ATTACHMENT 1

CRITERIA FOR THE RE-EVALUATION OF CONCRETE MASONRY WALLS INDIAN POINT GENERATING STATION, UNIT 2

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CRITERIA FOR THE RE-EVALUATION

OF CONCRETE MASONRY WALLS

FOR THE

INDIAN POINT GENERATING STATION, UNIT 2

1.0 GENERAL

1.1 Purpose

This specification is provided to establish design requirements and criteria for the use in re-evaluating the structural adequacy of concrete block walls as required by the NRC IE Bulletin 80-11, Masonry Wall Design, dated May 8, 1980.

1.2 Scope

The re-evaluation shall determine whether the concrete masonry walls will perform their intended function under loads and load combinations specified herein. It is necessary to insure the operability of safety related systems either attached or adjacent to the walls under the postulated loads and load combinations. Verification of wall adequacy shall take into account of support condition, global response of wall, and local transfer of load. Evaluation of anchor bolts and embedments are not considered to be within the scope of IE Bulletin 80-11.

2.0 GOVERNING CODES

For the purposes of re-evaluation, the American Concrete Institute, "Building Code Requirements for Concrete Masonry Structures" (ACI 531-79) will be used, unless as otherwise specified herein.

3.0 LOADS AND LOAD COMBINATIONS

The walls shall be evaluated for appropriate load combinations including dead loads, thermal loads, pipe loads, operating and design basis earthquakes.

4.0 MATERIALS

The project specifications indicate that materials used for the performance of the work were originally specified to meet the following requirements.

4.1 Concrete Masonry Units

Hollow concrete blocks: ASTM C-90-52

Solid concrete blocks: Min. compressive strength 2000 psi
Min. density 150 lbs per cu. ft.
(ASTM C-145 Grade U)

4.2 Mortar

Mortar and mortar materials: 1 part Portland cement, 1 part lime, 6 parts sand (ASTM C-270 Type N)

4.3 Grout

None specified

4.4 Horizontal Joint Reinforcing

"Dur-o-wal" truss type 12-EH extra heavy

4.5 Bar Reinforcement

None specified

5.0 DESIGN ALLOWABLES

5.1 Stresses

Allowable stresses for the loads and load combinations given in Section 3.0 will be as given in this section based on the following compressive strengths:

Hollow Concrete Units	f'_m = 750 psi
Solid Concrete Units	f'_m = 950 psi
Mortar	m_o = 750 psi

The allowable stresses for service loads shall be the S values given in Table 1. For walls subjected to thermal effects the allowable stress shall be 1.3 times the S values given in Table 1. The allowable stresses for the factored loads shall be the U values given in Table 1.

5.2 Damping

The damping values to be used shall be as follows:

2% - Operating Basis Earthquake

4% - Design Basis Earthquake

6.1 Structural Response of Masnonry Walls

The masonry walls shall be analyzed for loads and load combinations as per Section 3.0 using linear elastic Structural analyses techniques

6.1.1 Out of Plane Response to Seismic Loads

The following sequence of analysis methods will be applied.

1. Walls without significant openings shall be assumed to be a simply supported beam spanning vertically and/or horizontally and the natural frequency shall be determined. A fully grouted wall may be evaluated either as an uncracked wall or it may be assumed that the mortar joint on the tension side is cracked and the moment of inertia calculated by neglecting the mortar and block on the tension side. If the latter is used the grout core tensile stress is evaluated.

2. The maximum moment and stress shall be determined by applying a sinusoidal load to the beam. The maximum value of the load shall be mass times acceleration taken from the response spectrum curve at the appropriate frequency for the fundamental mode. If only one mode of vibration is calculated, the moments and stresses shall be multiplied by 1.10 to account for higher mode effects.

3. If the calculated stresses exceed the allowables or the wall has a significant opening (s), the wall shall be modeled as a plate with appropriate boundary conditions. The finite element dynamic method of analysis will be used. For a multimode analysis the modal responses shall be combined using the square root of the sum of the squares.

4. If the calculated stresses exceed the allowables and the wall is multiwythe, steps 1, 2 and 3 shall be repeated using composite action if the wall contains a verifiable collar joint.

5. If the calculated stresses exceed the allowables in step 3 for a single wythe wall and step 4 for a multiwythe wall, the wall will be evaluated for operability.

6.1.2 Frequency Variations in Out of Plane

Uncertainties in structural frequencies of the masonry wall resulting from variations in mass, modulus of elasticity, material and section properties shall be taken into account by varying the modulus of elasticity as follows:

Ungrouted Walls - $1000f'_m$ to $600\ f'_m$

Grouted or Solid Walls - $1200f'_m$ to $800f'_m$

If the wall frequency using the lower value of E is on the higher frequency side of the peak of the response spectrum, it is considered conservative to use the lower value of E. If the wall frequency is on the lower frequency side of the peak of the response spectrum, the peak acceleration shall be used. If the frequency of the wall using the higher value of E is also on the lower frequency side of the peak, the higher value of E may be used with its appropriate spectral value provided due consideration is given to frequency variations resulting from all possible boundary conditions.

6.1.3 In Plane and Out of Plane Effects

Provided both the allowable stress criteria for out of plane effects and the in plane stress or strain criteria are satisfied, the walls shall be considered to satisfy the re-evaluation criteria. If either criterion is exceeded, walls will be evaluated for operability.

6.1.4 Stress Calculations

All stress calculations shall be performed by conventional methods prescribed by the Working Stress Design method. The collar joint shear stress shall be determined by the relationship VQ/Ib.

6.2 Accelerations

For a wall spanning between two floors the average of the spectra for the floor above and below shall be used to determine the stresses in the walls .

6.3 Interstory Drift Effects

The magnitude of interstory drift effects shall be determined from the dynamic analysis or other methods.

6.4 In Plane Effects

If a masonry wall is a load bearing structural element, shear stresses shall be evaluated and compared with the allowable stresses of Table 1.

If the wall is an infill panel or non-load bearing element, shear stresses resulting from interstory drift effects will not be calculated. In this case the imposed interstory deflections of Sec. 6.3 shall be compared to the displacements calculated from the following permissible strains for service loads. For factored loads the strains shall be multiplied by 1.67. The deflection shall be calculated by multiplying the permissible strain by the wall height.

Unconfined Walls (1)

$\gamma_u = 0.001$

Confined Walls (2)

$\gamma_c = 0.0008$

Notes: (1) An unconfined wall is attached on one vertical boundary and its base.

(2) A confined wall is attached in one of the following ways:

(a) On all four sides.
(b) On the top and bottom of the wall.
(c) On the top, bottom and one vertical side of the wall.
(d) On the bottom and two vertical sides of the wall.

If an infill panel or non-load bearing element is subjected to both interstory drift effects and shear stresses due to inplane loads from equipment or piping, the following criteria shall apply:

$$\frac{\text{actual inplane shear stress}}{\text{allowable inplane shear stress}} + \frac{\text{actual interstory deflection}}{\text{allowable interstory deflection}} \leq 1$$

A more refined analysis may be performed if necessary.

6.5 Equipment

If the total weight of attached equipment is less than 100 lbs., the effect of the equipment on the wall shall be neglected. If the total weight of the equipment is greater than 100 lbs., the mass of the equipment shall be added to that of the wall in calculating the frequency of the wall.

Stresses resulting from non-rigid equipment shall be calculated by applying a static load consisting of the weight of equipment multiplied by the peak acceleration of the response spectrum for the floor level above the wall. If the frequency of the equipment is known it may be used to determine the static load. For rigid equipment, the load on the wall may be accounted for by adding the mass of the equipment to that of the wall.

Stresses resulting from each piece of equipment weighing more than 100 lbs. shall be combined with those from the wall inertia loads using the absolute sum method. The SRSS method may be used provided its application is justified.

6.6 Distribution of Concentrated Out of Plane Loads

6.6.1 Beam or One Way Action

For beam action local moments and stresses under a concentrated load shall be determined using beam theory. An effective width of four times the wall thickness shall be used. However, such moments shall not be taken as less than that for two way plate action.

6.6.2 Plate or Two Way Action

For plate action local, moments and stresses under a concentrated load, shall be determined using a finite element analysis.

6.6.3 Localized Block Pullout

For a concentrated load block pullout shall be checked using the allowable values for unreinforced shear walls in Table 1.

7.0 ALTERNATIVE ACCEPTANCE CRITERIA (OPERABILITY)

When, due to out-of-plane loading, the allowable stresses for unreinforced masonry are exceeded, the arching theory for masonry walls may be used to measure the capacity of the walls. Due regard must be paid to the boundary conditions.

7.1 Limiting Deflection

The deflection of the three-hinged arch could be determined by assuming that the arch members are analogous to regular compression members in a truss. The method of virtual work (unit load method) may be used to compute the deflection at the arch interior hinge. The calculated deflection should not be more than 0.3T where the "T" is the thickness of the wall. A determination should be made as to whether such calculated displacements would adversely impact the function of safety-related systems attached and/or adjacent to the wall.

7.2 Allowable Stresses

The total resistance of the wall (f) shall be calculated using the following stresses:

I. Tensile stress through the assumed tension crack shall be $6\sqrt{f'_c}$ for grouted walls or f_t for ungrouted walls.

II. The crushing stress of block material - $0.85f'_m$.

By applying a factor of safety of 1.5 to the total resistance (f) as calculated above, the allowable load on the wall is limited to f/1.5.

7.3 Boundary Supports

The boundary supports should be checked to ensure that they are capable of transmitting the reaction forces. The effect of support stiffness on the reaction forces should be considered.

Table 1: Allowable Stresses in Unreinforced Masonry

Description	S		U	
	Allowable (psi)	Maximum (psi)	Allowable (psi)	Maximum (psi)
Compressive				
Axial[1]	$0.22f'_m$	1000	$0.44f'_m$	2000
Flexural	$0.33f'_m$	1200	$0.85f'_m$	3000
Bearing				
On full area	$0.25f'_m$	900	$0.62f'_m$	2250
On one-third area or less	$0.375f'_m$	1200	$0.95f'_m$	3000
Shear				
Flexural members[2, 3]	$1.1\sqrt{f'_m}$	50	$1.7\sqrt{f'_m}$	75
Shear walls[2]	$0.9\sqrt{f'_m}$	34	$1.35\sqrt{f'_m}$	51
Tension				
Normal to bed joints				
Hollow units	$0.5\sqrt{m_o}$	25	$0.83\sqrt{m_o}$	42
Solid or grouted	$1.0\sqrt{m_o}$	40	$1.67\sqrt{m_o}$	67
Parallel to bed joints[4]				
Hollow units	$1.0\sqrt{m_o}$	50	$1.67\sqrt{m_o}$	84
Solid or grouted	$1.5\sqrt{m_o}$	80	$2.5\sqrt{m_o}$	134
Grout Core	$2.5\sqrt{f'_c}$		$4.2\sqrt{f'_c}$	
Collar joints				
Shear		8		12
Tension		8		12
Joint Reinforcing Steel				
Tension	$0.5F_y$	30,000.	$0.9F_y$	

Notes to Table 1:

(1) These values should be multiplied by $(1 - (\frac{h}{40t})^3)$.

(2) Use net bedded area with these stresses.

(3) For stacked bond construction use two-thirds of the values specified.

(4) For stacked bond construction use two-thirds of the values specified for tension normal to the bed joints in the head joints of stacked bond construction.