RE-EVALUATION OF

SAFETY RELATED CONCRETE MASONRY WALLS

AT

LASALLE COUNTY STATION

The Commonwealth Edison Company

Chicago, Illinois

November 19, 1982

Re-evaluation of Safety Related Concrete Masonry Walls at LaSalle County Station

1.0 Introduction

The submittals which Commonwealth Edison Company (CECo) has made to date in response to IE Bulletin 80-11 for LaSalle Units 1&2 are listed in Table 1 attached. Since the last submittal, CECo has voluntarily reassessed the safety related concrete masonry walls at LaSalle County using a more stringent design criteria.

This report summarizes the current status of the safety related concrete masonry walls at LaSalle County including the results of the recent reassessment. It is CECo's judgement that the safety related concrete masonry walls currently satisfy the requirements of IE Bulletin 80-11 and that no further modifications are justified or warranted.

2.0 Structural Functions of the Masonry Walls

2.1 As mentioned in earlier responses, all the safety-related concrete masonry walls at the LaSalle County Station, Units 1&2 function as non-load bearing, interior partition walls. They do not form an integral part of the vertical or lateral load resisting system for the safety related structures. These walls are separated from the floor above to prevent any gravity or seismic load transfer to these walls. Certain partition walls have a dual purpose of acting as either shielding walls and/or fire walls.

2.2 No major piping or equipment has been attached to Category I masonry walls. Attachments which have been allowed are very light items, typically less than 180 pounds per attachment. The following describes the types of attachments which have been made to these walls with expansion anchor or through bolt plate assemblies.

A. Electrical component supports, including conduit supports and electrical cable tray hanger supports.

B. Mechanical component supports, including small bore piping (2 1/2" diameter and under), and instrumentation lines. There is no large bore (greater than 2 1/2" diameter) piping, either safety-related or non-safety related, supported on the concrete masonry walls.

3.0 Masonry Wall Construction

3.1 All safety-related concrete masonry walls have been constructed as either single or multi-wythe hollow or solid block walls with full mortar bedding of the units using

running bond construction. No cavity wall construction has been used. The wythes in multiple wythe walls have been bonded together using a combination of the following techniques:

A. Full mortar collar joints

B. Continuous truss type joint reinforcement every second course which overlaps the adjacent wythes

C. The use of concrete masonry header blocks

3.2 Concrete masonry wall construction for LaSalle County Units 1 and 2 has been performed under Sargent & Lundy Specification No. J-2598. This document, describing in detail the concrete masonry construction requirements, was submitted by Commonwealth Edison Company to the NRC under reference letter No. 2 of Table 1.

3.3 The masonry wall construction requirements conform to NCMA-1979 which is in general agreement with the Uniform Building Code - 1979 and ACI 531-79.

4.0 Loads and Load Combinations

4.1 The loads and load combinations for the safety related concrete masonry walls are in agreement with the LaSalle County Units 1 and 2 FSAR, and are also in agreement with the SEB Interim Criteria, Rev. 1, July 1981.

4.2 It has been verified that no safety-related concrete masonry walls associated with the operation of LaSalle County Units 1&2 are subject to impact or pressurization loads or missiles due to pipe whip, pipe break, jet impingement, and/or tornado. Also, no safety-related concrete masonry walls are intended to function as water barriers.

5.0 Allowable Stresses

5.1 The safety related concrete masonry walls for LaSalle County Units 1 and 2 have been designed using NCMA-1979 allowable stresses corresponding to the special inspection category. Commonwealth Edison Company's QA/QC procedures for the construction of safety related concrete masonry walls substantiate compliance with the inspection requirements of the SEB Interim Criteria, Rev. 1, July 1981.

5.2 Table 2, attached, gives a comparison of the allowable stresses as used for the LaSalle County Station vs ACI 531-79, both for OBE and SSE load combinations. For discussion of these stresses see Section 8 "Conclusions."

The allowable stresses used for the LaSalle County Station Units 1&2 are in agreement with the LaSalle County FSAR and SER.

6.0 Analysis Procedures for Concrete Masonry Walls

6.1 The seismic analysis for the safety related concrete masonry walls meets the requirements of the LaSalle County Units 1&2 FSAR.

6.2 Determination of Dynamic Lateral Loads

Concrete masonry walls have been analyzed based on conventional elastic methods. Dynamic lateral loads have been determined by an equivalent static method using the expression

$$W_D = g_W W_W + g_a W_a$$

where

W_D = Dynamic lateral load

W_W = Weight of concrete masonry wall

W_a = Uniform or concentrated attachment load on the wall

g_W = Wall acceleration using appropriate damping values per Section 6.4

g_a = Peak acceleration for attachment loads using appropriate damping values per Section 6.4

6.3 Wall Frequency Calculations

The natural frequency of concrete masonry walls has been determined using standard expressions for single degree of freedom systems and using the section properties of the wall based on the nominal masonry unit sizes. Frequency calculations have been based on moment of inertia of an uncracked section because applied moments are always less than the moment capacities of uncracked sections.

The walls have been assumed as simply supported spanning horizontally or vertically or as horizontal cantilevers, as applicable. Steel columns embedded in the wall provide lateral support for out-of-plane loads for horizontally spanning walls.

6.4 Determination of Wall Accelerations and Accelerations for Attachment Loads

The safety related concrete masonry walls at LaSalle County have been designed using damping values of 4% for OBE and SRV load combinations, and 7% for OBE or SSE with SRV and LOCA load combinations. The response spectra used in the

analysis has been based upon the floor at the bottom of the wall. The voluntary reassessment of the concrete masonry walls subsequent to our earlier responses considered the following design criteria:

A. Wall Accelerations

1. Damping values of 2% for OBE and SRV load combinations and 4% for OBE or SSE with SRV and LOCA load combinations were used.

2. The following frequency range to account for any material variation and other uncertainties affecting the response of the wall was used:

Solid/Grouted Units	0.9f - 1.1f
Hollow Units	0.8f - 1.0f

where

f = frequency determined per requirements of Section 6.3 based on $E_m = 1000\ f'_m$

E_m = Modulus of elasticity for concrete masonry

f'_m = Masonry compressive strength. A value of of 1350 psi is used for LaSalle County Station

3. The design "g" value was determined by reading the largest value within the frequency range from the response spectra curves for each floor elevation at the top and bottom of the wall elevations and using the average of the two maximum values.

4. The design value of "g" was increased by 1.05 to account for participation of higher modes when wall frequency was less than 33 cps.

B. Accelerations for Attachment Loads

1. Damping values of 2% for OBE and 4% for SSE load combinations were used for attachment loads.

2. The peak "g" value at each floor elevation corresponding to top and bottom of the wall elevations was used to determine the design "g" value by taking the average of the two "g" values.

7.0 <u>Design of Concrete Masonry Walls</u>

7.1 Concrete masonry walls have been designed based on working stress principles. The design moments have been obtained

considering a 12 inch wide beam strip. The walls have been assumed as simply supported or horizontally cantilevered, as applicable, with due consideration to the boundary conditions.

7.2 Structural steel columns have been used to provide lateral support for the masonry walls for out-of-plane loads, thereby creating horizontally spanning simply supported conditions.

The structural steel columns are not subject to any load in the vertical direction as the top connections of the columns have been provided with vertical slotted holes.

7.3 Approximately 420 out of 442 (95%) safety related concrete masonry walls have been designed to span horizontally, thereby precluding the use of tension perpendicular to the bed joints.

7.4 Only 10 out of 442 ($\simeq$ 2%) unreinforced walls have been designed to span vertically. These walls do not exceed the allowable tensile stress perpendicular to the bed joints. Twelve out of 442 walls have been designed as vertically spanning reinforced masonry walls. All the reinforced masonry walls form enclosures for elevators.

7.5 No overstress factor has been used in the design of masonry walls for load combinations containing OBE seismic loads which is in compliance with SEB Interim Criteria, Rev. 1, July 1981.

7.6 All concrete masonry walls have been designed for out-of-plane seismic loadings. Vertical seismic acceleration is less than 1.0g for all of these walls, thus causing no net tension on the wall.

7.7 The applied moment due to out-of-plane dynamic loads and attachment loads is always less than the uncracked moment capacity of the masonry wall. As such, moment of inertia of the uncracked section has been used for frequency calculations and hence, the dynamic response of the wall.

7.8 Horizontal joint reinforcement has not been considered for calculating the flexural strength of the wall.

7.9 The local pull-out effect due to an attachment load has been considered in the design. This design condition is not critical for the structural integrity of the wall.

7.10 The masonry walls have been analyzed as rigid for their in-plane behavior. In-plane loads have not been calculated for each wall. However, a sample of 32 walls was evaluated for in-plane inertial loads and in-plane reaction loads. Based

on the review of the 32 walls, which appear to be the most critical for in-plane loads, it has been determined that actual shear or tensile stresses due to simultaneous application of both in-plane inertial and in-plane reaction loads are within the Project Criteria allowable values.

7.11 Out-of-plane drift effects due to relative displacement of one floor with respect to the other are not imposed on the masonry walls at the LaSalle County Station for the following reasons:

A. There is a 1" gap between the top of the walls and the underside of the floor diaphragms above

B. The top connections of the masonry lateral support steel columns are pinned connections.

7.12 In-plane drift effects have been evaluated for the masonry walls with the following conditions:

A. As mentioned earlier in Section 2.0, masonry walls are not part of the primary vertical or lateral load resisting system. They are non-load bearing, interior partition walls.

B. In-plane interstory drift is an imposed displacement on a masonry wall, and the resultant in-plane load is, therefore, a function of the in-plane shear stiffness of the masonry wall.

The in-plane stiffness is unpredictable, therefore a strain criteria, rather than stress criteria, is more reliable for evaluating drift effects. Shear strain values of 0.001 under SSE conditions and 0.0006 (= 0.001/1.67) under OBE conditions have been selected as acceptable maximum allowable values for the safety related concrete masonry walls at LaSalle County. The SSE allowable strain corresponds to initiation of cracking in masonry, and not the failure of the wall. Therefore, the criteria is conservative.

The maximum shear strain in safety related masonry walls at LaSalle County under SSE conditions is 0.0004"/" which corresponds to the maximum strain in the reinforced concrete shear walls. This strain is significantly less than 0.001"/".

8.0 Conclusions

8.1 The materials, testing, analysis, design, construction and inspection of safety related concrete masonry walls for LaSalle County Units 1 and 2 conform to NCMA-1979, which is in general agreement with the Uniform Building Code-1979.

8.2 Reassessment of all the safety related concrete masonry walls based on the reevaluation criteria as submitted here indicated that the majority of the walls did not require any modifications. Walls which did not meet the reevaluation criteria were provided with fixes, as necessary.

8.3 The allowable stresses and other design and construction requirements specified in ACI 531-79 are essentially the same as given in NCMA-1979.

8.4 Table 2 compares the NCMA allowable stresses which have been used for the LaSalle County masonry walls with ACI 531-79 allowable stresses, both for OBE & SSE load combinations.

From Table 2 the following observations are made:

A. The project allowable tensile stress perpendicular to the bed joints is lower under OBE load combinations and exceeds ACI 531-79 values by 19% to 25% under SSE load.

The above increases in ACI 531-79 allowable tensile stress perpendicular to the bed joints under SSE Load combinations are not critical because the majority of the safety related walls at LaSalle County span horizontally. There are only 10 walls for both Units 1&2 which have been designed as vertically spanning walls utilizing the allowable tensile stress for unreinforced masonry. However, only 3 out of 10 walls have actual stresses exceeding ACI 531-79 allowable stresses. Moreover, these walls form either labyrinths or small enclosures required for shielding and as such, do not support primary structural load resisting elements of the building.

B. The project allowable tensile stress parallel to the bed joints exceeds ACI 531-79 value by 4% under OBE load combinations and 3% to 16% under SSE load combinations.

The above increases in ACI 531-79 allowable tensile stress parallel to the bed joints are not a concern because horizontal joint reinforcement which has been ignored in the design does contribute towards the flexural strength of the wall. Moreover, there are only 15 out of 442 walls ($\simeq$ 3%) which have actual stresses exceeding ACI 531-79 allowable value. Also, as pointed out in CECo's earlier response per reference letter No. 2 of attached Table 1, the project allowable stress has an average factor of safety of 5.6 against failure loads under OBE load combinations and 3.35 (5.6/1.67) under SSE load combinations.

C. The project allowable shear stress is lower under OBE load combinations and exceeds ACI 531-79 value by 10% under SSE load combinations.

The above increases in ACI 531-79 allowable shear stress under SSE load combination can be justified because the maximum actual shear stress on any masonry wall at LaSalle County is only 35% of project allowable stress which is equivalent to 38% of ACI 531-79 allowable value.

8.5 It is Commonwealth Edison Company's judgement that the voluntary reassessment criteria as has been used for LaSalle County, Units 1&2 is appropriate and no further modifications to the safety related concrete masonry walls are justified.

TABLE 1

List of Reference Letters Submitted by Commonwealth Edison Company in Response to IE Bulletin 80-11

1. D. L. Peoples' letter to D. G. Eisenhut, dated July 8, 1980, in response to Information Request on Category I Masonry Walls Employed by Plants Under CP and OL Review, dated April 21, 1980.

2. L. O. DelGeorge's letter to B. J. Youngblood, dated February 4, 1981, in response to the Request for Additional Information on Category I Masonry Wall Design, dated January 19, 1981.

3. L. O. DelGeorge's letter to A. Schwencer, dated April 24, 1981, providing response to R. L. Tedesco's letter to J. S. Abel, dated March 2, 1981, requesting additional information in the design of concrete masonry walls for LaSalle County, Units 1 and 2.

4. C. W. Schroeder's letter to R. D. Walker dated February 24, 1982, providing "Final Report in Response to NRC I.E. Bulletin 80-11, Masonry Wall Design for LaSalle County Station."

TABLE 2

COMPARISON OF ALLOWABLE STRESSES (INSPECTED WORKMANSHIP) FOR UNREINFORCED CONCRETE MASONRY DESIGN

TYPE M MORTAR; f'_m = 1350 psi; m_o = 2500 psi

Type of Stress (a)	Type of Masonry Unit (b)	Normal & OBE Load Combinations		SSE Load Combinations		Ratio of Project Criteria Allowable Stress to ACI 531-79 Allowable Stress	
		Project Criteria (psi)	ACI 531-79 (psi)	Project Criteria (psi) (c)	ACI 531-79 (psi) (d)	Normal OBE Comb.	SSE Load Comb.
Tension Perpendicular to bed joints (F_{t1})	H	23	25	38	32	0.92	1.19
	S&G	39	40	65	52	0.97	1.25
Tension parallel to bed joints (F_{t11})	H	46	50	77	75	0.92	1.03
	S&G	78	75	130	112	1.04	1.16
Shear (v)	H	34	40	57	52	0.85	1.10
	S&G	34	40	57	52	0.85	1.10

(a) Masonry stresses such as bearing, flexural compressive stress are not critical for design and are omitted from the comparison table. Project criteria is compatible with NCMA-1979.

(b) H = Hollow concrete masonry; S = Solid concrete masonry; G = Grouted concrete masonry

(c) Values in this column are calculated using an overstress factor of 1.67 for all types of stresses.

(d) Values in this column are based on using SEB recommended overstress factors; 1.3 for shear (v) and tension perpendicular to bed joints (F_{t1}), 1.5 for tension parallel to bed joints (F_{t11}).