-related walls subjected to out-of-plane loads indicates the 100% of the horizontally spanning walls fall within the SEB allowable stresses. Tension perpendicular to the bed joint is neglected for these walls. Vertically spanning walls incorporate vertical reinforcement to carry the tension perpendicular to the bed joint.

For in-plane loading, shear stresses under SSE load combinations for all walls except one fall within the SEB allowable stress of 43 psi. The remaining wall is stressed to 44 psi which is within 3% of the SEB allowable and, therefore, acceptable. Tension perpendicular to the bed joint was neglected for overturning and stability calculations.

6. Provide sample calculations to indicate how the effects of higher modes of vibration are accounted for in the masonry wall analysis.

Response

A sample calculation has been provided in the response to question number 4. As illustrated in that calculation a 1.05 amplification factor is used to account for the participation of higher order modes of vibration.

The 1.05 factor is based on a parametric finite element study to determine the effect of the participation of higher modes. The walls were modelled as plate elements and were subject to a uniform 1g response spectrum. The study bounded all wall aspect ratios, boundary conditions and openings typical at the Zion station. When considering the first eight modes of vibration it was determined that 99% of the response was from the 1st mode. The 1.05 factor is an upper bound and is, therefore, adequate to include the effect of higher modes for concrete masonry walls at Zion.

7. Indicate the mode of failure of each wall not qualified under the working condition. Provide details of proposed modifications for each wall with sketches and demonstrate through sample calculations that the wall will be qualified after modification.

Response

The information regarding walls originally found to be not qualified is on file with our Architect Engineers and is available for your review at their offices. A sample calculation has been included in response to Question Number 4.

8. Provide a status report for the proposed modifications to the walls that do not meet the acceptance criteria described in Reference 4.

Response

The masonry wall modifications and their completion schedule have been reviewed and approved by the NRC Region III (Reference 2).

As of this date, all modifications but one have been completed. One nonconforming wall remains in an office area that is presently undergoing modification to house computer equipment for support of our Emergency Response Facilities. Completion of the modifications of that wall is tied to the completion of the computer modifications, which is presently scheduled for December 31, 1982.

REFERENCES

1. November 6, 1980, letter from J. S. Abel to J. G. Keppler, transmitting 180-day response to I.E. Bulletin 80-11.

2. March 2, 1982, letter from C. E. Norelius to Cordell Reed transmitting I.E. Inspection Report Nos. 50-295/82-06 and 50-304/82-06/

TABLE A

COMPARISON OF ALLOWABLE STRESSES IN PSI (INSPECTED WORKMANSHIP)
FOR UNREINFORCED CONCRETE MASONSRY DESIGN

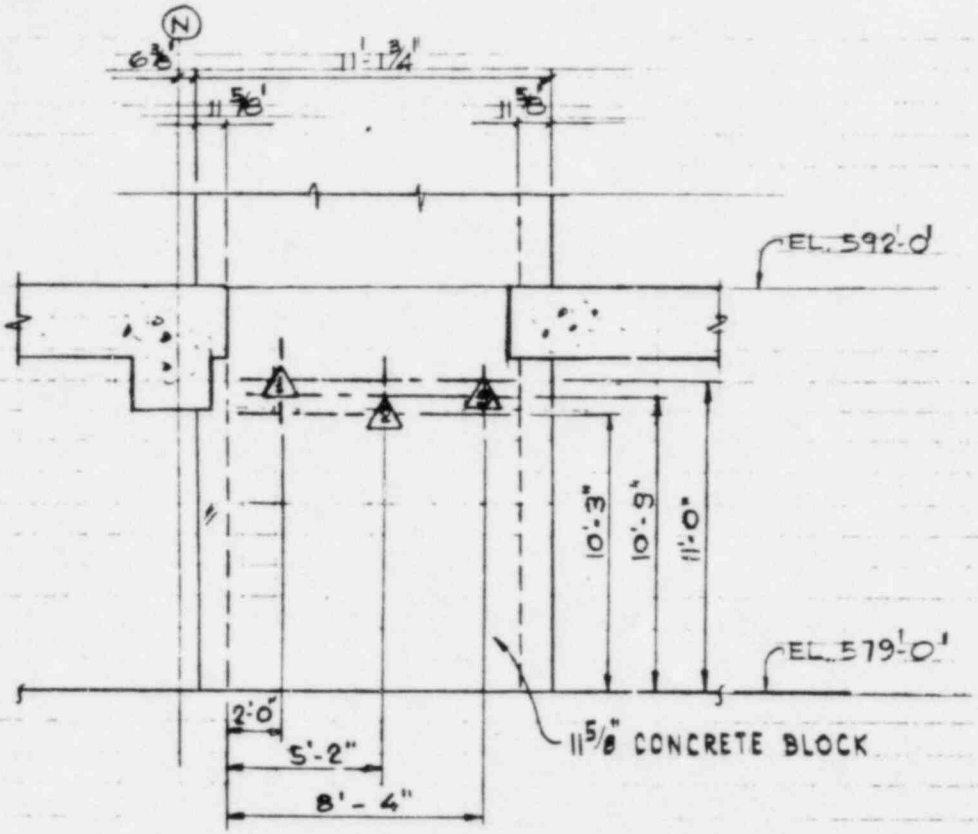
TYPE N MORTAR f'_m = 900 psi M_o = 750 psi

No.	Stress	Type of Masonry Unit	SSE Load Combinations (a) Criteria Used on Zion	(b) SEB Interim Criteria Rev. 1
1.	Tension Perpendicular to Bed Joints F_{t1}	H	19	17
		S&G	36	35
2.	Tension Parallel to Bed Joints F_{t11}	H	45	41
		S&G	69	62
3.	Shear	H	50	43
		S&G	50	43
4.	Flexure Compressive Stress F_m	All	600	750
5.	Bearing: On Full Area	All	376	563
	On 1/3 Area or less	All	563	843
6.	Bar Reinforcing Fy=40,000 psi		0.9 Fy	0.9 Fy
7.	Continuous Wire Reinforcing Fy=70,000 psi		0.9 Fy	0.9 Fy

(a) Criteria used on Zion is compatible with NCMA-1974

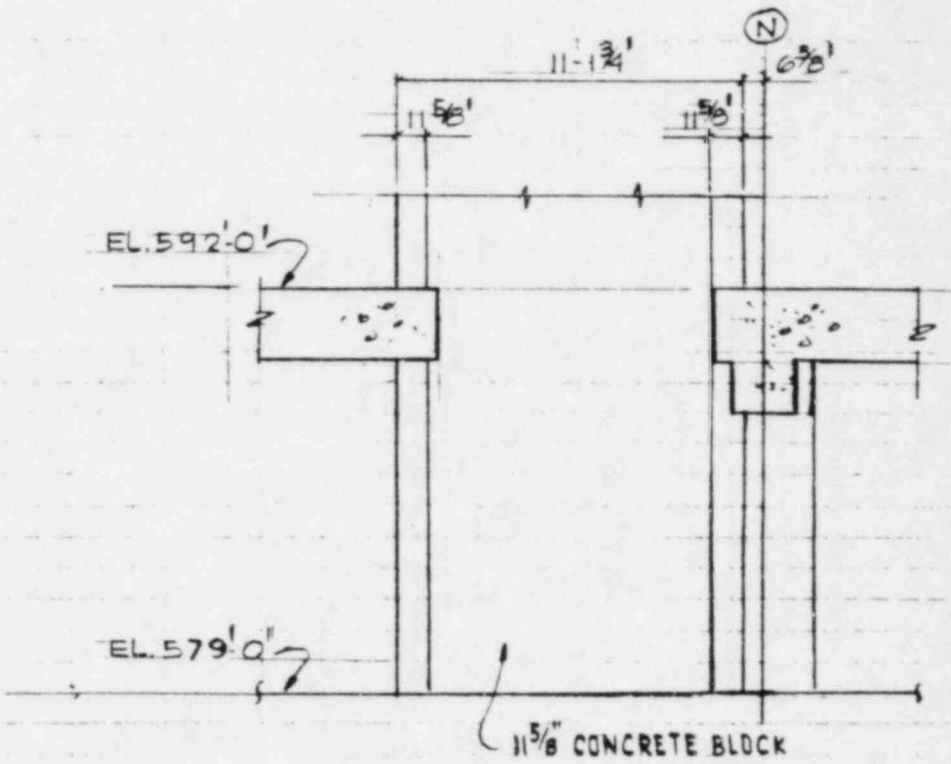
(b) SEB Interim Criteria Rev. 1 is compatible with ACI 531-79

H = Hollow Concrete Masonry
S = Solid Concrete Masonry
G = Grouted Concrete Masonry



WALL A-579-9A SOUTH ELEV.

SCALE: 1/4" = 1'-0"



WALL A-579-9 NORTH ELEV.

SCALE: 1/4" = 1'-0

EXAMPLE CALCULATION

SARGENT & LUNDY CHICAGO	Client CECO	Prepared by	Date	Calc. For	Calc. No. 6213-[illegible]
	Project ZION STATION 1&2	Reviewed by	Date		Rev. Date
	Proj. No. 6213-00 Equip. No.	Approved by	Date	Safety-Related Non-Safety-Related	Page of

ATTACHMENT NUMBER	HANGER I.D. NUMBER	NUMBER OF LINES	LINE SIZE	LINE TYPE	LINE I.D. NUMBER	OTHER ATTACHMENTS	WEIGHT PER FT. (LB/FT)	TRIBUTARY LENGTH (FT)	P* (LBS) (LOAD ON ATTACHMENT)	P* (IN) (ECCENTRICITY OF ATTACHED LI	P** (LBS) (SELF WEIGHT O ATTACHMENT	TOTAL (LBS)	REMARKS
	—	1	2"	IC	—		6.9	4	27.6			27.6	
1	—	1	2½"	IC	—		9.8	4	39.2			39.2	
	—	1	1"	IC	—		2.4	4	9.6			9.6	
											7.6	7.6	
												84.0	
	—	1	2"	IC	—		6.9	4	27.6			27.6	
2	—	1	2½	IC	—		9.8	4	39.2			39.2	
	—	1	1"	IC	—		2.4	4	9.6			9.6	
											7.6	7.6	
												84.0	
	—	1	2"	IC	—		6.9	4	27.6			27.6	
3	—	1	2½"	IC	—		9.8	4	39.2			39.2	
	—	1	1"	IC	—		2.4	4	9.6			9.6	
											7.6	7.6	
												84.0	

Form 00433 Rev 1

SARGENT LUNDY

Client CECO

Project ZION UNIT 1 & 2

Prepared by Date

Reviewed by Date

Approved by Date

Calcs For BLOCK WALL LOADS TABLE

WALL NO.

Safety-Related Non-Safety-Related

Calc No 6217-EW

Rev Date

Page of

OUT-OF-PLANE ANALYSIS

WALL A-579-9 t = 11 5/8"

CONSTRUCTION Hollow Block, Joint Reinforcing @ 16" c.c.

SPAN : Simply Supported, 10'-2 1/8"

FREQUENCY & C-VALUES

$f_{max} = 31.5 \times \sqrt{\frac{900}{1350}}$ 25.7 cps

$f_{min} = 31.5 \times \sqrt{\frac{540}{1350}}$ 19.9 cps

MAXIMUM C-VALUES FOR ABOVE FREQUENCY RANGE:

ELEV. 579'-0" OBE @ 2% Damping = 0.15 x 1.05 = 0.16

SSE @ 2% Damping = 0.30 x 1.05 = 0.32

ELEV. 592'-0" OBE @ 2% Damping = 0.20 x 1.05 = 0.21

SSE @ 2% Damping = 0.38 x 1.05 = 0.40

WALL SELF LOADING:

OBE: $S_{OBE} \times W_w$ = 0.21 x 49.6 psf = 10.4 psf

SSE: $S_{SSE} \times W_w$ = 0.40 x 49.6 psf = 20.0 psf

ATTACHMENT C-VALUES:

ELEV. 592'-0" S_{OBE} = 1.0 @ 2% Damping

S_{SSE} = 0.96 @ 2% Damping

WALL MOMENT & SHEAR CAPACITIES

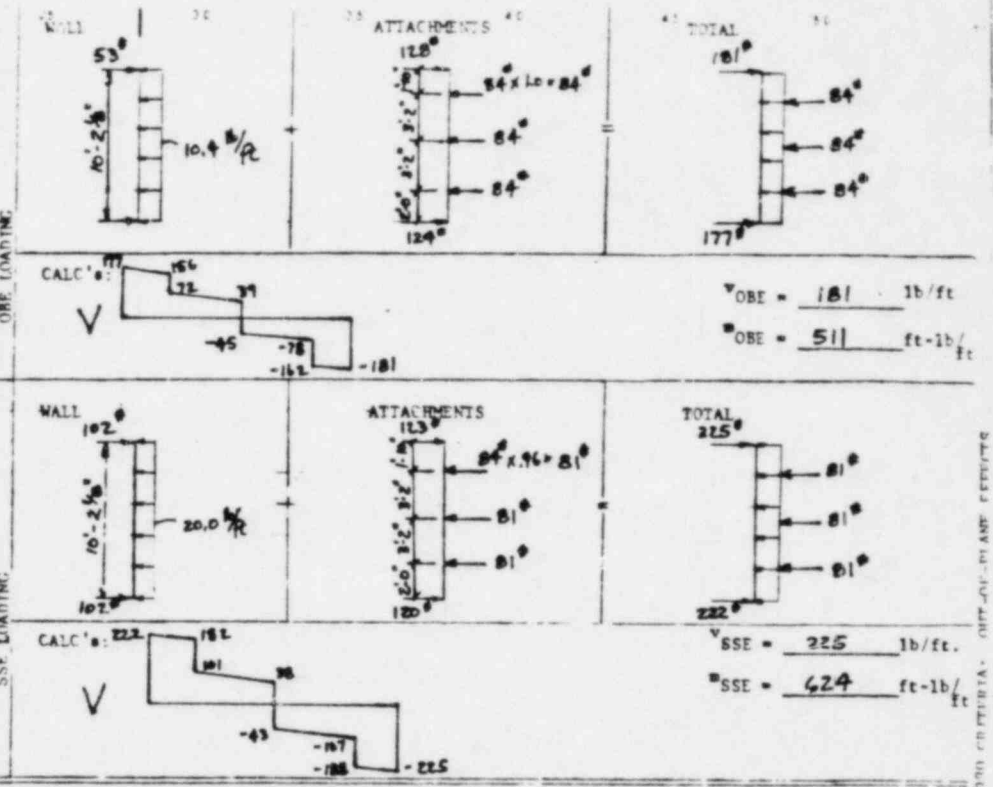
W_{OBE} = 1732 lb/ft

V_{SSE} = 2598 lb/ft

M_{OBE} = 522 ft-lb/ft

M_{SSE} = 872 ft-lb/ft

CAPACITIES BASED ON AN EFFECTIVE WIDTH OF 1 FT.



V_{OBE} = 181 lb/ft

M_{OBE} = 511 ft-lb/ft

V_{SSE} = 225 lb/ft.

M_{SSE} = 624 ft-lb/ft

WALL: V_{OBE}/V_{OBE} = 181/1732 = 0.10 < 1.0

V_{SSE}/V_{SSE} = 225/2598 = 0.09 < 1.0

M_{OBE}/M_{OBE} = 511/522 = 0.98 < 1.0

M_{SSE}/M_{SSE} = 624/872 = 0.72 < 1.0

SUPPORT 1: V_{OBE}/V_{OBE} = 181/436 = 0.42 < 1.0

V_{SSE}/V_{SSE} = 225/727 = 0.31 < 1.0

SUPPORT 2: V_{OBE}/V_{OBE} = SUPPORTED BY REINFORCED CONCRETE WALL < 1.0

V_{SSE}/V_{SSE} = < 1.0

ARGENT LUNDY

Client: CECO

Project: 2107

Proj. No.: 6213-04 Eq. No.: I-4-0

Prepared by: Date

Reviewed by: Date

Approved by: Date

Calcs For: WALL

Safety-Related Non-Safety-Related

Calc No. 6213-E-4

Rev. Date

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IN-PLANE ANALYSIS

WALL CONSTRUCTION Hollow Block TYPE II
Jt. Reinf. @ 16" c.c.

UNCONFINED OR PARTIALLY CONFINED WALLS (TYPES I-IV)

WITHOUT VERTICAL REINFORCEMENT

WALL DESIGN PARAMETERS

t_w = 11 5/8 (in.) γ = 105 PCF
h_s = 11 (ft.) W_w = 49.6 PSF
l_w = 10.2' (ft.)

N_{rOBE} = 97 lbs./ft. } From P. D69A
N_{rSSE} = 148 lbs./ft. }
N_{LOBE} = 181 lbs./ft. } From P. ___
N_{LSSE} = 225 lbs./ft. }

NET TENSION AND COMPRESSION STRESSES

A_w = 58.4 in²/ft (10.2') = 596 in² S_w = 1/6 (58.4 in²/ft)(10.2')² (12 in/ft) = 12,150 in³

OBE:

ϵ_H = 0.12 ELEV. 592'-0" @ 2% DAMPING

N_{OBE} = 97 + 10.2'(49.6)(12) = 158 lbs./ft.

M = 1/2 (158)(11')² x 12"/1' = 114,708 in-lbs.

P_e = (1-0.6)(49.6)(10.2')(11') = 5,231 lbs.

$f_m = \frac{M}{S_w} = \frac{114,708}{12,150}$ = 9.4 PSI

$f_a = \frac{P_e}{A_w} = \frac{5,231}{596}$ = 8.8 PSI

F_a = .225(900)[1 - (12(h)/(40 t_w))³] = 198 PSI

F_m = 297 PSI F_e = 14 psi

$\frac{f_a}{F_a} + \frac{f_m}{F_m} = \frac{8.8}{198} + \frac{9.4}{297}$ = 0.08 ≤ 1.0

If $\frac{M}{S_w} - \frac{P_e}{A_w} > 0$? ___ if so, OK

$f_c = f_m - f_a$ = 9.4 - 8.8 = 0.6 psi < 14 psi

SSE:

ϵ_H = 0.22 ELEV. 592'-0" @ 2% DAMPING

N_{SSE} = 148 + 10.2'(49.6)(.22) = 259 lbs./ft.

M = 1/2 (259)(11')² x 12"/1' = 188,034 in-lbs.

P_e = (1-0.12)(49.6)(10.2')(11') = 4900 lbs.

$f_m = \frac{M}{S_w} = \frac{188,034}{12,150}$ = 15.5 PSI

$f_a = \frac{P_e}{A_w} = \frac{4900}{596}$ = 8.2 PSI

F_a = 1.67 x 198 psi = 331 PSI

F_m = 594 PSI F_e = 14 psi x 1.33 = 19 psi

$\frac{f_a}{F_a} + \frac{f_m}{F_m} = \frac{8.2}{331} + \frac{15.5}{594}$ = 0.05 ≤ 1.0

If $\frac{M}{S_w} - \frac{P_e}{A_w} > 0$? ___ if so, OK

$f_c = f_m - f_a$ = 15.5 - 8.2 = 7.3 psi < 19 psi

AVERAGE SHEAR STRESS

OBE:

$V_I = \frac{W h_w}{A_w} = \frac{158(11')}{596}$ = 2.9 PSI

$V_L' = \frac{V_L h_w}{A_w} = \frac{181(11')}{596}$ = 3.3 PSI

$V_m' = \sqrt{(V_I)^2 + (V_L')^2}$ = 4.4 PSI

V_m = 33 PSI

V_m'/V_m = 0.13 < 1.0

SSE:

$V_I = \frac{W h_w}{A_w} = \frac{259(11')}{596}$ = 4.8 PSI

$V_L' = \frac{V_L h_w}{A_w} = \frac{225(11')}{596}$ = 4.2 PSI

$V_m' = \sqrt{(V_I)^2 + (V_L)^2}$ = 6.4 PSI

V_m = 50 PSI

V_m'/V_m = 0.13 ≤ 1.0

WALL RE-EVALUATION FOR IN-PLANE LOADS

Form 00433 Rev 1

SARGENT & LUNDY CHICAGO	Client CECO	Prepared by	Date	Calc For WALL	Calc No 6213-EW
	Project ZION	Reviewed by	Date		Rev Date
	Proj. No 6213-00 Equip No EW-8	Approved by	Date	X Safety-Related Non-Safety-Related	Page of