ACTION ITEM 16

COMPARISON BETWEEN FINITE ELEMENT PLATE ANALYSIS AND ONE WAY BEAM ACTION

Prepared for

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1 INTRODUCTION

The Nuclear Regulatory Commission (NRC) staff on June 9-11,1981 reviewed the criteria and calculations performed on IE Bulletin 80-11 "Masonry Wall Design" for the Point Beach Nuclear Power Plant. Action Item 16 resulting from the review meeting stated that the licensee will provide comparative analyses on three types of Point Beach masonry walls (four sides simply supported, three sides simply supported, and two sides - vertical and horizontal - simply supported) using both the plate assumption and one-way beam action in two orthogonal directions.

This short report is in response to that action item and presents the analysis methodology, the analysis results, a discussion of the results, and the conclusions.

2 ANALYSIS METHODOLOGY

All walls were analyzed in accordance with the procedures given in "Criteria for the Re-evaluation of Concrete Masonry Walls for the Point Beach Nuclear Power Plant." Specifically, a finite element plate analysis was used to assess the out-of-plane response of the wall. The computer program SAP5A was used to perform the finite element dynamic analysis, utilizing the response spectrum method.

This method of analysis was selected because it was capable of explicitly incorporating the effects of equipment and pipe loads, openings due to doors, pipes and cable trays, and different boundary conditions.

In order to provide a comparative analysis based on a beam solution, the formulation of the beam solution is derived as follows. The beam was assumed to be uniform and prismatic. The fundamental frequency and mode shape was calculated with either simply supported or cantilever boundary conditions and these were then used to calculate the maximum moment in the beam. The relevant formulae for the simply supported beam and cantilever beam are given in Table 1.

3 RESULTS

A summary of the maximum moments obtained on both horizontal and vertical strips for two walls (19/9 and 20/9) with four sides simply supported, for one wall (65-1/15) with two sides simply supported, and for two walls (111-1/23 and 113/23) with three sides simply supported are given in Table 2.

In the case of the two walls with four simply supported sides the beams were simply supported in both the horizontal and vertical directions. In the case of the two walls with three simply supported sides the beams were simply supported in the horizontal direction and a cantilever in the vertical direction since the wall was not supported at the top. In the case of the wall with two simply supported sides the beams were cantilevers in both the horizontal and vertical directions.

4 DISCUSSION OF RESULTS

The maximum moments calculated on a vertical strip from the beam formulae were all greater than the maximum moments calculated from the plate analysis. The maximum moments calculated on a horizontal strip from the beam formulae were greater than the maximum moments calculated from the plate analysis for the walls with four and two sides simply supported. For the walls with three sides simply supported the maximum moments obtained from the beam formulae were less than those calculated from the plate analysis.

For the examples given a beam analysis of walls in both orthogonal directions and simply supported on four and two sides would be conservative. For the examples given of a wall supported on three sides and not on the top a beam analysis would have produced non-conservative results if the wall had been assumed to span only in the horizontal direction. If, however, it had been checked as a cantilever beam in the vertical direction, the vertical moments would have exceeded those obtained from a plate analysis.

5 CONCLUSIONS

The walls at Point Beach Nuclear Power Plant were dynamically analyzed as finite element plates so that the effects of equipment and pipe loads, door and other openings and different boundary conditions could be explicitly included in the analytical results. If beam analyses had been used on walls with two and four sides simply supported this method of analysis would have been conservative for the three examples given. If beam analyses had been used for walls with three simply supported sides and they had been assumed to span in only the horizontal direction then a beam analysis would have been non-conservative.

It is clear that a beam analysis may not always produce conservative results and furthermore it is very difficult to account for the effects of openings and equipment and pipe loads in a beam analysis. Therefore the finite element plates used to analyze the walls is considered to produce a realistic evaluation of the stresses in the walls and to accurately account for the effects of openings and equipment loads.

TABLE 1

FORMULAE FOR BEAMS

	Simply Supported Beam	Cantilever Beam
Fundamental Frequency	$\frac{\pi}{2}\sqrt{\frac{EI}{\bar{m}L^4}}$	$\frac{(1.875)^2}{2\pi}\sqrt{\frac{EI}{\bar{m}L^4}}$
Fundamental Mode Shape	$\sin\frac{\pi}{L}x$	$\sin ax - \sinh ax + 0.742 (\cosh ax - \cos ax)$ $a = 1.875/L$
Maximum Moment	$\bar{m}\ddot{v}\left(\frac{L}{\pi}\right)^2$	$\bar{m}\ddot{v}\ \frac{L^2}{2.3700}$

E = modulus of elasticity

I = modulus of inertia

$\bar{m}$ = mass per unit length

L = span length

$\ddot{v}$ = seismic acceleration

TABLE 2

COMPARISON OF MAXIMUM MOMENTS
OBTAINED FROM PLATE AND BEAM ANALYSES

Wall No.	Status	M_x	M_{xb}	M_x	M_{yb}
19/9 Four Sides	P	398.9	565.7	184.7	988.1
	U	319.8	469.9	148.1	823.4
20/9 Four Sides	P	173.9	313.2	122.7	989.2
	U	142.2	259.9	100.3	824.3
64-E/15 Two Sides	G	85.96	223.64	103.2	1351.70
	U	44.58	121.37	53.51	653.07
111-1/23 Three Sides	P	205.8	103.6	202.7	999.2
	U	179.9	90.4	176.9	813.5
113/23 Three Sides	P	265.3	107.6	631.8	999.2
	U	236.6	90.5	563.8	813.50

Note: (1) P = Partially Grouted; G = Grouted; U = Ungrouted
(2) M_x and M_y are the maximum moments on the horizontal and vertical strips respectively obtained from the plate analyses
(3) M_{xb} and M_{yb} are the maximum moments on the horitontal and vertical strips respectively obtained from the beam analyses