ENCLOSURE 6

GEH Technical Report

DE-ES-0090 Revision 0

Local Analysis Model for GDCS Pool

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For GE-Hitachi Nuclear Energy

Dominion North Anna Unit 3 ESBWR

Package: RCCV

Title: Local Analysis Model for GDCS Pool

CLASSIFY	CATEGORY	DISTRIBUTION	COPY	DISTRIBUTION	COPY
1. PLAN	1. FOR APPROVAL				
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(5) CALCULATION REPORT					
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REVISION STATUS SHEET

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1. INTRODUCTION

There are three GDCS pools supported on top of the diaphragm floor of RCCV for NA3 site-specific SSE loads in combination with other loads considered in the ESBWR standard plant design following the same standard design analysis methodology and acceptance criteria.

There are two types of GDCS pool size. One of them (180° direction) is large, and two of them (90° and 270° directions) are small. The pools on one side are contained by the RCCV wall and on the other side by walls made of structural steel.

The GDCS pool walls away from the RCCV are made of carbon steel plates lined with stainless steel cladding and backed up with vertical and horizontal steel structural framing system.

Stress analysis of the GDCS pool is carried out with NASTRAN.

To evaluate the stress, independent shell model simulating plates and beam model simulating horizontal beams and vertical columns are developed and FEM analysis is performed.

2. EVALUATION METHOD AND RESULT

2.1 FEM ANALYSIS PROCEDURE

For the GDCS pool, the detail stress evaluation is performed using local models. Both large and small pools are modeled and analyzed. The stresses against seismic loads and hydrodynamic loads are calculated statically by FEM with the acceleration obtained from floor response spectrum. The analysis approach used for NA3 is the same as that used for the standard plant.

2.2 ANALYSIS MODEL

3 dimensional shell and beam models shown in Figure 2-1 for both large and small pools are used simulating plate and beam/column steels.

The number of node point : 122

The number of element : 219

These numbers are same in large pool model and small pool model.

2.3 BOUNDARY CONDITION

Boundary condition of 3 dimensional shell and beam model is shown in Figure 2-1.

Plates connected with RCCV are fixed perfectly, but bars connected with RCCV or plates are supported simply in FEM analysis. The support condition of top and second top of horizontal beam members are pin supported. The support conditions of other beams and columns are fixed.

2.4 MATERIAL PROPERTY

Material properties are shown in Table 2-1.

Material properties refer to Reference 3 (a).

2.5 LOAD AND ANALYSIS METHOD

Stress analysis on the GDCS pool is carried out against following loads.

(1) Dead load including hydrostatic pressure load

·Weight of steel part (wall and beam/column): 148.3ton for large pool, 137.3ton for small pool

·Water head pressure depending on the depth : Maximum depth is 6.8 m

These loads are applied statically.

(2) Thermal load

FEM analysis of thermal load is carried out in the case of Table 2-2. These temperatures are based on Reference 3 (a). These temperatures are applied statically to the FEM model.

Underwater temperatures are applied to the steel structures (wall, beam/column) below water level.

Constraint displacements (six component) from analytical result of integral model for thermal loads are applied to I/F point (top plate of diaphragm floor, both ends of pool, bracing member support points) of local models.

(3) Dynamic loads

Dynamic loads include seismic, SRV and LOCA load

a. Evaluation procedure

Stresses are calculated with the acceleration obtained from FRS regardless of the frequencies of the GDCS pool.

Evaluation of natural frequency and dynamic loads for the GDCS pool are as follows.

Step 1: Obtain the natural frequencies of the GDCS pool with NASTRAN. Concerning the horizontal direction, whole pool water mass is added to GDCS pool wall and RCCV pool wall uniformly.

Step 2: Obtain the highest accelerations from the FRSs of each direction (X, Y, Z) beyond the fundamental frequencies obtained in Step 1.

Step 3: Multiply the accelerations of each direction obtained in Step 2 by 1.5.

Step 4: Obtain the stress due to the load with the vertical and horizontal equivalent densities respectively by gravitational acceleration 9.80665 m/s^2 (1G) subjected to the GDCS pool.

Step 5: Multiply the stress in Step 4 by the vertical and horizontal accelerations obtained in Step 3 respectively.

Step 6: Combine the stresses due to the accelerations of x, y and z directions obtained in Step 4 using SRSS method in accordance with Appendix A of Reference 3 (f).

b. Natural frequency

Calculation of the natural frequency is carried out by NASTRAN with 3 dimensional shell and beam models in Figure 2-1.

(a) Horizontal calculation

It is assumed that pool water mass is distributed uniformly on the GDCS pool wall and RCCV wall except for the bracing members. The total applied masses of pool water and steel parts (wall and beam/column) are 537.2 ton for large pool and 456.0 ton for small pool. Predominant modes of the large and small pools are 15.55Hz and 19.41Hz respectively. Mode of response is shown in Figure 2-2.

(b) Vertical calculation

Predominant modes of the bracing members of the large and small pools are 15.56 Hz and 22.17 Hz respectively. Modes of response are shown in Figure 2-2. While, natural frequencies of other parts except for the bracing members are more than 100Hz.

c. Dynamics loads

Seismic, SRV and LOCA load are decided by 1.5 times the highest accelerations beyond the fundamental frequency of the GDCS pool in FRSs, which are from Reference 3 (d) and (e), regardless of the frequencies, Elevation of seismic load for the GDCS pool is applied for EL 27000 and EL 17500, while SRV and LOCA loads are applied for EL 27500, EL 21300 and EL 17500. Damping ratio of 4% is applied to obtain the FRSs. The accelerations for the stress calculation of the GDCS pool are shown in Table 2-3.

d. Combination of stresses

The stresses of each x, y and z direction are combined together using SRSS method in accordance with Appendix A of Reference 3 (f).

3. REFERENCE

(a) GE Document #26A6558 R4, "General Civil Design Criteria"

(b) GE Document #26A6647 R3, "Seismic Analysis of Reactor/Fuel Building Complex"

(c) GE Document #26A6651 R3, "RB Structural Design Report"

(d) GE Document # DBR-0006780 R1, "North Anna 3 RB/FB Seismic Analyses Bounding Results and In-Structure Response Spectra"

(e) EA Document # 092-134-F-C-00009 R2, "SRVD. LOCA Hydrodynamic & AP Dynamic Responses in RBFB and RCCV"

(f) Hitachi Document # DC-OG-0053 R5, "Structural Design Report for Containment Internal Structures"

(g)GE Document SER-DMN-028 R0, "RB/FB Stress Analysis Result Data for North Anna 3"

(h) Hitachi Drawing # 310RB76-134 R2, "Design Drawings for GDCS Pool"

Table 2-1 Material properties

Modulus of elasticity [MPa]	200000
Thermal expansion [-]	1.17×10^{-5}
Poisson's ratio [-]	0.3
Density [MN/m^3]	0.0770

Table 2-2 Condition at FEM analysis against thermal load

	time	Temperature (℃)		Remarks
		Aerial	Underwater	
Normal Operation	Normal	57	43	Depth of water: 6.8 m
LOCA	5sec	133.7	43	Depth of water: 4.41 m Depth of water:0.3m
	6min	171	43	
	10hr	150	110	
	72hr	150	110	

Table 2-3 Design accelerations for the stress calculation of the GDCS pools

	Large				Small			
	NS	EW	UD		NS	EW	UD	
			Bracing	Others			Bracing	Others
Seismic	4.29	3.96	18.95	3.92	4.29	3.89	7.04	3.92
SRV	0.94	0.94	0.60	0.27	0.94	0.94	0.33	0.27
LOCA	3.89	3.89	2.13	1.39	3.89	3.89	2.13	1.39

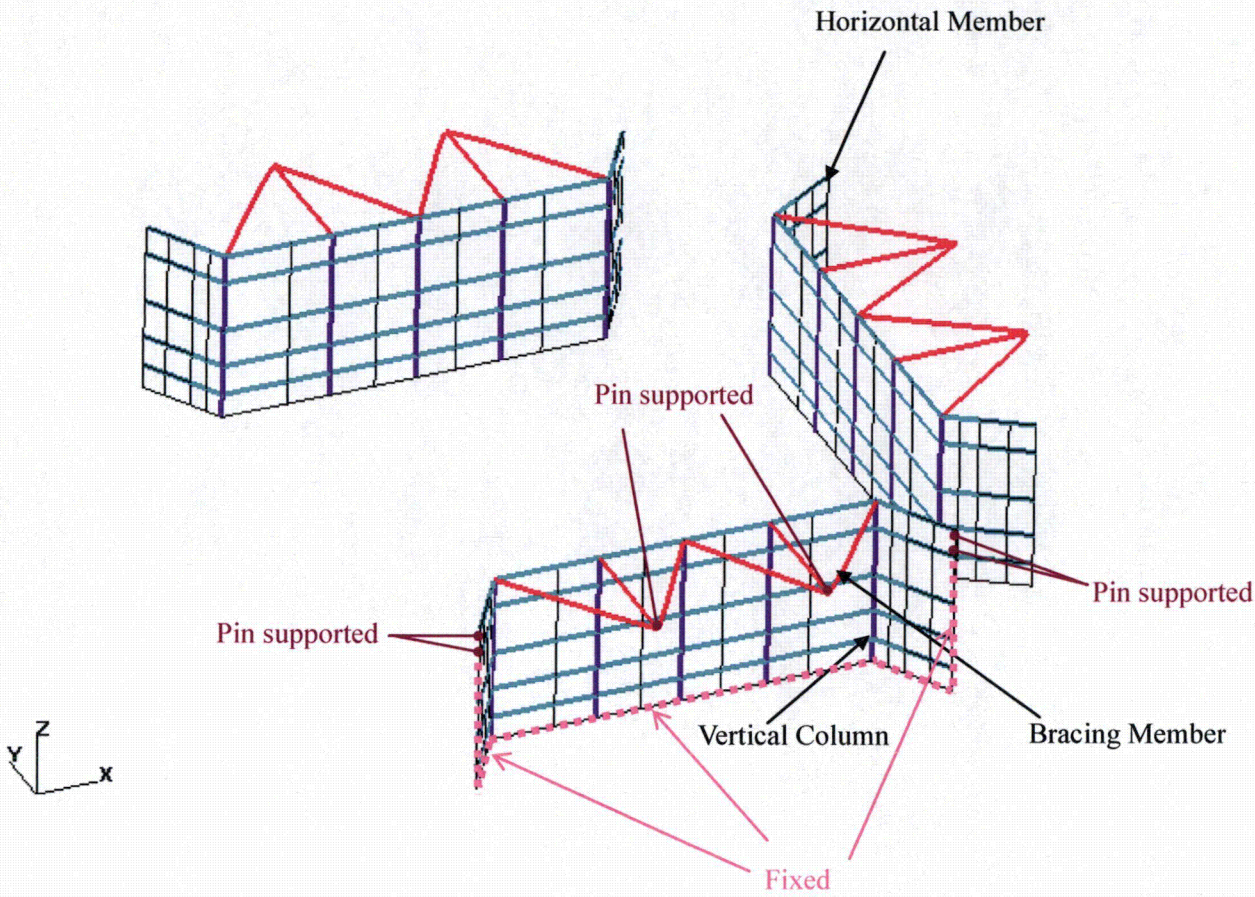
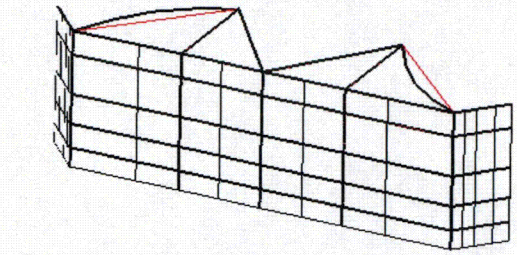
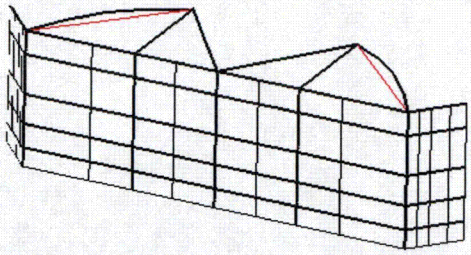


Figure 2-1 FEM analysis model



DEFORMED SHAPE. MODE=1 FREQ= 1.55548E+01
ESBWR GDCS-POOL(LARGE)



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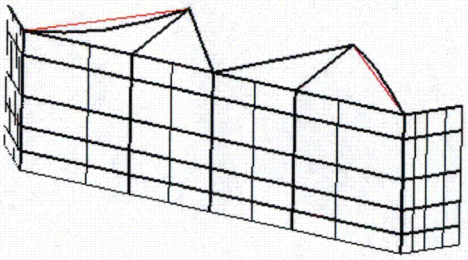

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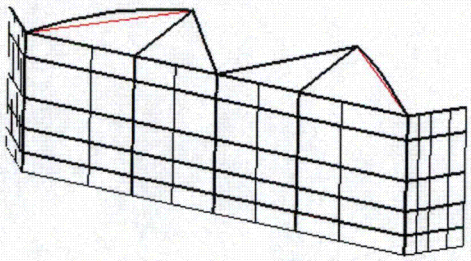

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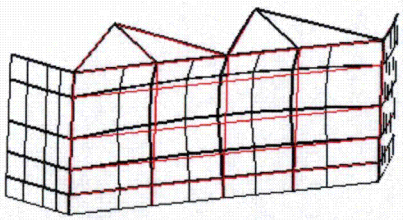
ESBWR GDCS-POOL(LARGE)

(a) Large



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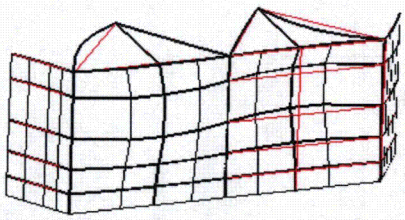
ESBWR GDCS-POOL(SMALL)



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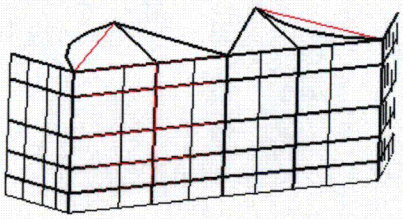

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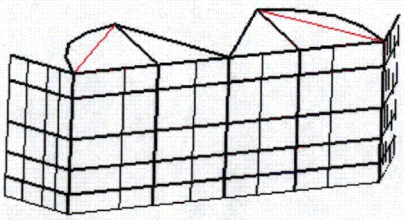

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ESBWR GDCS-POOL(SMALL)

(b) Small

Figure 2-2 Mode shape