Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, D.C. 20555

Direct tel: 412-374-6306
Direct fax: 412-374-5005
e-mail: sterdia@westinghouse.com

Your ref: Project Number 740
Our ref: DCP/NRC1858

April 5, 2007

Subject: AP1000 COL Response to Request for Additional Information (TR #3)

In support of Combined License application pre-application activities, Westinghouse is submitting responses to NRC requests for additional information (RAI) on AP1000 Standard Combined License Technical Report 3, APP-GW-S2R-010, Rev. 0, Extension of Nuclear Island Structures Seismic Analysis. These RAI responses are submitted as part of the NuStart Bellefonte COL Project (NRC Project Number 740). The information included in the responses is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification.

The responses are provided for request TR3-21 and TR3-23, transmitted in NRC letter dated December 5, 2006 from Steven D. Bloom to Andrea Sterdis, Subject: Westinghouse AP1000 Combined License (COL) Pre-application Technical Report 3 – Request for Additional Information (TAC No. MD2358).

Pursuant to 10 CFR 50.30(b), the responses to requests for additional information on Technical Report 3 are submitted as Enclosure 1 under the attached Oath of Affirmation.

It is expected that when the RAIs on Technical Report 3 are complete, the technical report will be revised as indicated in the responses and submitted to the NRC. The RAI responses will be included in the document.

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

A. Sterdis, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

D079

/Attachment

1. "Oath of Affirmation," dated April 5, 2007

/Enclosure

1. Response to Requests for Additional Information on Technical Report No. 3, RAI-TR03-021 and RAI-TR03-023

cc:	S. Bloom	-	U.S. NRC	1E	1A
	S. Coffin	-	U.S. NRC	1E	1A
	G. Curtis	-	TVA	1E	1A
	P. Grendys	-	Westinghouse	1E	1A
	P. Hastings	-	Duke Power	1E	1A
	C. Ionescu	-	Progress Energy	1E	1A
	D. Lindgren	-	Westinghouse	1E	1A
	A. Monroe	-	SCANA	1E	1A
	M. Moran	-	Florida Power & Light	1E	1A
	C. Pierce	-	Southern Company	1E	1A
	E. Schmiech	-	Westinghouse	1E	1A
	G. Zinke	-	NuStart/Entergy	1E	1A

ATTACHMENT 1

"Oath of Affirmation"

ATTACHMENT 1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:	)
NuStart Bellefonte COL Project	)
NRC Project Number 740	)

APPLICATION FOR REVIEW OF
"AP1000 GENERAL COMBINED LICENSE INFORMATION"
FOR COL APPLICATION PRE-APPLICATION REVIEW

W. E. Cummins, being duly sworn, states that he is Vice President, Regulatory Affairs & Standardization, for Westinghouse Electric Company; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission this document; that all statements made and matters set forth therein are true and correct to the best of his knowledge, information and belief.

W. E. Cummins
Vice President
Regulatory Affairs & Standardization

Subscribed and sworn to
before me this 5th day
of April 2007.

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Debra McCarthy, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Aug. 31, 2009
Member, Pennsylvania Association of Notaries

Debra McCarthy
Notary Public

ENCLOSURE 1

Response to Requests for Additional Information on Technical Report No. 3

RAI-TR03-021 and RAI-TR03-023

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR03-021
Revision: 0

Question:

21. The staff's review of Section 6.2 identified a number of items in need of clarification or explanation. The staff requests Westinghouse to address the following:

    a. The fourth paragraph of page 91 of 154 states "In Section 6.3 a comparison of member forces obtained from seismic static and time history analyses is given." Please confirm that the reference should be to Section 6.4.

    b. The last paragraph of page 91 of 154 states "For those local flexible structures that are amplified, apply an additional acceleration to these structures equal to the difference between the average uniform amplified component accelerations and rigid body component equivalent static accelerations. These accelerations are to be considered in local design of the flexible portion of the structure but do not need to be considered in areas of the structure away from the local flexibility. They can be applied in a series of individual load vectors." It is not obvious to the staff how this methodology has been implemented, and whether the effects of increased accelerations on locally flexible structures can be ignored in areas of the structure away from the locally flexible structures. The sum total of all the flexible masses times the corresponding acceleration increments may impose non-negligible additional loads on the overall structure, in the two horizontal directions and in the vertical direction. Therefore, Westinghouse is requested to (1) describe in greater detail the implementation of this methodology, including a numerical example; and (2) provide a quantitative technical basis for the conclusion that the effects of increased accelerations on locally flexible structures can be ignored in areas of the structure away from the locally flexible structures.

    c. The top paragraph of Page 93 of 154 states "The vertical equivalent static seismic accelerations at (Shield Bldg) elevations 294.93 ft and 333.13 ft are obtained directly from the maximum time history results by taking the average of locations at opposite ends of a diameter. The vertical accelerations from the 3D finite element model at the shield building edges at these elevations are significantly influenced by the horizontal loading. If they are used for the vertical equivalent accelerations, the horizontal response would be double counted in the vertical direction." It is not obvious to the staff how this methodology has been implemented, and whether it is even appropriate. Therefore, Westinghouse is requested to submit a numerical example, based on elevation 333.13 ft of the Shield Building, to demonstrate the implementation of this methodology. In this example, please also include the vertical acceleration value that would be obtained if this methodology was NOT implemented.

d. Confirm that in Table 6.2-7, the referenced table numbers should be 6.2-3, 6.2-4, 6.2-5, and 6.2-6.

e. In Page 99, under the heading "Seismic Accelerations for Evaluation of Building Overturning," states "The dynamic response of the structure affecting overturning and basemat lift off is primarily the first mode response at about 3 hertz on hard rock. This reduces to about 2.4 hertz on soil sites as shown in the 2D ANSYS and SASSI analyses. The higher auxiliary building accelerations of Table 6.2-2 are not considered in overturning since they are from higher frequency modes greater than 2.4 hertz. Amplified response of individual walls in the Auxiliary Building and the IRWST need not be considered since they are local responses that do not effect overturning." For the overturning analysis, the staff is concerned that the methodology employed may not predict an overall moment on the basemat that envelops the maximum overturning moment for all site conditions. Westinghouse is requested to provide its technical basis for the conservatism of the methodology employed.

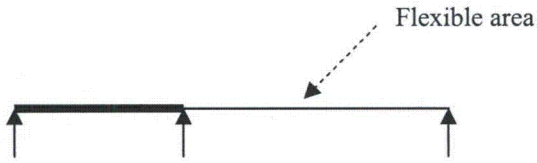
Westinghouse Response:

a. It is confirmed that the reference should be Section 6.4 and not Section 6.3.

b. The methodology being used does not neglect the effect of the locally flexible structures on the structures away from the flexible areas. The wording in the technical report is changed to avoid any confusion. The new wording is given below:

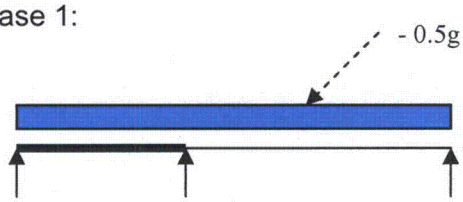
"For those local flexible structures that are amplified, apply an additional acceleration to these structures equal to the difference between the average uniform amplified component acceleration and the rigid body component equivalent static acceleration. These accelerations are to be considered in local design of the flexible portion of the structure. The effect of these additional accelerations on the seismic loadings in areas of the structure away from the local flexibility are to be considered in design."

The methodology being used allows the analyst the ease of applying the inertia loads by first applying the seismic accelerations using the accelerations of the associated structure as if it is not flexible. Then, using an additional load case, apply the incremental acceleration to the flexible portion. This procedure is shown below using a simple two span beam with three supports and one flexible area. This structure is subjected to vertical seismic excitation. The equivalent static acceleration for the beam at this elevation is equal to 0.5g vertical, and the flexible area has an average uniform vertical seismic acceleration of 0.8g.

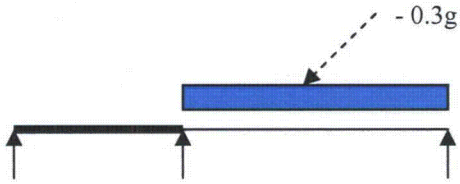


The following load cases are considered in this example with the vertical load being down. Other, cases of course would be with the vertical excitation up.

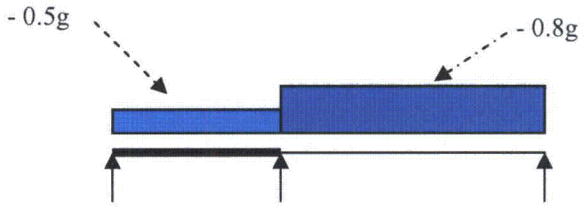
Load case 1:



Load Case 2: This load case is applied only to the flexible area. The inertia loading is the incremental portion above 0.5g that will act only on the flexible area (0.8g - 0.5g = 0.3g). It is noted that there are separate load cases for each of the flexible floors so that worst loading on the structures away from the flexible areas is obtained.



The results of the local load cases are combined absolutely with the results of the "rigid" portion in the same direction. The three directions are then combined by SRSS. The resultant member forces, that includes the "rigid" portions, reflect the total seismic inertial load on the structure.



Therefore, the effects of increased accelerations on locally flexible structures are not ignored in areas of the structure away from the locally flexible structures.

c. The seismic response of the shield building roof has been reviewed. It has been concluded that a seismic component associated with the rotational response of the PCCS tank should also be included in addition to the translational seismic acceleration component. The AP1000 shield building roof design is being modified as part of the evaluation of an airplane crash. The rotational response of the PCCS tank will be addressed in the redesign of the shield building roof.

d. It is confirmed that in Table 6.2-7, the referenced table numbers should be 6.2-3, 6.2-4, 6.2-5, and 6.2-6. This will be corrected in the report. It is noted that the values given in Table 6.2-6 have been revised. The new values will be updated as noted in the section addressing Technical Report Revisions.

e. The conservatism of the overall moment on the basemat is addressed in Section 2.6.1.2 of the Nuclear Island Basemat and Foundation report (Reference 1). This part of the RAI should be considered during the review of this report.

Reference:

1. APP-GW-GLR-044, Rev 0, "Nuclear Island Basemat and Foundation", October, 2006

Design Control Document (DCD) Revision:

DCD revisions are not shown for each RAI. A single set of proposed revisions is given in the response to RAI-TR03-013. The revisions are based on the material in the technical report as well as in the RAI responses. The revisions include changes to Section 3.7 and the addition of a new Appendix 3G providing a summary of the seismic analyses.

PRA Revision:

None

Technical Report (TR) Revision:

The last paragraph of page 91 of 154 will be modified to:

"For those local flexible structures that are amplified, apply an additional acceleration to these structures equal to the difference between the average uniform amplified component acceleration and the rigid body component equivalent static acceleration. These accelerations are to be considered in local design of the flexible portion of the structure. The effects of these additional accelerations on the seismic loadings in areas of the structure away from the local flexibility are to be considered in design."

In Section 6.2, the discussion related to the shield building will be revised to reflect the proposed change to the shield building roof design.

Revise Table 6.2-6 to the following:

Table 6.2-6 – CIS Equivalent Static Seismic Accelerations
Units: g [1]

Elevation [2]	East Side			West Side		
	X	Y	Z	X	Y	Z
66.5	0.33	0.36	0.36	0.33	0.36	0.36
82.5	0.33	0.36	0.36	0.33	0.36	0.36
99	0.35	0.36	0.36	0.35	0.36	0.36
103	0.36	0.36	0.36	0.36	0.36	0.36
107.17	0.37	0.36	0.36	0.37	0.36	0.36
134.25	0.58	0.56	0.39	0.59	0.56	0.39
153	0.71	0.59	0.39	0.74	0.66	0.40
164.95				0.85	0.83	0.41

Notes to Table 6-.2-6:

(1) X = North-South; Y = East-West; Z = Vertical
(2) Linear interpolation between elevations is acceptable.

Revise Table 6.2-7, the referenced table numbers should be 6.2-3, 6.2-4, 6.2-5, and 6.2-6.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR03-023
Revision: 0

Question:

The staff review of Section 6.4 identified a number of items in need of clarification or explanation. The staff requests Westinghouse to address the following:

a. A comparison of equivalent static acceleration results to the worst-case time history results is presented for a small number of selected locations. It is not clear to the staff why these specific locations were selected for comparison, and whether they are representative of all other locations in the structural model. Therefore, Westinghouse is requested to (1) explain the basis for selecting these specific locations for presentation in the report, and (2) confirm that a comprehensive comparison was conducted in order to validate that the equivalent static acceleration results generally envelop the worst-case time history results, and that any under predictions are minor.

b. The staff noted that the only significant under-prediction documented in Section 6.4 is for TY at ASB south elevation 107 ft. The equivalent static result is 76.7 ksf; the worst time history result is 89.5 ksf. This represents a 15% under-prediction. Please discuss whether this is the maximum under-prediction identified. If not, please explain the criteria applied to justify the acceptability of under-predictions, in reaching the conclusion that the equivalent static acceleration method of analysis provides an acceptable basis for structural design.

Westinghouse Response:

This section of the technical report was discussed during the meeting in December. The report compares results from the equivalent static analysis of the detailed NI05 model to time history results from the NI20 model. It was agreed that the comparisons of equivalent static results against those from the time history should be made on the same model (NI20). The revised Section 6.4 of the report is provided in this response.

a. The locations were selected to provide comparisons at representative locations throughout the nuclear island where there would be significant member forces. Some were selected close to the base of structures where seismic loads would be maximum. For the shield building, elements were selected just above the interface of the cylinder and the dish at elevation 107' and on the cylinder at elevation 211'. Three structures within the containment internal structure were selected: refueling canal south west wall; south wall of west steam generator compartment; and north east IRWST wall (CA02). These are the walls selected as critical sections for which results are given in subsection 3.8.3.5.8.1 of the DCD. Three locations in the

auxiliary building were selected at elevation 107' and 135'. The locations are considered representative of the behavior throughout the nuclear island. Results for these locations have been added to the revised section.

b. Other locations of under predictions were identified and discussed in part (a) of this RAI using the NI20 model for both the equivalent static and time history analyses for the rock case. The equivalent static acceleration results compare reasonably with those from the time history analyses particularly at the locations of maximum member forces that control the design. Therefore, the use of seismic equivalent static accelerations is acceptable.

Reference:

None

Design Control Document (DCD) Revision:

DCD revisions are not shown for each RAI. A single set of proposed revisions is given in the response to RAI-TR03-013. The revisions are based on the material in the technical report as well as in the RAI responses. The revisions include changes to Section 3.7 and the addition of a new Appendix 3G providing a summary of the seismic analyses.

PRA Revision:

None

Technical Report (TR) Revision:

Section 6.4 will be revised as shown on the following pages. Note that the shield building roof beams have been removed at this time since the AP1000 shield building roof design is being modified as part of the evaluation of an airplane crash.

6.4 Comparison of Forces, Moments, and Stress for Building Design

The structural design of the ASB and CIS building has been performed using equivalent static seismic accelerations applied to the detailed NI05 finite element model. To show that the equivalent static results are appropriate for design, equivalent static results are compared to the time history results for the NI20 model on hard rock. Member forces obtained from the equivalent static seismic analyses at two elevations of the shield building, in three elements of the auxiliary building, and at three elevations of the containment internal structure are compared at the same locations to results obtained from seismic time history analyses. These locations are shown in Figure 6.4-1 and 6.4-2 for elevation 107' and 211' of the shield building. Figure 6.4-3 shows the locations in the ASB. Figure 6.4-4 shows the location of the walls in the CIS and Figure 6.4-5 shows the element numbers in the NI20 model. The CIS locations are at the refueling canal, south wall of the west steam generator compartment, and north east wall of the IRWST (structural module CA02). The coordinate system for the ASB and CIS elements is defined in Figure 6.4-6, X is horizontal, and Y is vertical for the local coordinate system.

Table 6.4-1 compares member forces at the two elevations of the shield building. The equivalent static member forces are the square root sum of squares (SRSS) of the three equivalent static components [north-south (NS), east-west (EW), and vertical (VT)] that were analyzed separately. The time history results are the maximum for each component throughout the time history. Results are also shown for a few selected times when one of the components is maximum. Design of the shield building reinforcement is controlled by the vertical force (TY) and the in-plane shear (TXY). The maximum member forces occur at elevation 100' on the west side. As shown by the table these member forces compare very well between the equivalent static and the time history analyses.

Table 6.4-2 compares member forces at the three locations within the Auxiliary Building. The significant equivalent static forces envelope the time history forces except for element 190. The time history TY force is less than 9 percent higher, and the time history shear force, which is of high value, at the time (8.915 seconds) TY is maximum is 19 percent lower than the equivalent static value. The time history TX forces are slightly higher than the equivalent static forces, but they are of small values.

Table 6.4-3 compares member forces in elements of the containment internal structures. The design of these walls is described in DCD subsection 3.8.3.5.8.1. The walls are concrete filled steel plate modules and have significant margin in most locations. Design loads include hydrostatic, hydrodynamic, pressure and thermal as well as seismic. The smallest margin is at the base of the south wall of the west steam generator compartment (see Table 3.8.3-5 (Sheet 3 of 3)). The controlling seismic load at this location is due to TY. The TY and TXY equivalent static forces are higher than the maximum time history forces. Some TX forces do exceed the equivalent static forces, but are of small magnitude relative to TY.

The equivalent static acceleration results compare reasonably with those from the time history analyses particularly at the locations of maximum member forces that control the design. Therefore, the use of seismic equivalent static accelerations is acceptable.

Table 6.4-1 - Shield Building Wall Force Comparisons

Element #	Location	Equivalent Static Force (kips/ft)			Time History Force (kips/ft)		
Elevation 107		**TX**	**TY**	**TXY**	**TX**	**TY**	**TXY**
651	**North**	15.84	126.25	145.40	16.03	153.10	118.60
651 t=10.49 sec					16.03	153.10	55.72
2886	**East**	29.00	215.35	60.98	25.44	197.60	52.18
668	**West**	39.98	344.21	157.13	43.01	340.80	160.40
668 t=8.96 sec					43.01	336.31	11.67
664	**South**	41.02	237.45	129.41	36.53	205.90	95.04
Elevation 211		**TX**	**TY**	**TXY**	**TX**	**TY**	**TXY**
924	**North**	25.57	152.64	128.72	28.33	188.50	119.30
924 t=10.49 sec					13.59	188.50	11.74
916	**East**	23.89	143.06	118.61	26.13	144.80	109.70
900	**West**	21.30	129.62	99.66	27.40	123.10	94.98
900 t=8.97 sec					27.40	87.12	2.44
908	**South**	27.32	174.57	140.08	25.80	172.10	134.20

Note: TX is horizontal and TY is vertical

Table 6.4-2 – Auxiliary Building Force Comparisons

	Equivalent Static Force (kips/ft)			Time History Force (kips/ft)		
Element	**TX**	**TY**	**TXY**	**TX**	**TY**	**TXY**
155	24.76	33.61	28.71	14.49	33.19	18.06
190	2.43	116.99	115.74	3.47	127.40	97.33
190 t=8.915 sec				2.62	127.40	93.28
2428	10.14	120.86	55.20	11.44	95.26	32.51

Note: TX is horizontal and TY is vertical

Table 6.4-3 – CIS Stress Comparisons

Refueling Canal SW Wall Elements	Equivalent Static Force (kips/ft)			Time History Force (kips/ft)		
	TX	TY	TXY	TX	TY	TXY
1846	1.44	9.11	28.73	7.77	8.28	23.19
1845	20.71	19.01	50.37	20.89	15.63	42.00
1852	4.68	30.37	43.21	7.67	26.80	35.68
1851	4.47	21.26	56.48	13.50	18.80	42.86
1861	13.25	54.33	48.20	22.18	47.59	41.10
1861 t =10.67 sec				22.18	14.46	10.76
1862	4.06	27.81	64.63	16.74	21.61	45.36
SGW South Wall Elements	**Equivalent Static Force (kips/ft)**			**Time History Force (kips/ft)**		
	TX	**TY**	**TXY**	**TX**	**TY**	**TXY**
1808	24.92	18.58	44.43	22.06	14.46	34.83
1807	33.63	14.11	32.95	25.53	11.89	25.41
1813	7.13	13.73	59.72	7.10	10.42	42.72
1812	7.19	32.74	32.99	9.68	27.53	26.59
1820	12.98	17.06	61.45	12.04	15.76	43.59
1819	6.19	69.33	41.49	6.63	50.65	33.70
1821	27.89	25.10	47.68	25.62	16.29	34.17
1822	11.21	102.37	40.98	28.28	84.16	39.97
1822 t =10.11 sec				28.28	73.18	23.22

Note: TX is horizontal and TY is vertical

Table 6.4-3 (cont) – CIS Stress Comparisons

CA02 Wall Elements	Equivalent Static Force (kips/ft)			Time History Force (kips/ft)		
	TX	TY	TXY	TX	TY	TXY
1832	13.46	26.69	43.32	12.56	18.43	31.41
1829	3.27	5.46	28.64	7.78	7.34	21.69
1827	5.50	8.47	13.61	5.63	10.87	10.70
1833	6.15	23.51	44.78	12.77	16.34	36.78
1830	11.04	23.18	40.02	13.84	17.18	33.34
1826	6.12	34.97	20.98	7.55	28.26	17.22
1834	11.60	25.12	52.44	12.77	17.75	44.39
1831	11.82	36.19	43.64	15.25	25.95	36.95
1831 t =10.48 sec				15.25	13.10	6.96
1828	14.73	62.84	27.20	19.63	55.12	28.71
1828 t=10.48 sec				19.63	11.18	9.81

Note: TX is horizontal and TY is vertical

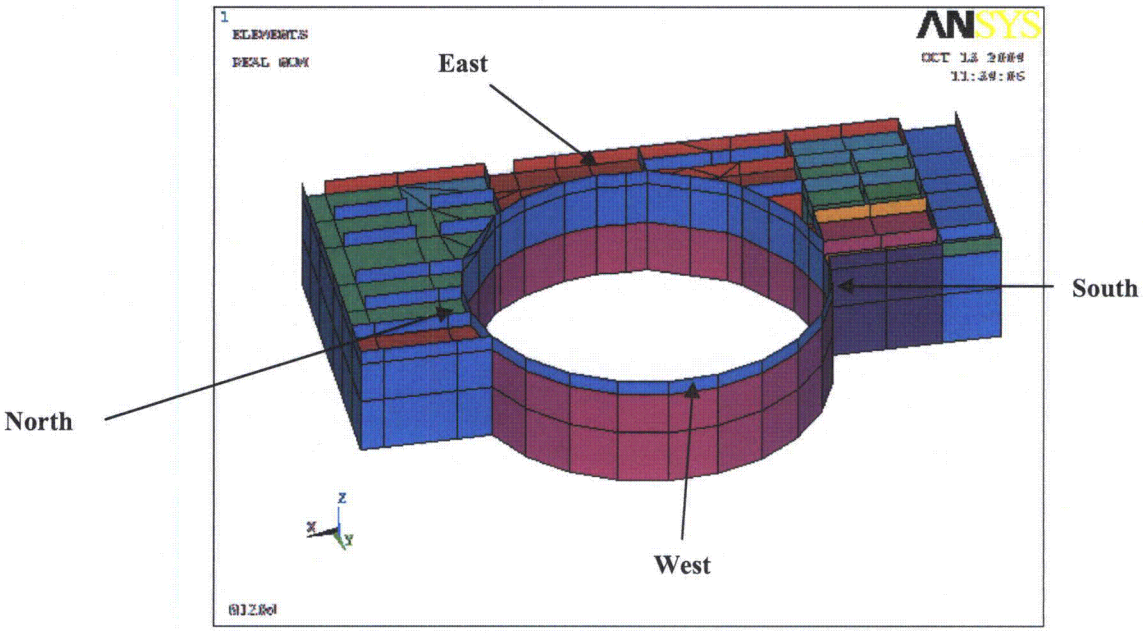


Figure 6.4-1 - Locations used for Comparison at Elevation 107'

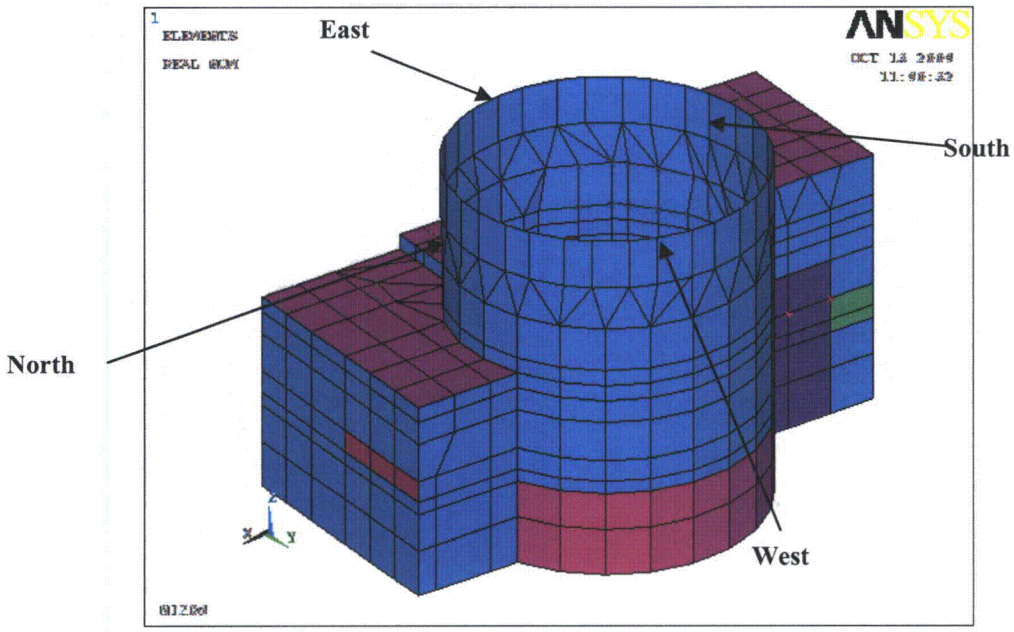
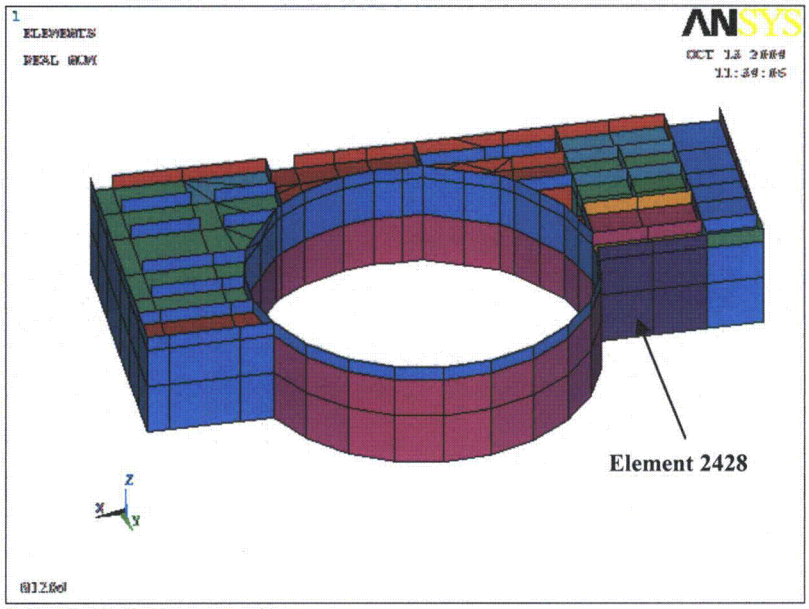
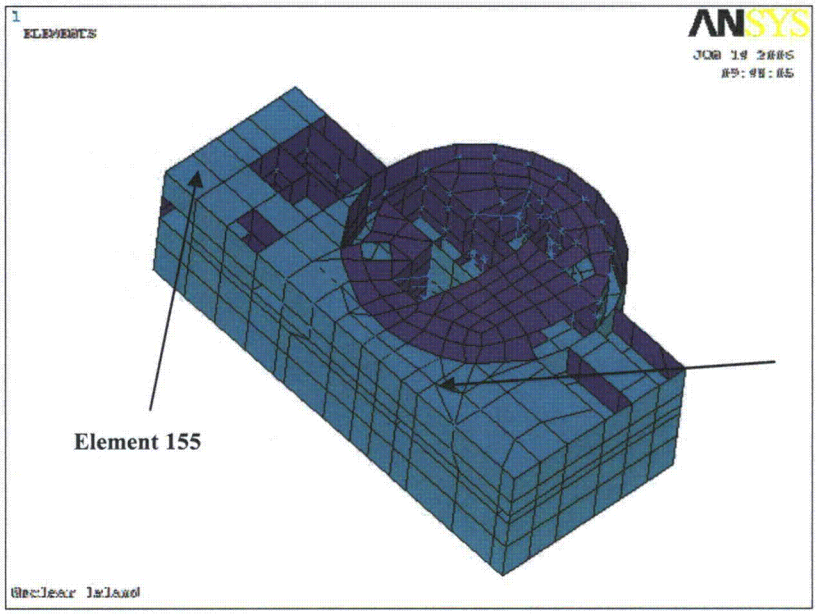


Figure 6.4-2 - Location for Comparison at Elevation 211'



Element at Elevation 107'



Elements at Elevation 135'

Figure 6.4-3 - Auxiliary Building Comparison Elements

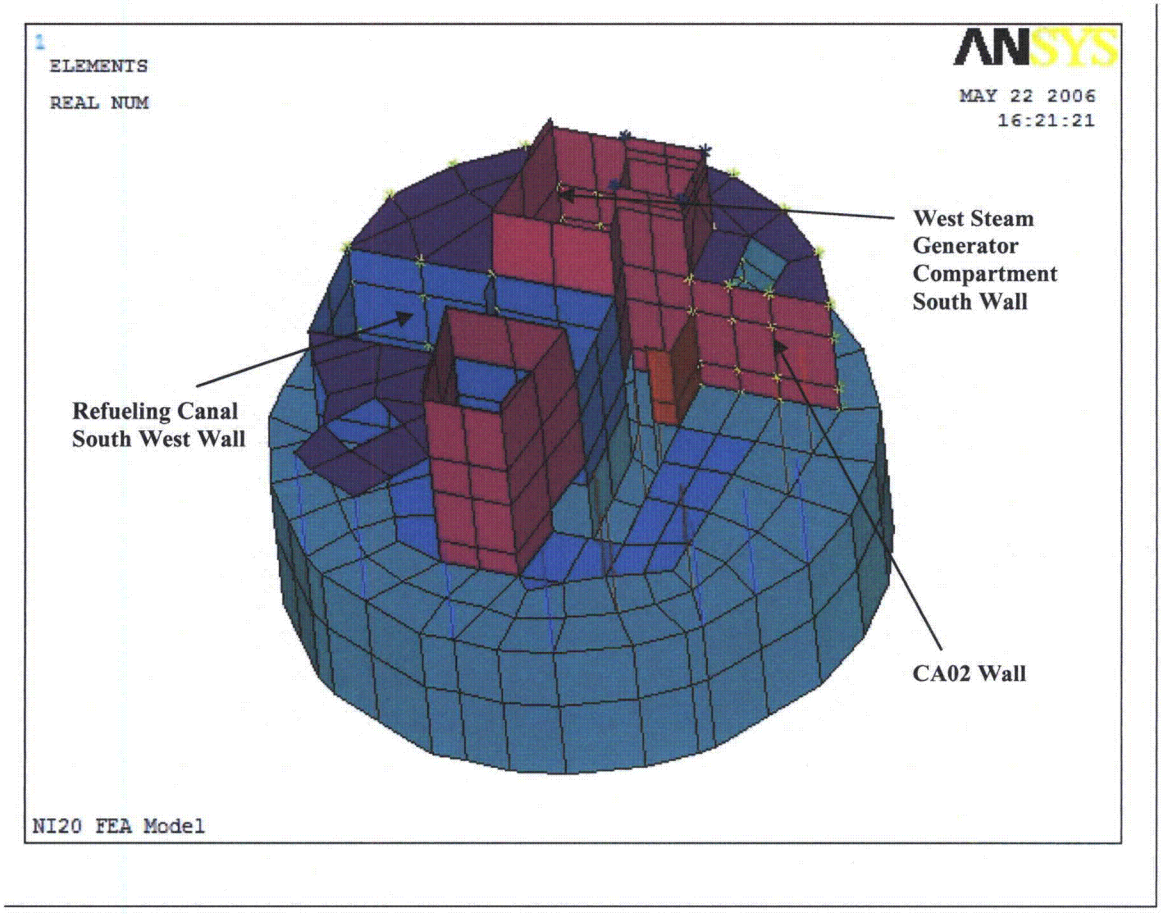
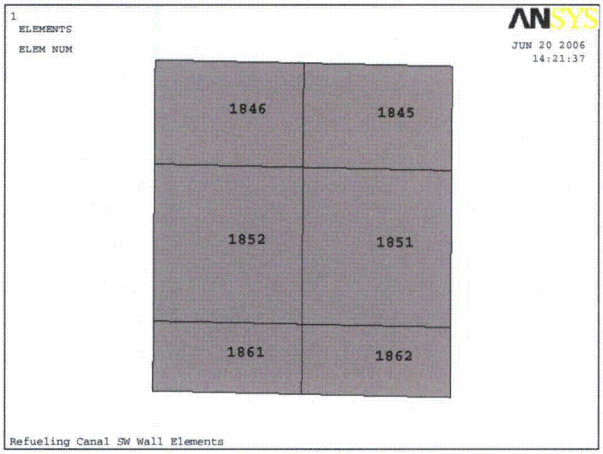
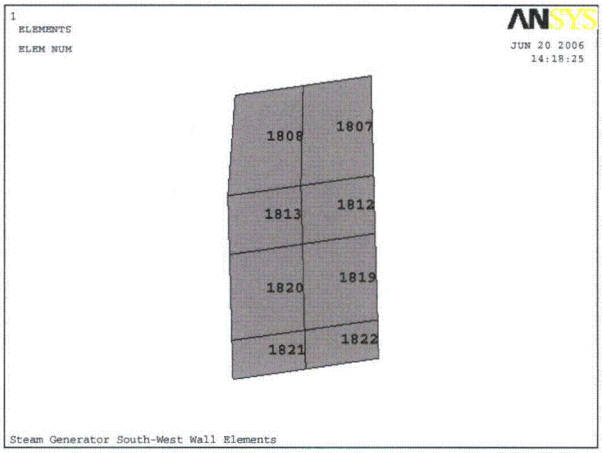


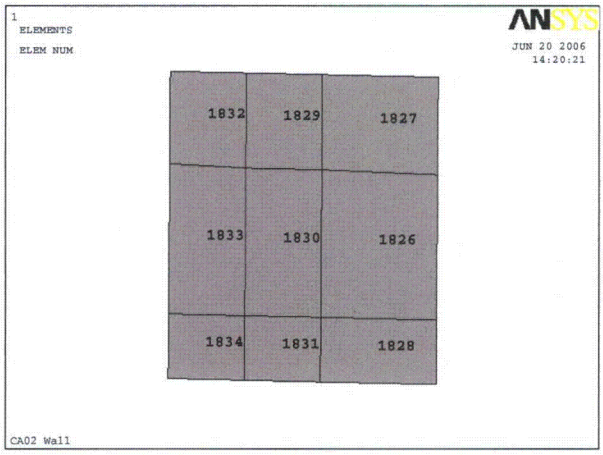
Figure 6.4-4 - Containment Internal Structures



Refueling Canal South West Wall



South Wall of West SG Compartment



CA20 IRWST North Wall

Figure 6.4-5 - CIS Walls - NI20 Element Numbers

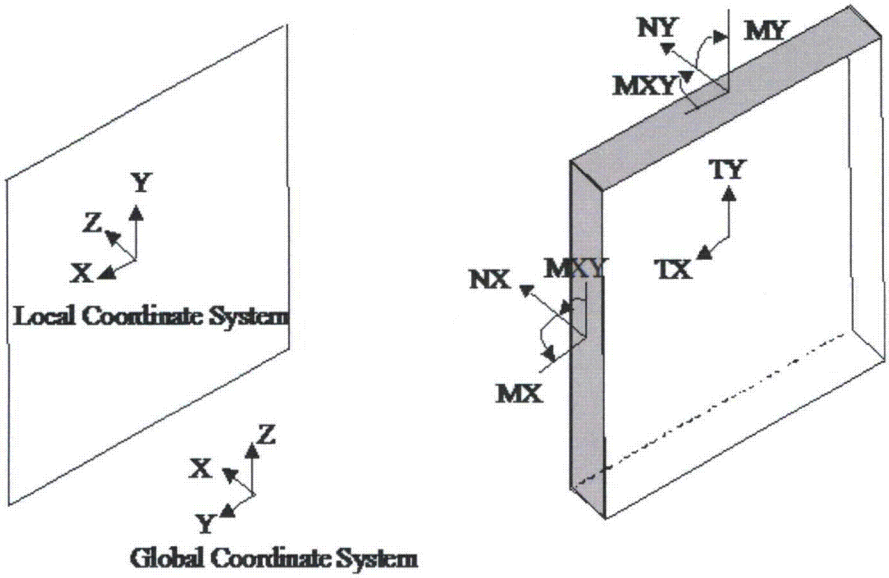


Figure 6.4-6 - Local and Global Coordinate System for ASB and CIS