GE Energy

James C. Kinsey
Project Manager, ESBWR Licensing

PO Box 780 M/C J-70
Wilmington, NC 28402-0780
USA

T 910 675 5057
F 910 362 5057
jim.kinsey@ge.com

MFN 06-262
Supplement 4

Docket No. 52-010

April 2, 2007

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Modified Reactor Building/Fuel Building Truncated Model, SER-ESB-038 Rev. 5**

As discussed during the December 2006 Structural Follow-up Audit, the subject report has been revised to document resolution of issues identified by the NRC and BNL. The revised report is contained in Enclosure 1 and the applicable input and output data is provided in the Enclosure 2 CD.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

References:

1. MFN 06-262 - Letter from David H. Hinds to U.S. Nuclear Regulatory Commission, *Reactor Building/Fuel Building Truncated Finite Element Model Analysis Data,* August 7, 2006
2. MFN 06-262, Supplement 1 - Letter from David H. Hinds to U.S. Nuclear Regulatory Commission, *Reactor Building/Fuel Building Finite Element Model Analysis Data – Truncated and Full Models*, August 21, 2006
3. MFN 06-262, Supplement 2 - Letter from David H. Hinds to U.S. Nuclear Regulatory Commission, *Final Reactor Building/Fuel Building Truncated Models*, November 8, 2006
4. MFN 06-262, Supplement 3 - Letter from David H. Hinds to U.S. Nuclear Regulatory Commission, *Modified Reactor Building/Fuel Building Truncated Models*, December 5, 2006

Enclosures:

1. MFN 06-262, Supp. 4 – Shimizu Engineering Report SER-ESB-038, Rev. 5, "Modified RBFB Truncated FE Model Analysis Data," January 9, 2007
2. MFN 06-262, Supp. 4 - NASTRAN Analysis Input Data and NASTRAN Analysis Results (CD)

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GE (with enclosures)
	RE Brown	GE (w/o enclosures)
	eDRF	0000-0063-4126

ENCLOSURE 1

MFN 06-262
Supplement 4

Shimizu Engineering Report SER-ESB-038, Rev. 5,

"Modified RBFB Truncated FE Model Analysis Data,"

January 9, 2007

Shimizu Engineering Report

Project	General Electric Company ESBWR Project	Shimizu Document No.	SER-ESB-038
Title	Modified RBFB Truncated FE Model Analysis Data	Rev.	5
		Issued Date	9/22/06
		Revised Date	1/9/07

NOTE:

This document provides the data for the truncated Reactor/Fuel Buildings Finite Element (FE) model analysis in response to NRC's request in the DCD audit for RAI 3.8 held on July, 2006.
NRC requested some modification for the FE model and the method of applying loads. This document provides the data modified in accordance with NRC's request.

[Note for Rev.5]
The modifications in accordance with NRC's request in this report were followings.

- The SFP pool gate gap was closed to meet the BNL's model.
- The plots of the force Nxy were added.
- The table which shows the relation NASTRAN element forces and BNL's that was added.
- The sketch of the direction of force on plane was provided.
- SFP wall (F3) model was offset to it' thickness center.
- The thickness of basemat inside RPV pedestal was changed from 4.0m to 5.1m.
- The hydrostatic load for SFP pool was modified to meet the BNL's analysis.

Details of NRC's requests and GE responses are described in Appendix C.

Rev.	Date	Note	Approve	Review	Prepare
5	1/9/07	FE model and load application method were updated per NRC's requests.	Y.O.	N.M.	T.T.
4	11/30/06	Addition of the plots of analysis results Revision to correct errors in analysis model and results	Y.O.	N.M.	T.T.
3	10/26/06	Addition of analysis results	Y.O.	N.M.	T.T.
2	10/12/06	Load conditions were updated per NRC comments.	Y.O.	N.M.	T.T.
1	9/27/06	Additional of modified truncated model	Y.O.	T.T.	T.T.
0	9/22/06	Initial Issue	Y.O.	T.T.	T.T.

Shimizu Corporation

Prepared by	T. Toyota	9/22/06
Reviewed by	T. Takahashi	9/22/06
Approved by	Y. Orito	9/22/06

Table of Contents

Lists of Tables

Lists of Figures

1. Scope

At NRC's audit on the ESBWR DCD RAI 3.8, NRC requested GE to provide the data needed to perform their verification analyses using a truncated Reactor Building and Fuel Building (RB/FB) Finite Element (FE) model. Per NRC's request, the data of the original truncated model analysis were provided by Reference 1. However, after reviewing of the original data, NRC requested to simplify and clarify the analysis data.

This report provides the load conditions and analysis model modified in accordance with NRC's request. NASTRAN analysis results for the modified load conditions are also included in this report.

Major modifications on the analysis data are as follows.

a. Load conditions: Loads applied to the model are simplified.

b. Analysis model: The model is modified for the following portions.

- Increase of Spent Fuel Pool slab (Basemat) thickness
- Increase of cylindrical wall thickness at the half north side under the Suppression Pool
- Addition of radial walls under the Suppression Pool

In addition to the above items, several changes are made per NRC's request provided at the 2nd structural audit held in December, 2006. Details of NRC's requests at the audit and GE's responses are described in Appendix C.

2. Reference

1. SER-ESB-027 "Reactor Building/Fuel Buildings Truncated FE Model Analysis Data," Rev. 1

3. Load Condition

Analyses are performed for the following loads individually.

- Dead Load, one case
- Pressure Load (at 72 hr. after LOCA), one case
- Seismic Load, 3 individual cases (North to South, West to East, Vertical upward)
- Hydrostatic Load, one case

The load conditions are summarized in Tables 3-1 through 3-6 and Figures 3-1 and 3-2. Figure 3-3 shows the names and locations of the walls in the truncated FE model.

The evaluation methods of the applied loads are described in the following sections.

It should be noted that the applied loads described in this report mean those applied to the top boundary nodes of the truncated model, i.e. boundary loads, unless noted otherwise.

In addition, loads are not applied to the cylindrical walls and radial walls under the Suppression Pool, since these walls are not connected to the RCCV wall nor RPV pedestal wall through normal rigid slabs. The walls are modeled to consider their constraint effects to the basemat.

The results from the dead load, pressure load, and hydrostatic load are combined with seismic loads which are combined with the 100/40/40 method. For the combinations of the seismic loads, refer to Section 3.2.

3.1 Dead Load

Dead loads applied to the model are evaluated based on the weight of the seismic stick model, which is described in the ESBWR DCD, Revision 1. Weights of the RBFB, RCCV, and RPV pedestal in the seismic model are converted to the uniform line loads as shown in Tables 3-7 through 3-9. For the RBFB walls, the weights are distributed to the modeled walls and columns in proportion to their sectional area.

It should be noted that the weights of the seismic stick model used in the calculations in Tables 3-7 through 3-9 do not include the self weights of structures included in the truncated FE model. Therefore, self weights of modeled structures need to be considered using the weight densities shown in Table 3-10. In the table, Young's modulus and Poisson's ratio used for analyses are also included for clarification. The values shown in the table are the same with those in Table 3G.1-12 of DCD, Rev.1.

Weights of equipments, such as the spent fuels and racks, on the basemat are not applied, since they are negligibly small in comparison with the self weight of the basemat.

3.2 Seismic Load

The following three direction loads are analyzed separately for seismic loads.

- Horizontal North to South: includes shear forces and overturning moments
- Horizontal West to East: includes shear forces and overturning moments
- Vertical upward

In the ESBWR DCD design, three components, i.e., two horizontal and one vertical, of the seismic loads are combined using the 100/40/40 method which is consistent with RG 1.92, Revision 2 requirements. Although the 100/40/40 method includes 48 cases of load combinations, few critical cases are selected and the combined results are provided together with the analysis results of three components of seismic loads.

3.2.1 *Shear Force*

Seismic shear forces are evaluated using the design seismic loads at the base of the buildings, which are described in the ESBWR DCD, Revision 1. As shown in Table 3-11, the loads for the RBFB are applied to the box walls which are parallel to the direction of the applied shear force. In the seismic stick model, stiffnesses of not only box walls but several inner walls are also considered. However, shear forces are applied to the box walls only in the truncated model analysis for simplification.

For the RCCV and RPV pedestal, loads are applied to the half areas of the walls as described in Tables 3-12 and 3-13.

3.2.2 *Overturning Moment*

Seismic overturning moments are evaluated based on the design seismic loads, which are described in the ESBWR DCD, Revision 1. Since the design overturning moment is defined at each floor level, the values at the top of the truncated model are calculated by the equation shown in Table 3-14.

Overturning moments are applied as vertical forces to the RBFB box walls, RCCV, and RPV pedestal. Evaluation methods of the applied loads are shown in Tables 3-15 through 3-17. For the RBFB box walls, loads are applied to not only the flange walls but also the web walls.

3.2.3 *Vertical Force*

Applied loads for the vertical earthquake are determined using the maximum axial forces obtained from seismic analyses, which are described in the ESBWR DCD, Revision 1. The loads are distributed to the wall in the same manner as the dead load. Tables 3-18 through 3-20 summarize the calculation results of the vertical seismic load.

3.3 Pressure Load

Analysis is performed for the pressure load at the LOCA after 72 hr (45 psig = 0.31 MPa). The loads are applied to the inside surface of the RPV pedestal and the top surface of the Basemat as a uniform pressure load as shown Figure 3-1.

As the boundary loads at the top of model, the loads in the radial and vertical directions, which are evaluated from the results of the global FE model analysis, are applied together with pressure loads. The loads are summarized in Table 3-21 and 3-22. The loads in the hoop direction are not considered since they are negligibly small.

3.4 Hydrostatic Load

Hydrostatic load applied to the inside surfaces of Spent Fuel Pool walls and slab are shown in Figure 3-2. The boundary loads are calculated as shown in Table 3-23.

The hydrostatic load and dead load are analyzed separately and the results are combined afterward.

4. Modified Truncated Model

The following modifications were made for the truncated model. They are summarized in Figure 4-1.

- Increase of Spent Fuel Pool slab (Basemat) thickness
- Increase of cylindrical wall thickness at the half north side under the Suppression Pool
- Addition of radial walls under the Suppression Pool

In addition, the following changes were made per NRC's request at the 2nd structural audit held in December 2006.

- One of the pool gate gaps (south side gate) is closed to maintain consistency with the NRC model.
- The fuel storage pool wall on F3 wall is updated using offset function.
- The thickness of basemat inside the RPV pedestal is increased to 5.1 m.

4.1 Spent Fuel Pool slab

The region of the Spent Fuel Pool slab is shown as the dot pattern in Figure 4-1. The thickness of slab elements is increased form 4.0 m to 5.5 m as shown in Figure 4-2.

4.2 Cylindrical Wall

The cylindrical wall at the north side, i.e. from 90° to 270°, under the Suppression Pool is indicated as the diagonal line pattern in Figure 4-1. Its thickness increased from 0.6 m to 1.4 m as shown in Figure 4-2.

4.3 Radial Wall

The radial walls shown as cross diagonal line pattern in Figure 4-1 are added to the modified truncated model. Their thicknesses are shown in the Figure 4-1. The radial walls in the modified truncated model are shown in Figure 4-2. As shown in Appendix A, the radial walls are modeled to the middle of B3F, EL -8700, as well as other walls.

The configurations of modified truncated model are shown in Appendix A. In the figures, node ID and element ID are indicated.

These elements are modeled as shell elements which have membrane, bending, and transverse shear stiffnesses. The modeling method of the shell element in the NASTRAN analysis is excerpted from the NASTRAN manual and attached in Appendix B for reference.

4.4 NASTRAN Analysis Input Data

Contents of NASTRAN input data provided are summarized in Tables 4-1 through 4-3.

5. Results of Analysis for Truncated Model

5.1 Table of Analysis Results

The analysis results obtained from NASTRAN Analysis are summarized in Table 5-1. They are NASTRAN output files.

Nodal displacements and element forces and moments obtained from each load case are shown in Excel files named "NASTRANNodeDisplacements.xls" and "NASTRANElementForces.xls."

Nodal displacements listed in the Excel files are defined in terms of the global coordinate system. Element forces and moments listed in the Excel files are defined in terms of the element coordinate system shown in Figures 5-1 and 5-2.

Table 5-2 summarizes the relations of force components between NRC's ANSYS model and GE's NASTRAN model.

5.2 Combined Nodal Displacements and Element Forces and Moments

Nodal displacements and element forces and moments of NASTRAN results are combined in accordance with load combinations shown in Tables 5-3, and they are shown in "CombinedNodeDisplacements.xls" and "CombinedElementForces.xls." Dead load combination considers the boundary force, self weight of model structures and hydrostatic load.

Seismic load combination for a critical case is selected using the following procedure. Chosen load combination is shown as LOAD #6 in Table 5-3.

a. Select typical areas which are representative of design forces in seismic load cases on basemat design. See Figure 5-3.

b. Calculate vertical displacements of each node for all cases of seismic load combination in accordance with 100/40/40 method. See Table5-4.

c. Choose the combination which generates the maximum displacement.

5.3 The Plots of Displacements and Section Forces and Moments

Displacements of walls and basemat are shown in Figure 5-5 through 5-64, and Section forces and moments of wall and basemat are shown in Figure 5-65 through 5-244. The basemat cut sections are shown in Figure 5-4.

Table 5-5 explains the locations and the load cases for the plots.

Displacements data and element forces and moments data used for the plots are included in the Excel files named "Plot_Displacement.xls" and "Plot_ElementForces.xls," respectively.

Table 3-1(1) Summary of Dead Load (Wall)

Components	Wall Name	Load Value (MN/m)	Direction
Axial	RA	-2.665	Vertical (+:Upward)
	RG	-2.665	
	R1	-2.665	
	R7	-2.665	
	F3-1	-4.797	
	F3-2	-2.665	
	Iw-R1	-1.333	
	Iw-R2	-1.333	
	Iw-R3	-1.333	
	Iw-R4	-1.333	
	Iw-F1	-2.332	
	Iw-F2	-1.999	
	Iw-F3	-1.999	
	Iw-F4	-1.999	
	Iw-F5	-1.333	
	Iw-F6	-0.800	
	Iw-F7	-2.532	
	Iw-F8	-2.665	
	Iw-F9	-1.333	
	Iw-F10	-1.333	
	Iw-F11	-1.333	
	Iw-F12	-1.532	
	Iw-F13	-1.333	
	RCCV	-5.328	
	Pedestal	-4.246	

Note1: These loads are applied to top of the wall shown in the table
Note2: For the locations of walls, see Figure 3-3.

Table 3-1(2) Summary of Dead Load (Column)

Components	Column Name	Load Value (MN)	Direction
Axial	C1	-2.998	Vertical (+:Upward)
	C2	-2.998	

Note1: These loads are applied to top of the wall shown in the table
Note2: For the locations of columns, see Figure 3-3.

Table 3-2 Summary of Seismic Shear Force

Components	Wall Name	Load Value (MN/m)	Direction
Shear (N to S)	RA	6.693	Horizontal (+:X)
	RG	6.693	
	RCCV_ns	4.225	
	Pedestal_ns	4.718	
Shear (W to E)	R1	6.687	Horizontal (+:Y)
	R7	6.687	
	F3-1	12.037	
	F3-2	6.687	
	RCCV_ew	5.096	
	Pedestal_ew	5.687	

Note1: These loads are applied to top of the wall shown in the table
Note2: For the locations of walls, see Figure 3-3.
Note3: Not all the walls in the seismic stick model are considered as loaded walls in the truncated model for purpose of simplicity.

Table 3-3(1) Summary of Seismic Overturning Moment (N to S)

Components	Wall	Load Value (MN/m)			Direction
		North Edge	South Edge	Constant	
Moment (N to S)	RA	6.594	-5.312	-	Vertical (+:Upward)
	RG	6.594	-5.312	-	
	R1	-	-	6.594	
	R7	-	-	-1.635	
	F3-1	-	-	-9.562	
	F3-2	-	-	-5.312	
	RCCV_ew	9.931	-9.931	-	
	Pedestal_ew	9.847	-9.847	-	

Note1: These loads are applied to top of the wall shown in the table
Note2: For the locations of walls, see Figure 3-3.
Note3: Not all the walls in the seismic stick model are considered as loaded walls in the truncated model for purpose of simplicity.
Note4: The loads on the RA and RG walls are linearly distributed between the edges.
Note5: For the RCCV and RPV pedestal, the loads are applied their flange portions as equivalently distributed loads.

Table 3-3(2) Summary of Seismic Overturning Moment (W to E)

Components	Wall	Load Value (MN/m)			Direction
		West Edge	East Edge	Constant	
Moment (W to E)	RA	-	-	-7.126	Vertical (+:Upward)
	RG	-	-	7.561	
	R1	7.561	-7.126	-	
	R7	7.561	-7.126	-	
	F3-1	-3.490	-12.827	-	
	F3-2	7.561	-1.939	-	
	RCCV_ns	13.141	-13.141	-	
	Pedestal_ns	12.460	-12.460	-	

Note1: These loads are applied to top of the wall shown in the table
Note2: For the locations of walls, see Figure 3-3.
Note3: Not all the walls in the seismic stick model are considered as loaded walls in the truncated model for purpose of simplicity.
Note4: The loads on the R1, R7, F3-1 and F3-2 walls are linearly distributed between the edges.
Note5: For the RCCV and RPV pedestal, the loads are applied their flange portions as equivalently distributed loads.

Table 3-4(1) Summary of Seismic Vertical Force (Wall)

Components	Wall Name	Load Value (MN/m)	Direction
Vertical (Axial)	RA	1.241	Vertical (+:Upward)
	RG	1.241	
	R1	1.241	
	R7	1.241	
	F3-1	2.234	
	F3-2	1.241	
	Iw-R1	0.621	
	Iw-R2	0.621	
	Iw-R3	0.621	
	Iw-R4	0.621	
	Iw-F1	1.086	
	Iw-F2	0.931	
	Iw-F3	0.931	
	Iw-F4	0.931	
	Iw-F5	0.621	
	Iw-F6	0.372	
	Iw-F7	1.179	
	Iw-F8	1.241	
	Iw-F9	0.621	
	Iw-F10	0.621	
	Iw-F11	0.621	
	Iw-F12	0.714	
	Iw-F13	0.621	
	RCCV	3.102	
	Pedestal	2.429	

Note1: These loads are applied to top of the wall shown in the table
Note2: For the locations of walls, see Figure 3-3.

Table 3-4(2) Summary of Seismic Vertical Force (Column)

Components	Column Name	Load Value (MN)	Direction
Axial	C1	1.396	Vertical (+:Upward)
	C2	1.396	

Note1: These loads are applied to top of the wall shown in the table
Note2: For the locations of columns, see Figure 3-3.

Table 3-5 Summary of Pressure Load

Components	Wall Name	Load Value (MN/m)	Direction
Radial & Vertical	RCCV	0.309	Radial (Outward: +)
		0.816	Vertical (+:Upward)
	Pedestal	0.909	Radial (Outward: +)
		-1.608	Vertical (+:Upward)

Note1: These loads are applied to top of the wall shown in the table.
Note2: Pressure loads applied to elements directly are shown in Figure 3-1.

Table 3-6 Summary of Hydrostatic Pressure Load

Components	Wall Name	Load Value (MN/m)	Direction
Horizontal	RA	0.835	+Y
	F3-1	0.835	+X
	Iw-F2	-0.835	+Y
	Iw-F3	-0.835	+Y
	Iw-F7	-0.835	+X

Note1: These loads are applied to top of the wall shown in the table.
Note2: Hydrostatic pressure loads applied to elements directly are shown in Figure 3-2.

Table 3-7 Evaluation of Dead Load for the RBFB

Load[*1] (MN)	Portion		Direction	Thickness[*2] (t: m)	Length[*2] (l: m)	Area (A: m^2)	Unit Load 1[*3] (MN/m^2)	Unit Load 2[*4] (MN/m MN)
-1030.3	Wall	RA	X	2.00	68.0	136.000		-2.665
		RG	X	2.00	68.0	136.000		-2.665
		R1	Y	2.00	47.0	94.000		-2.665
		R7	Y	2.00	47.0	94.000		-2.665
		F3-1	Y	3.60	16.6	59.760		-4.797
		F3-2	Y	2.00	30.4	60.800		-2.665
		Iw-R1	X	1.00	12.0	12.000		-1.333
		Iw-R2	X	1.00	12.0	12.000		-1.333
		Iw-R3	Y	1.00	12.0	12.000		-1.333
		Iw-R4	Y	1.00	12.0	12.000		-1.333
		Iw-F1	X	1.75	4.2	7.350		-2.332
		Iw-F2	X	1.50	2.1	3.150		-1.999
		Iw-F3	X	1.50	12.9	19.350		-1.999
		Iw-F4	X	1.50	8.1	12.150		-1.999
		Iw-F5	X	1.00	12.9	12.900		-1.333
		Iw-F6	X	0.60	16.8	10.080		-0.800
		Iw-F7	Y	1.90	16.6	31.540		-2.532
		Iw-F8	Y	2.00	4.1	8.200		-2.665
		Iw-F9	Y	1.00	8.4	8.400		-1.333
		Iw-F10	Y	1.00	5.5	5.500		-1.333
		Iw-F11	Y	1.00	6.8	6.800		-1.333
		Iw-F12	Y	1.15	5.5	6.325		-1.532
		Iw-F13	Y	1.00	8.4	8.400		-1.333
	Column	C1	-	1.50	1.5	2.250		-2.998
		C2	-	1.50	1.5	2.250		-2.998
	Total		-	-	-	773.205	-1.333	-

*1: Load is the same value as the stick model weight.
*2: Thickness and length are dimensions in the FE Model
*3: "Unit Load 1" is the load per unit area. Unit Load 1 = Load / Total A
*4: "Unit Load 2"of wall is the load per unit length.(MN/m) Unit Load 2 = Unit Load 1 * t
"Unit Load 2"of column is the nodal force.(MN) Unit Load 2 = Unit Load 1 * A

Table 3-8 Evaluation of Dead Load for the RCCV

Load*1 (MN)	Portion	Direction	Thickness (t: m)	Length*2 (l: m)	Unit Load*3 (MN/m)
-636.1	RCCV	-	2.00	119.4	-5.328

*1: Load is the same value as the stick model weight.
*2: Length = 19.0 (Radius of the modeled RCCV wall) * 2 * π
*3: "Unit Load" is the load per unit length. Unit Load = Load / l

Table 3-9 Evaluation of Dead Load for the RPV Pedestal

Load*1 (MN)	Portion	Direction	Thickness (t: m)	Length*2 (l: m)	Unit Load*3 (MN/m)
-181.4	Pedestal	-	2.40	42.7	-4.246

*1: Load is the same value as the stick model weight.
*2: Length = 6.8 (Radius of the modeled RPV pedestal) * 2 * π
*3: "Unit Load" is the load per unit length. Unit Load = Load / l

Table 3-10 Weight Densities and Other Material Constants for Analysis

	Reinforced Concrete		**Steel**
	Basemat f'c=4000psi 27.6MPa	Others f'c=5000psi 34.5MPa	Carbon Steel Liner
Young's Modulus (MPa)	2.49×10^4	2.78×10^4	2.00×10^1
Poisson's Ratio	0.17		0.3
Weight Density (MN/m^3)	0.0235		0.0770

Table 3-11 Evaluation of the Seismic Shear Force for the RBFB

Seismic Direction	Load*1 (MN)	Portion*6	Direction*2	Thickness*3 (t: m)	Length*3 (l: m)	Area (A: m^2)	Unit Load 1*4 (MN/m^2)	Unit Load 2*5 (MN/m)
N to S	910.3	RA	X	2.00	68.0	136.00		6.693
		RG	X	2.00	68.0	136.00		6.693
		Total	-	-	-	272.00	3.347	-
W to E	1031.7	R1	Y	2.00	47.0	94.00		6.687
		R7	Y	2.00	47.0	94.00		6.687
		F3-1	Y	3.60	16.6	59.76		12.037
		F3-2	Y	2.00	30.4	60.80		6.687
		Total	-	-	-	308.56	3.344	-

*1: Load is the design seismic shear force at the bottom of the RBFB Walls.
*2: Walls in the same direction as seismic direction are considered.
*3: Thickness and length are dimensions on the FE Model
*4: "Unit Load 1" is the load per unit area. Unit Load 1 = Load / Total A
*5: "Unit Load 2" is the load per unit length. Unit Load 2 = Unit Load 1 * t
*6: Not all the walls in the seismic stick model are considered as loaded walls in the truncated model for purpose of simplicity.

Table 3-12 Evaluation of the Seismic Shear Force for the RCCV

Seismic Direction	Load*1 (MN)	Portion*2	Direction	Thickness (t: m)	Length*3 (l: m)	Unit Load*4 (MN/m)
N to S	252.2	RCCV_ns	X	2.00	59.7	4.225
W to E	304.2	RCCV_ew	Y	2.00	59.7	5.096

*1: Load is the design seismic shear force at the bottom of RCCV.
*2: For the portion where the load is applied, see Figure 3-3.
*3: Length is evaluated as effective length. Length = 19.0 (Radius on the FE Model) * 2 * π /2
*4: "Unit Load" is the load per unit length. Unit Load = Load / l

Table 3-13 Evaluation of the Seismic Shear Force for the RPV Pedestal

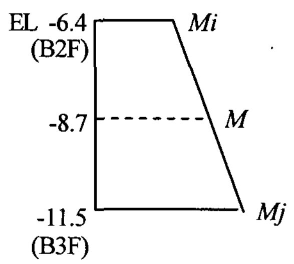
Seismic Direction	Load*1 (MN)	Portion*2	Direction	Thickness (t: m)	Length*3 (l: m)	Unit Load*4 (MN/m)
N to S	100.8	Pedestal_ns	X	2.40	21.4	4.718
W to E	121.5	Pedestal_ew	Y	2.40	21.4	5.687

*1: Load is the design seismic shear force at the bottom of RPV Pedestal.
*2: For the portion where the load is applied, see Figure 3-3.
*3: Length is evaluated as effective length. Length = 6.8 (Radius on the FE Model) * 2 * π /2
*4: "Unit Load" is the load per unit length. Unit Load = Load / l

Table 3-14 Moment of the Top of Truncated Model

	Level (m)	Stick Model		Moment* (MNm)		
		EID	NID	#	Direction of Earthquake	
					NS	EW
RBFB	-6.4		101	*Mi*	29734	30234
	-8.7	1101		*M*	31614	32604
	-11.5		2	*Mj*	33902	35490
RCCV	-6.4		201	*Mi*	9560	12719
	-8.7	1201		*M*	10140	13418
	-11.5		2	*Mj*	10846	14269
RPV Pedestal	-6.4		301	*Mi*	1056	1350
	-8.7	1301		*M*	1288	1630
	-11.5		2	*Mj*	1570	1970

Note1: Mi, Mj: design overturning moment
Note2: Moments (M) at EL-8.7m are applied as boundary loads.
The moment (M) is calculated from the following equation.



$$M = \frac{(-6.4-(-8.7))\cdot(Mj-Mi)}{(-6.4-(-11.5))} + Mi$$
$$= \frac{2.3\cdot(Mj-Mi)}{5.1} + Mi$$

Table 3-15(1) Evaluation of the Seismic Moment for the RBFB (N to S)

Load[*1] (MN·m)	Portion[*8]	Direction[*2]	Thickness[*3] (t: m)	Length[*3] (l: m)	Area (A: m^2)	Distance (d0: m) R1 ~ Wall C.	C. of Stiff. from R1 (m)[*4]	Distance (d: m) C. of Stiff .~Wall C.	Moment of Inertia (I: m^4)[*5]	Distance from C. of Stiff (m) North Edge	Distance from C. of Stiff (m) South Edge	Unit Load1[*6] ($MN/m^2/m$)	Unit Load (MN/m)[*7] North Edge	Unit Load (MN/m)[*7] South Edge	Unit Load (MN/m)[*7] Constant
31614	RA	parallel	2.00	68.0	136.000	34.00		3.660	54227	37.660	-30.340		6.594	-5.312	
	RG	parallel	2.00	68.0	136.000	34.00		3.660	54227	37.660	-30.340		6.594	-5.312	
	R1	perpendicular	2.00	47.0	94.000	0.00		37.660	133352	-	-				6.594
	R7	perpendicular	2.00	47.0	94.000	47.00		-9.340	8231	-	-				-1.635
	F3-1	perpendicular	3.60	16.6	59.760	68.00		-30.340	55073	-	-				-9.562
	F3-2	perpendicular	2.00	30.4	60.800	68.00		-30.340	55986	-	-				-5.312
	Total	-	-	-	580.560		37.660		361097			0.088			

*1: Refer to Table 3-14.
*2: Direction of wall relative to direction of seismic load
*3: Thickness and length are dimensions on the FE Model.
*4: Center of Stiffness = Σ(A*d0)/Total A
*5: Moment Inertia (parallel Wall) = $A * d^2 + t * l^3 / 12$
Moment Inertia (perpendicular Wall) = $A * d^2 + l * t^3 / 12$
*6: Unit Load1 = Load / Total I
*7: Unit Load2 is calculated from the following equations.
Parallel Wall: Unit Load2 = Unit Load1 * t * Distance from C. of Stiff.
Perpendicular Wall: Unit Load2 = Unit Load1 * t * d
*8: Not all the walls in the seismic stick model are considered as loaded walls in the truncated model for purpose of simplicity.

Table 3-15(2) Evaluation of the Seismic Moment for the RBFB (W to E)

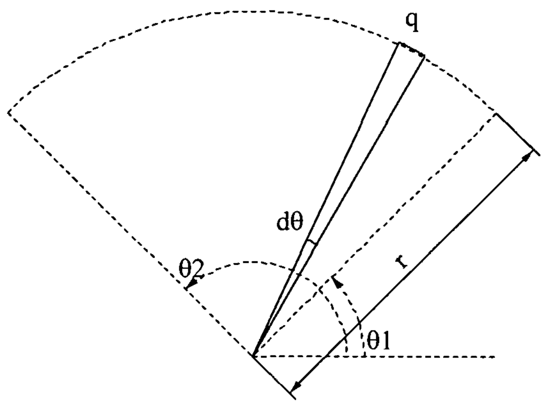
Load*1 (MN·m)	Portion*8	Direction*2	Thickness*3 (t: m)	Length*3 (l: m)	Area (A: m²)	Distance (d0: m) R1 ~ Wall C.	C. of Stiff. from R1 (m)*4	Distance (d: m) C. of Stiff .~Wall C.	Moment of Inertia (I: m⁴)*5	Distance from C. of Stiff (m) West Edge	Distance from C. of Stiff (m) East Edge	Unit Load1*6 (MN/m²/m)	Unit Load (MN/m)*7 West Edge	Unit Load (MN/m)*7 East Edge	Unit Load (MN/m)*7 Constant
32604	RA	perpendicular	2.00	68.0	136.000	47.00		-22.805	70772	-	-				-7.126
	RG	perpendicular	2.00	68.0	136.000	0.00		24.195	79662	-	-				7.561
	R1	parallel	2.00	47.0	94.000	23.50		0.695	17349	24.195	-22.805		7.561	-7.126	
	R7	parallel	2.00	47.0	94.000	23.50		0.695	17349	24.195	-22.805		7.561	-7.126	
	F3-1	parallel	3.60	16.6	59.760	38.70		-14.505	13945	-6.205	-22.805		-3.490	-12.827	
	F3-2	parallel	2.00	30.4	60.800	15.20		8.995	9602	24.195	-6.205		7.561	-1.939	
	Total	-	-	-	580.560		24.195		208680			0.156			

*1: Refer to Table 3-14.
*2: Direction of wall relative to direction of seismic load
*3: Thickness and length are dimensions on the FE Model.
*4: Center of Stiffness = Σ(A*d0)/Total A
*5: Moment Inertia (parallel Wall) = $A * d^2 + t * l^3 / 12$
Moment Inertia (perpendicular Wall) = $A * d^2 + l * t^3 / 12$
*6: Unit Load1 = Load / Total I
*7: Unit Load2 is calculated from the following equations.
Parallel Wall: Unit Load2 = Unit Load1 * t * Distance from C. of Stiff.
Perpendicular Wall: Unit Load2 = Unit Load1 * t * d
*8: Not all the walls in the seismic stick model are considered as loaded walls in the truncated model for purpose of simplicity.

Table 3-16 Evaluation of the Seismic Moment for the RCCV

Seismic Direction	Load[*1] (MN·m)	Portion	Direction	Model Radius (r: m)	Unit Load[*2] (q: MN/m)
N to S	10140	RCCV_ew	Y	19.00	9.931
W to E	13418	RCCV_ns	X	19.00	13.141

*1: Refer to Table 3-14.
*2: Unit Load = Load / (2 * 20.5 * r2) (Refer to the following figure.)



$$M = 2\int_{\theta 1}^{\theta 2} q \cdot r \cdot \sin\theta \cdot r \cdot d\theta$$
$$= 2\sqrt{2} \cdot q \cdot r^2$$
$$\therefore\ q = \frac{M}{2\sqrt{2}r^2}$$

Table 3-17 Evaluation of the Seismic Moment for the RPV Pedestal

Seismic Direction	Load[*1] (MN·m)	Portion	Direction	Model Radius (r: m)	Unit Load[*2] (q: MN/m)
N to S	1288	Pedestal_ew	Y	6.80	9.847
W to E	1630	Pedestal_ns	X	6.80	12.460

*1: Refer to Table 3-14.
*2: Unit Load = Load / (2 * 20.5 * r2) (Refer to the figure in Table 3-16.)

Table 3-18 Evaluation of the Seismic Vertical Force for the RBFB

Load*1 (MN)	Portion		Direction	Thickness*2 (t: m)	Length*2 (l: m)	Area (A: m²)	Unit Load 1*3 (MN/m²)	Unit Load 2*4 (MN/m MN)
479.8	Wall	RA	X	2.00	68.0	136.000		1.241
		RG	X	2.00	68.0	136.000		1.241
		R1	Y	2.00	47.0	94.000		1.241
		R7	Y	2.00	47.0	94.000		1.241
		F3-1	Y	3.60	16.6	59.760		2.234
		F3-2	Y	2.00	30.4	60.800		1.241
		Iw-R1	X	1.00	12.0	12.000		0.621
		Iw-R2	X	1.00	12.0	12.000		0.621
		Iw-R3	Y	1.00	12.0	12.000		0.621
		Iw-R4	Y	1.00	12.0	12.000		0.621
		Iw-F1	X	1.75	4.2	7.350		1.086
		Iw-F2	X	1.50	2.1	3.150		0.931
		Iw-F3	X	1.50	12.9	19.350		0.931
		Iw-F4	X	1.50	8.1	12.150		0.931
		Iw-F5	X	1.00	12.9	12.900		0.621
		Iw-F6	X	0.60	16.8	10.080		0.372
		Iw-F7	Y	1.90	16.6	31.540		1.179
		Iw-F8	Y	2.00	4.1	8.200		1.241
		Iw-F9	Y	1.00	8.4	8.400		0.621
		Iw-F10	Y	1.00	5.5	5.500		0.621
		Iw-F11	Y	1.00	6.8	6.800		0.621
		Iw-F12	Y	1.15	5.5	6.325		0.714
		Iw-F13	Y	1.00	8.4	8.400		0.621
	Column	C1	-	1.50	1.5	2.250		1.396
		C2	-	1.50	1.5	2.250		1.396
	Total		-	-	-	773.205	0.621	-

*1: Load is the maximum axial force of dynamic analysis by the stick model.
*2: Thickness and length are dimensions on the FE Model
*3: "Unit Load 1" is the load per unit area. Unit Load 1 = Load / Total A
*4: "Unit Load 2" is the load per unit length. Unit Load 2 = Unit Load 1 * t.

Table 3-19 Evaluation of the Seismic Vertical Force for the RCCV

Load*1 (MN)	Portion	Direction	Thickness (t: m)	Length*2 (l: m)	Unit Load*3 (MN/m)
370.3	RCCV	-	2.00	119.4	3.102

*1: Load is the maximum axial force obtained from the stick model seismic analysis.
*2: Length = 19.0 (Radius on the FE Model) * 2 * π
*3: "Unit Load" is the load per unit length. Unit Load = Load / l

Table 3-20 Evaluation of the Seismic Vertical Force for the RPV Pedestal

Load*1 (MN)	Portion	Direction	Thickness (t: m)	Length*2 (l: m)	Unit Load*3 (MN/m)
103.8	Pedestal	-	2.40	42.7	2.429

*1: Load is the maximum axial force obtained from the stick model seismic analysis.
*2: Length = 6.8 (Radius on the FE Model) * 2 * π
*3: "Unit Load" is the load per unit length. Unit Load = Load / l

Table 3-21 Evaluation of the Pressure Load for the RCCV

Average Force*1 (MN/node)		Nodal Tributary Length*2 (L: m)	Unit Load (MN/m) *3	
Radial	Vertical		Radial	Vertical
0.768	2.031	2.487	0.309	0.816

Note1: Average Forces are calculated from nodal force at EL -8.7m of the global FE model analysis
Note2: L = 19.0(Radius of the modeled RCCV wall) * 2 * π / 48(nodes)
Note3: Unit Load = [Average Force] / L

Table 3-22 Evaluation of the Pressure Load for the RPV Pedestal

Average Force*1 (MN/node)		Nodal Tributary Length*2 (L: m)	Unit Load (MN/m) *3	
Radial	Vertical		Radial	Vertical
0.809	-1.432	0.890	0.909	-1.608

Note1: Average Forces are calculated from nodal force at EL -8.7m of the global FE model analysis
Note2: L = 6.8(Radius of the modeled RPV pedestal) * 2 * π / 48(nodes)
Note3: Unit Load = [Average Force] / L

Table 3-23 Evaluation of the Hydrostatic Pressure Load for the Spent Fuel Pool

Spent Fuel Pool Water			Truncated Model		
Top (EL. m)	Bottom (EL. m)	Depth (m)	Model Top (EL. m)	Depth above Model d (m)	Boundary Load* L (MN/m)
4.35	-10.00	14.35	-8.7	13.05	0.835

*: Boundary Load is calculated by the following equation. (Refer to Figure 3-2.)
L = 1.0(t/m3) * d * 9.807 * d / 2 / 1000

Table 4-1 NASTRAN Control Data Files

Load	Control Data File	Note
Dead Load	DL.dat	Boundary Force
	GRAV.dat	Self Weight of Modeled Structures
Seismic Load	EQNS.dat	N to S
	EQEW.dat	W to E
	EQZ.dat	Vertical
Pressure Load	PL.dat	
Hydrostatic Load	FL.dat	

Table 4-2 NASTRAN Model Data Files

	Model Data File	Note
Common	cood	Coordinate System Definition
	node_truncated.txt	Grid points (Building)
	soil_node.prn	Grid points (Soil)
	elem_truncated.txt	Shell and bar elements
	rbar_truncated.txt	Rigid bar
	pshell_truncated.txt	Properties of shell elements.
	pbar_truncated.txt	Properties of bar elements.
	mat_truncated.txt	Material properties
Soil Spring	elas_o.prn	Soil spring for vertical loads
	elas_s.prn	Soil spring for horizontal loads

Table 4-3 NASTRAN Load Data Files

Load	Load Data File	Note	Reference Table and Figure
Dead Load	DL.prn	Vertical Force at Top of Model	Table 3-1
	grav.txt	Self Weight of Modeled Structures	Table 3-10
Seismic Load	EQNS.prn	Shear Force (NS) at Top of Model	Table 3-2
	EQEW.prn	Shear Force (WE) at Top of Model	Table 3-2
	EMNS.prn	Moment (NS) Top of Model	Table 3-3
	EMEW.prn	Moment (WE) at Top of Model	Table 3-3
	EQZ.prn	Vertical Force at Top of Model	Table 3-4
Pressure Load	PL.prn	Pressure at Top of Model	Table 3-5 Figure 3-1
	pl_truncated.txt	Pressure inside RPV Pedestal	
Hydrostatic Load	FL.prn	Pressure at Top of Model	Table 3-6 Figure 3-2
	fl_truncated.txt	Pressure inside SF Pool	

Table 5-1 NASTRAN Output Files

Load	Control Data File	Note
Dead Load	DL.f06	Boundary Force
	GRAV.f06	Self Weight of Modeled Structures
Seismic Load	EQNS.f06	N to S
	EQEW.f06	W to E
	EQZ.f06	Vertical
Pressure Load	PL.f06	
Hydrostatic Load	FL.f06	

Table 5-2 Force Table

Portion	Force Components	
	ANSYS	NASTRAN
Wall & Basemat Section C	N	Ny
	Nz	Nx
	Qx	Nxy
	Qy	Qy
	Qz	Qx
	Mx	My
	Mz	Mx
Basemat Section A & Basemat Section B	N	Nx
	Nz	Ny
	Qx	Nxy
	Qy	Qx
	Qz	Qy
	Mx	Mx
	Mz	My

Table 5-3 Load Combination

LOAD	#		Combination							Note
			Factor	Label		Factor	Label		Factor	Label	
Dead Load	1		1.00 ×	MDL1[*1]	+	1.00 ×	MDL2[*2]				Combined Dead Load
Pressure Load	2		1.00 ×	MPL[*3]							
Seismic Load	3		1.00 ×	MEQN[*4]							N to S
	4		1.00 ×	MEQE[*5]							W to E
	5		1.00 ×	MEQZ[*6]							Vertical Upward
	6	-	0.40 ×	MEQN	-	1.00 ×	MEQE	-	0.40 ×	MEQZ	See Section 5.2 and Table 5-4 for details of case selection
Hydrostatic	7		1.00 ×	MFLO[*7]							
Overall	8		1.00 ×	MDL1	+	1.00 ×	MDL2				
		+	1.00 ×	MPL	+	1.00 ×	MFLO				
		-	0.40 ×	MEQN	-	1.00 ×	MEQE	-	0.40 ×	MEQZ	

Note: *1: MDL1: Case applied the boundary force of Dead Load
*2: MDL2: Case applied the self weight of model structures of Dead Load
*3: MPL : Case applied the Pressure Load
*4: MEQN: Case applied the horizontal seismic load (N to S)
*5: MEQE: Case applied the horizontal seismic load (W to E)
*6: MEQZ: Case applied the vertical seismic load (upward)
*7: MFLO: Case applied the Hydrostatic load

Table 5-4 Maximum Vertical Displacement of Basemat and Load Cases

Node ID	Maximum Vertical Displacement (mm)	Combination at Maximum Displacement			Note
		Horizontal		Vertical	
		N to S	W to E	Upward	
80001	20.0	0.4	-0.4	-1.0	
80201	22.7	0.4	-0.4	-1.0	
80213	26.6	0.4	0.4	-1.0	
80225	26.0	-0.4	-0.4	-1.0	
80237	26.6	0.4	-0.4	-1.0	
80551	23.2	0.4	-0.4	-1.0	
80563	60.2	-0.4	1.0	-0.4	
80575	49.5	-1.0	-0.4	-0.4	
80587	61.3	-0.4	-1.0	-0.4	
90001	121.2	-0.4	-1.0	-0.4	Critical Combination
90031	97.8	0.4	-1.0	-0.4	
90481	118.0	-0.4	1.0	-0.4	
90511	111.1	0.4	1.0	-0.4	

Table 5-5 Location and Load Cases for the Plots

	Portion	Location		Load Cases	Components
Displacement	Wall	R1	wall top	Dead Load Pressure Load Seismic Load (NtoS) Seismic Load (WtoE) Seismic Load (Upward) Hydrostatic Load	Displacements X Dir. Y Dir Z Dir.
		R7/F1	wall top		
		F3	wall top		
		RA	wall top		
		RG	wall top		
		below RCCV	wall top		
		RPV Pedestal	wall top		
	Basemat	Section A			
		Section B			
		Section C			
Section Force	Wall	R1	wall base		Axial Force Nx, Ny Moments Mx, My Shear Forces Qx, Qy
		R7/F1	wall base		
		F3	wall base		
		RA	wall base		
		RG	wall base		
		below RCCV	wall base		
		RPV Pedestal	wall base		
	Basemat	Section A			
		Section B			
		Section C			

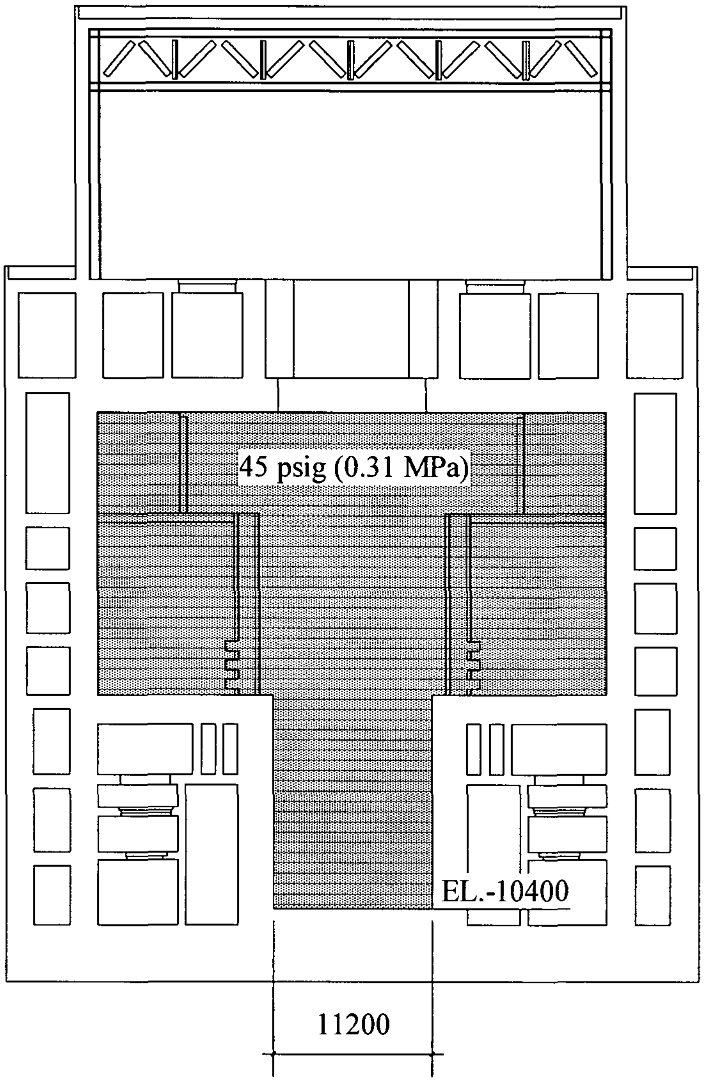


Figure 3-1 Pressure Load Applied to the RCCV Wall and the Basemat at 72 hr. after LOCA

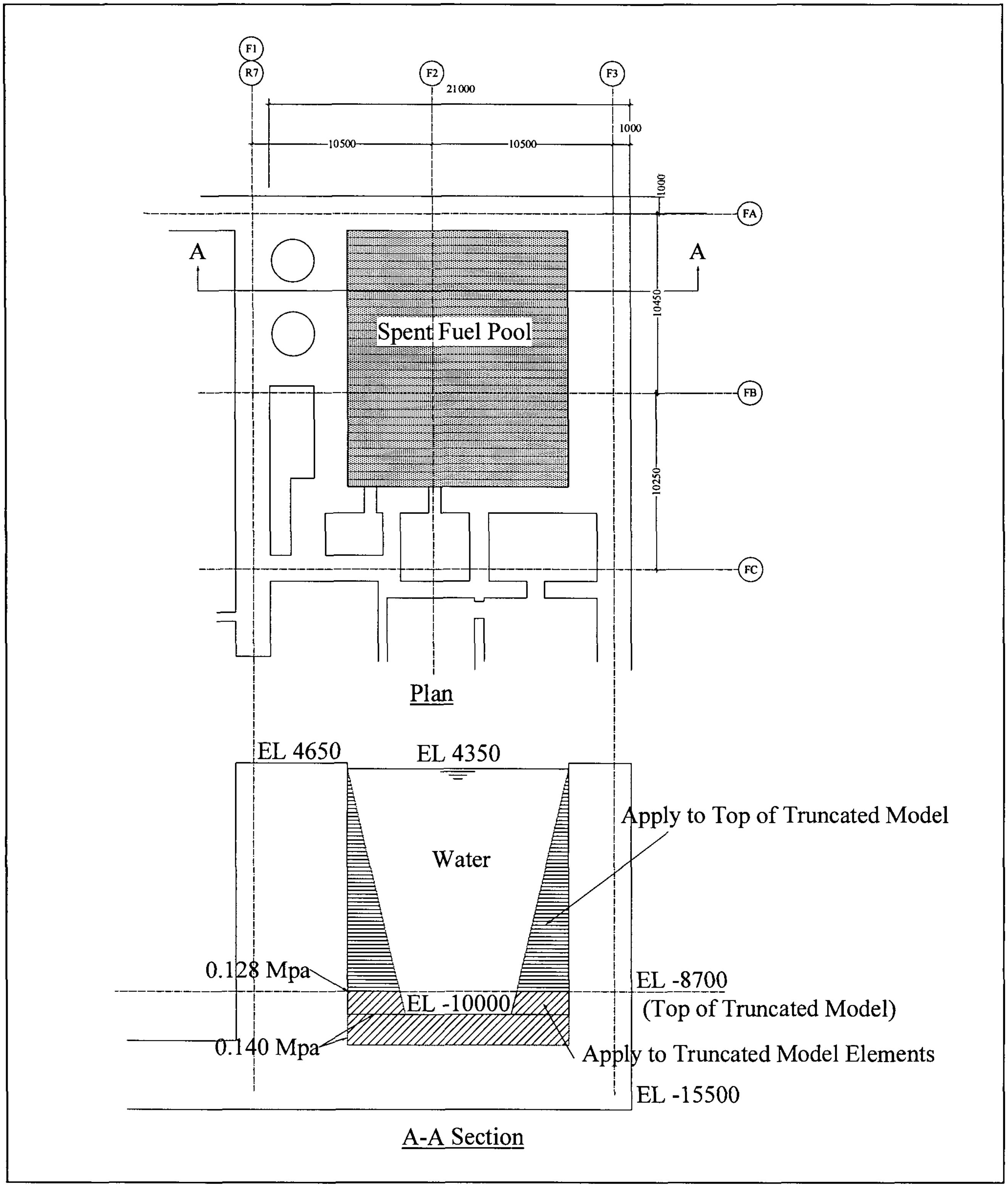


Figure 3-2 Hydrostatic Load Applied to the Spent Fuel Pool Walls and the Basemat

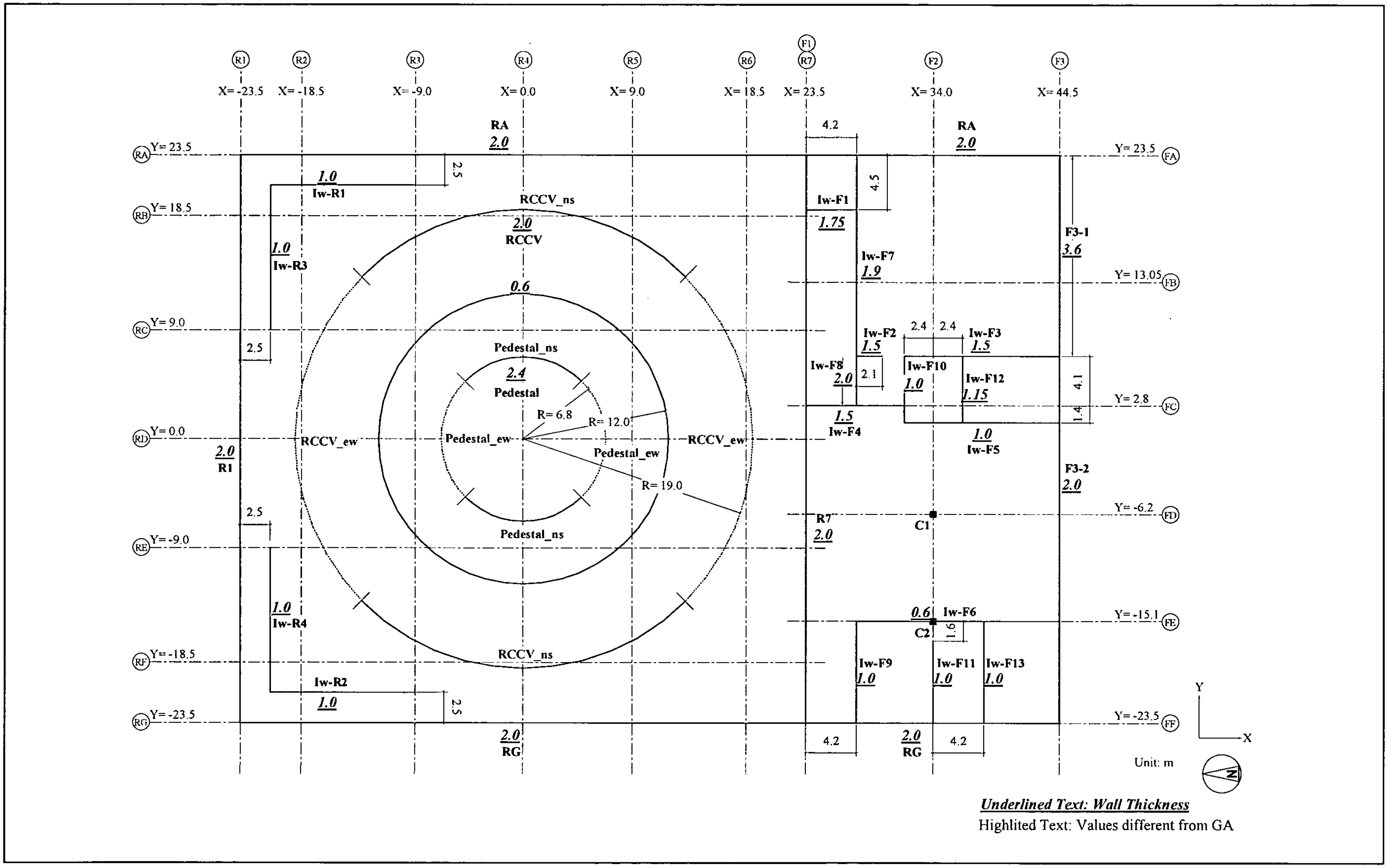


Figure 3-3 Wall Information of Truncated Model

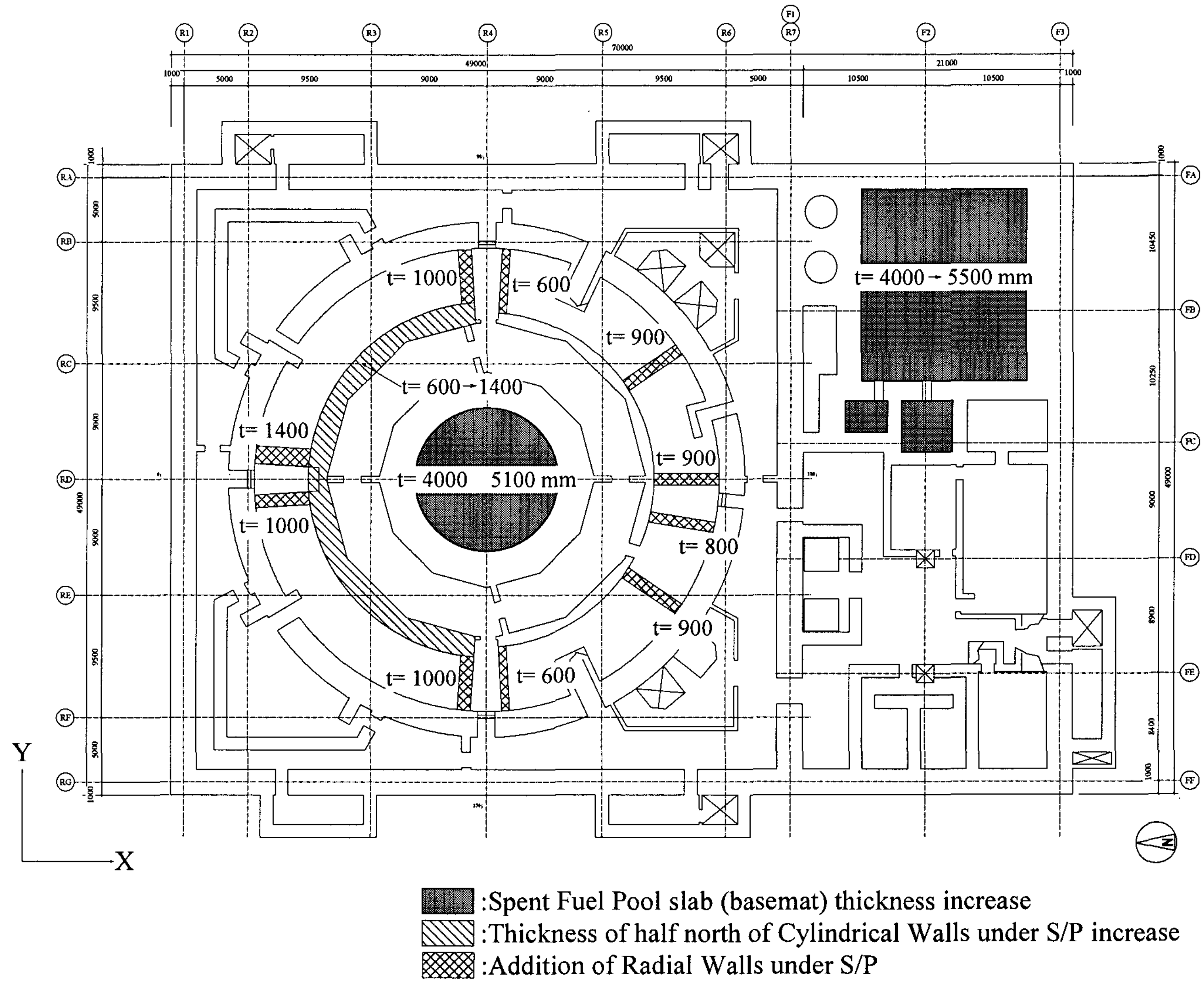


Figure 4-1 Modification in Truncated Model

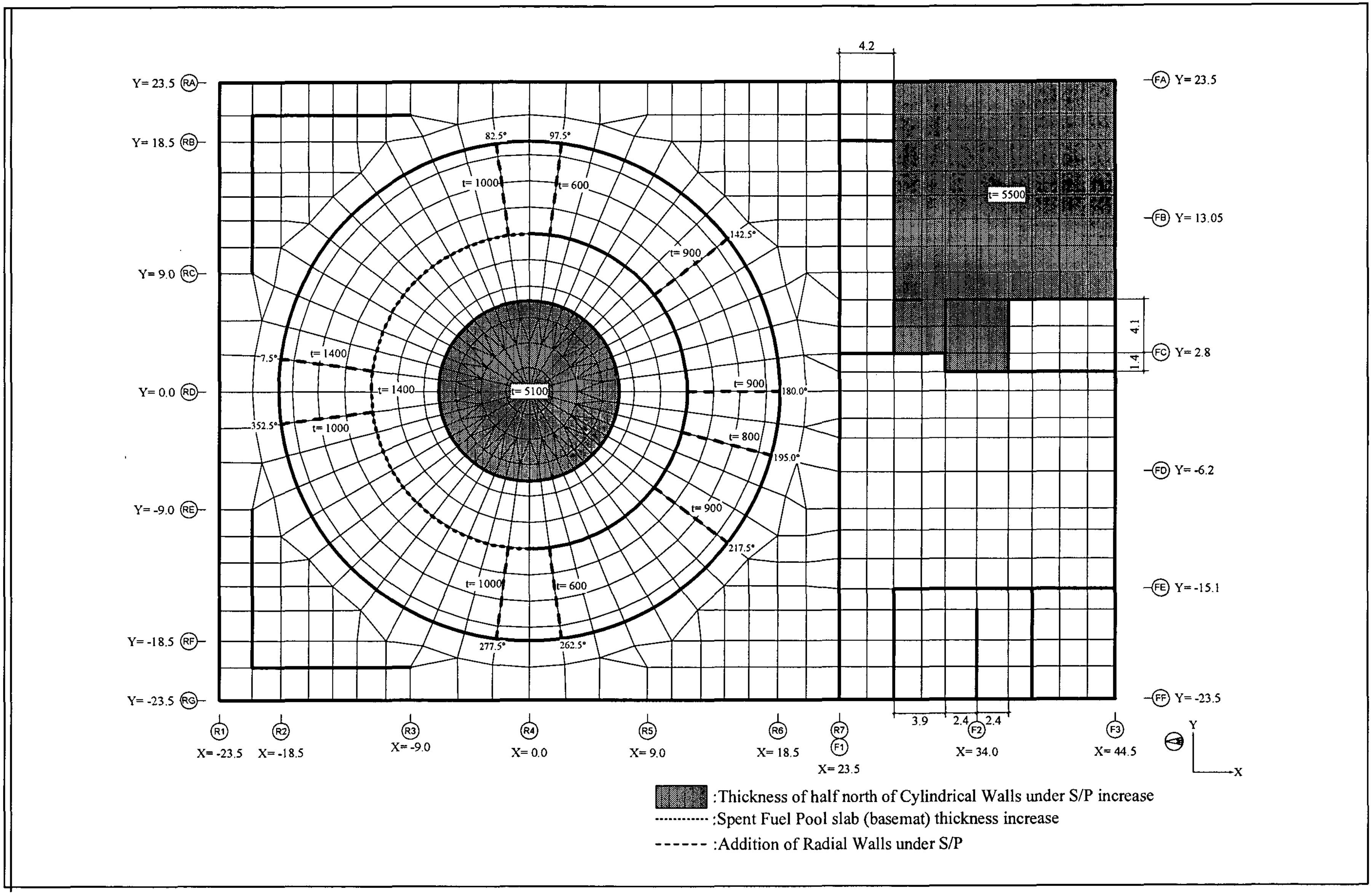
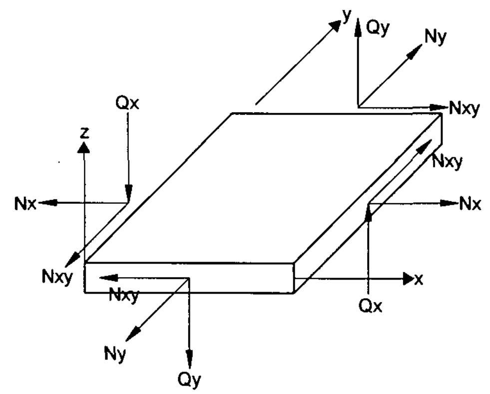
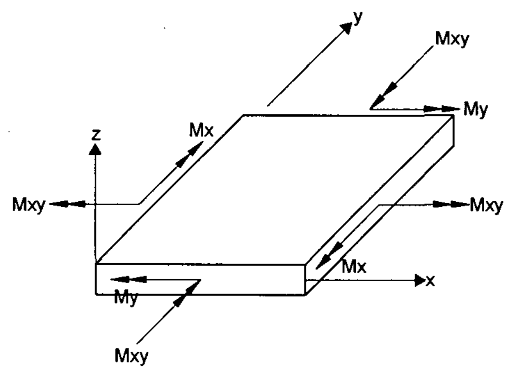


Figure 4-2 Modified Truncated Model



Membrane and Shear Forces



Moments

Definition of Element Coordinate System

Structure	x	y	z
RCCV Wall RPV Pedestal External Wall	horizontal	vertical	outward
Wall in N-S Direction	horizontal	vertical	toward West
Wall in E-W Direction	horizontal	vertical	toward South
Foundation Mat Floor Slab Top Slab	toward South	toward West	downward
Suppression Pool Slab	radial	circumferential	downward

Figure 5-1 Forces and Moments in Shell Element

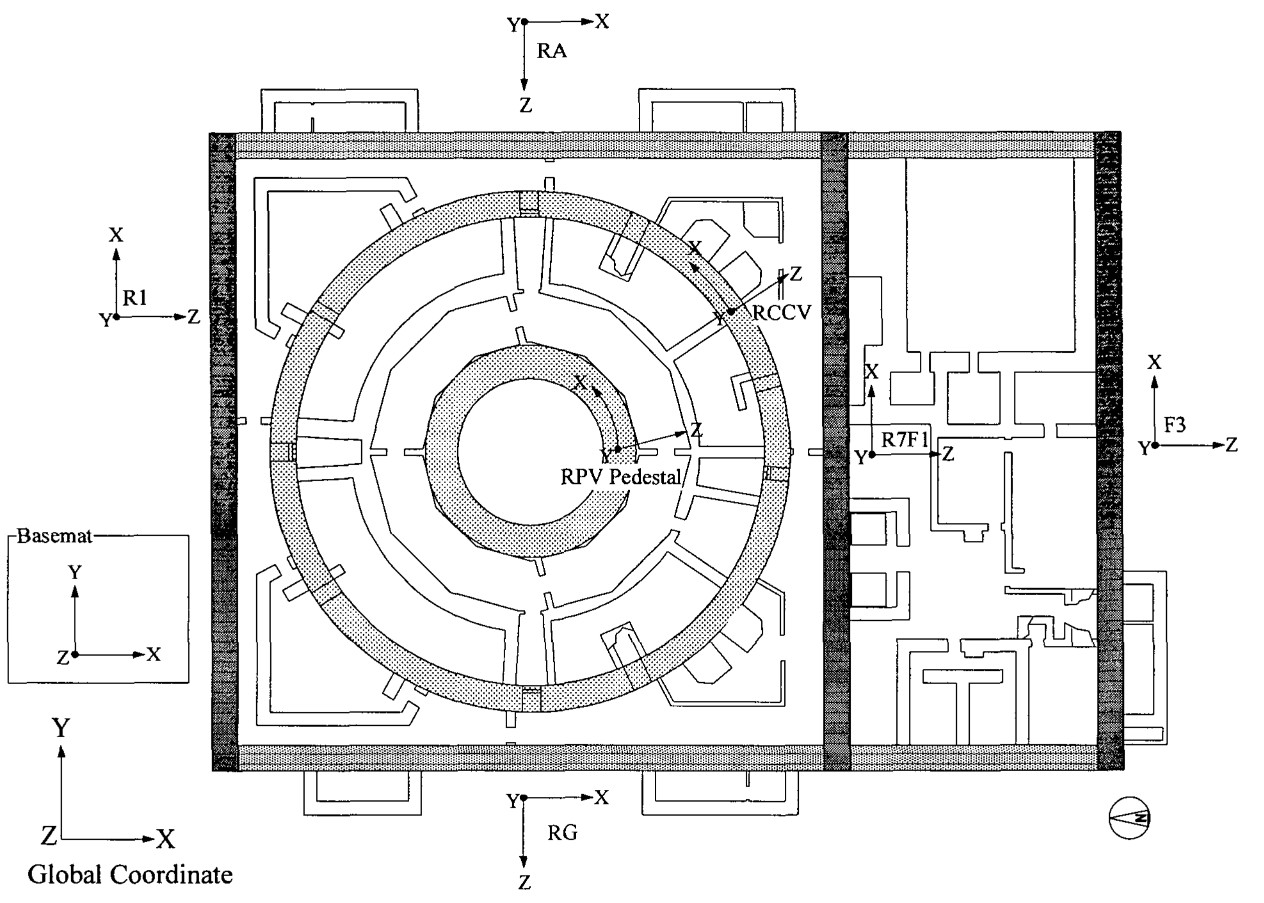


Figure 5-2 Positive Direction of Forces

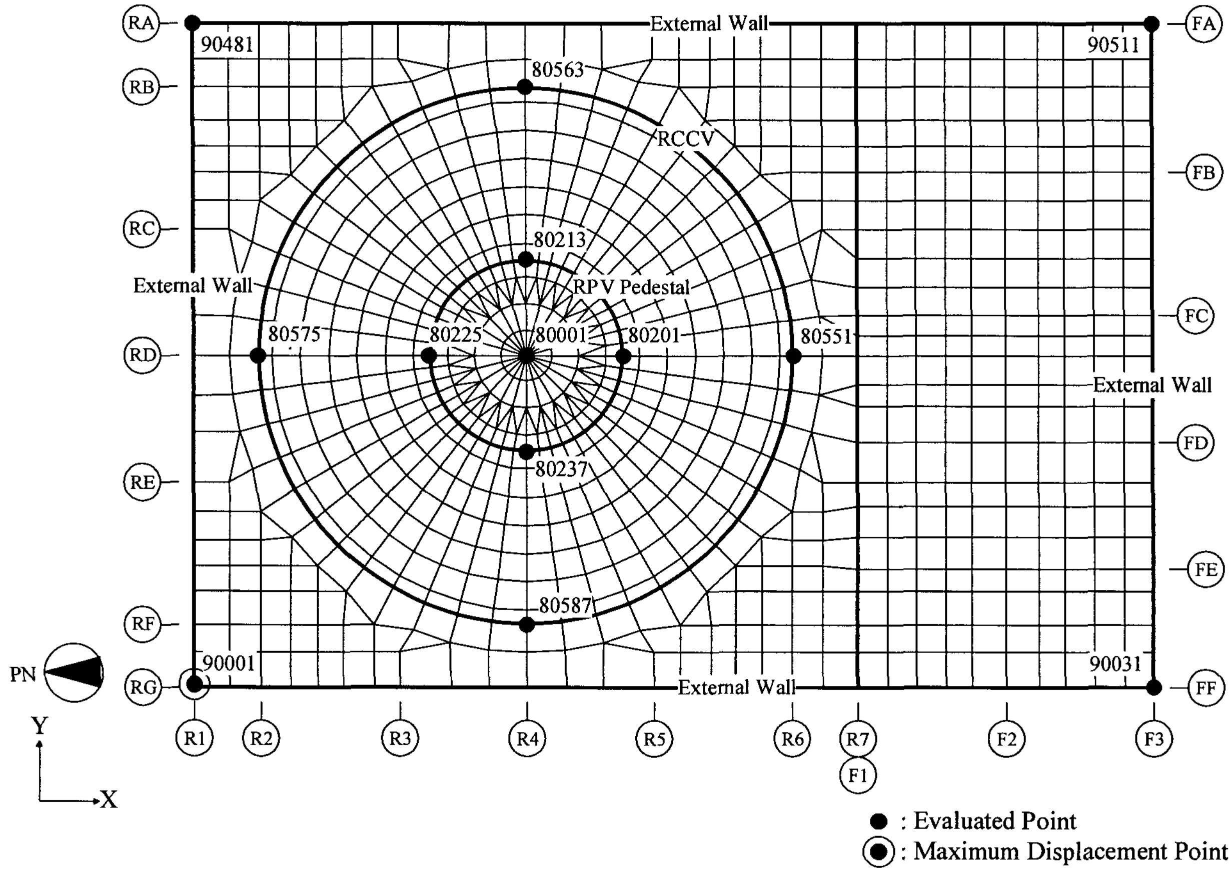
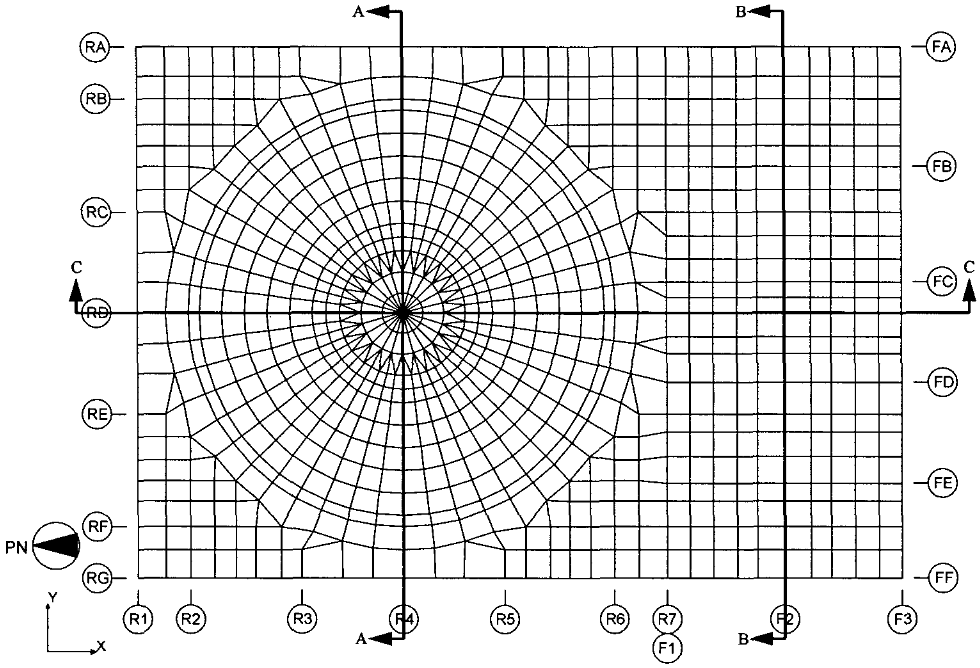
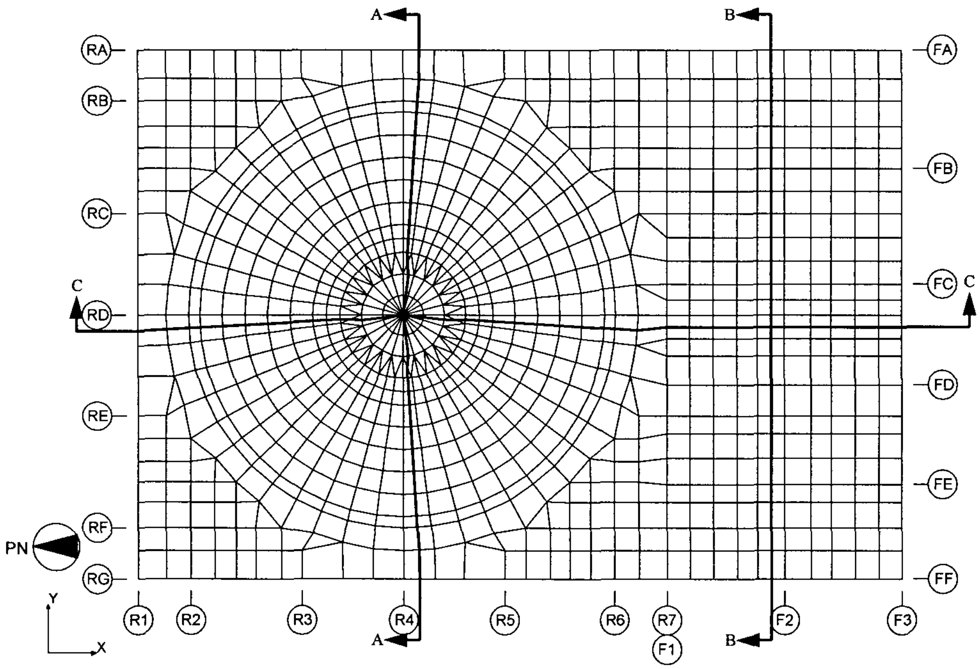


Figure 5-3 Selected Points for Combination of Seismic Loads



For Displacement



For Section Force and Moment

Figure 5-4 Basemat Cut Section

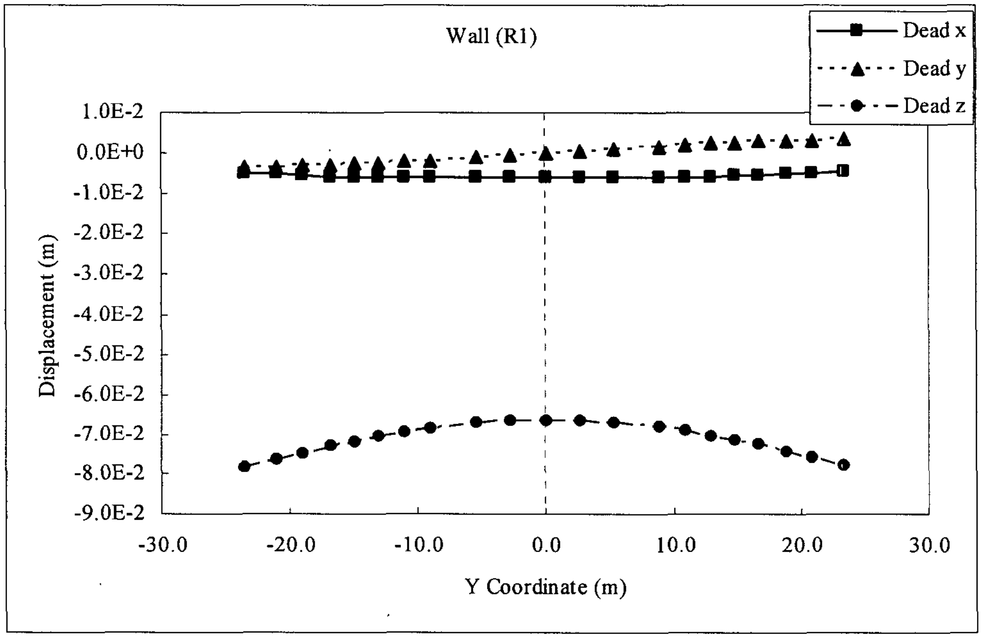


Figure 5-5 Displacement at R1 Wall for Dead Load

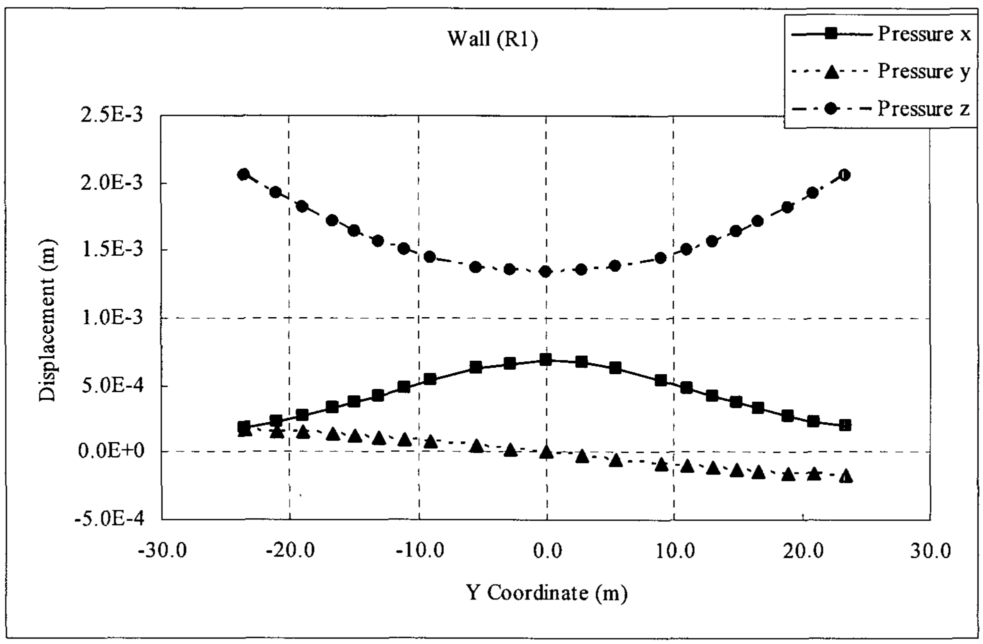


Figure 5-6 Displacement at R1 Wall for Pressure Load

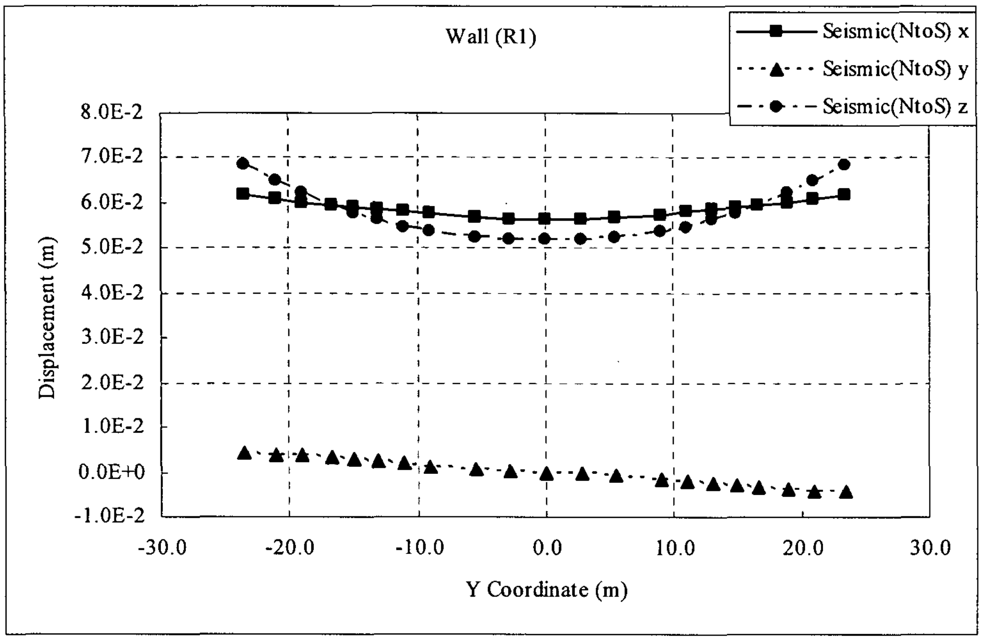


Figure 5-7 Displacement at R1 Wall for Seismic Load (N to S)

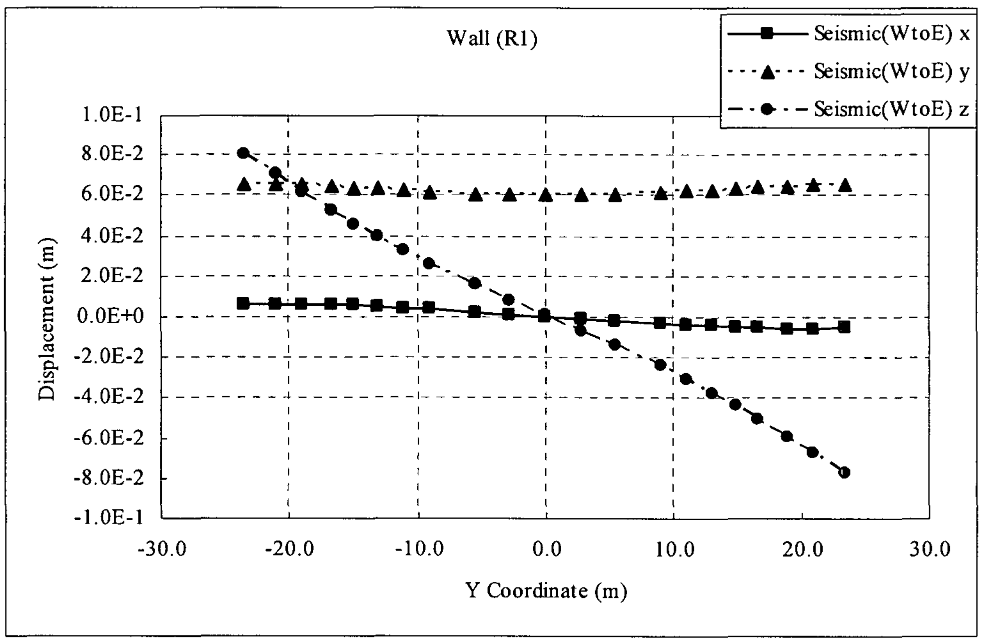


Figure 5-8 Displacement at R1 Wall for Seismic Load (W to E)

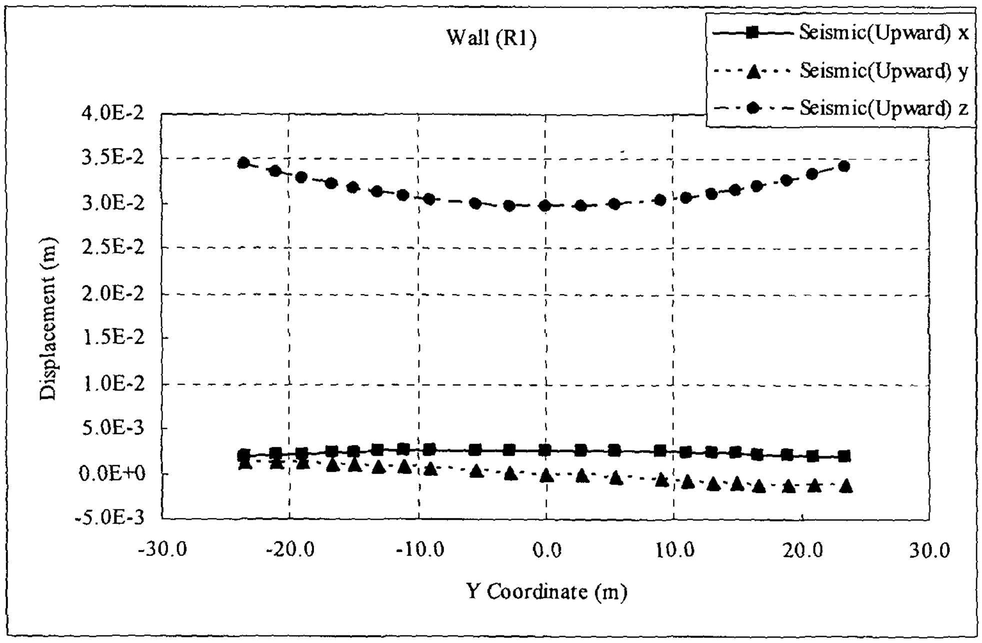


Figure 5-9 Displacement at R1 Wall for Seismic Load (Vertical; Upward)

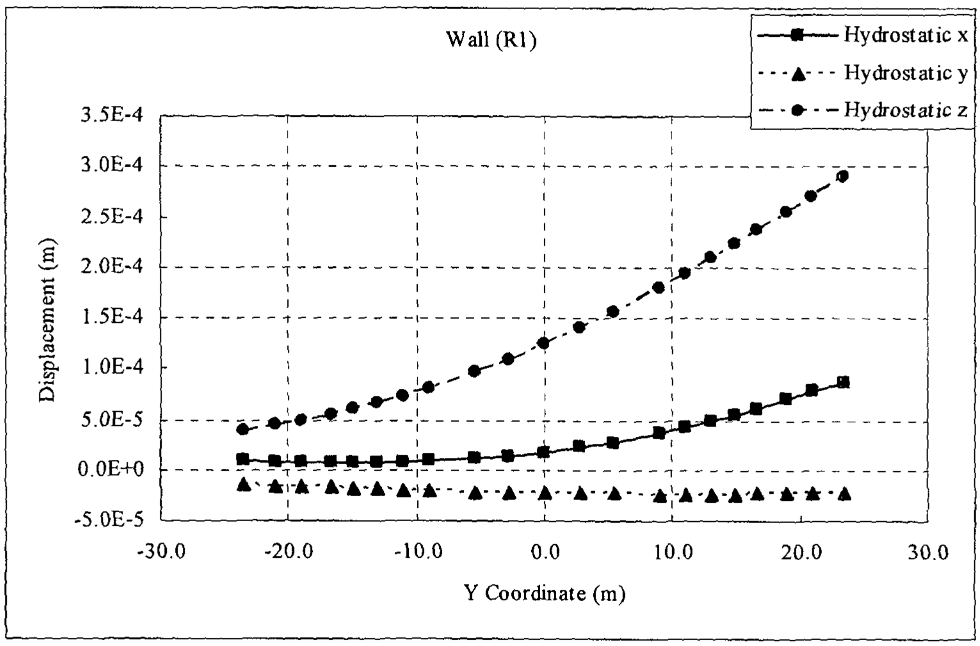


Figure 5-10 Displacement at R1 Wall for Hydrostatic Load

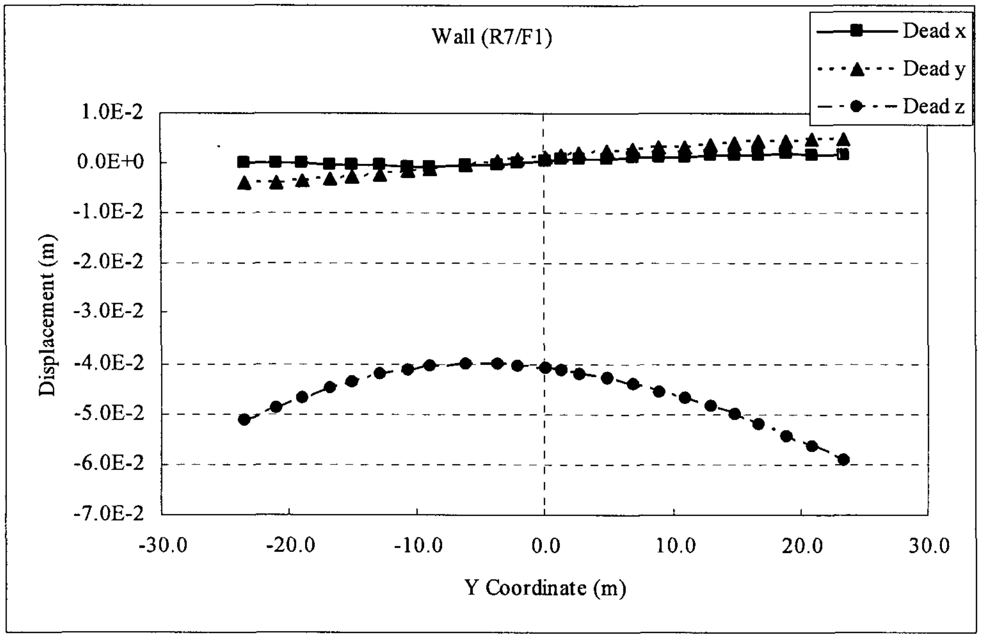


Figure 5-11 Displacement at R7/F1 Wall for Dead Load

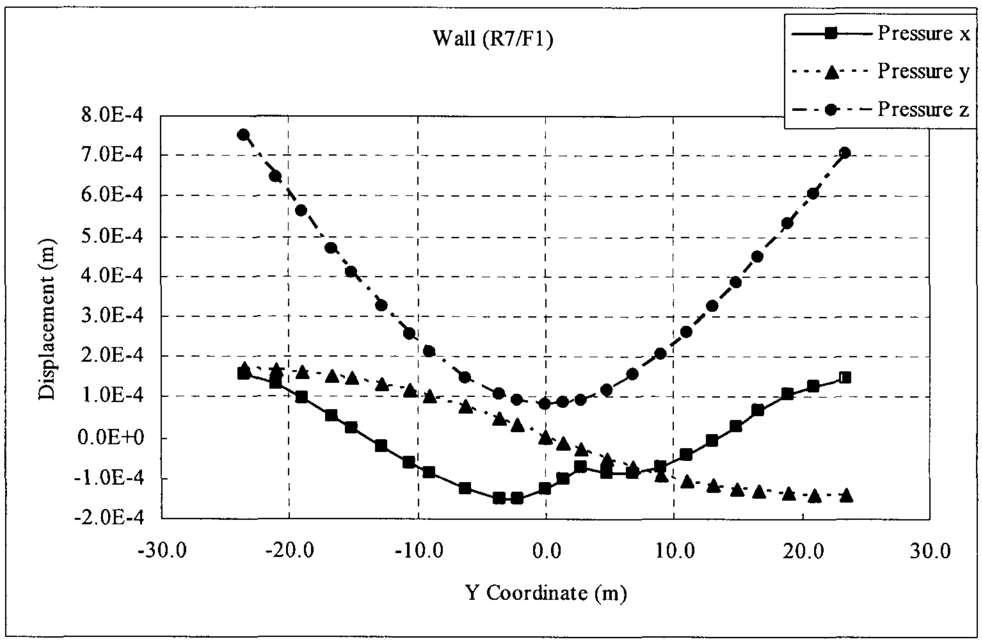


Figure 5-12 Displacement at R7/F1 Wall for Pressure Load

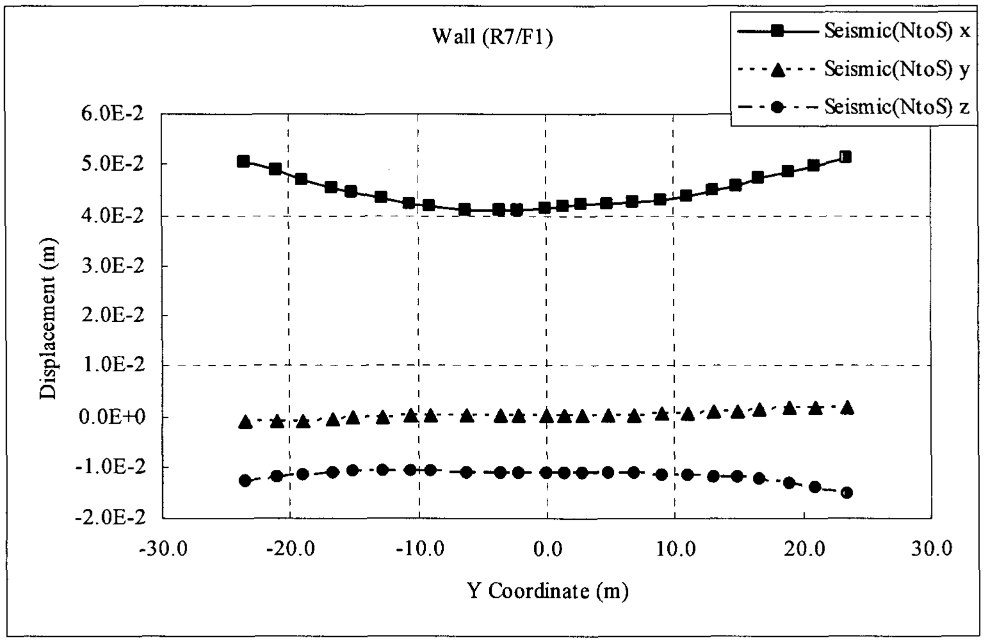


Figure 5-13 Displacement at R7/F1 Wall for Seismic Load (N to S)

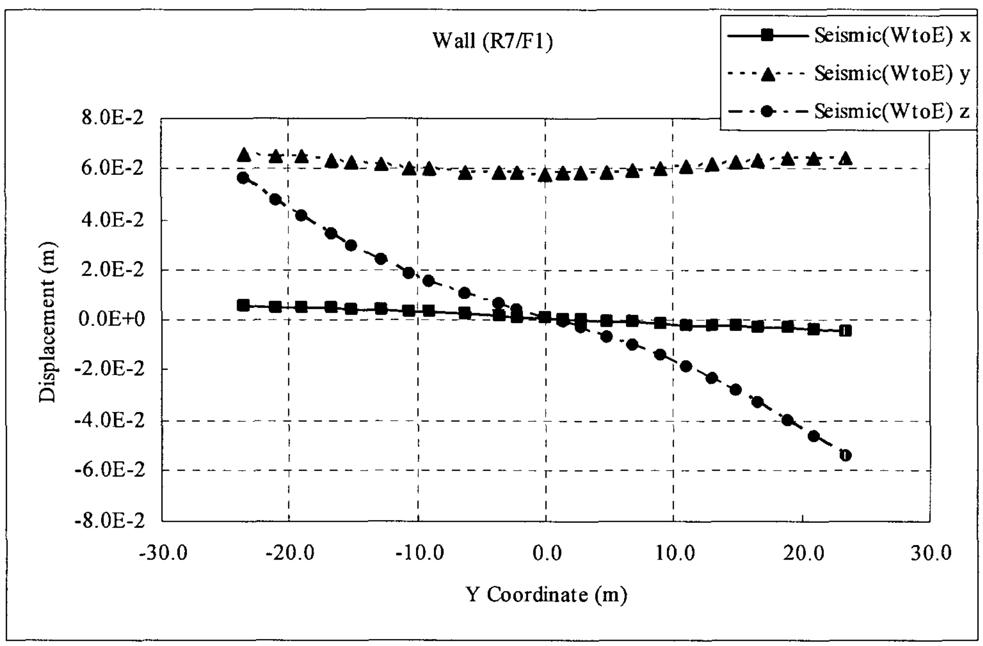


Figure 5-14 Displacement at R7/F1 Wall for Seismic Load (W to E)

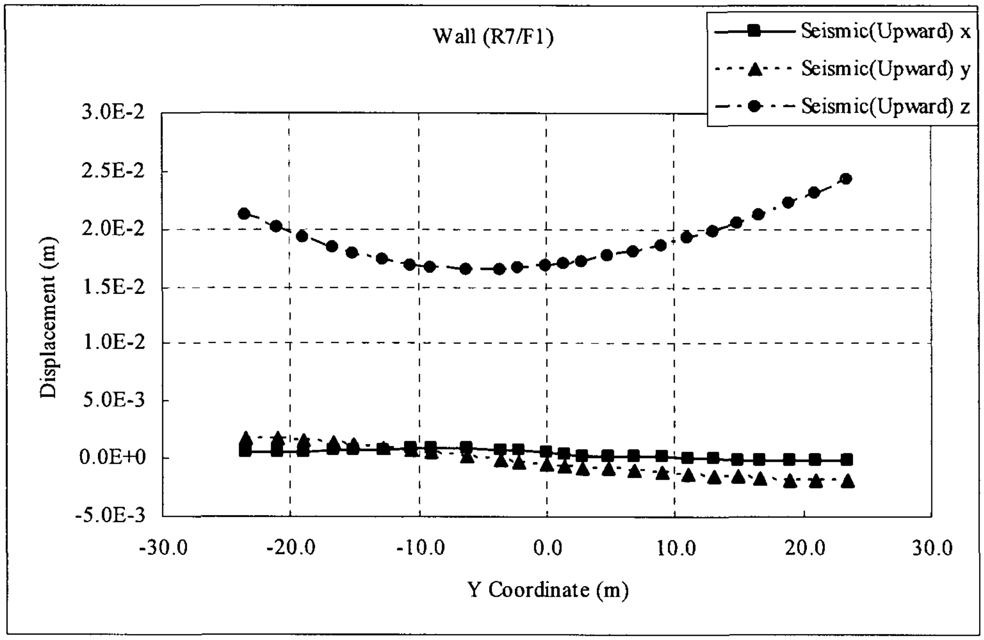


Figure 5-15 Displacement at R7/F1 Wall for Seismic Load (Vertical; Upward)

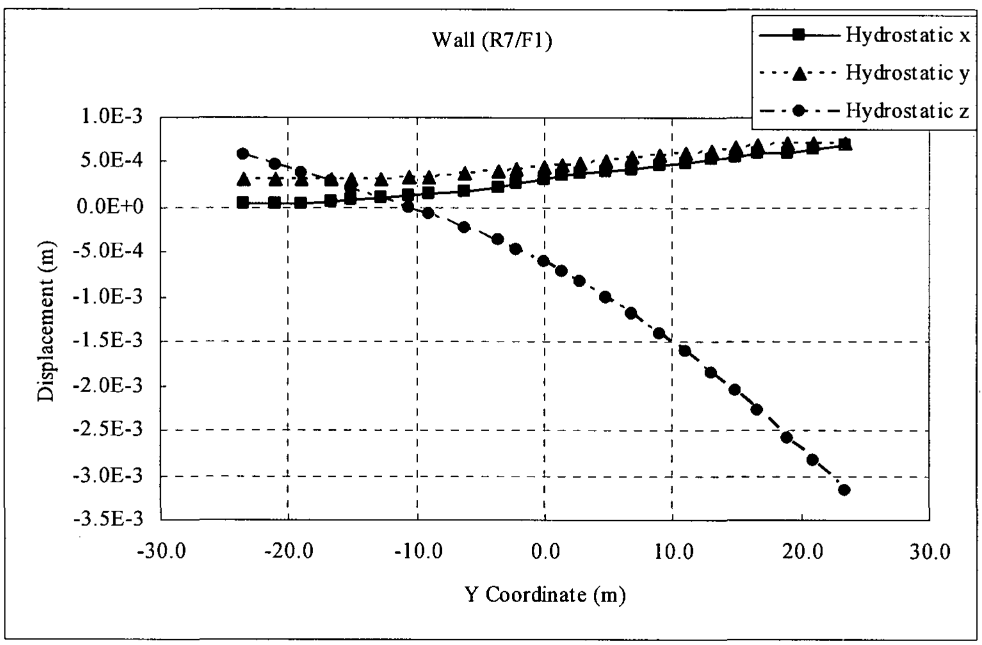


Figure 5-16 Displacement at R7/F1 Wall for Hydrostatic Load

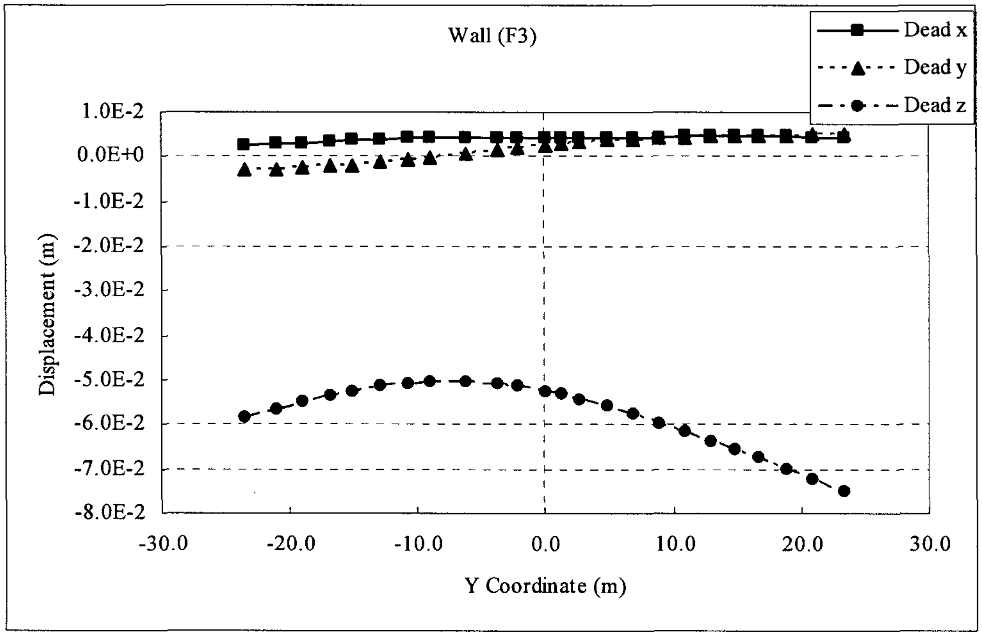


Figure 5-17 Displacement at F3 Wall for Dead Load

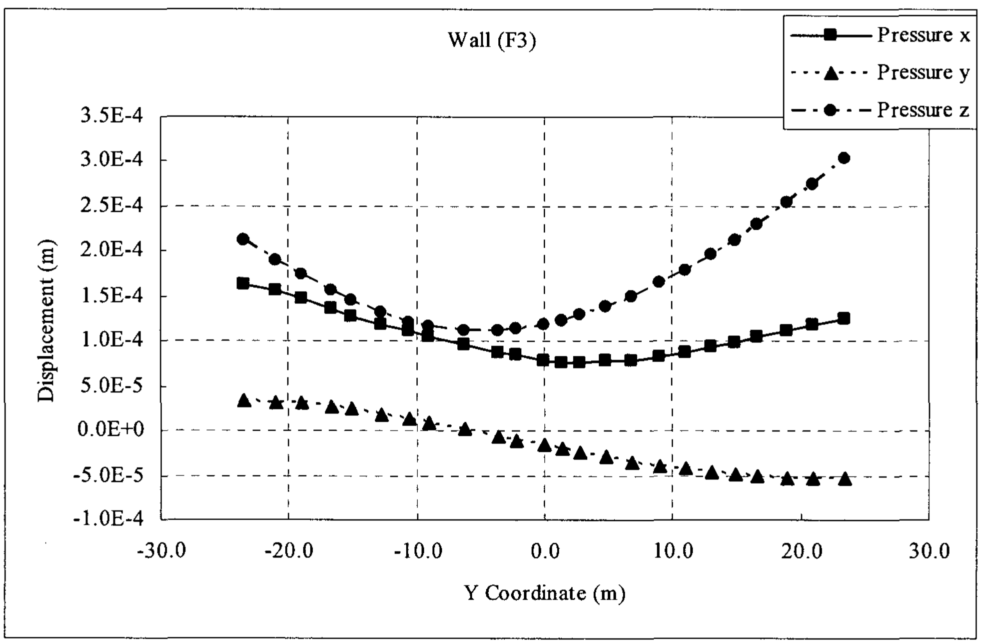


Figure 5-18 Displacement at F3 Wall for Pressure Load

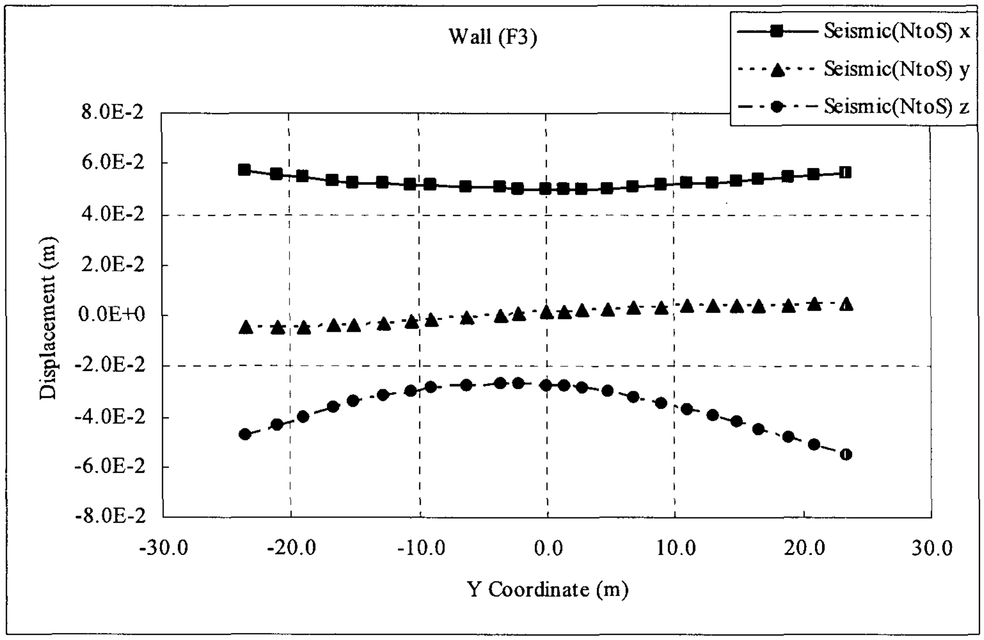


Figure 5-19 Displacement at F3 Wall for Seismic Load (N to S)

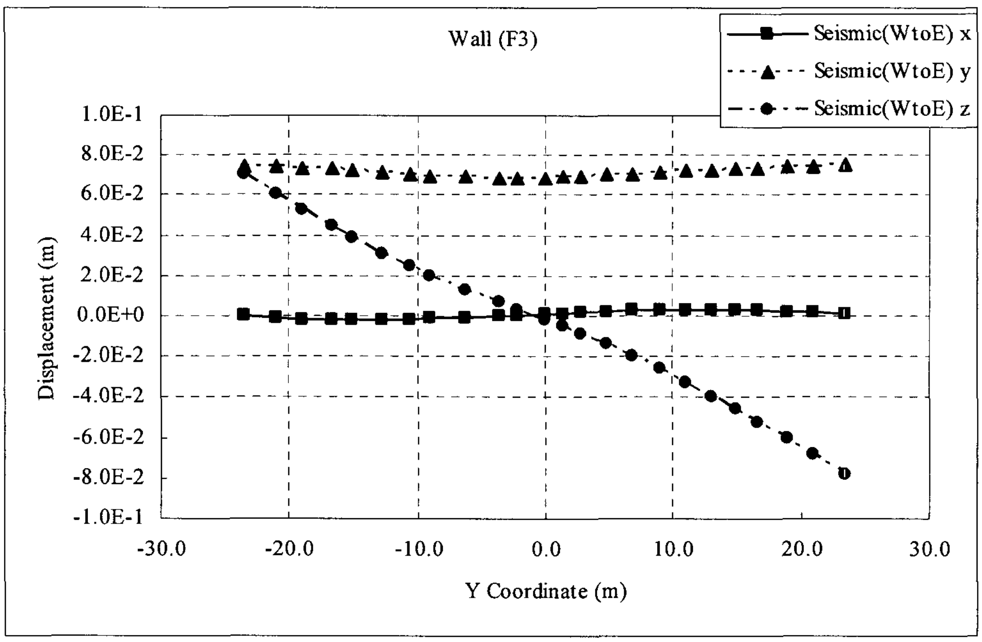


Figure 5-20 Displacement at F3 Wall for Seismic Load (W to E)

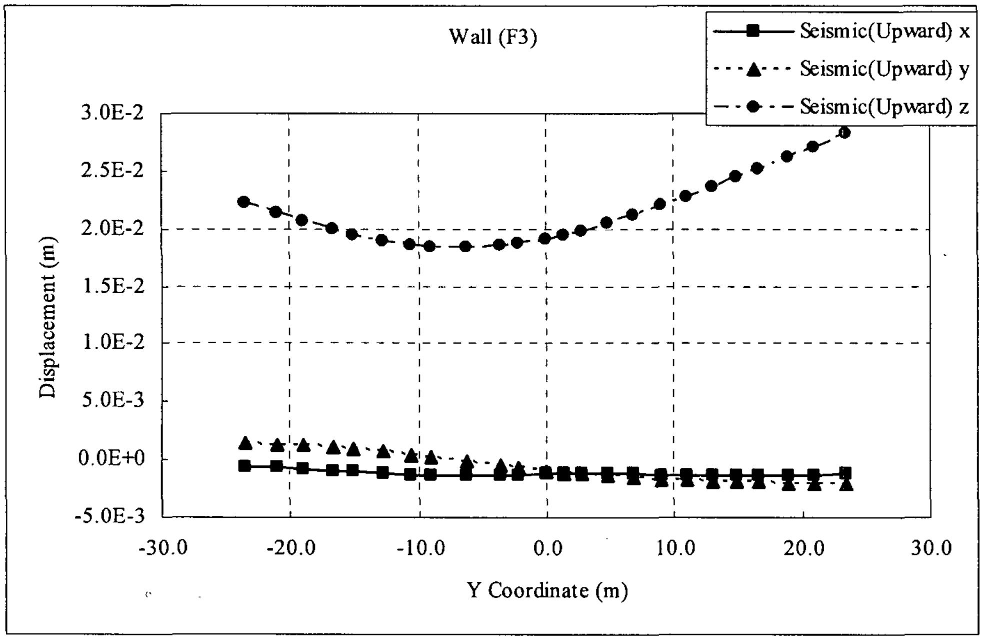


Figure 5-21 Displacement at F3 Wall for Seismic Load (Vertical; Upward)

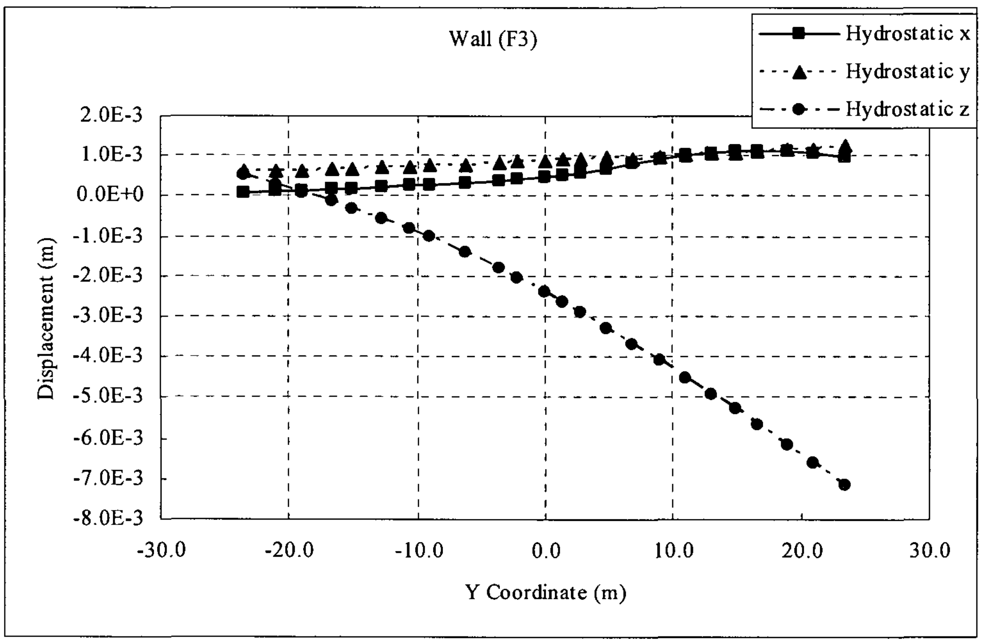


Figure 5-22 Displacement at F3 Wall for Hydrostatic Load

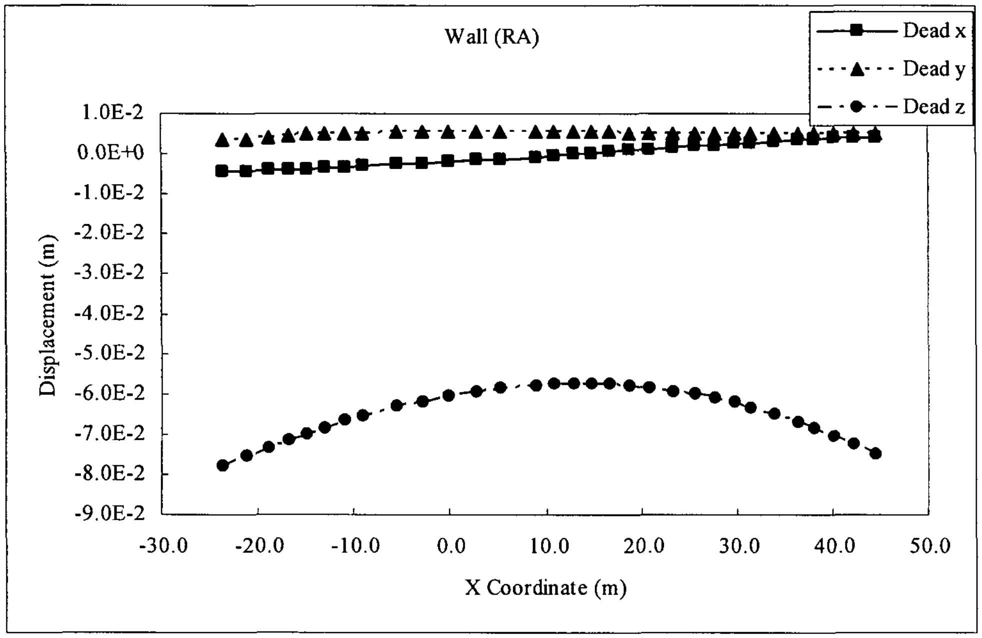


Figure 5-23 Displacement at RA Wall for Dead Load

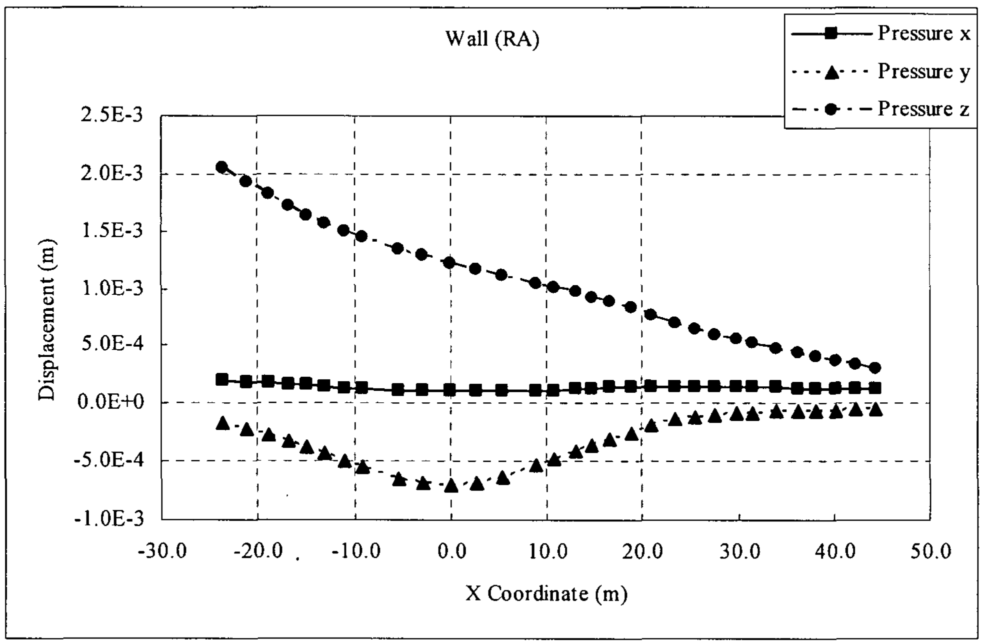


Figure 5-24 Displacement at RA Wall for Pressure Load

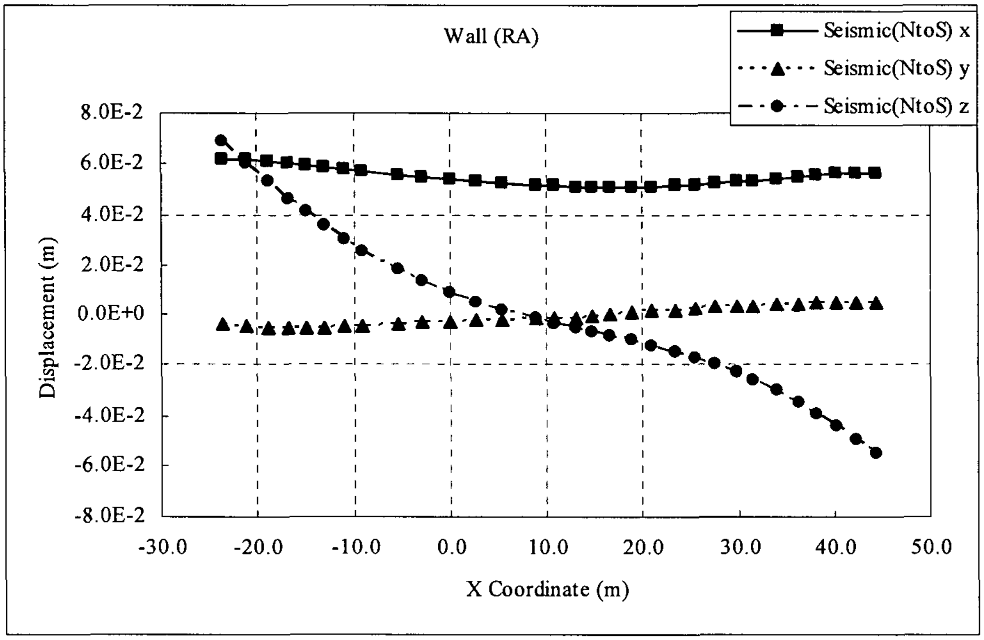


Figure 5-25 Displacement at RA Wall for Seismic Load (N to S)

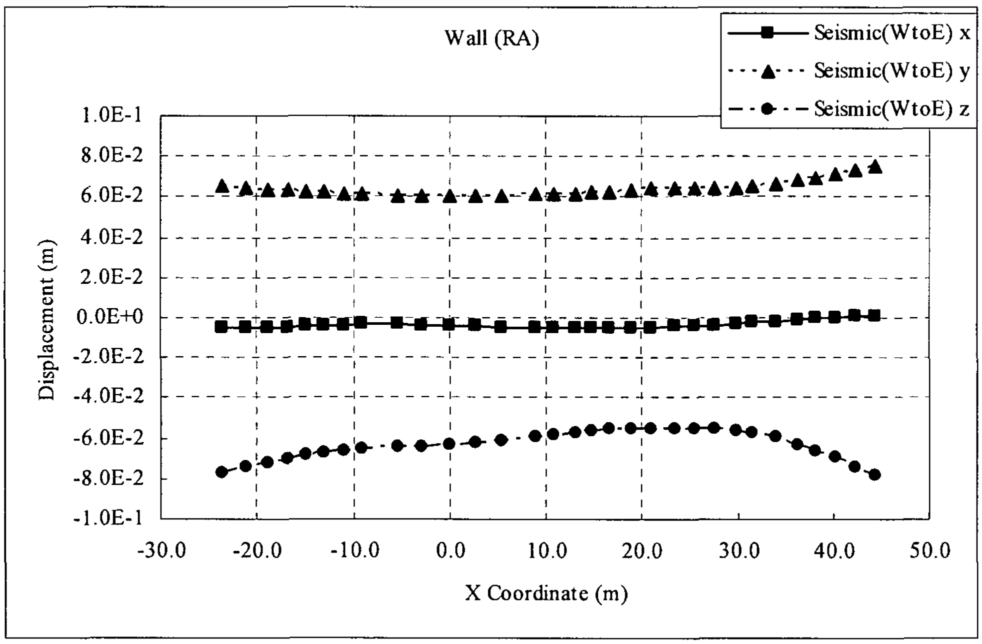


Figure 5-26 Displacement at RA Wall for Seismic Load (W to E)

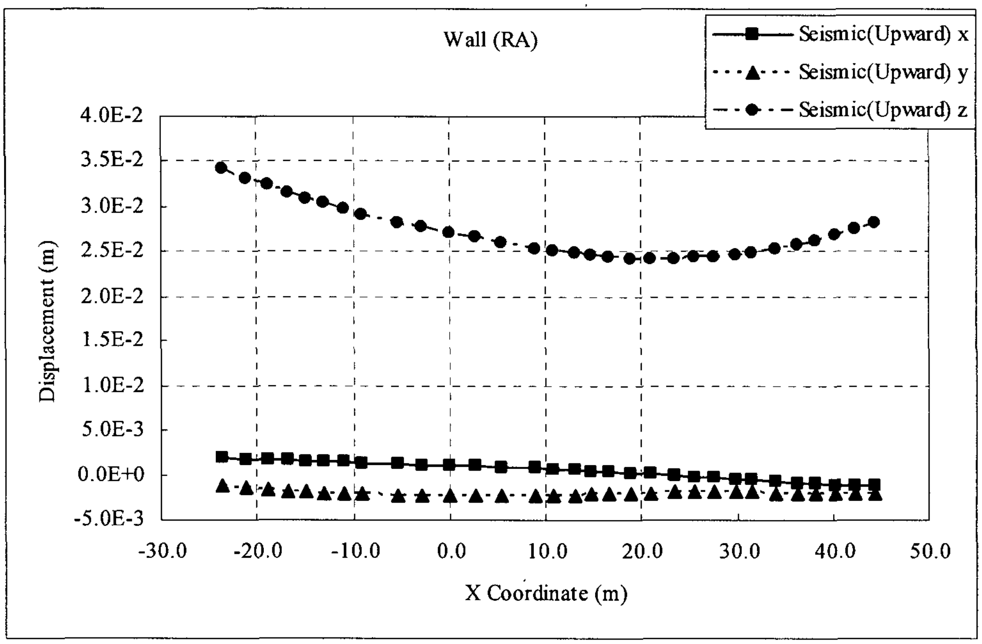


Figure 5-27 Displacement at RA Wall for Seismic Load (Vertical; Upward)

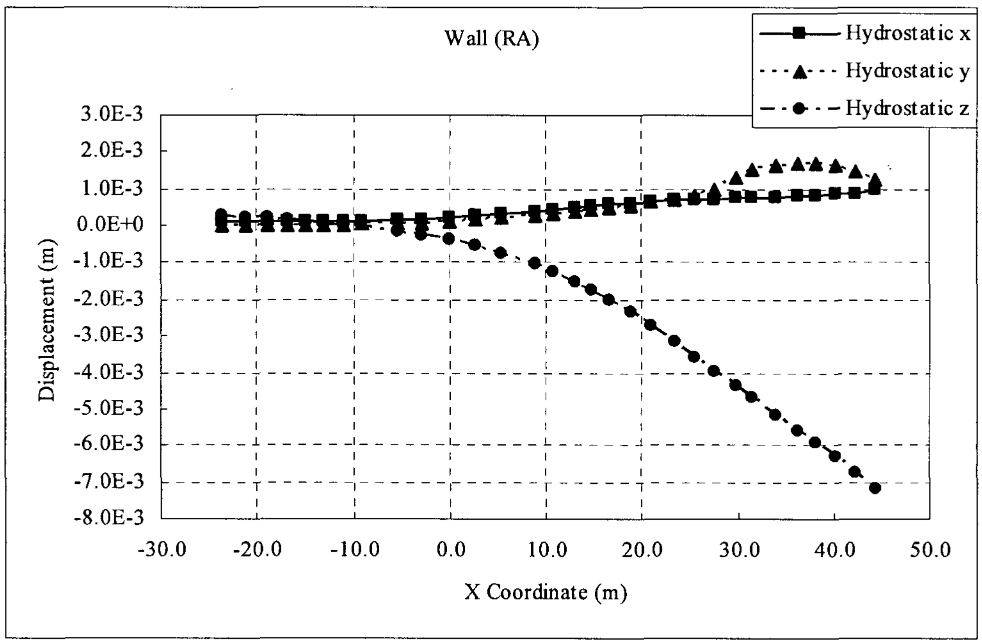


Figure 5-28 Displacement at RA Wall for Hydrostatic Load

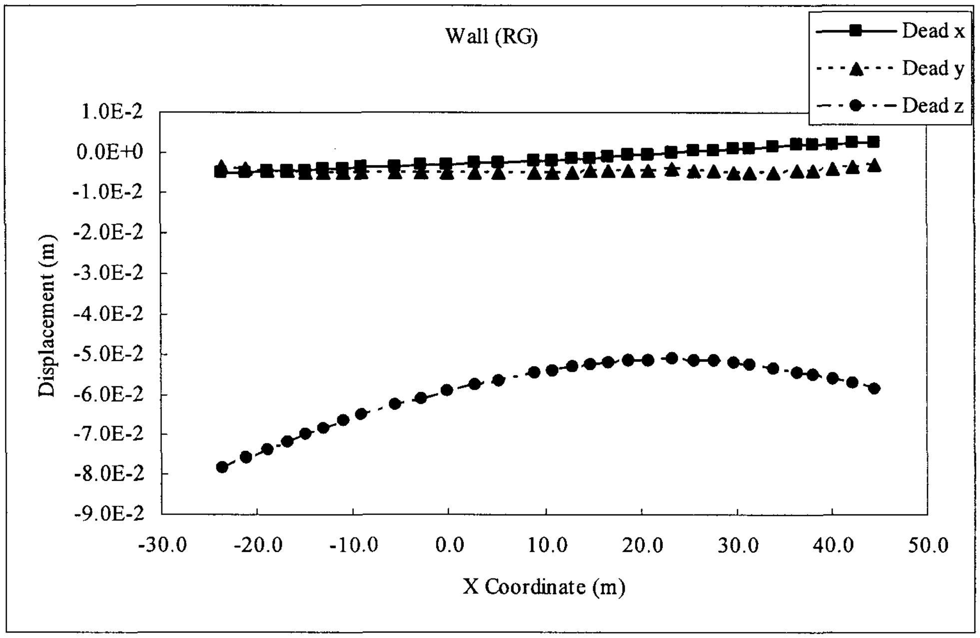


Figure 5-29 Displacement at RG Wall for Dead Load

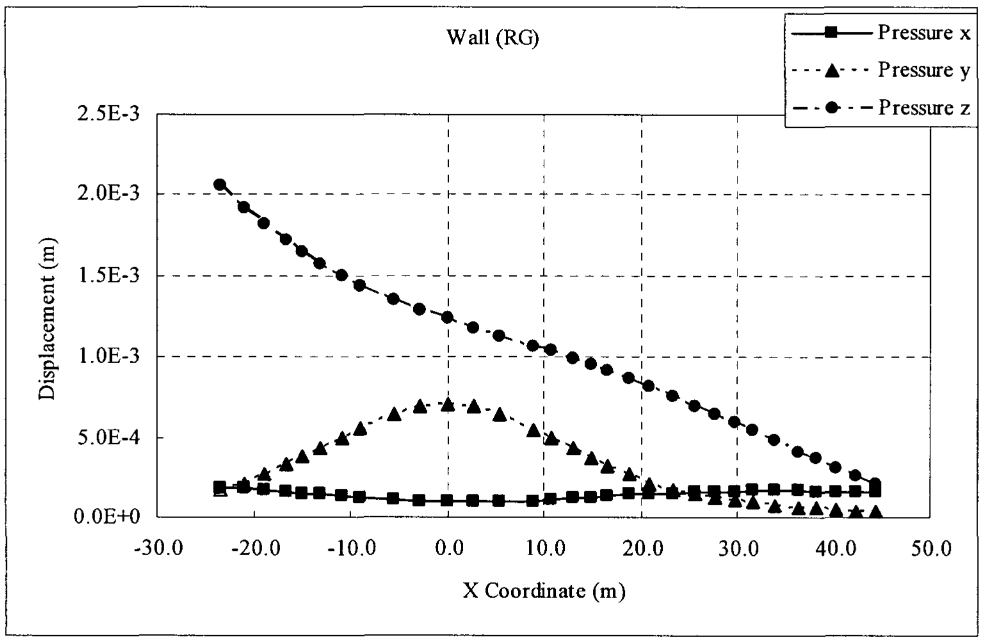


Figure 5-30 Displacement at RG Wall for Pressure Load

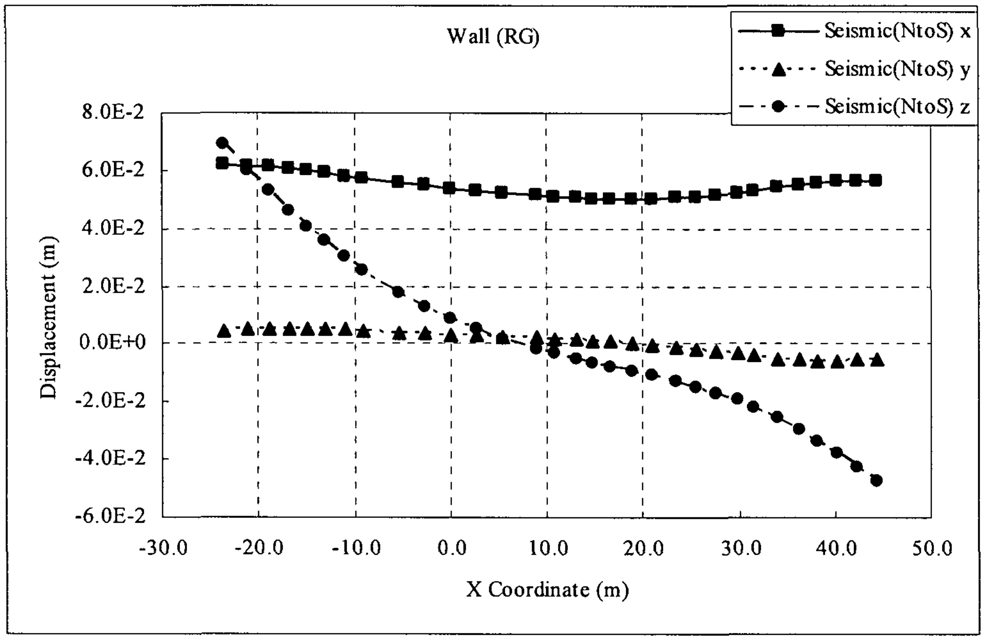


Figure 5-31 Displacement at RG Wall for Seismic Load (N to S)

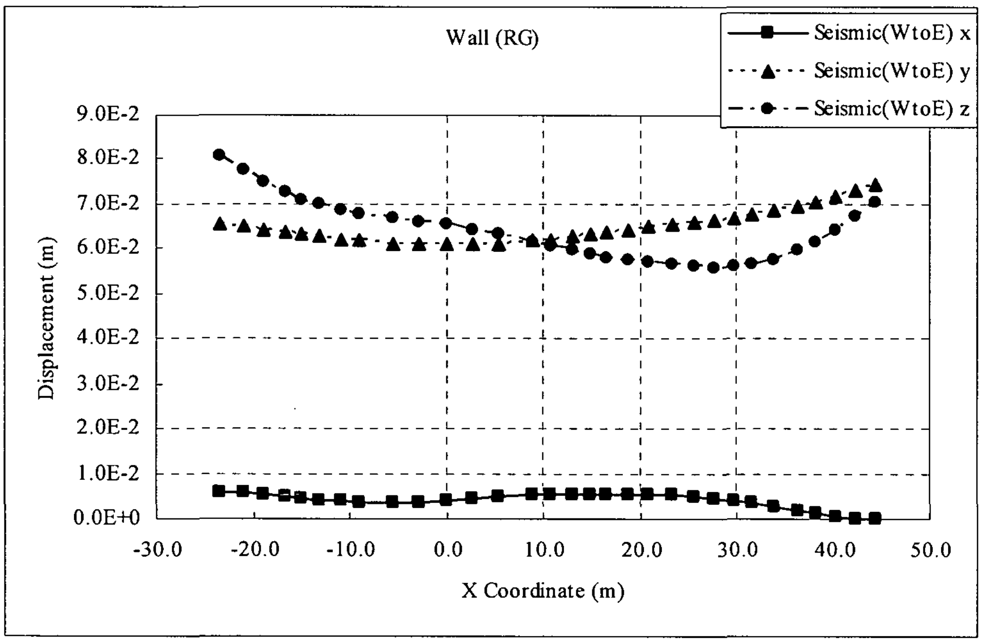


Figure 5-32 Displacement at RG Wall for Seismic Load (W to E)

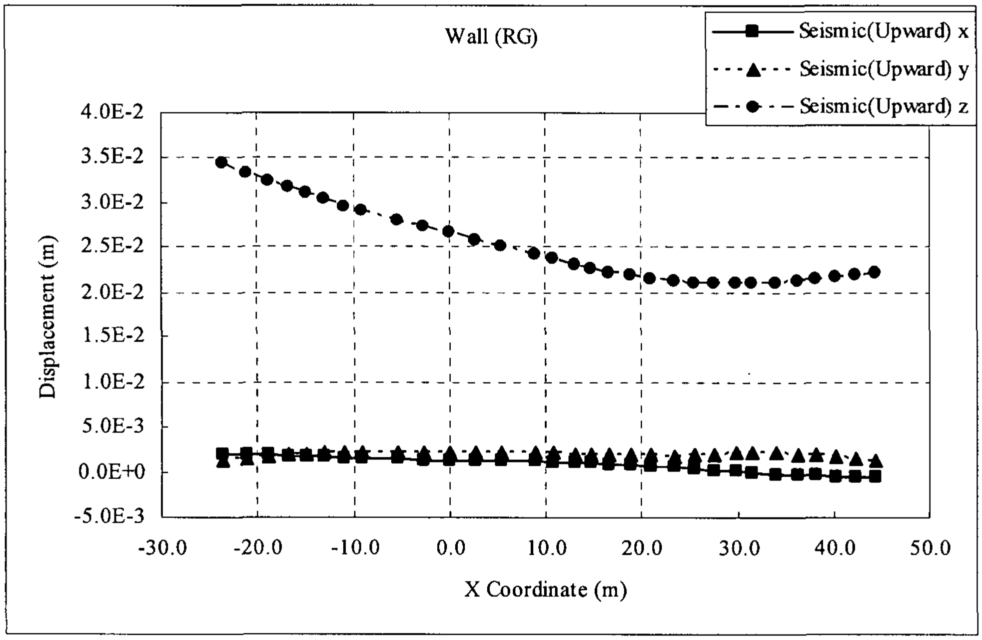


Figure 5-33 Displacement at RG Wall for Seismic Load (Vertical; Upward)

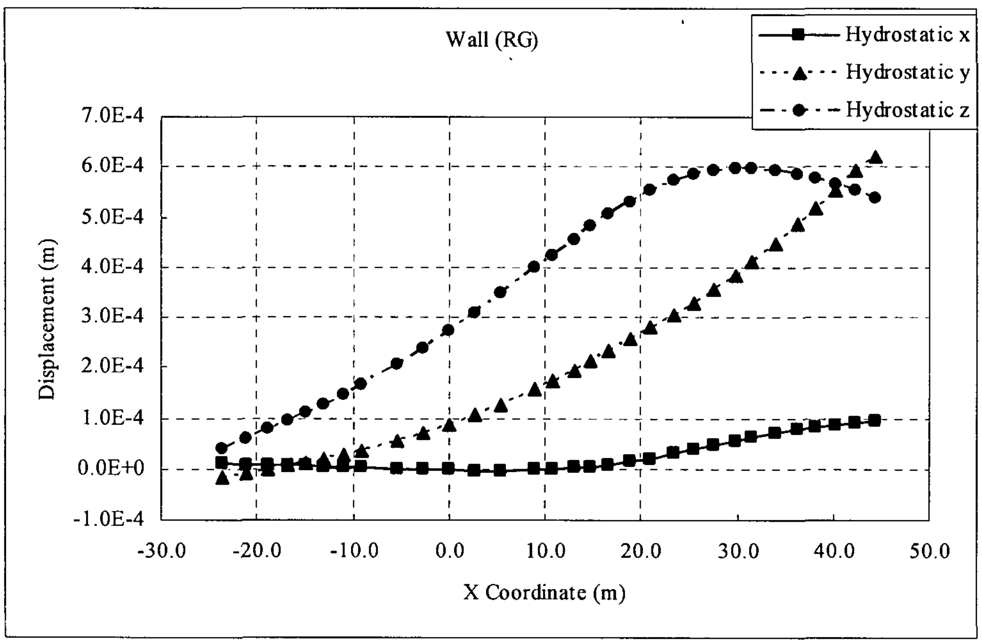


Figure 5-34 Displacement at RG Wall for Hydrostatic Load

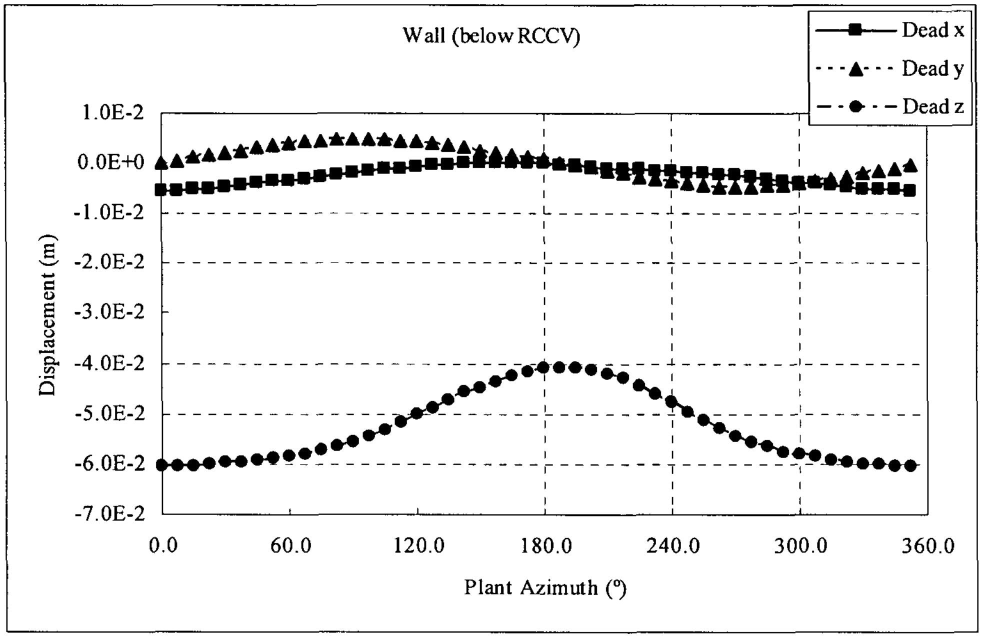


Figure 5-35 Displacement at Wall below RCCV for Dead Load

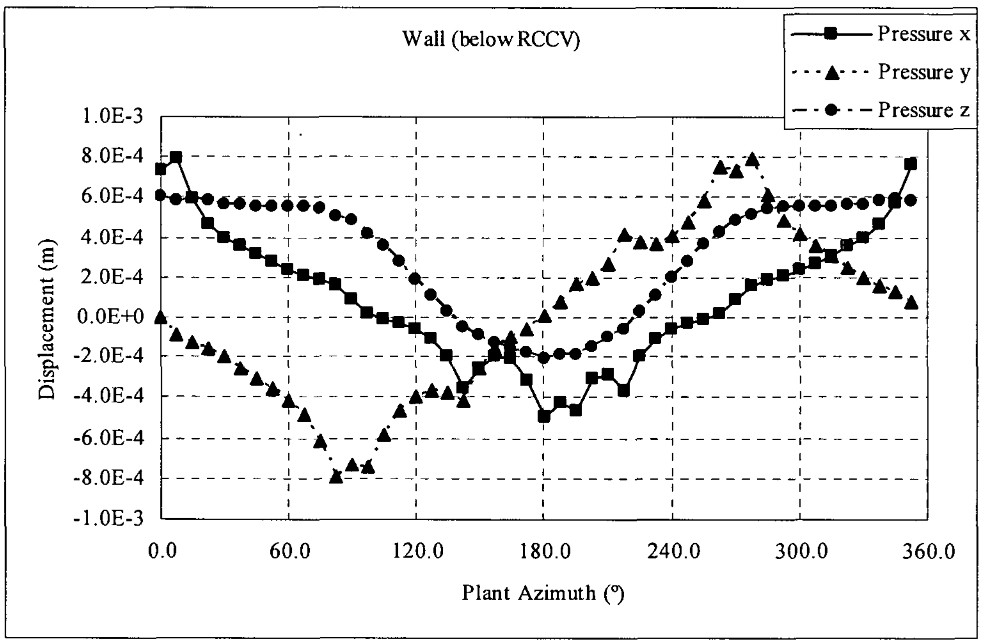


Figure 5-36 Displacement at Wall below RCCV for Pressure Load

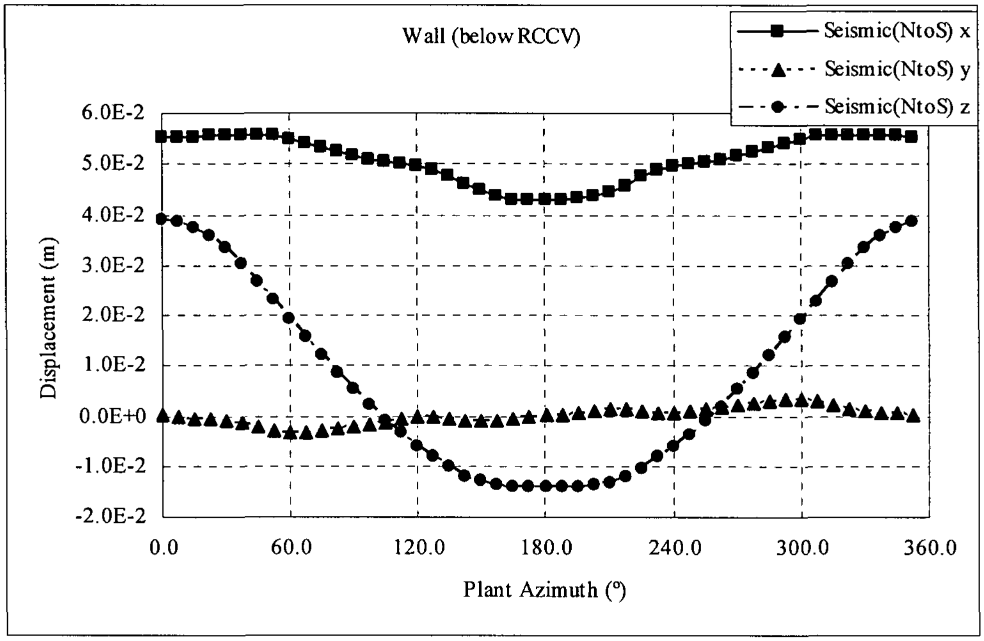


Figure 5-37 Displacement at Wall below RCCV for Seismic Load (N to S)

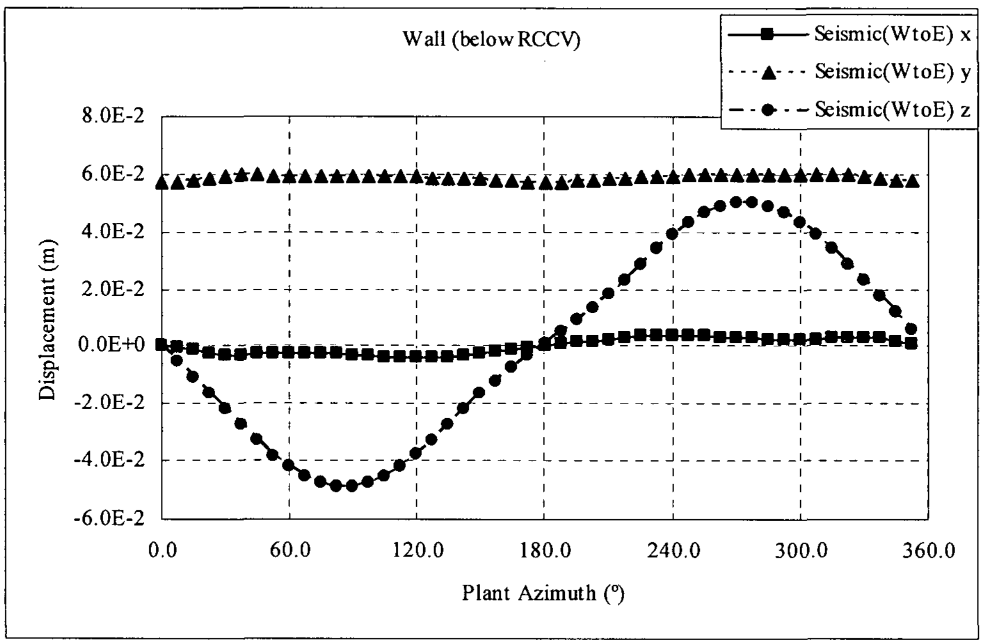


Figure 5-38 Displacement at Wall below RCCV for Seismic Load (W to E)

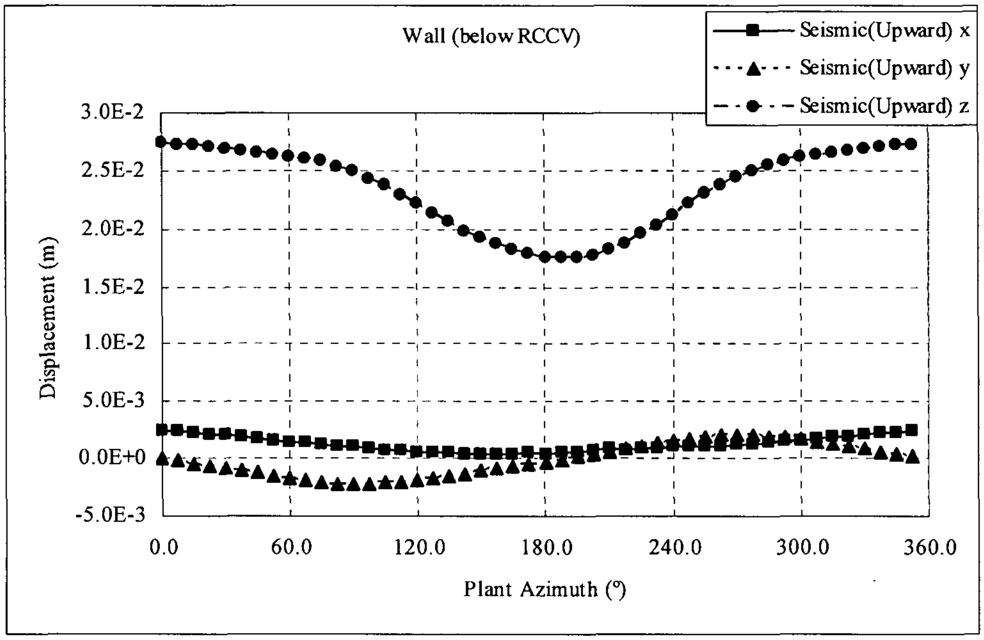


Figure 5-39 Displacement at Wall below RCCV for Seismic Load (Vertical; Upward)

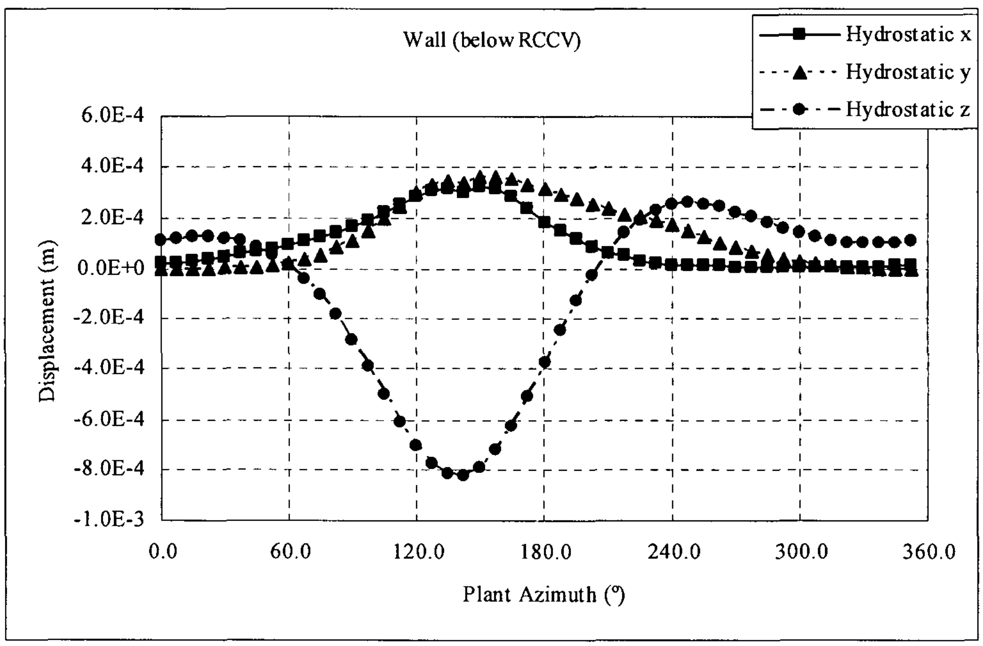


Figure 5-40 Displacement at Wall below RCCV for Hydrostatic Load

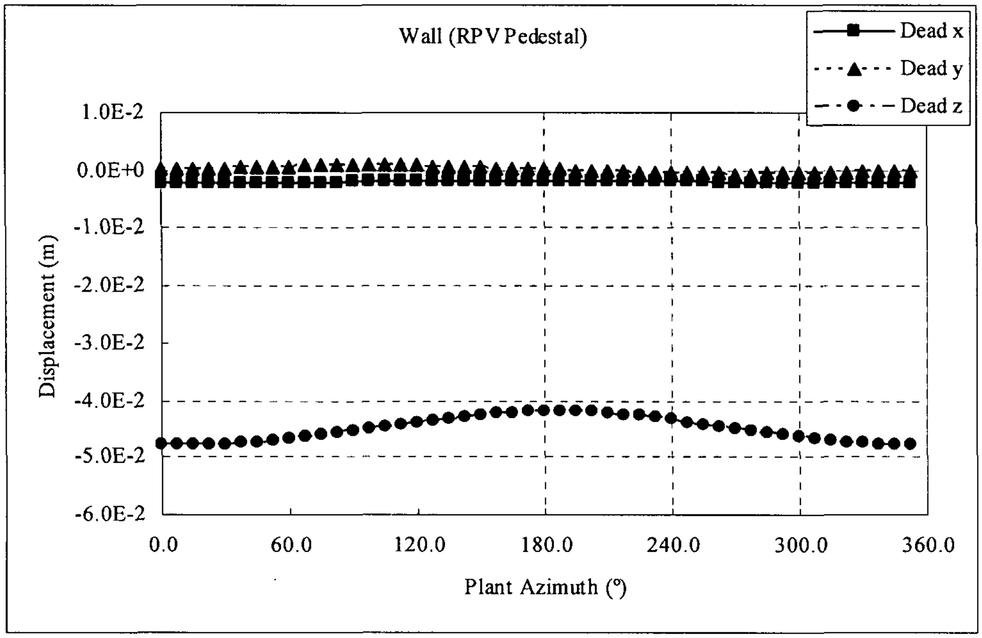


Figure 5-41 Displacement at RPV Pedestal Wall for Dead Load

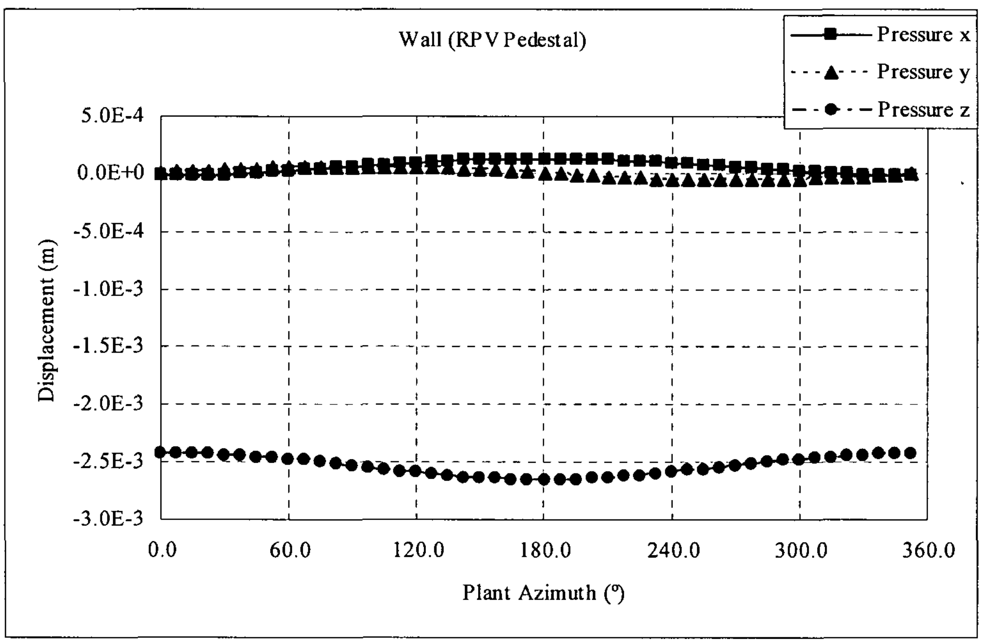


Figure 5-42 Displacement at RPV Pedestal Wall for Pressure Load

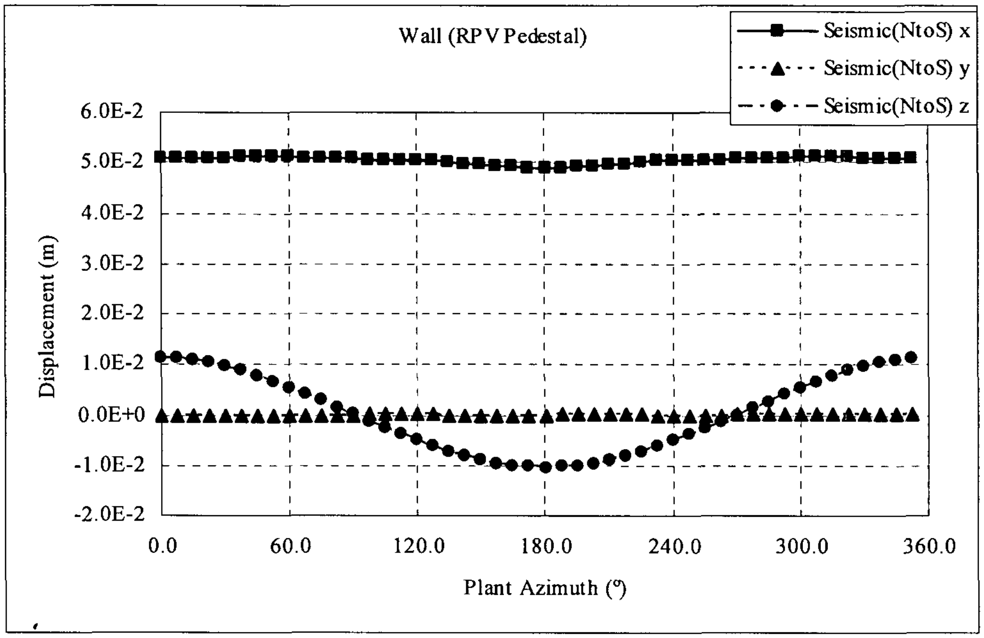


Figure 5-43 Displacement at RPV Pedestal Wall for Seismic Load (N to S)

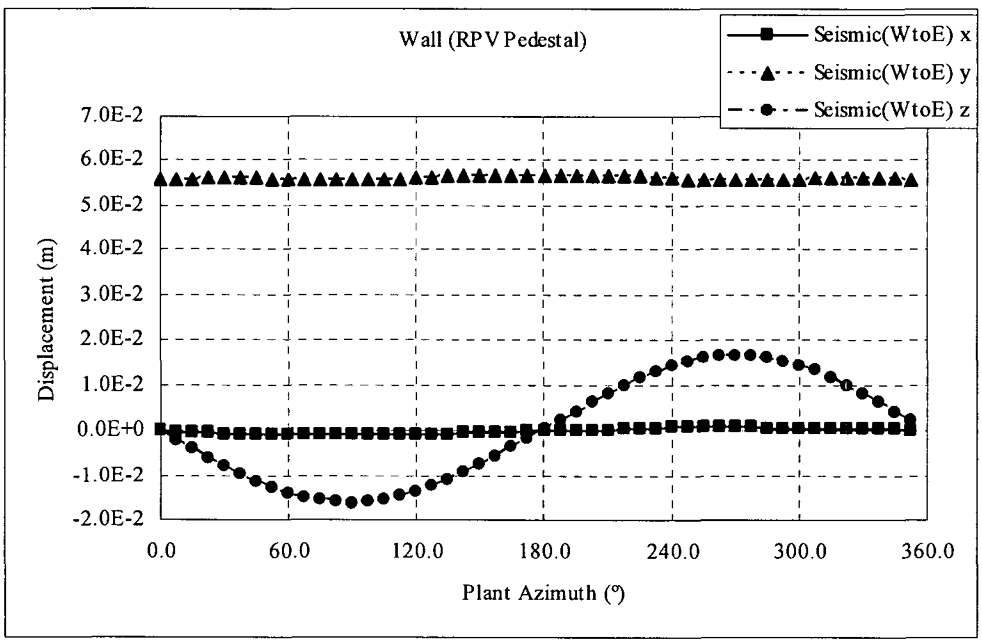


Figure 5-44 Displacement at RPV Pedestal Wall for Seismic Load (W to E)

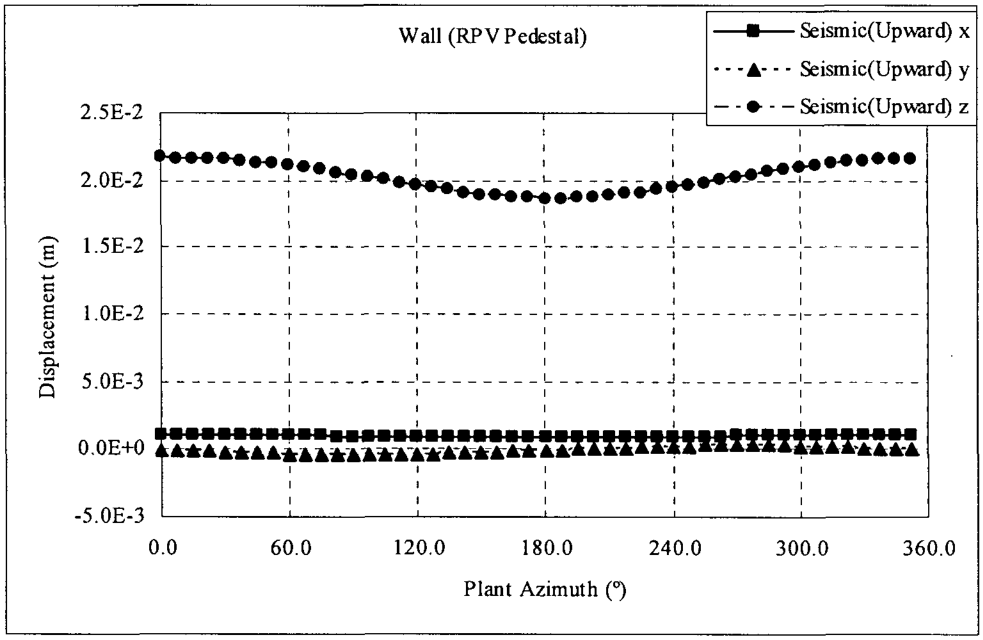


Figure 5-45 Displacement at RPV Pedestal Wall for Seismic Load (Vertical; Upward)

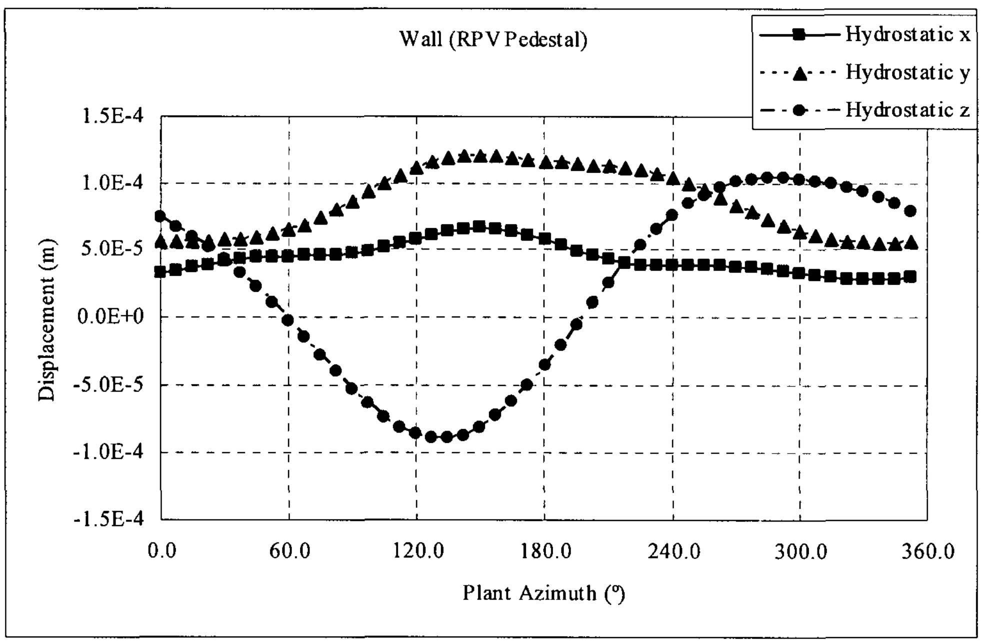


Figure 5-46 Displacement at RPV Pedestal Wall for Hydrostatic Load

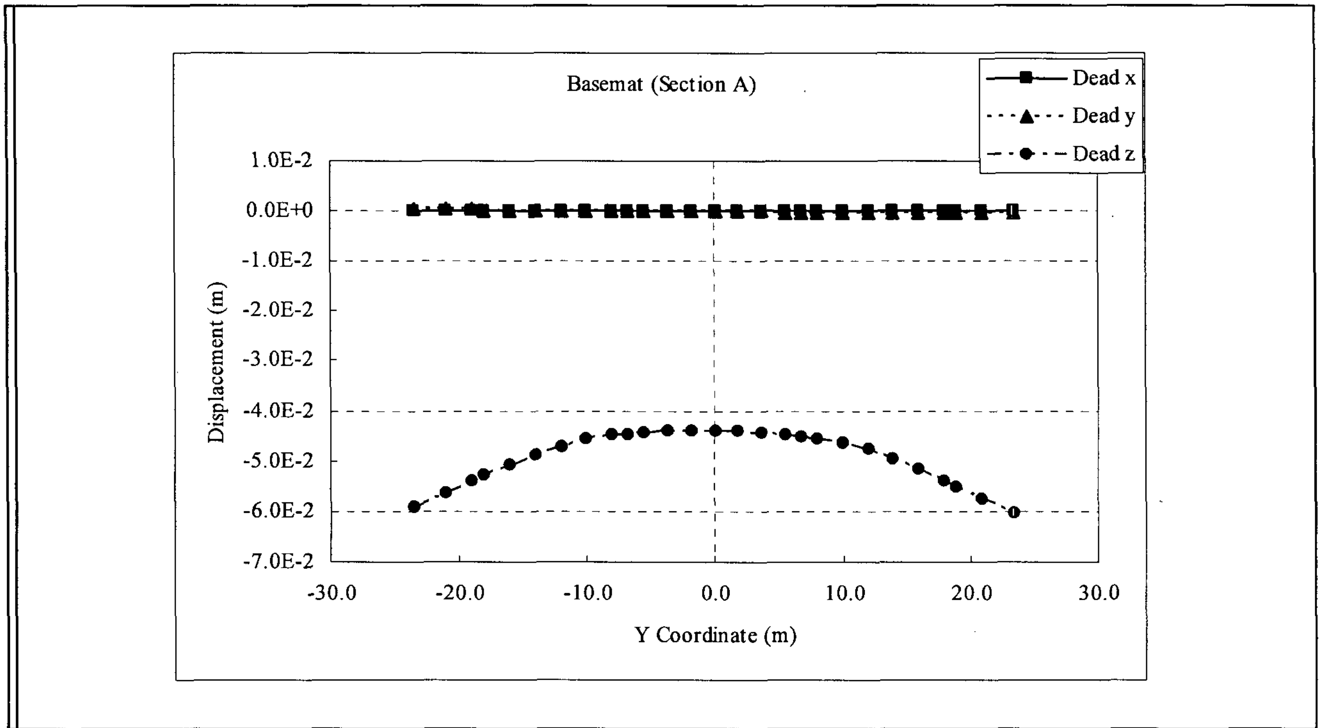


Figure 5-47 Displacement at Basemat Section A for Dead Load

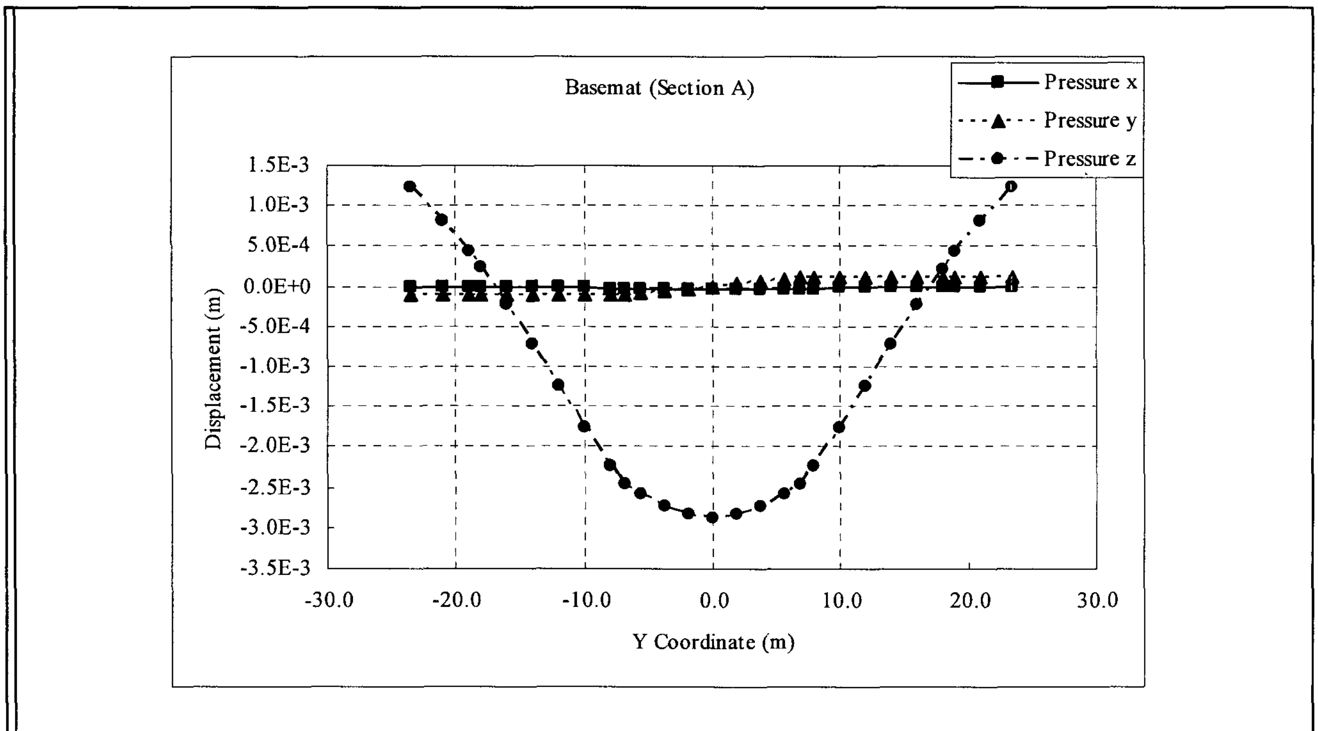


Figure 5-48 Displacement at Basemat Section A for Pressure Load

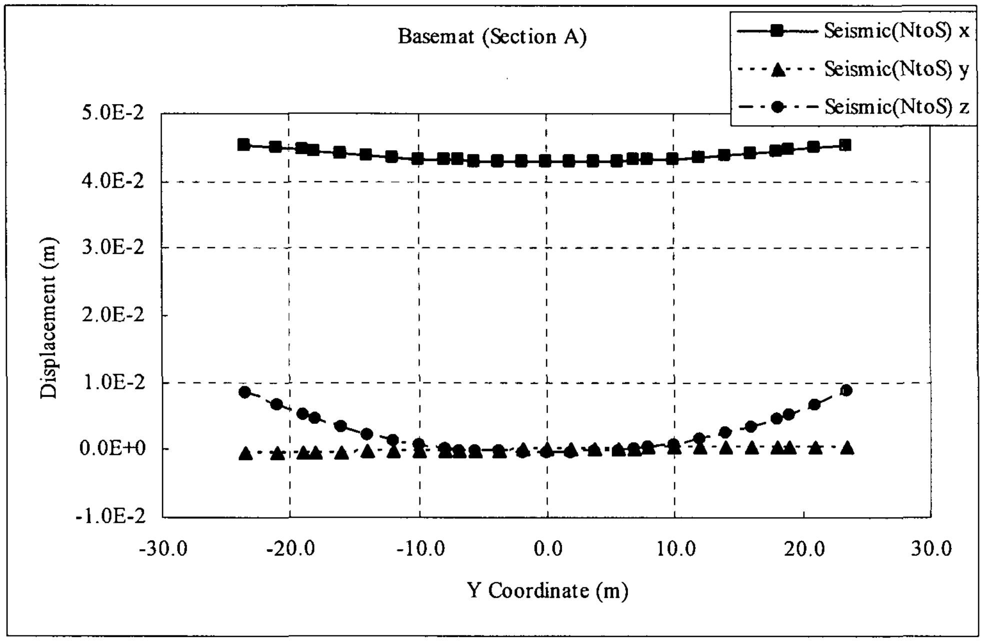


Figure 5-49 Displacement at Basemat Section A for Seismic Load (N to S)

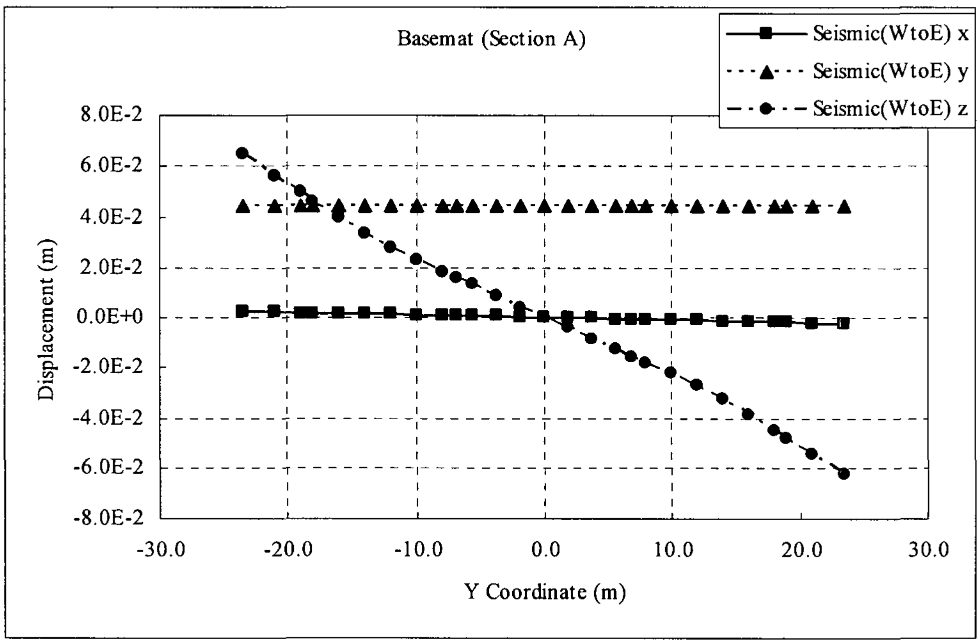


Figure 5-50 Displacement at Basemat Section A for Seismic Load (W to E)

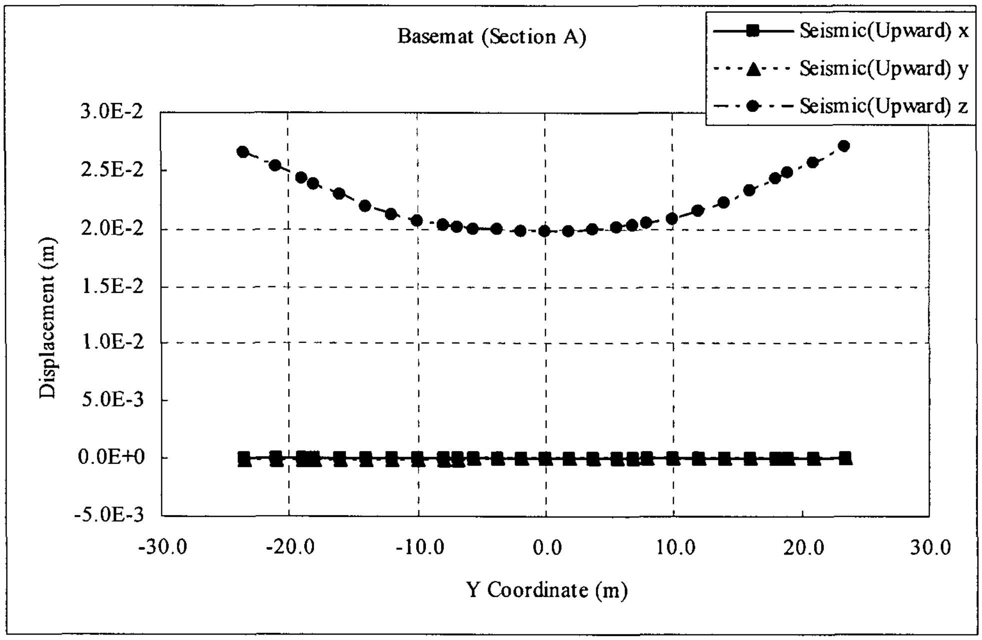


Figure 5-51 Displacement at Basemat Section A for Seismic Load (Vertical; Upward)

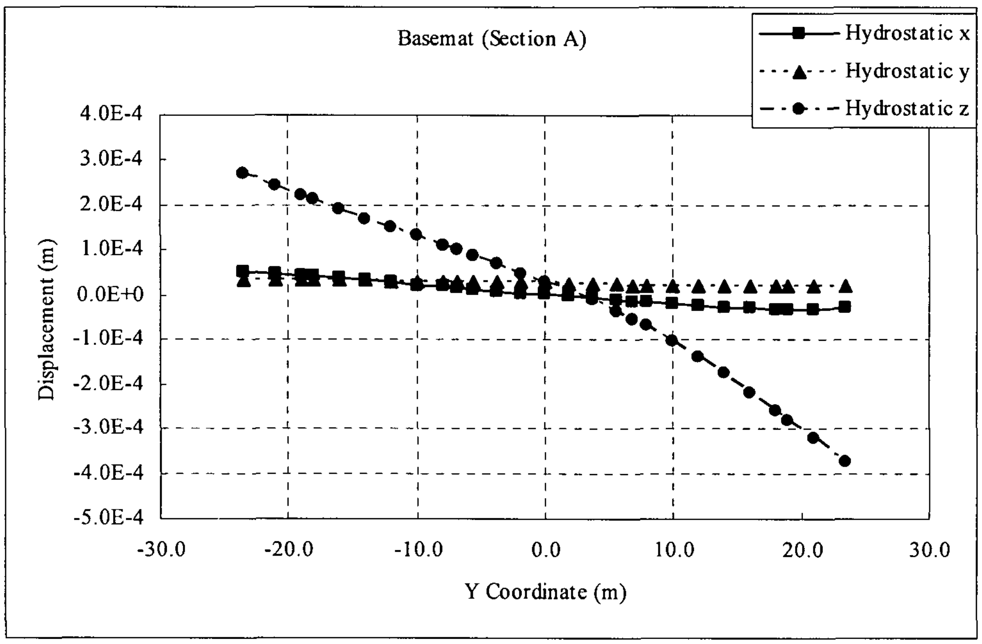


Figure 5-52 Displacement at Basemat Section A for Hydrostatic Load

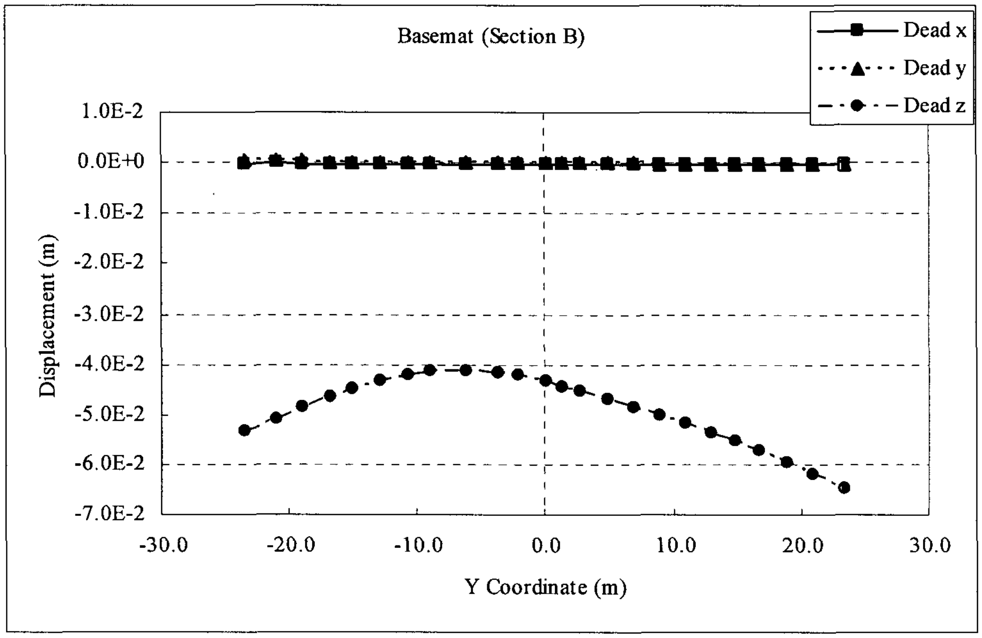


Figure 5-53 Displacement at Basemat Section B for Dead Load

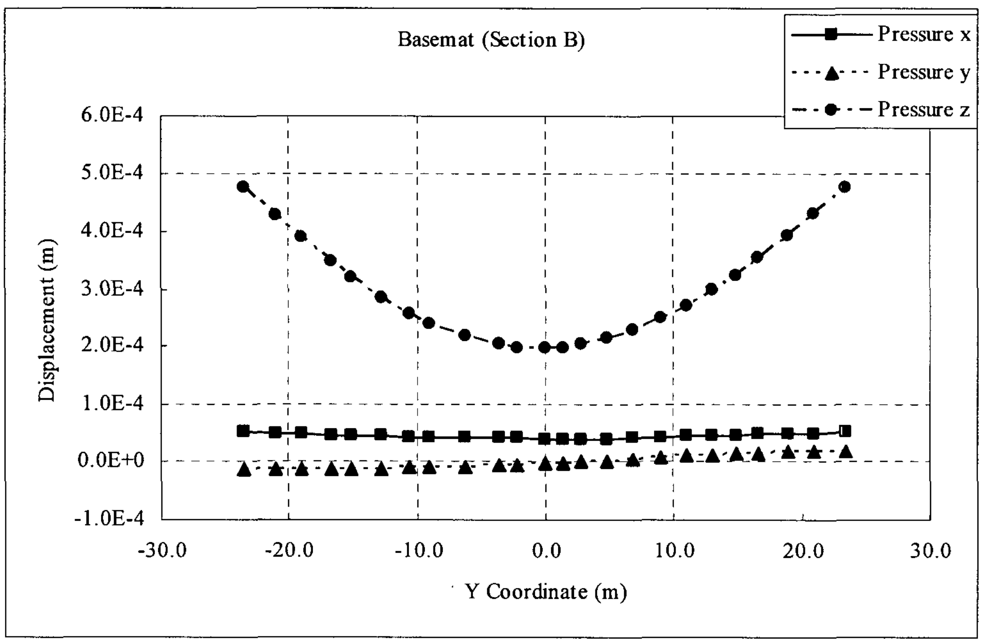


Figure 5-54 Displacement at Basemat Section B for Pressure Load

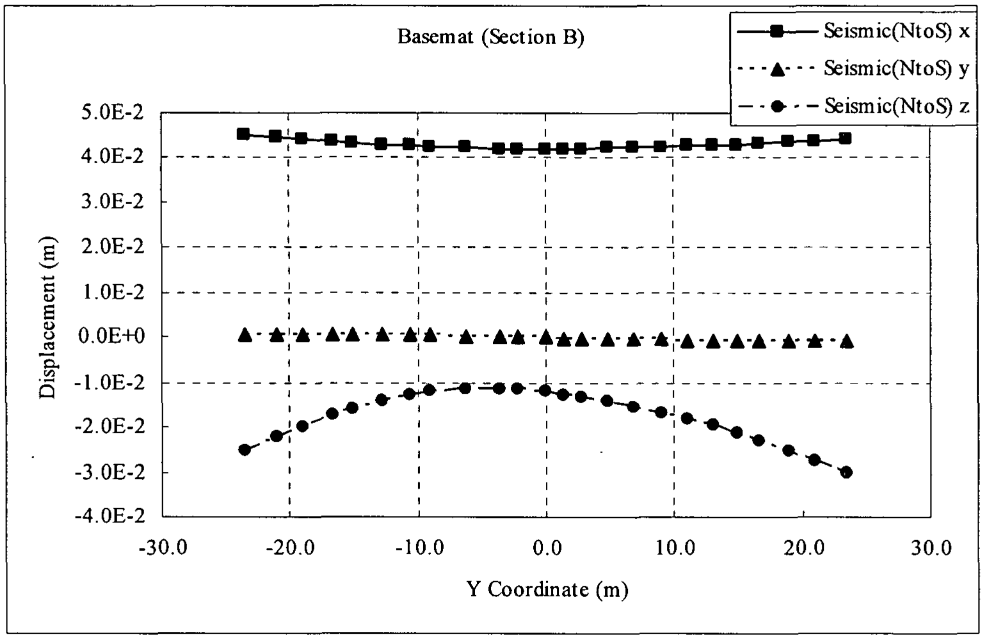


Figure 5-55 Displacement at Basemat Section B for Seismic Load (N to S)

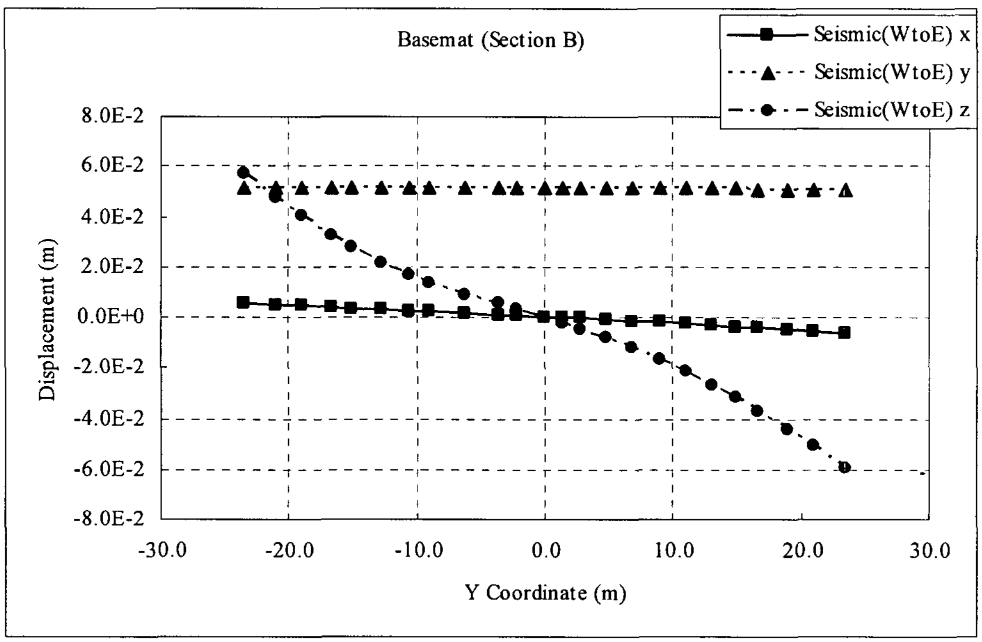


Figure 5-56 Displacement at Basemat Section B for Seismic Load (W to E)

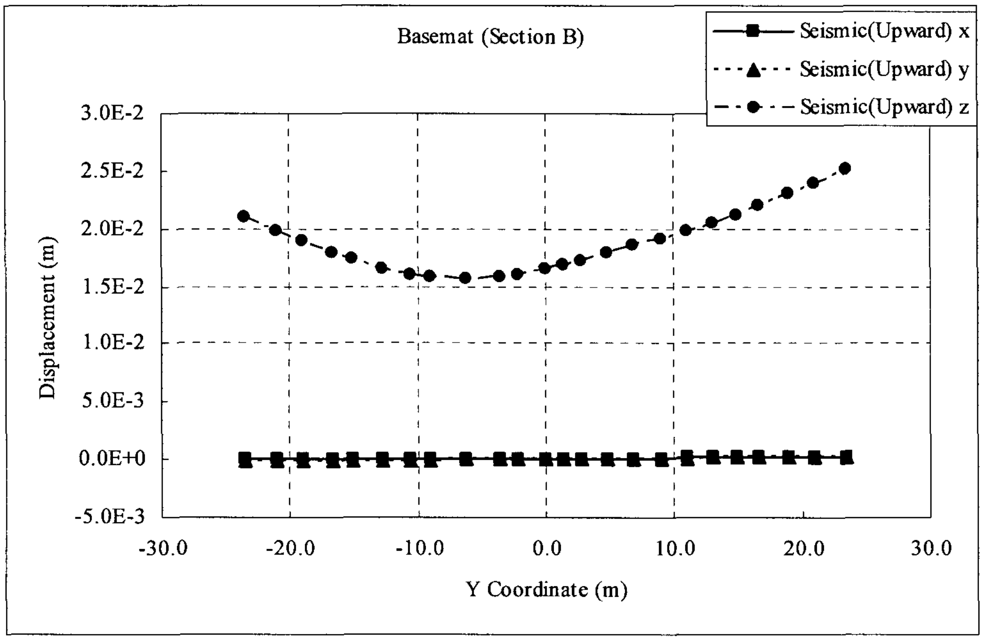


Figure 5-57 Displacement at Basemat Section B for Seismic Load (Vertical; Upward)

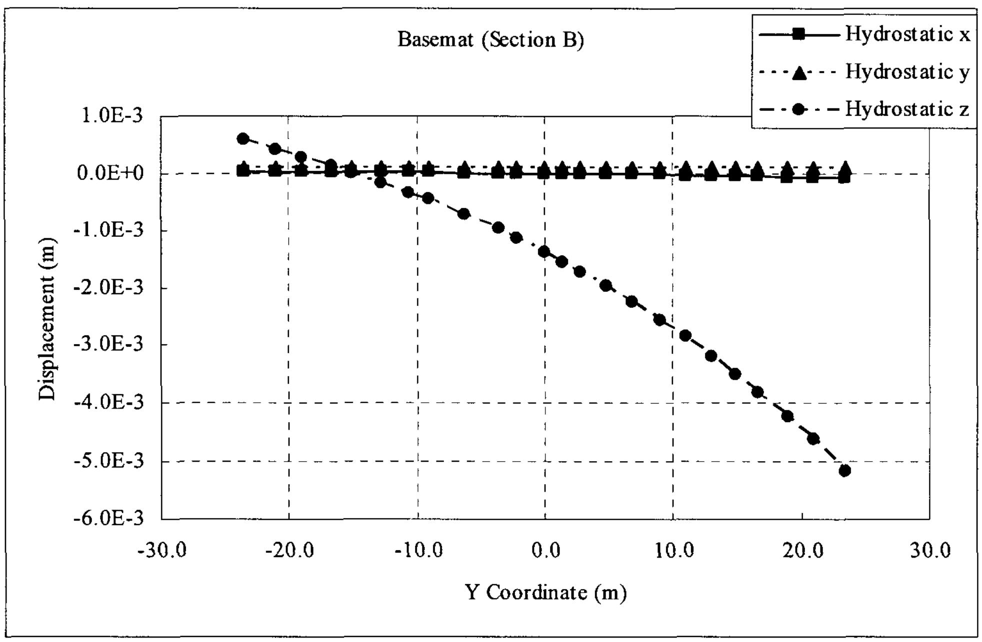


Figure 5-58 Displacement at Basemat Section B for Hydrostatic Load

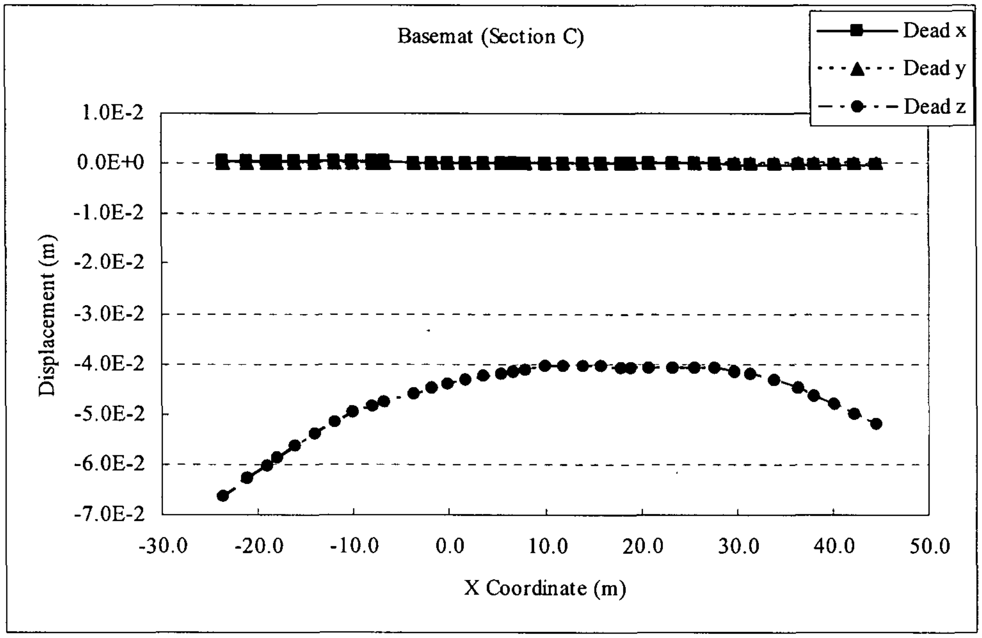


Figure 5-59 Displacement at Basemat Section C for Dead Load

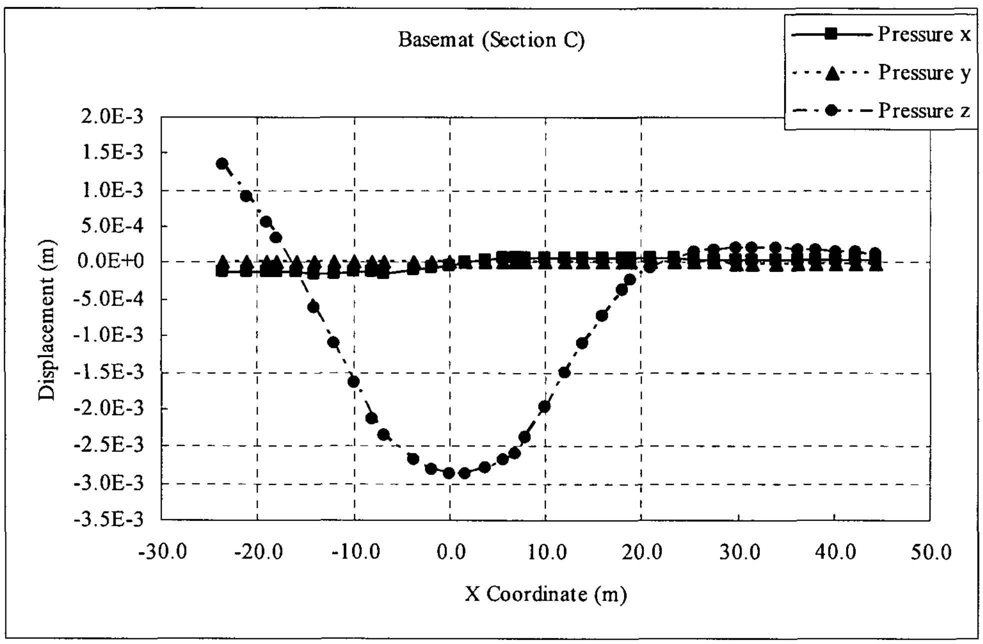


Figure 5-60 Displacement at Basemat Section C for Pressure Load

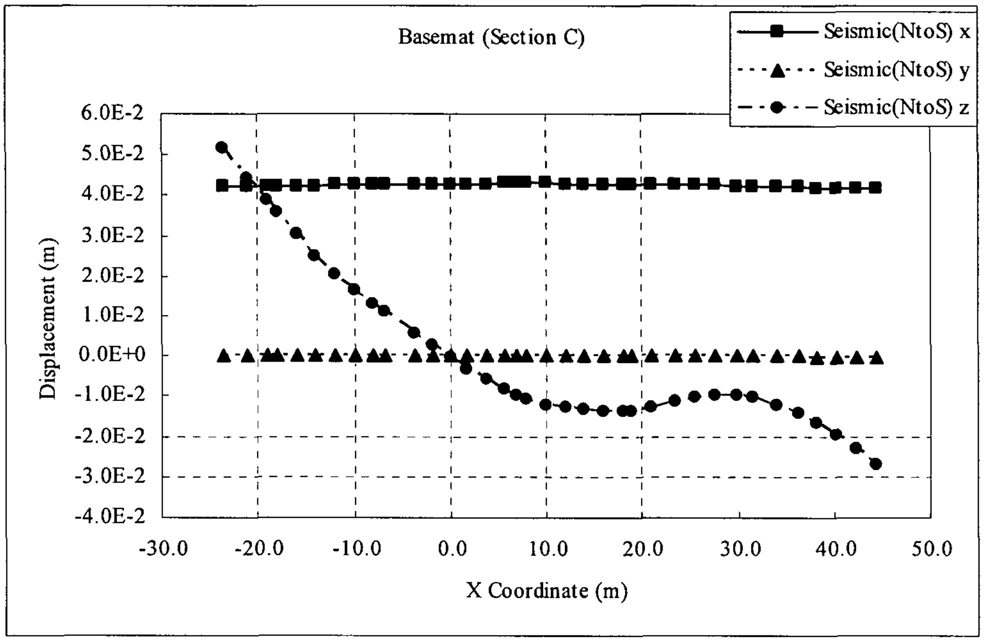


Figure 5-61 Displacement at Basemat Section C for Seismic Load (N to S)

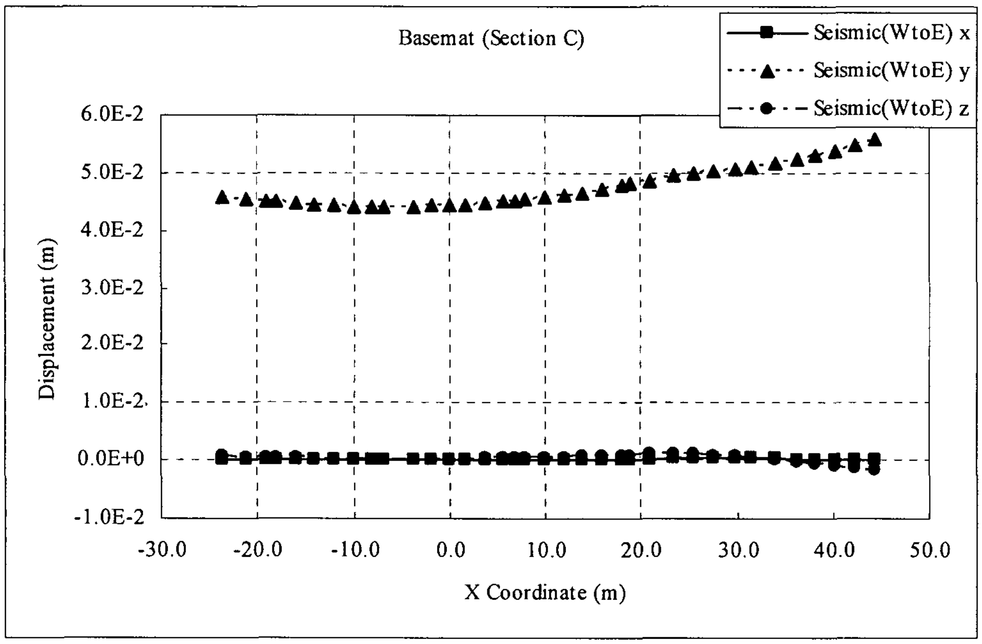


Figure 5-62 Displacement at Basemat Section C for Seismic Load (W to E)

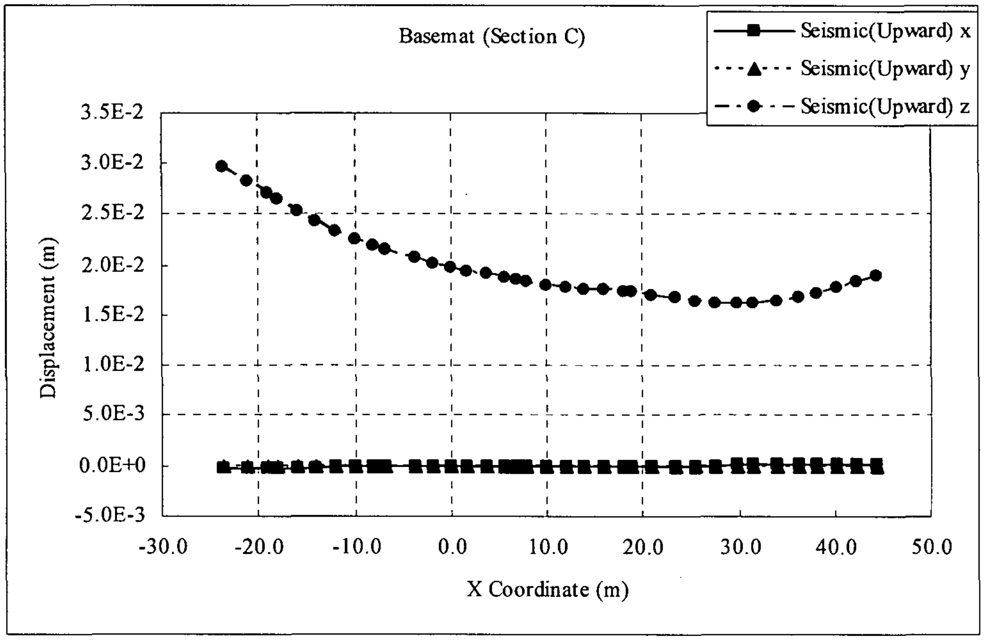


Figure 5-63 Displacement at Basemat Section C for Seismic Load (Vertical; Upward)

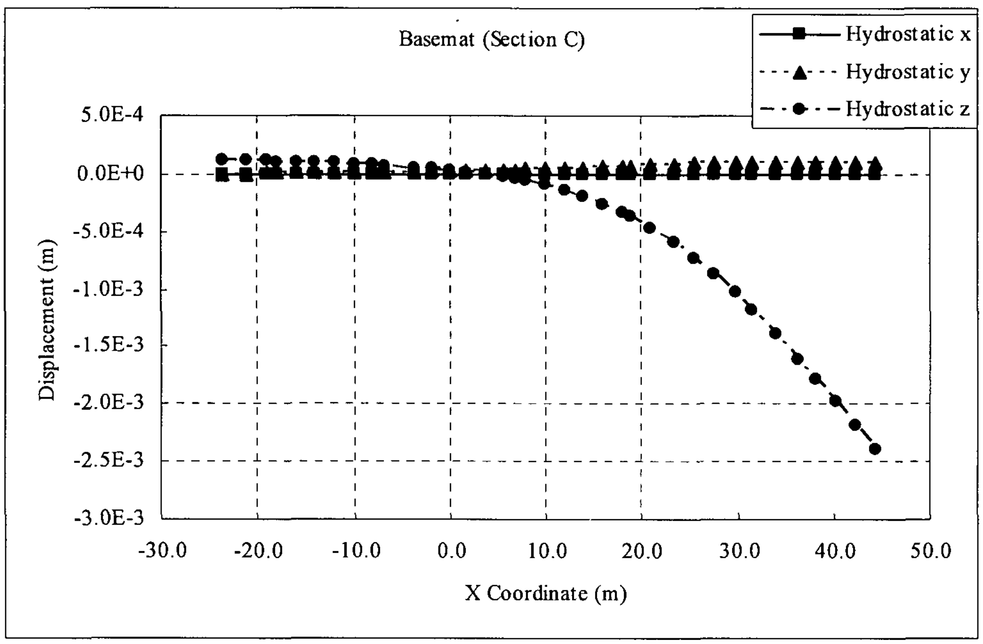


Figure 5-64 Displacement at Basemat Section C for Hydrostatic Load

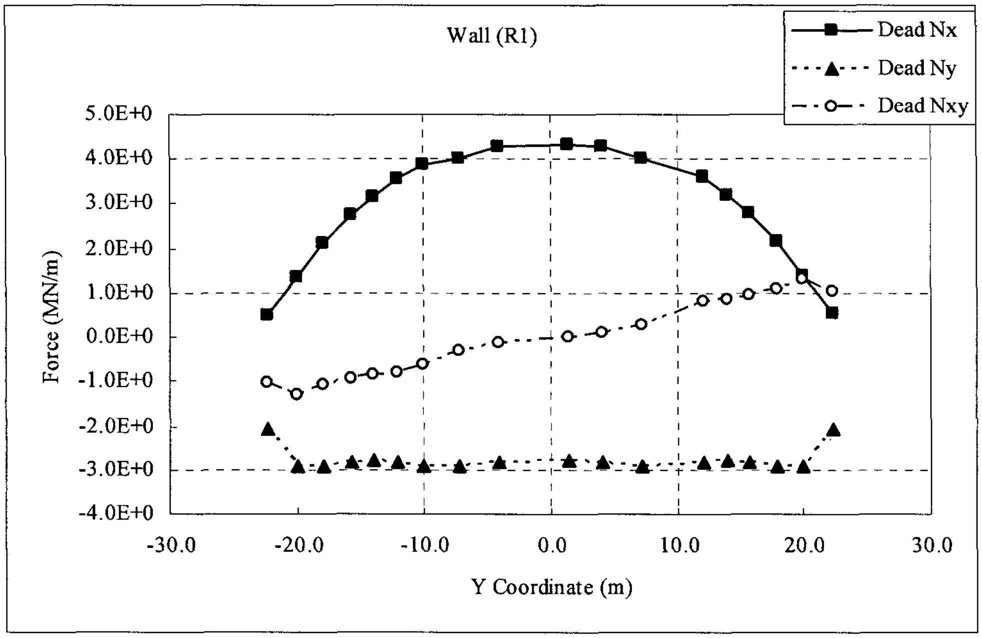


Figure 5-65 Axial Forces at R1 Wall for Dead Load

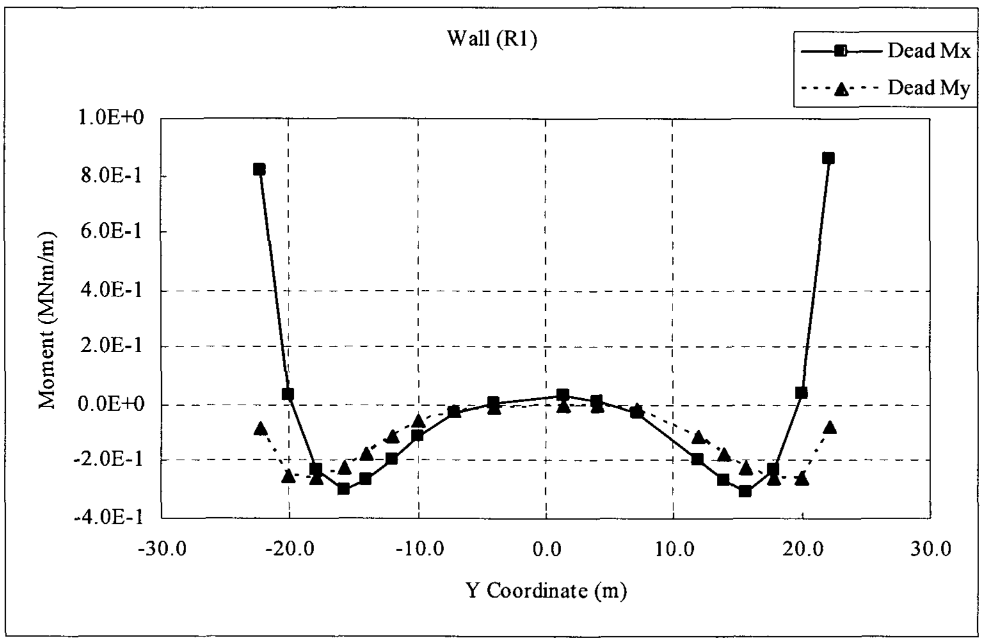


Figure 5-66 Moments at R1 Wall for Dead Load

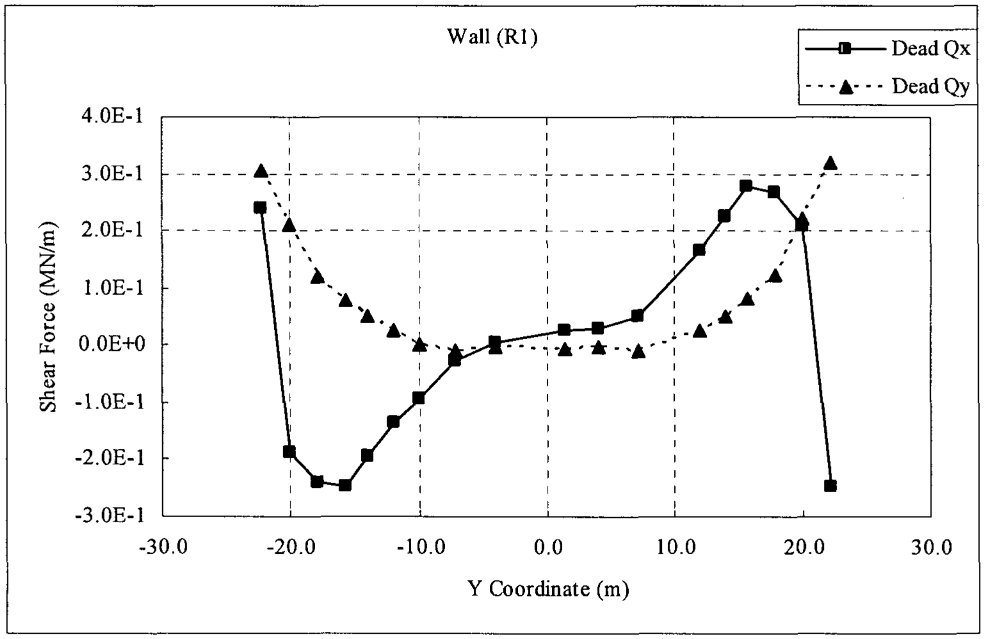


Figure 5-67 Shear Forces at R1 Wall for Dead Load

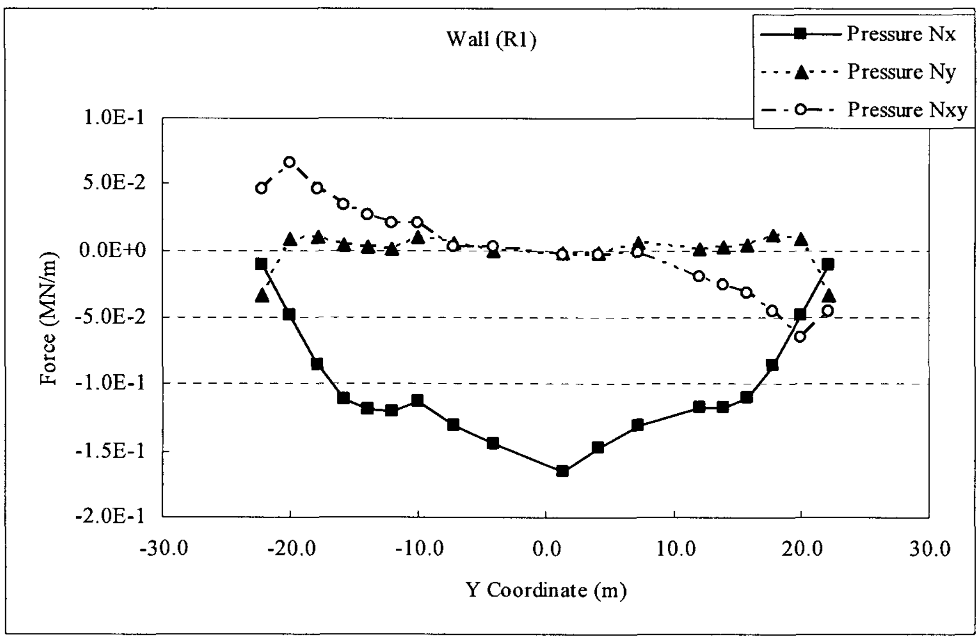


Figure 5-68 Axial Forces at R1 Wall for Pressure Load

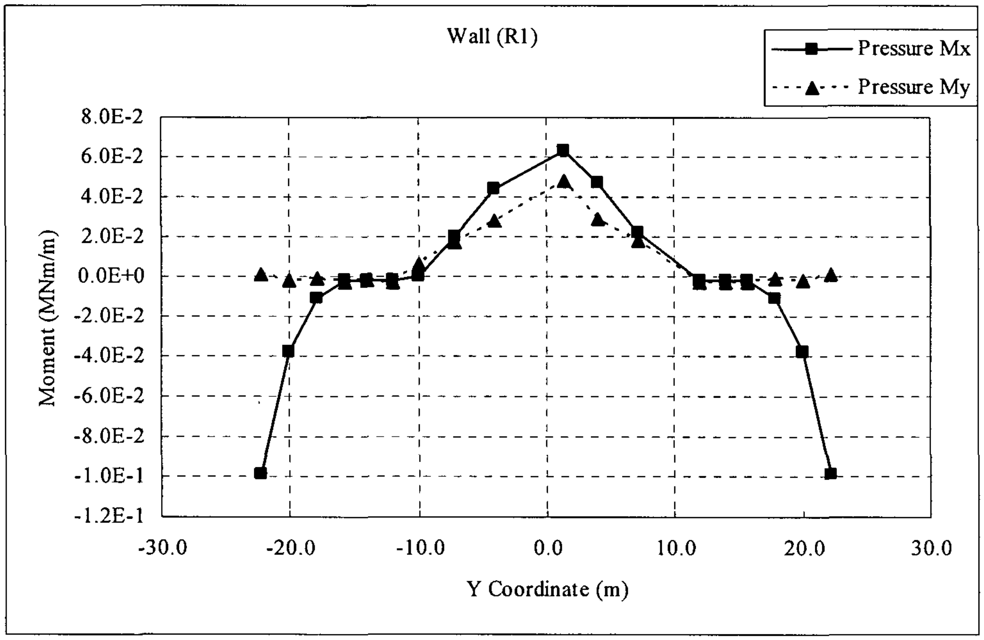


Figure 5-69 Moments at R1 Wall for Pressure Load

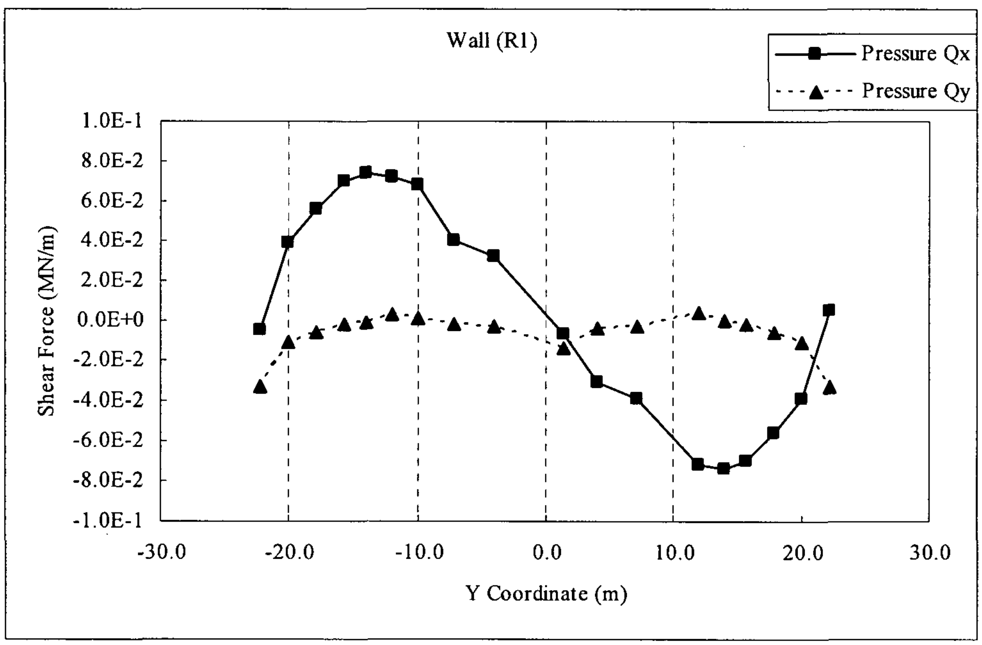


Figure 5-70 Shear Forces at R1 Wall for Pressure Load

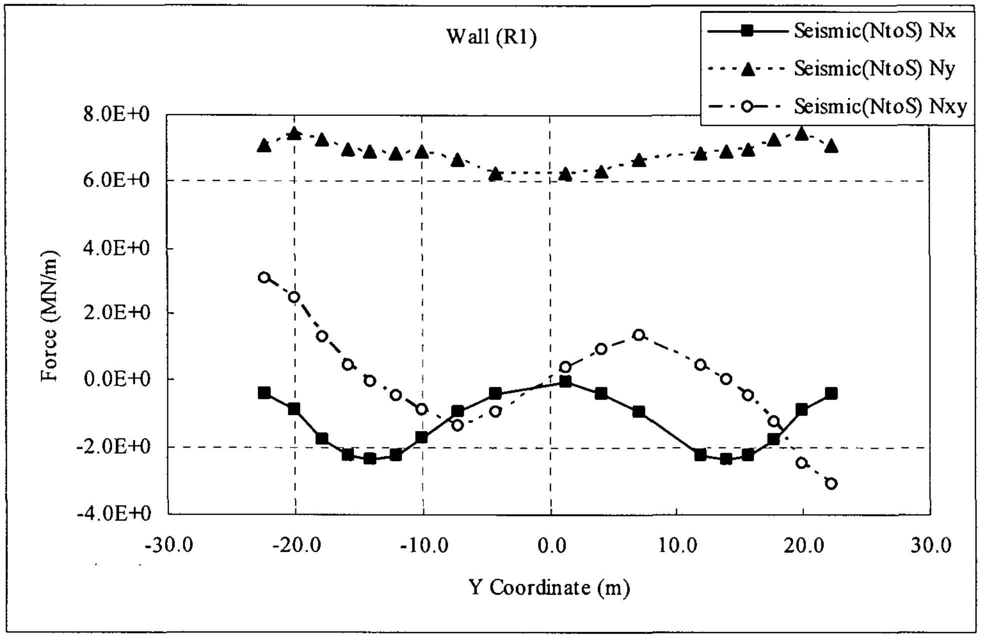


Figure 5-71 Axial Forces at R1 Wall for Seismic Load (N to S)

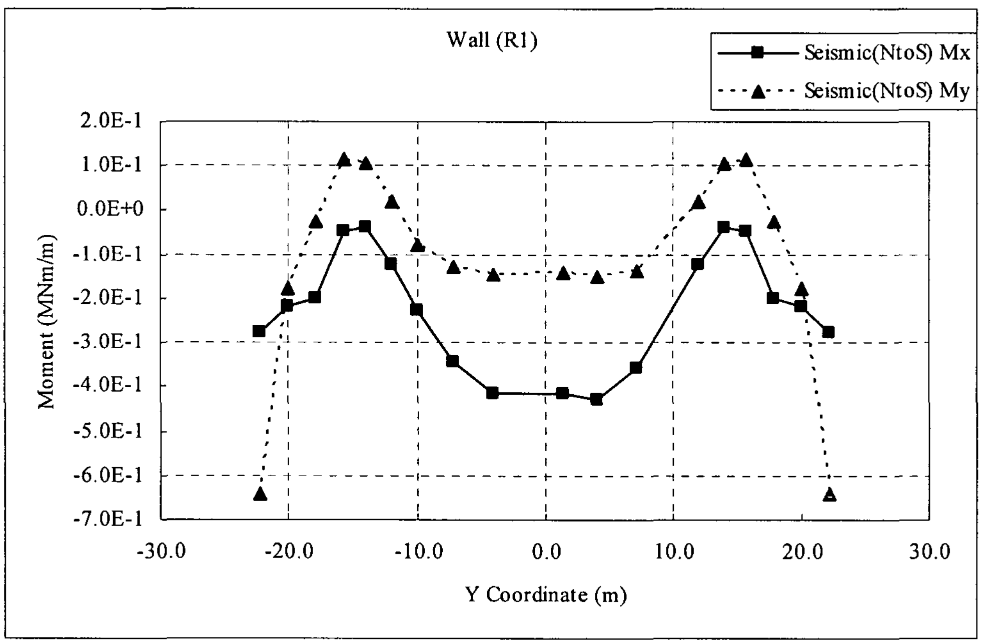


Figure 5-72 Moments at R1 Wall for Seismic Load (N to S)

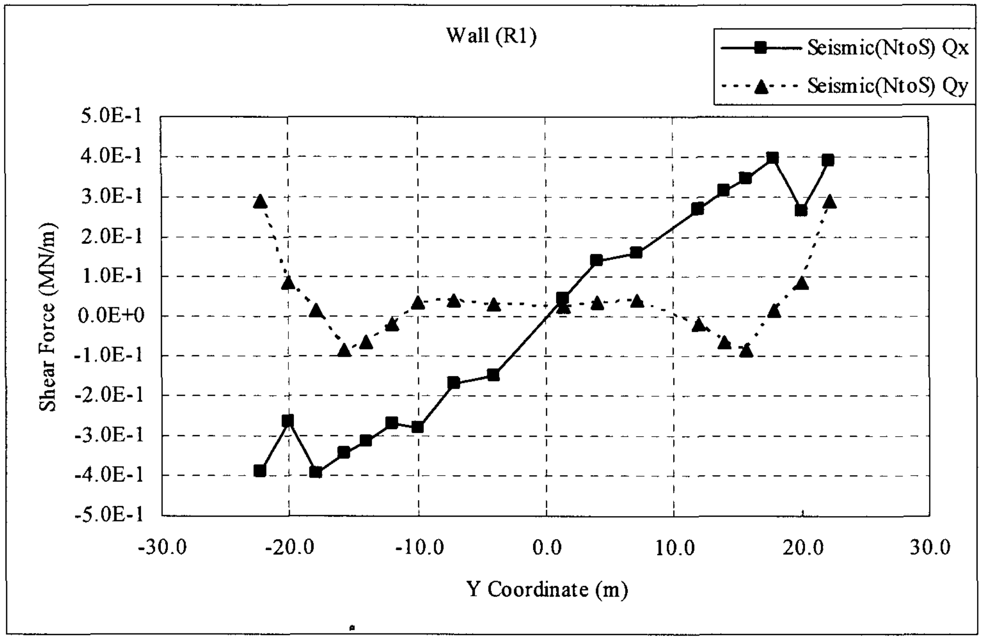


Figure 5-73 Shear Forces at R1 Wall for Seismic Load (N to S)

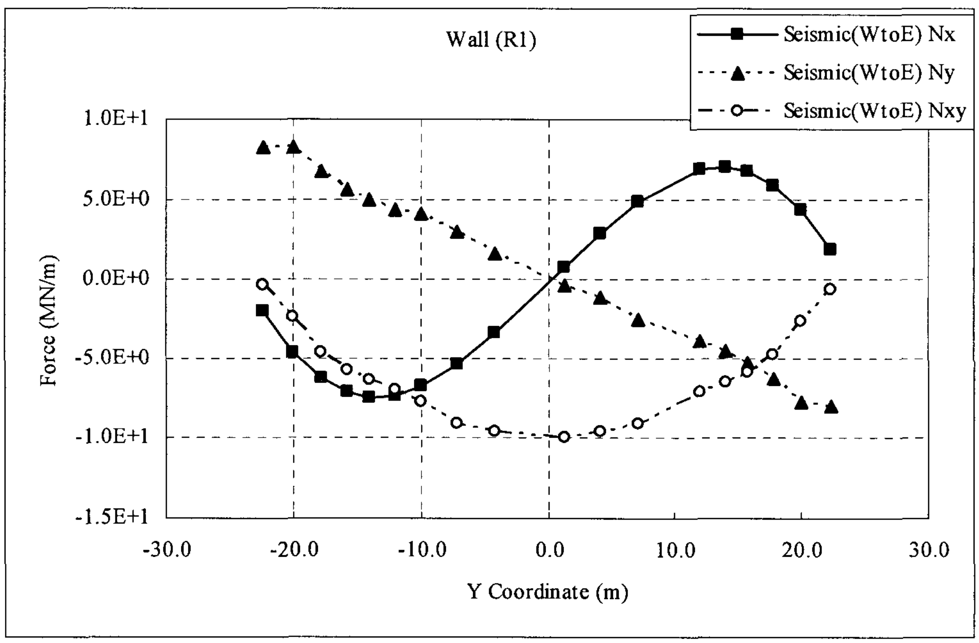


Figure 5-74 Axial Forces at R1 Wall for Seismic Load (W to E)

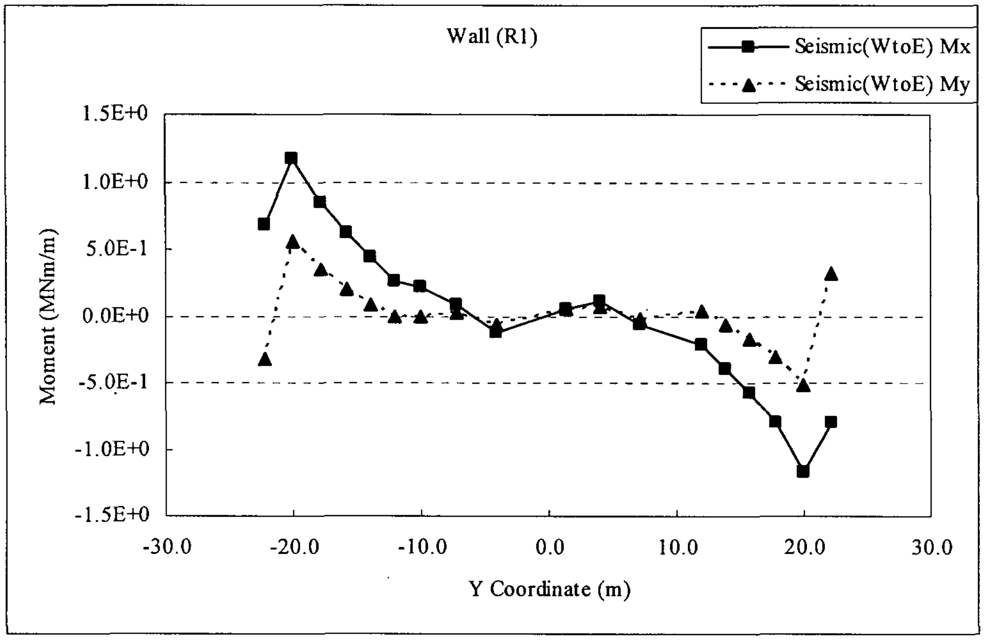


Figure 5-75 Moments at R1 Wall for Seismic Load (W to E)

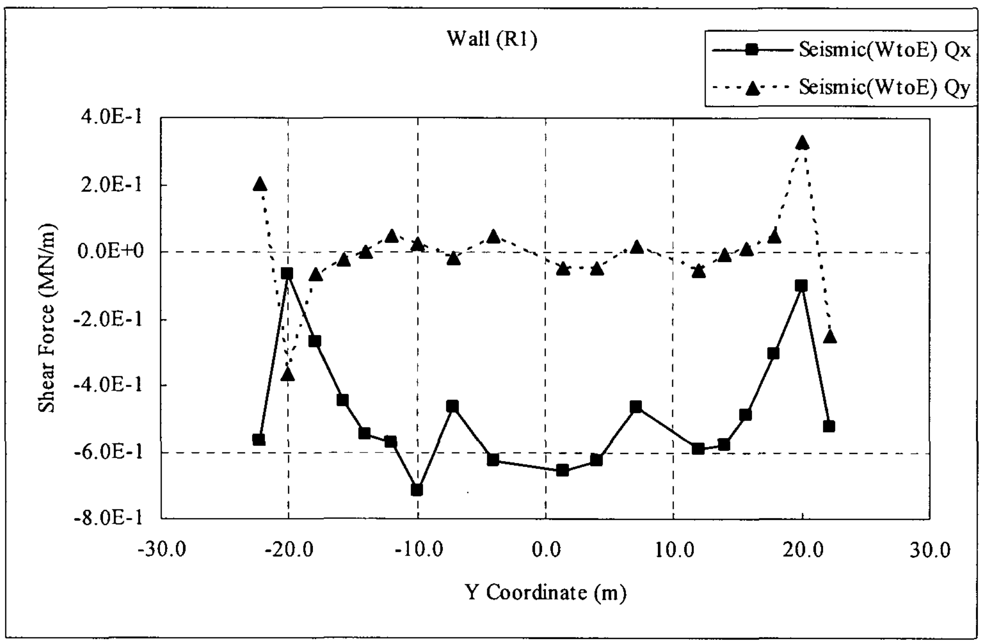


Figure 5-76 Shear Forces at R1 Wall for Seismic Load (W to E)

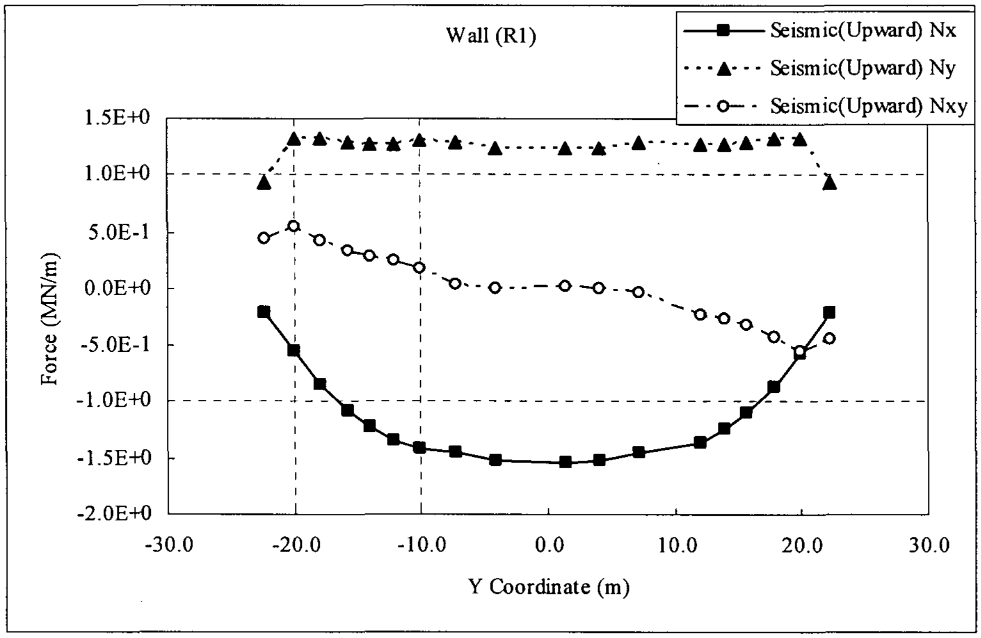


Figure 5-77 Axial Forces at R1 Wall for Seismic Load (Vertical; Upward)

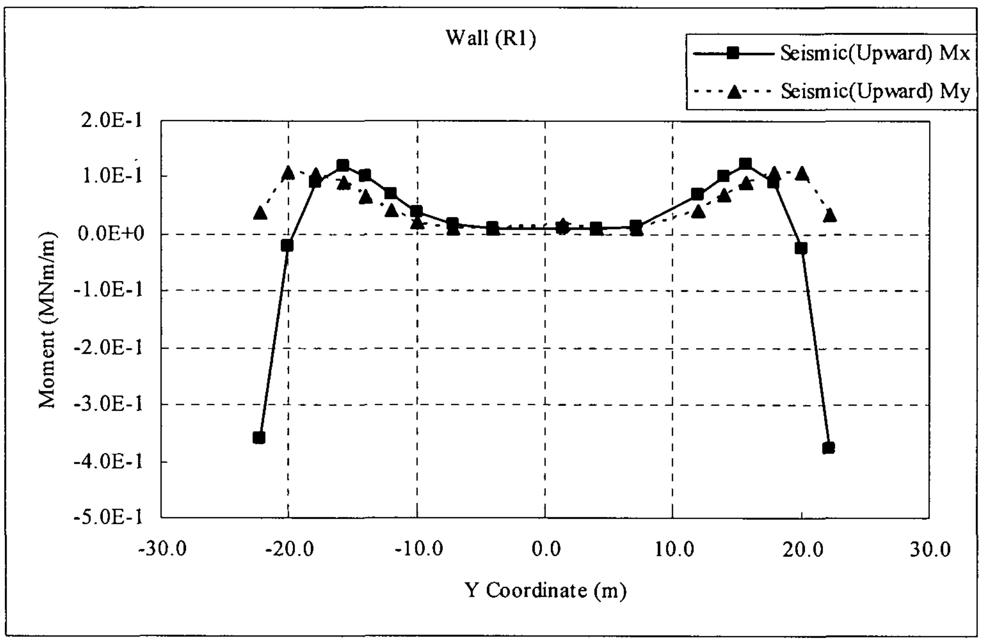


Figure 5-78 Moments at R1 Wall for Seismic Load (Vertical; Upward)

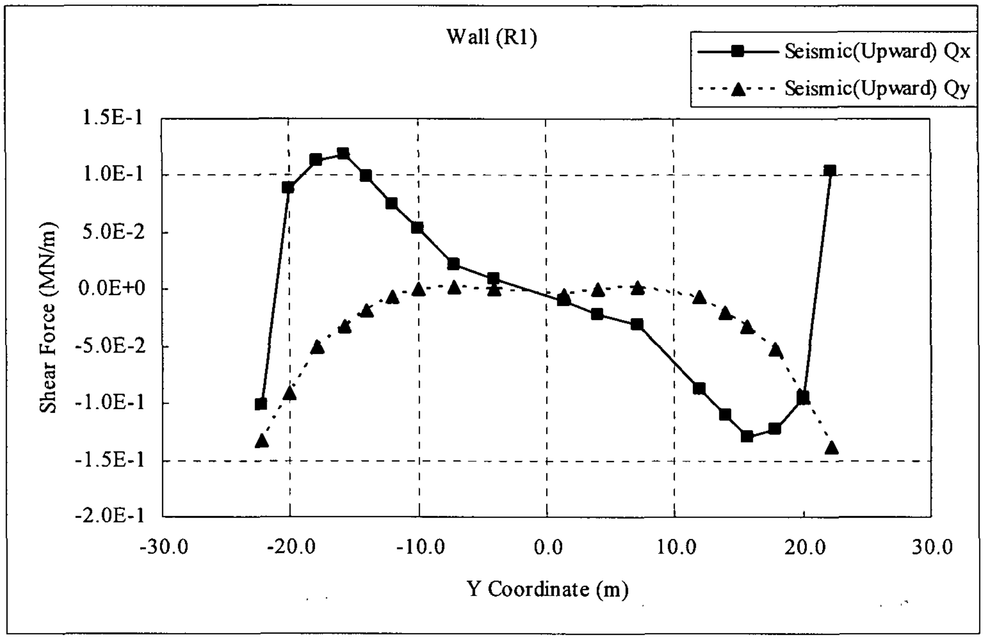


Figure 5-79 Shear Forces at R1 Wall for Seismic Load (Vertical; Upward)

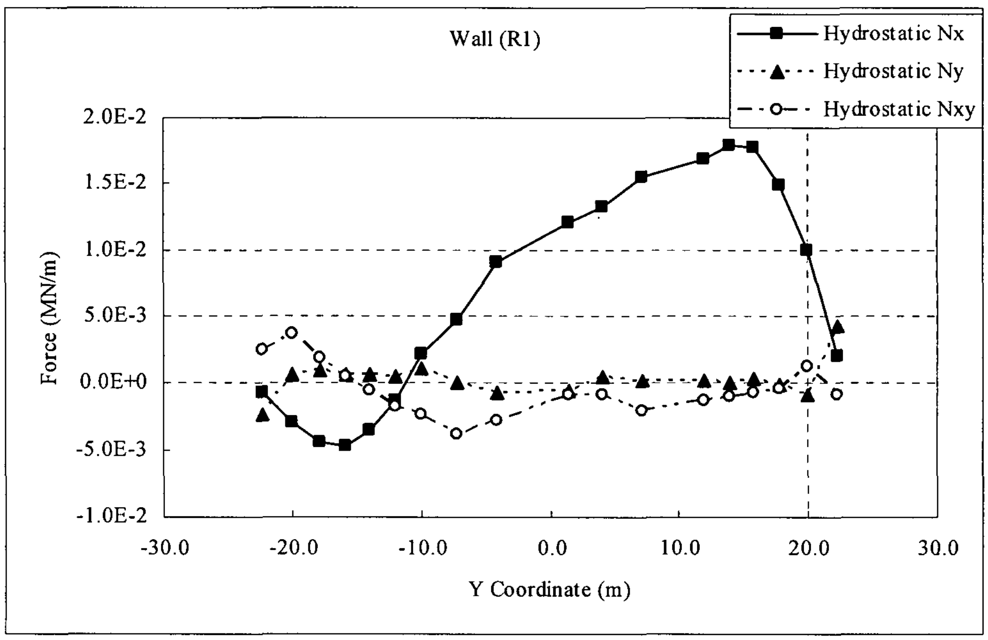


Figure 5-80 Axial Forces at R1 Wall for Hydrostatic Load

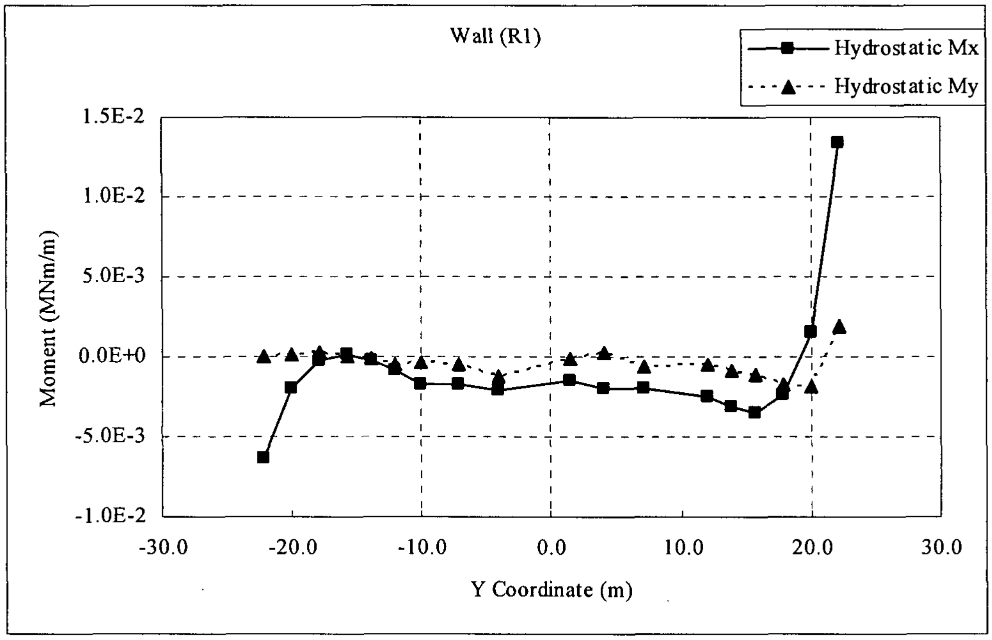


Figure 5-81 Moments at R1 Wall for Hydrostatic Load

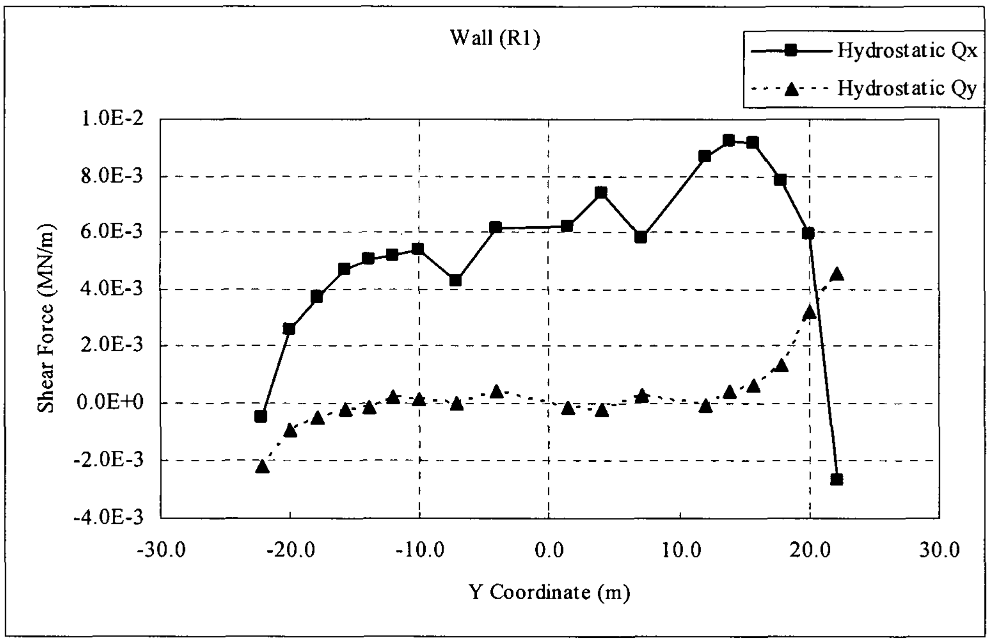


Figure 5-82 Shear Forces at R1 Wall for Hydrostatic Load

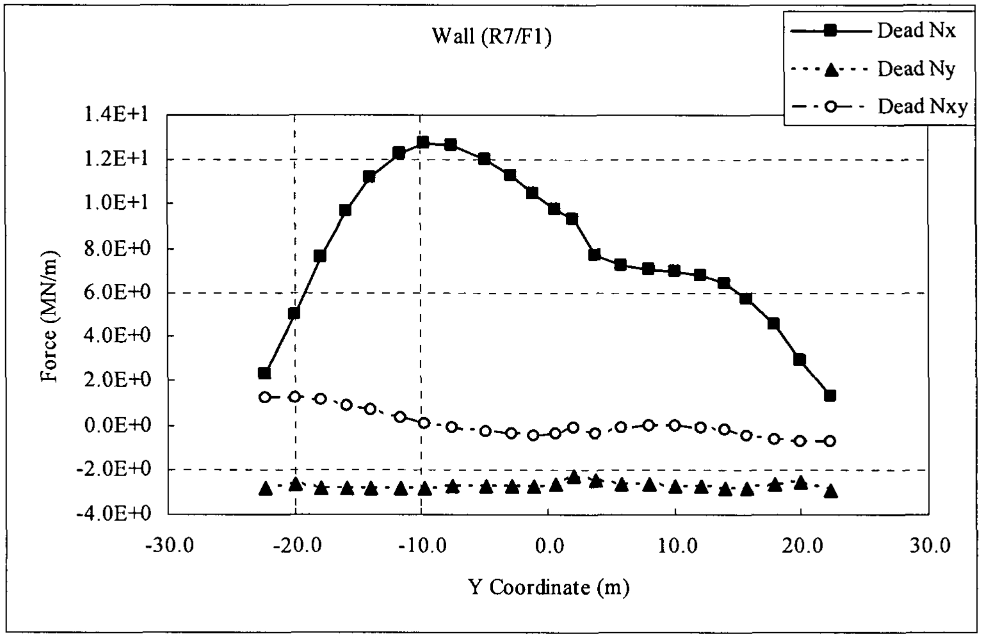


Figure 5-83 Axial Forces at R7/F1 Wall for Dead Load

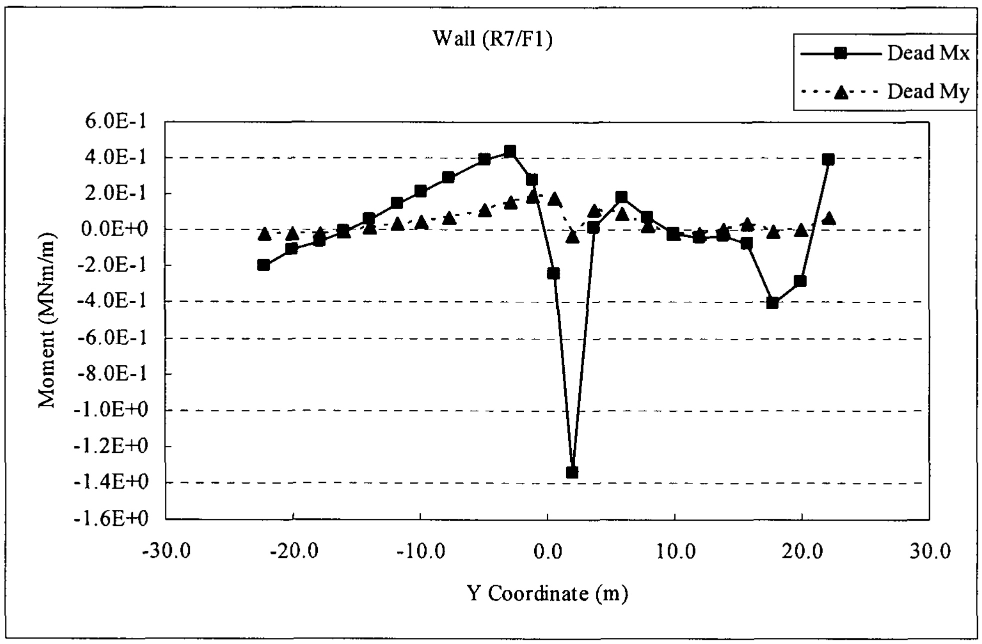


Figure 5-84 Moments at R7/F1 Wall for Dead Load

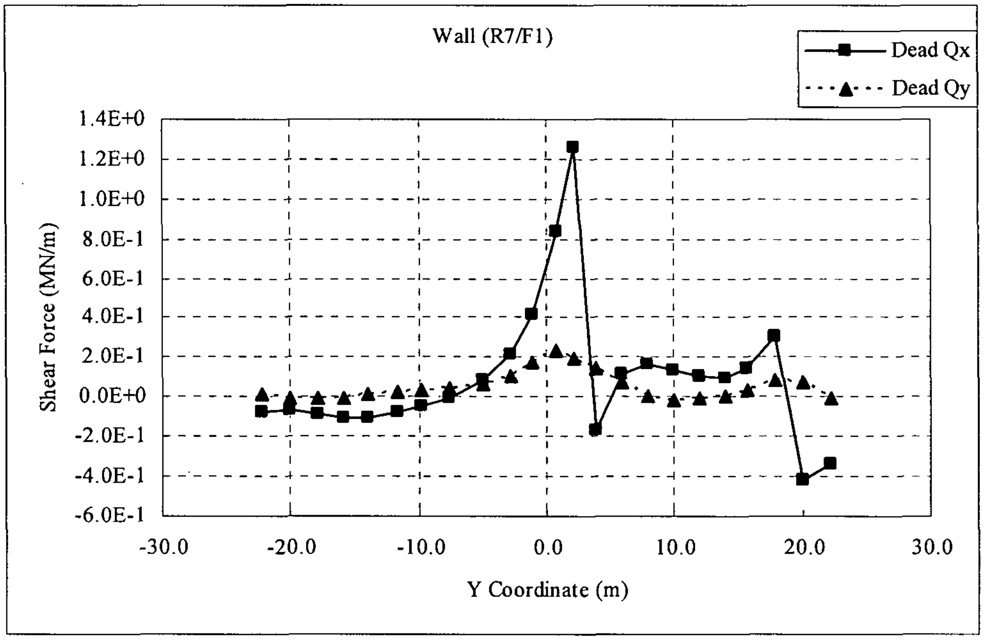


Figure 5-85 Shear Forces at R7/F1 Wall for Dead Load

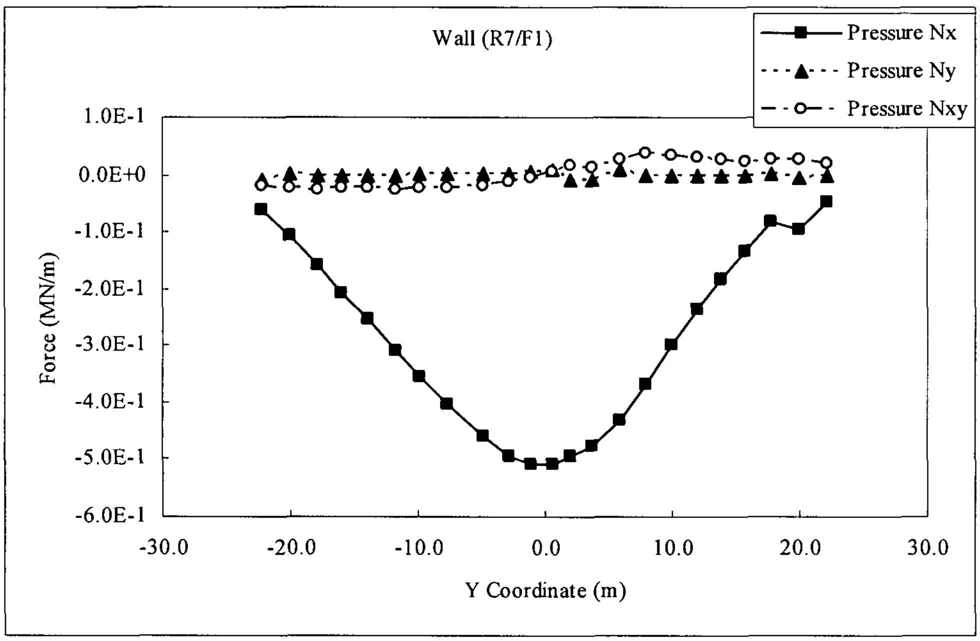


Figure 5-86 Axial Forces at R7/F1 Wall for Pressure Load

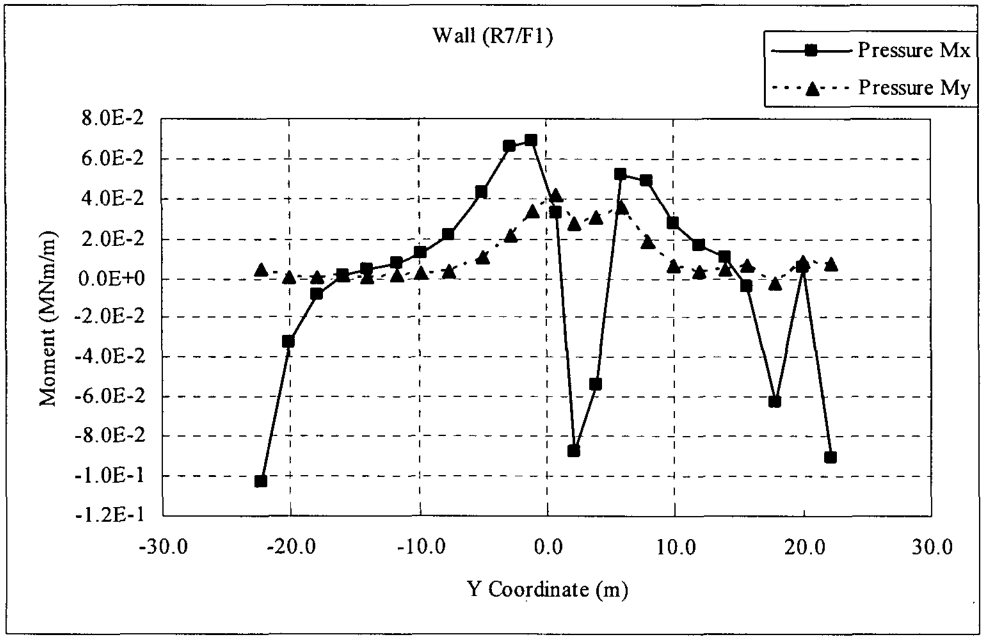


Figure 5-87 Moments at R7/F1 Wall for Pressure Load

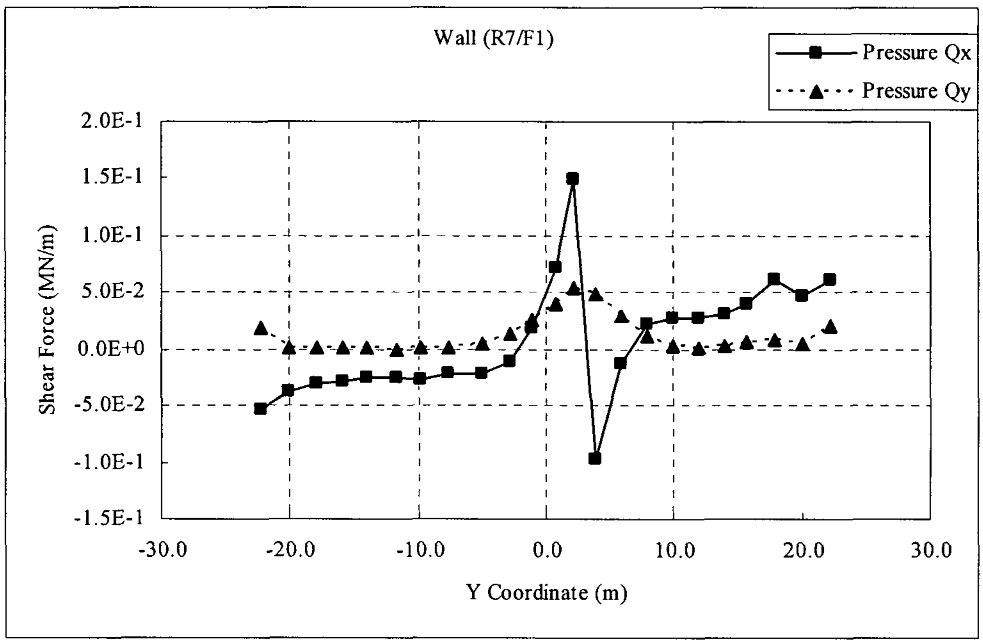


Figure 5-88 Shear Forces at R7/F1 Wall for Pressure Load

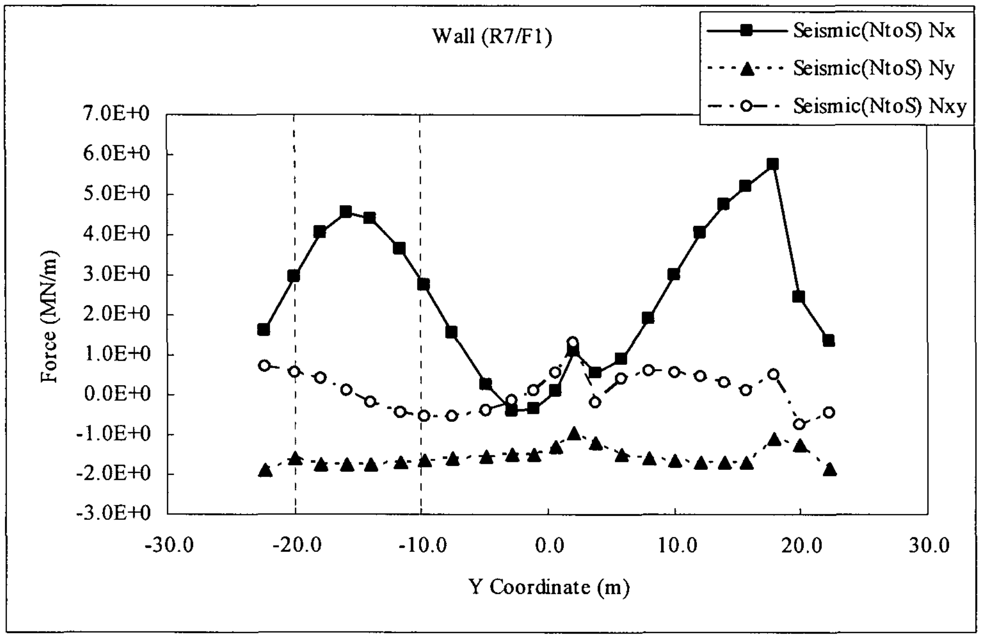


Figure 5-89 Axial Forces at R7/F1 Wall for Seismic Load (N to S)

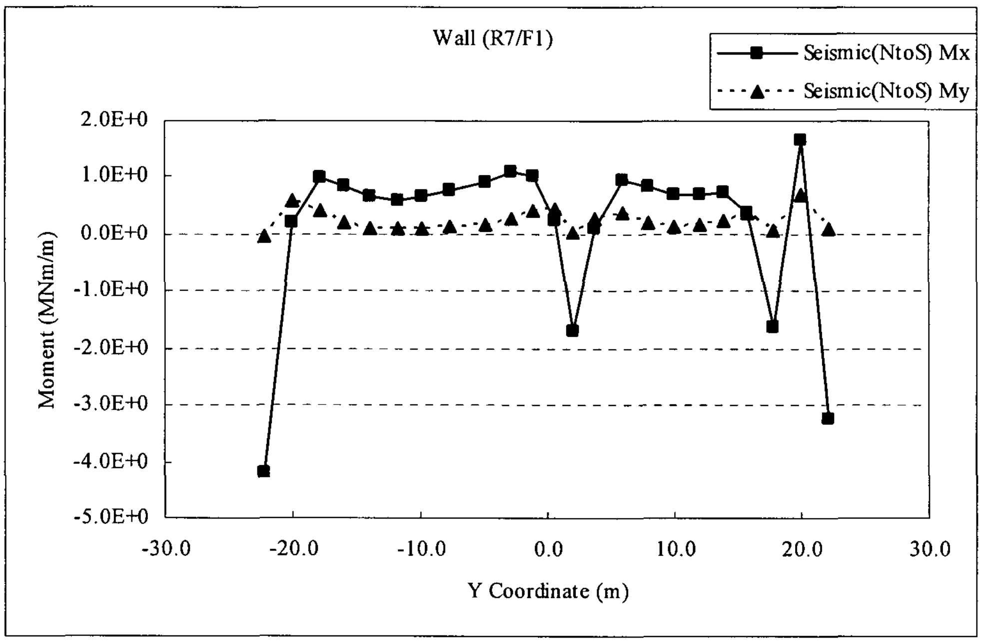


Figure 5-90 Moments at R7/F1 Wall for Seismic Load (N to S)

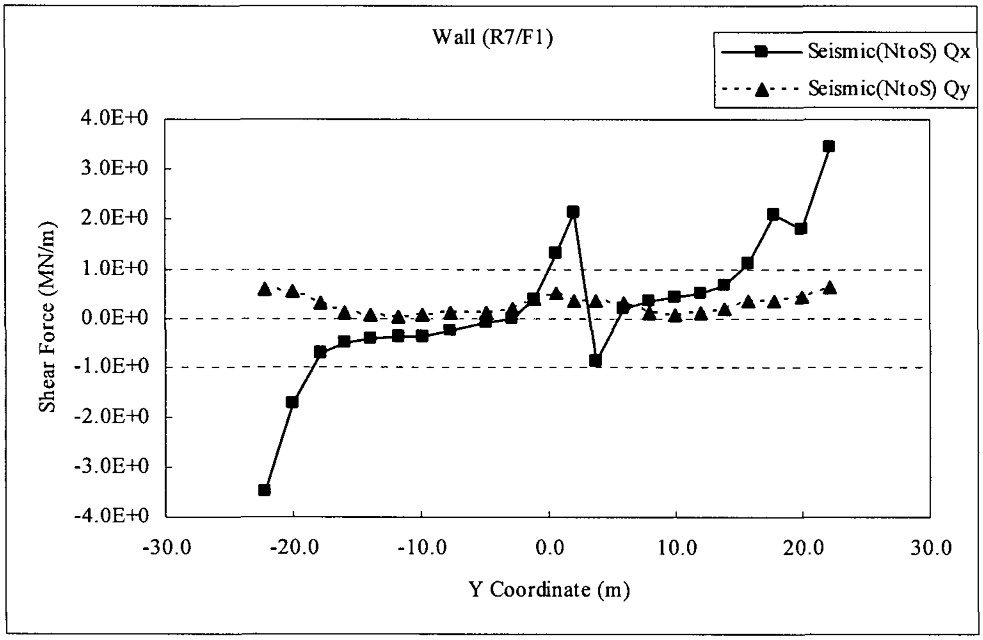


Figure 5-91 Shear Forces at R7/F1 Wall for Seismic Load (N to S)

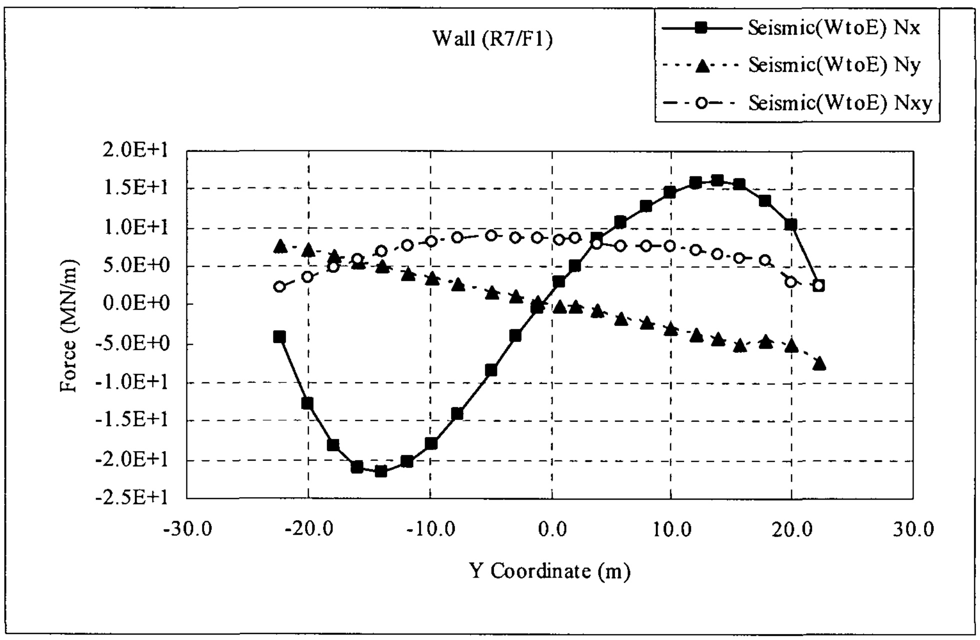


Figure 5-92 Axial Forces at R7/F1 Wall for Seismic Load (W to E)

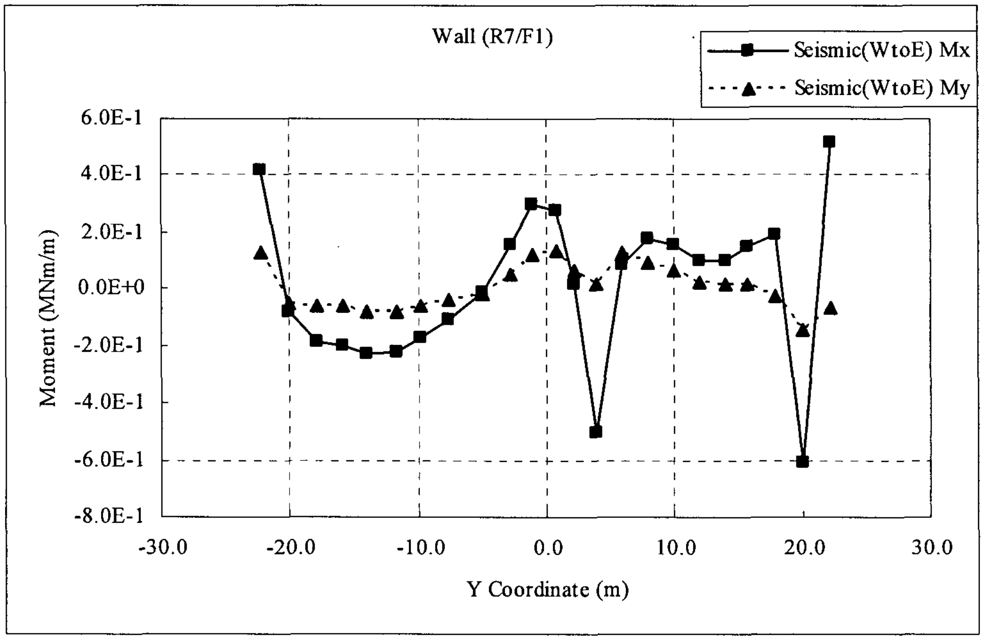


Figure 5-93 Moments at R7/F1 Wall for Seismic Load (W to E)

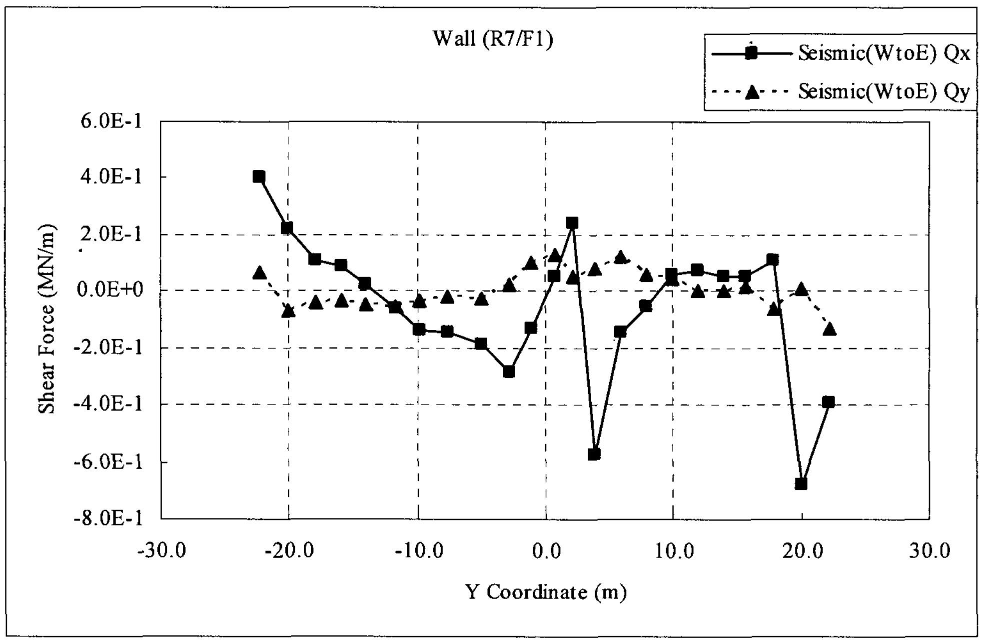


Figure 5-94 Shear Forces at R7/F1 Wall for Seismic Load (W to E)

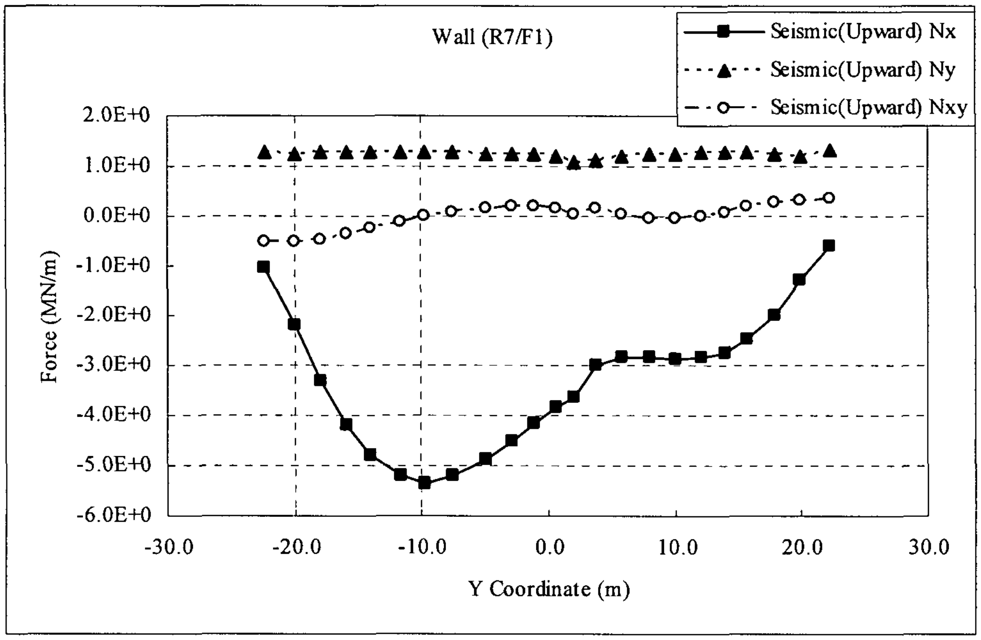


Figure 5-94 Axial Forces at R7/F1 Wall for Seismic Load (Vertical; Upward)

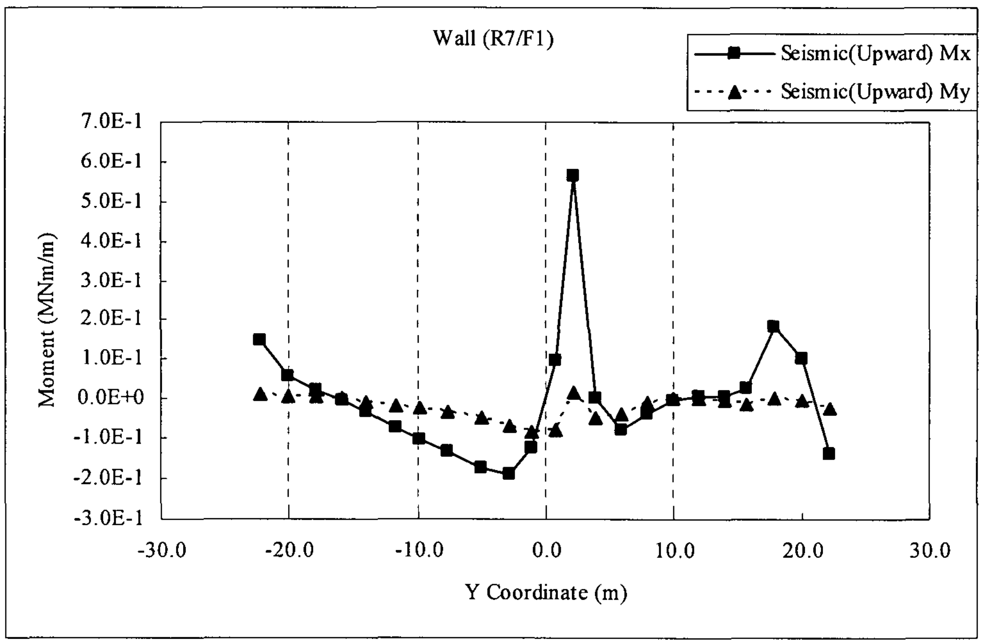


Figure 5-96 Moments at R7/F1 Wall for Seismic Load (Vertical; Upward)

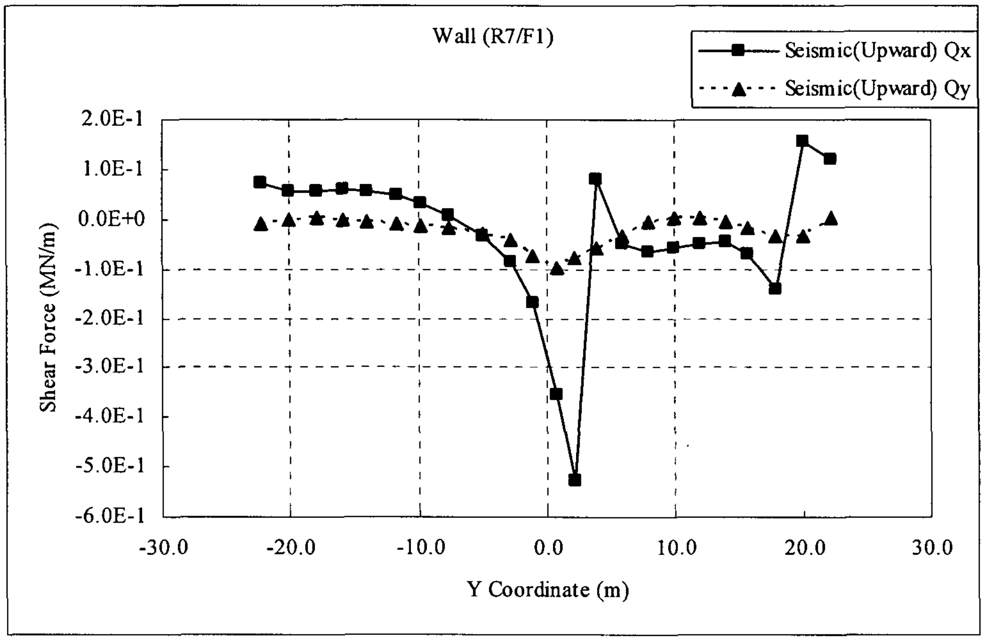


Figure 5-97 Shear Forces at R7/F1 Wall for Seismic Load (Vertical; Upward)

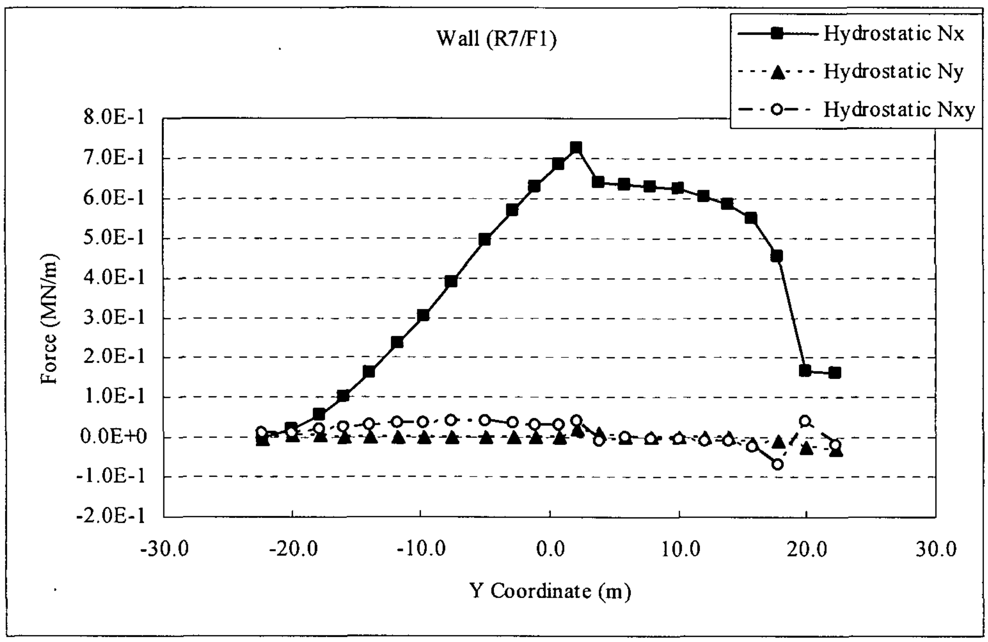


Figure 5-98 Axial Forces at R7/F1 Wall for Hydrostatic Load

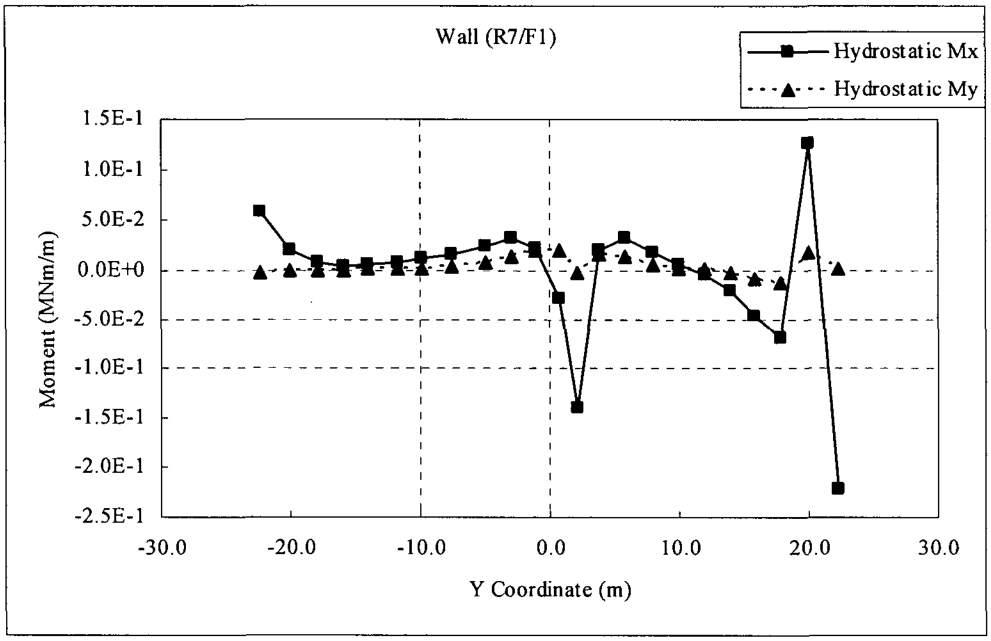


Figure 5-99 Moments at R7/F1 Wall for Hydrostatic Load

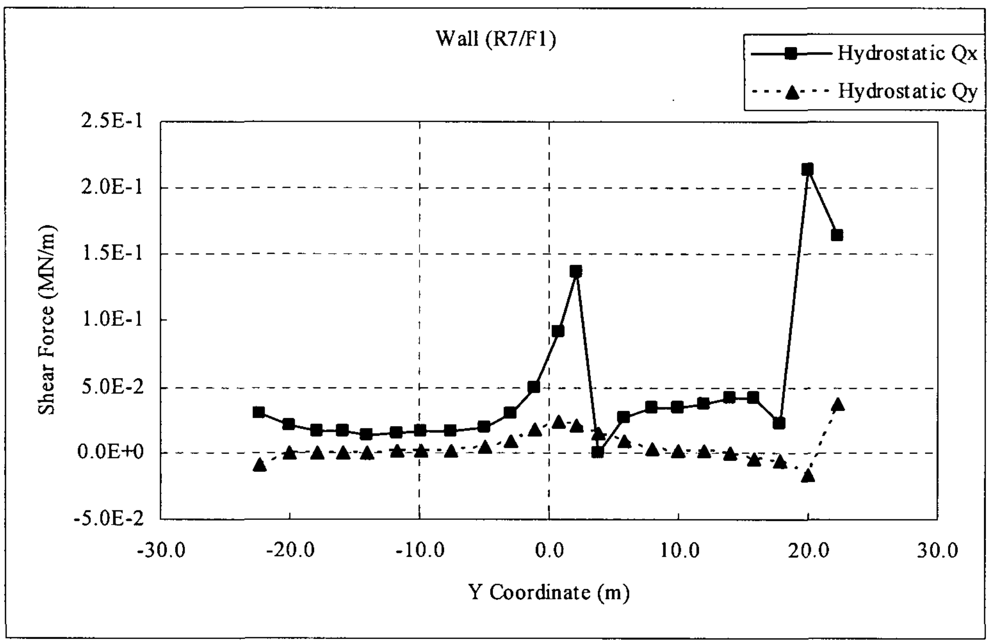


Figure 5-100 Shear Forces at R7/F1 Wall for Hydrostatic Load

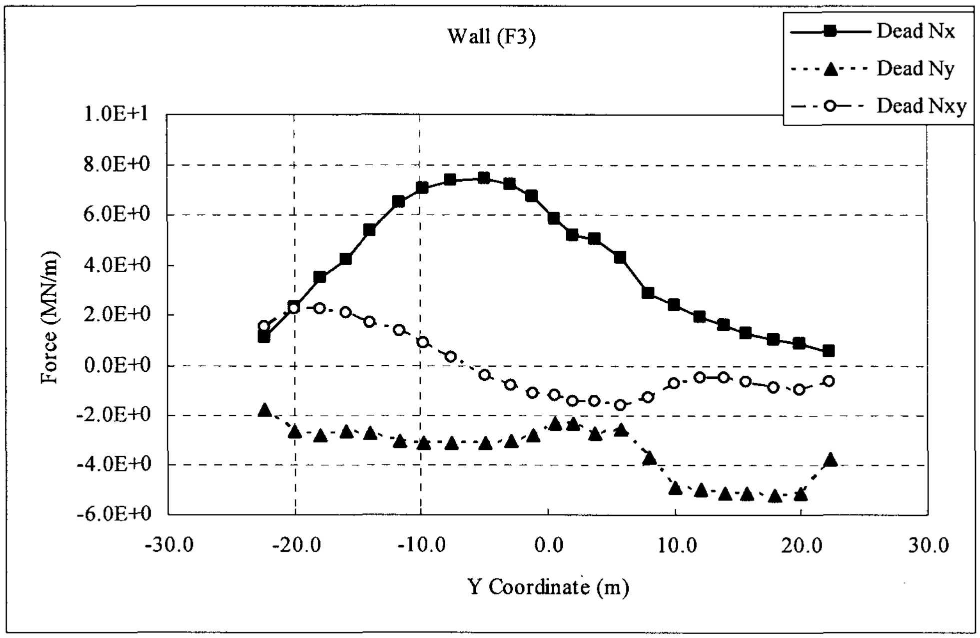


Figure 5-101 Axial Forces at F3 Wall for Dead Load

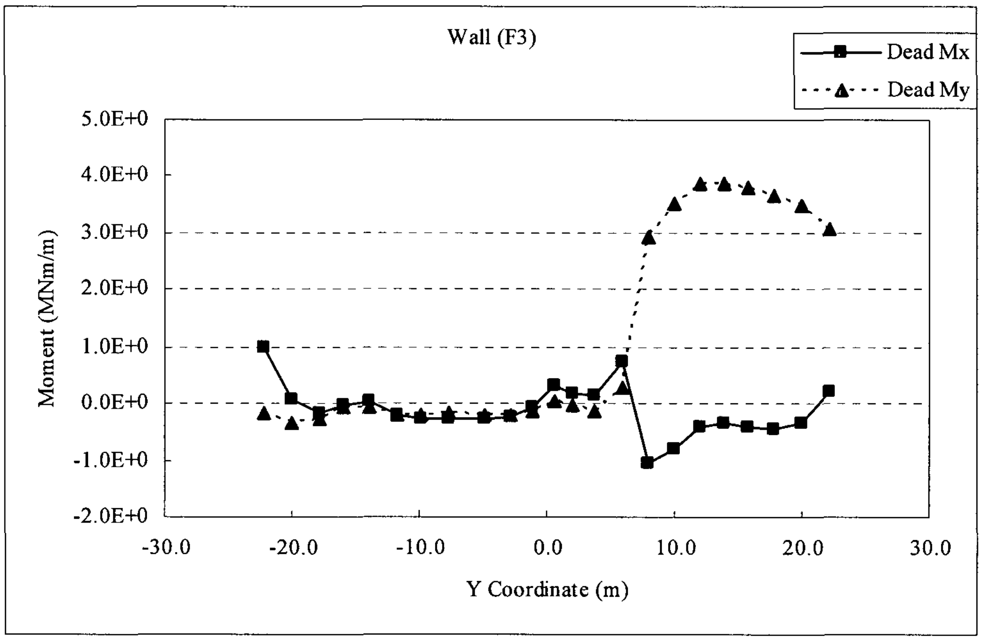


Figure 5-102 Moments at F3 Wall for Dead Load

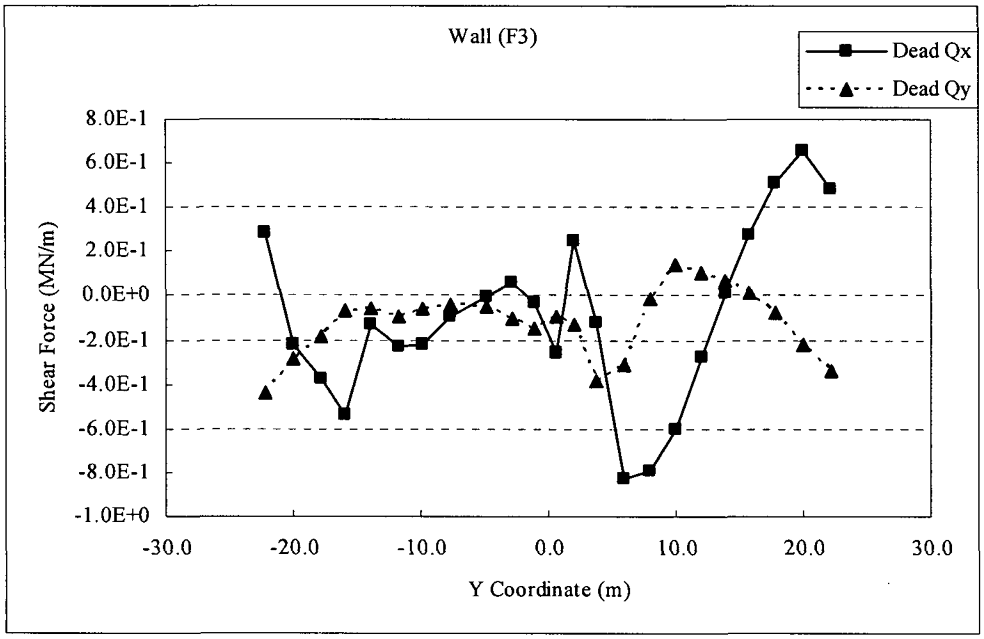


Figure 5-103 Shear Forces at F3 Wall for Dead Load

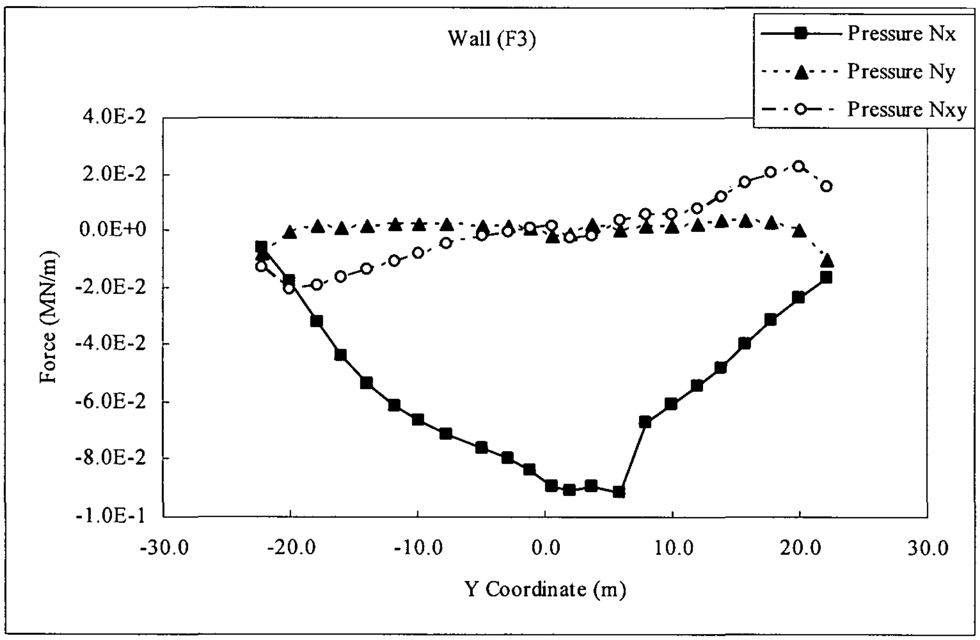


Figure 5-104 Axial Forces at F3 Wall for Pressure Load

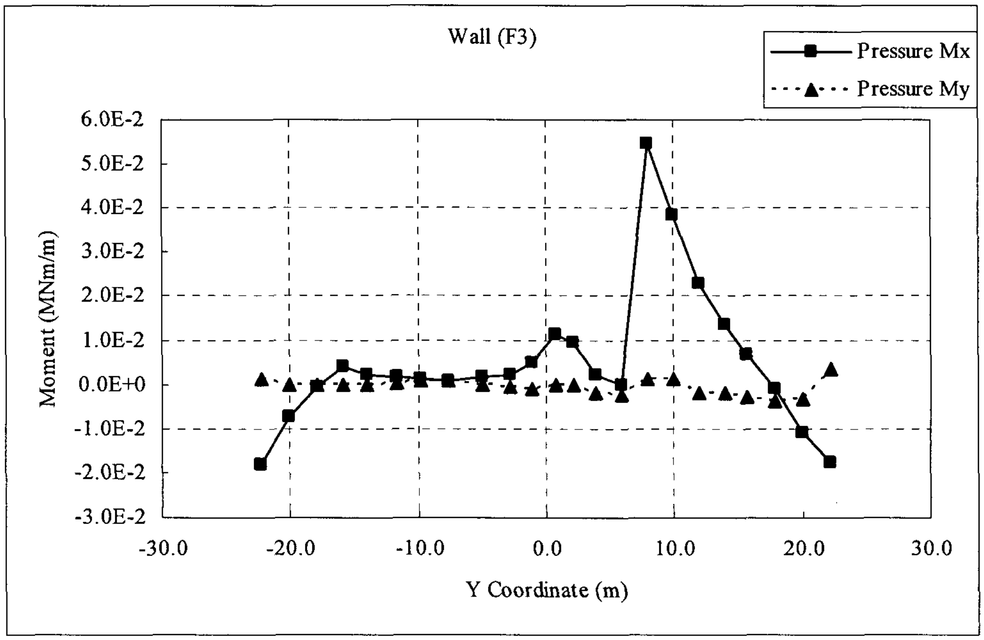


Figure 5-105 Moments at F3 Wall for Pressure Load

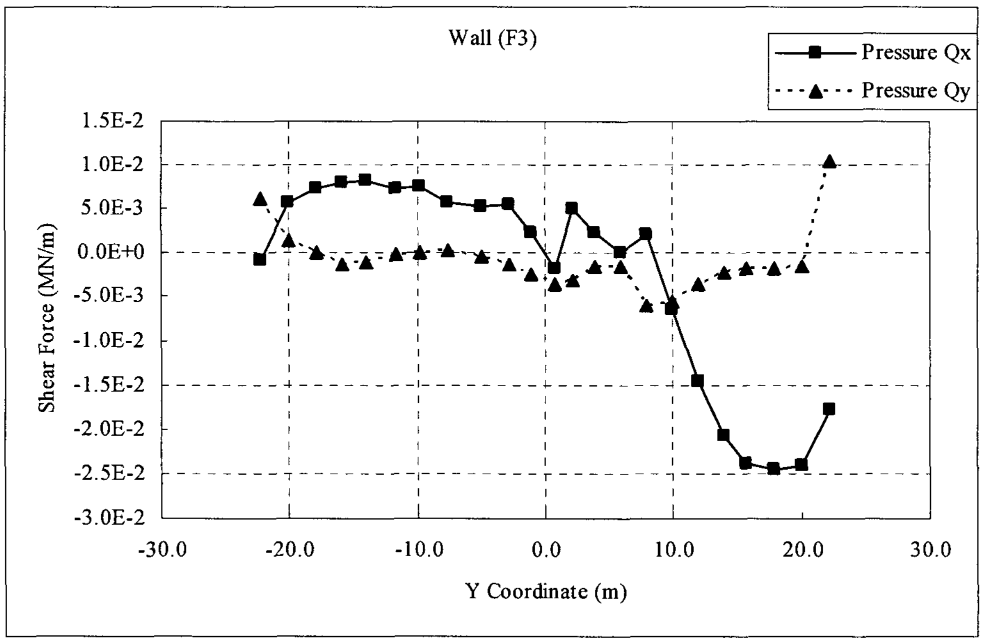


Figure 5-106 Shear Forces at F3 Wall for Pressure Load

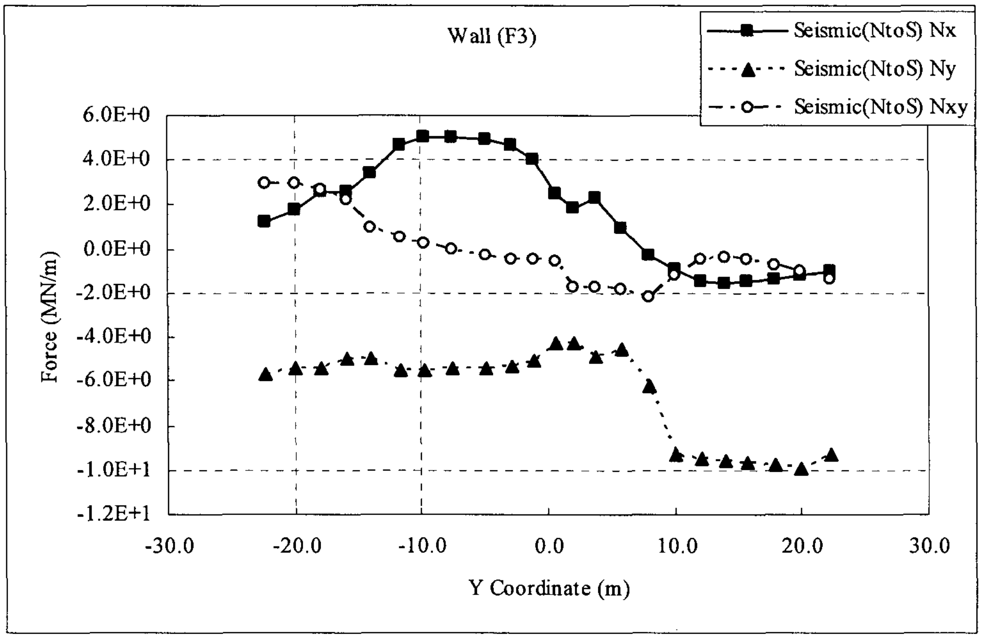


Figure 5-107 Axial Forces at F3 Wall for Seismic Load (N to S)

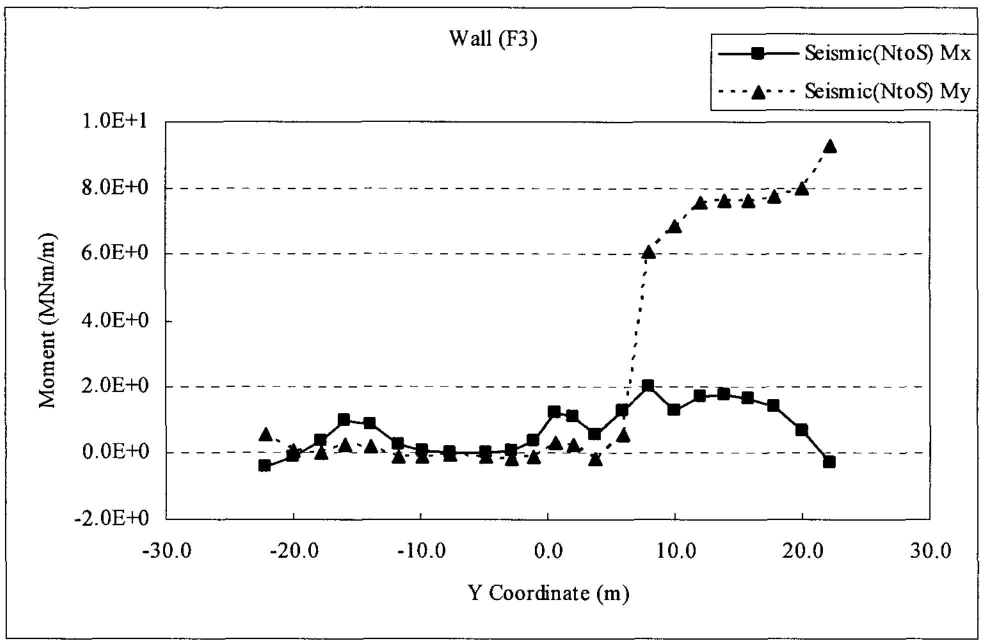


Figure 5-108 Moments at F3 Wall for Seismic Load (N to S)

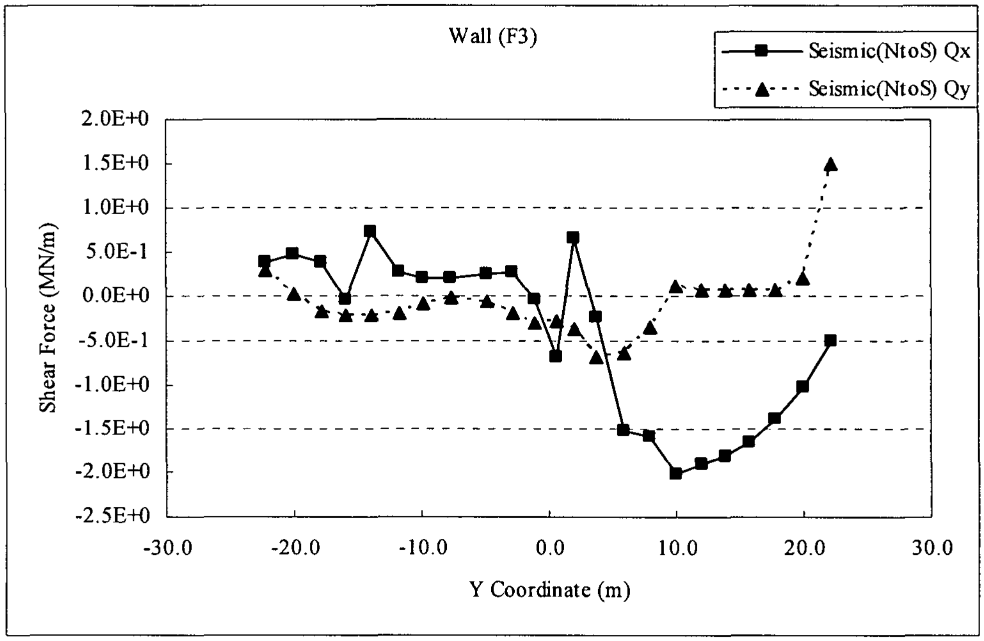


Figure 5-109 Shear Forces at F3 Wall for Seismic Load (N to S)

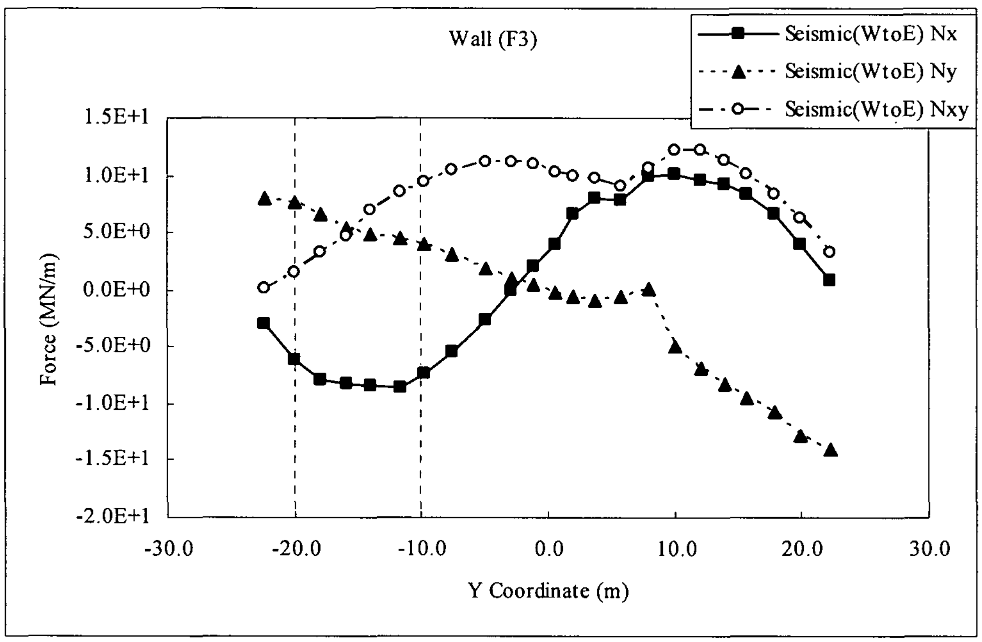


Figure 5-110 Axial Forces at F3 Wall for Seismic Load (W to E)

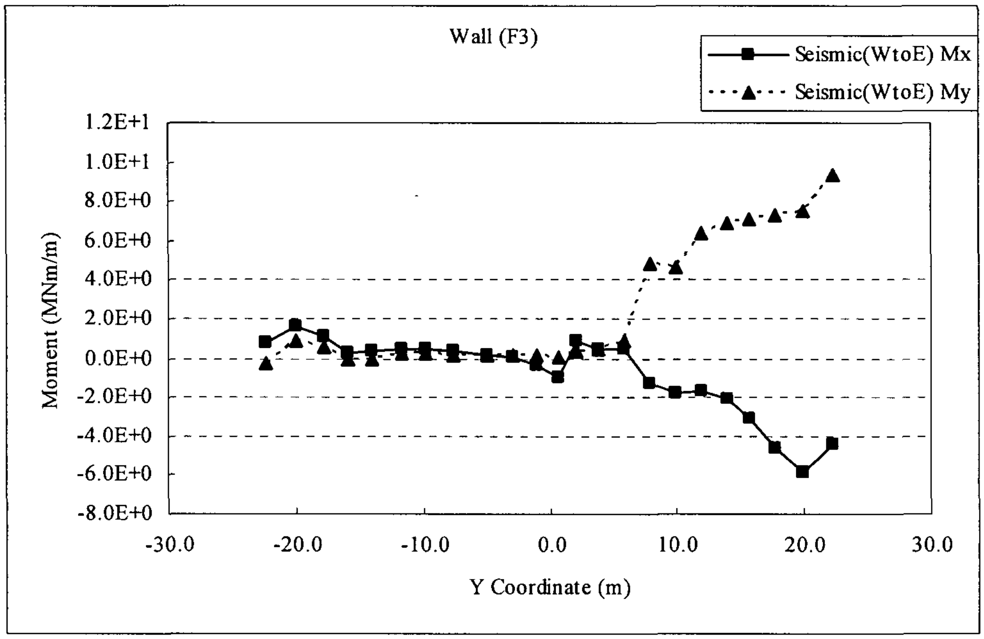


Figure 5-111 Moments at F3 Wall for Seismic Load (W to E)

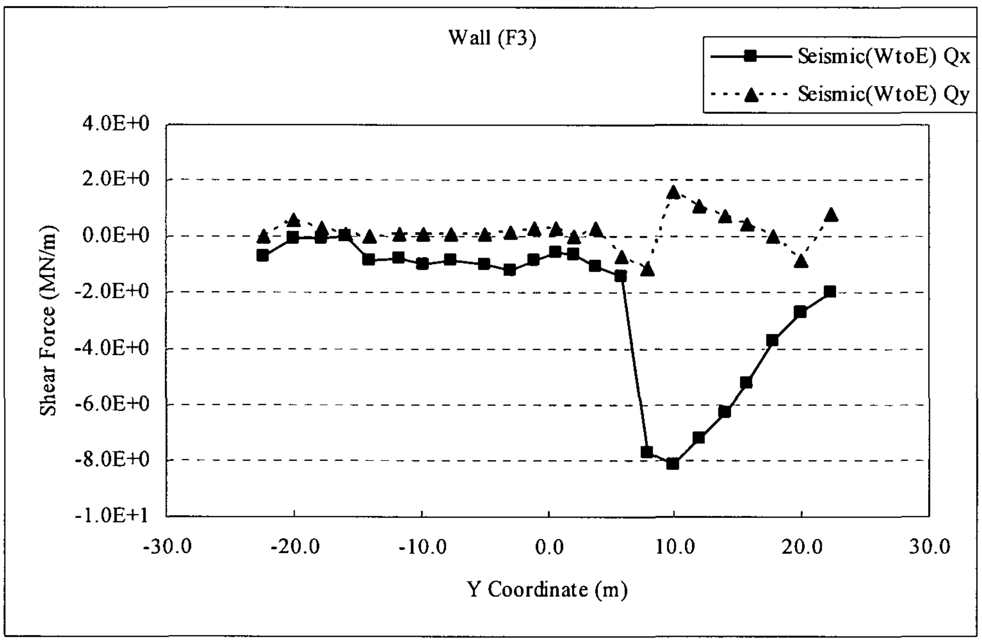


Figure 5-112 Shear Forces at F3 Wall for Seismic Load (W to E)

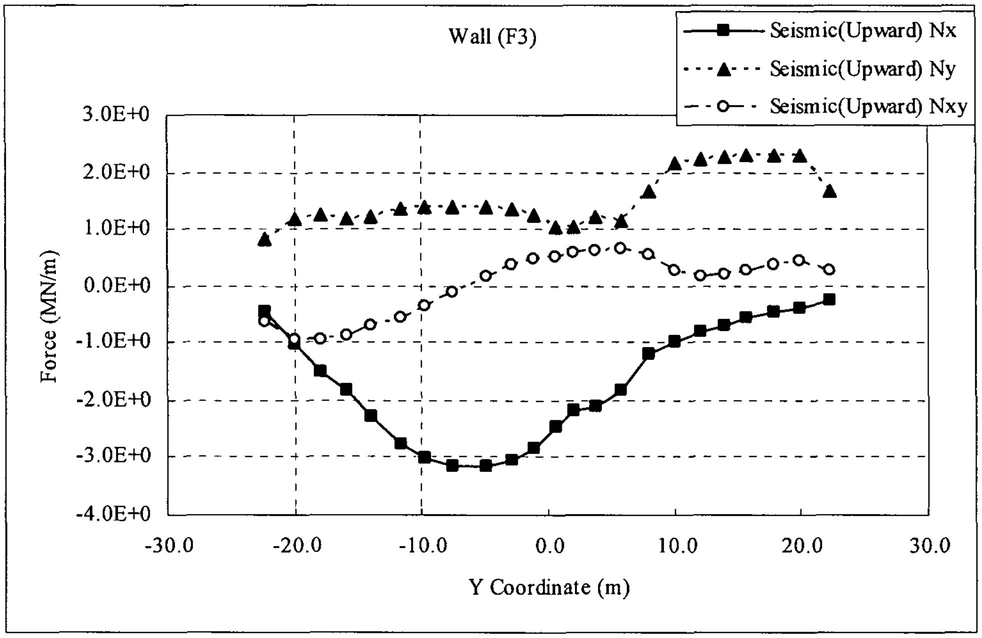


Figure 5-113 Axial Forces at F3 Wall for Seismic Load (Vertical; Upward)

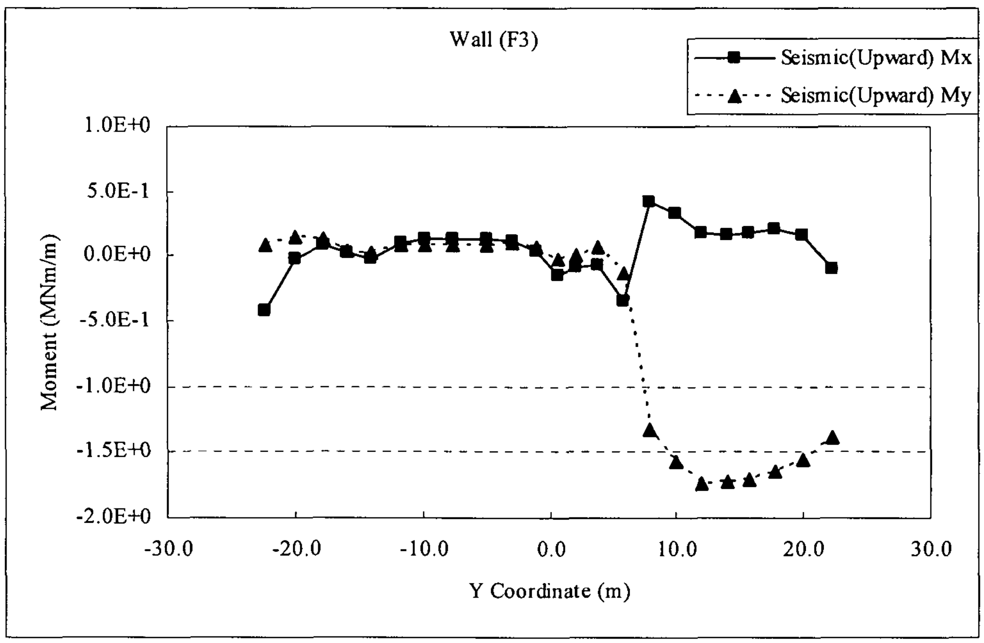


Figure 5-114 Moments at F3 Wall for Seismic Load (Vertical; Upward)

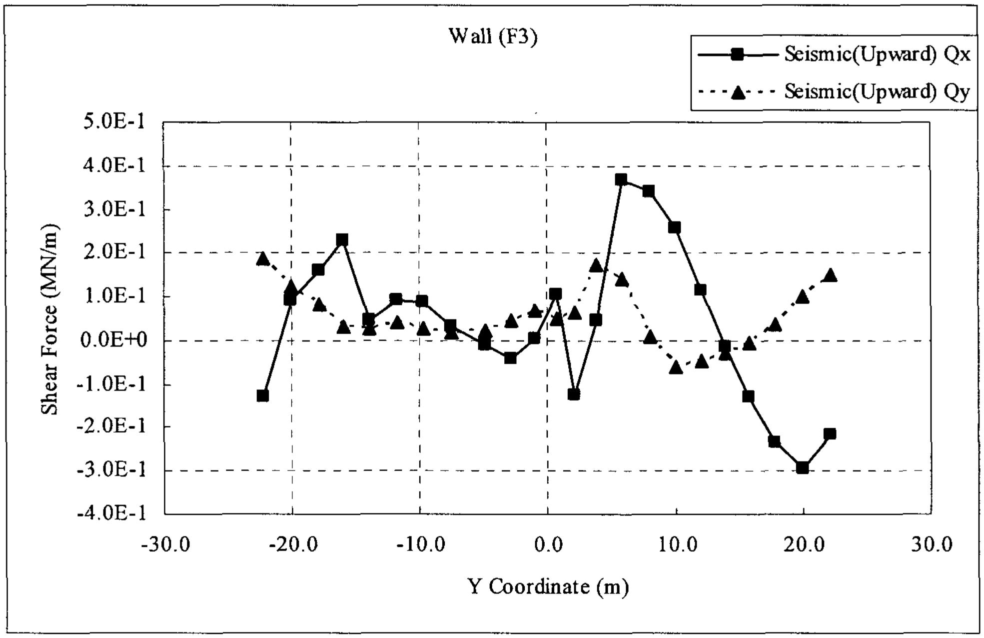


Figure 5-115 Shear Forces at F3 Wall for Seismic Load (Vertical; Upward)

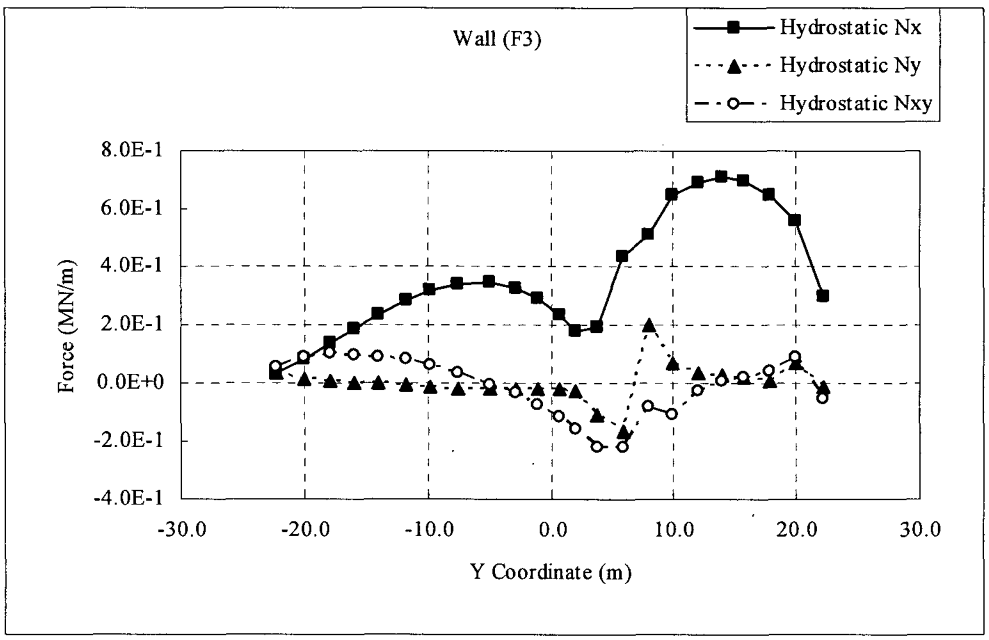


Figure 5-116 Axial Forces at F3 Wall for Hydrostatic Load

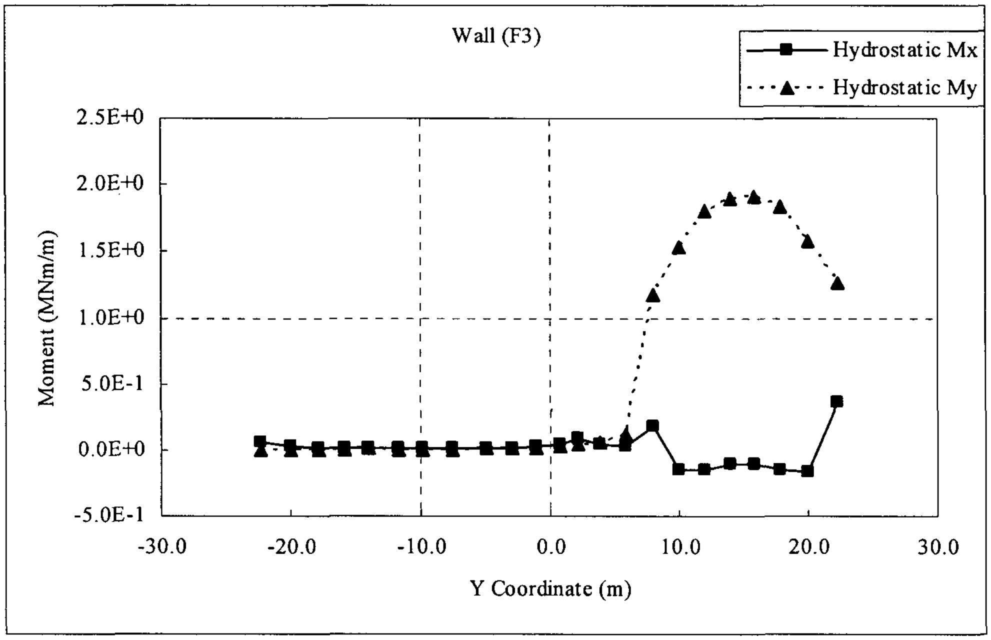


Figure 5-117 Moments at F3 Wall for Hydrostatic Load

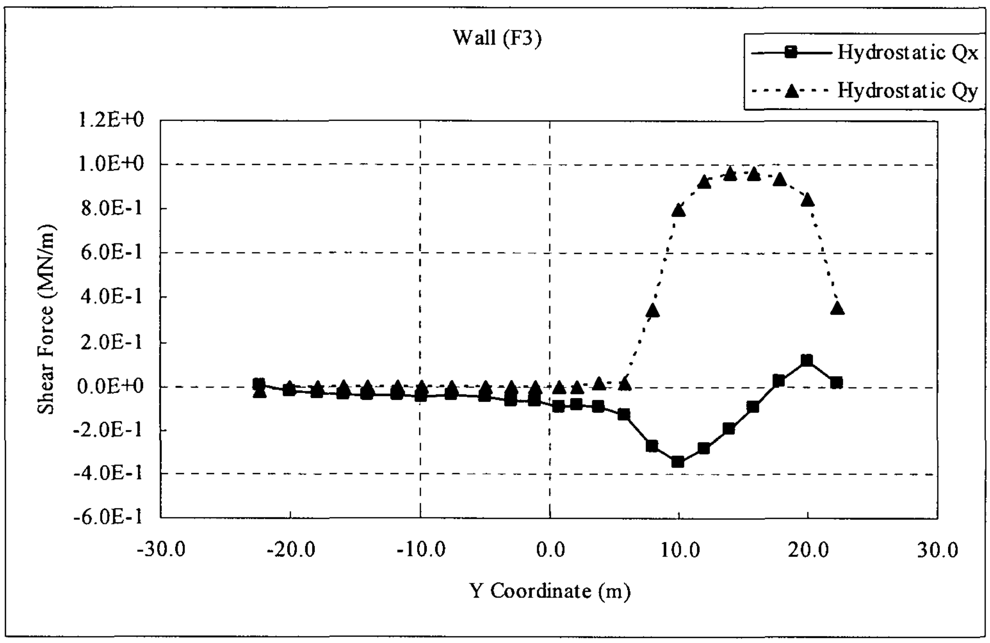


Figure 5-118 Shear Forces at F3 Wall for Hydrostatic Load

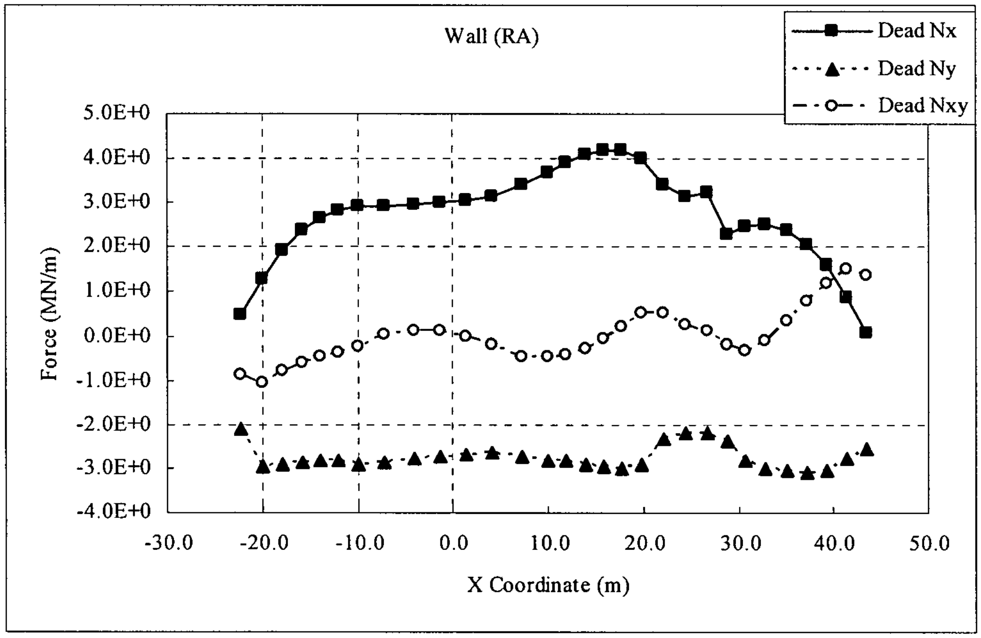


Figure 5-119 Axial Forces at RA Wall for Dead Load

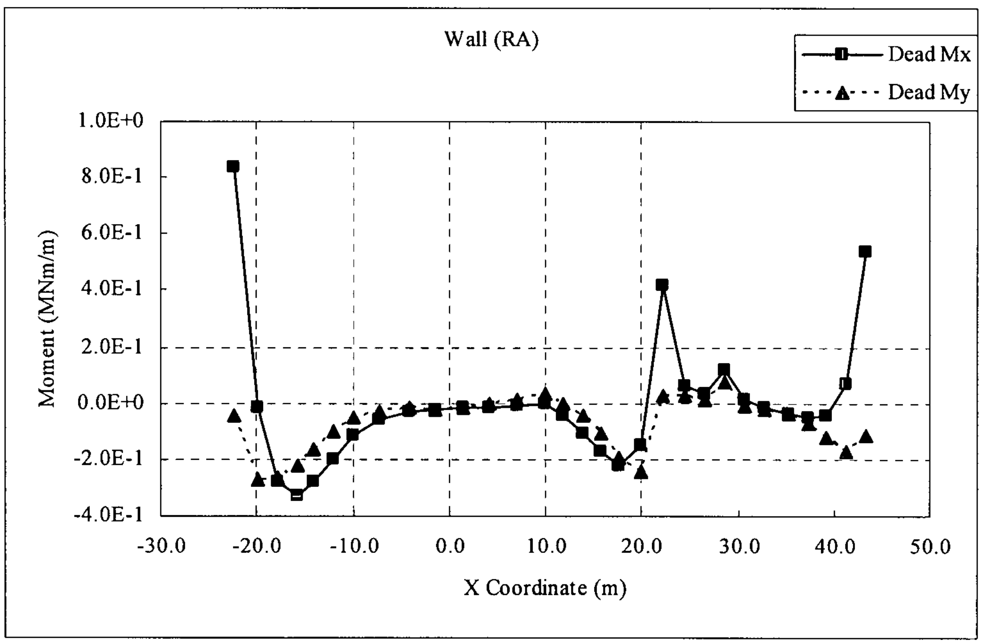


Figure 5-120 Moments at RA Wall for Dead Load

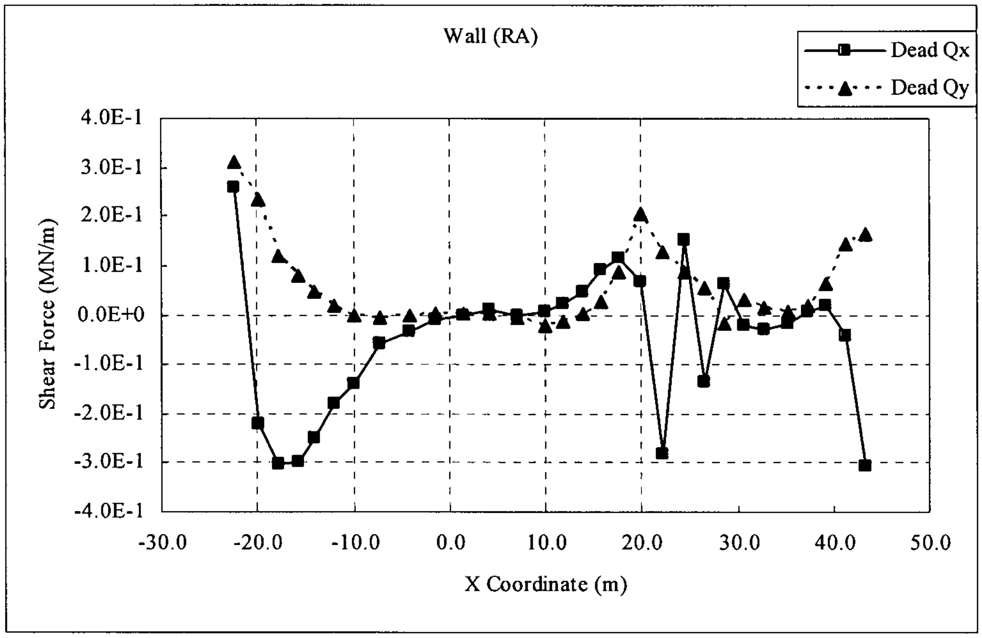


Figure 5-121 Shear Forces at RA Wall for Dead Load

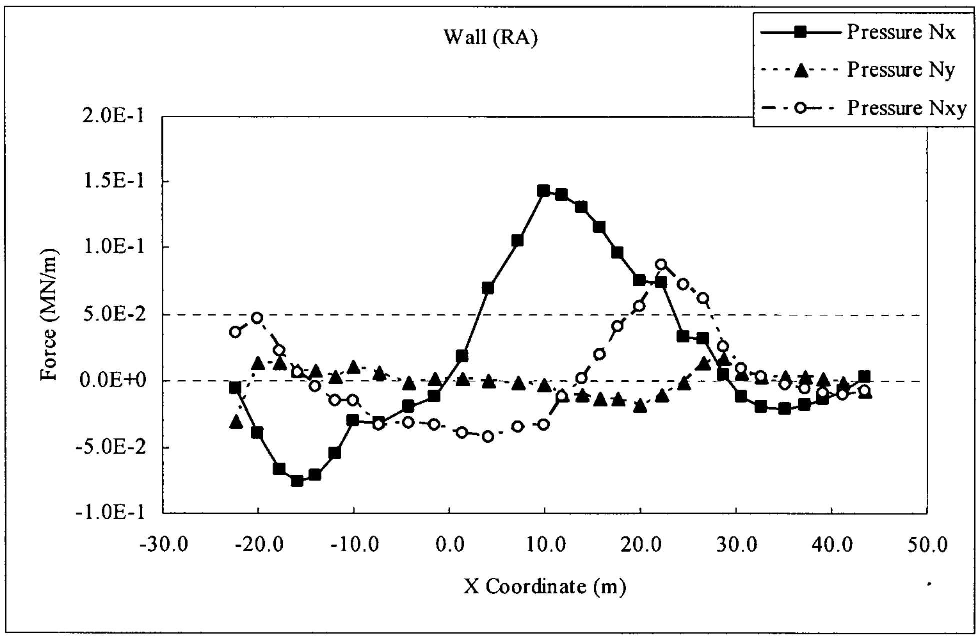


Figure 5-122 Axial Forces at RA Wall for Pressure Load

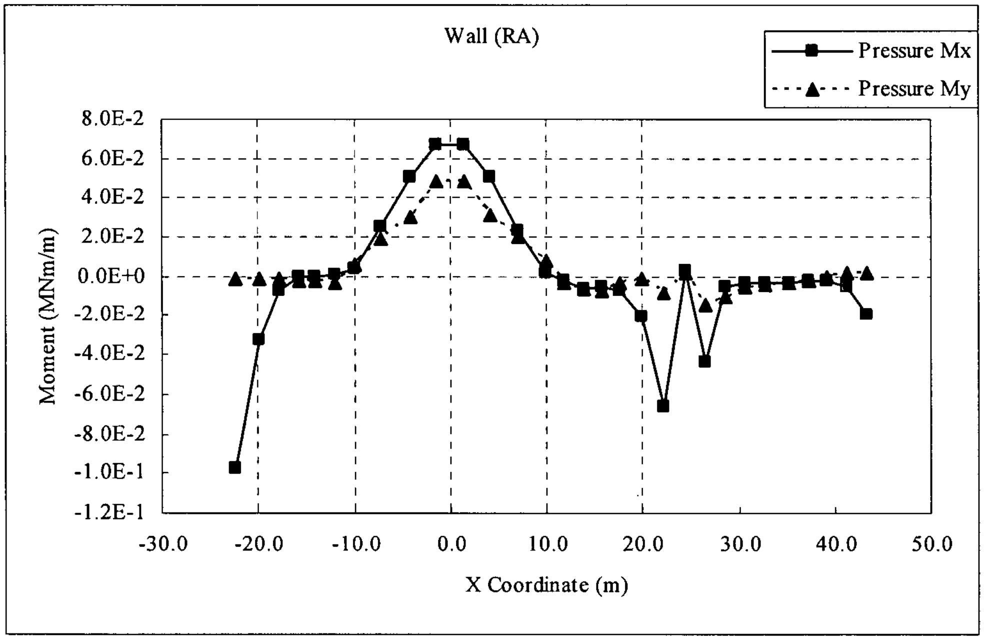


Figure 5-123 Moments at RA Wall for Pressure Load

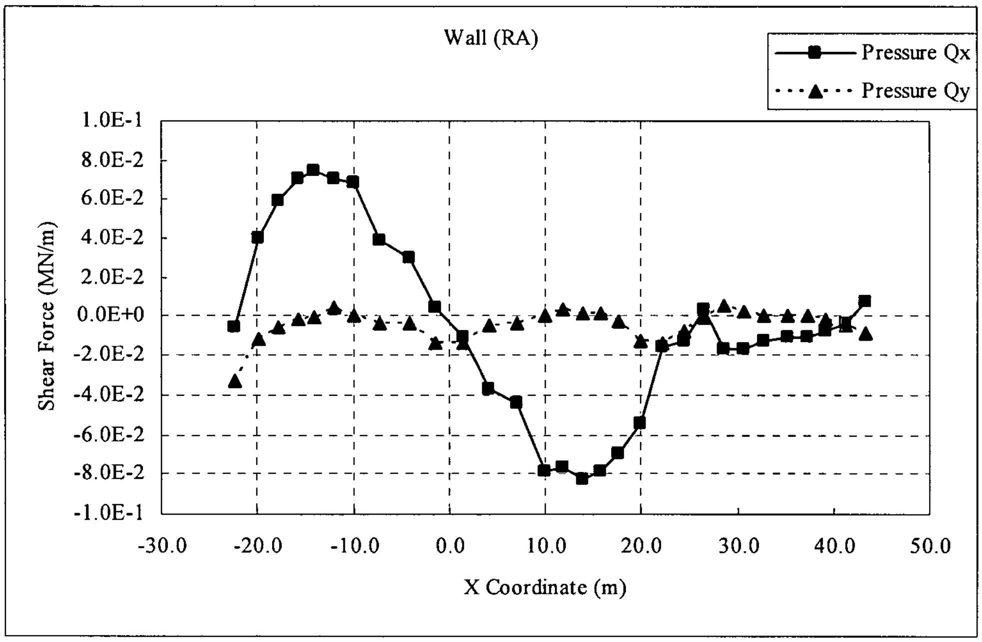


Figure 5-124 Shear Forces at RA Wall for Pressure Load

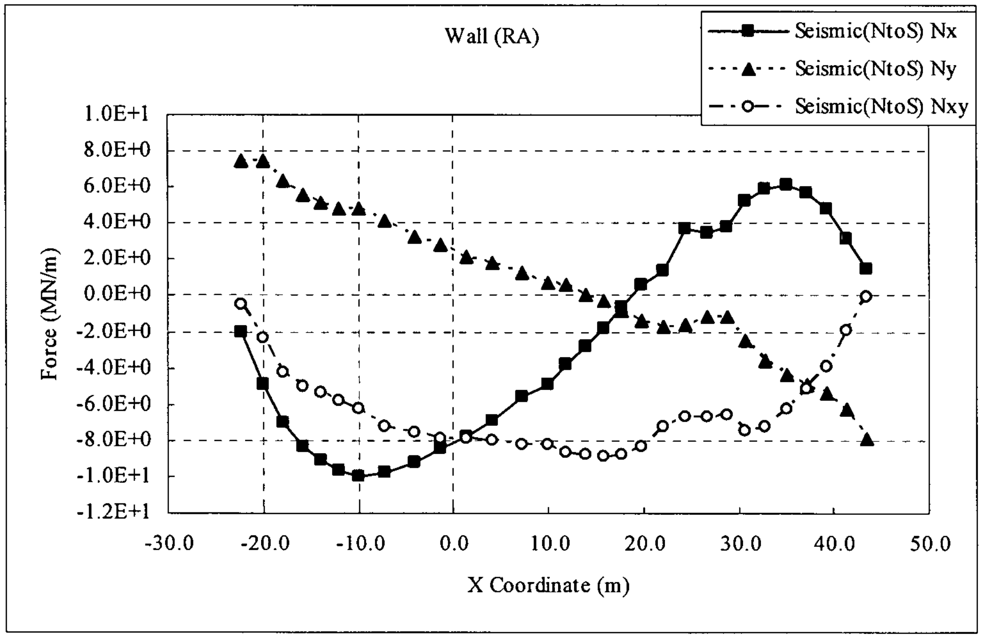


Figure 5-125 Axial Forces at RA Wall for Seismic Load (N to S)

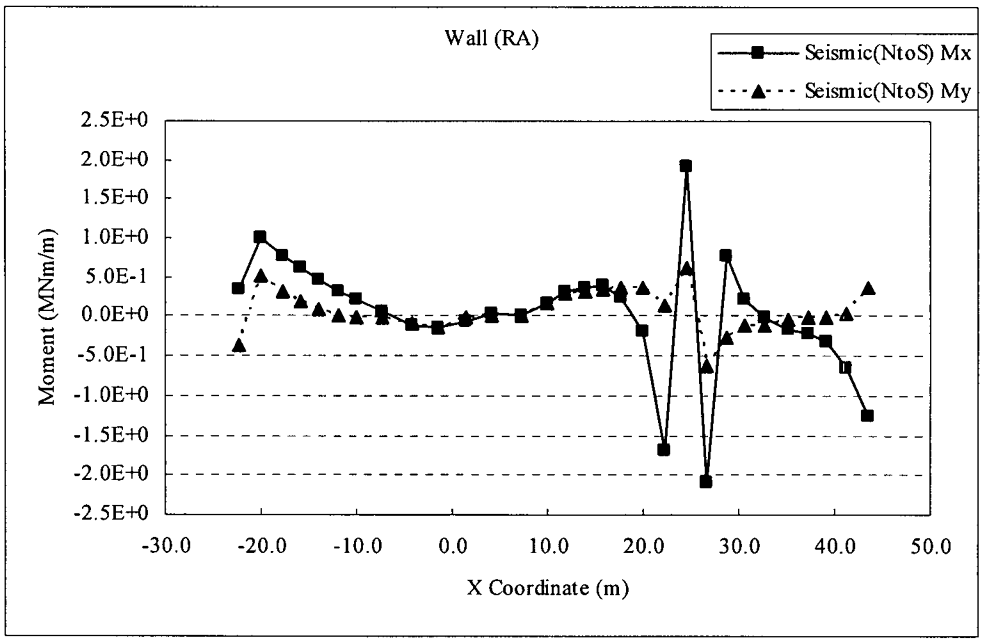


Figure 5-126 Moments at RA Wall for Seismic Load (N to S)

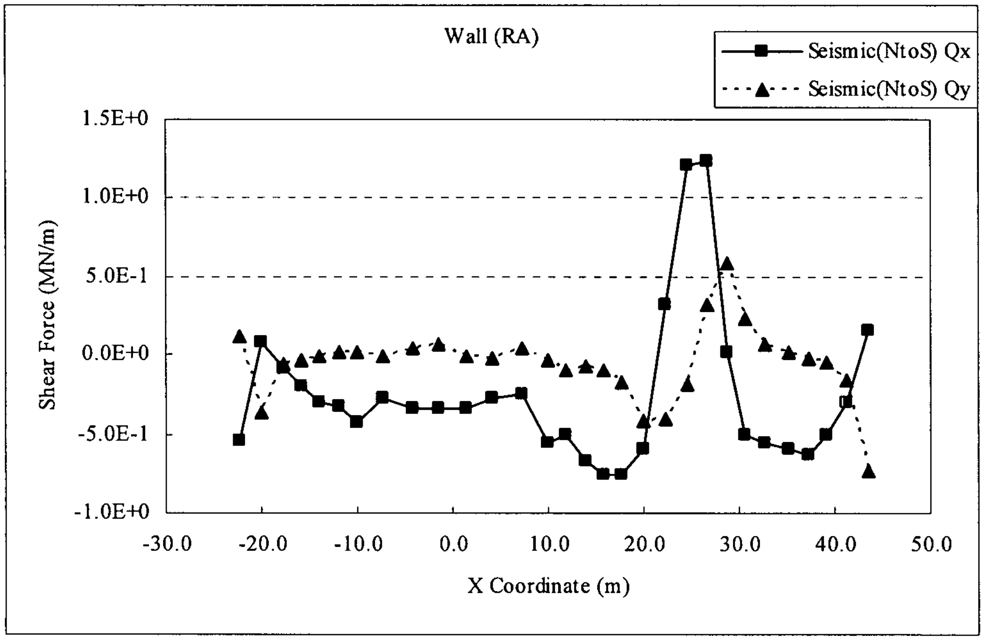


Figure 5-127 Shear Forces at RA Wall for Seismic Load (N to S)

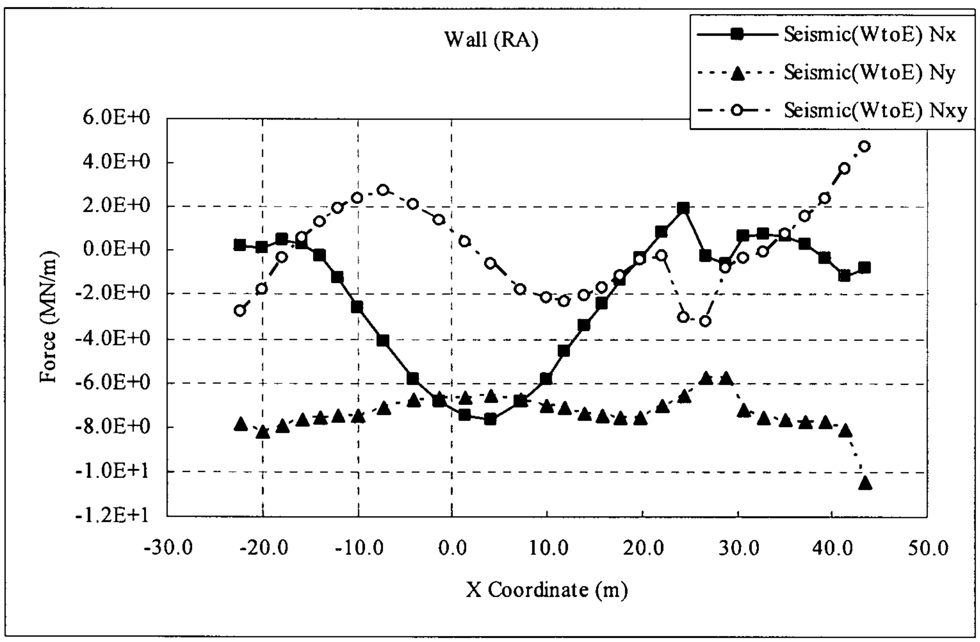


Figure 5-128 Axial Forces at RA Wall for Seismic Load (W to E)

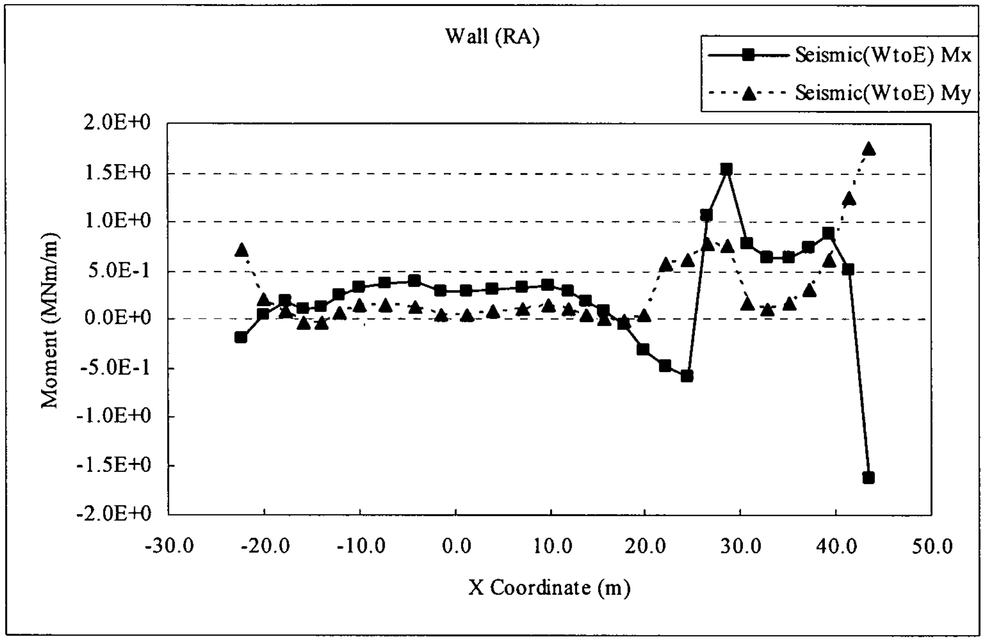


Figure 5-129 Moments at RA Wall for Seismic Load (W to E)

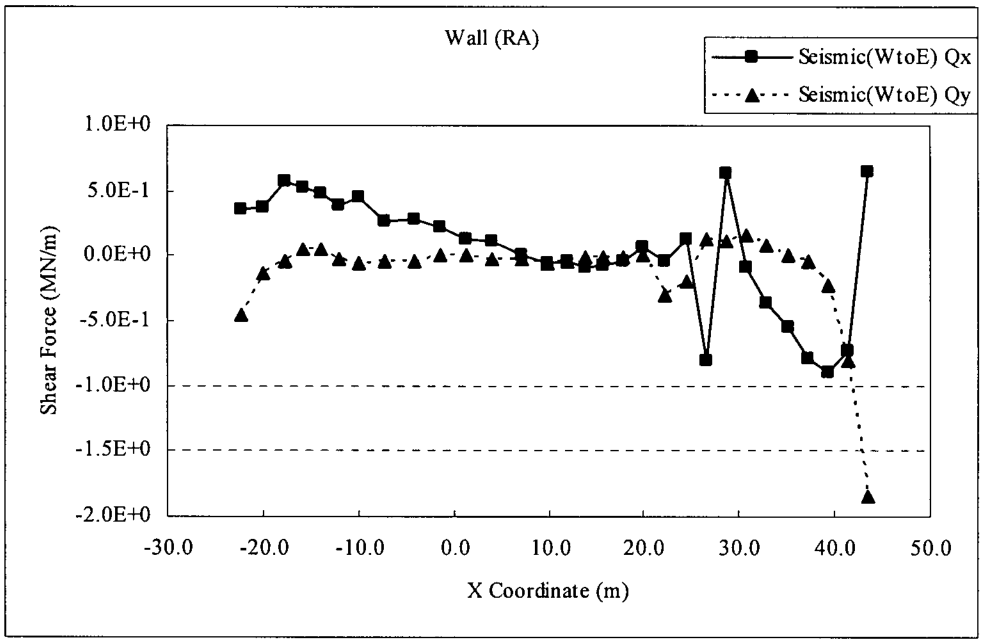


Figure 5-130 Shear Forces at RA Wall for Seismic Load (W to E)

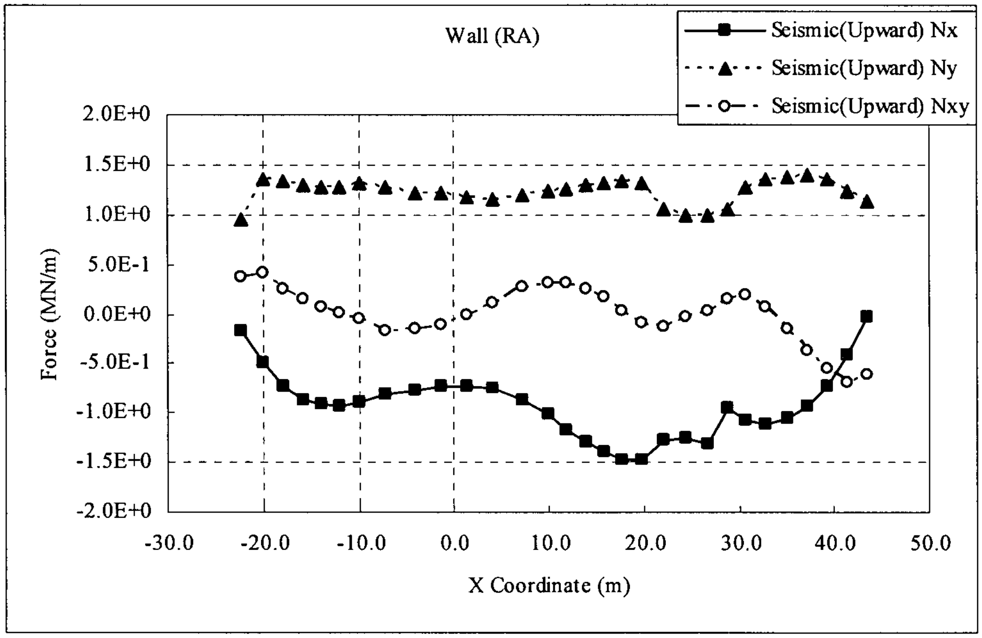


Figure 5-131 Axial Forces at RA Wall for Seismic Load (Vertical; Upward)

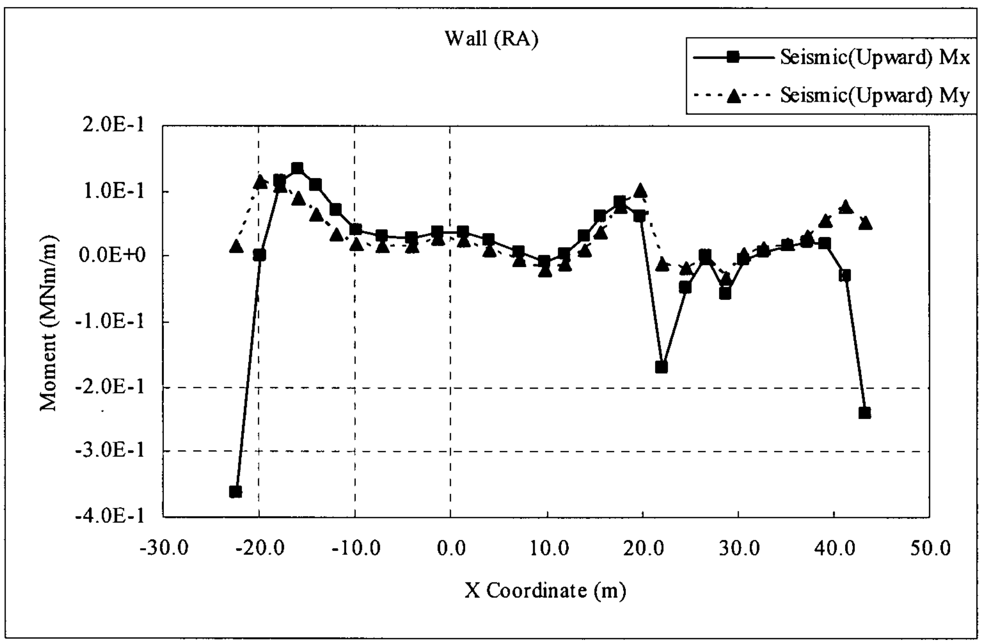


Figure 5-132 Moments at RA Wall for Seismic Load (Vertical; Upward)

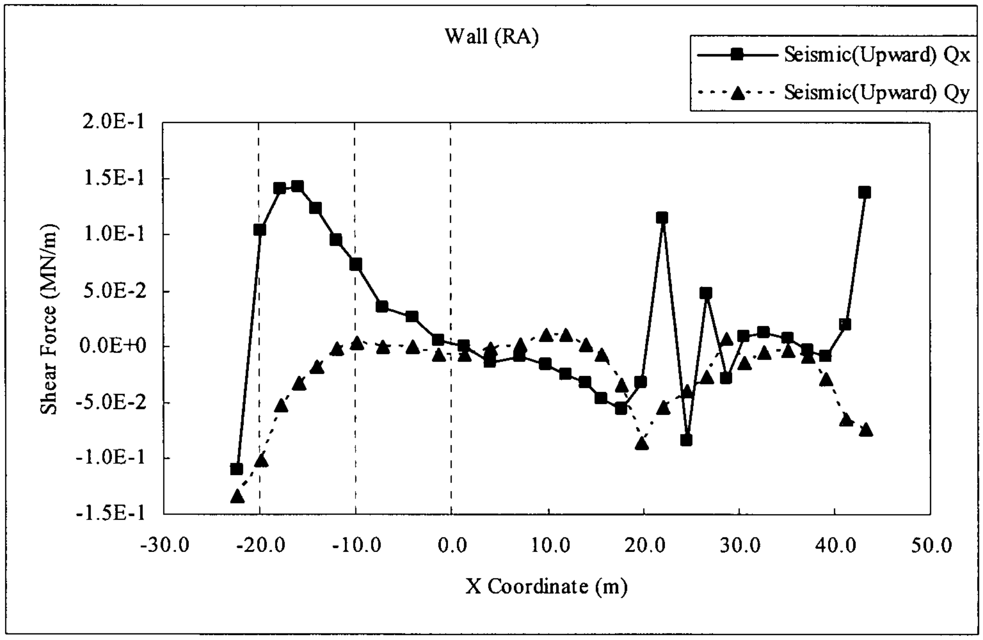


Figure 5-133 Shear Forces at RA Wall for Seismic Load (Vertical; Upward)

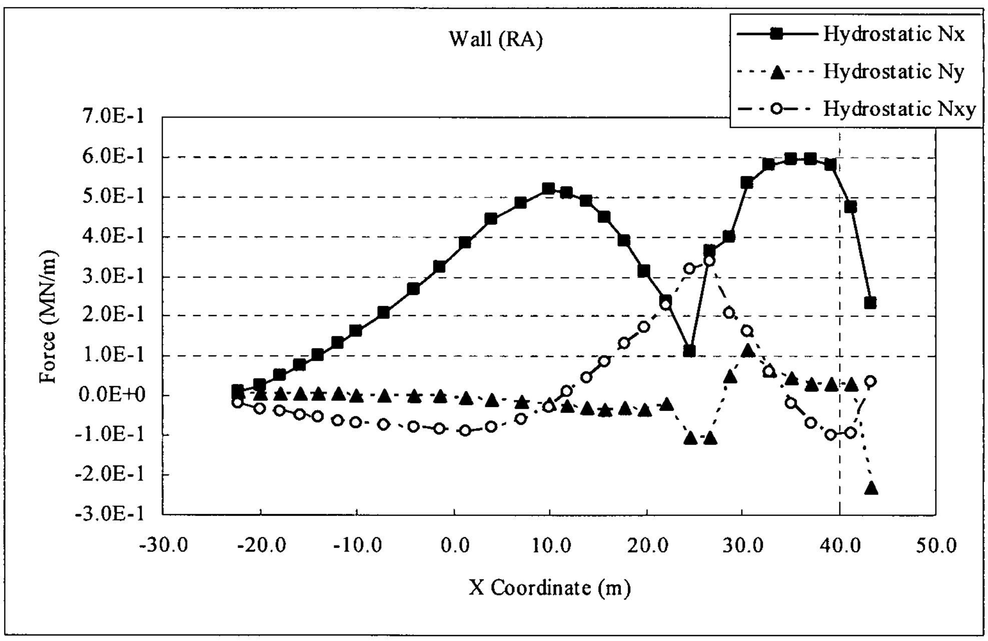


Figure 5-134 Axial Forces at RA Wall for Hydrostatic Load

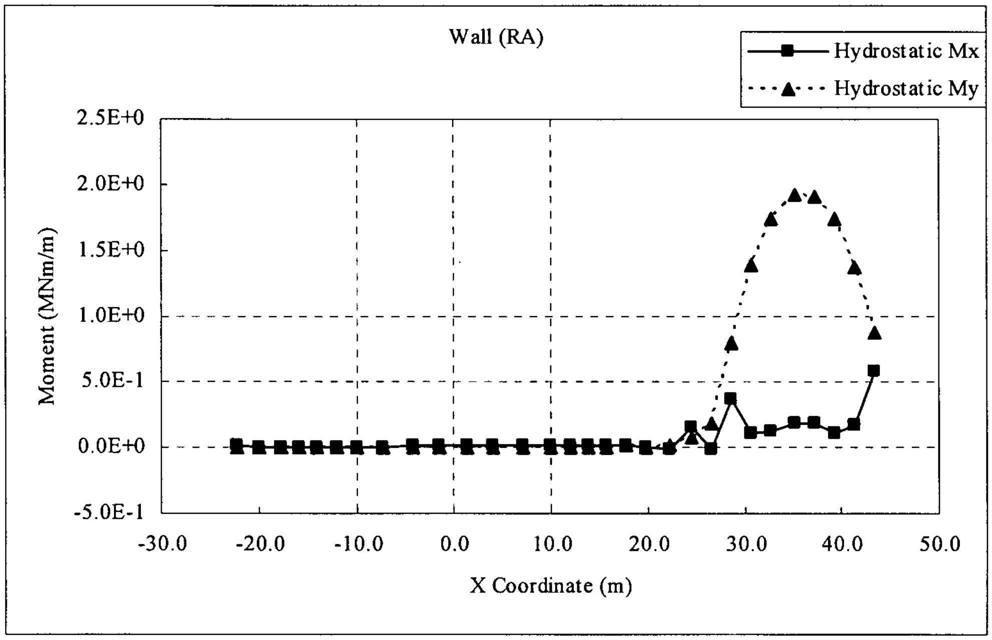


Figure 5-135 Moments at RA Wall for Hydrostatic Load

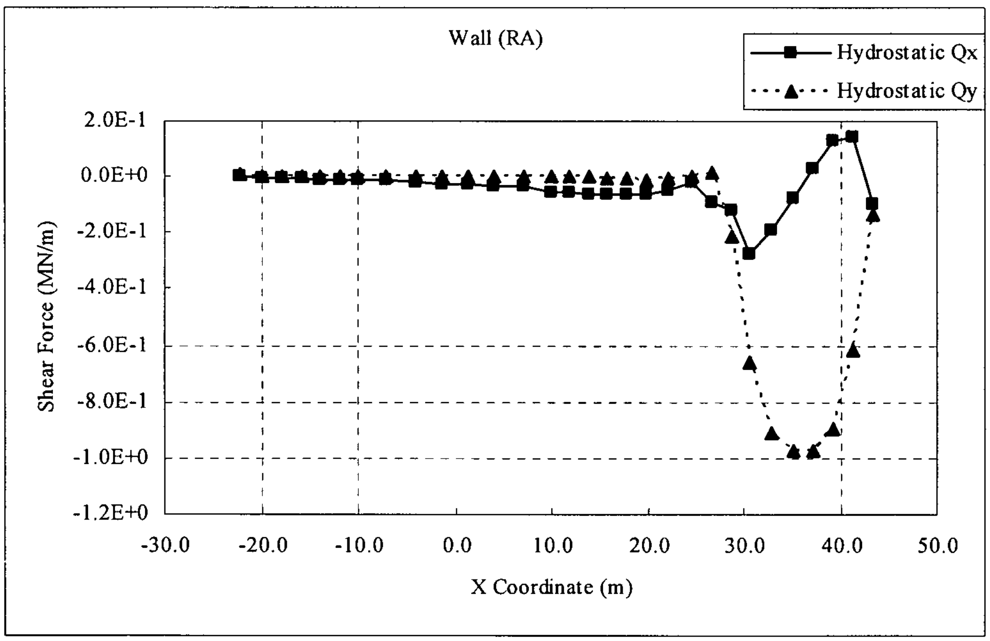


Figure 5-136 Shear Forces at RA Wall for Hydrostatic Load

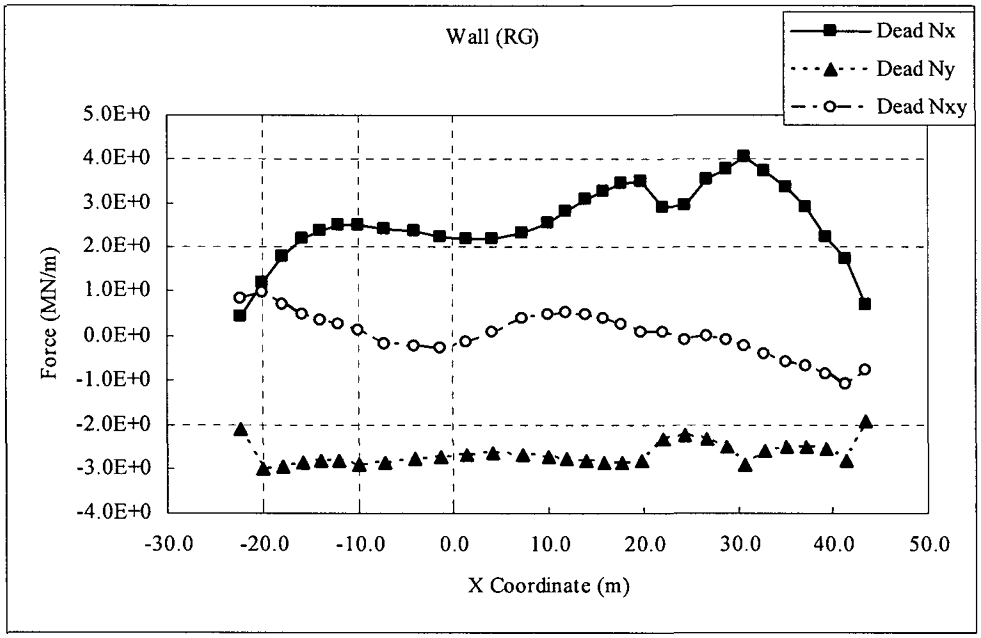


Figure 5-137 Axial Forces at RG Wall for Dead Load

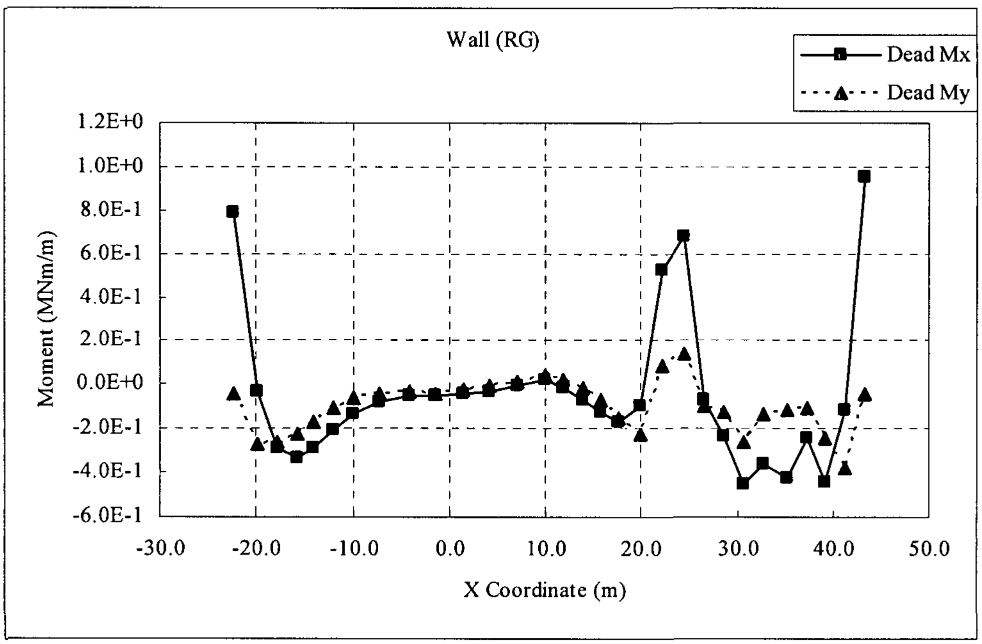


Figure 5-138 Moments at RG Wall for Dead Load

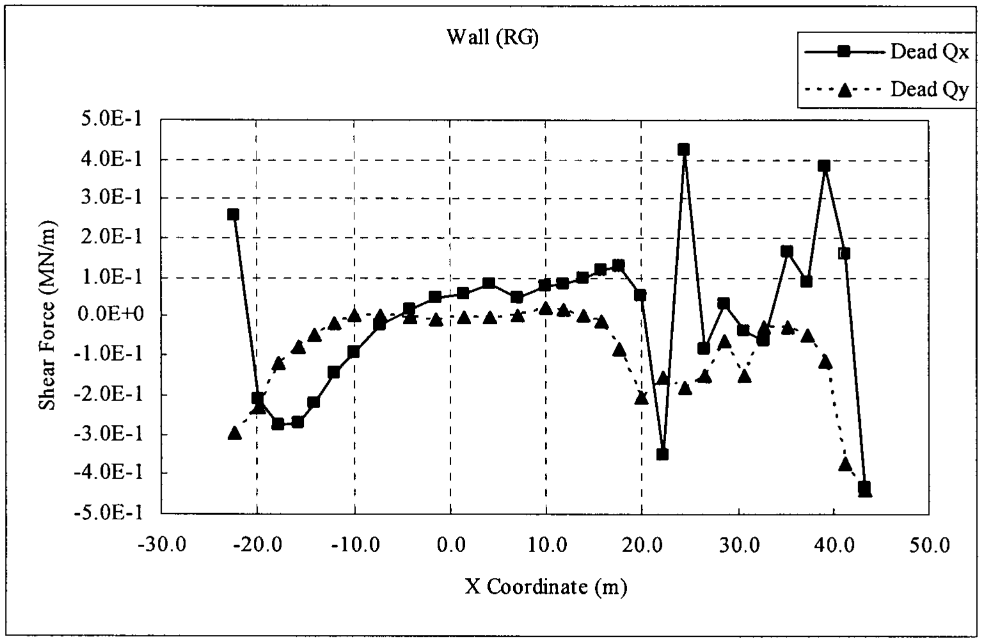


Figure 5-139 Shear Forces at RG Wall for Dead Load

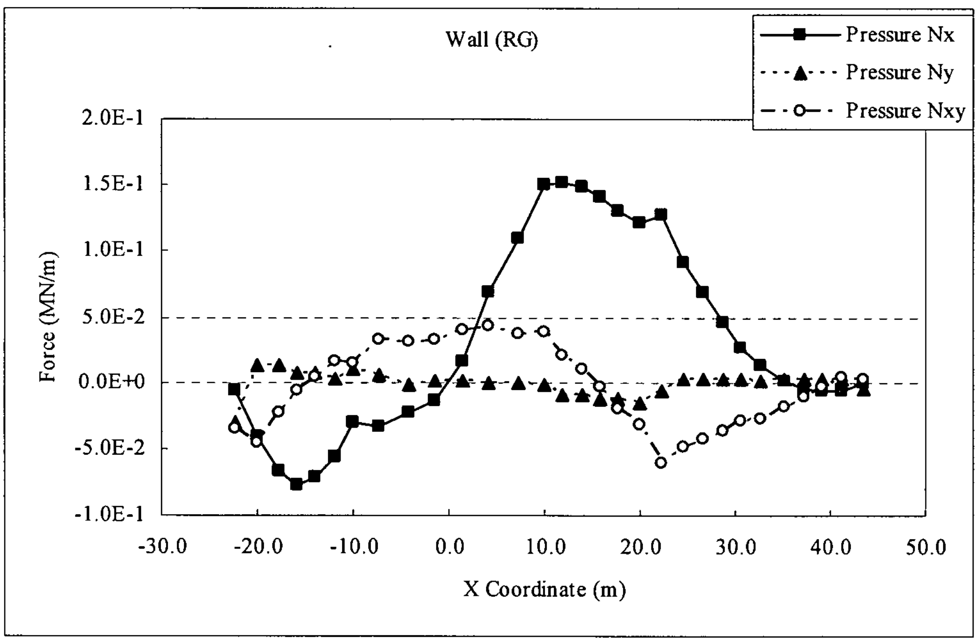


Figure 5-140 Axial Forces at RG Wall for Pressure Load

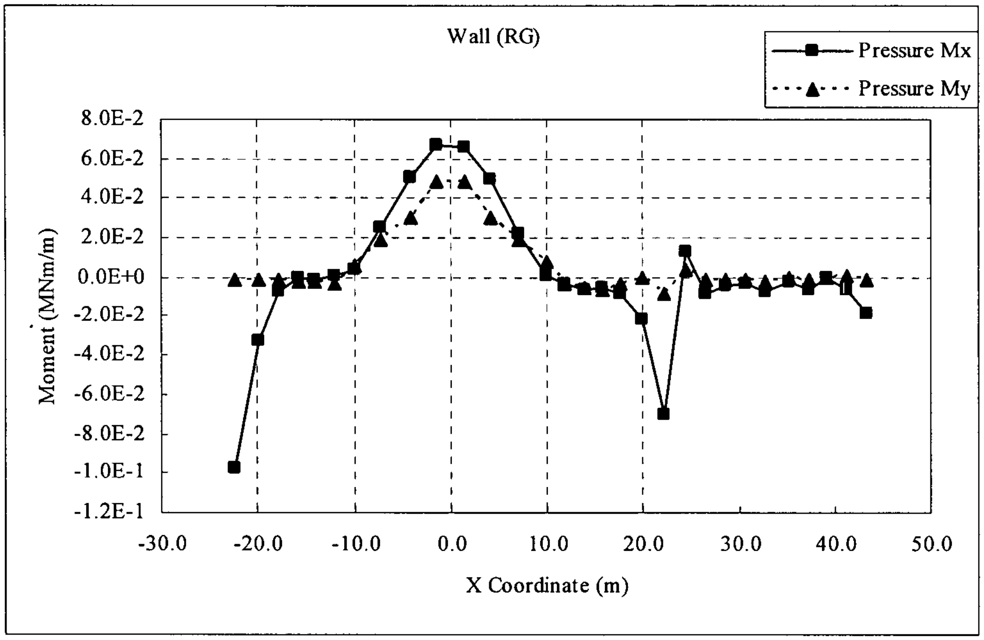


Figure 5-141 Moments at RG Wall for Pressure Load

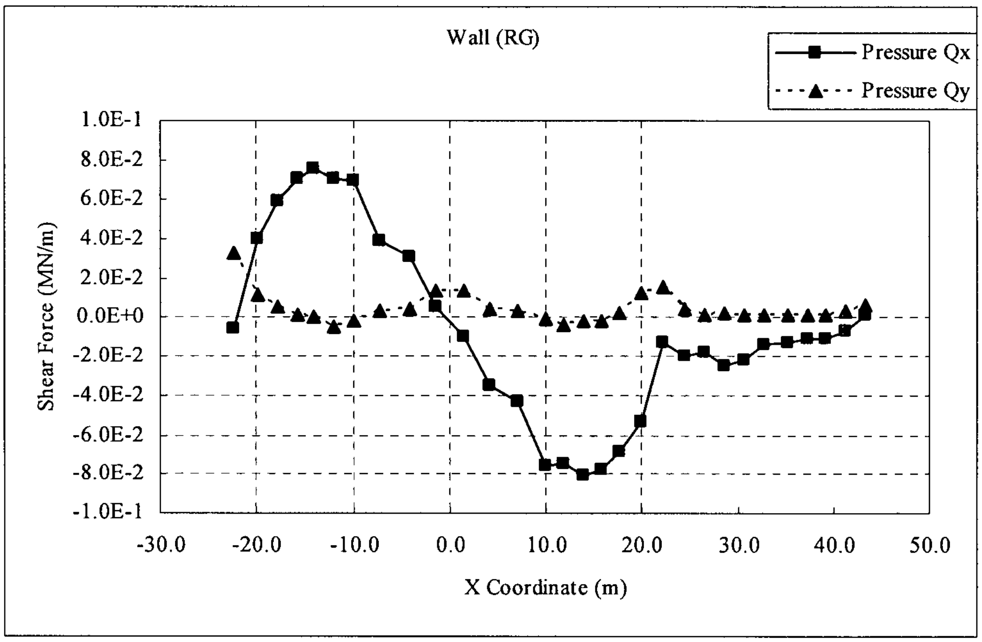


Figure 5-142 Shear Forces at RG Wall for Pressure Load

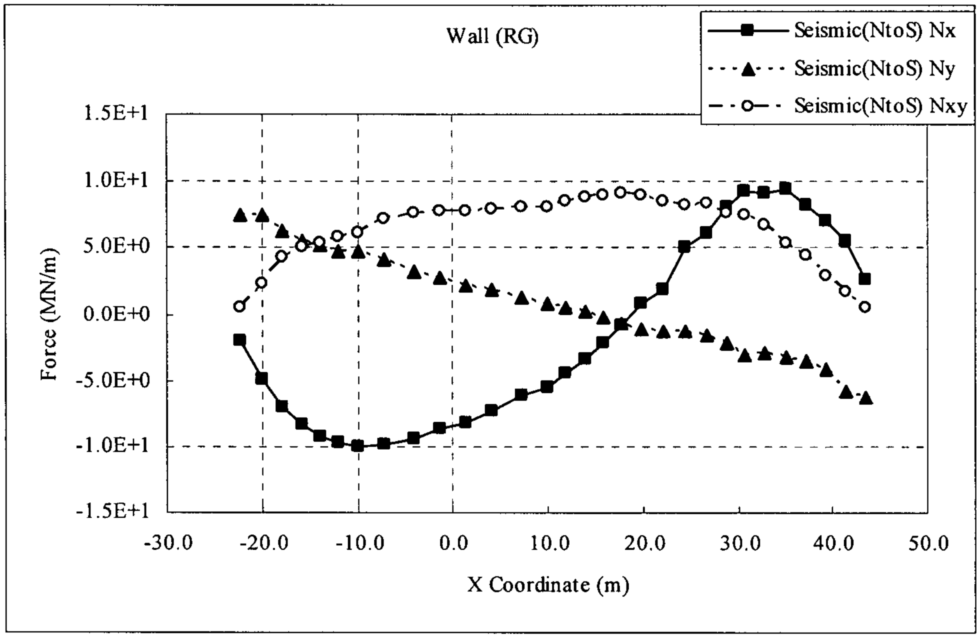


Figure 5-143 Axial Forces at RG Wall for Seismic Load (N to S)

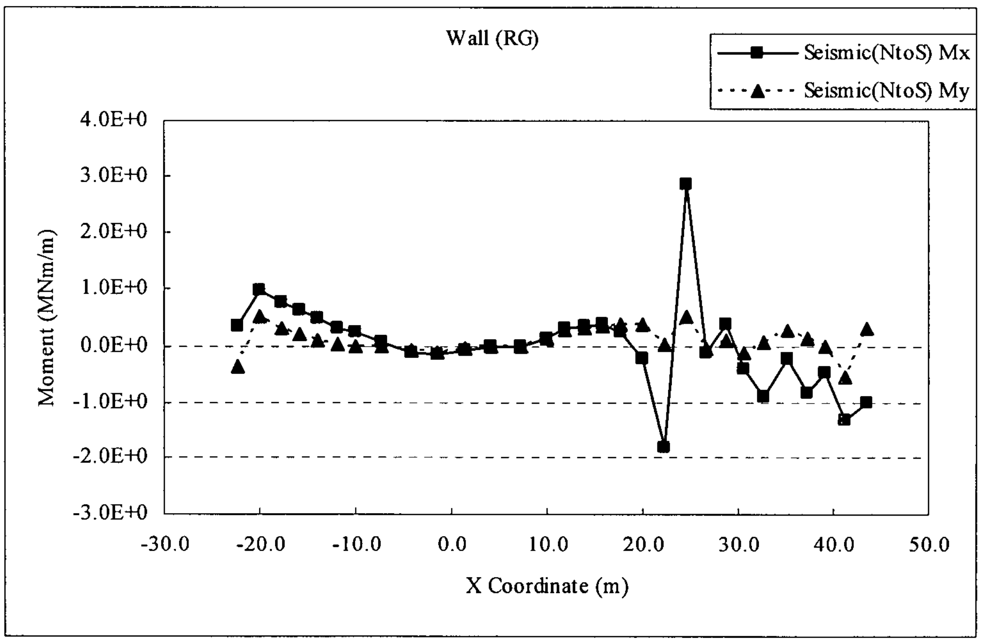


Figure 5-144 Moments at RG Wall for Seismic Load (N to S)

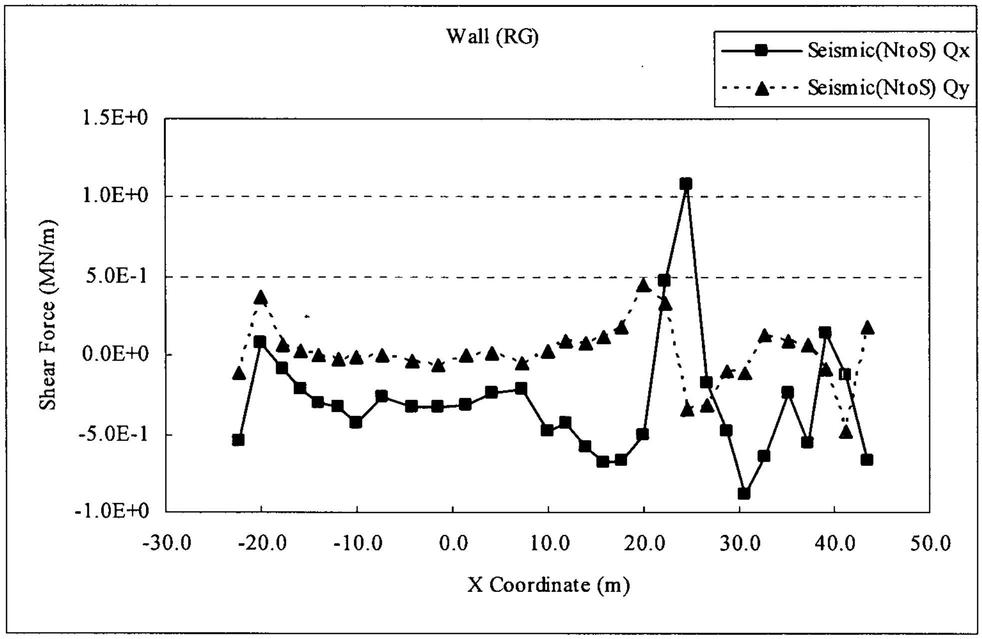


Figure 5-145 Shear Forces at RG Wall for Seismic Load (N to S)

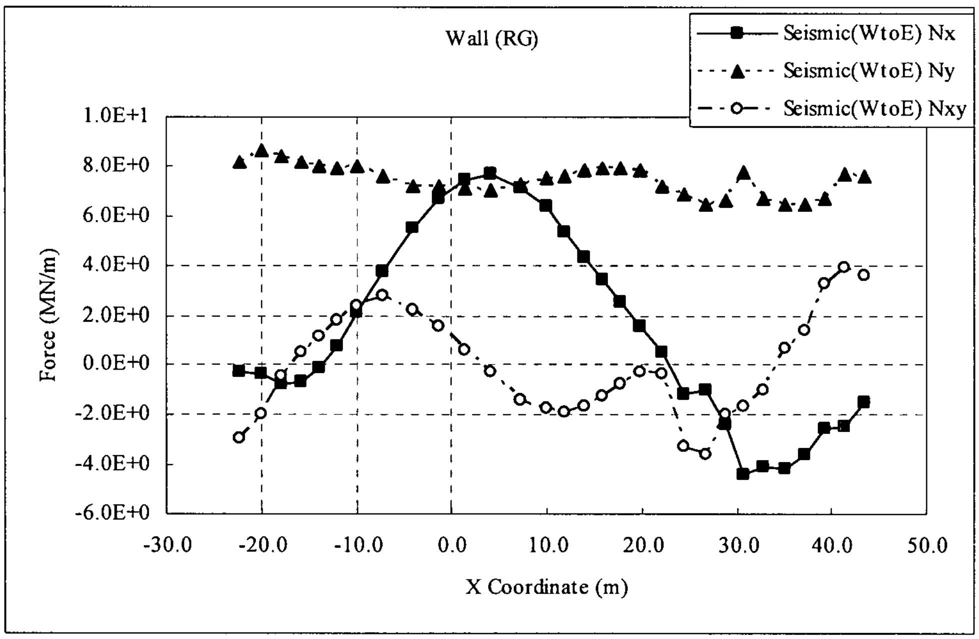


Figure 5-146 Axial Forces at RG Wall for Seismic Load (W to E)

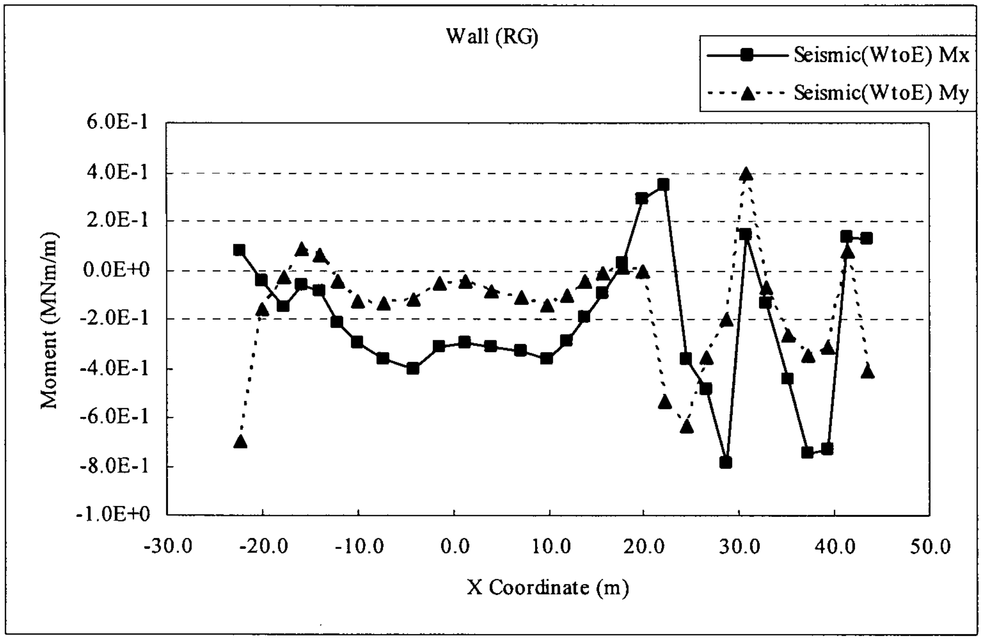


Figure 5-147 Moments at RG Wall for Seismic Load (W to E)

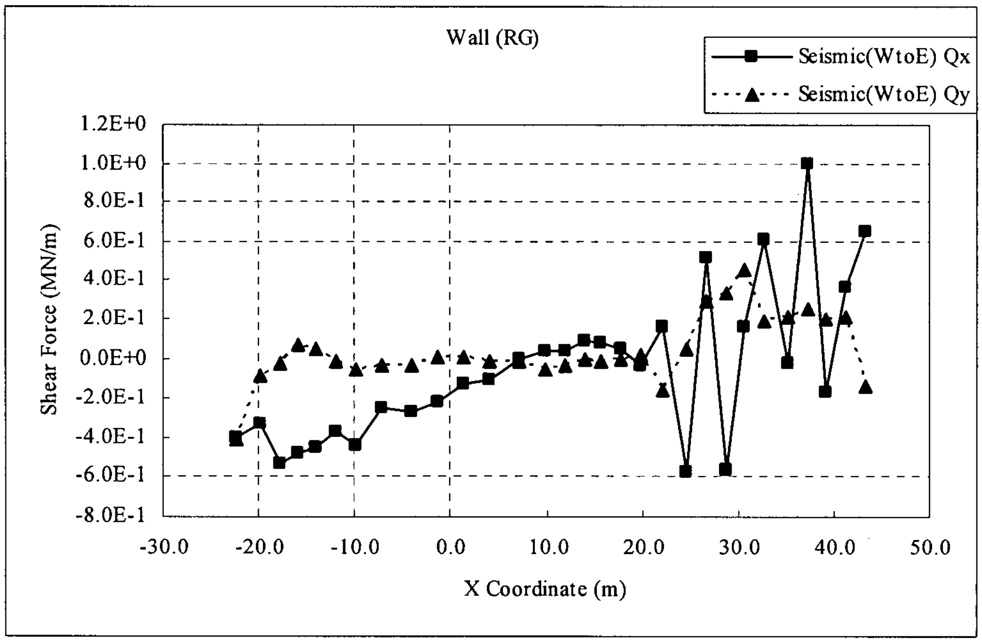


Figure 5-148 Shear Forces at RG Wall for Seismic Load (W to E)

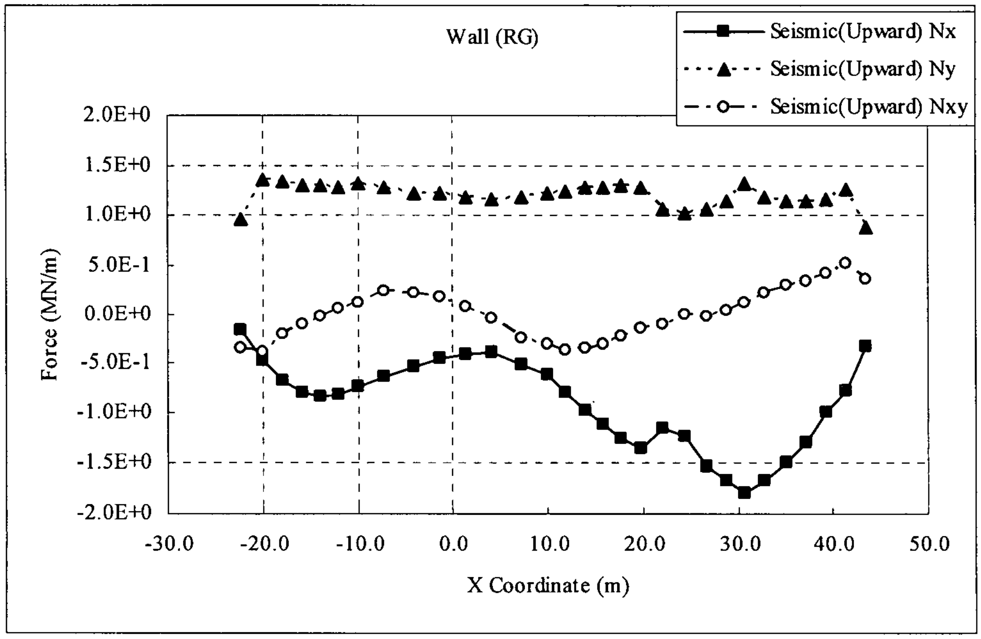


Figure 5-149 Axial Forces at RG Wall for Seismic Load (Vertical; Upward)

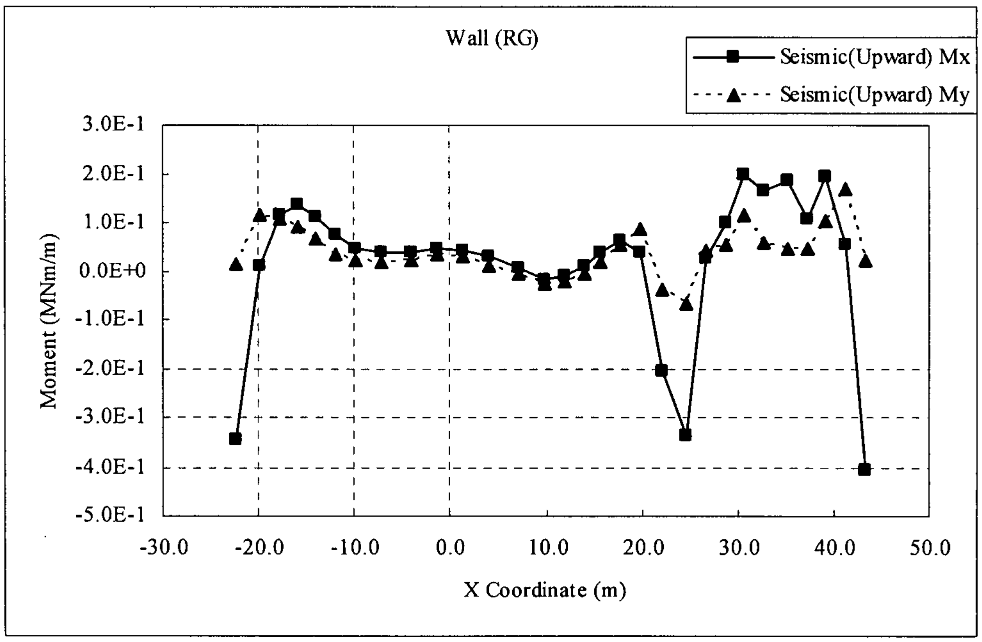


Figure 5-150 Moments at RG Wall for Seismic Load (Vertical; Upward)

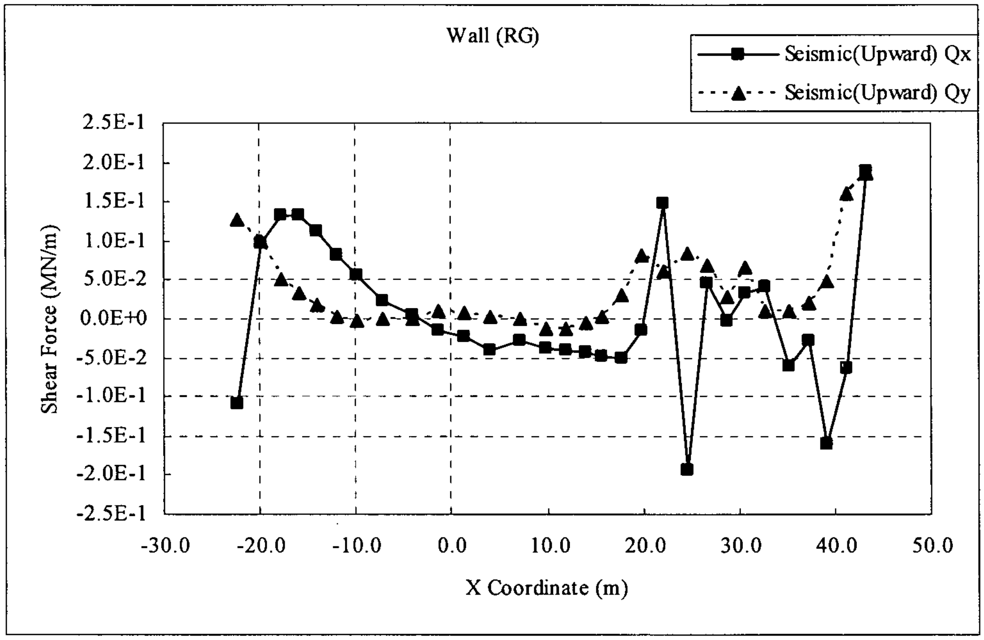


Figure 5-151 Shear Forces at RG Wall for Seismic Load (Vertical; Upward)

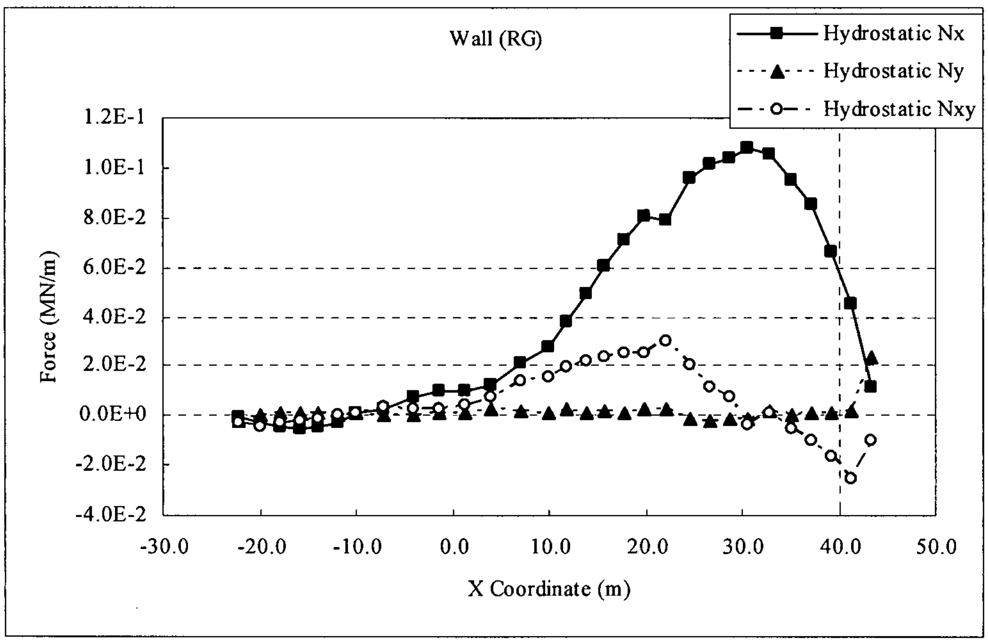


Figure 5-152 Axial Forces at RG Wall for Hydrostatic Load

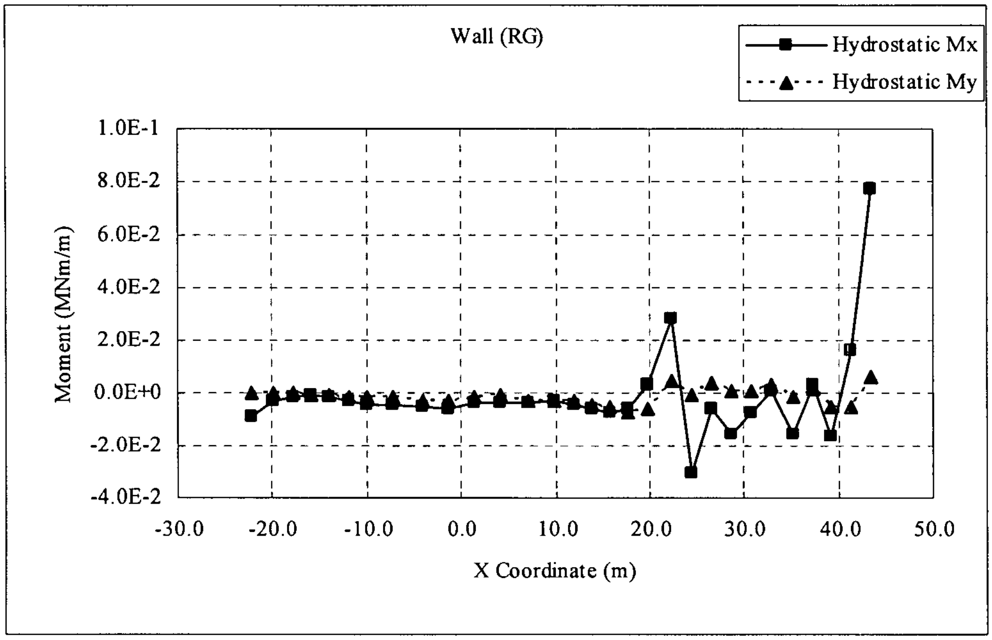


Figure 5-152 Moments at RG Wall for Hydrostatic Load

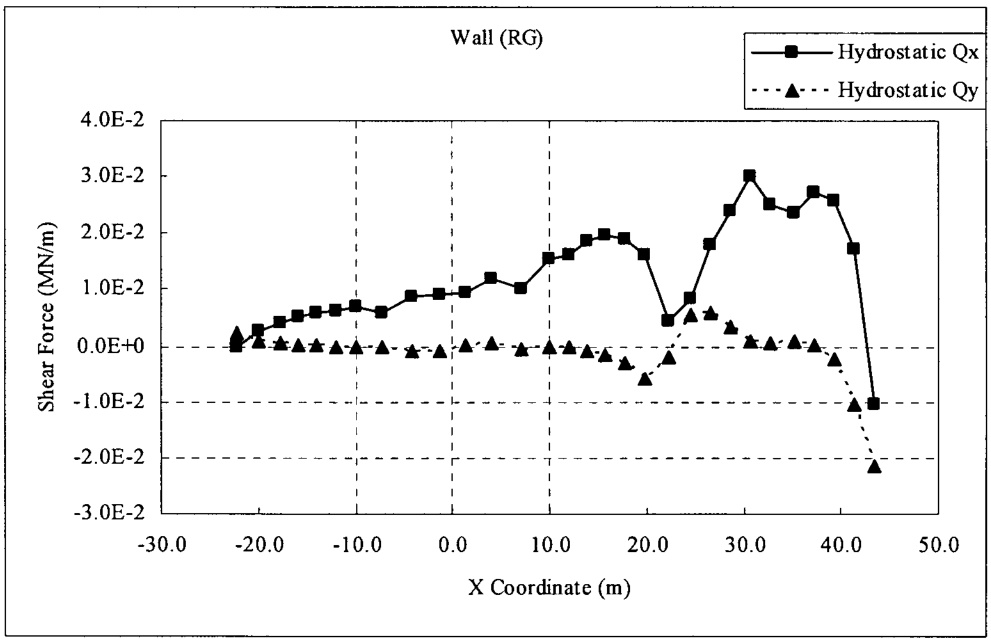


Figure 5-154 Shear Forces at RG Wall for Hydrostatic Load

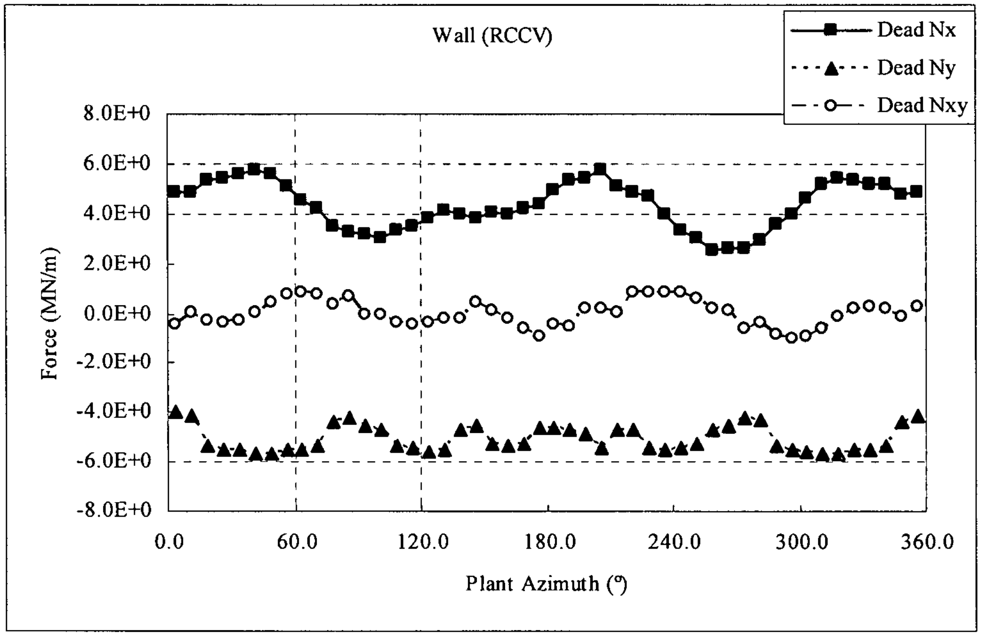


Figure 5-155 Axial Forces at Wall below RCCV for Dead Load

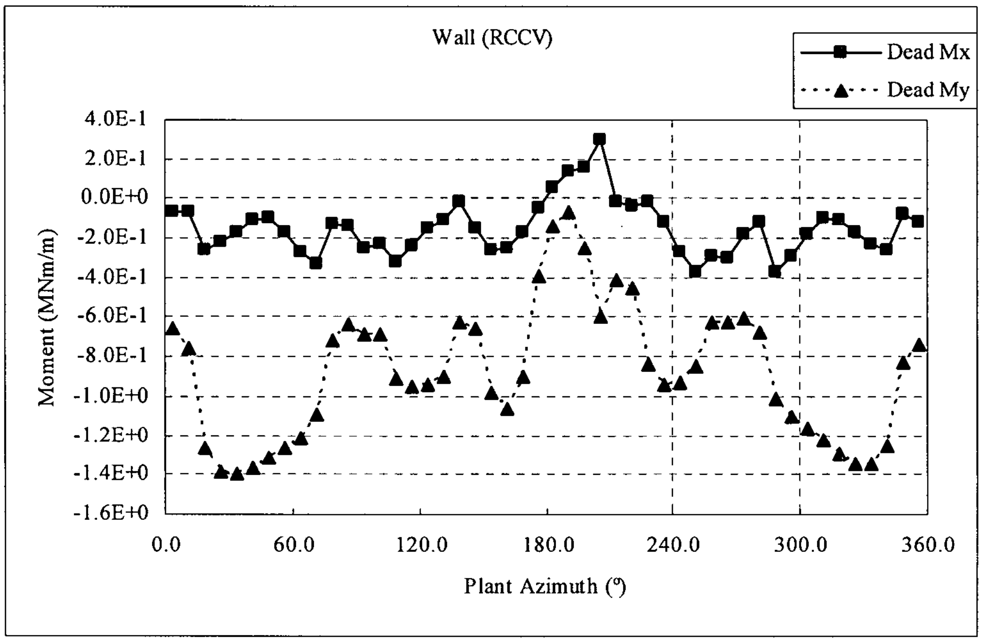


Figure 5-156 Moments at Wall below RCCV for Dead Load

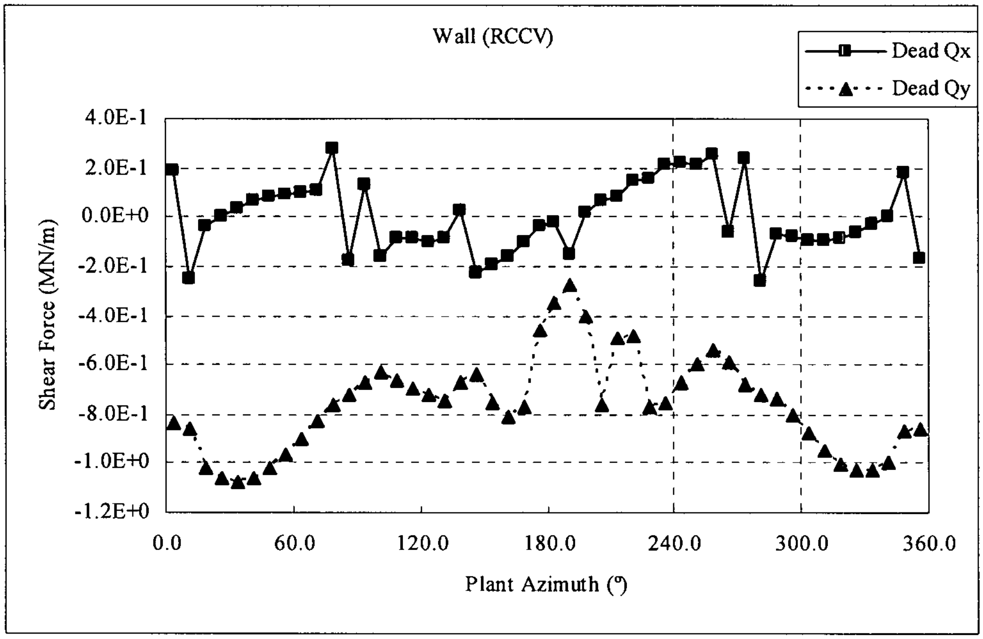


Figure 5-157 Shear Forces at Wall below RCCV for Dead Load

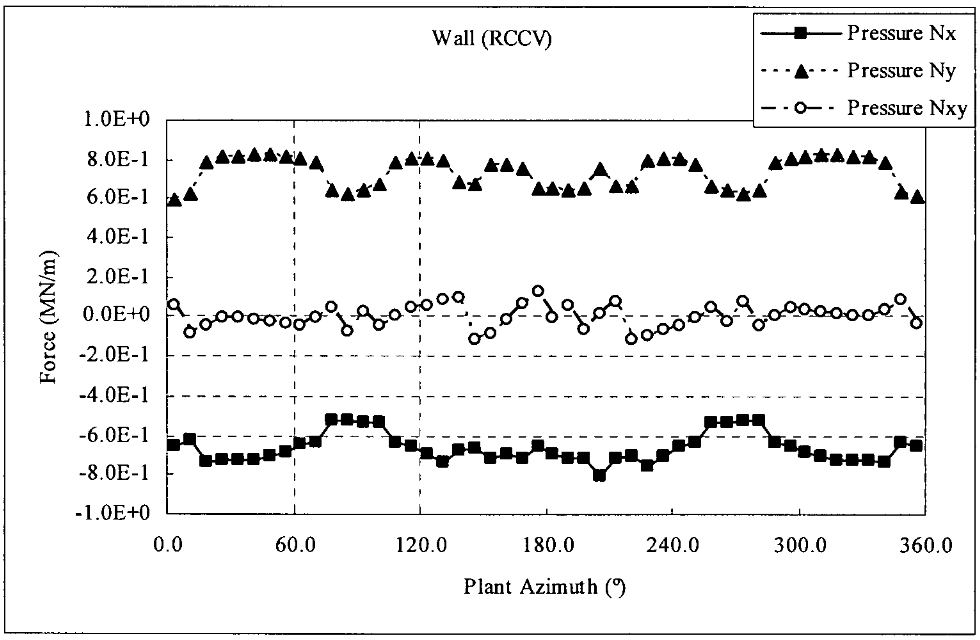


Figure 5-158 Axial Forces at Wall below RCCV for Pressure Load

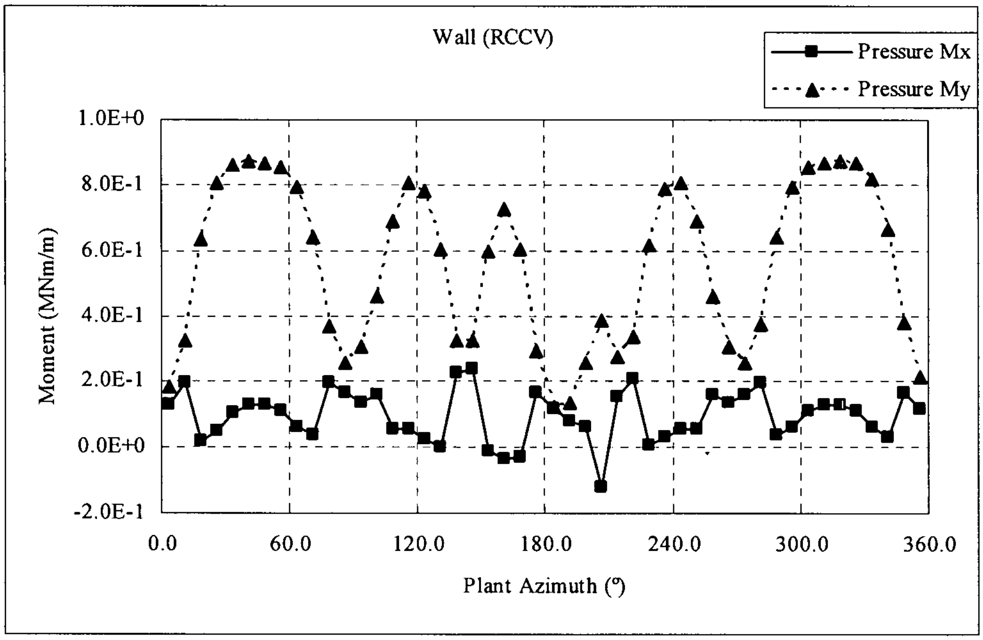


Figure 5-159 Moments at Wall below RCCV for Pressure Load

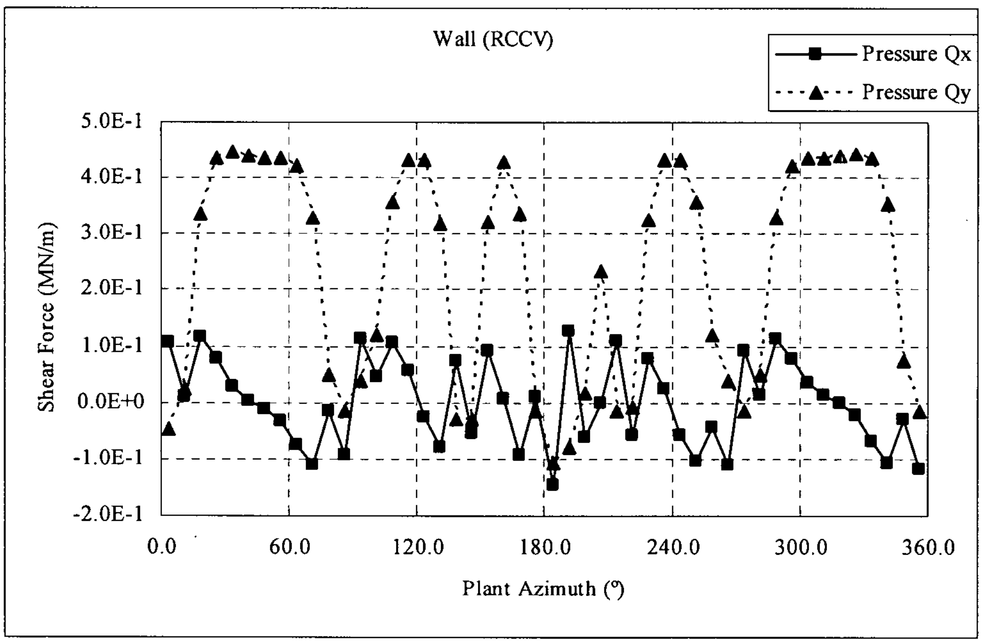


Figure 5-160 Shear Forces at Wall below RCCV for Pressure Load

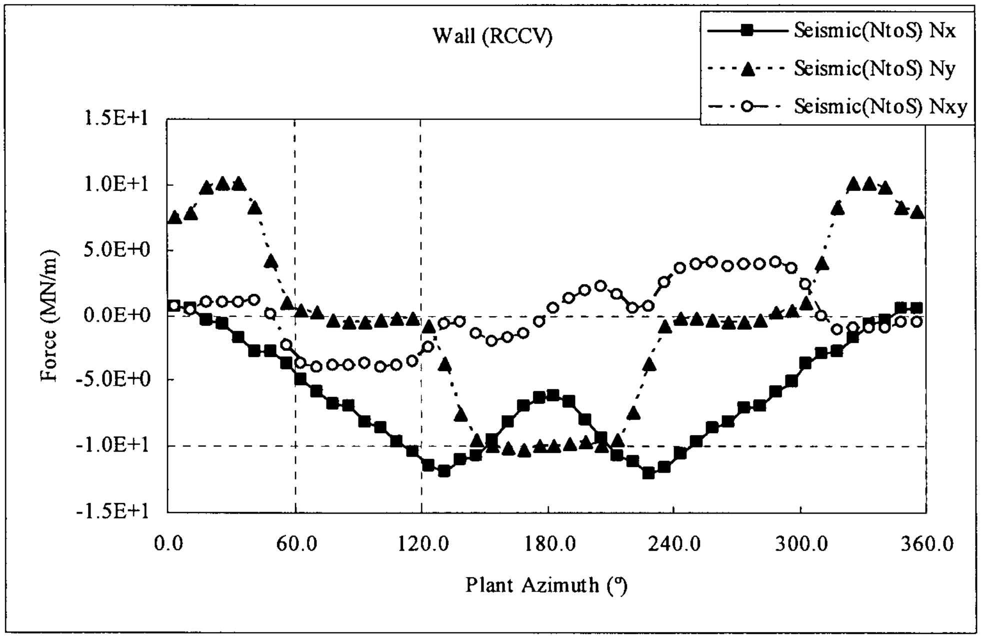


Figure 5-161 Axial Forces at Wall below RCCV for Seismic Load (N to S)

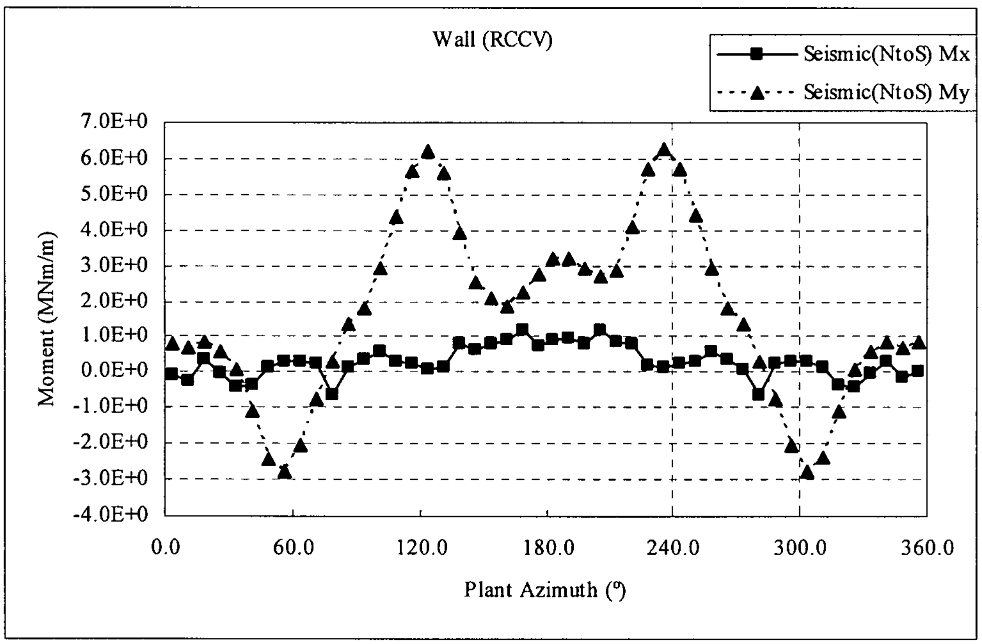


Figure 5-162 Moments at Wall below RCCV for Seismic Load (N to S)

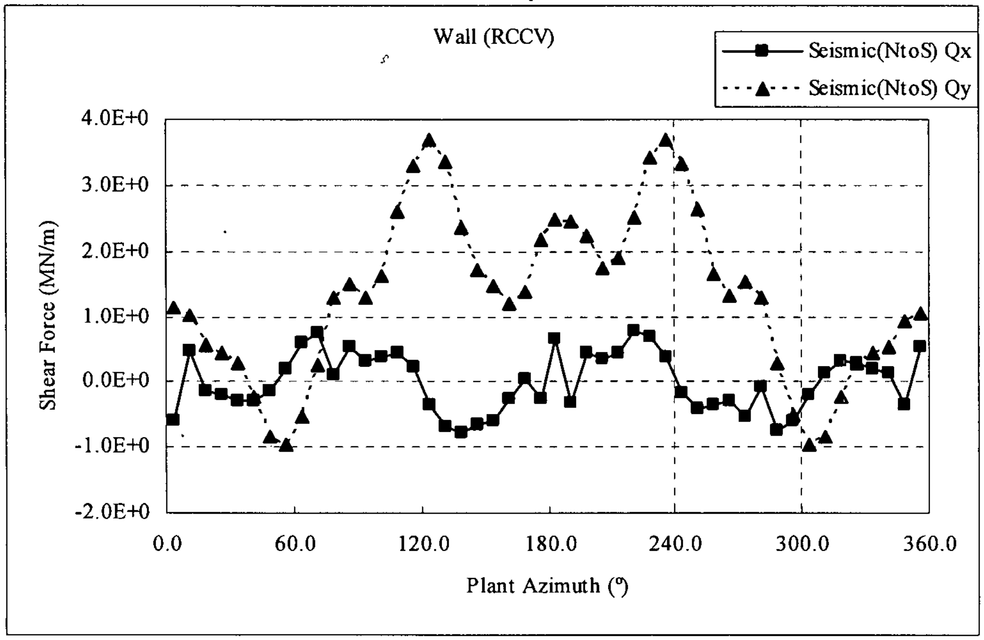


Figure 5-163 Shear Forces at Wall below RCCV for Seismic Load (N to S)

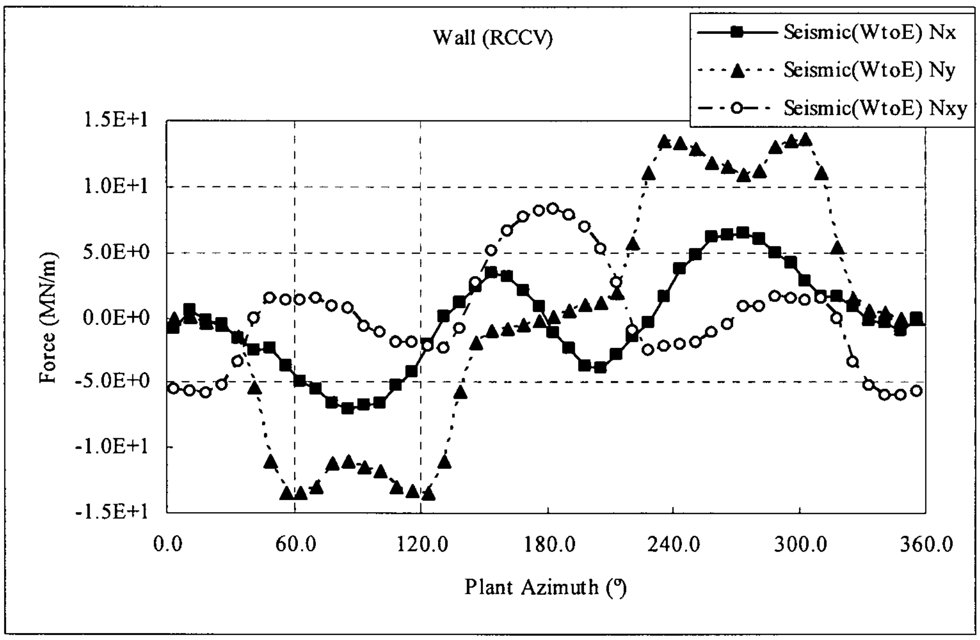


Figure 5-164 Axial Forces at Wall below RCCV for Seismic Load (W to E)

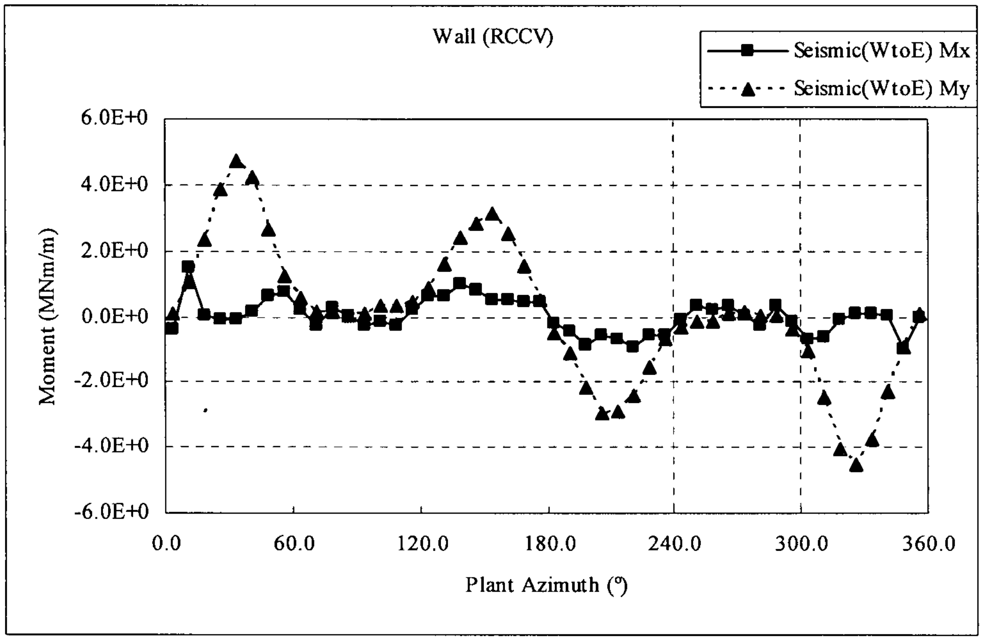


Figure 5-165 Moments at Wall below RCCV for Seismic Load (W to E)

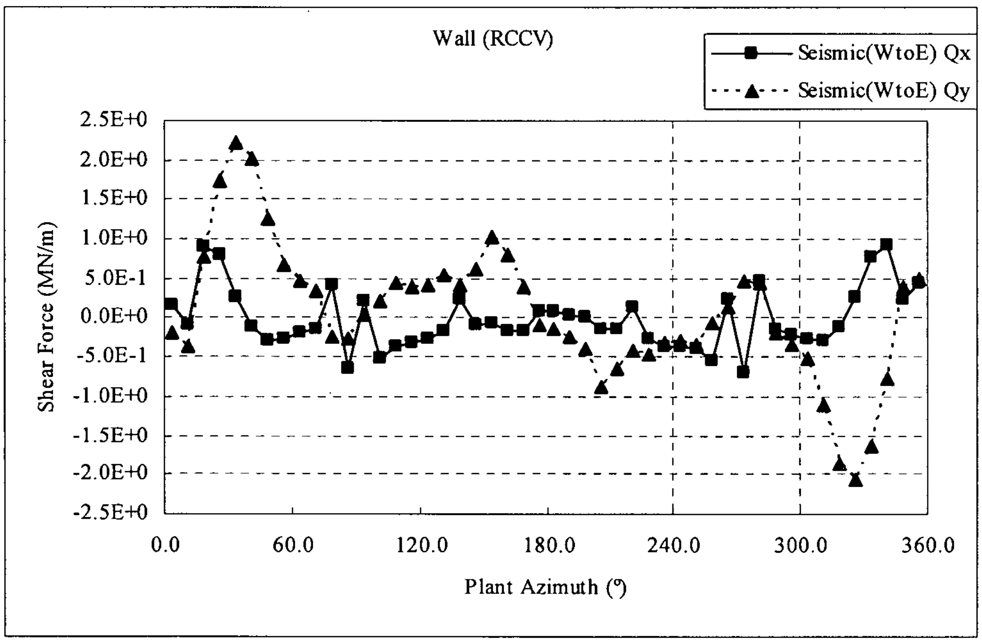


Figure 5-166 Shear Forces at Wall below RCCV for Seismic Load (W to E)

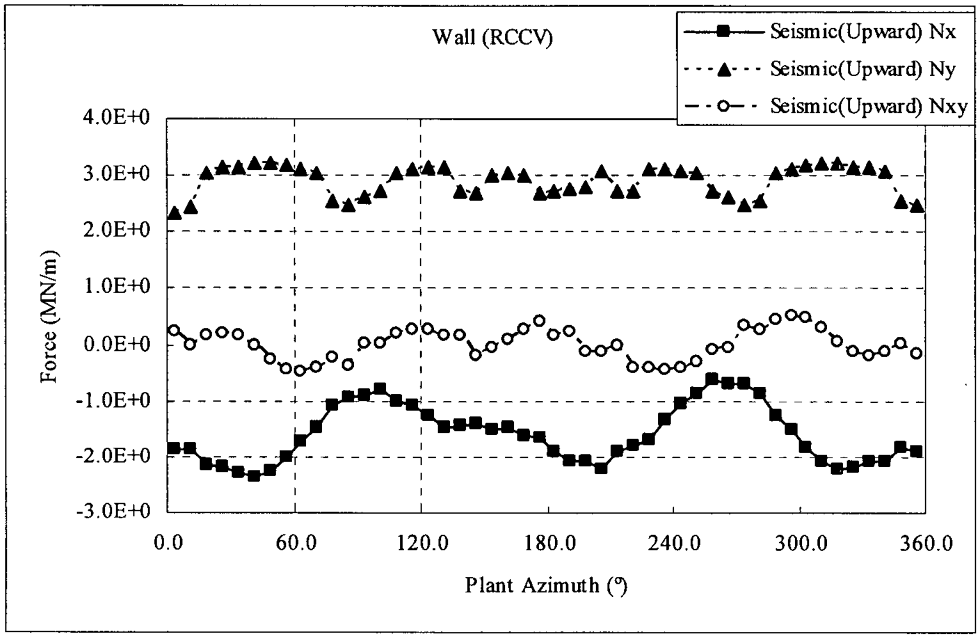


Figure 5-167 Axial Forces at Wall below RCCV for Seismic Load (Vertical; Upward)

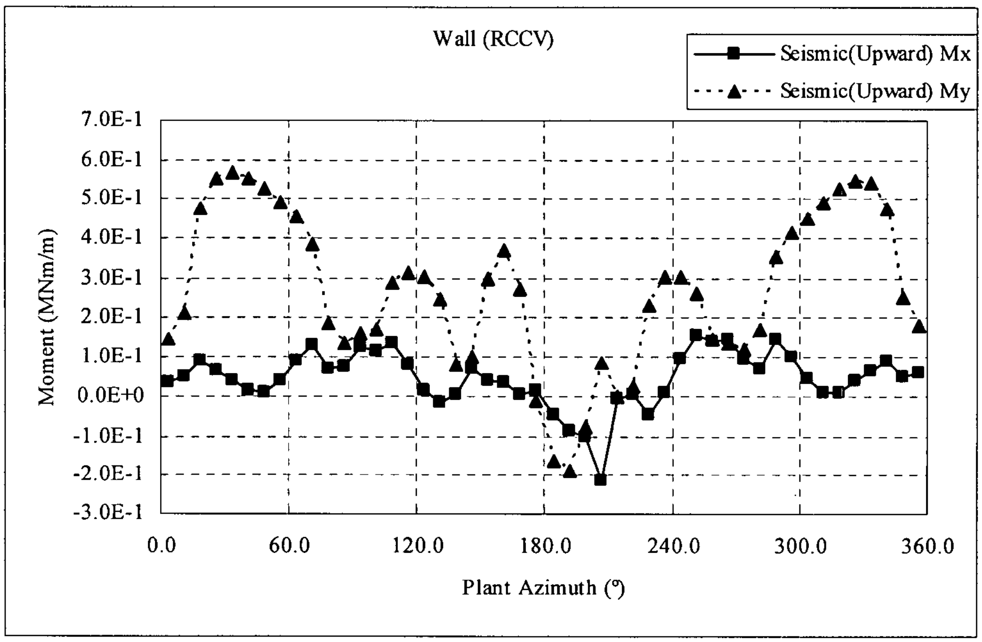


Figure 5-168 Moments at Wall below RCCV for Seismic Load (Vertical; Upward)

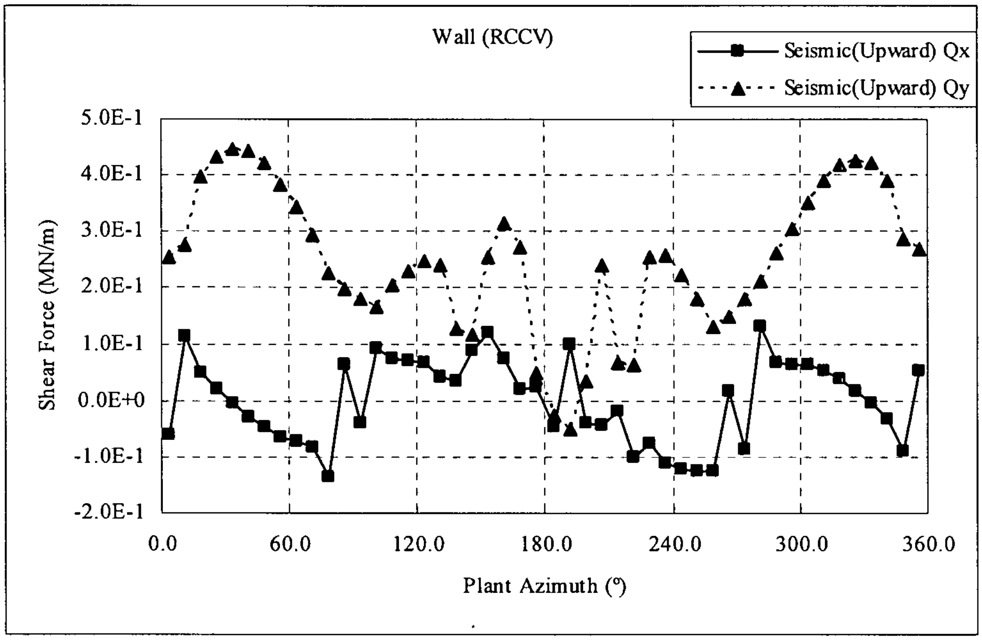


Figure 5-169 Shear Forces at Wall below RCCV for Seismic Load (Vertical; Upward)

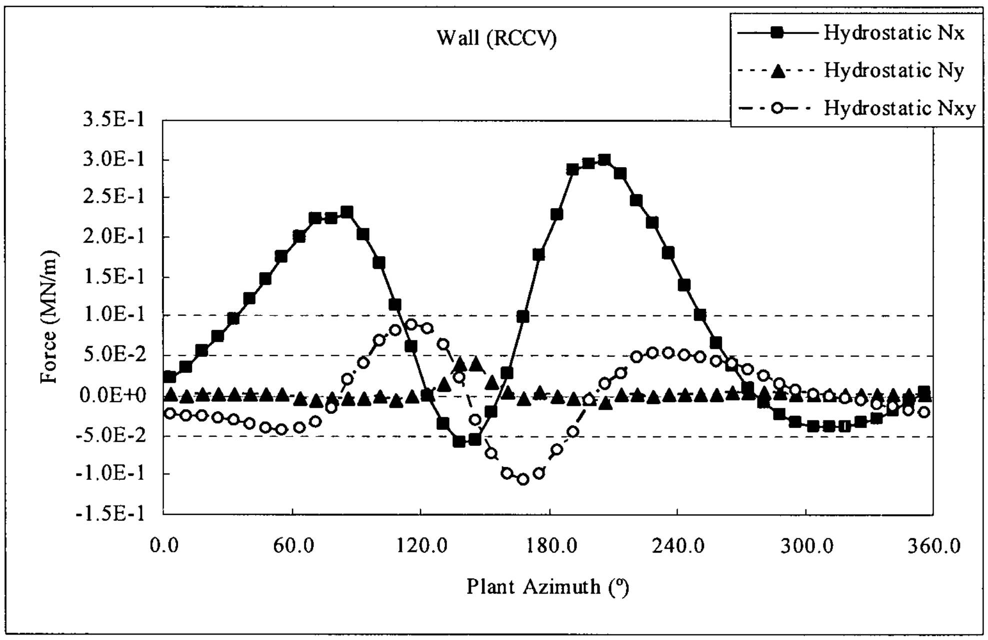


Figure 5-170 Axial Forces at Wall below RCCV for Hydrostatic Load

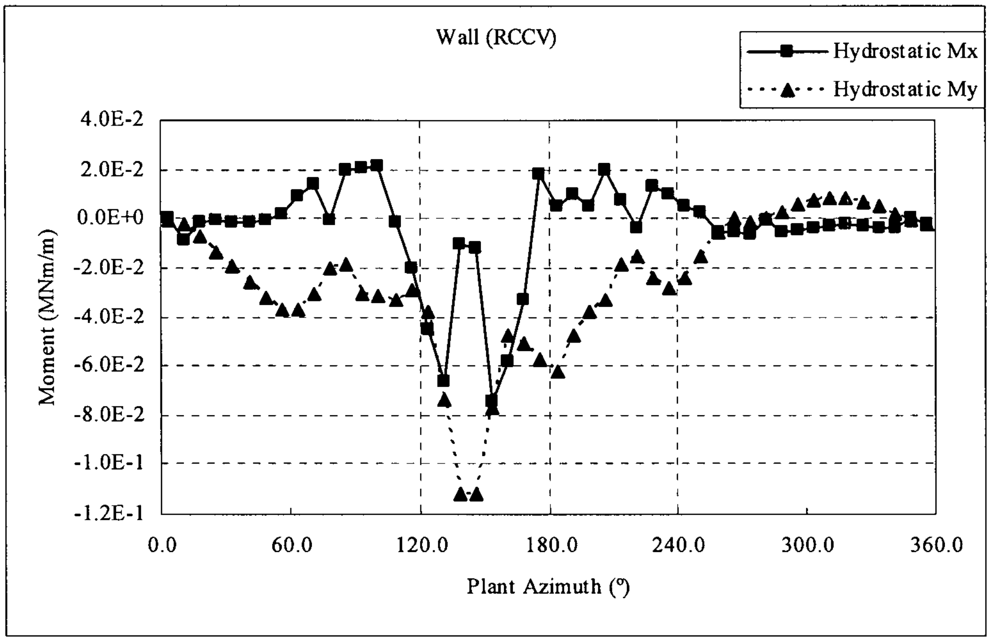


Figure 5-171 Moments at Wall below RCCV for Hydrostatic Load

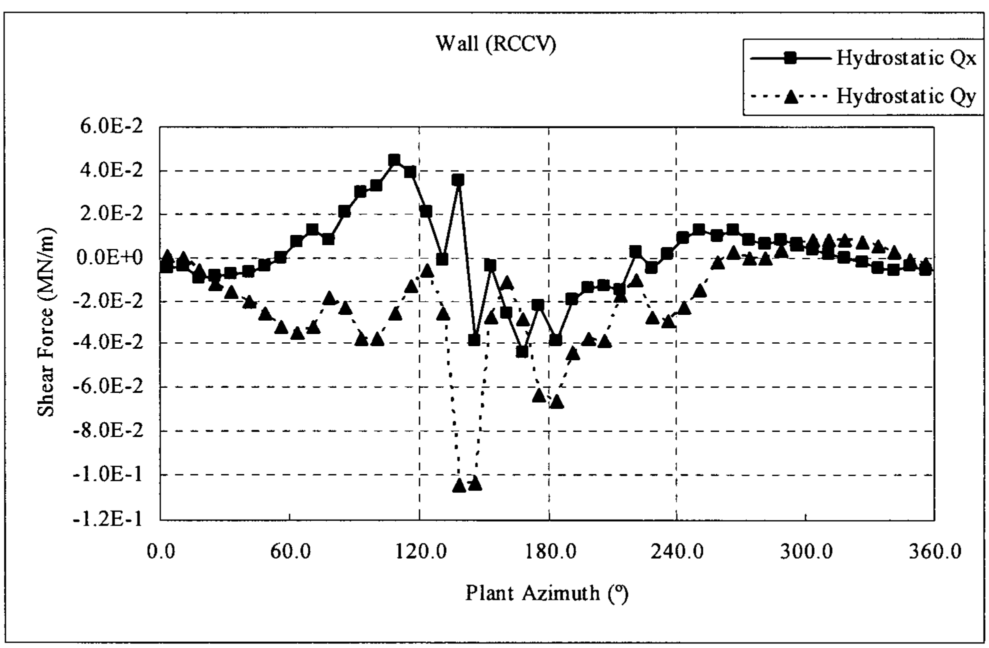


Figure 5-172 Shear Forces at Wall below RCCV for Hydrostatic Load

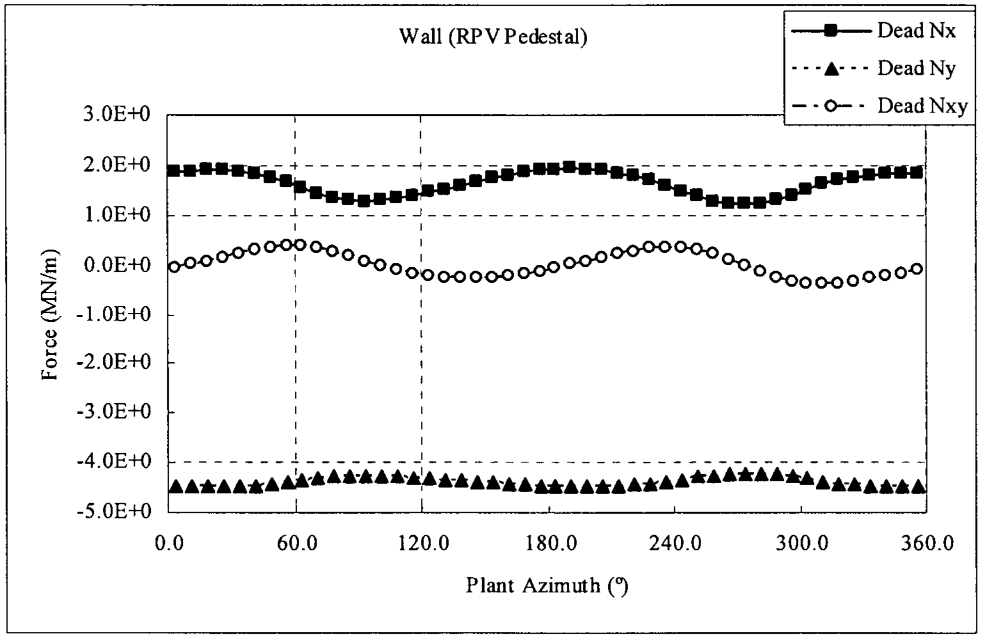


Figure 5-173 Axial Forces at RPV Pedestal Wall for Dead Load

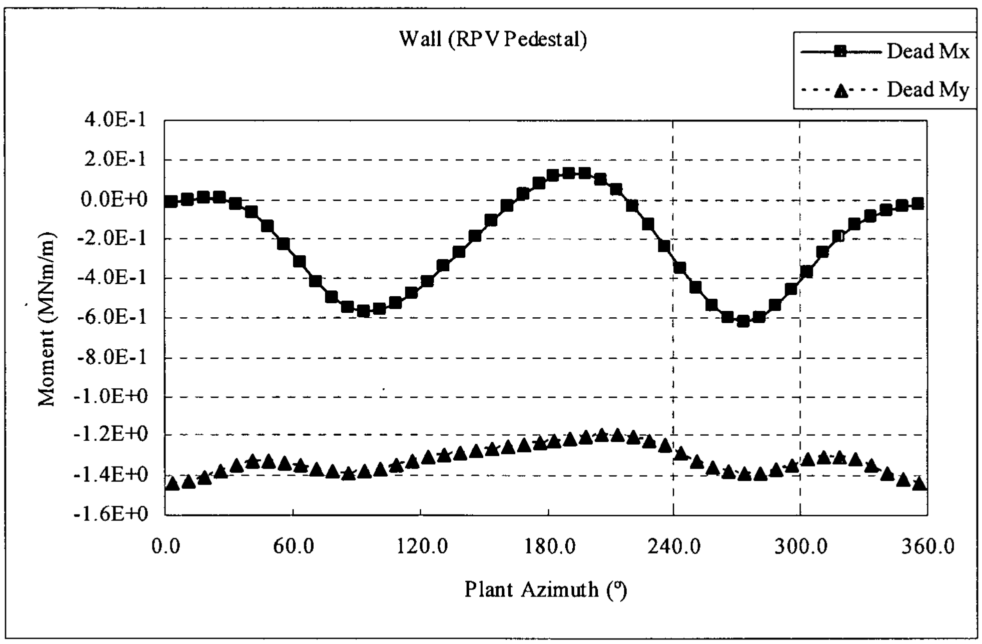


Figure 5-174 Moments at RPV Pedestal Wall for Dead Load

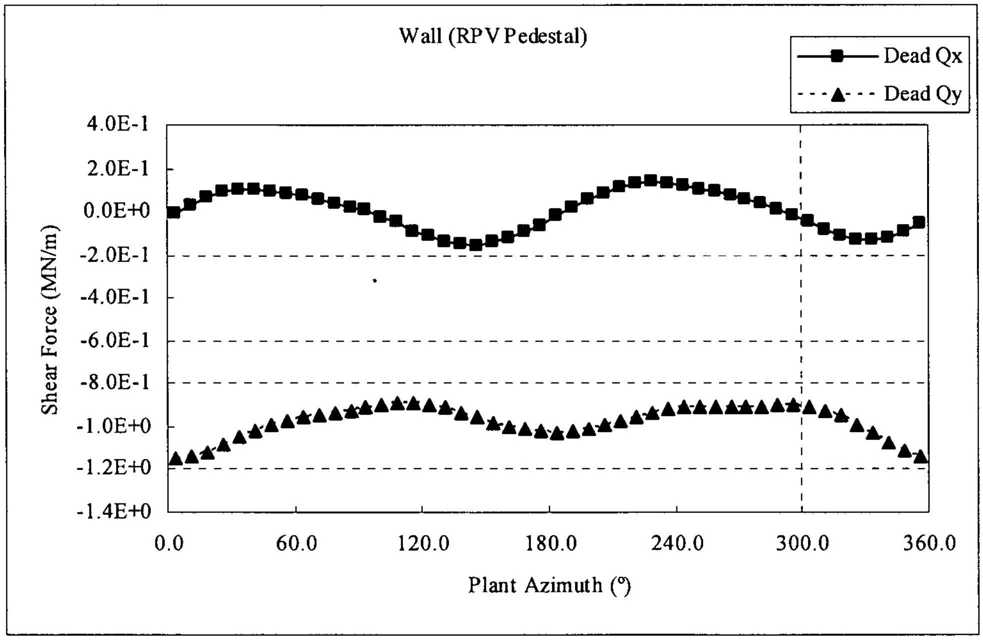


Figure 5-175 Shear Forces at RPV Pedestal Wall for Dead Load

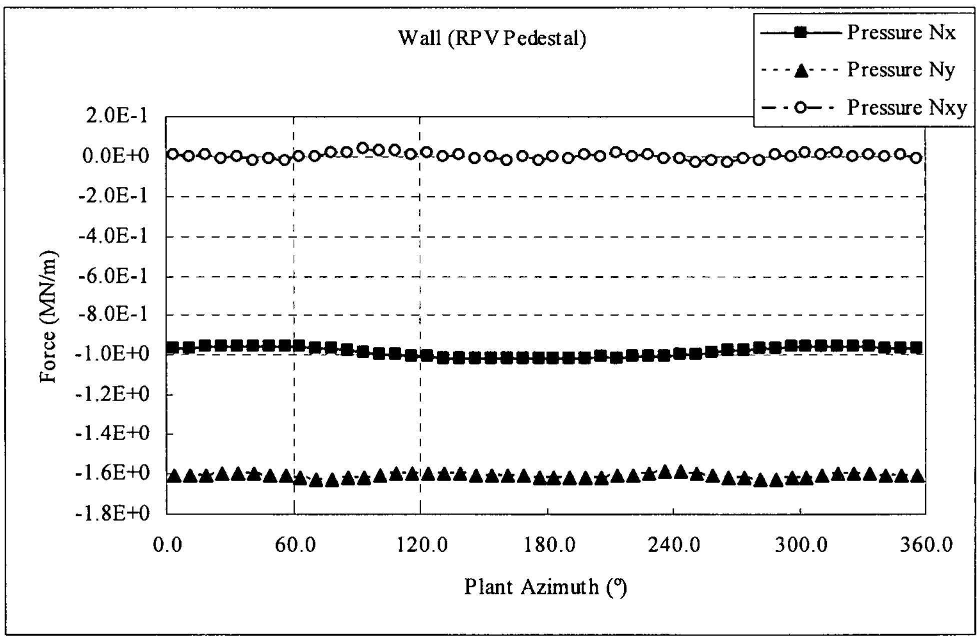


Figure 5-175 Axial Forces at RPV Pedestal Wall for Pressure Load

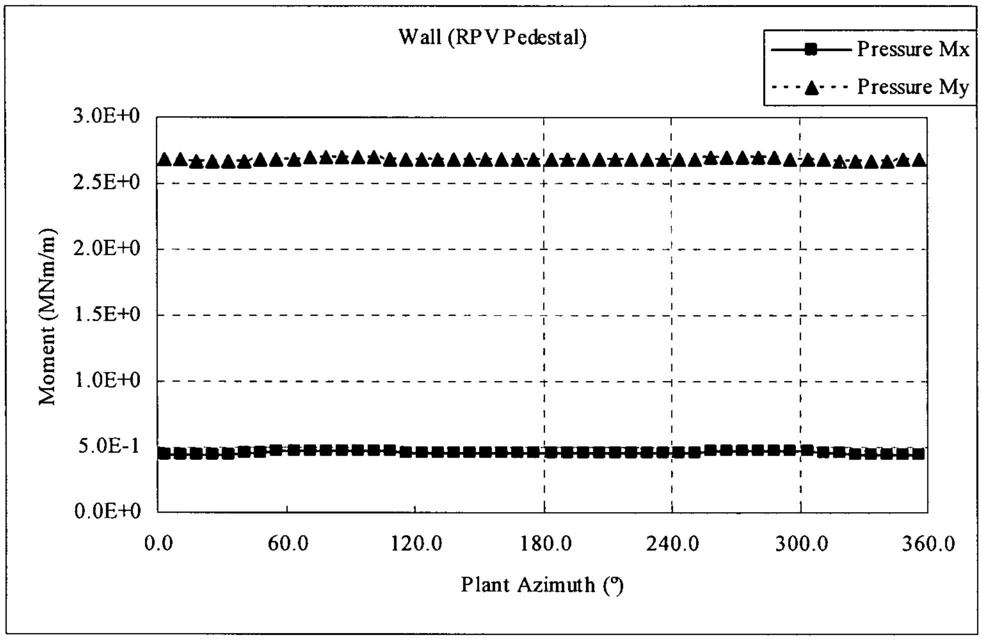


Figure 5-176 Moments at RPV Pedestal Wall for Pressure Load

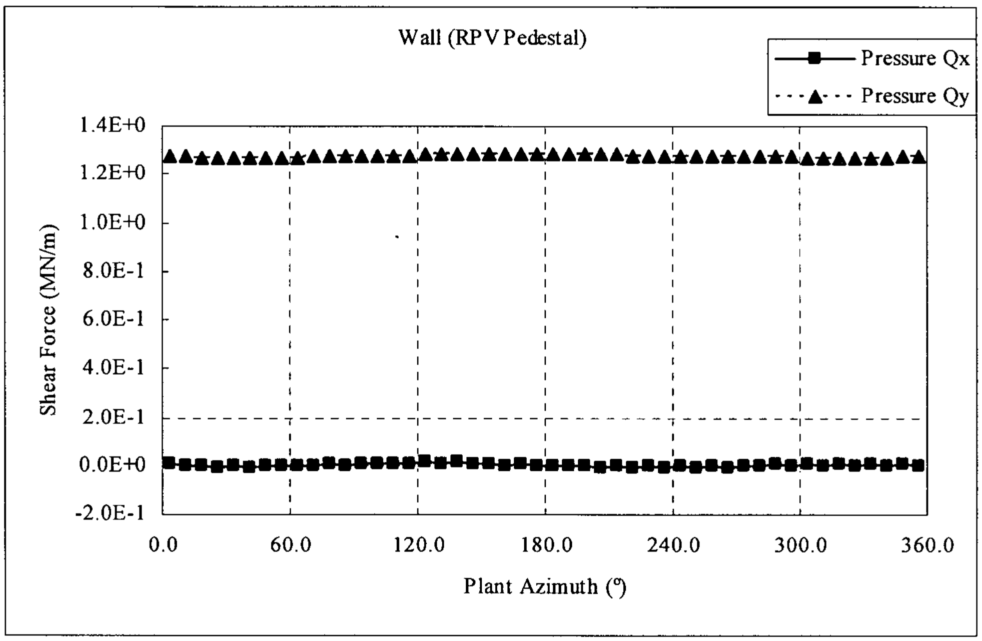


Figure 5-178 Shear Forces at RPV Pedestal Wall for Pressure Load

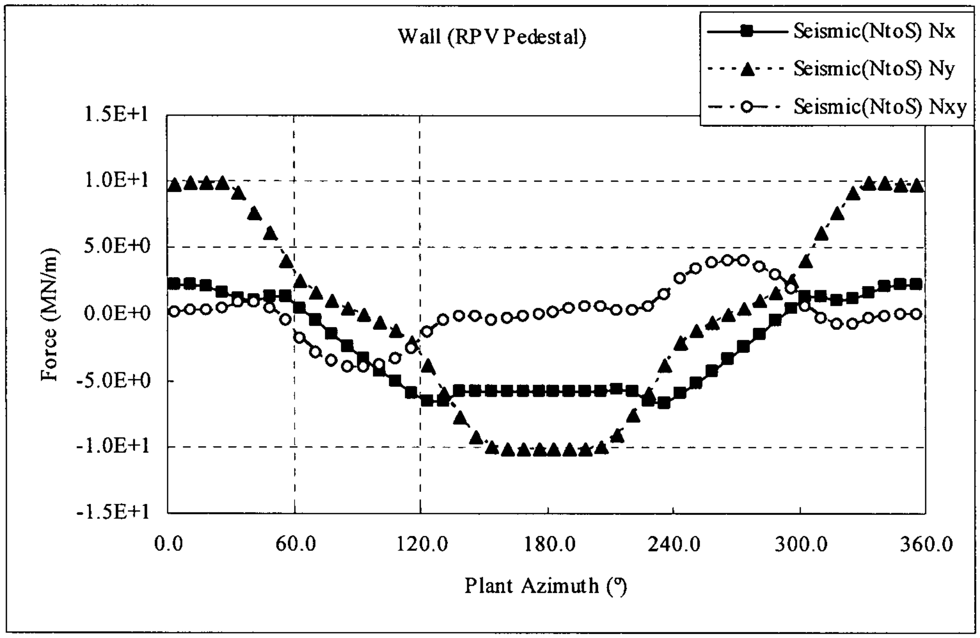


Figure 5-179 Axial Forces at RPV Pedestal Wall for Seismic Load (N to S)

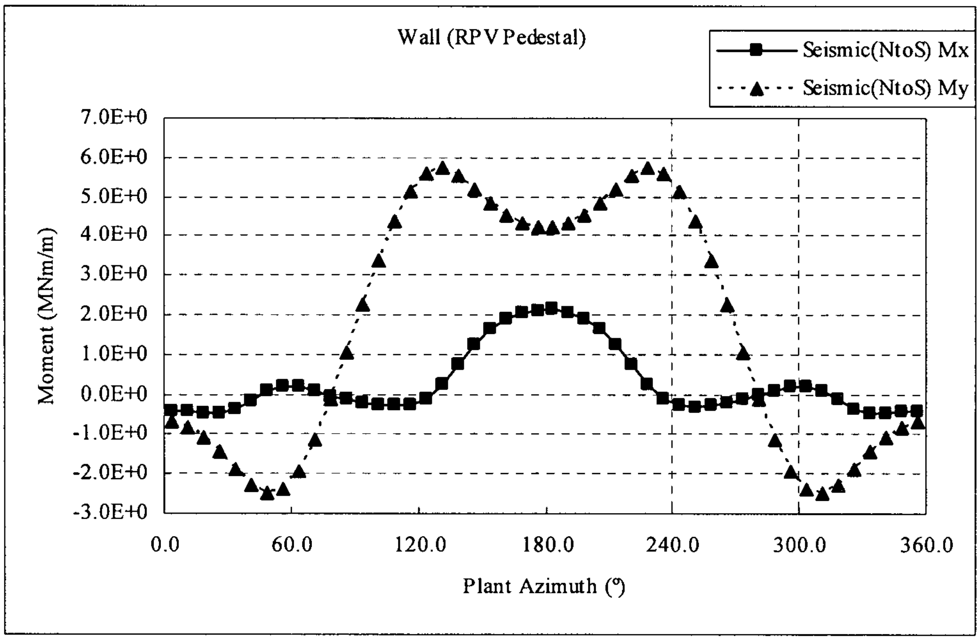


Figure 5-180 Moments at RPV Pedestal Wall for Seismic Load (N to S)

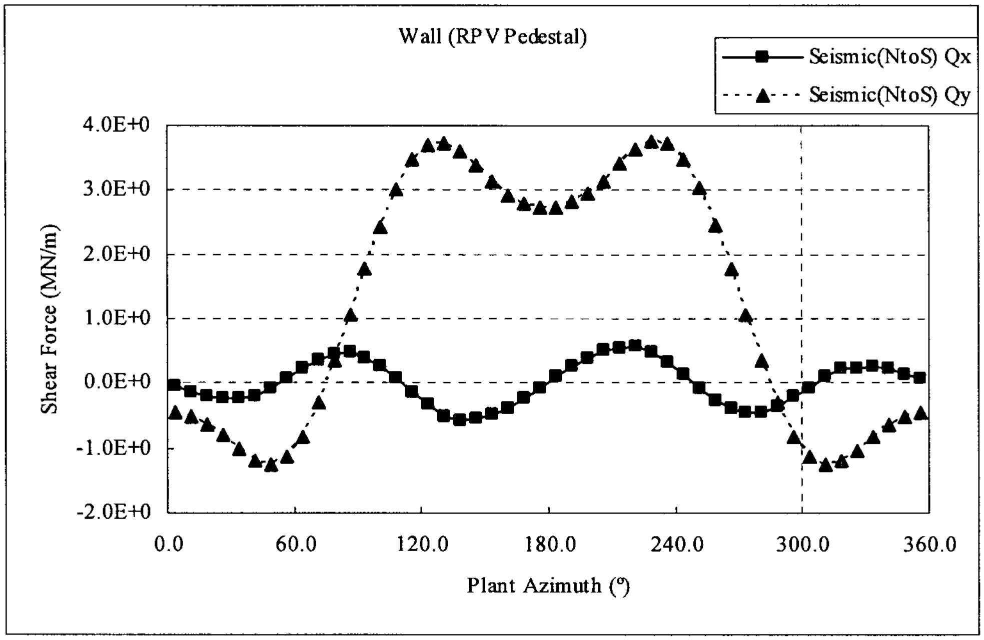


Figure 5-181 Shear Forces at RPV Pedestal Wall for Seismic Load (N to S)

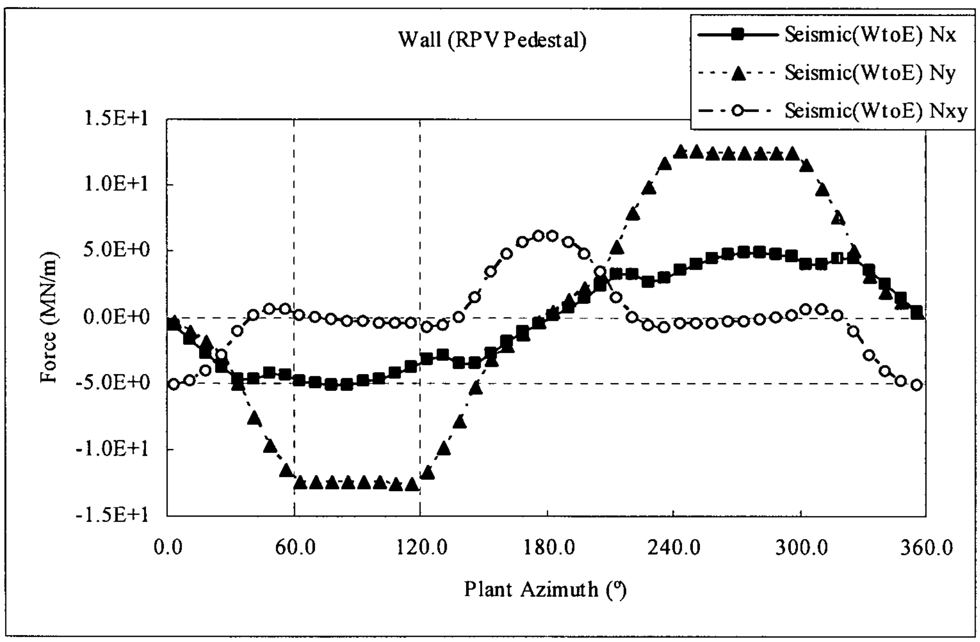


Figure 5-182 Axial Forces at RPV Pedestal Wall for Seismic Load (W to E)

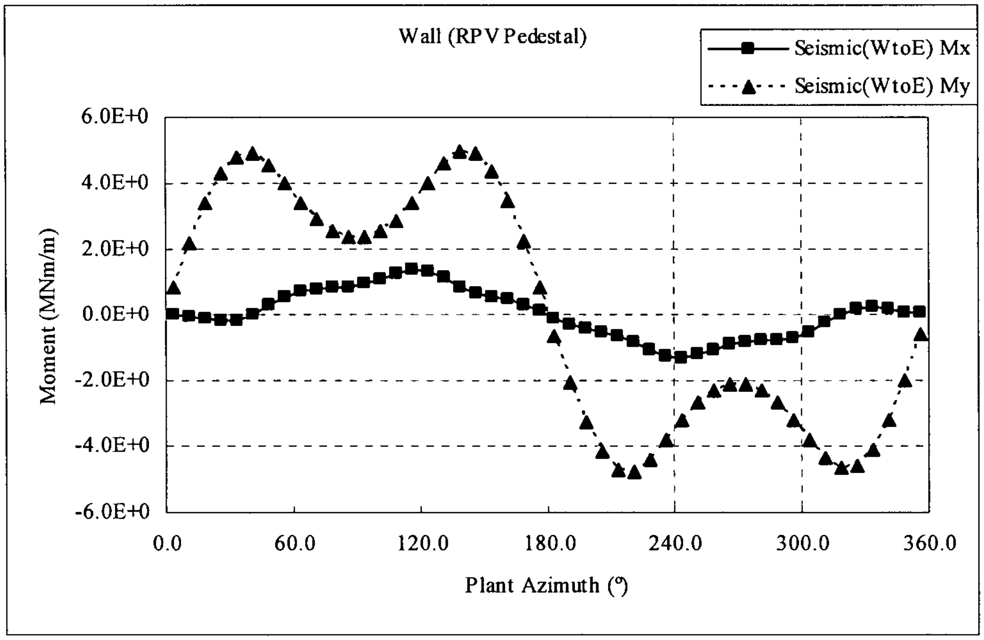


Figure 5-183 Moments at RPV Pedestal Wall for Seismic Load (W to E)

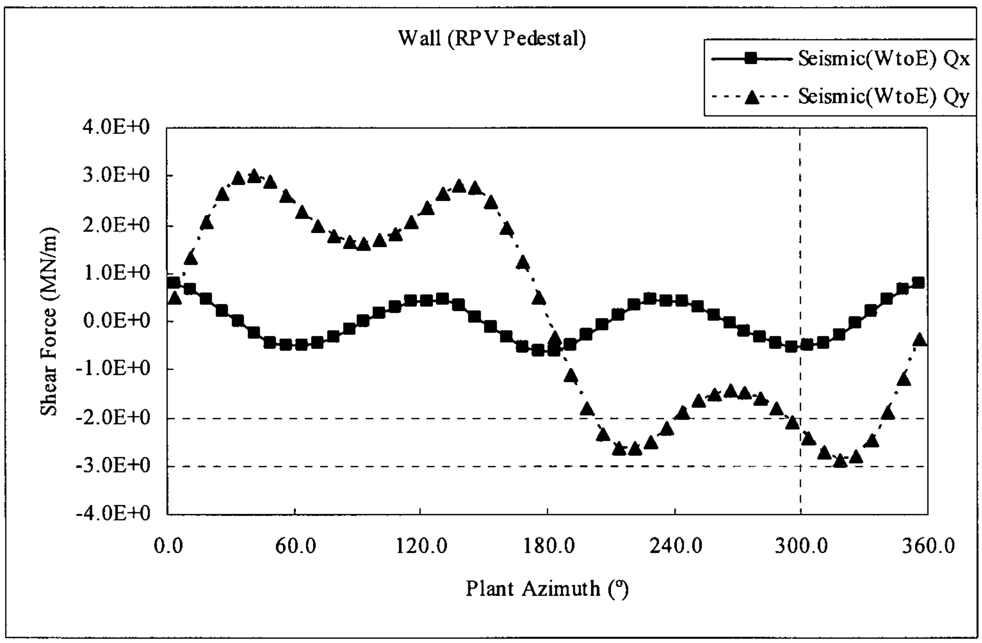


Figure 5-184 Shear Forces at RPV Pedestal Wall for Seismic Load (W to E)

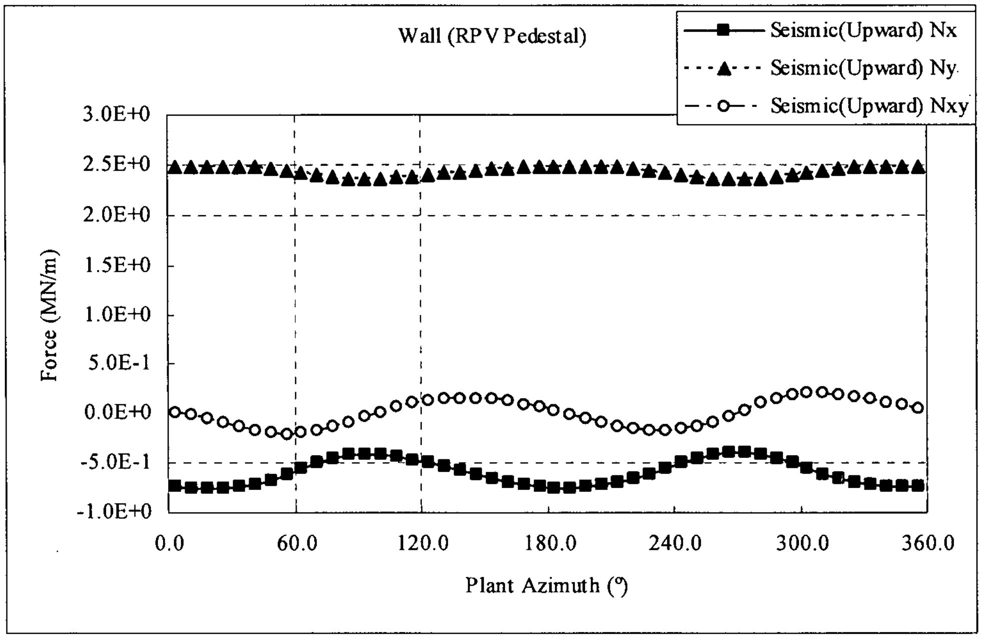


Figure 5-185 Axial Forces at RPV Pedestal Wall for Seismic Load (Vertical; Upward)

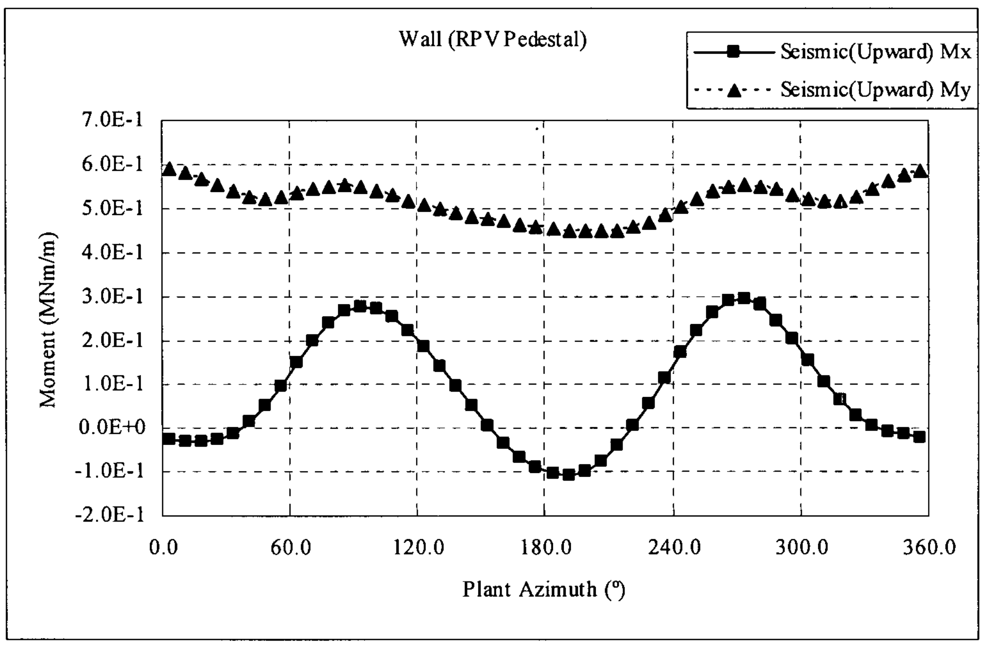


Figure 5-186 Moments at RPV Pedestal Wall for Seismic Load (Vertical; Upward)

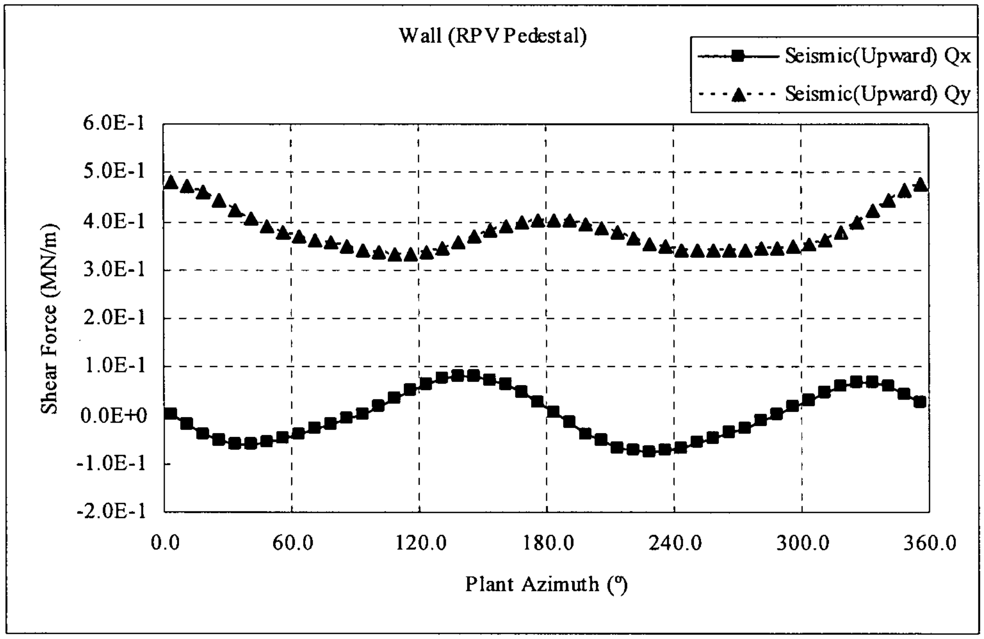


Figure 5-187 Shear Forces at RPV Pedestal Wall for Seismic Load (Vertical; Upward)

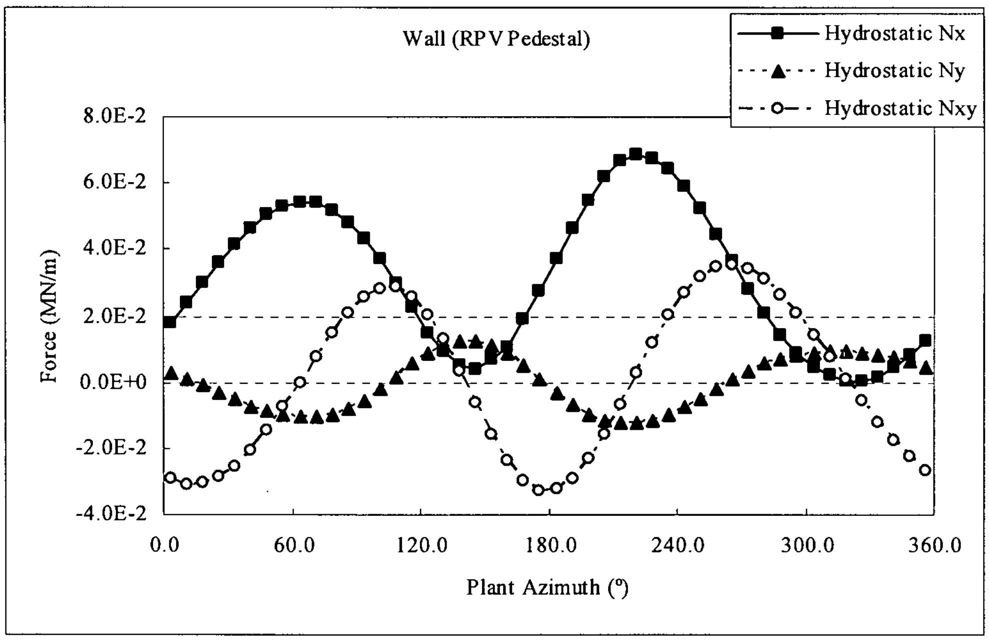


Figure 5-188 Axial Forces at RPV Pedestal Wall for Hydrostatic Load

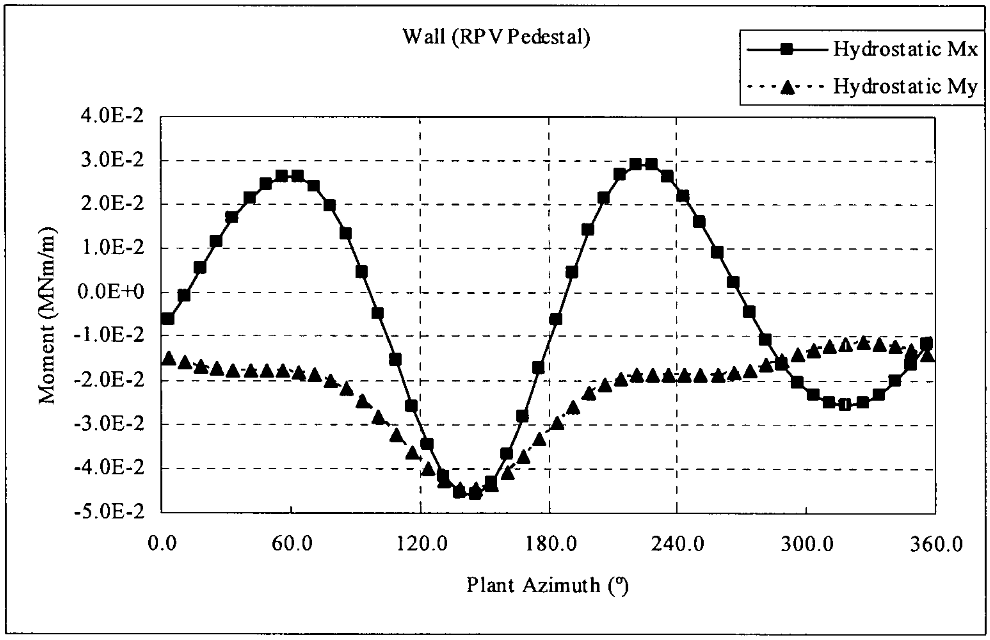


Figure 5-189 Moments at RPV Pedestal Wall for Hydrostatic Load

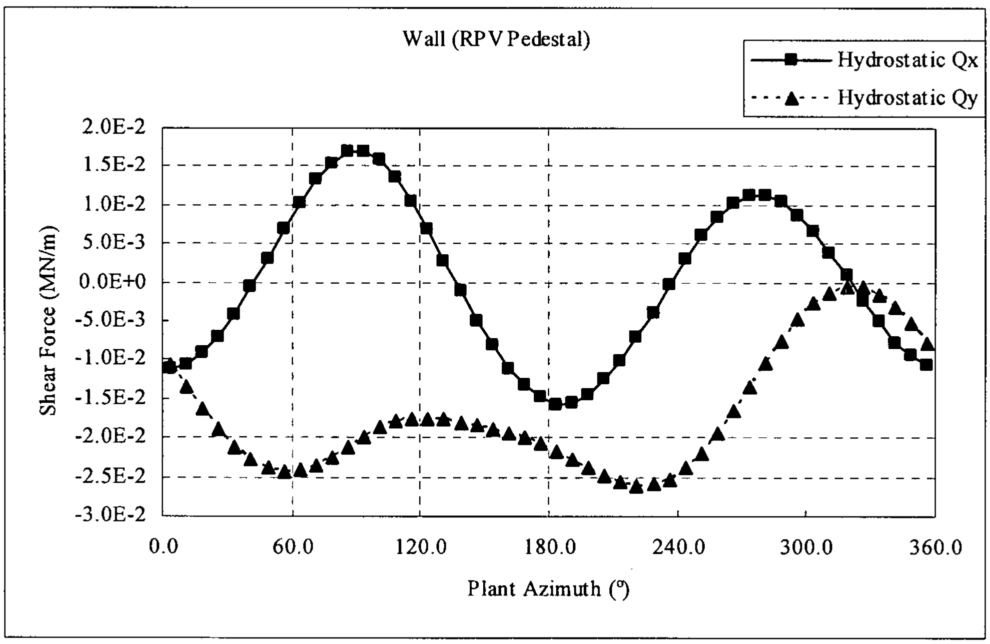


Figure 5-190 Shear Forces at RPV Pedestal Wall for Hydrostatic Load

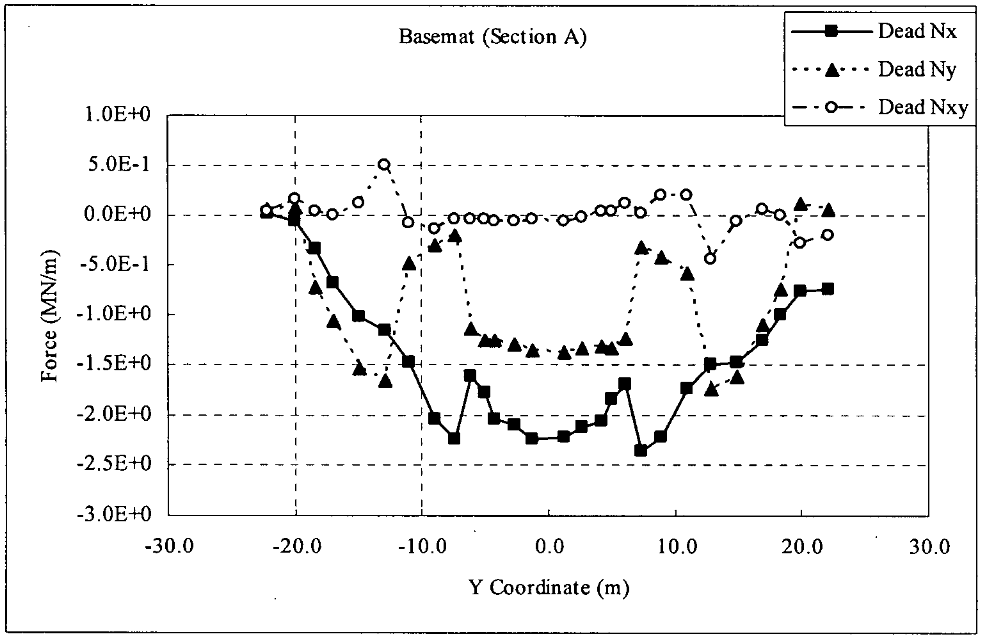


Figure 5-191 Axial Forces at Basemat Section A for Dead Load

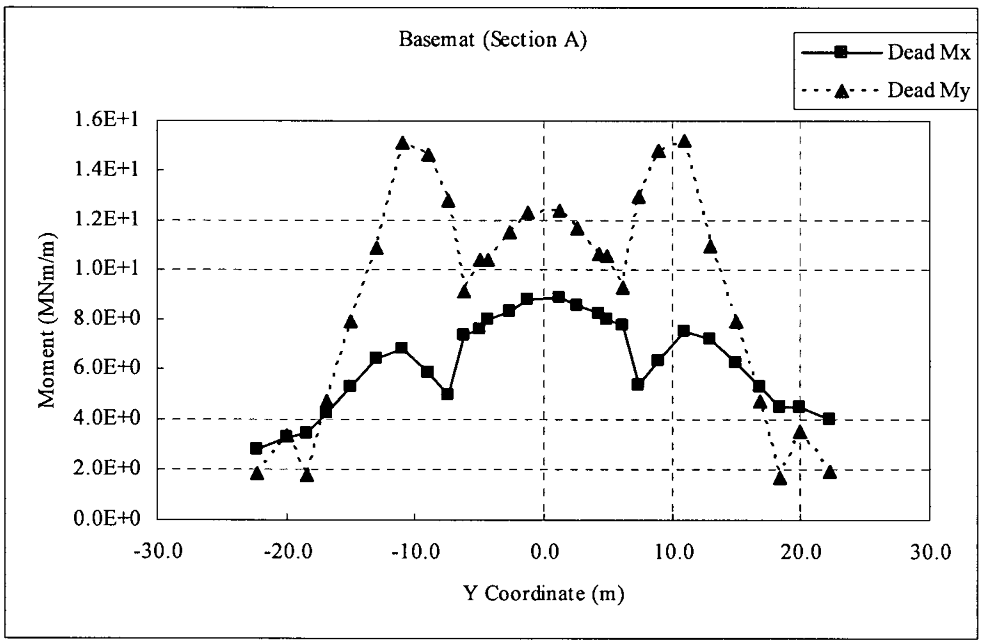


Figure 5-192 Moments at Basemat Section A for Dead Load

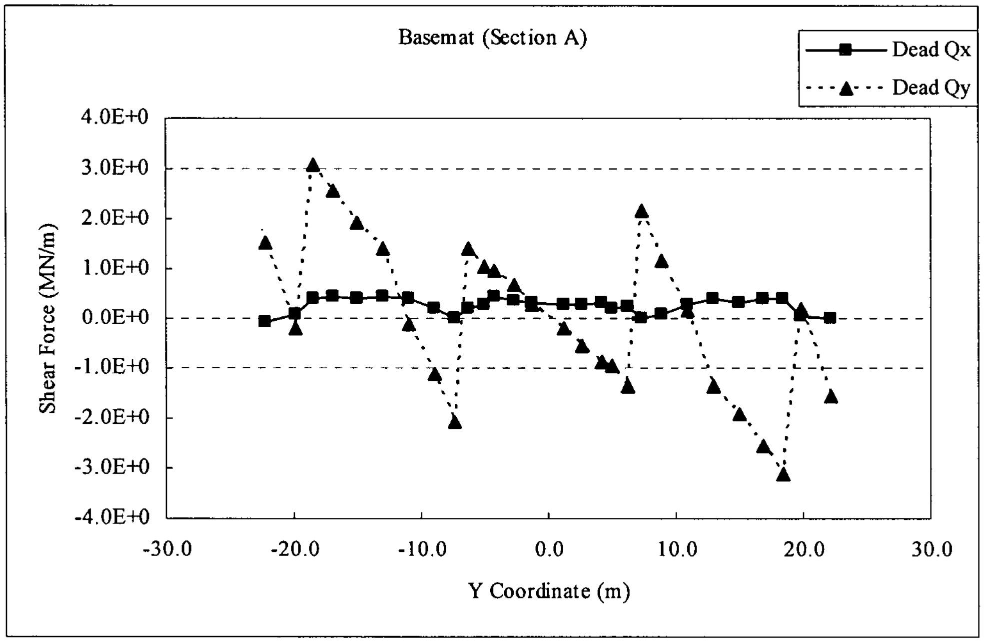


Figure 5-193 Shear Forces at Basemat Section A for Dead Load

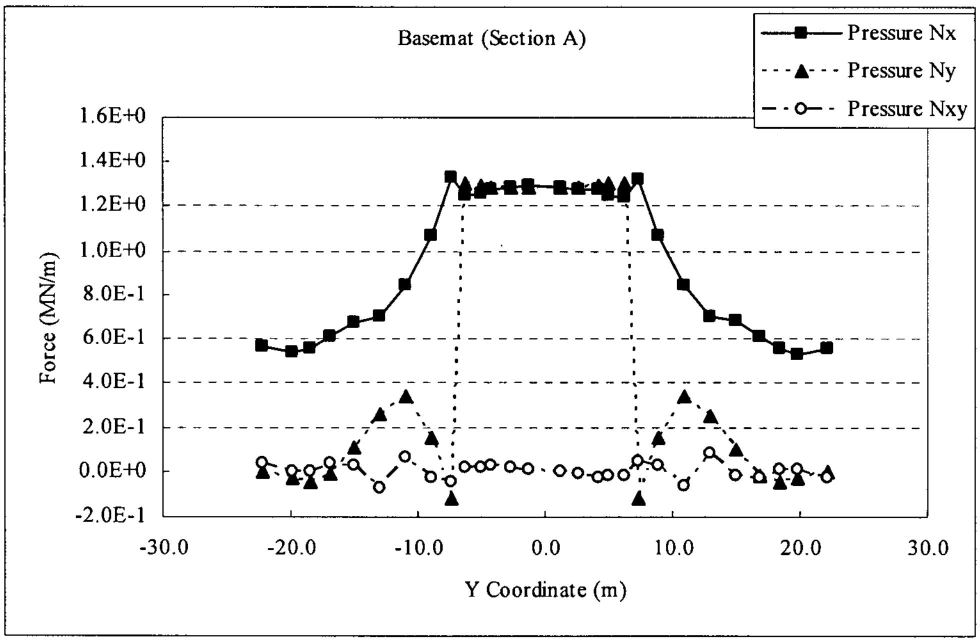


Figure 5-194 Axial Forces at Basemat Section A for Pressure Load

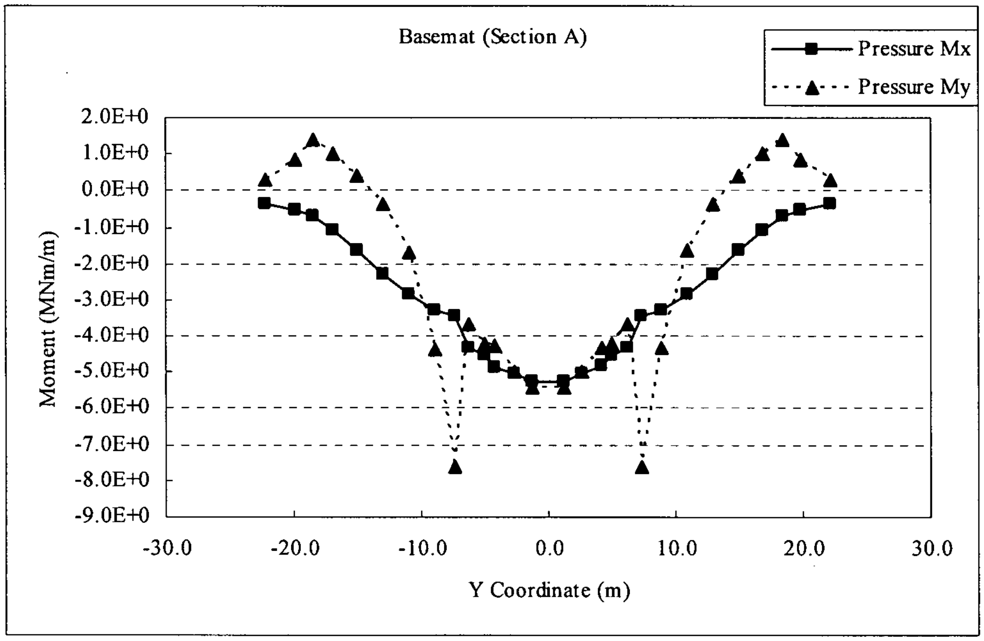


Figure 5-195 Moments at Basemat Section A for Pressure Load

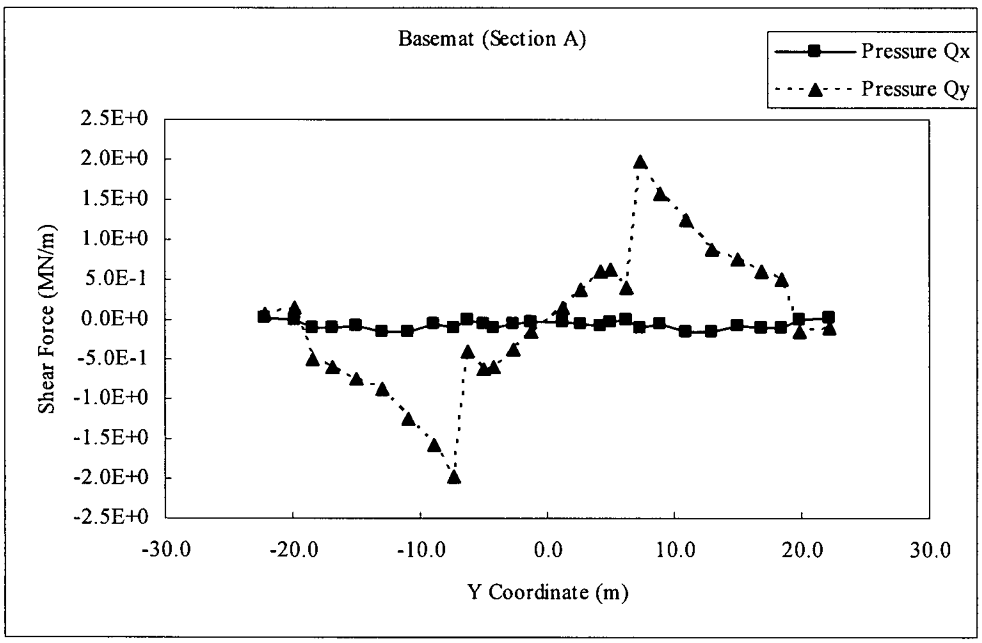


Figure 5-196 Shear Forces at Basemat Section A for Pressure Load

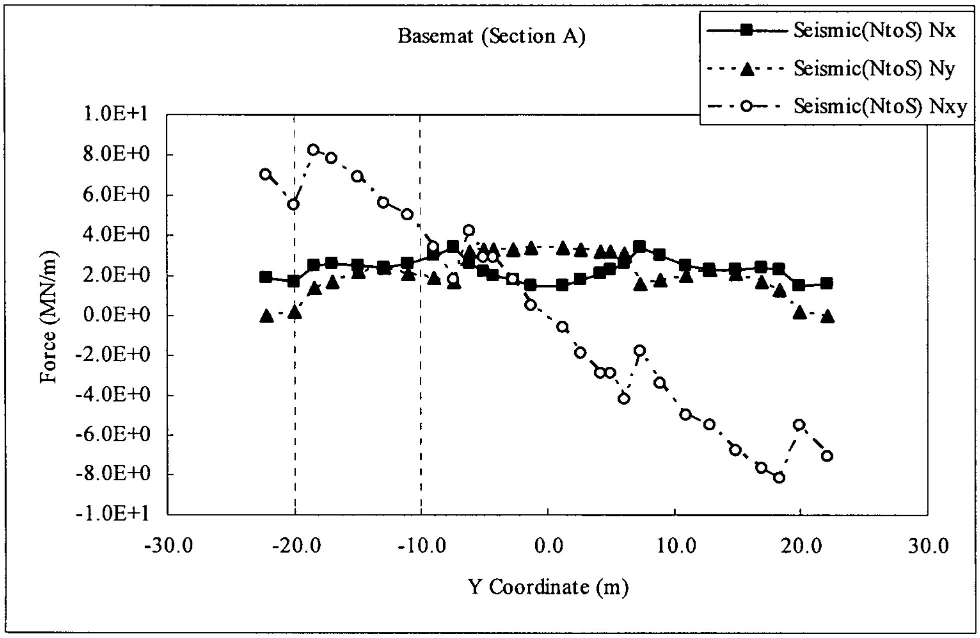


Figure 5-197 Axial Forces at Basemat Section A for Seismic Load (N to S)

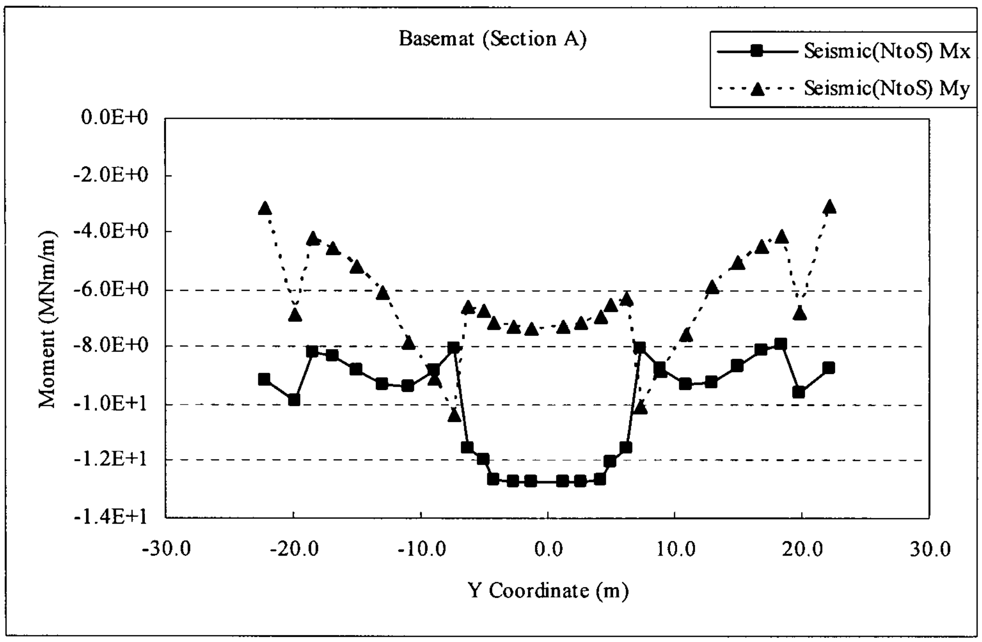


Figure 5-198 Moments at Basemat Section A for Seismic Load (N to S)

Figure 5-199 Shear Forces at Basemat Section A for Seismic Load (N to S)

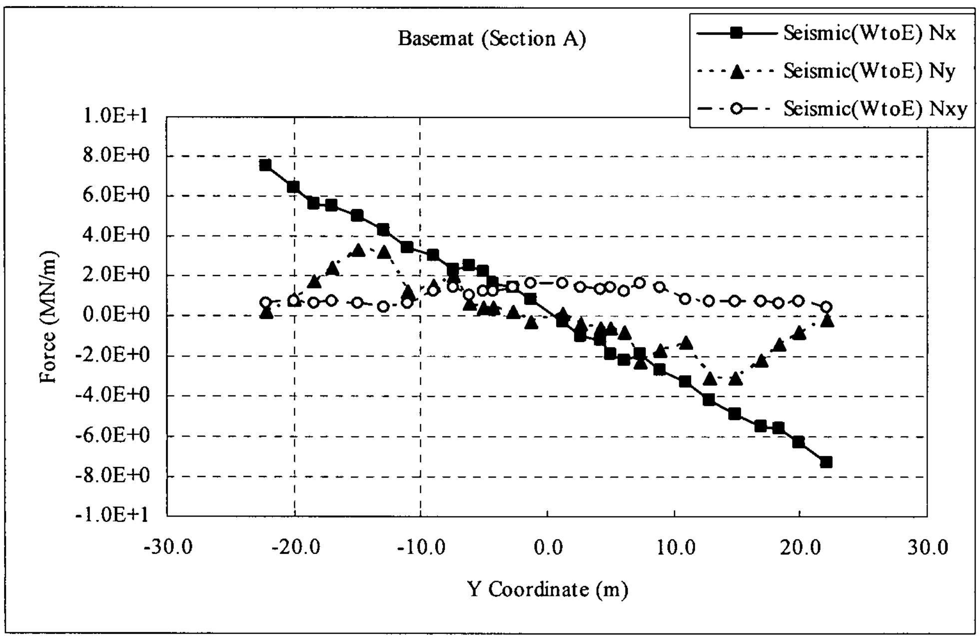


Figure 5-200 Axial Forces at Basemat Section A for Seismic Load (W to E)

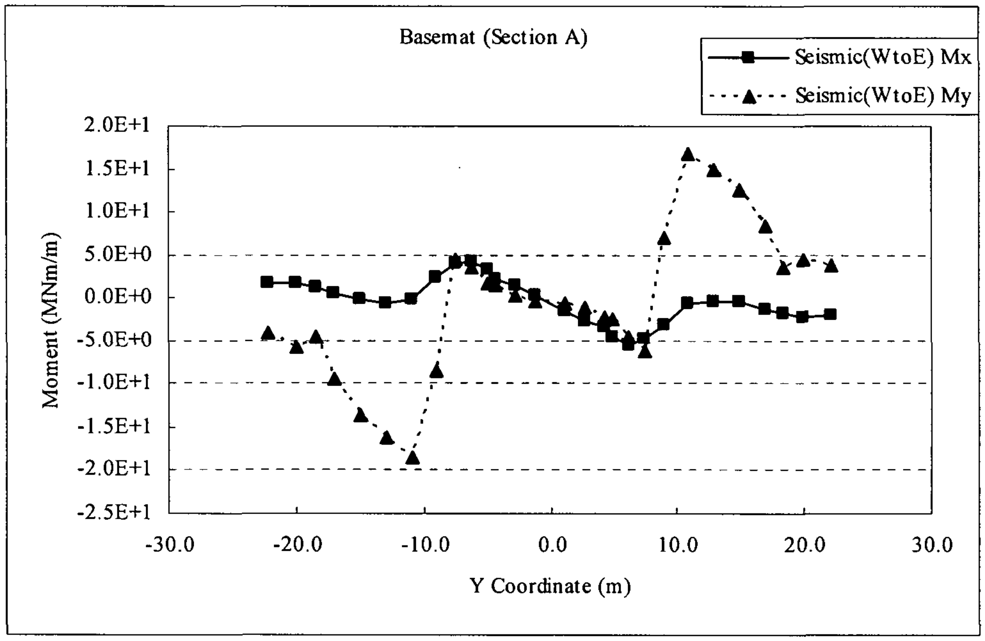


Figure 5-201 Moments at Basemat Section A for Seismic Load (W to E)

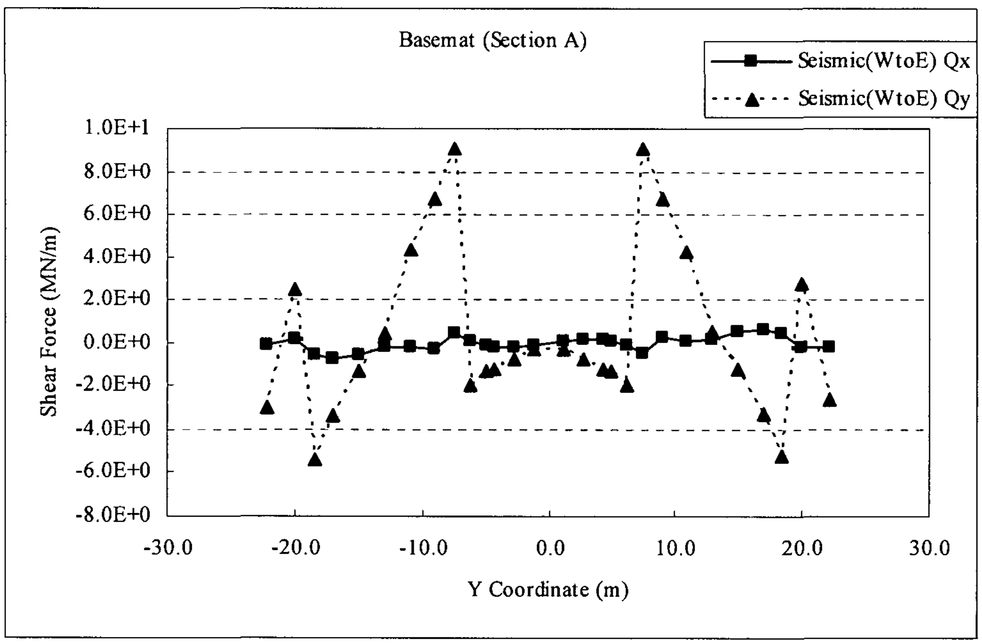


Figure 5-202 Shear Forces at Basemat Section A for Seismic Load (W to E)

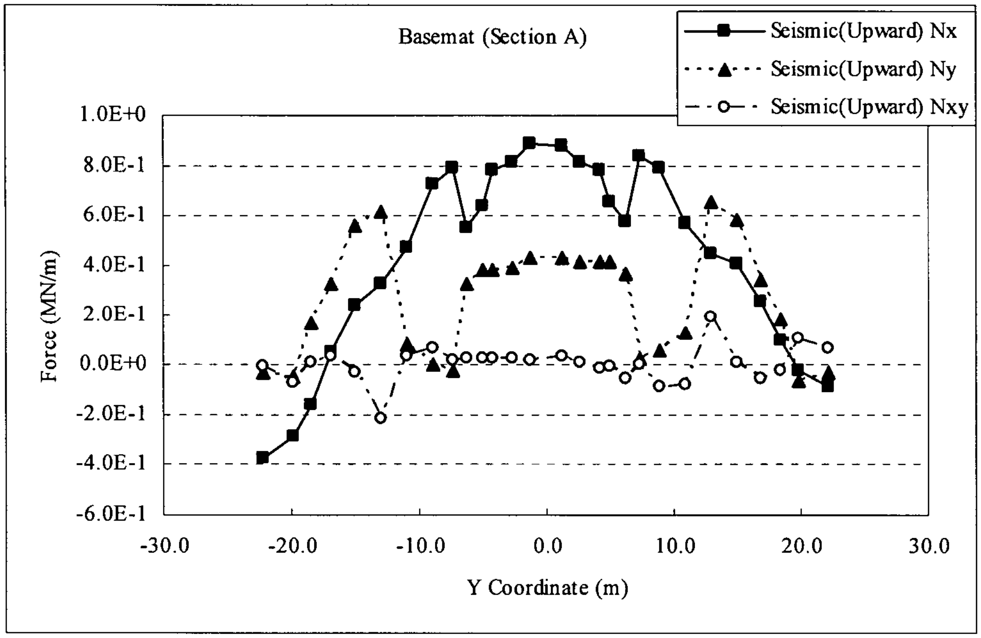


Figure 5-203 Axial Forces at Basemat Section A for Seismic Load (Vertical; Upward)

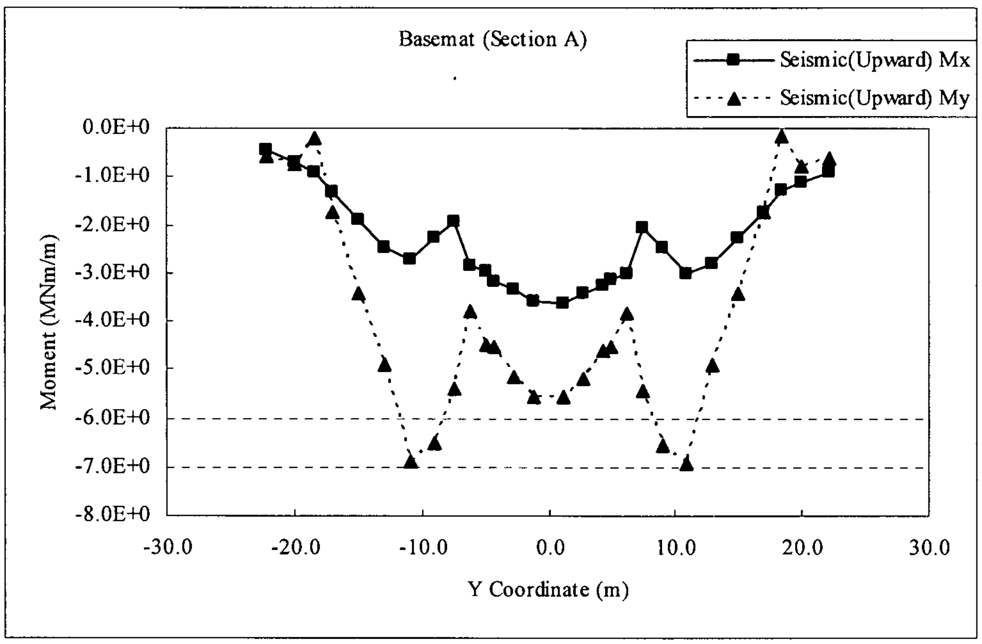


Figure 5-204 Moments at Basemat Section A for Seismic Load (Vertical; Upward)

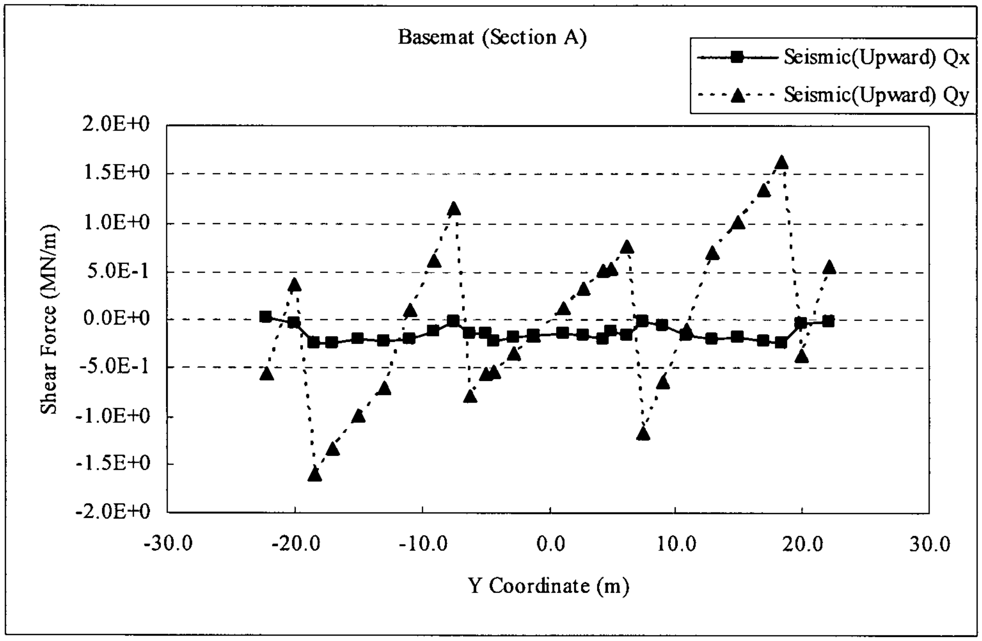


Figure 5-205 Shear Forces at Basemat Section A for Seismic Load (Vertical; Upward)

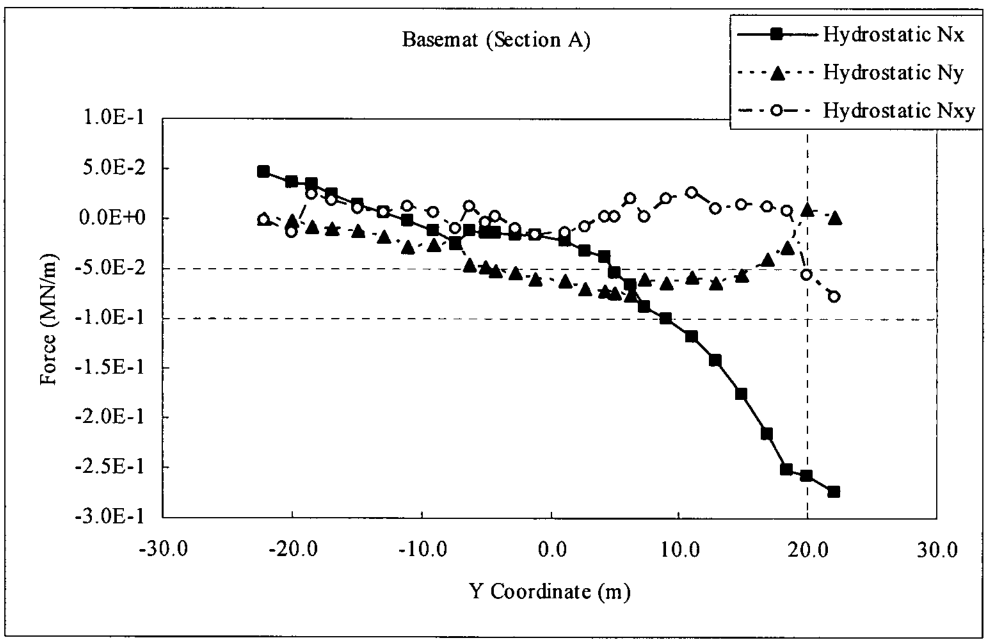


Figure 5-206 Axial Forces at Basemat Section A for Hydrostatic Load

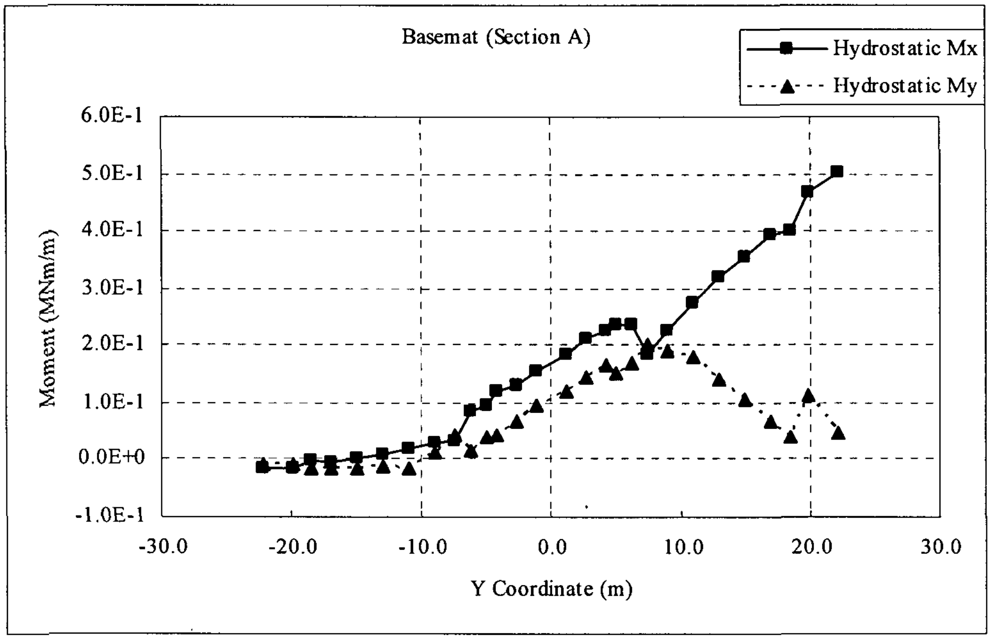


Figure 5-207 Moments at Basemat Section A for Hydrostatic Load

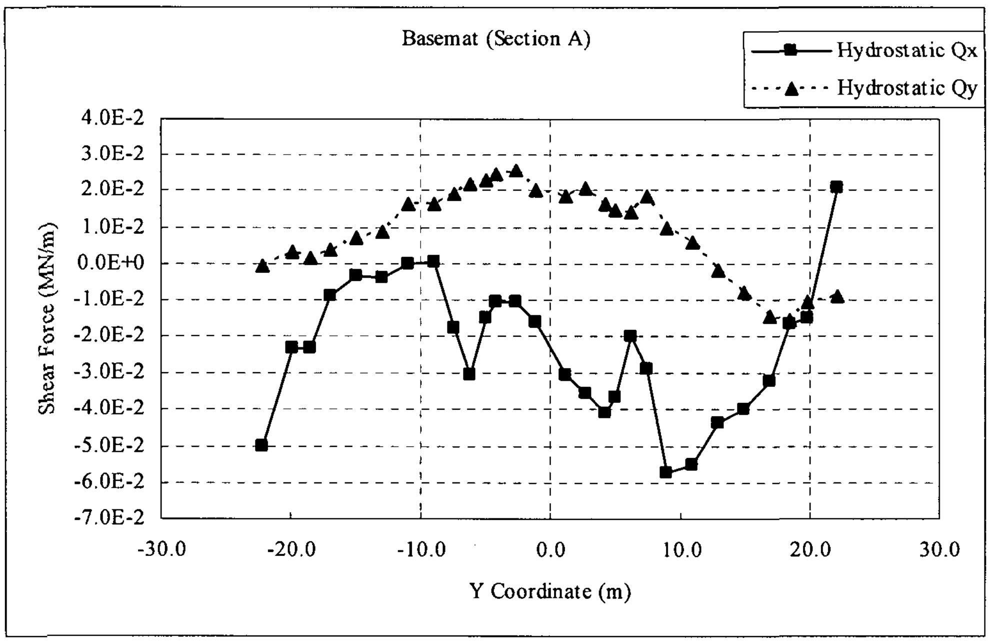


Figure 5-208 Shear Forces at Basemat Section A for Hydrostatic Load

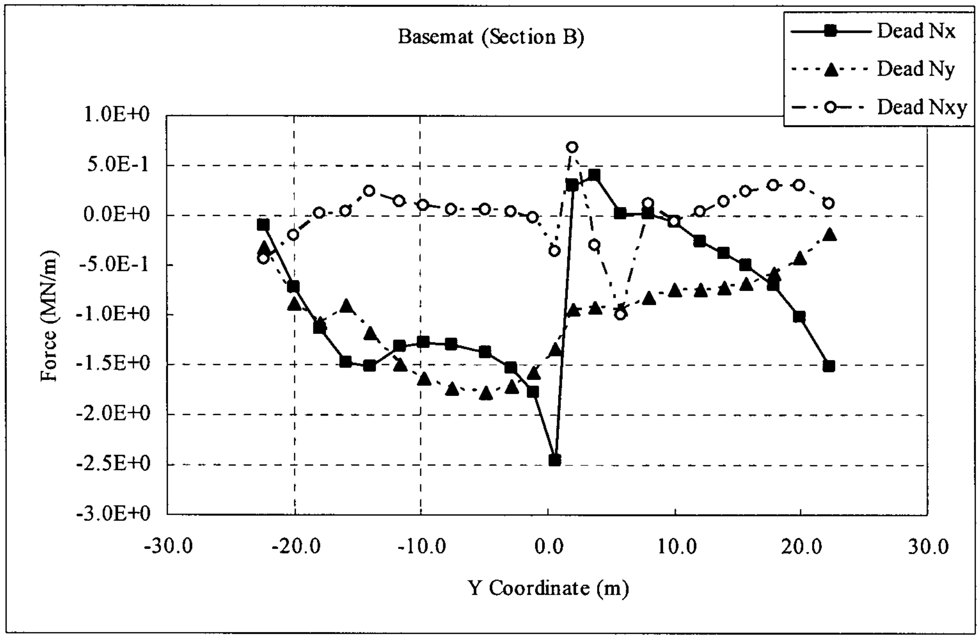


Figure 5-209 Axial Forces at Basemat Section B for Dead Load

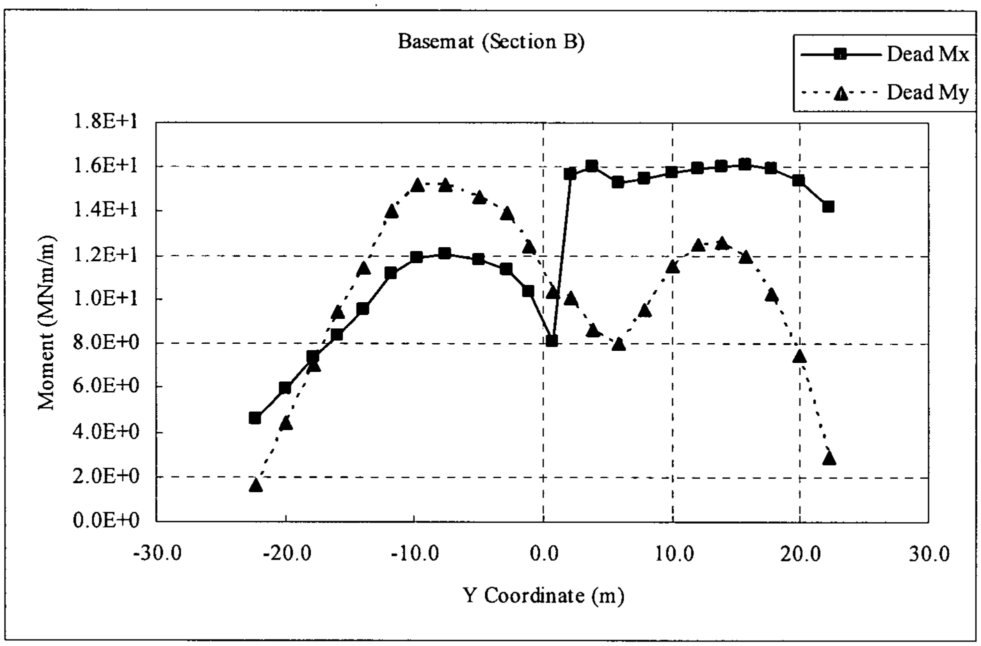


Figure 5-210 Moments at Basemat Section B for Dead Load

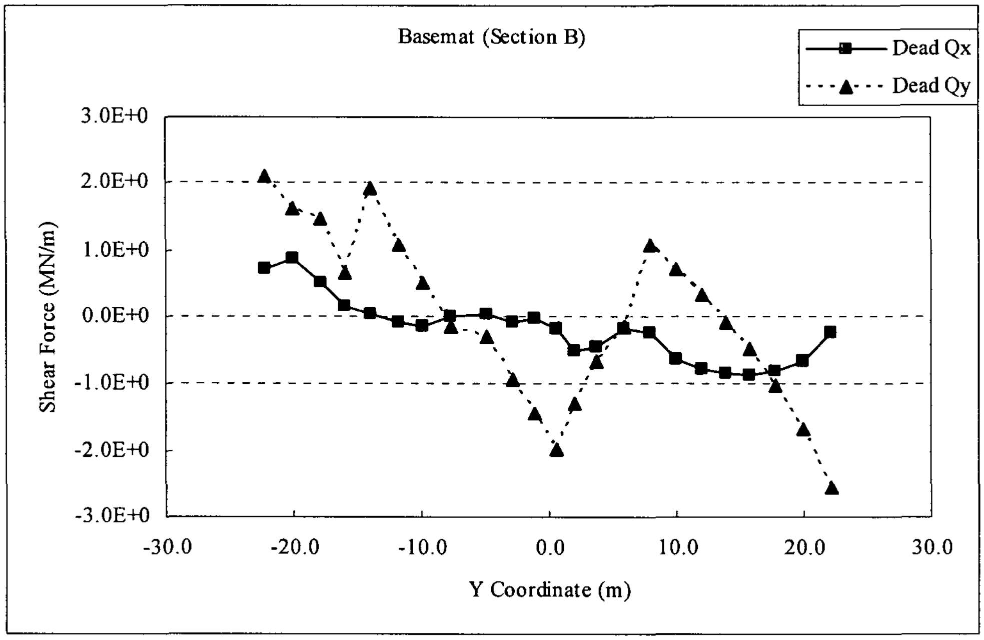


Figure 5-211 Shear Forces at Basemat Section B for Dead Load

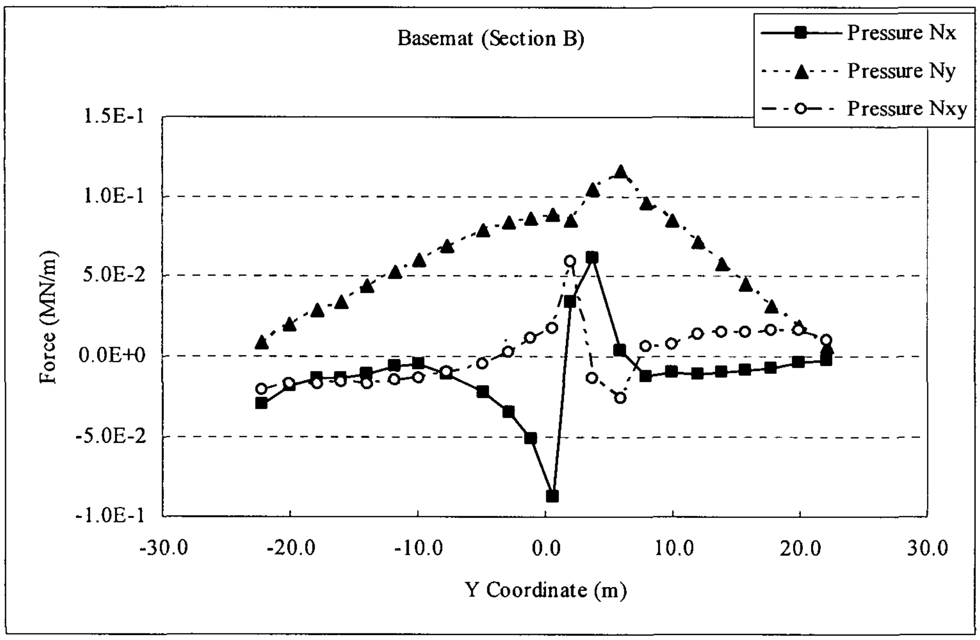


Figure 5-212 Axial Forces at Basemat Section B for Pressure Load

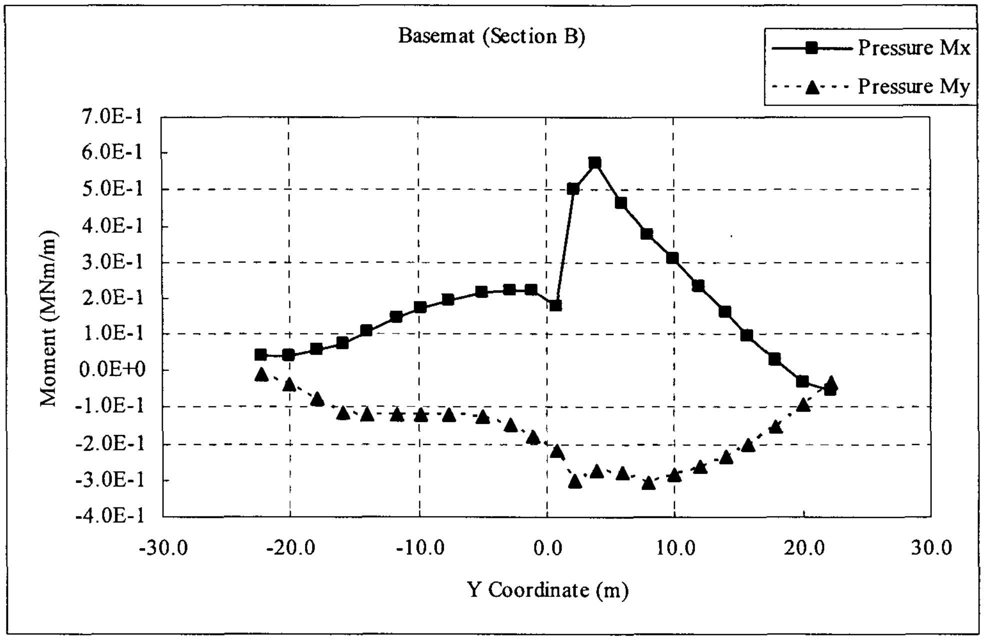


Figure 5-213 Moments at Basemat Section B for Pressure Load

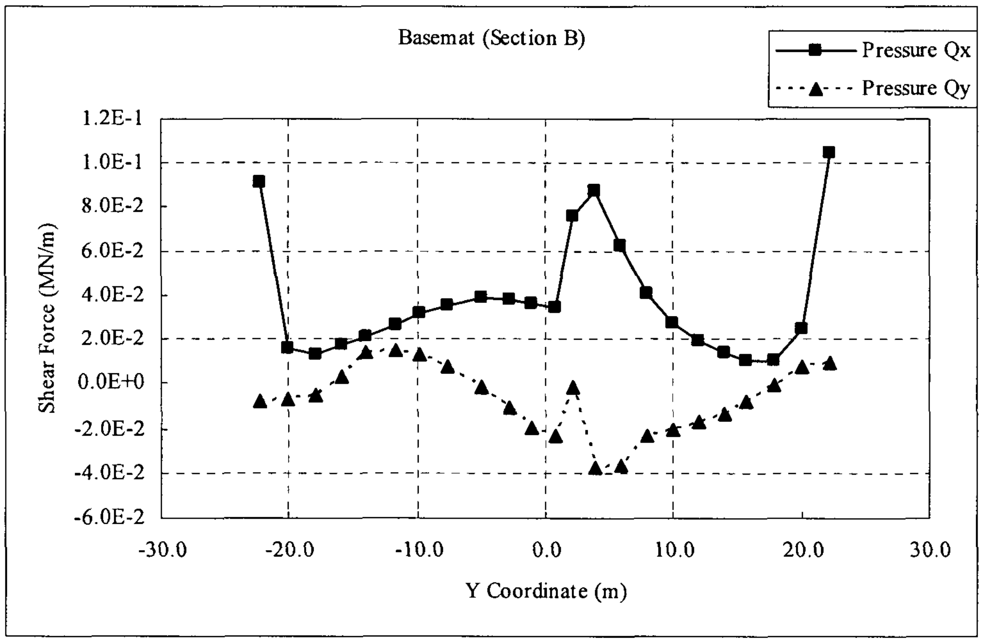


Figure 5-214 Shear Forces at Basemat Section B for Pressure Load

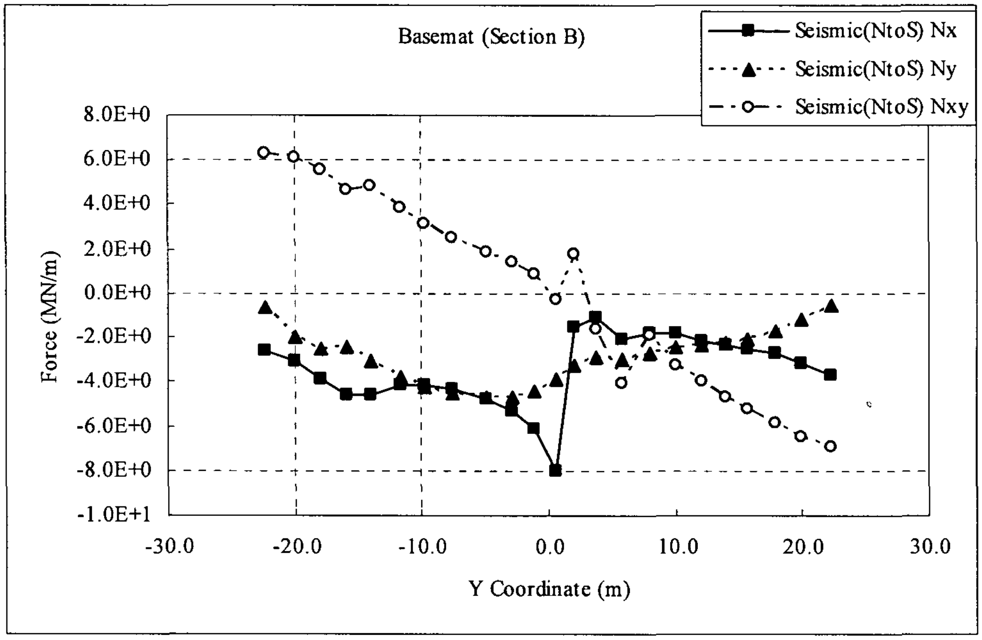


Figure 5-215 Axial Forces at Basemat Section B for Seismic Load (N to S)

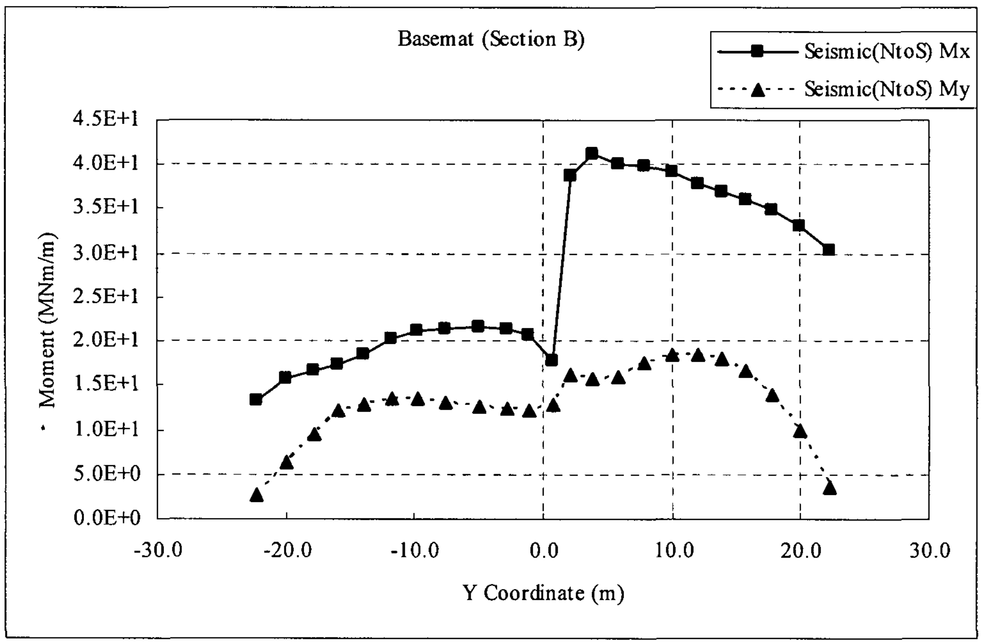


Figure 5-216 Moments at Basemat Section B for Seismic Load (N to S)

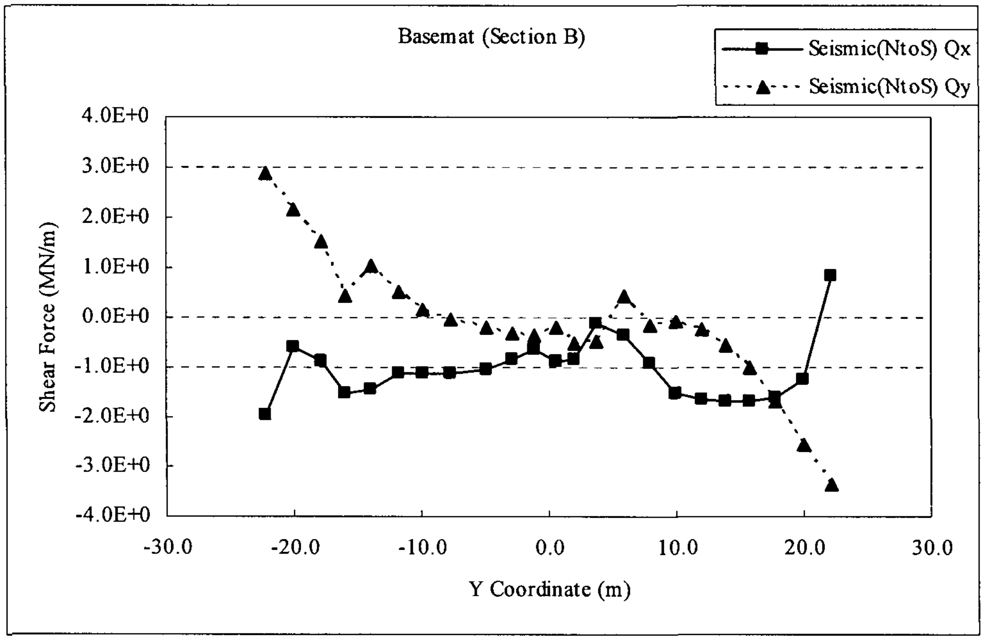


Figure 5-217 Shear Forces at Basemat Section B for Seismic Load (N to S)

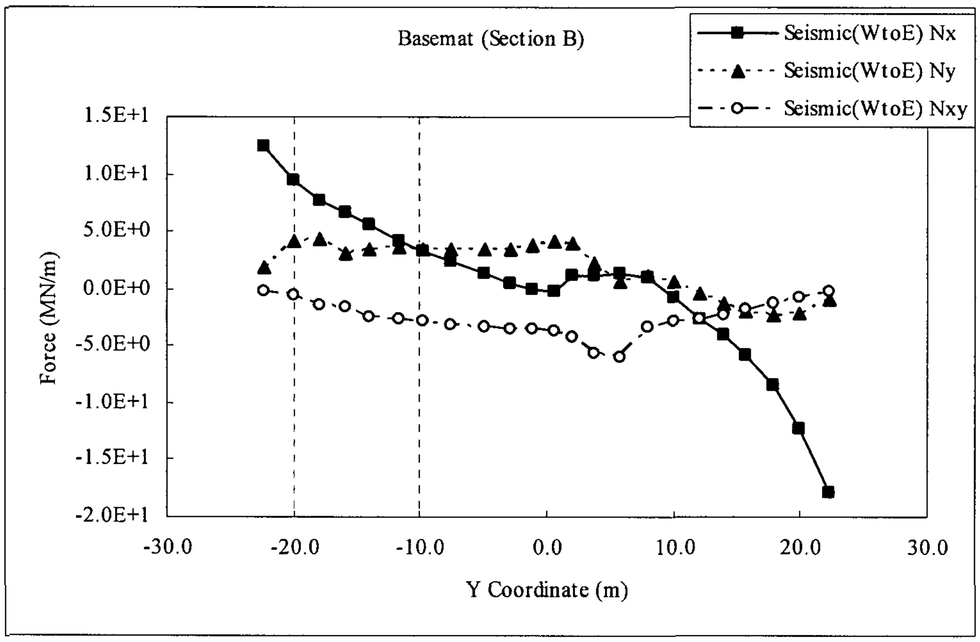


Figure 5-218 Axial Forces at Basemat Section B for Seismic Load (W to E)

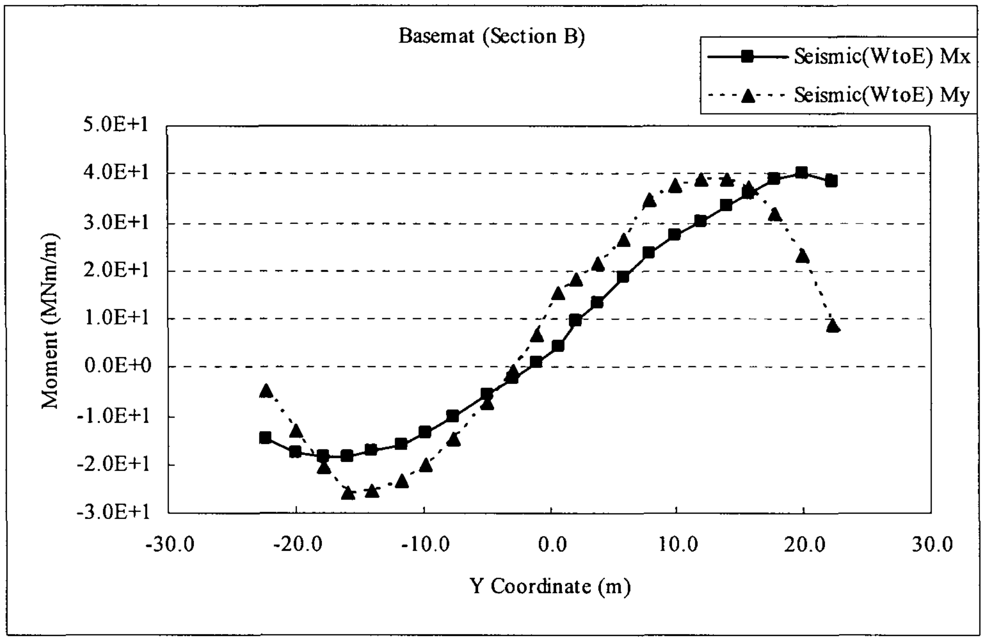


Figure 5-219 Moments at Basemat Section B for Seismic Load (W to E)

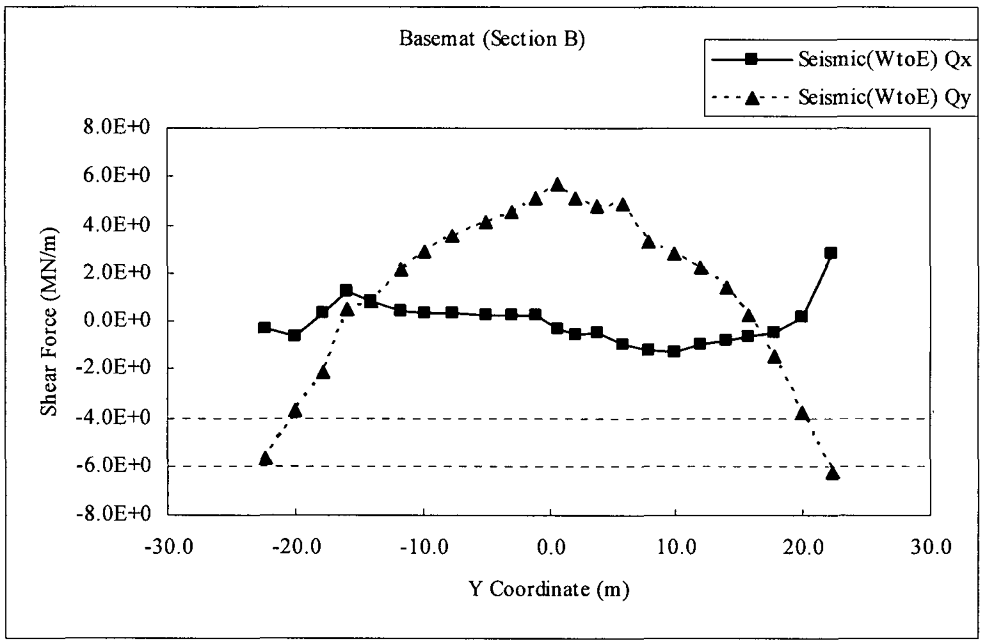


Figure 5-220 Shear Forces at Basemat Section B for Seismic Load (W to E)

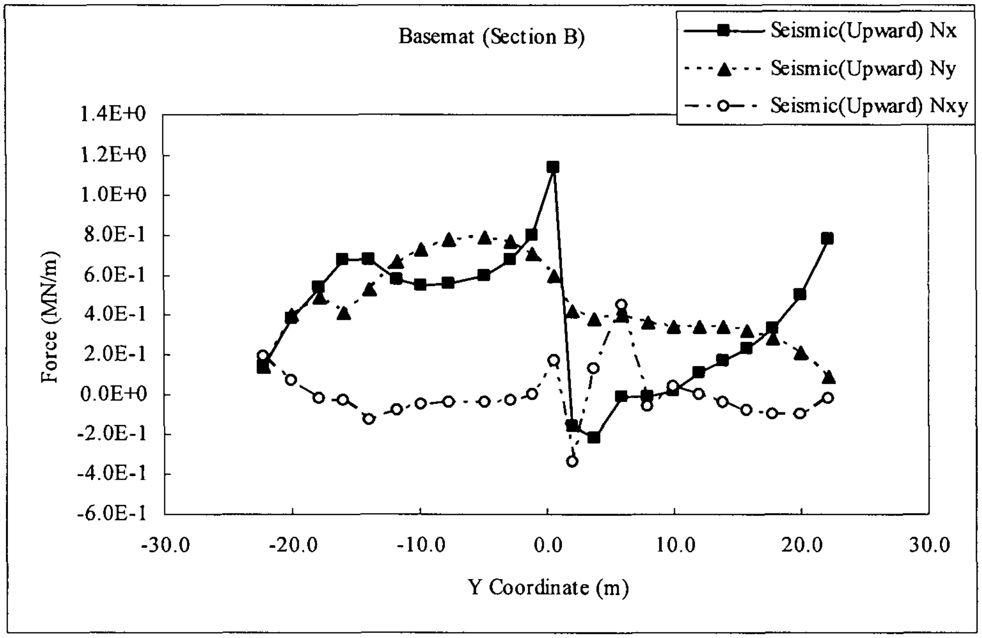


Figure 5-221 Axial Forces at Basemat Section B for Seismic Load (Vertical; Upward)

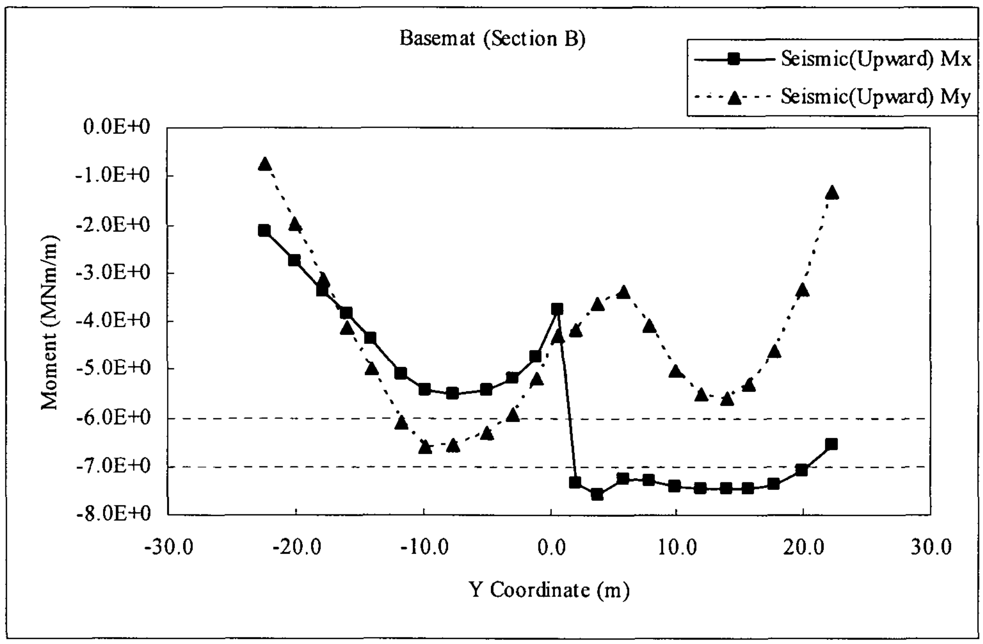


Figure 5-222 Moments at Basemat Section B for Seismic Load (Vertical; Upward)

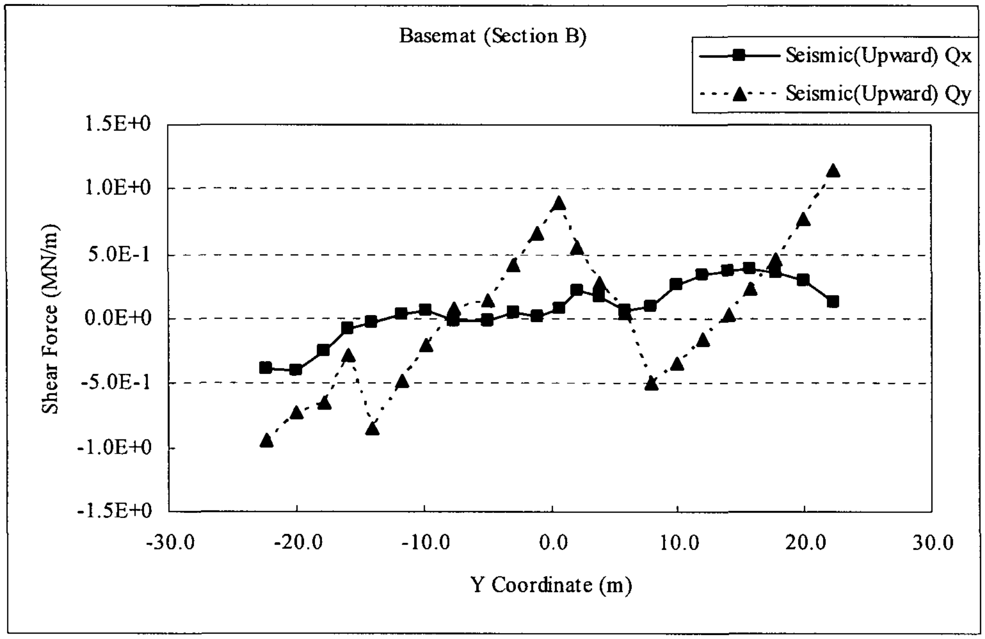


Figure 5-223 Shear Forces at Basemat Section B for Seismic Load (Vertical; Upward)

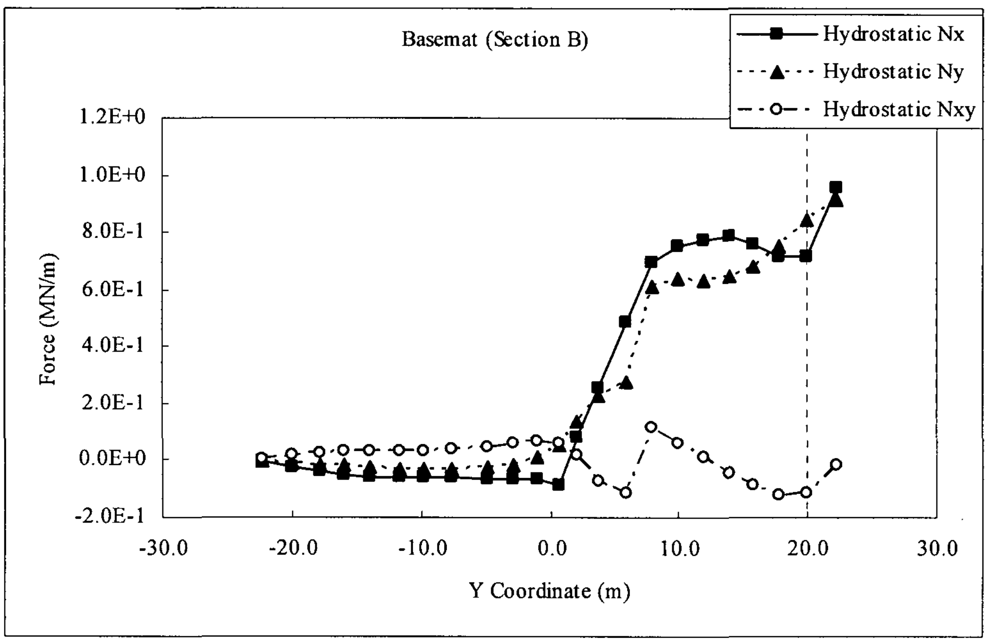


Figure 5-224 Axial Forces at Basemat Section B for Hydrostatic Load

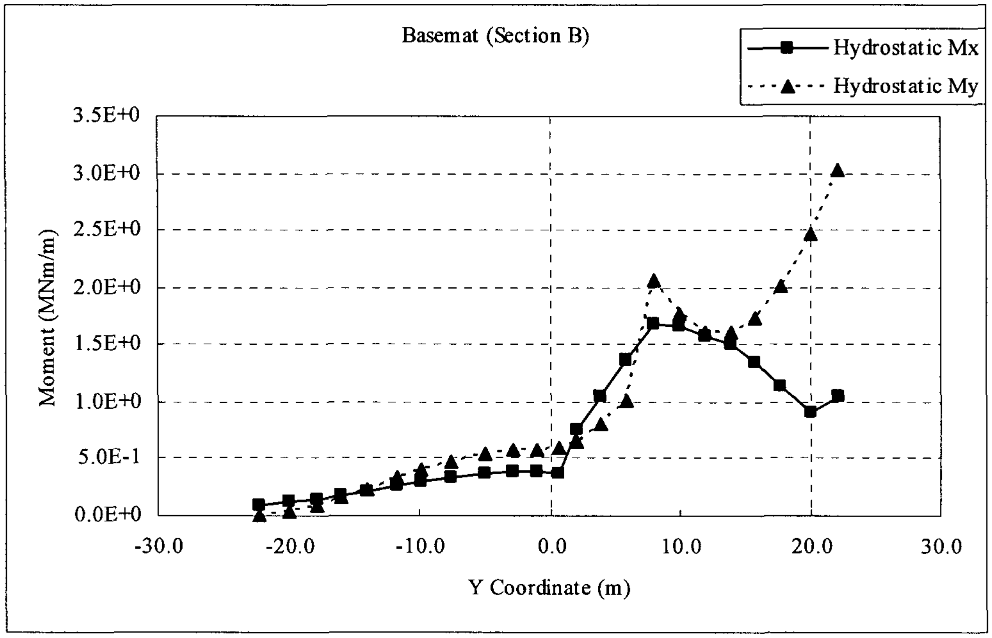


Figure 5-225 Moments at Basemat Section B for Hydrostatic Load

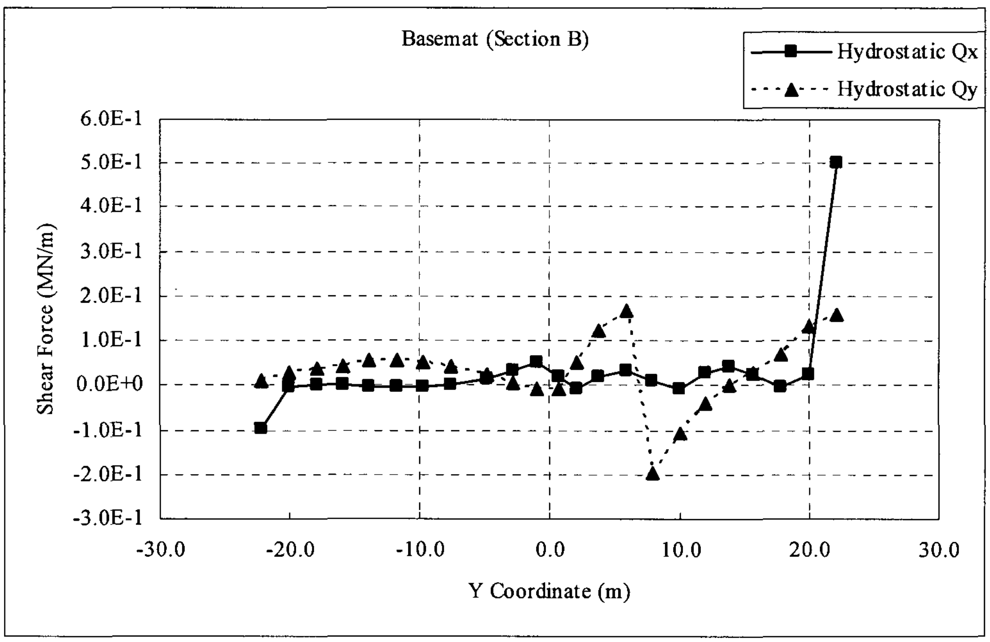


Figure 5-226 Shear Forces at Basemat Section B for Hydrostatic Load

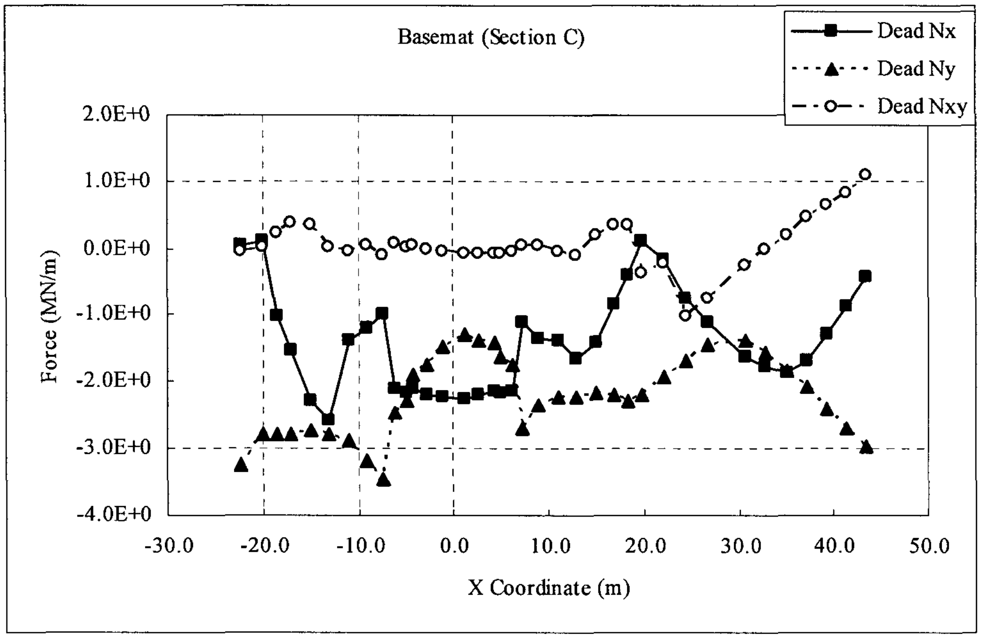


Figure 5-227 Axial Forces at Basemat Section C for Dead Load

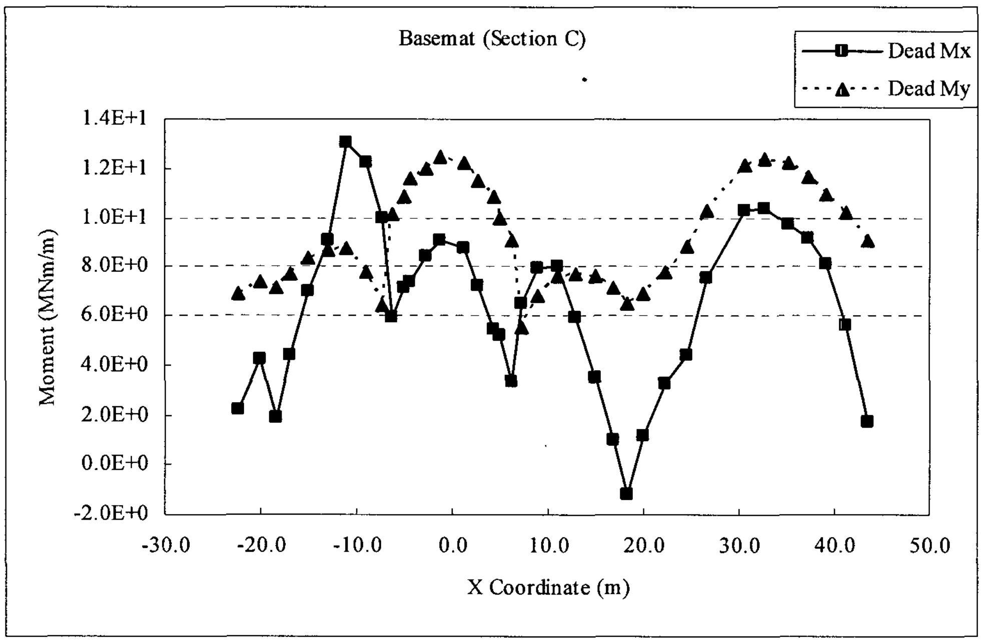


Figure 5-228 Moments at Basemat Section C for Dead Load

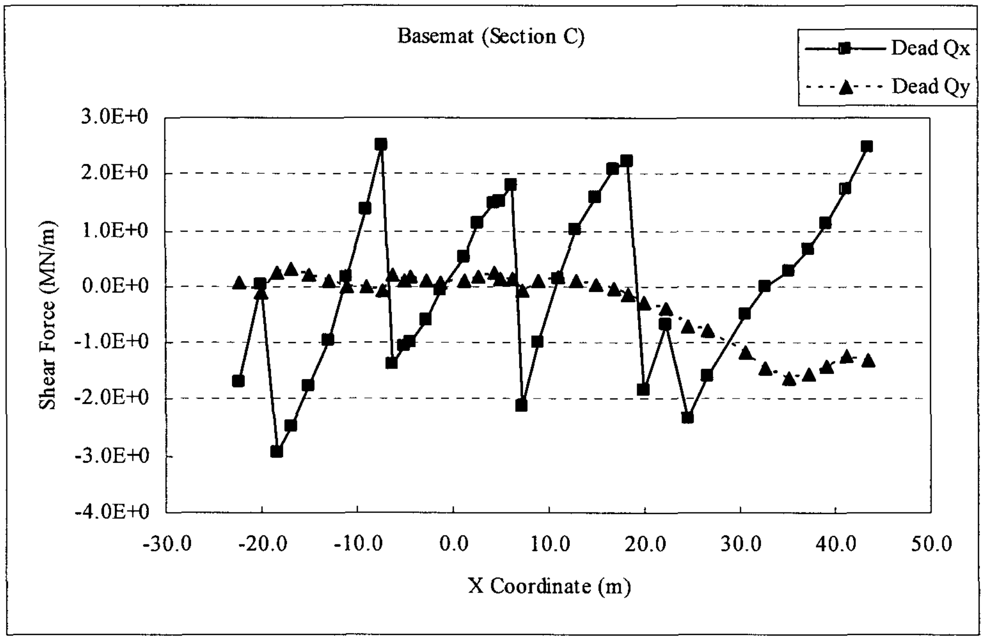


Figure 5-229 Shear Forces at Basemat Section C for Dead Load

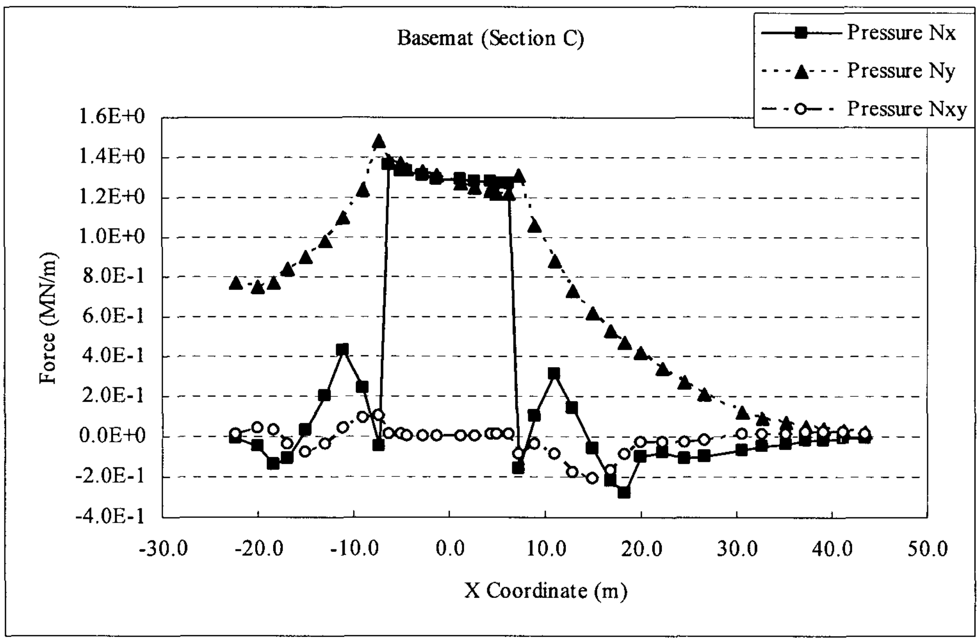


Figure 5-230 Axial Forces at Basemat Section C for Pressure Load

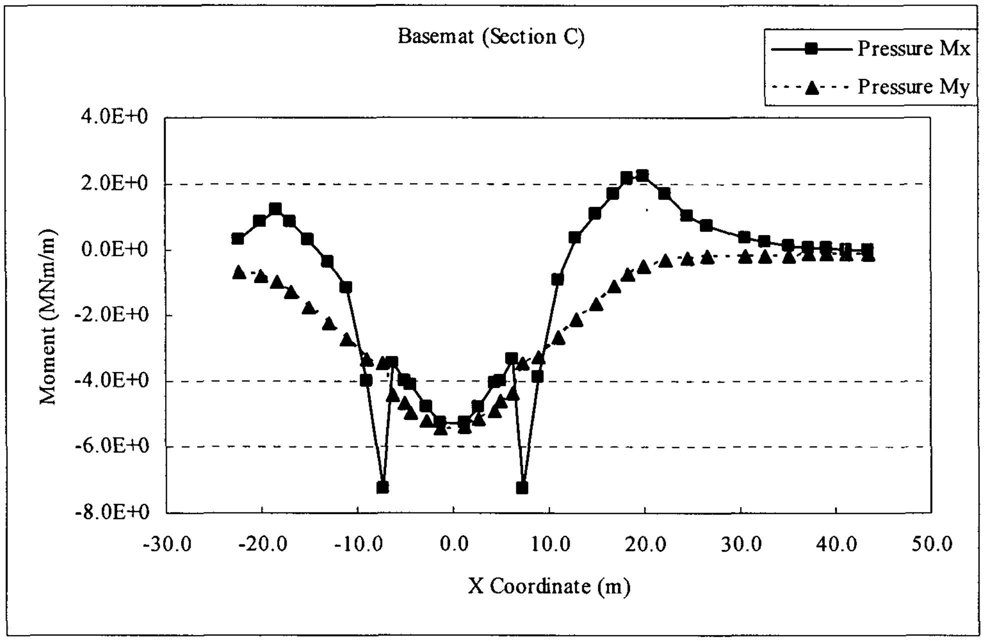


Figure 5-231 Moments at Basemat Section C for Pressure Load

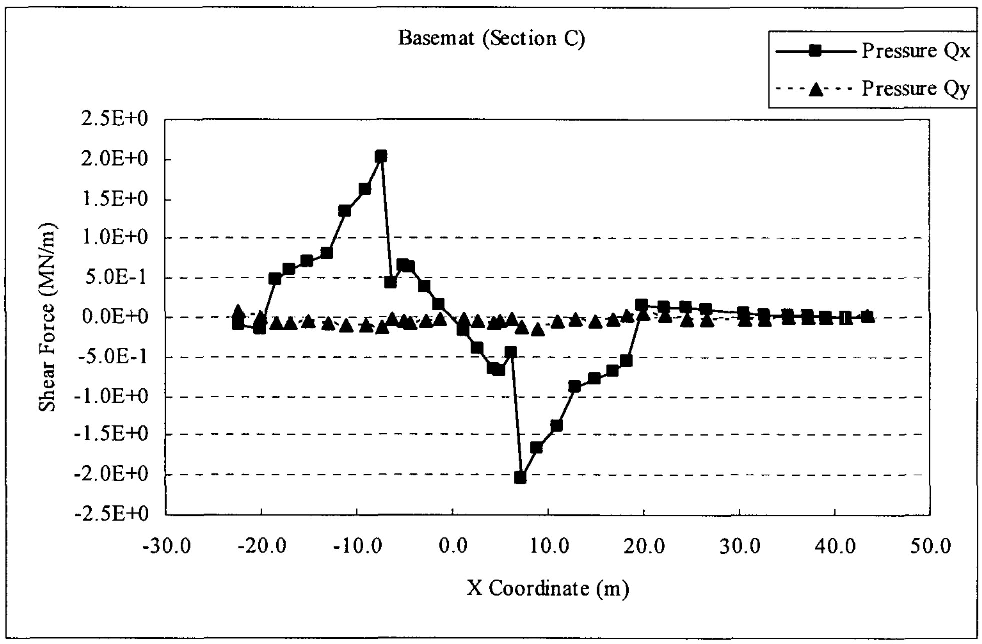


Figure 5-232 Shear Forces at Basemat Section C for Pressure Load

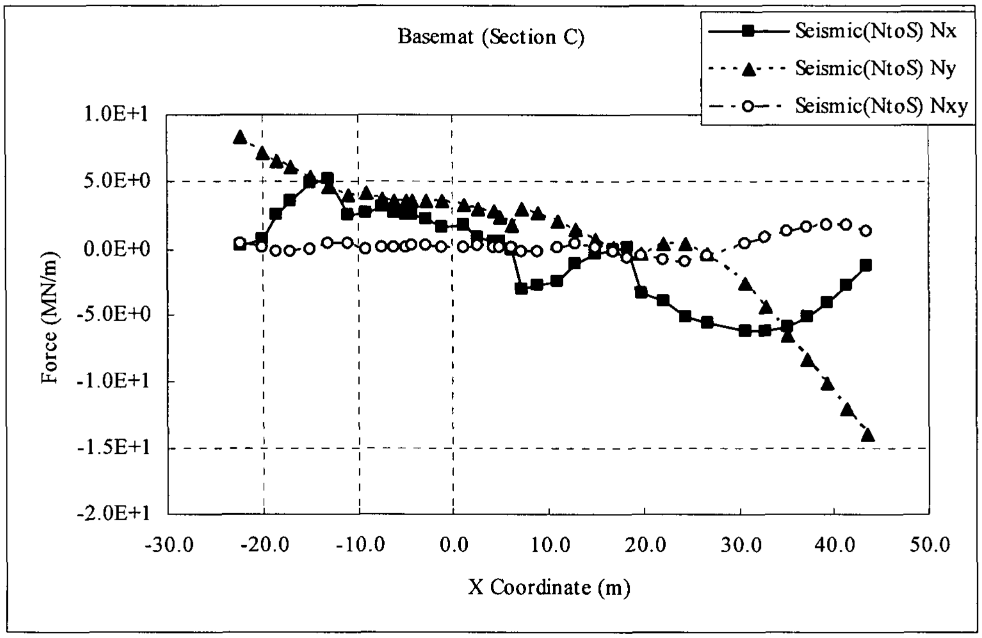


Figure 5-233 Axial Forces at Basemat Section C for Seismic Load (N to S)

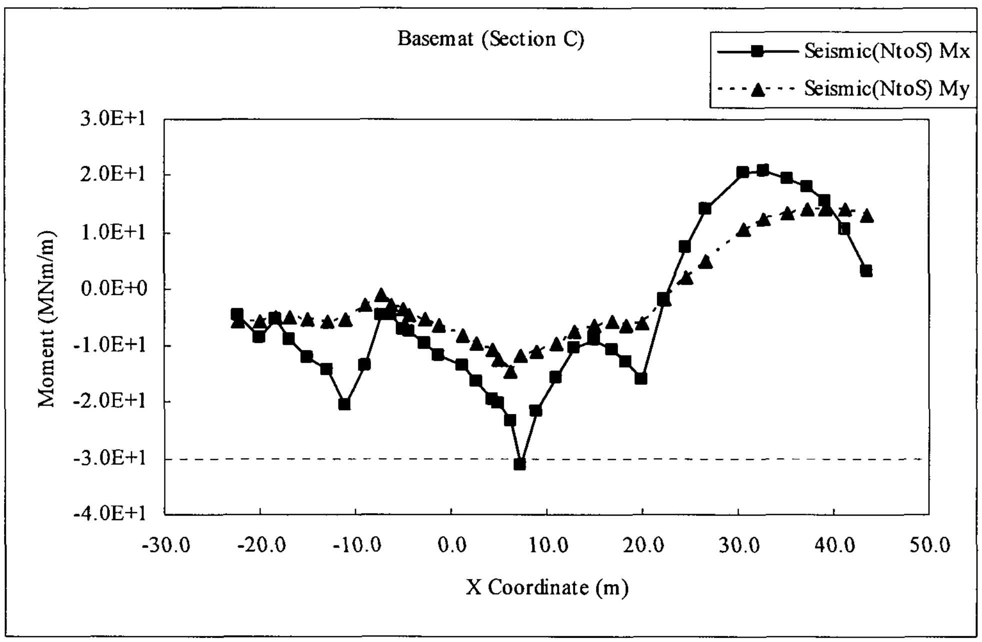


Figure 5-234 Moments at Basemat Section C for Seismic Load (N to S)

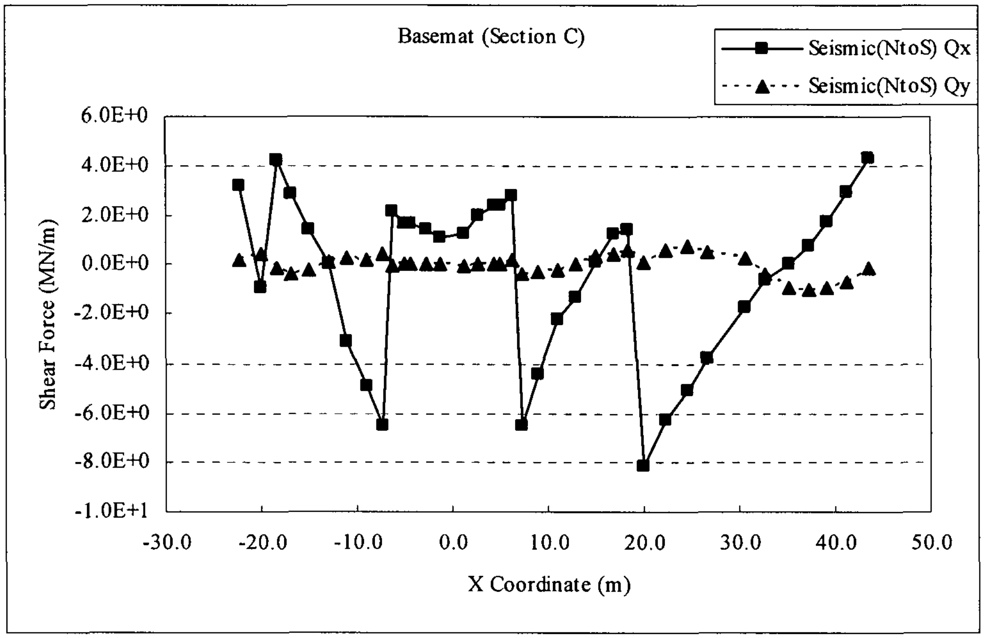


Figure 5-235 Shear Forces at Basemat Section C for Seismic Load (N to S)

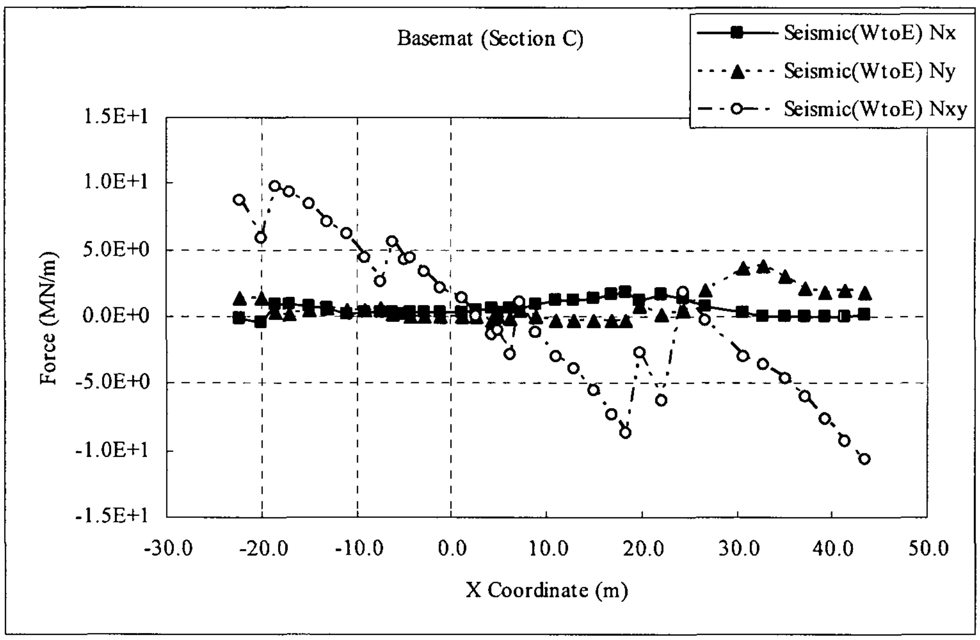


Figure 5-236 Axial Forces at Basemat Section C for Seismic Load (W to E)

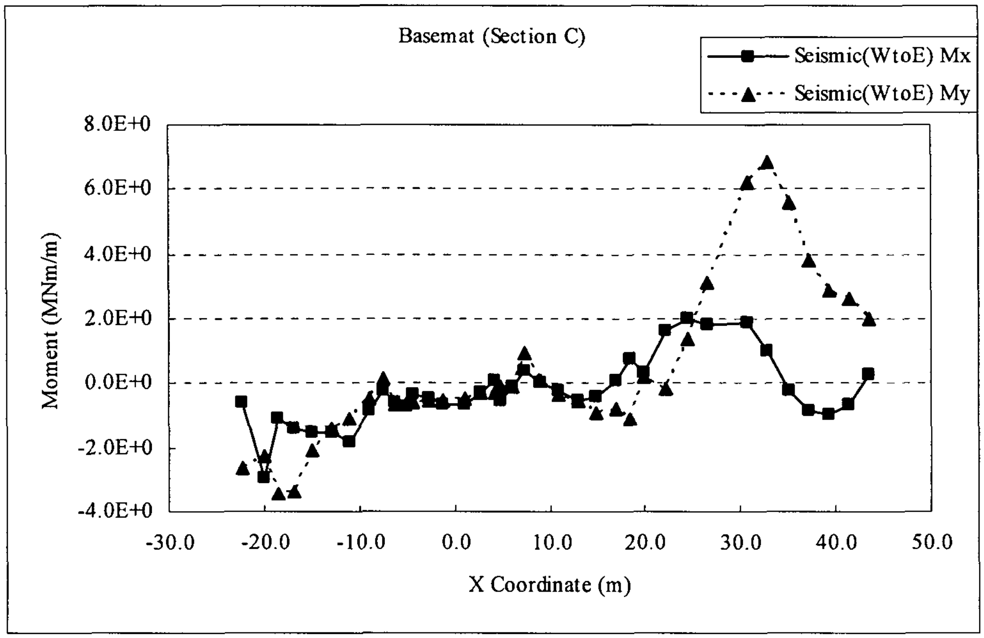


Figure 5-237 Moments at Basemat Section C for Seismic Load (W to E)

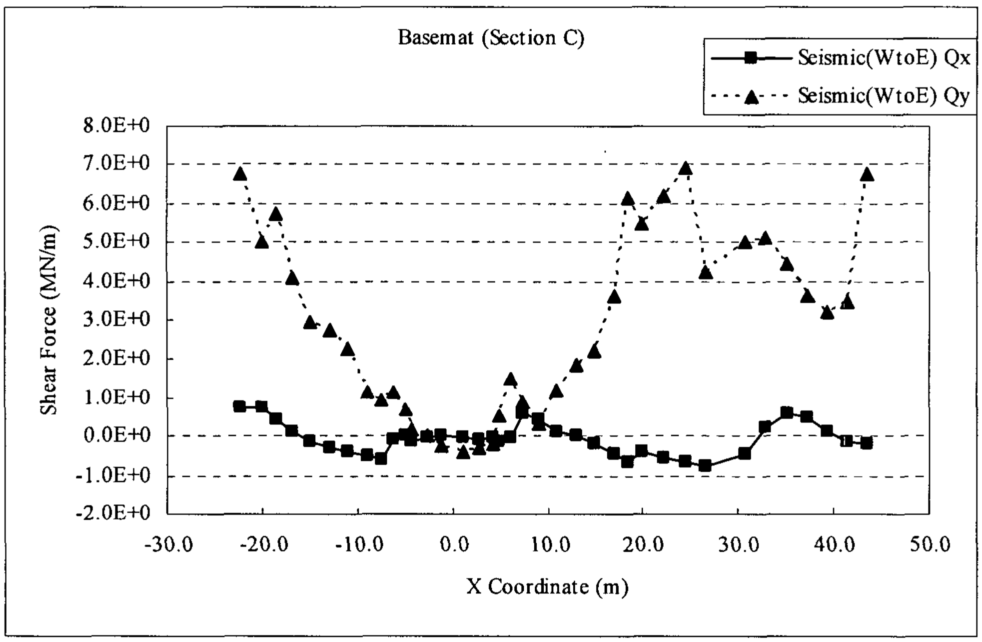


Figure 5-238 Shear Forces at Basemat Section C for Seismic Load (W to E)

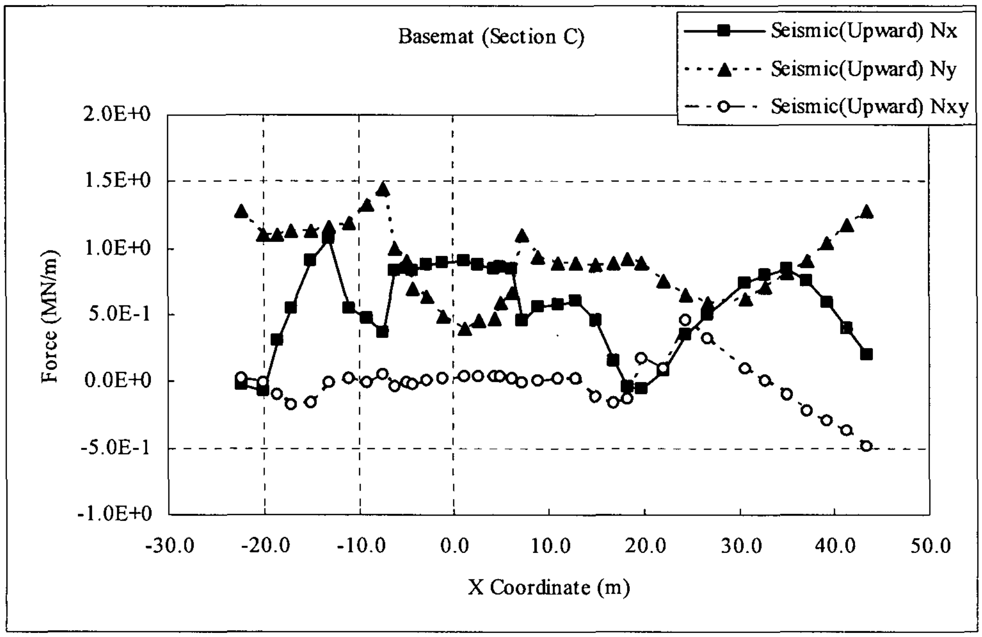


Figure 5-239 Axial Forces at Basemat Section C for Seismic Load (Vertical; Upward)

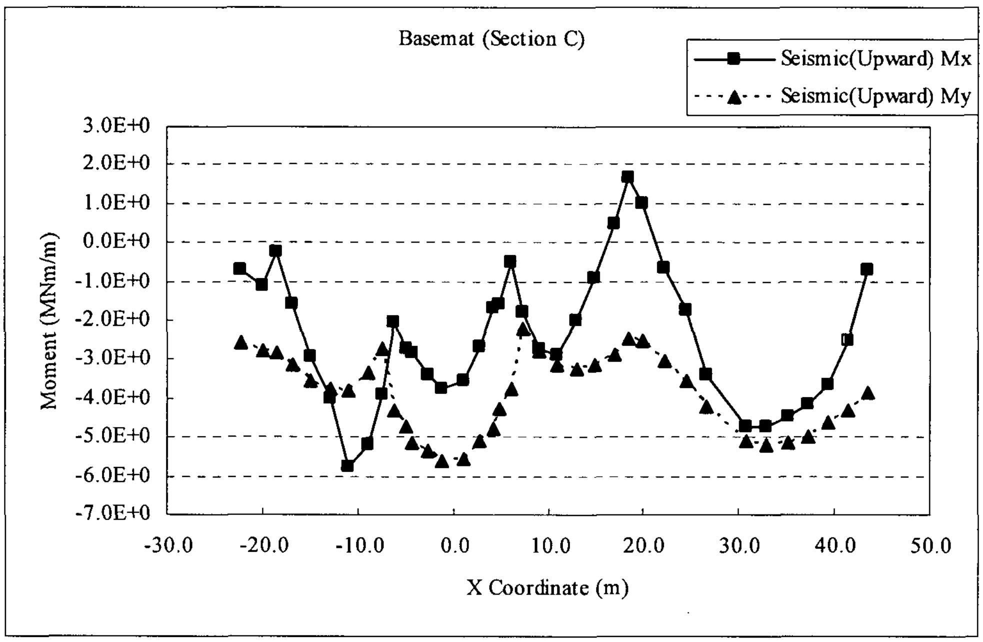


Figure 5-240 Moments at Basemat Section C for Seismic Load (Vertical; Upward)

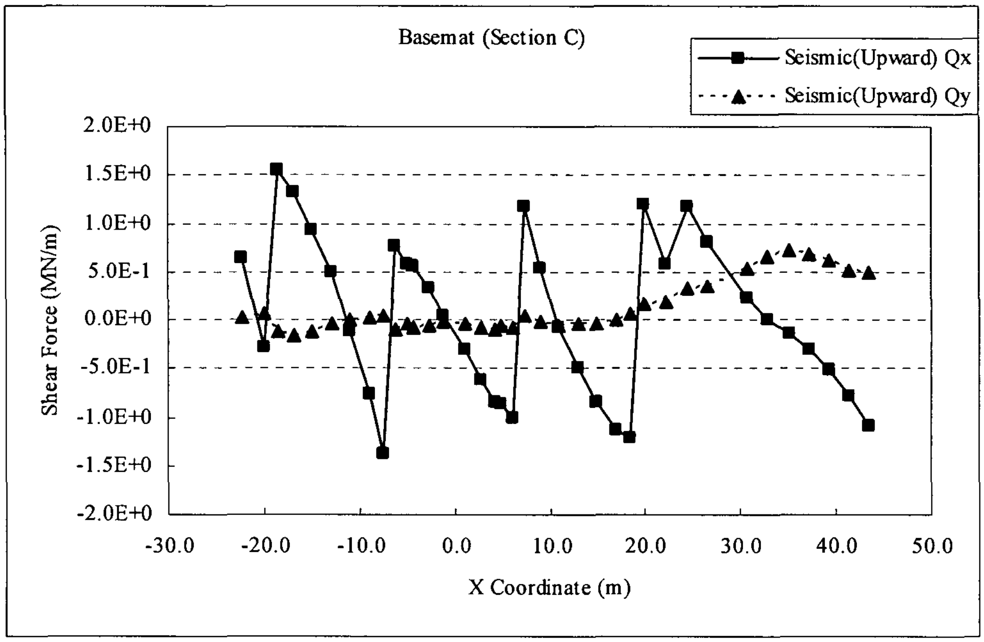


Figure 5-241 Shear Forces at Basemat Section C for Seismic Load (Vertical; Upward)

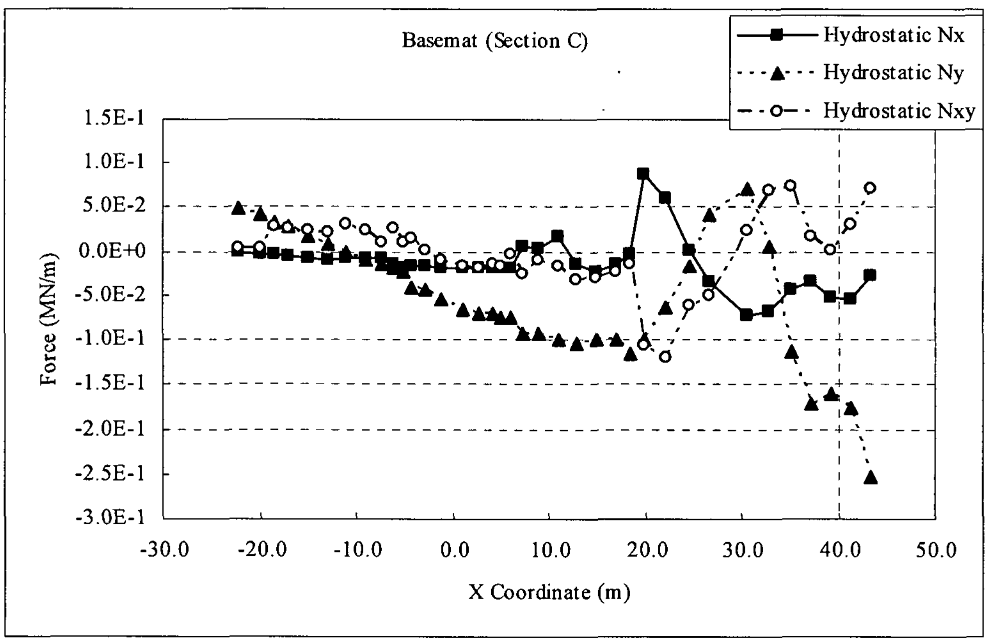


Figure 5-242 Axial Forces at Basemat Section C for Hydrostatic Load

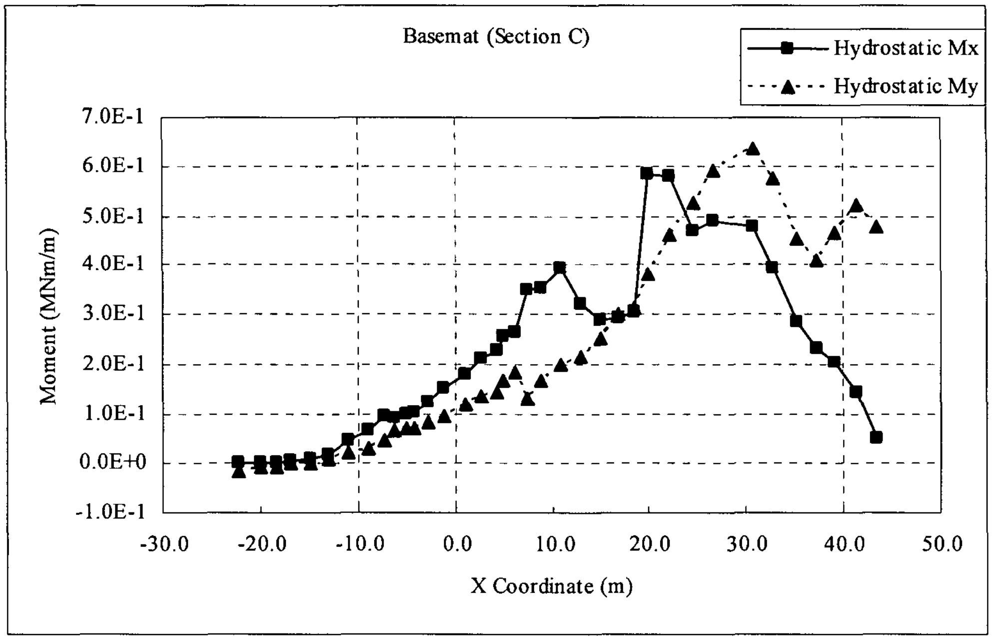


Figure 5-243 Moments at Basemat Section C for Hydrostatic Load

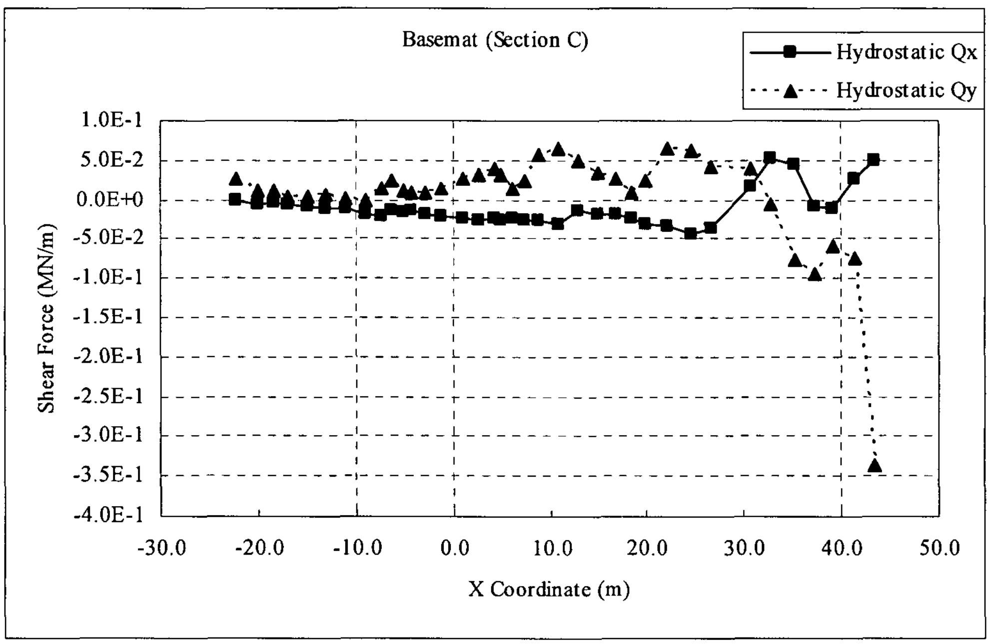
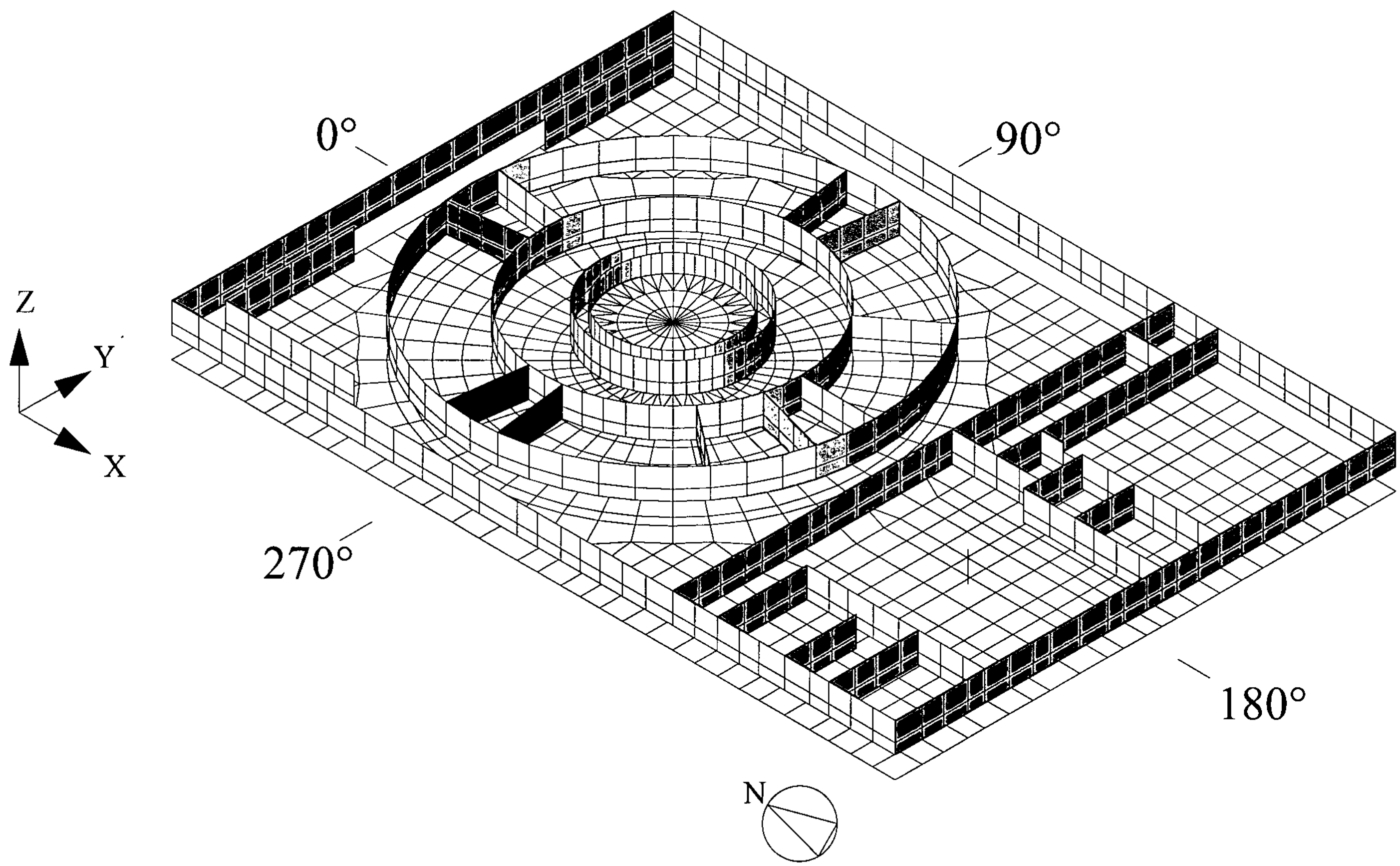
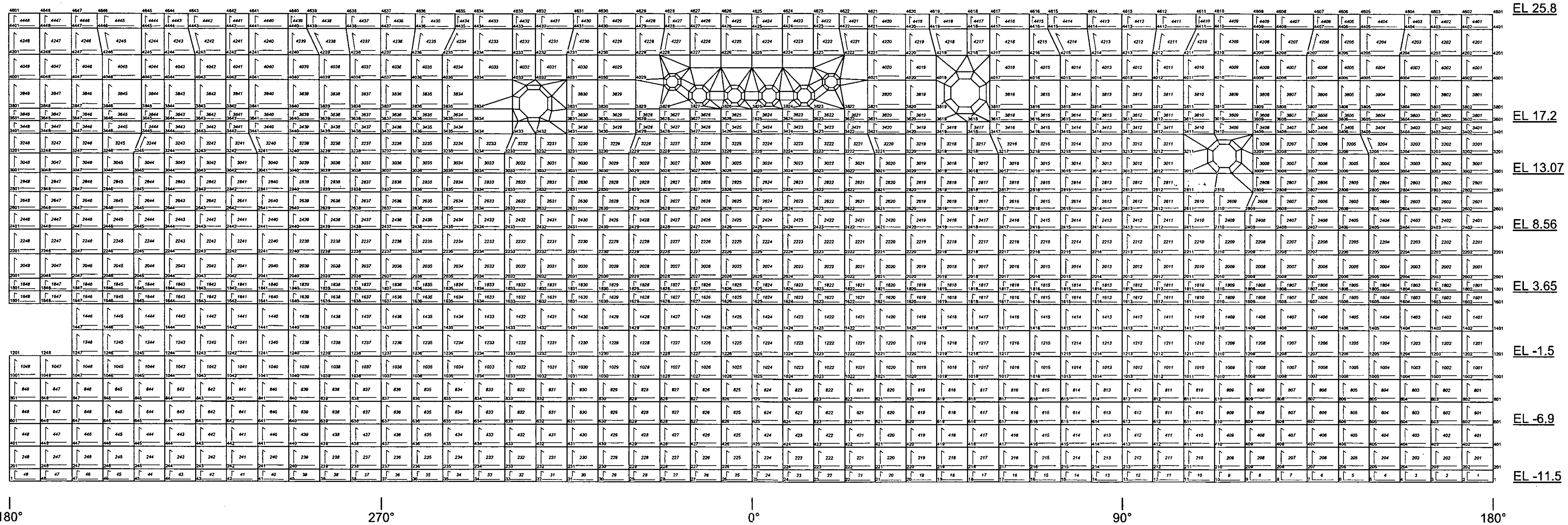


Figure 5-244 Shear Forces at Basemat Section C for Hydrostatic Load

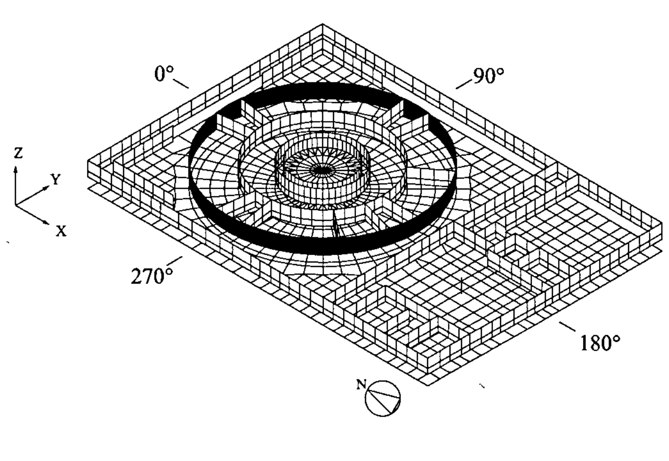
Appendix A Figures of Analysis Model



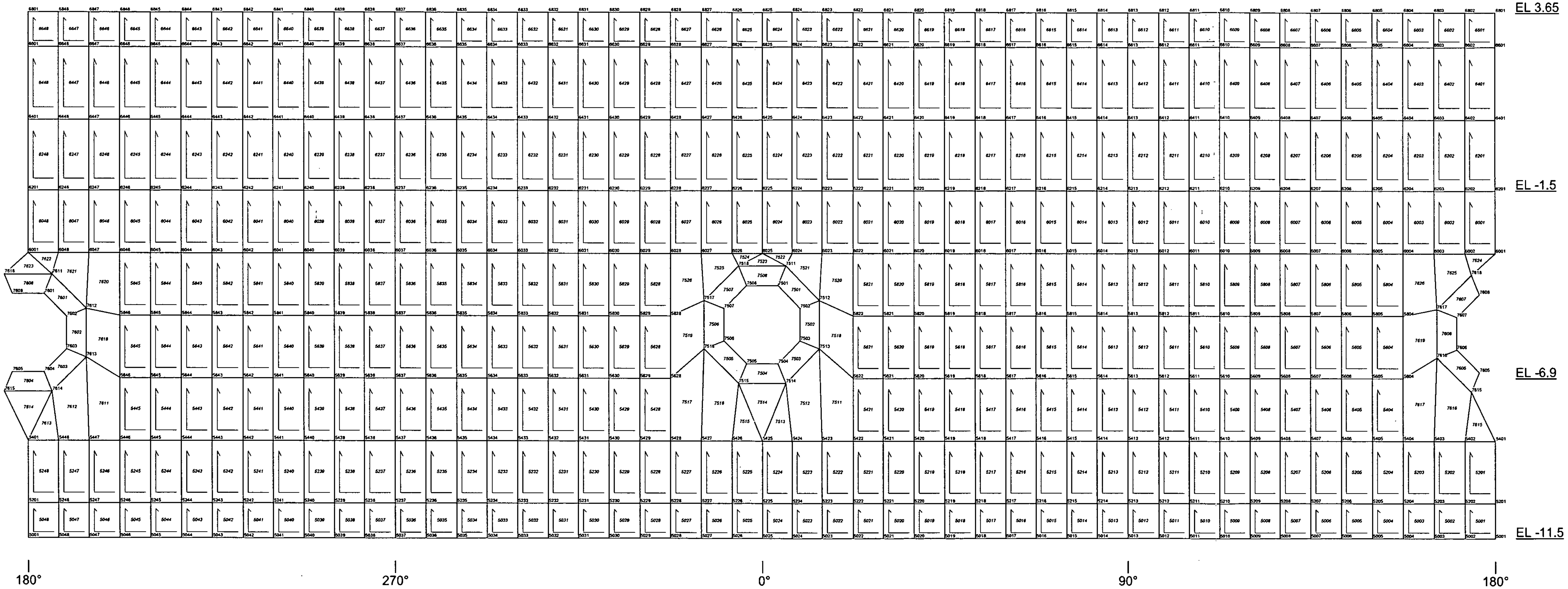
Modified Truncated Model



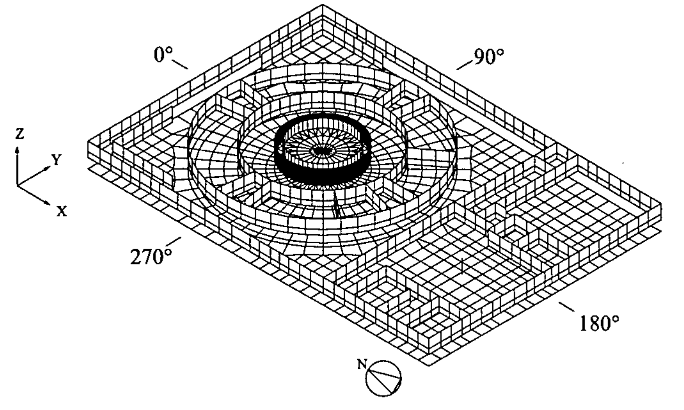
View: from Inside to Outside



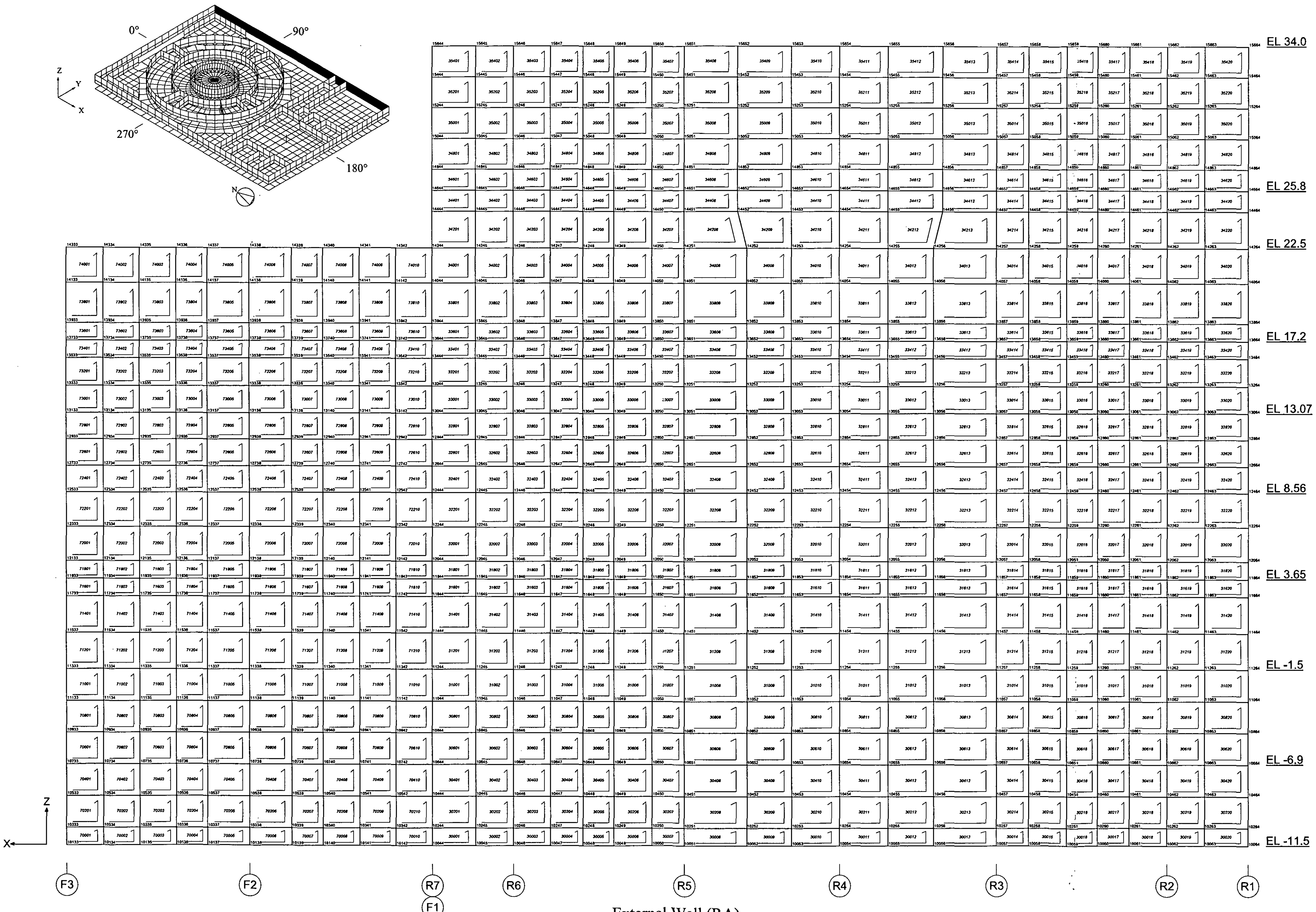
RCCV & Cylinder Wall below RCCV



View: from Inside to Outside

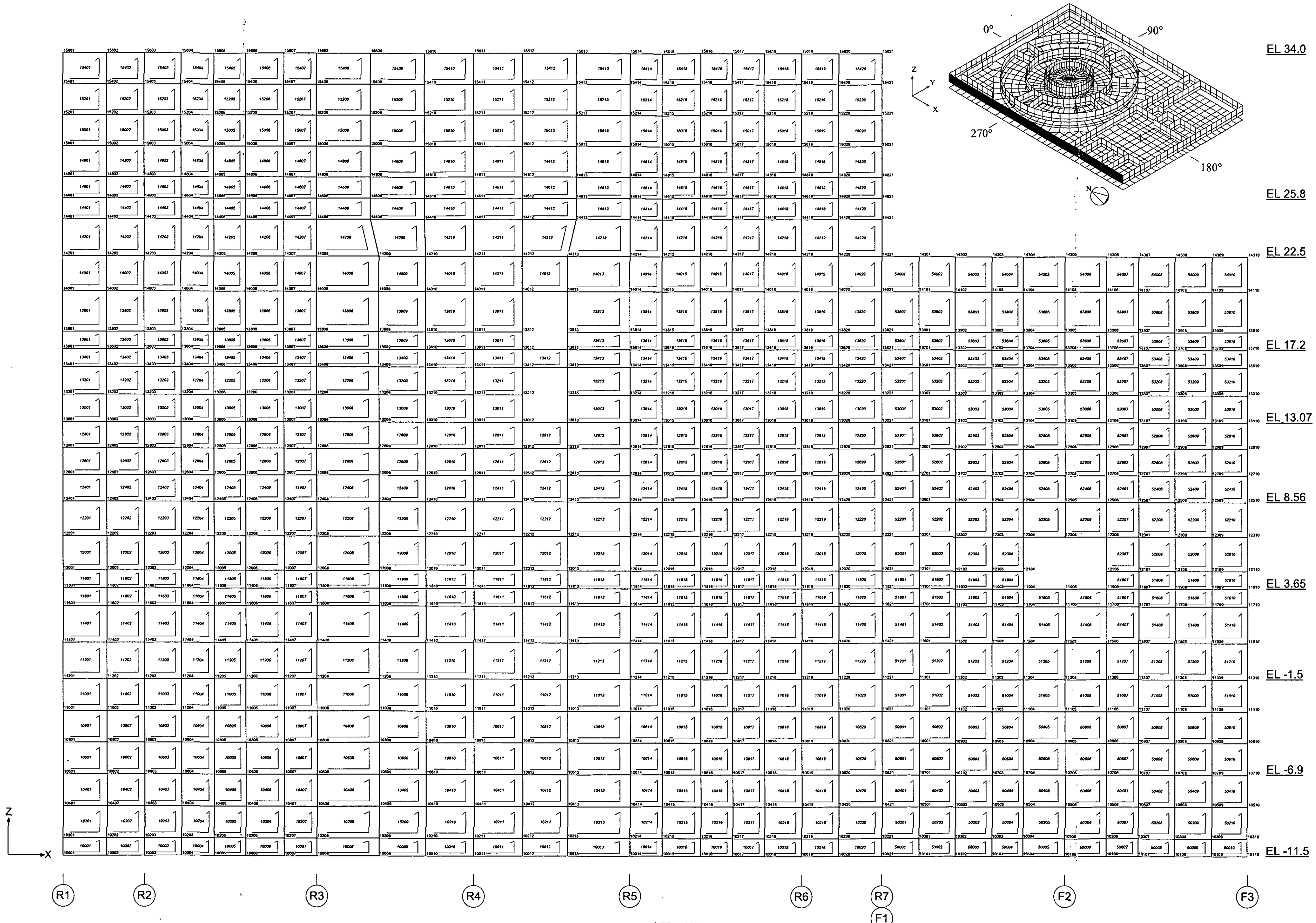


RPV Pedestal



External Wall (RA)

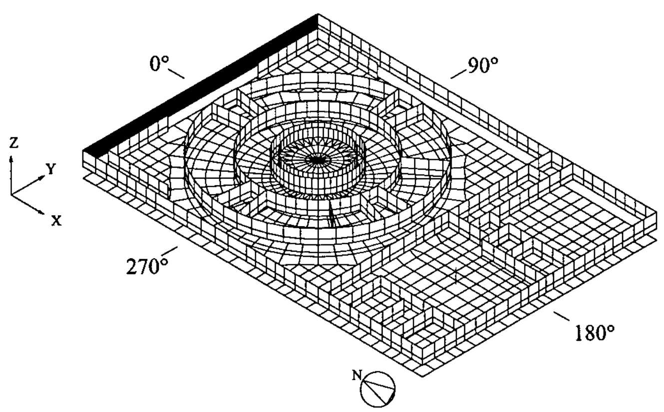
View: from Outside (East) to Inside (West)

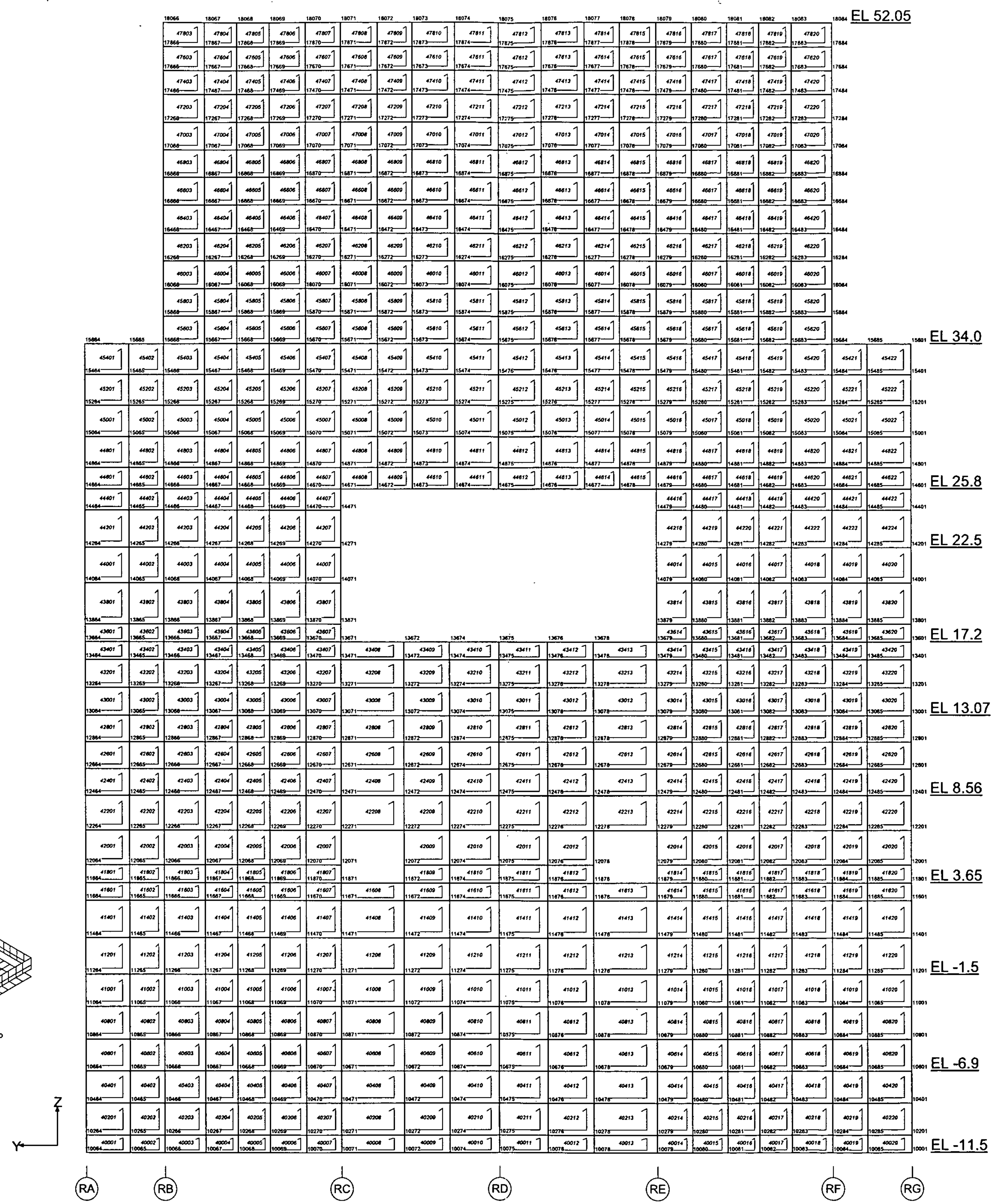


External Wall (RG)

A-5

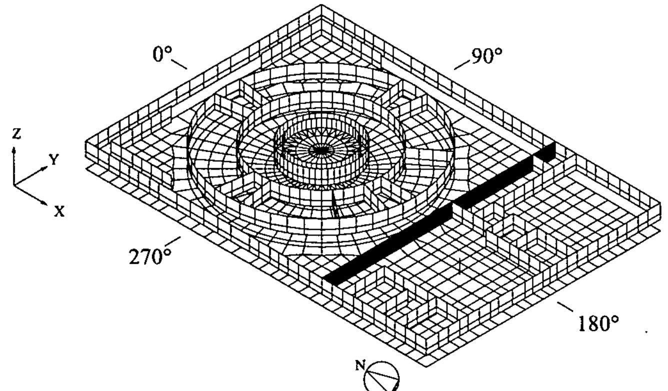
View: from Outside (West) to Inside (East)

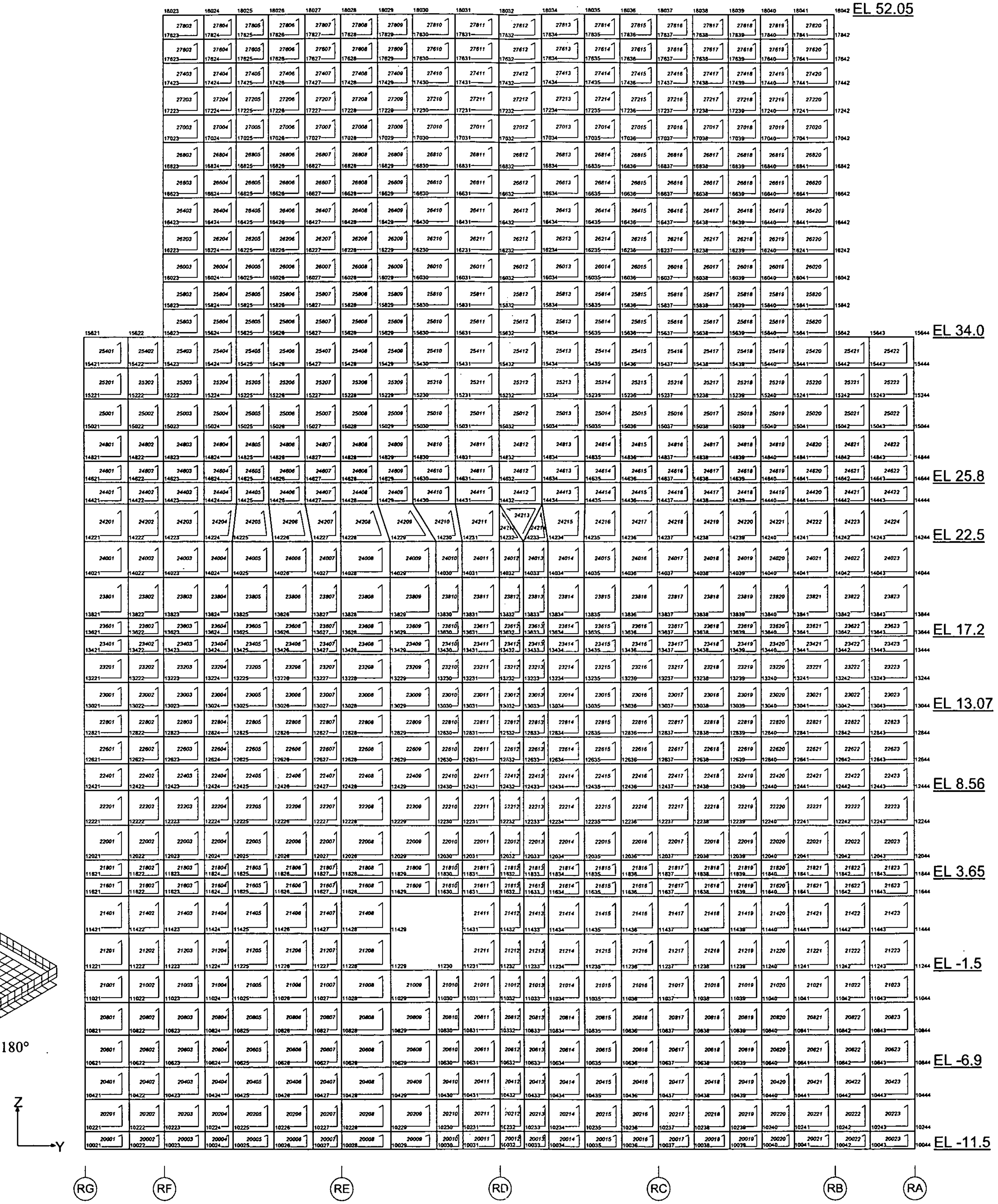




View: from Outside (North) to Inside (South)

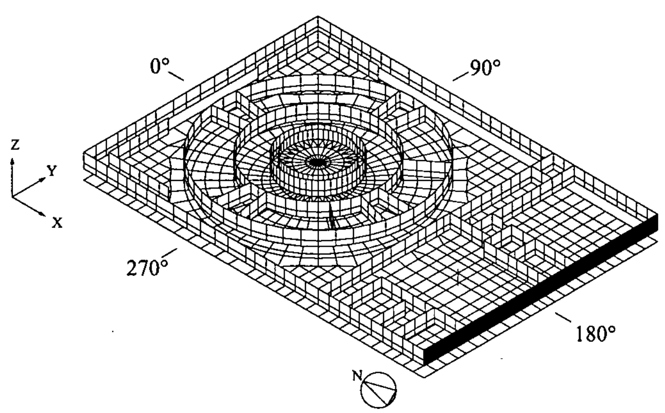
External Wall (R1)
A-6

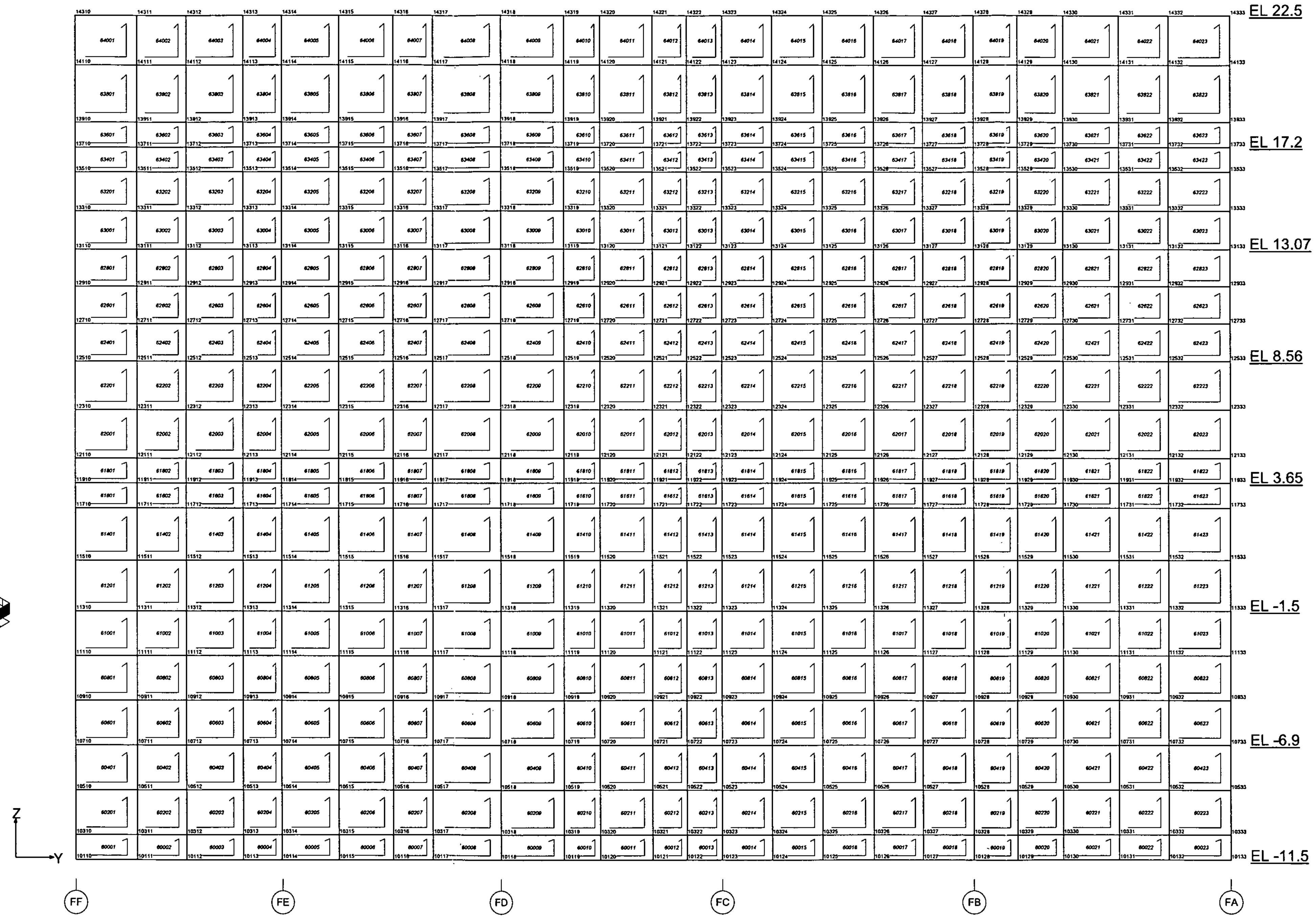




View: from FB (South) to RB (North)

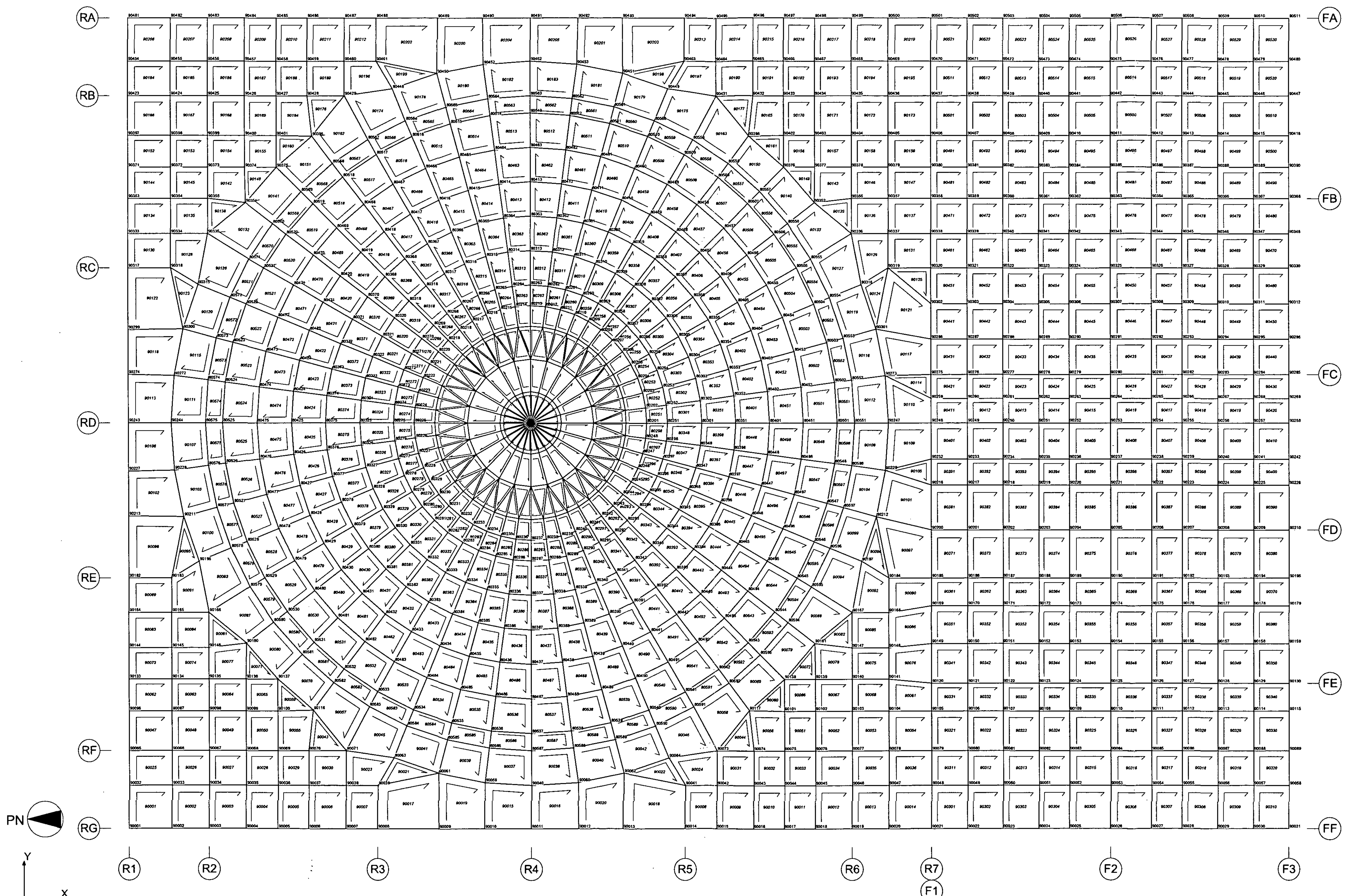
External Wall (R7)



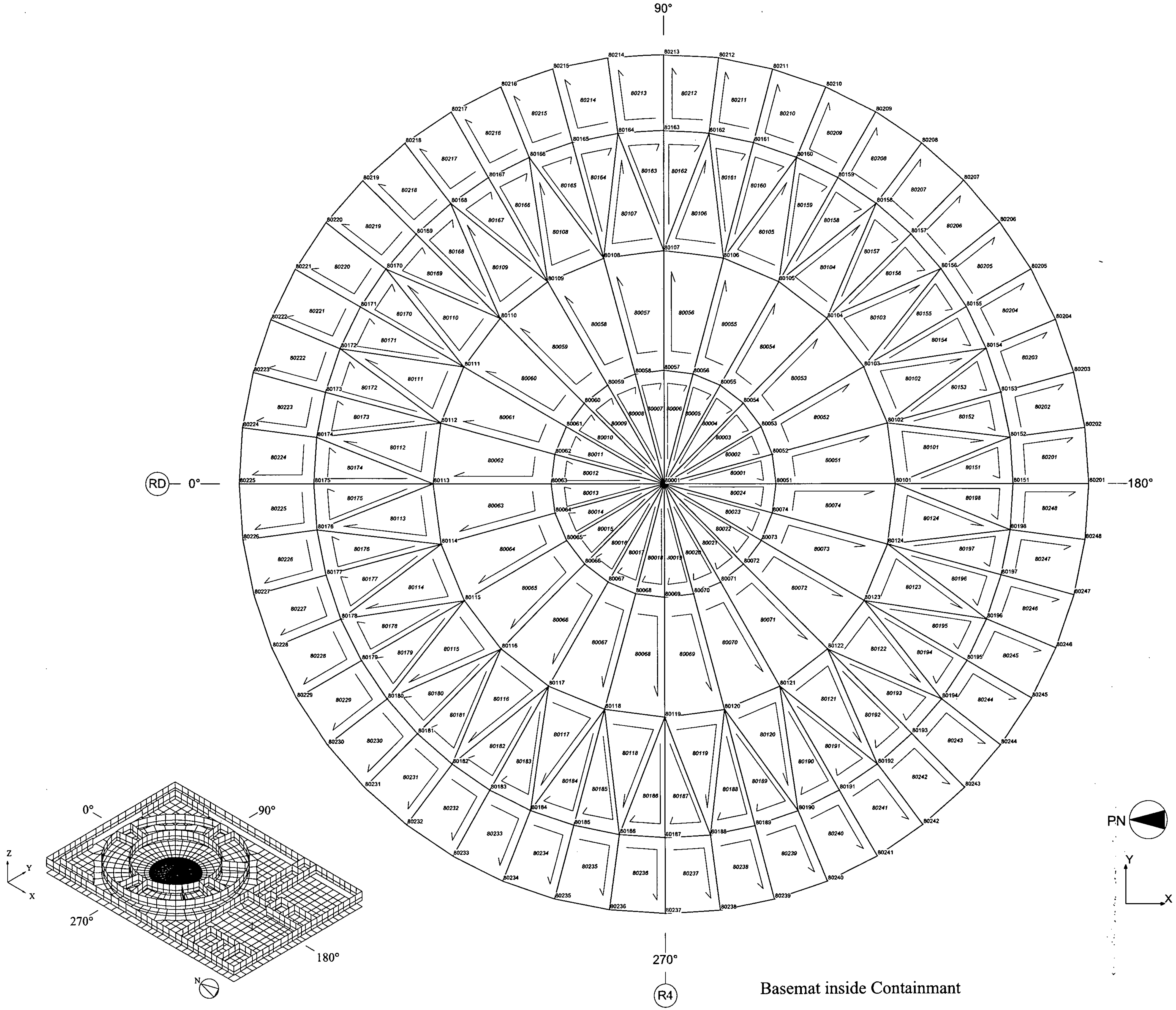


View: from Outside (South) to Inside (North)

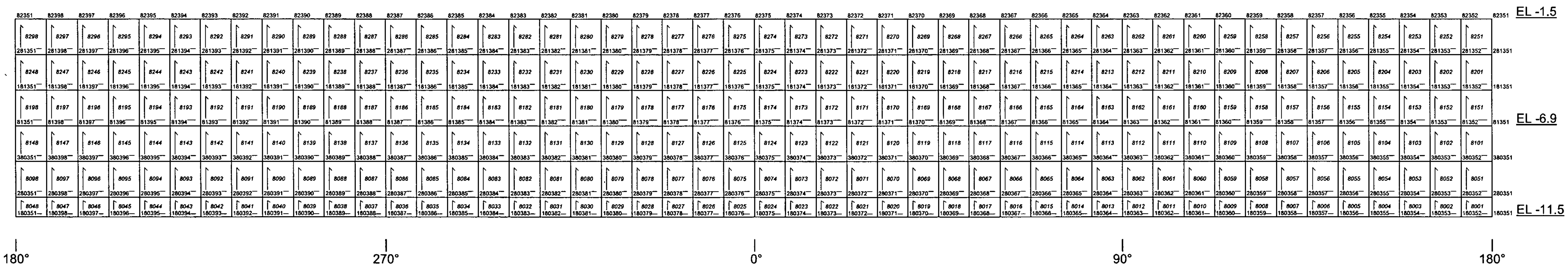
External Wall (F3)

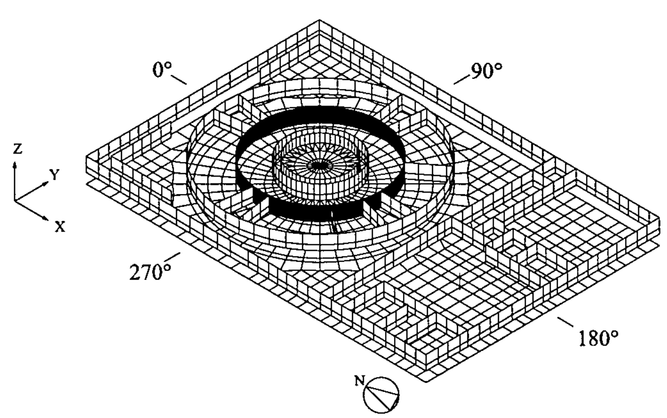

RA
RB
RC
RD
RE
RF
RG
FA
FB
FC
FD
FE
FF
R1
R2
R3
R4
R5
R6
R7
F1
F2
F3
PN
Y
X

Basemat



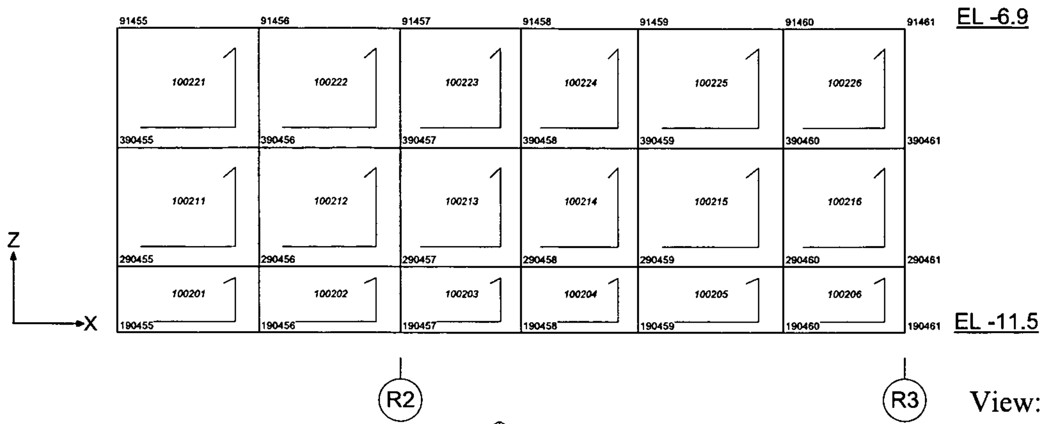
Basemat inside Containmant



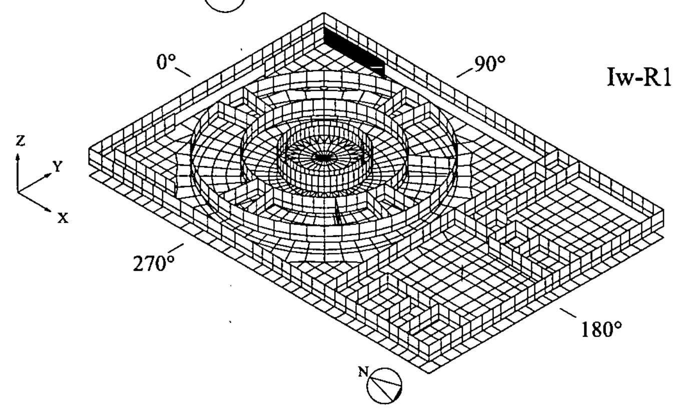


View: from Inside to Outside

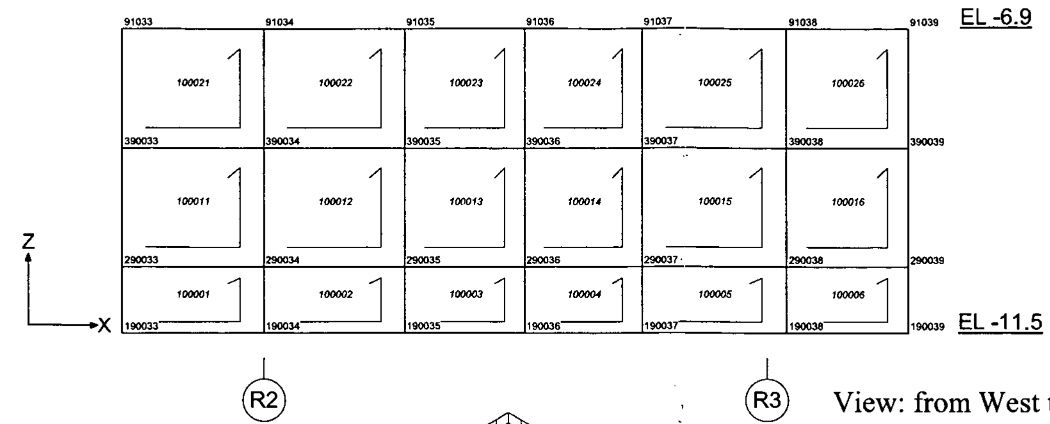
Cylindrical Inner Wall



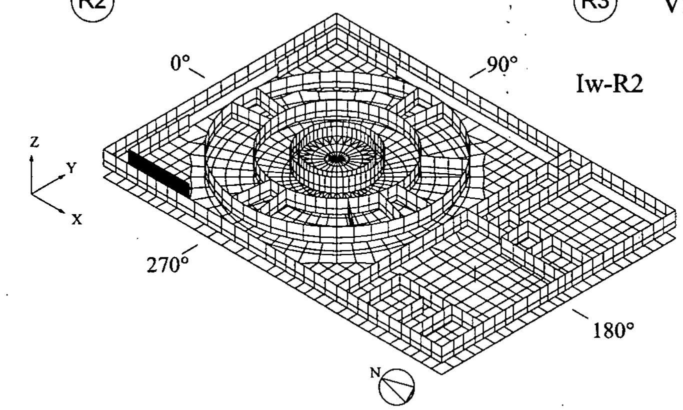
View: from West to East



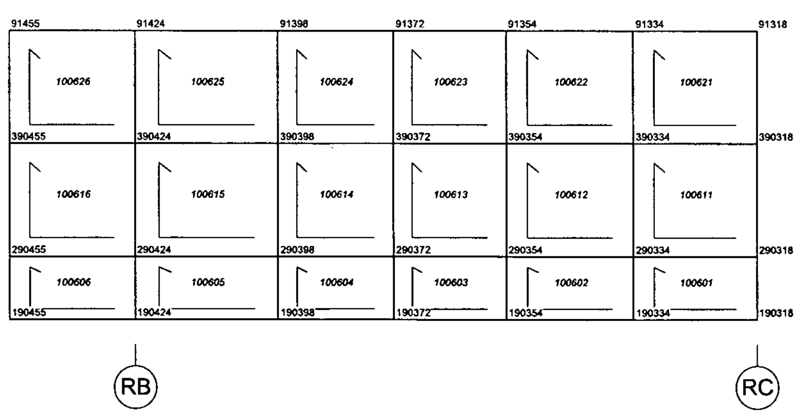
Iw-R1



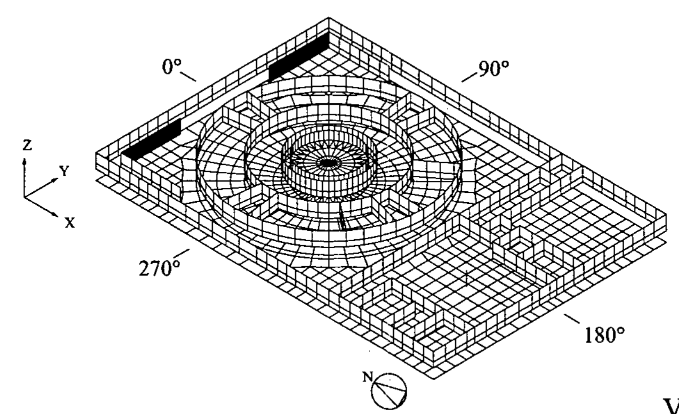
View: from West to East

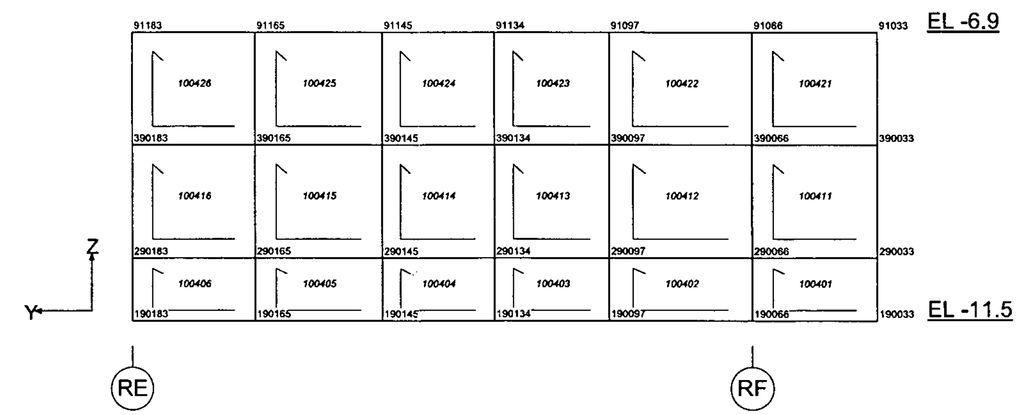


Iw-R2



Iw-R3

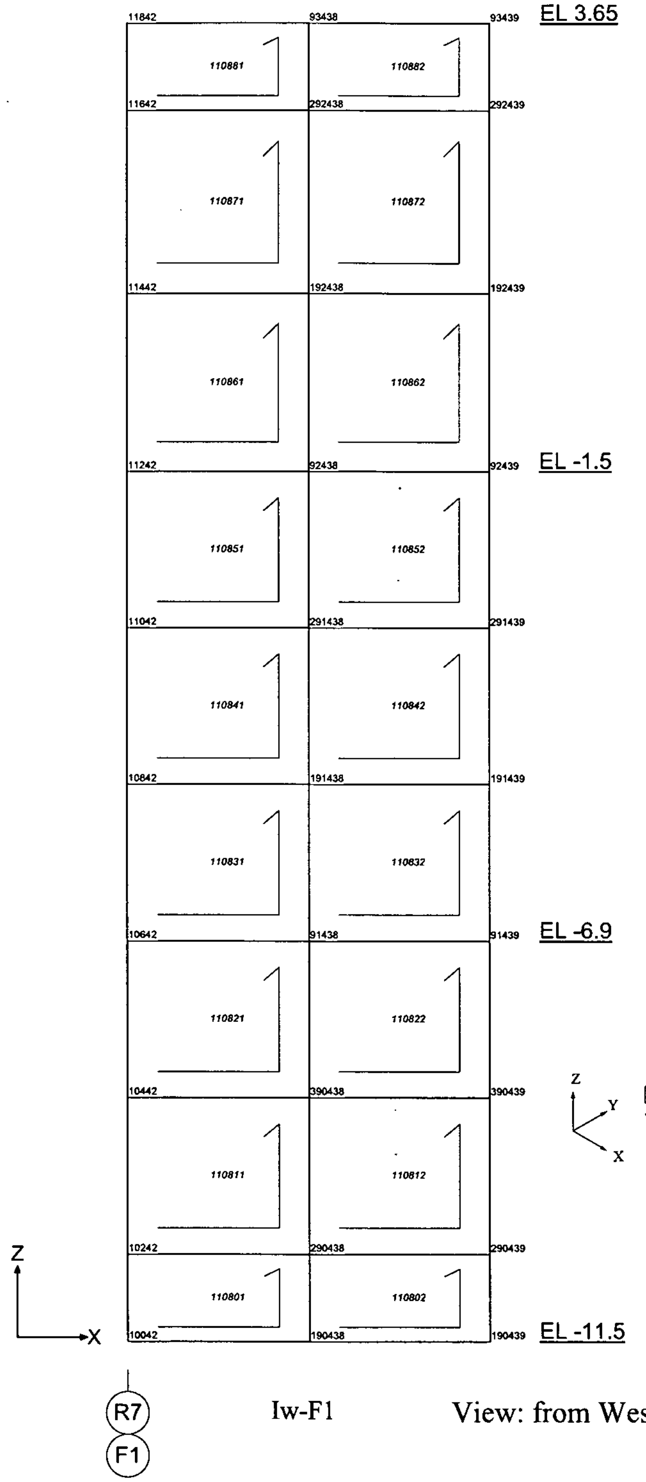


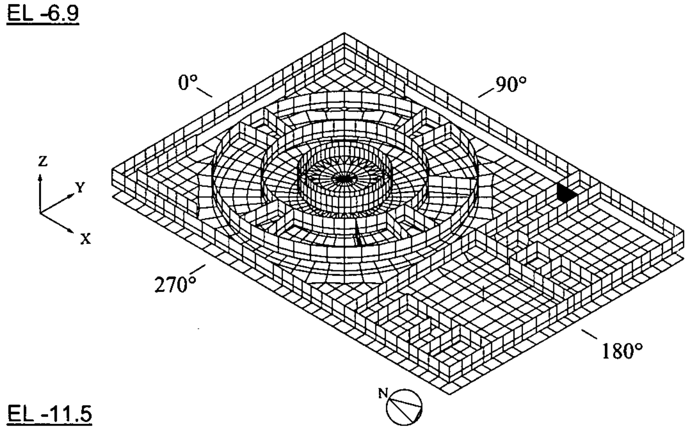


Iw-R4

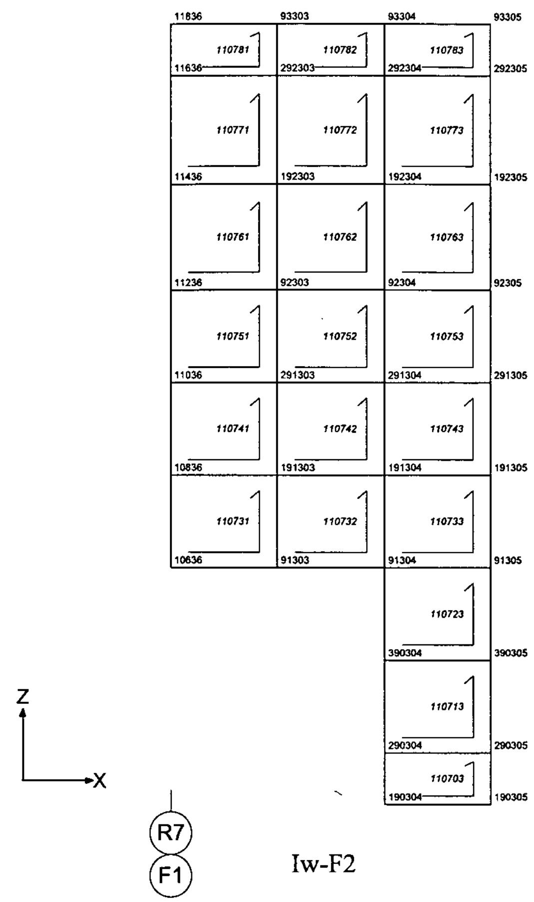
View: from North to South

Inner Wall (in Reactor Building)

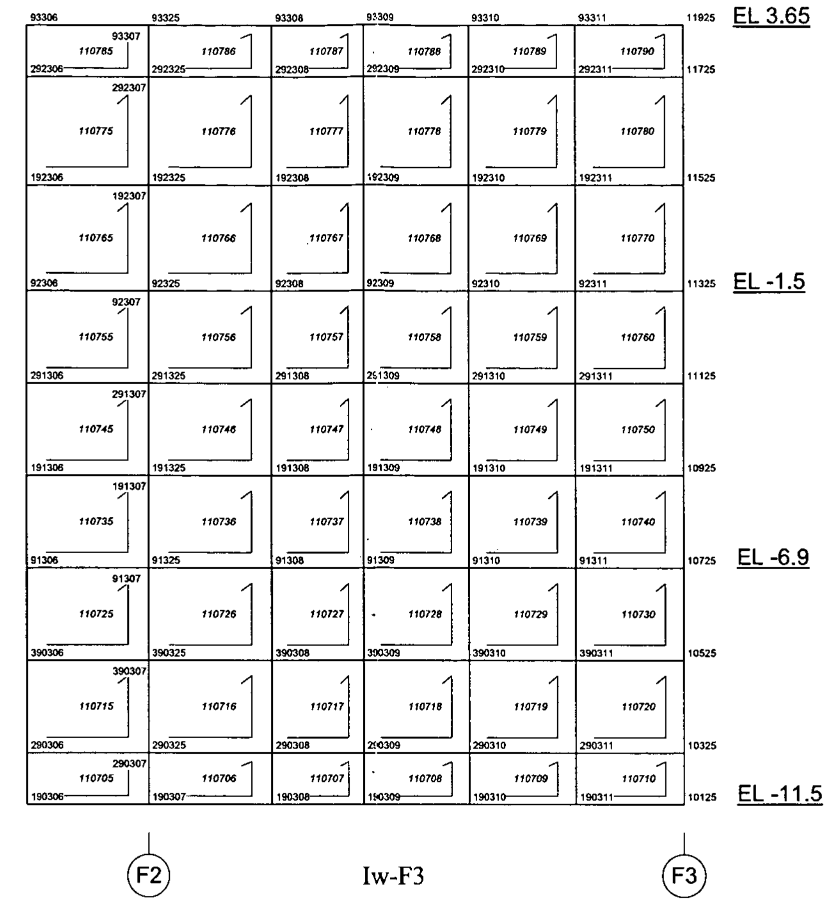




Iw-F1 View: from West to East

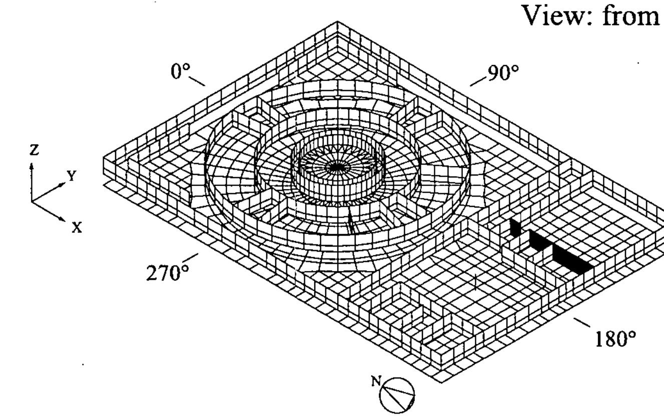


Iw-F2

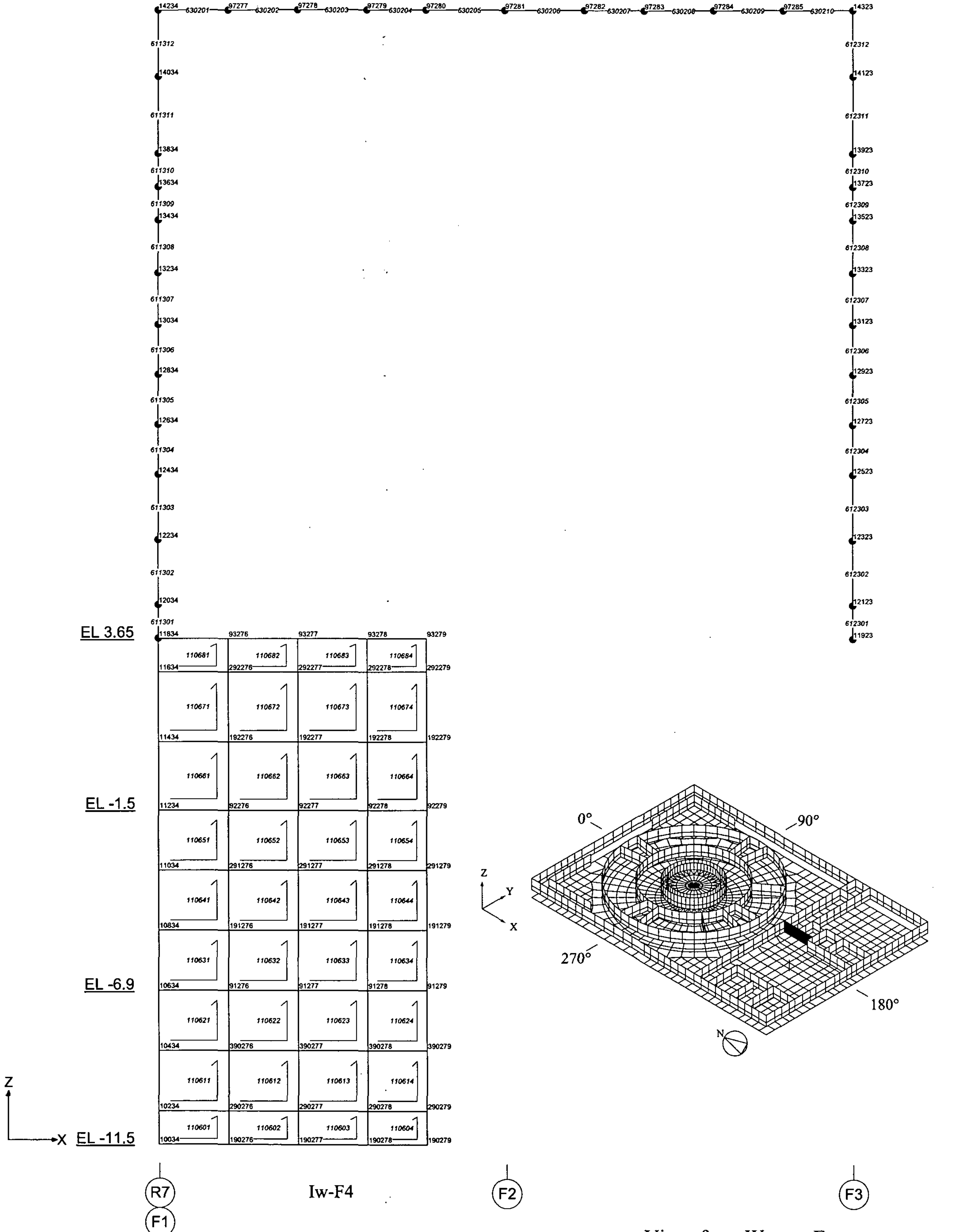


Iw-F3

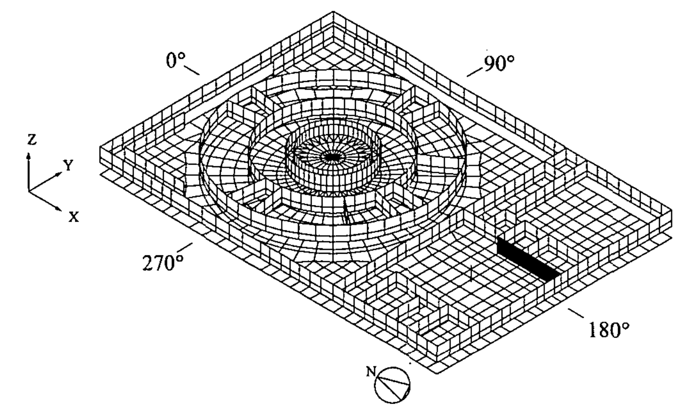
View: from West to East

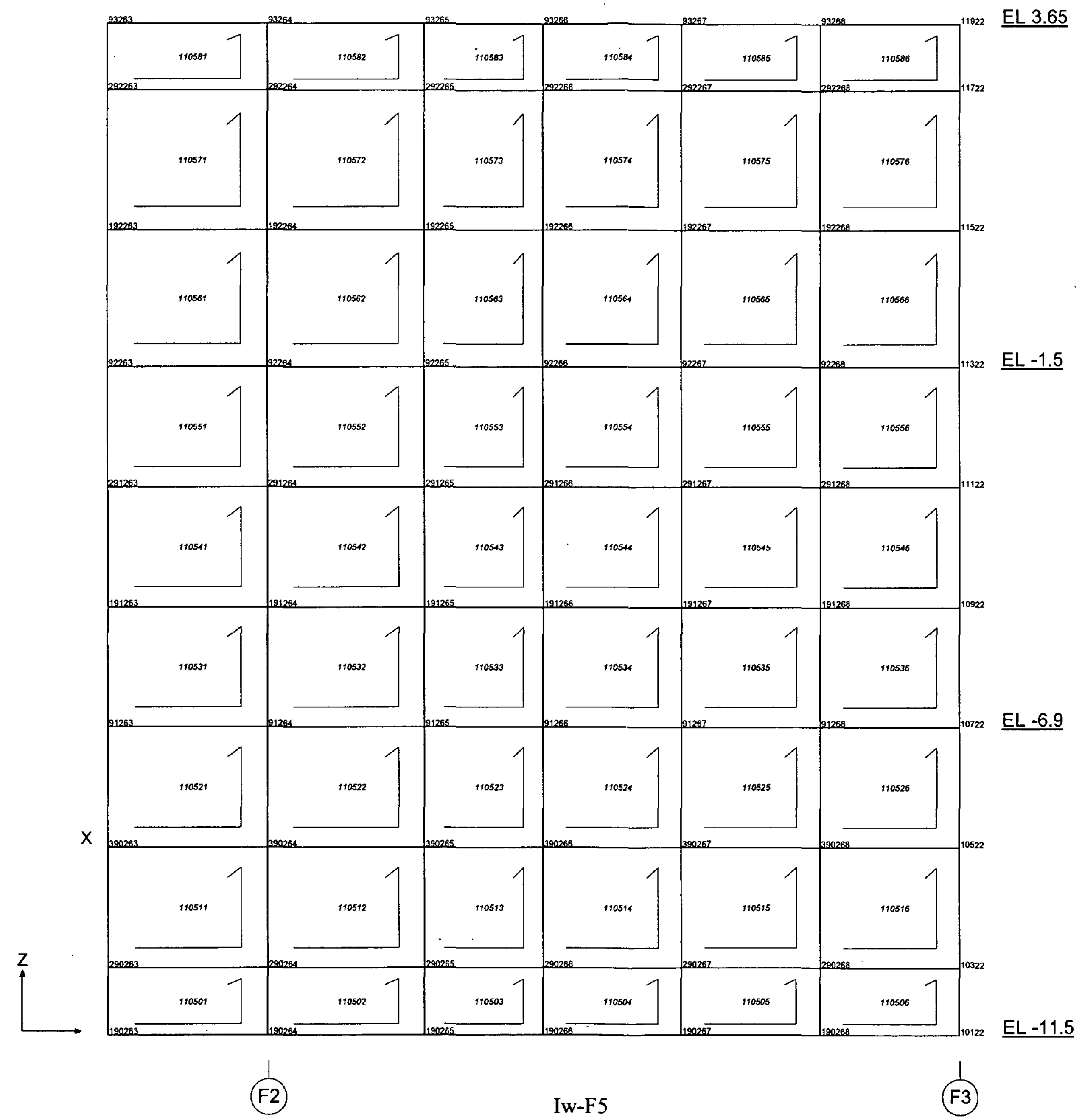


Inner Wall (X Direction 1; in Fuel Building)



Iw-F4



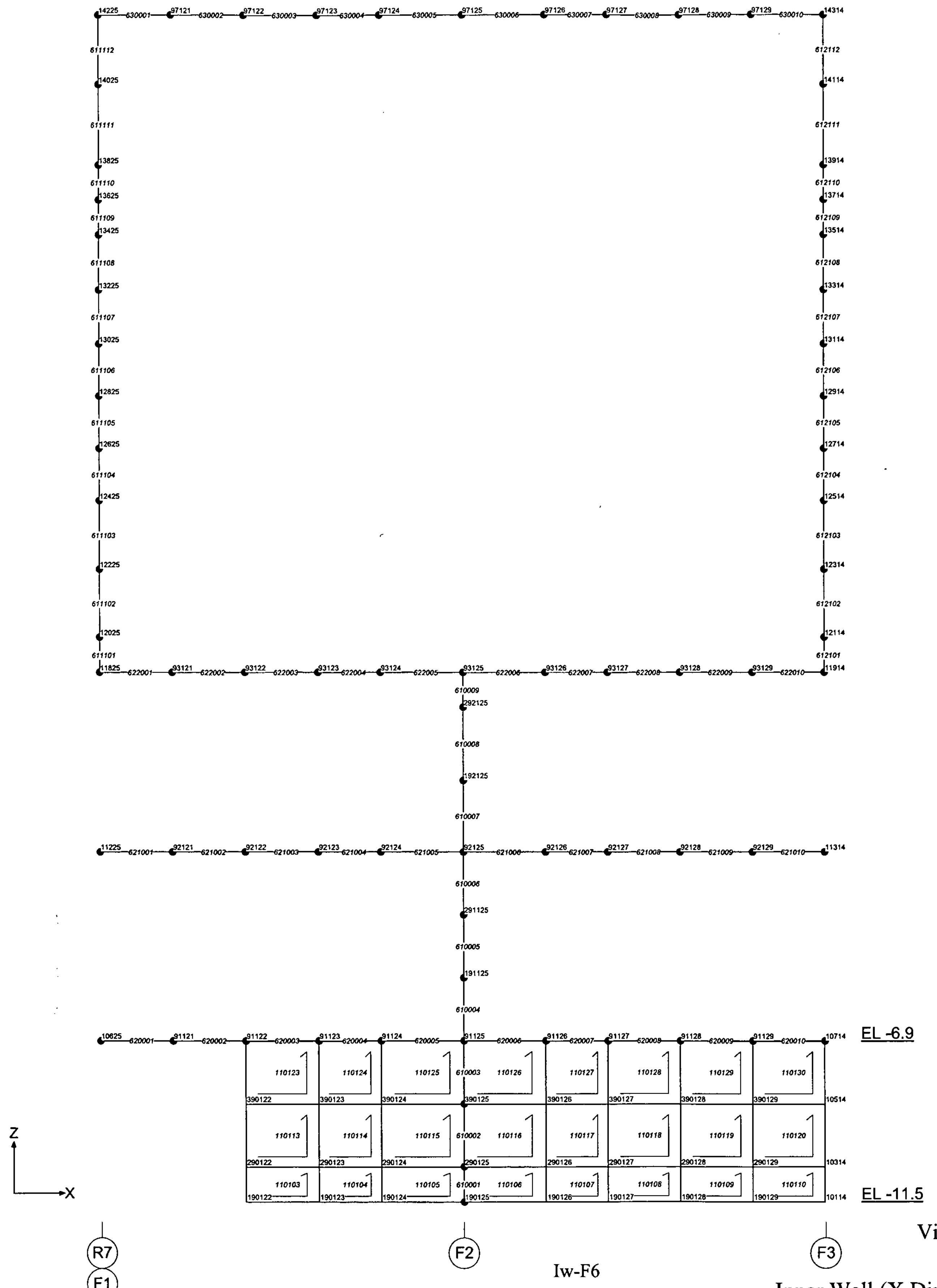


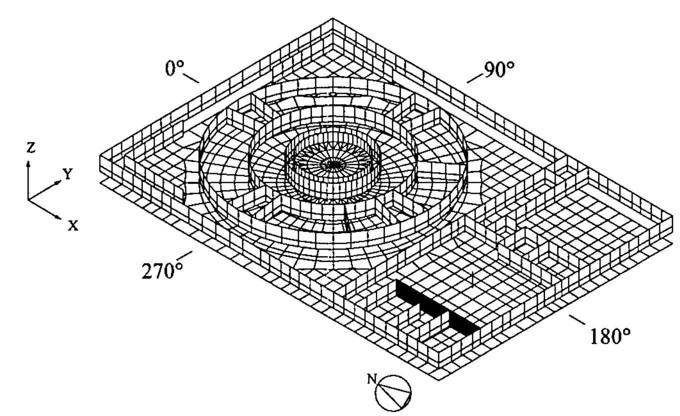
Iw-F5

View: *from West to East*

View: *from West to East*

Inner Wall (X Direction 2; in Fuel Building)

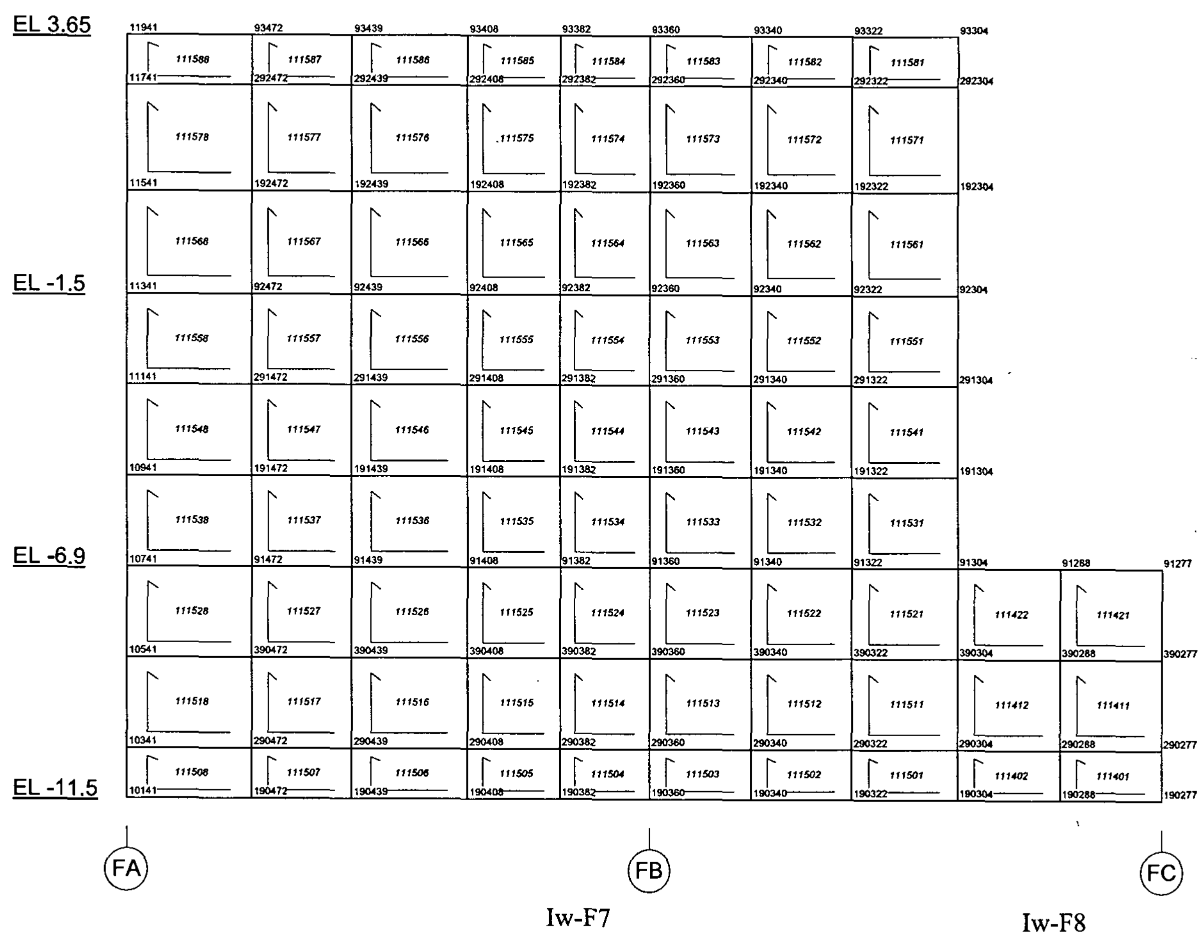


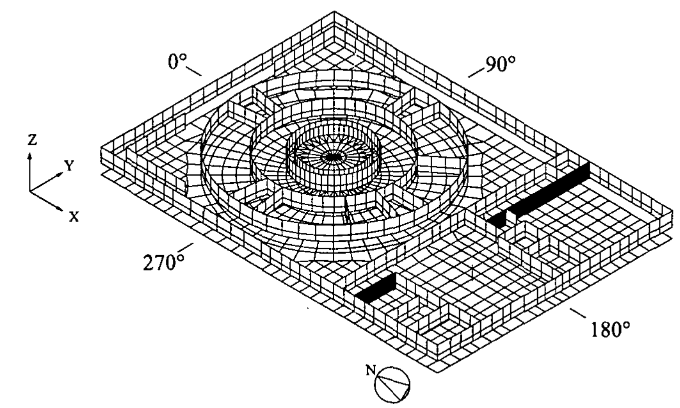


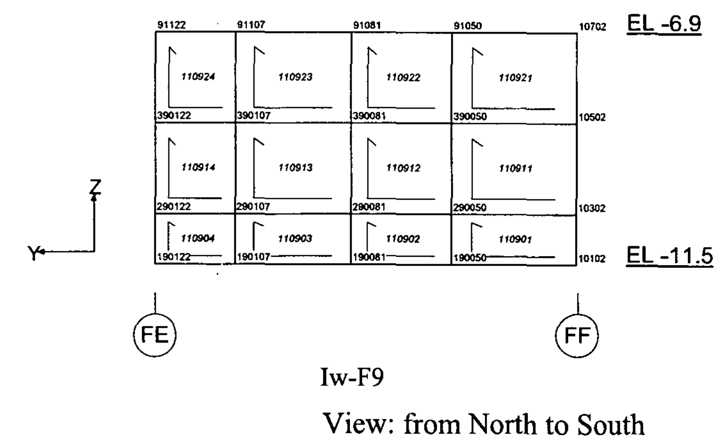
View: from West to East

Iw-F6

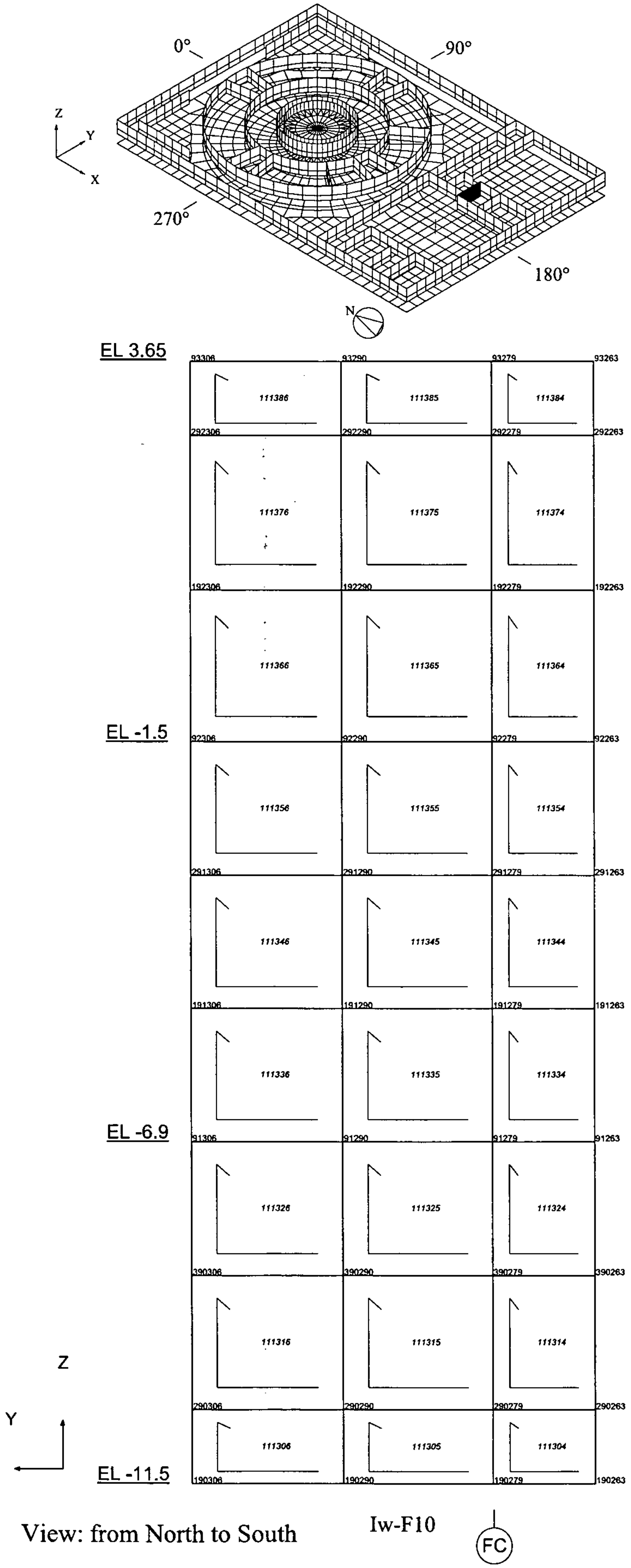
Inner Wall (X Direction 3; in Fuel Building)





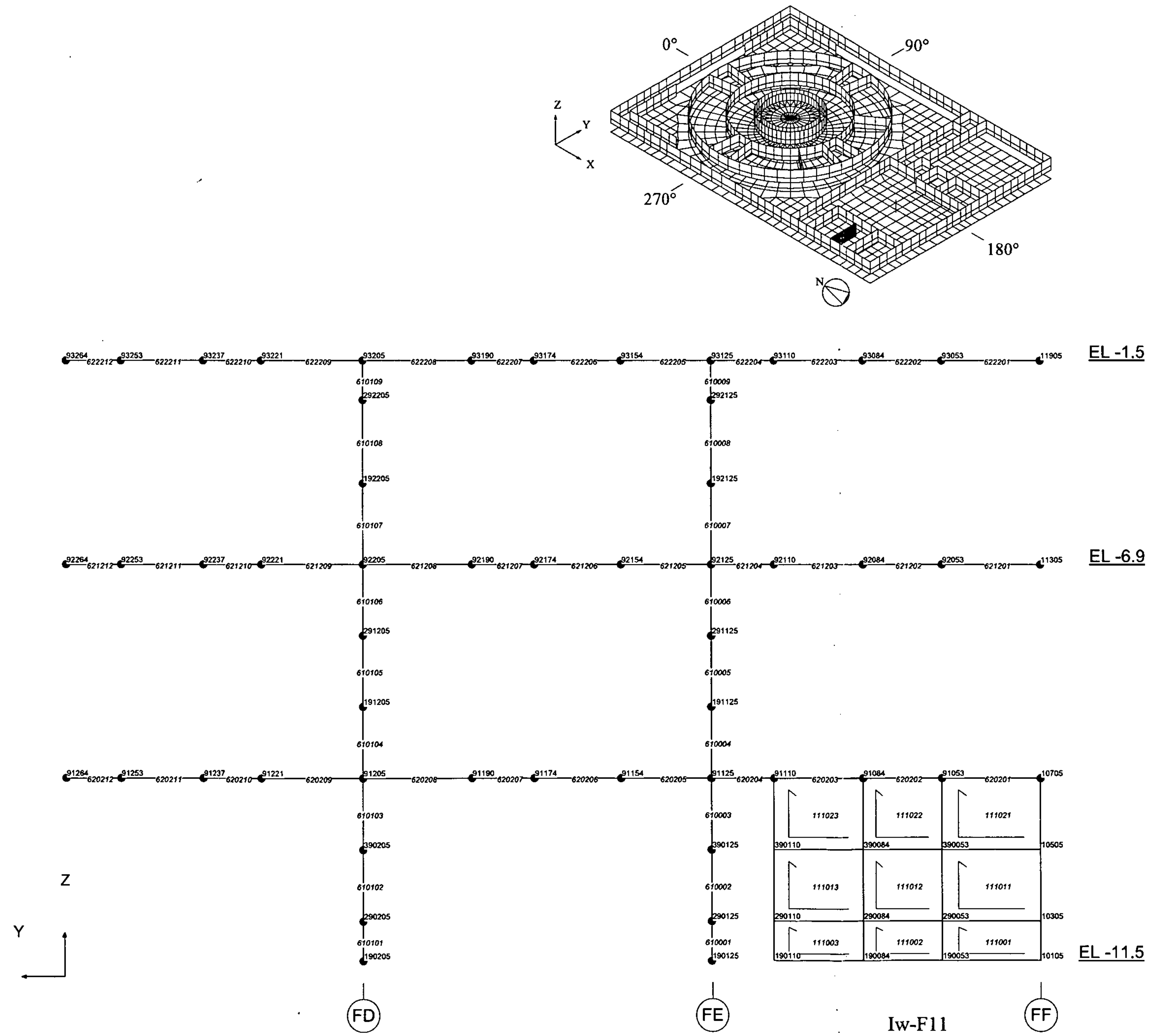


Inner Wall (Y Direction 1; in Fuel Building)



View: from North to South

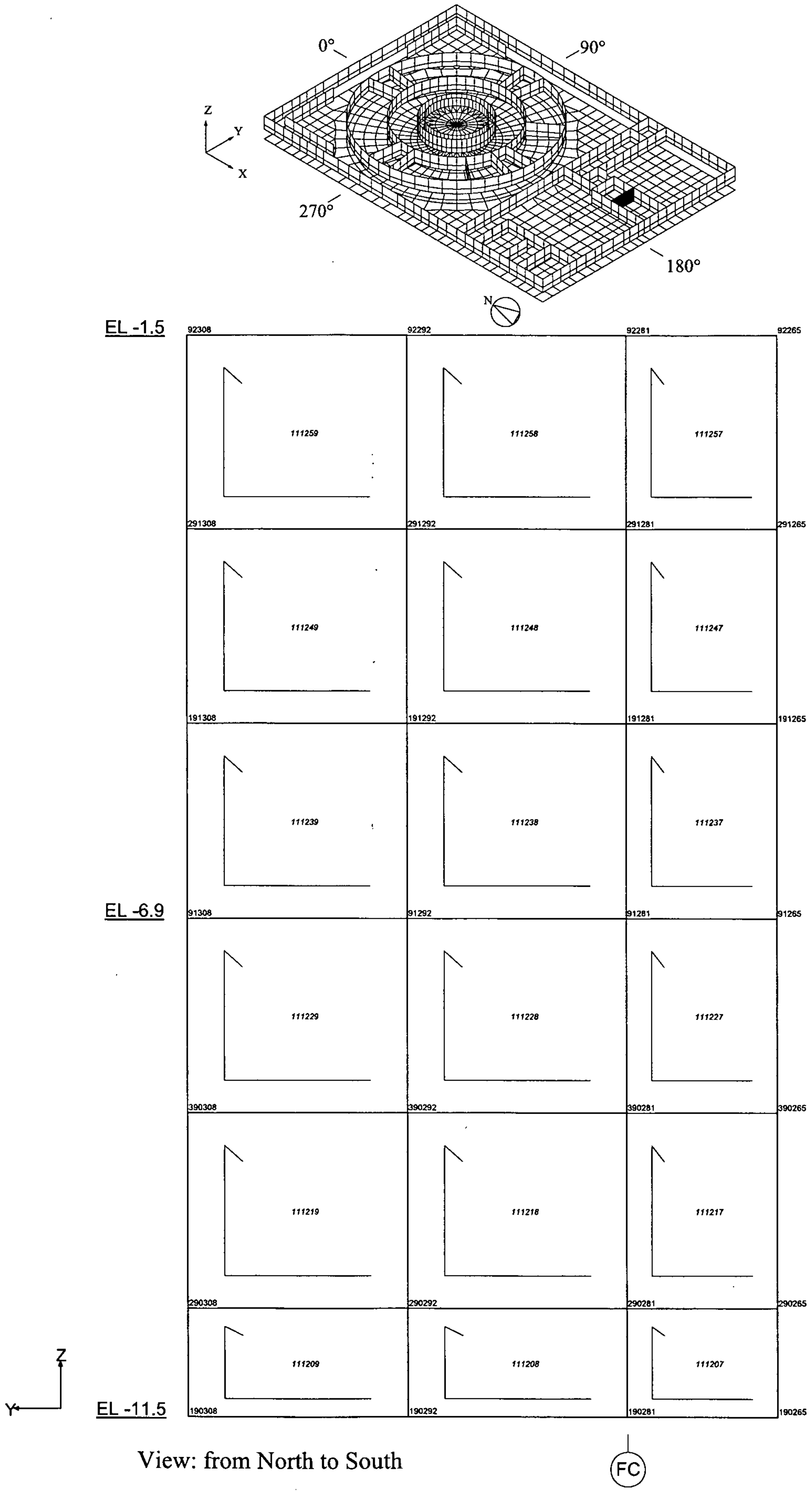
Iw-F10



Iw-F11

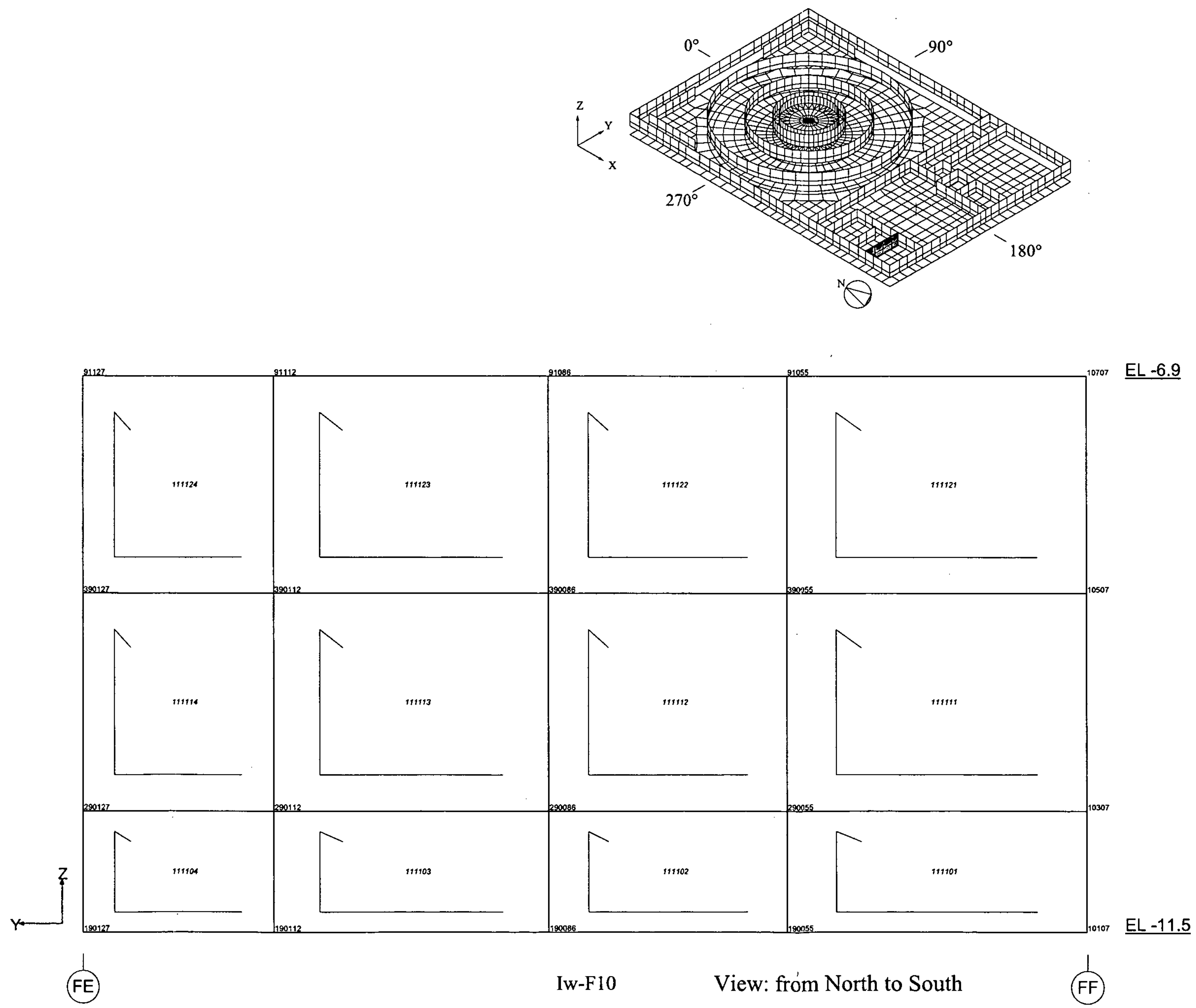
Inner Wall (Y Direction 2; in Fuel Building)

View: from North to South



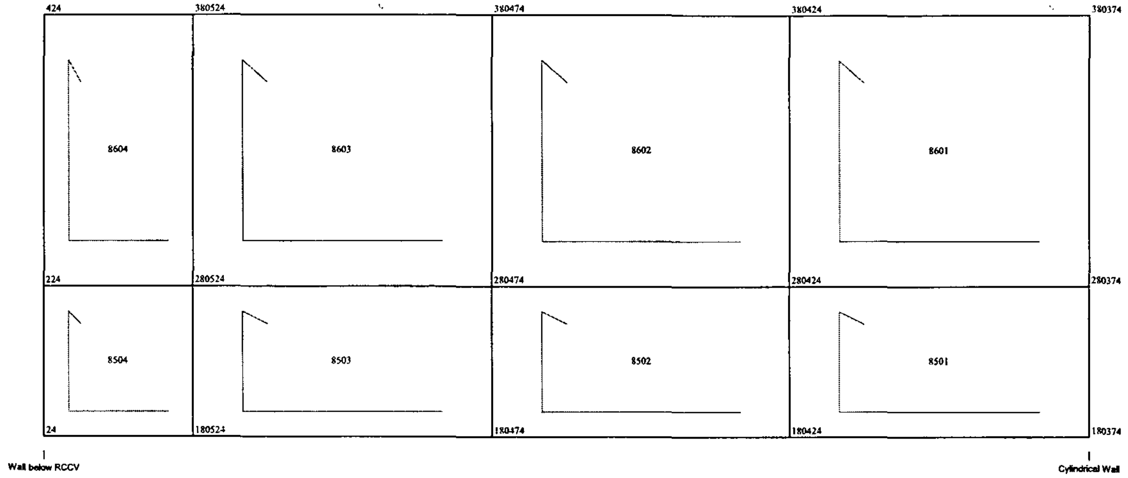
View: from North to South

Iw-F12

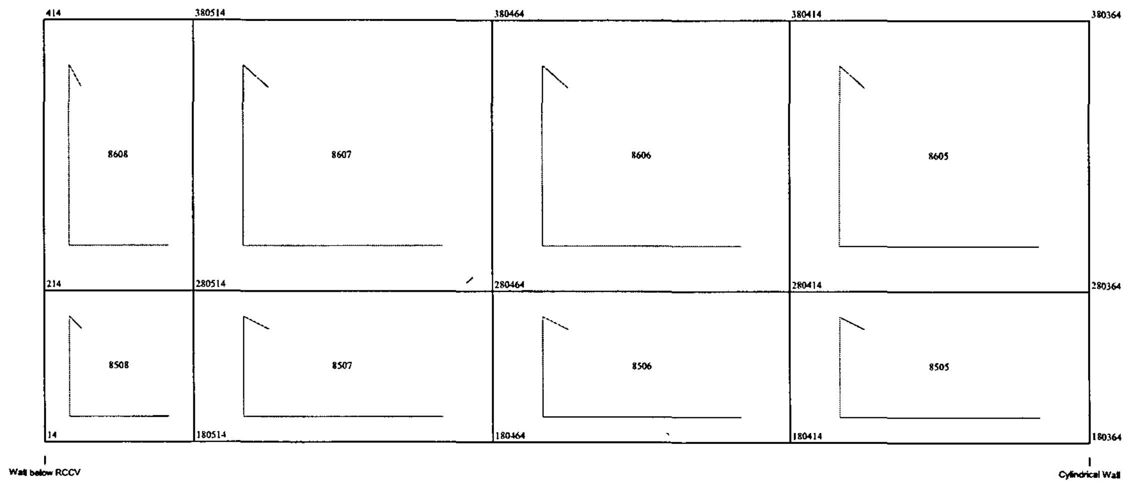


Iw-F10 View: from North to South

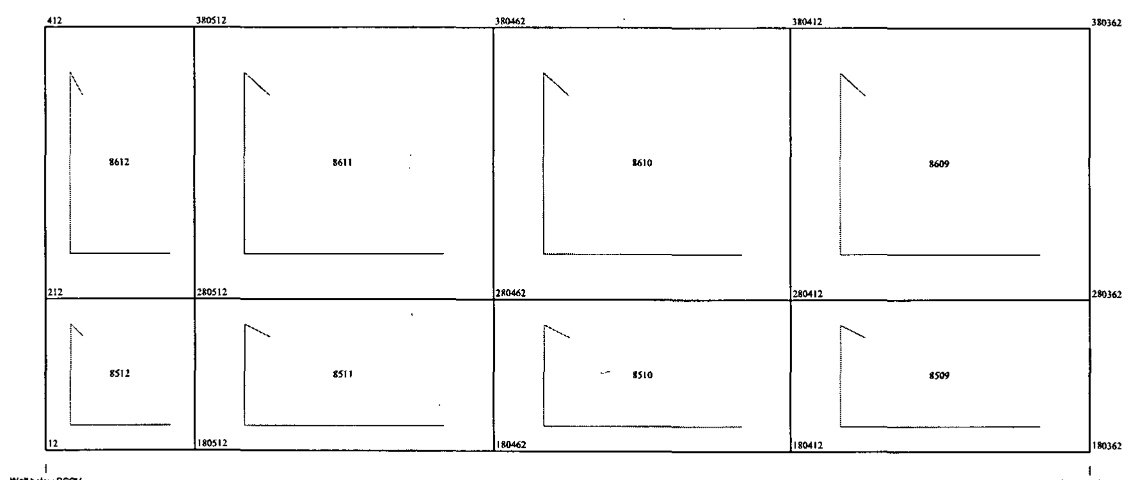
Inner Wall (Y Direction 3; in Fuel Building)



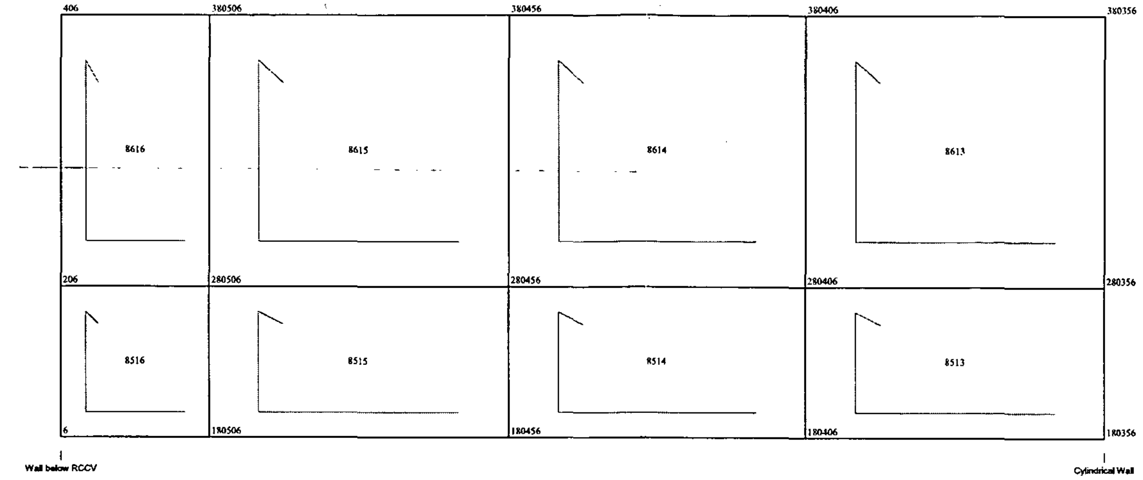
Radial Inner Wall (No.1: 7.5°)



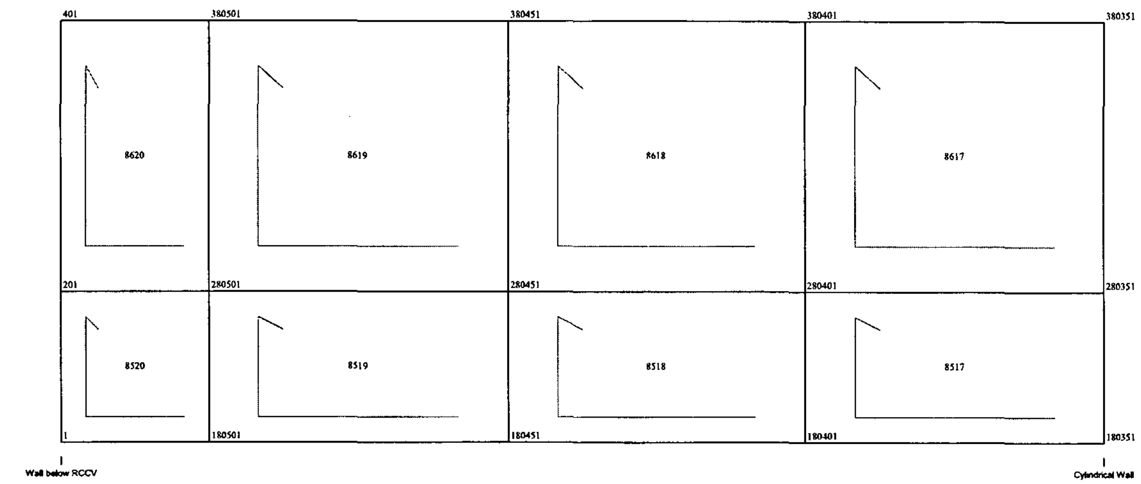
Radial Inner Wall (No.2: 82.5°)



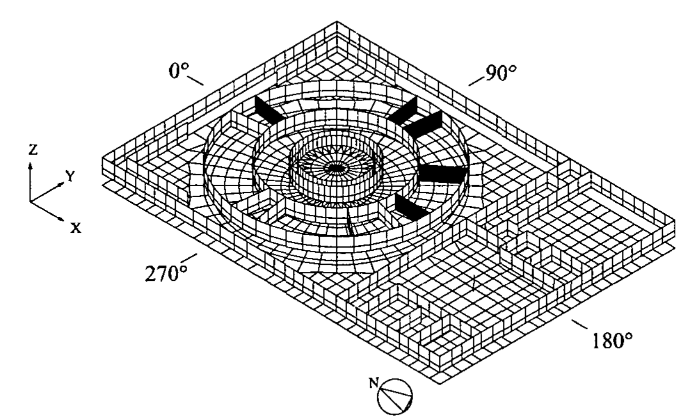
Radial Inner Wall (No.3: 97.5°)

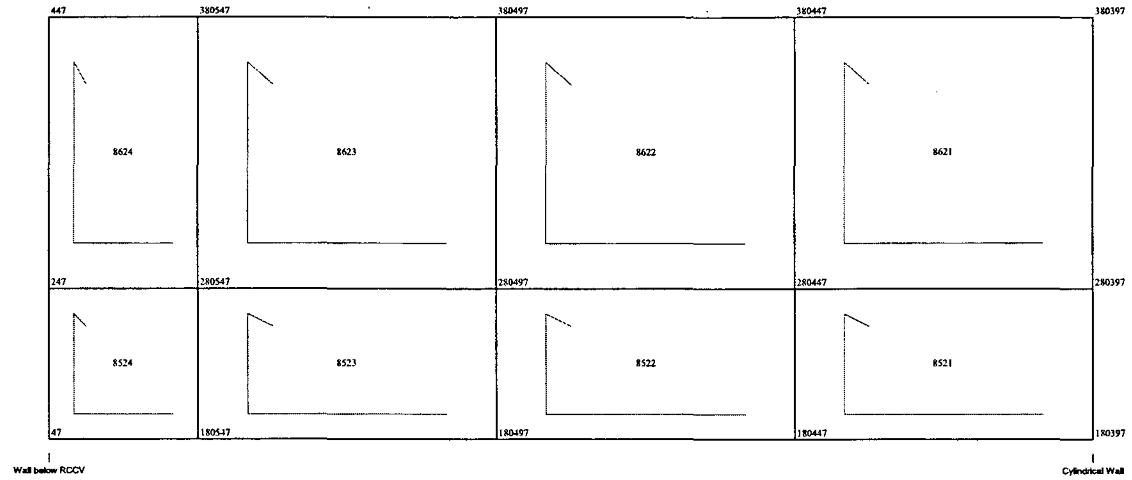


Radial Inner Wall (No.4: 142.5°)

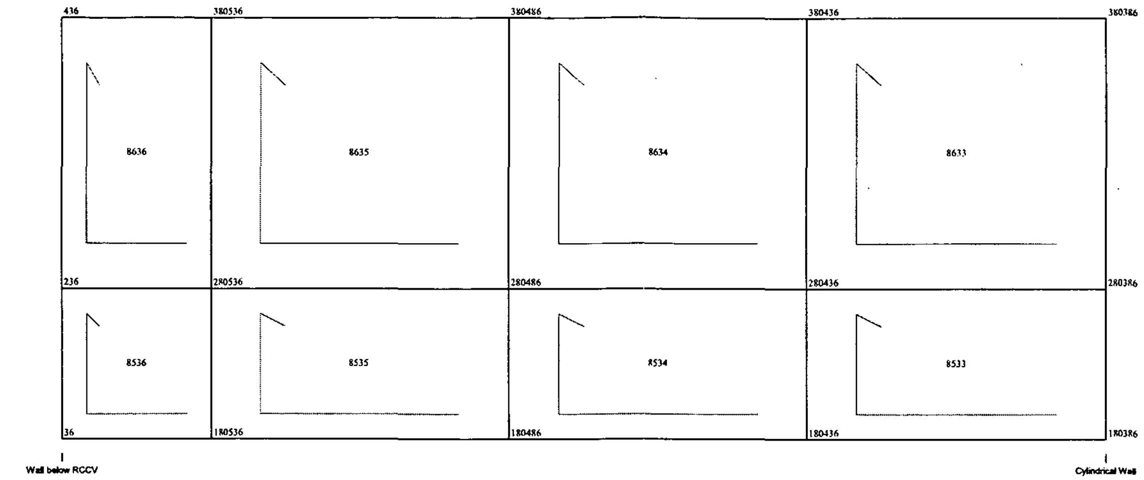


Radial Inner Wall (No.5: 180.0°)

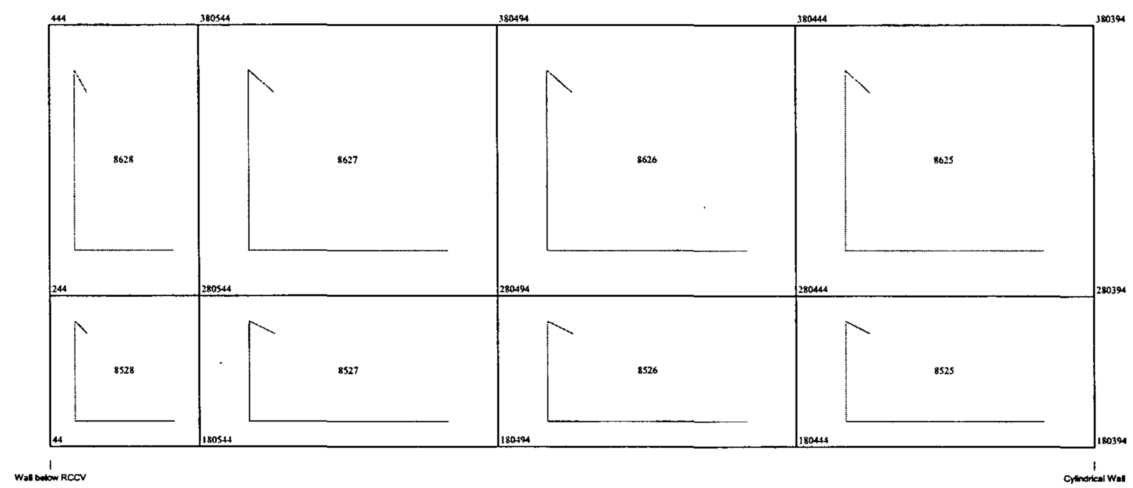




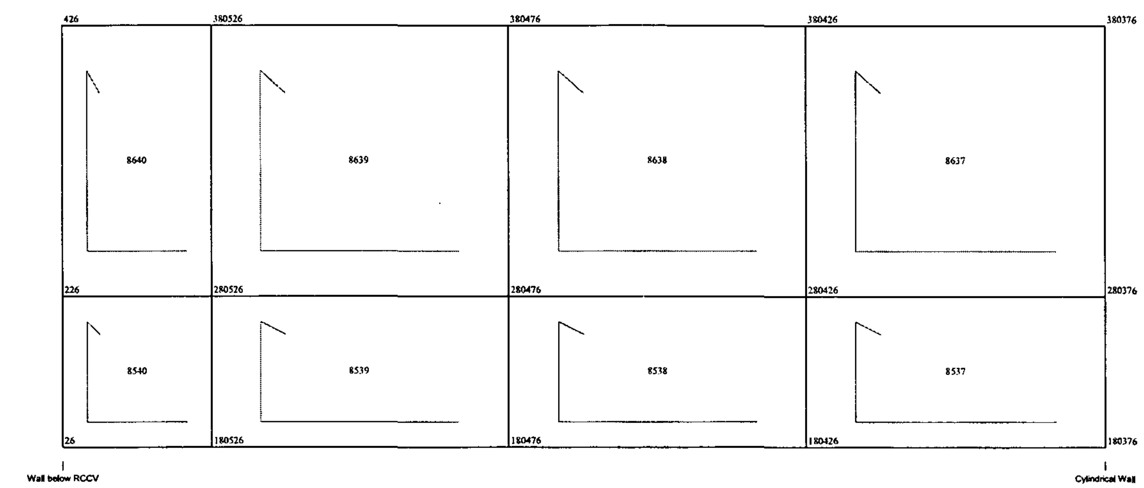
Radial Inner Wall (No.6: 195.0°)



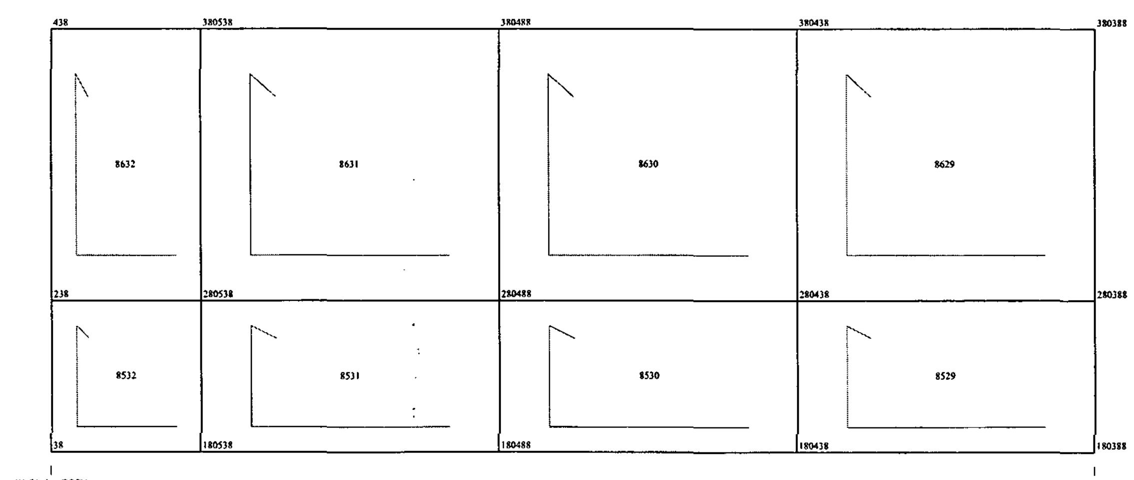
Radial Inner Wall (No.9: 277.5°)



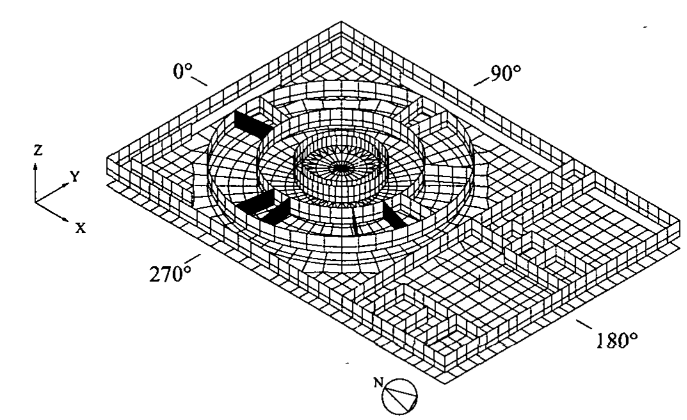
Radial Inner Wall (No.7: 217.5°)

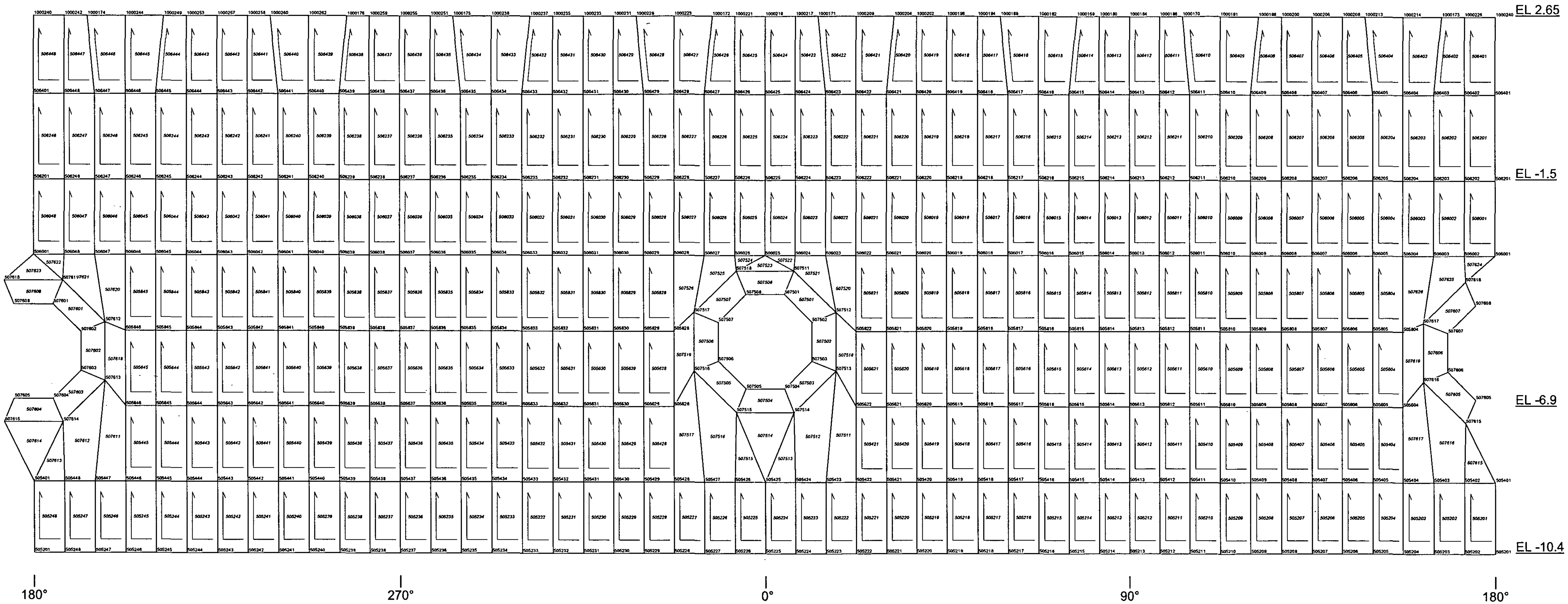


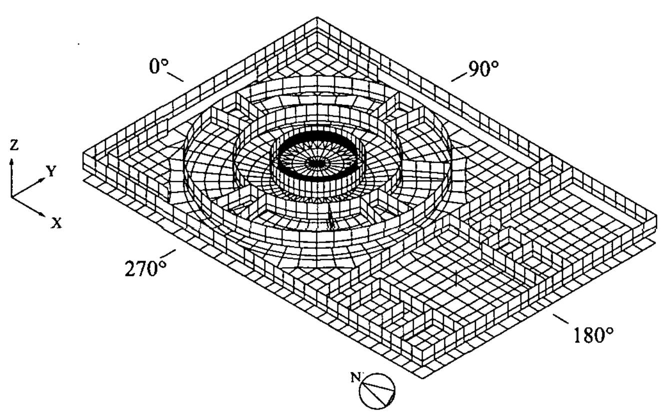
Radial Inner Wall (No.10: 352.5°)



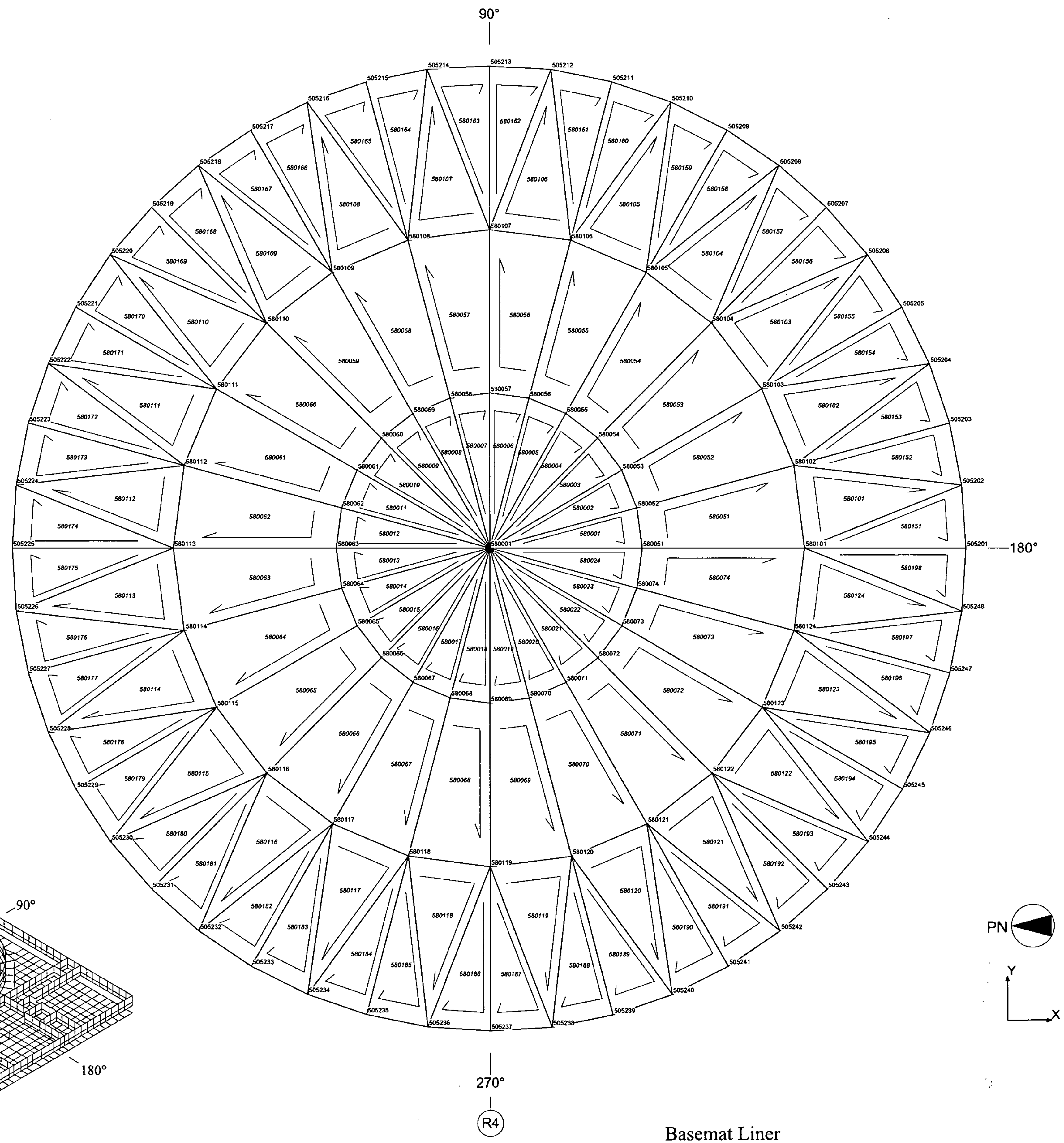
Radial Inner Wall (No.8: 262.5°)

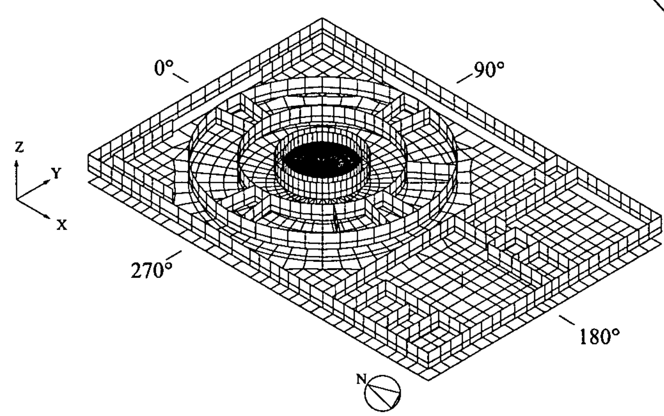






RPV Pedestal Liner





Basemat Liner

Appendix B Definition of Shell Element Property in NASTRAN User Manual

PSHELL Shell Element Property

Defines the membrane, bending, transverse shear, and coupling properties of thin shell elements.

Format:

1	2	3	4	5	6	7	8	9	10
PSHELL	PID	MID1	T	MID2	12I/T**3	MID3	TS/T	NSM	
	Z1	Z2	MID4						

Example:

PSHELL	203	204	1.90	205	1.2	206	0.8	6.32	
	+.95	-.95							

Field	Contents
PID	Property identification number. (Integer > 0)
MID1	Material identification number for the membrane. (Integer ≥ 0 or blank)
T	Default membrane thickness for Ti on the connection entry. If T is blank then the thickness must be specified for Ti on the CQUAD4, CTRIA3, CQUAD8, and CTRIA6 entries. (Real or blank)
MID2	Material identification number for bending. (Integer ≥ -1 or blank)
12I/T**3	Bending moment of inertia ratio, $12I/T^3$. Ratio of the actual bending moment inertia of the shell, *I*, to the bending moment of inertia of a homogeneous shell, $T^3/12$. The default value is for a homogeneous shell. (Real > 0.0; Default = 1.0)
MID3	Material identification number for transverse shear. (Integer > 0 or blank; unless MID2 > 0, must be blank.)
TS/T	Transverse shear thickness ratio, T_s/T. Ratio of the shear thickness, (T_s), to the membrane thickness of the shell, *T*. The default value is for a homogeneous shell. (Real > 0.0; Default = .833333)
NSM	Nonstructural mass per unit area. (Real)

Z1, Z2	Fiber distances for stress calculations. The positive direction is determined by the right-hand rule, and the order in which the grid points are listed on the connection entry. See Remark **11.** for defaults. (Real or blank)
MID4	Material identification number for membrane-bending coupling. See Remarks **6.** and **13.** (Integer > 0 or blank, must be blank unless MID1 > 0 and MID2 > 0, may not equal MID1 or MID2.)

Remarks:

1. All PSHELL property entries should have unique identification numbers with respect to all other property entries.
2. The structural mass is calculated from the density using the membrane thickness and membrane material properties. If MID1 is blank, then the density is obtained from the MID2 material.
3. The results of leaving an MID field blank (or MID2 = -1) are:

MID1	No membrane or coupling stiffness
MID2	No bending, coupling, or transverse shear stiffness
MID3	No transverse shear flexibility
MID4	No bending-membrane coupling unless ZOFFS is specified on the connection entry. See Remark **6.**
MID2=-1	See Remark **12.**

Note: MID1 and MID2 must be specified if the ZOFFS field is also specified on the connection entry.

4. The continuation entry is not required.
5. The structural damping (GE on the MATi entry) is obtained from the MID1 material. If MID1 is blank, then it is obtained from the MID2 material. If PARAM,SHLDAMP,DIFF or DIFF is any other character except SAME, then the structural damping K^4 matrix is computed using the GE entries on the MATi entries according to rules in the following table. If a single PSHELL corresponds to row 8 of the table, then all PSHELLs in the model will follow the rule of row 8. Rows 1-7 is an attempt to maintain upward compatibility, if a user inadvertently places a SHLDAMP,DIFF in the model

Caution:	Large values of damping associated with an MID4 entry, when using PARAM,SHLDAMP,DIFF, can cause structural instability in transient dynamics.

Table 8-30 SHELL Structural Damping Rules

SHELL Structural Damping Rules					
Row	MID1	MID2	MID3	MID4	K^4 based on
1*	v	v			MID1 GE value
2	v				MID1 GE value
3	v	-1			MID1 GE value
4	v	v			MID1 GE value
5		v			MID2 GE value
6		v	v		MID2 GE value
7	v1	v2	v3	v4	$n \rightarrow$ total number of non blank vi $m \rightarrow$ total number of non zero ge_i If: n = m and $ge_i = ge_2 = \ldots = ge_m$ Or: $m = 1$ and $ge_1 \neq 0$ Or: $m = 0$ MID1 GE value
8	v1	v2	v3	v4	Otherwise: $ge_1 \cdot$ membrane-stiff $+ ge_2 \cdot$ bending-stiff $+ ge_3 \cdot$ transverse shear-stiff $+ ge_4 \cdot$ bending-membrane-stiff is used

* v $\rightarrow$ MIDi values the same, vi $\rightarrow$ MIDi values different or blank

$ge_i \rightarrow$ GE value from a MATj entry associated with MIDi

If for row 8, a $ge_i = 0$ it is replaced by $ge_i = 1.-8$

6. The following should be considered when using MID4.

- The MID4 field should be left blank if the material properties are symmetric with respect to the middle surface of the shell. If the element centerline is offset from the plane of the grid points but the material properties are symmetric, the preferred method for modeling the offset is by use of the ZOFFS field on the connection entry. Although the MID4 field may be used for this purpose, it may produce ill-conditioned stiffness matrices (negative terms on factor diagonal) if done incorrectly.
- Only one of the options MID4 or ZOFFS should be used; if both methods are specified the effects are cumulative. Since this is probably not what the user intented, unexpected answers will result. Note that the mass properties are not modified to reflect the existence of the offset when the ZOFFS and MID4 methods are used. If the weight or mass properties of an offset plate are to be used in an analysis, the RBAR method must be used to represent the offset. See "**Shell Elements (CTRIA3, CTRIA6, CTRIAR, CQUAD4, CQUAD8, CQUADR)**" on page 119 of the MSC.Nastran Reference Manual.
- The effects of MID4 are not considered in the calculation of differential stiffness. Therefore, it is recommended that MID4 be left blank in buckling analysis.

7. This entry is referenced by the CTRIA3, CTRIA6, CTRIAR, CQUAD4, CQUAD8, and CQUADR entries via PID.
8. For structural problems, MIDi must reference a MAT1, MAT2, or MAT8 material property entry
9. If the transverse shear material MID3 or the membrane-bending coupling term MID4 references a MAT2 entry, then G33 must be zero. If MID3 references a MAT8 entry, then G1Z and G2Z must not be zero.
10. For heat transfer problems, MIDi must reference a MAT4 or MAT5 material property entry.
11. The default for Z1 is -T/2, and for Z2 is +T/2. T is the local plate thickness defined either by T on this entry or by membrane thicknesses at connected grid points, if they are input on connection entries.
12. For plane strain analysis, set MID2=-1 and set MID1 to reference a MAT1 entry. In-plane loads applied to plain strain elements are interpreted as line-loads with a value equal to the load divided by the thickness. Thus, if a thickness of "1.0" is used, the value of the line-load equals the load value. Pressure can be approximated with multiple line loads where the pressure value equals the line-load divided by the length between the loads.

13. For the CQUADR and CTRIAR elements, the MID4 field should be left blank because their formulation does not include membrane-bending coupling.
14. If MIDi is greater than or equal to 10^8, then parameter NOCOMPS is set to +1 indicating that composite stress data recovery is desired. (MIDi greater than 10^8 are generated by PCOMP entries.)
15. For a material nonlinear property, MID1 must reference a MATS1 entry and be the same as MID2, unless a plane strain (MID2 = -1) formulation is desired. Also, MID3 cannot reference a MATS1 entry.
16. If transverse shear flexibility is specified for a model with curved shells where the loading is dominated by twist, results will not converge and may be inaccurate. PARAM,SNORM should be set for this unique model condition.

Appendix C Response to Discussion about Truncated Model at NRC 2nd Audit

Appendix C Response to Discussion about Truncated Model at NRC 2nd Audit

Confirmation Items

1. *Close SFP Poll gate Gap to meet the NRC model*
2. *Confirm load combination 0.4NS+1.0EW-0.4V vs. Rev.3*
3. *BNL: check displacement*
4. *provide the force Nxy*
5. *provide forces table (7 walls and 3 sections): show the relation NASTRAN and model*
6. *provide excel sheet (graph and data, give the clear names to sheet)*
7. *show positive direction of forces on plan view sketch*
8. *BNL: re-estimate graph based on element-center elevation to compare forces of both model*
9. *add offset to SFP wall(F3)*
10. *confirm the possibility of expression forces on line(forces on node)*
11. *basemat thickness inside pedestal to 5.1 m*
12. *confirm the attached level of soil spring on basemat*
13. *confirm the adequacy of hydro-pressure on model*
14. *identify possible reason of differences*
15. *identify possible reason of knuckle and large gradient*

GE Response

Items 1), 4) through 7), 9), 11), and 13) are incorporated into Revision 5 of this report.

1) One of the pool gate gaps (south side gate) on Modified truncated model is closed to maintain consistency with the NRC model.

2) Load combination -0.4NS-1.0EW-0.4V considered in Revision 4 of SER-ESR-038 is confirmed to be the critical load combination.

3) BNL seems to have used soil springs for non-seismic loads in the analysis case for seismic load. The soil spring stiffness values for horizontal seismic load and other loads are those shown in DCD Table 3G.1-1.

4) New tables including Nxy forces are added.

5), 6), 7) The requested table, Excel sheet and sketch are added.

8) The elevation of element estimated in truncated model is at center of the bottom row of shell elements. BNL is requested to meet this condition. This elevation is EL -11.0 m.

9) The fuel storage pool wall on F3 wall is updated using offset function per NRC's comment.

10) It is difficult to obtain the forces on nodes from NASTRAN results. GE expects the differences are not significant.

11) Modified truncated model is updated to change the basemat thickness inside pedestal to 5.1 m.

12) The soil springs are attached to the basemat at the middle of basemat thickness. GE has confirmed that the results are not sensitive the attached level of soil springs.

13) Hydro-pressure is updated to apply actual magnitude onto the modified truncated model in Revision 5 of the subject report.

14), 15) In the 2nd structural audit held on December 12, 2006 BNL and GE identified some differences between the results of both models. The possible reasons for the identified differences are summarized below. BNL's ANSYS results received at the audit and re-calculated GE's NASTRAN results are compared in Figures C-1 through C-40.

i) *Forces on the intersection portion of walls:* There are differences of forces at the intersections of outer walls as marked in Figure C-13 for instance. BNL's results show the force concentration caused by the stiffening effect of L or T configuration of walls. From structural design point of view there is no impact on the wall design because rebars which come from both walls are arranged into these sections.

ii) *The knuckles of out-of –plane shear distribution:* In the seismic event, the walls in parallel to the seismic direction have knuckles on the edge of the walls. For example, as shown in Figure C-11, the corner portion of R1/RG of R1 wall has a knuckle in out-of-plane shear force (Qy) for the W-E seismic load condition in GE's results, but BNL's results do not have this configuration. Besides, in case of F3 wall, this configuration can also be found in BNL's results. GE considers that the knuckles are caused by the constraint effects of the wall and basemat connected perpendicular to the subject wall. GE assumes the some part of differences comes from the difference of estimation levels between both models as pointed out above 8).

iii) *The differences of magnitude of forces appeared on basemat inside pedestal:* The result of re-analysis using the updated model shows better agreement. In case of seismic load the magnitude of forces has to be re-compared because BNL's soil spring may not be adequate as pointed out above 3).

iv) *The differences of magnitude of forces appeared on outer wall of Fuel Storage Pool (FSP):* For the out-of-plane shear forces and moments on RA and F3 wall located around FSP in case of Hydrostatic load, BNL's results are lower than those of GE. GE assumes the some part of differences comes from the difference of estimation levels between both models as pointed out above 8). In order to have a better understanding of the differences, GE would like to request BNL to confirm the input data for Hydrostatic load.

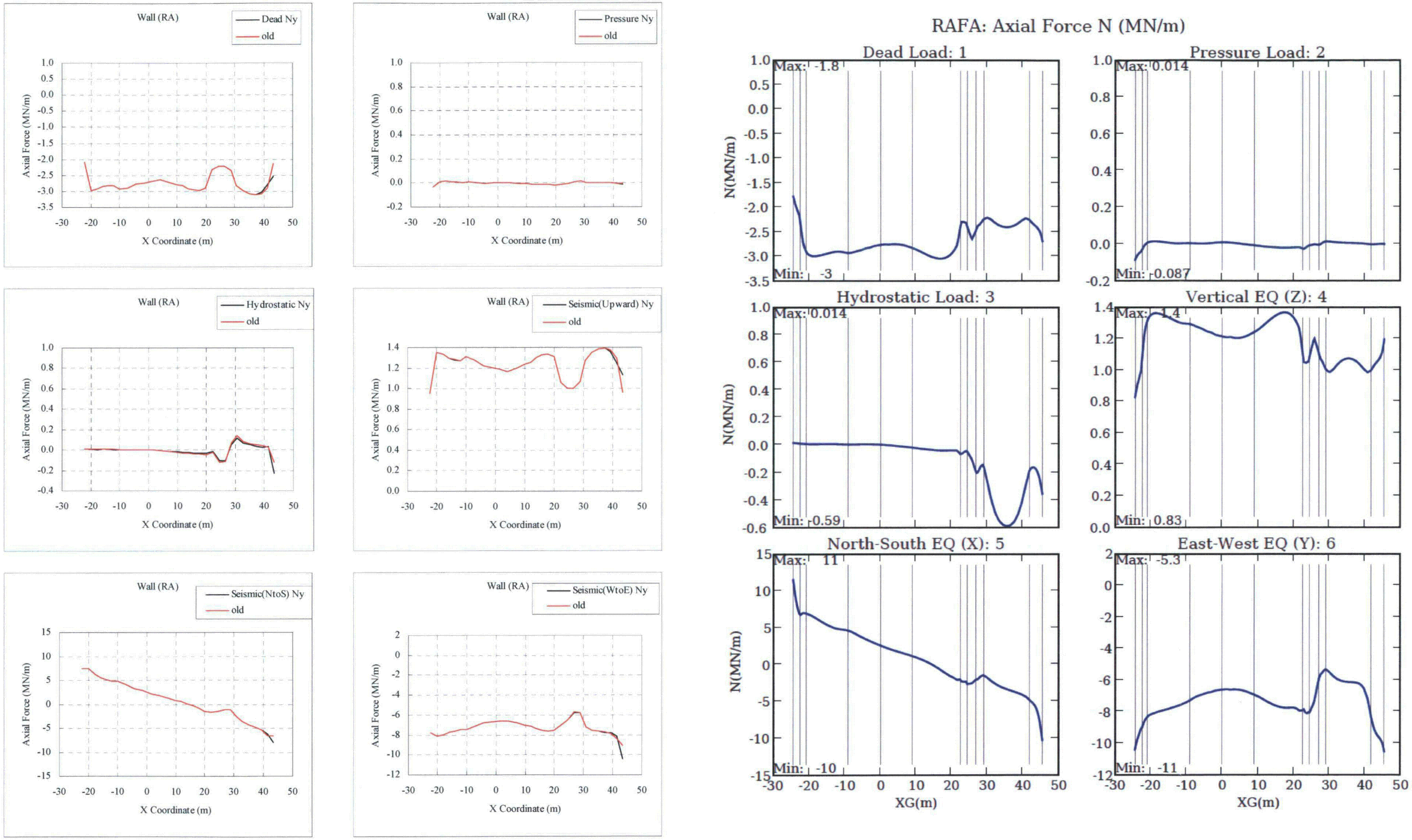


Figure C-1 Element Forces Comparison NASTRAN to ANSYS (RA FA Wall: Axial Force [MN/m])

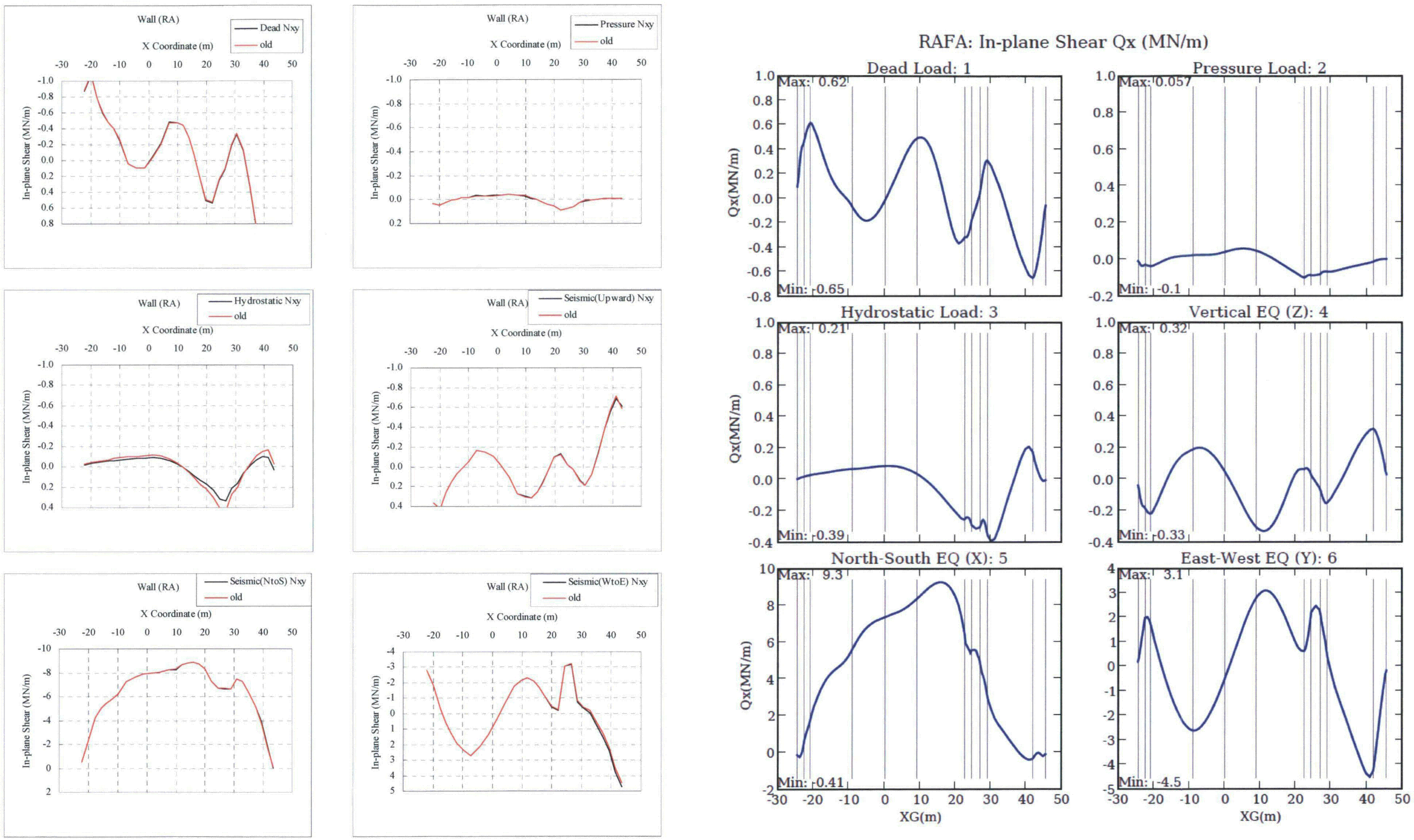


Figure C-2 Element Forces Comparison NASTRAN to ANSYS (RA FA Wall: In-plane Shear [MN/m])

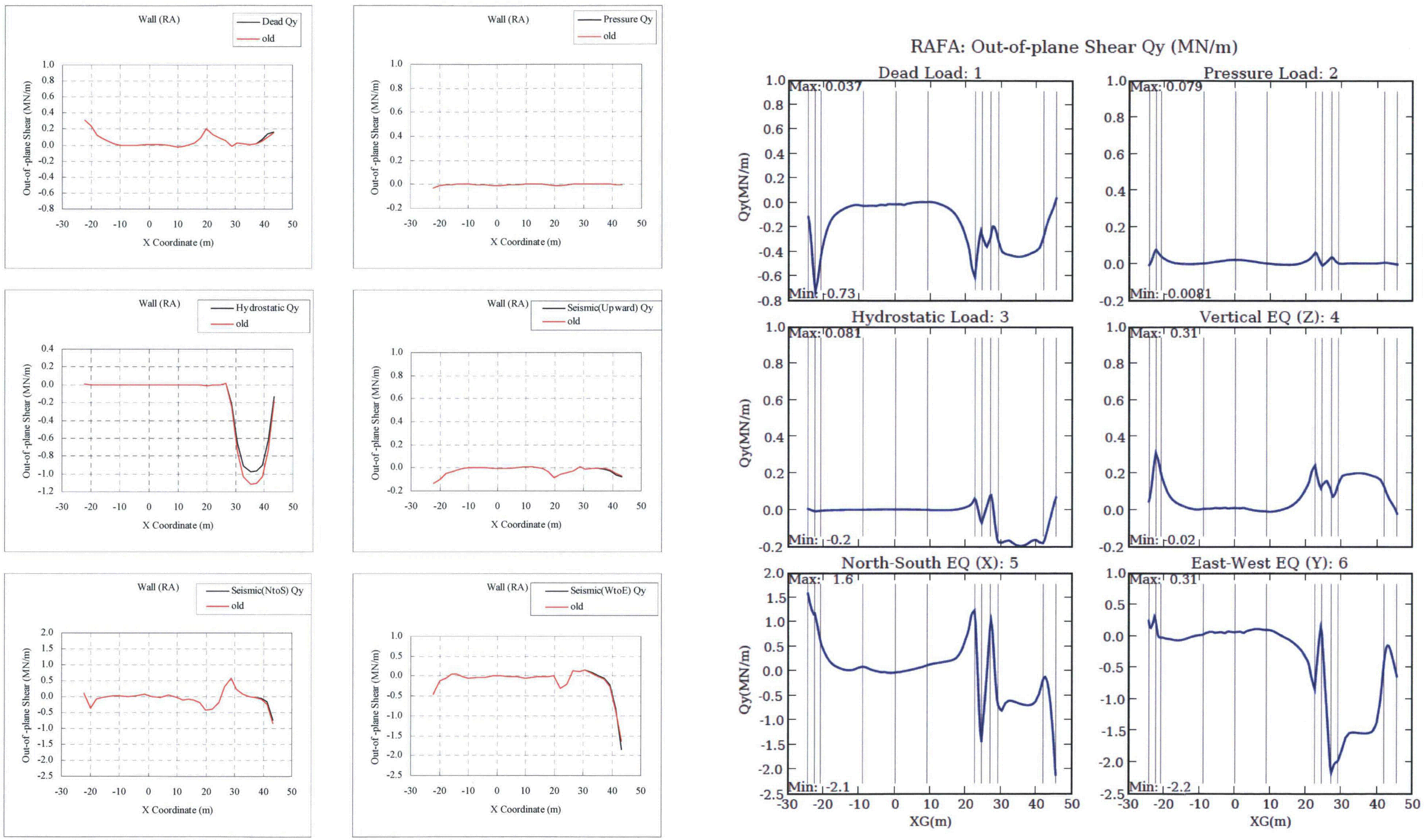


Figure C-3 Element Forces Comparison NASTRAN to ANSYS (RA FA Wall: Out-of-plane Shear [MN/m])

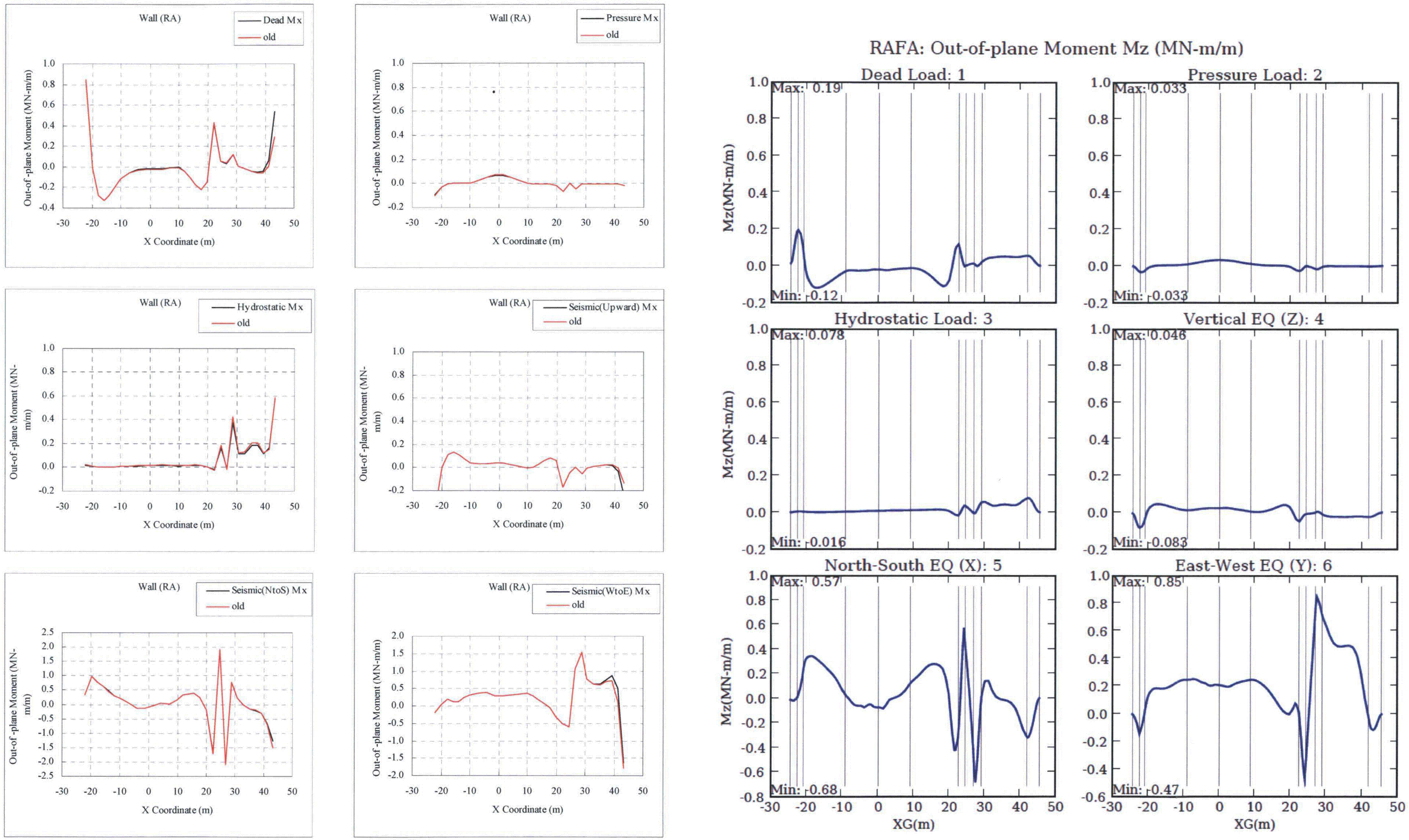


Figure C-4 Element Forces Comparison NASTRAN to ANSYS (RA FA Wall: Out-of-plane Moment [MN-m/m])

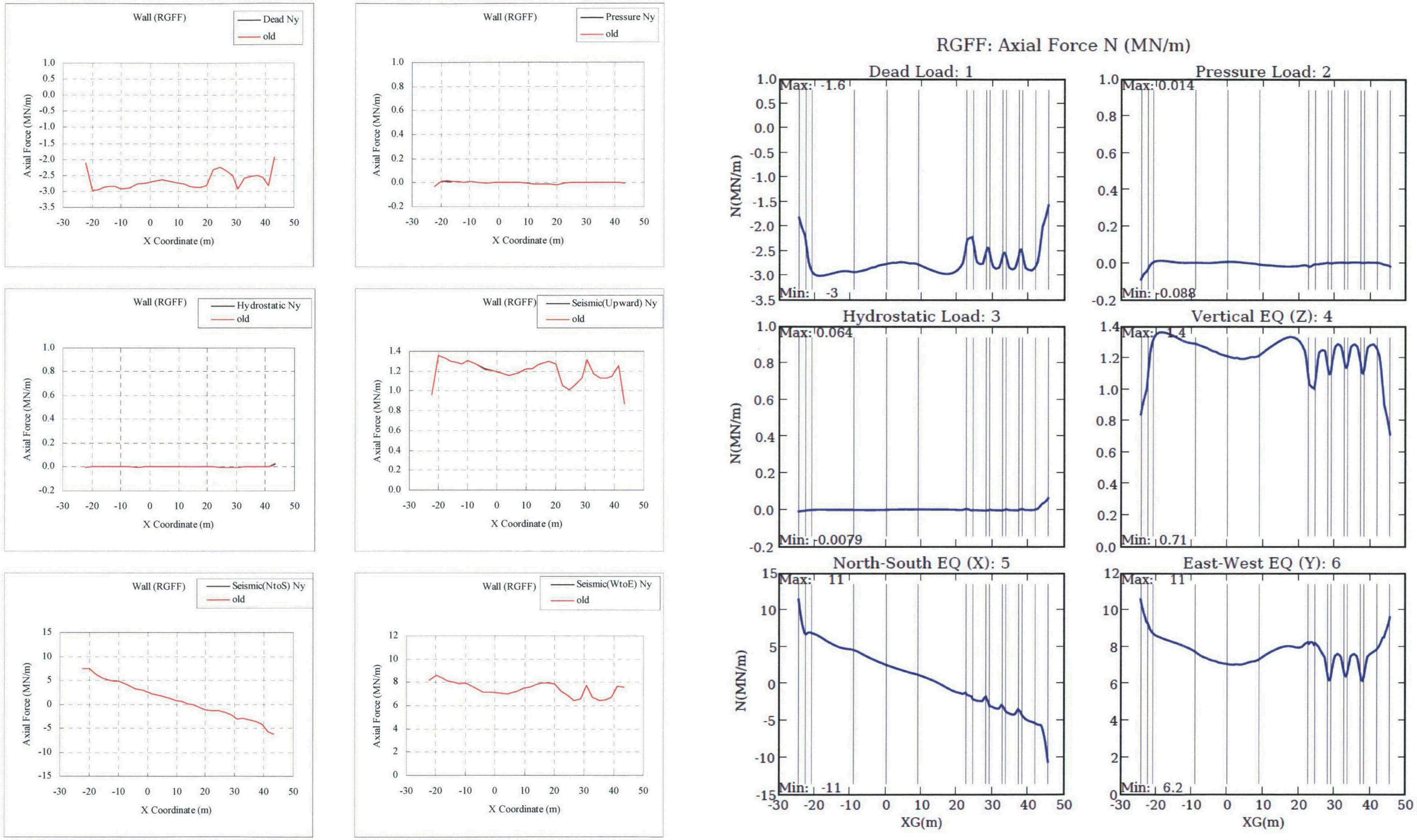


Figure C-5 Element Forces Comparison NASTRAN to ANSYS (RG FA Wall: Axial Force [MN/m])

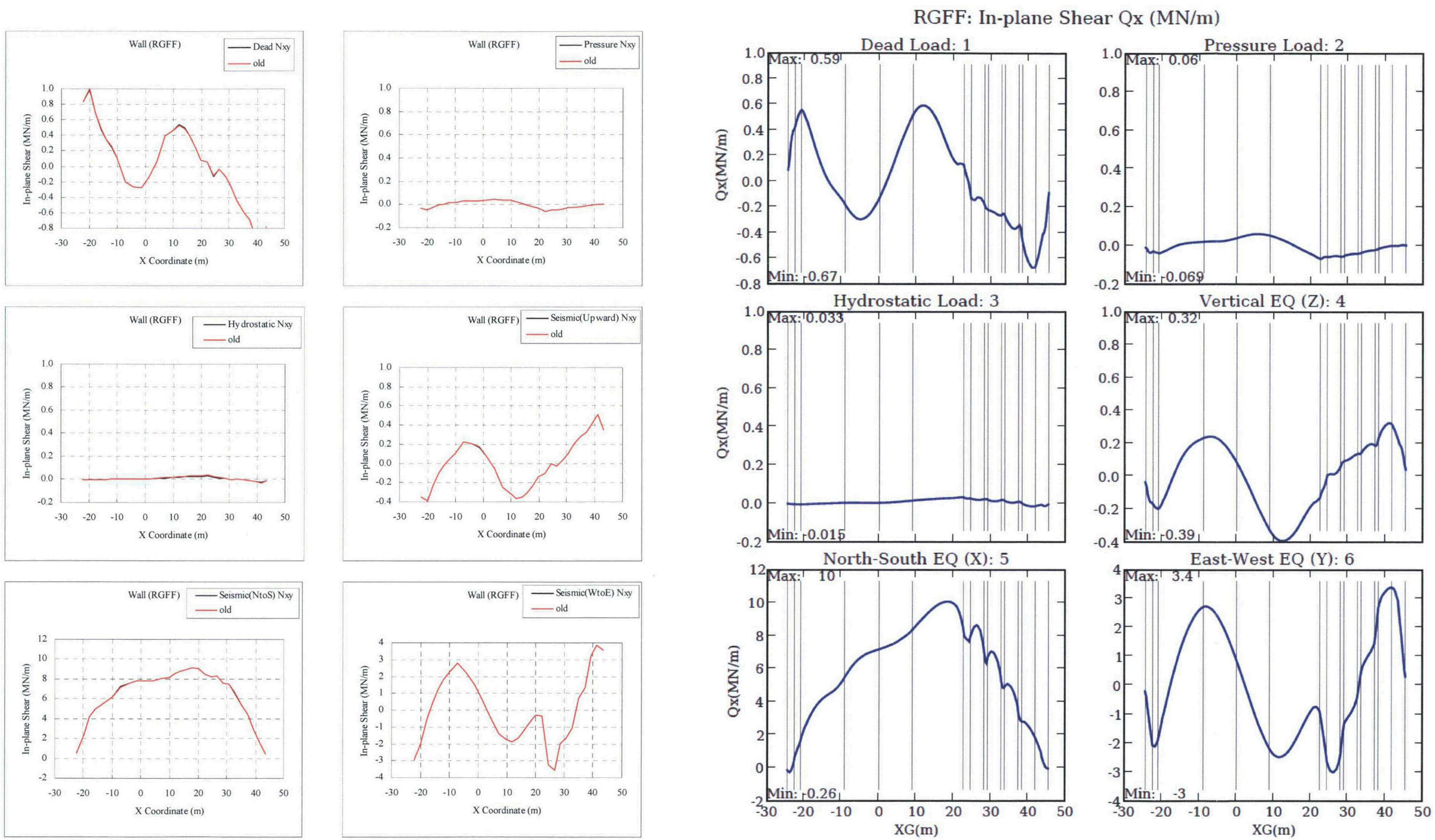


Figure C-6 Element Forces Comparison NASTRAN to ANSYS (RG FF Wall: In-plane Shear [MN/m])

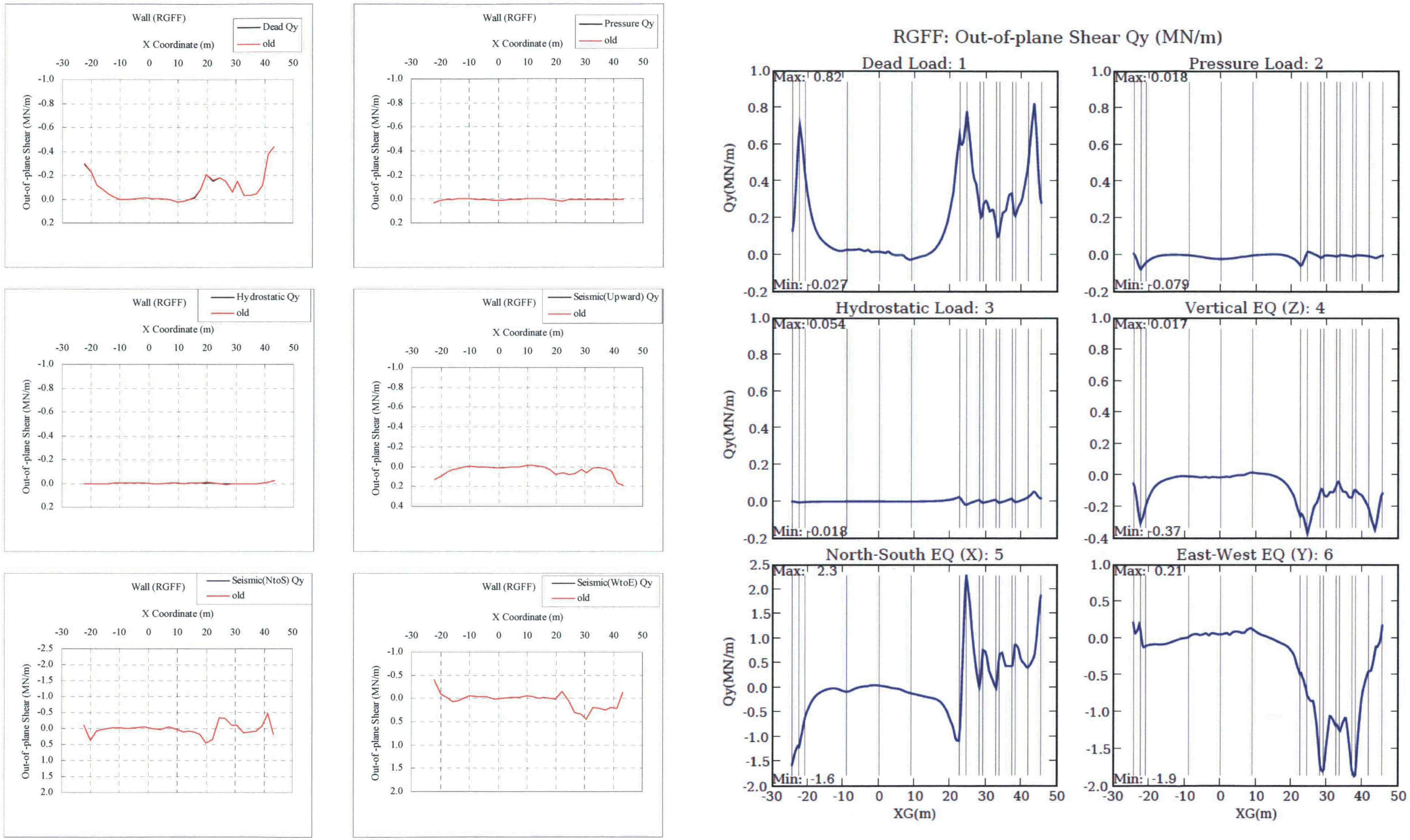


Figure C-7 Element Forces Comparison NASTRAN to ANSYS (RG FF Wall: Out-of-plane Shear [MN/m])

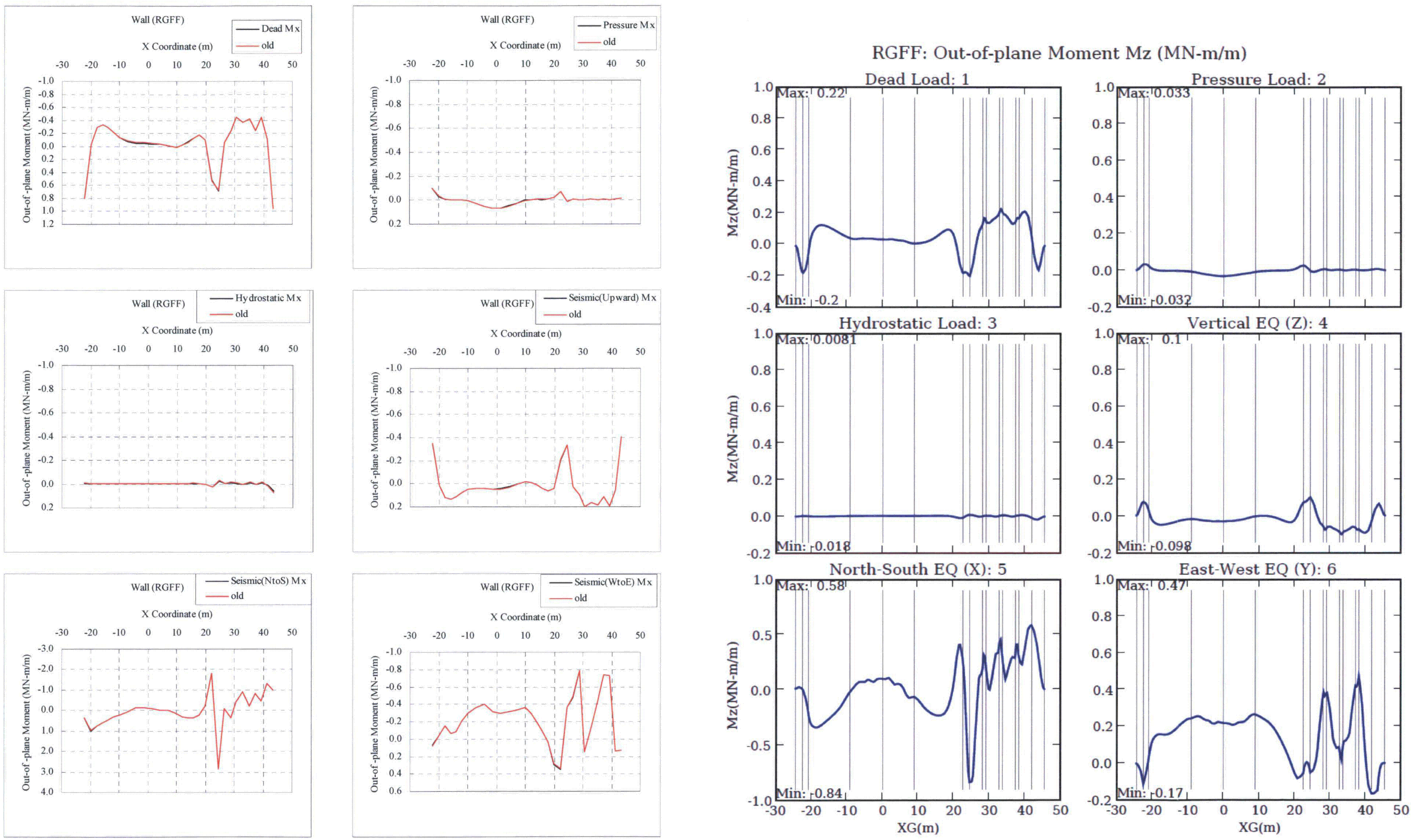


Figure C-8 Element Forces Comparison NASTRAN to ANSYS (RG FF Wall: Out-of-plane Moment [MN-m/m])

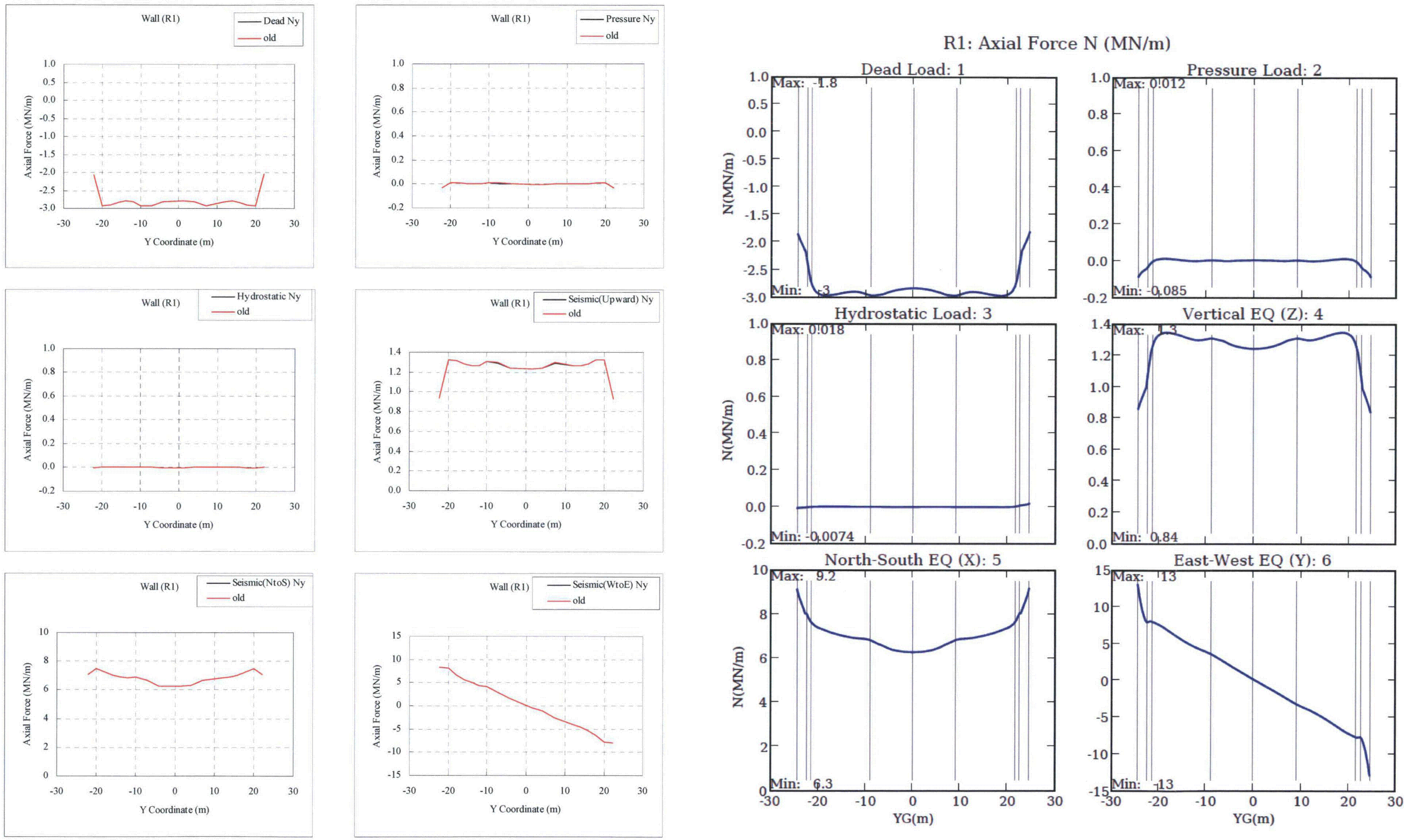


Figure C-9 Element Forces Comparison NASTRAN to ANSYS (R1 Wall: Axial Force [MN/m])

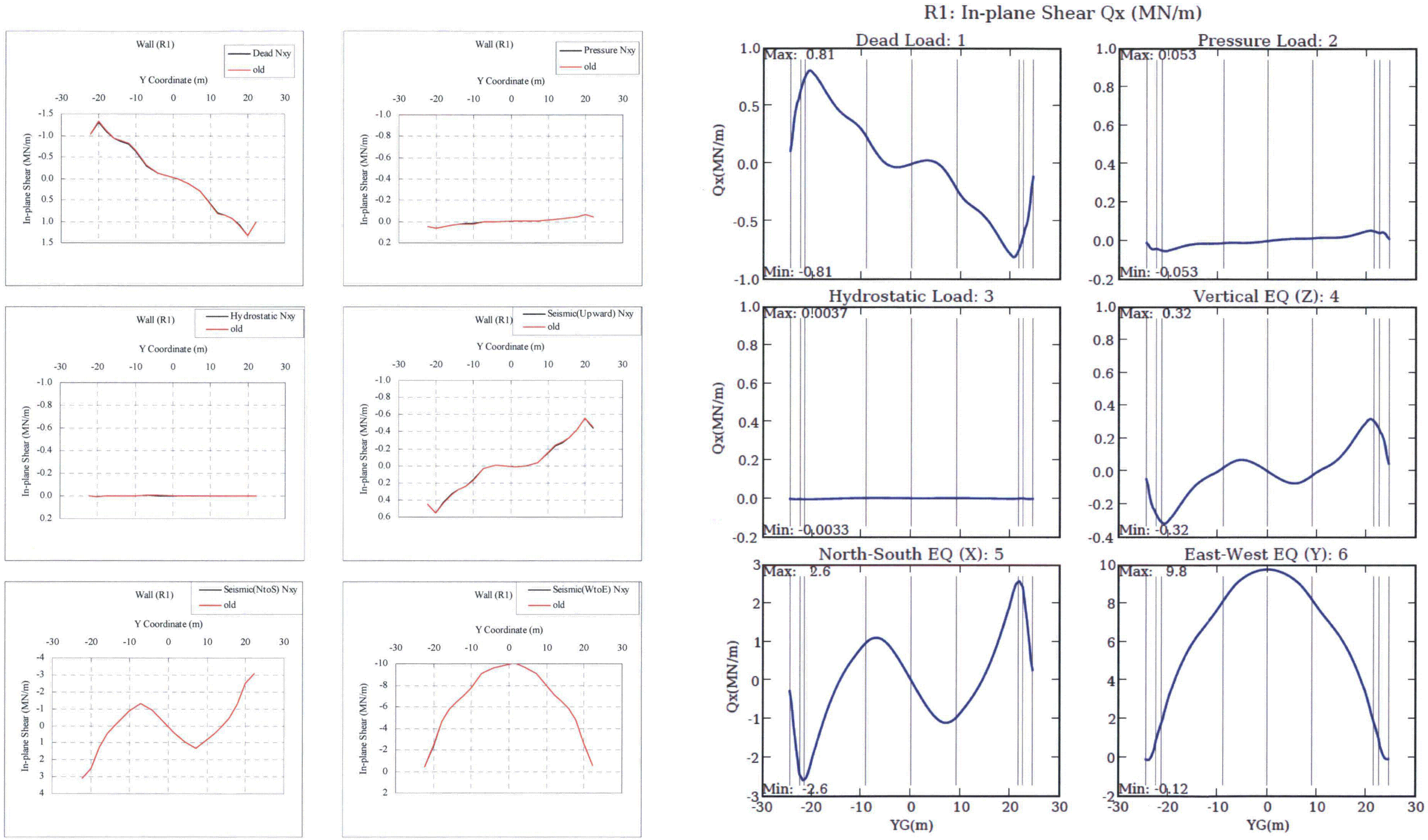
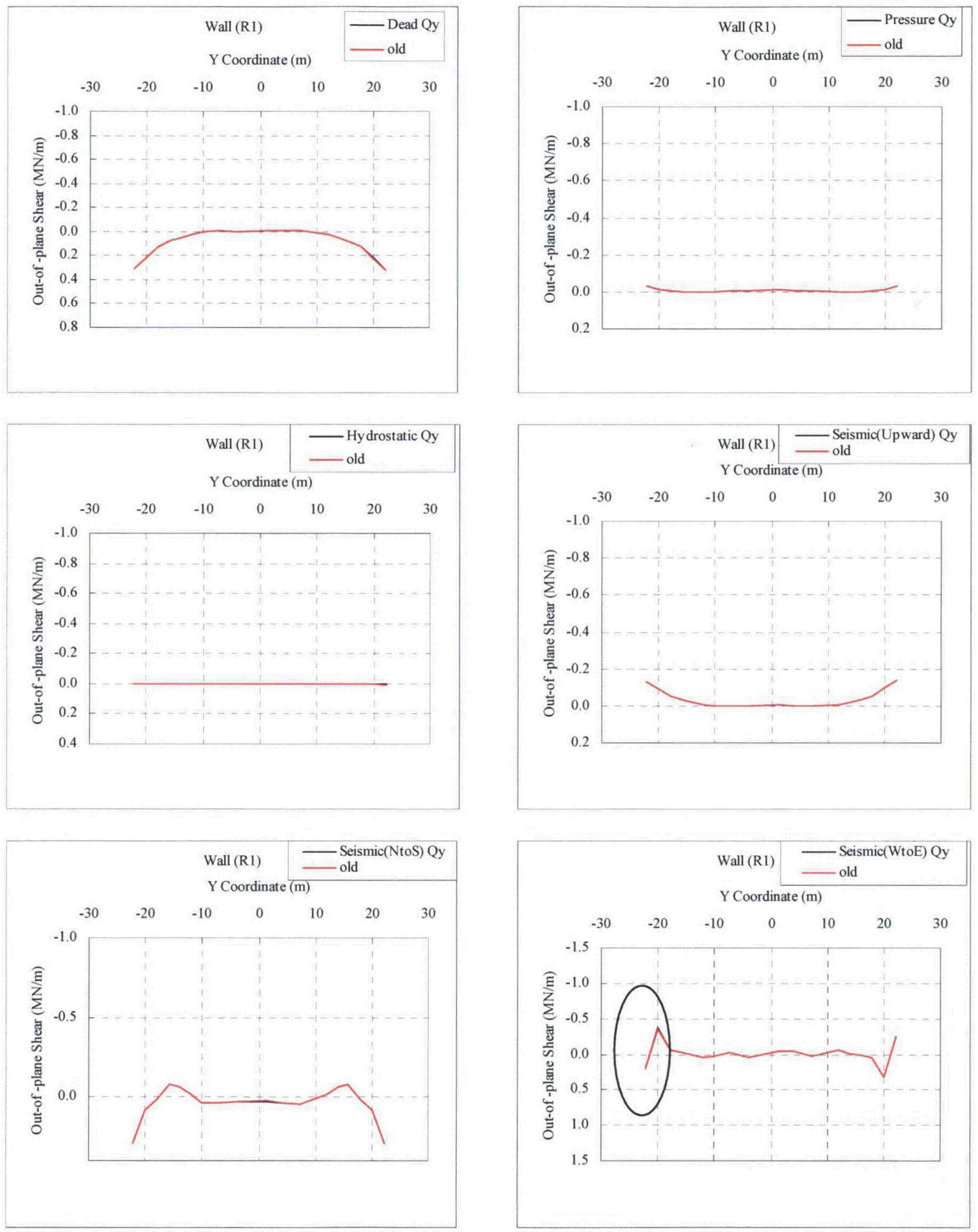


Figure C-10 Element Forces Comparison NASTRAN to ANSYS (R1 Wall: In-plane Shear [MN/m])



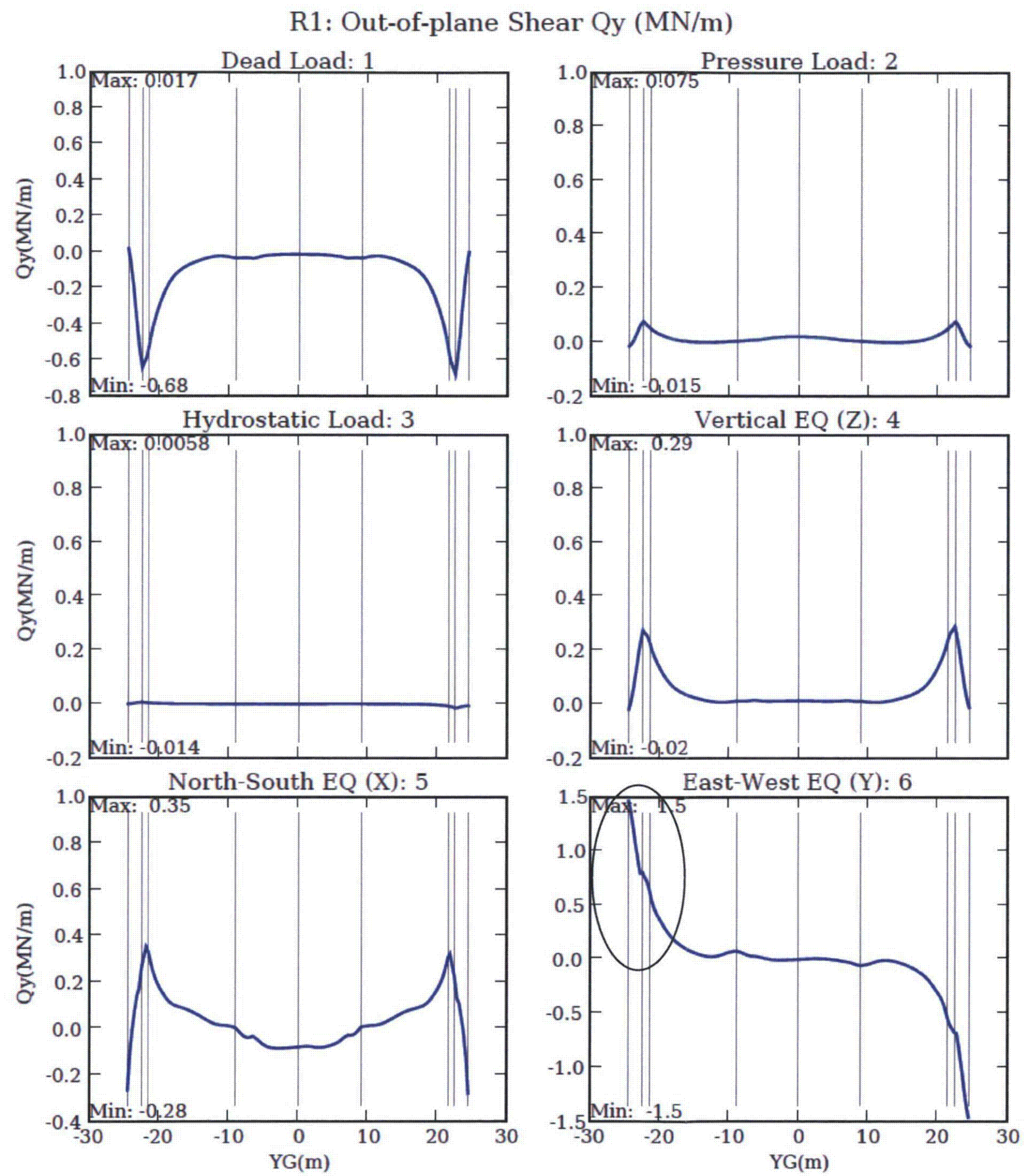


Figure C-11 Element Forces Comparison NASTRAN to ANSYS (R1 Wall: Out-of-plane Shear [MN/m])

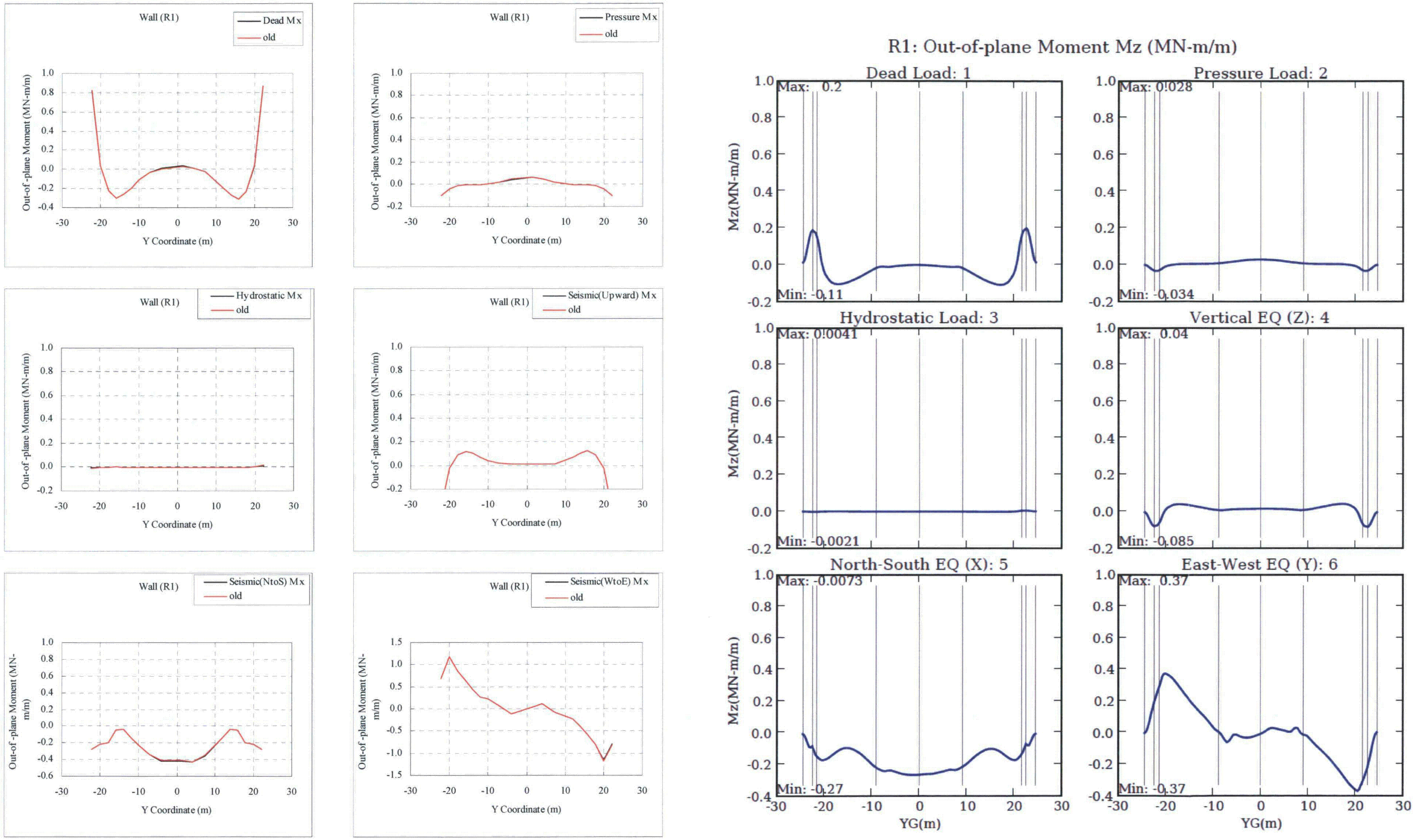


Figure C-12 Element Forces Comparison NASTRAN to ANSYS (R1 Wall: Out-of-plane Moment [MN-m/m])

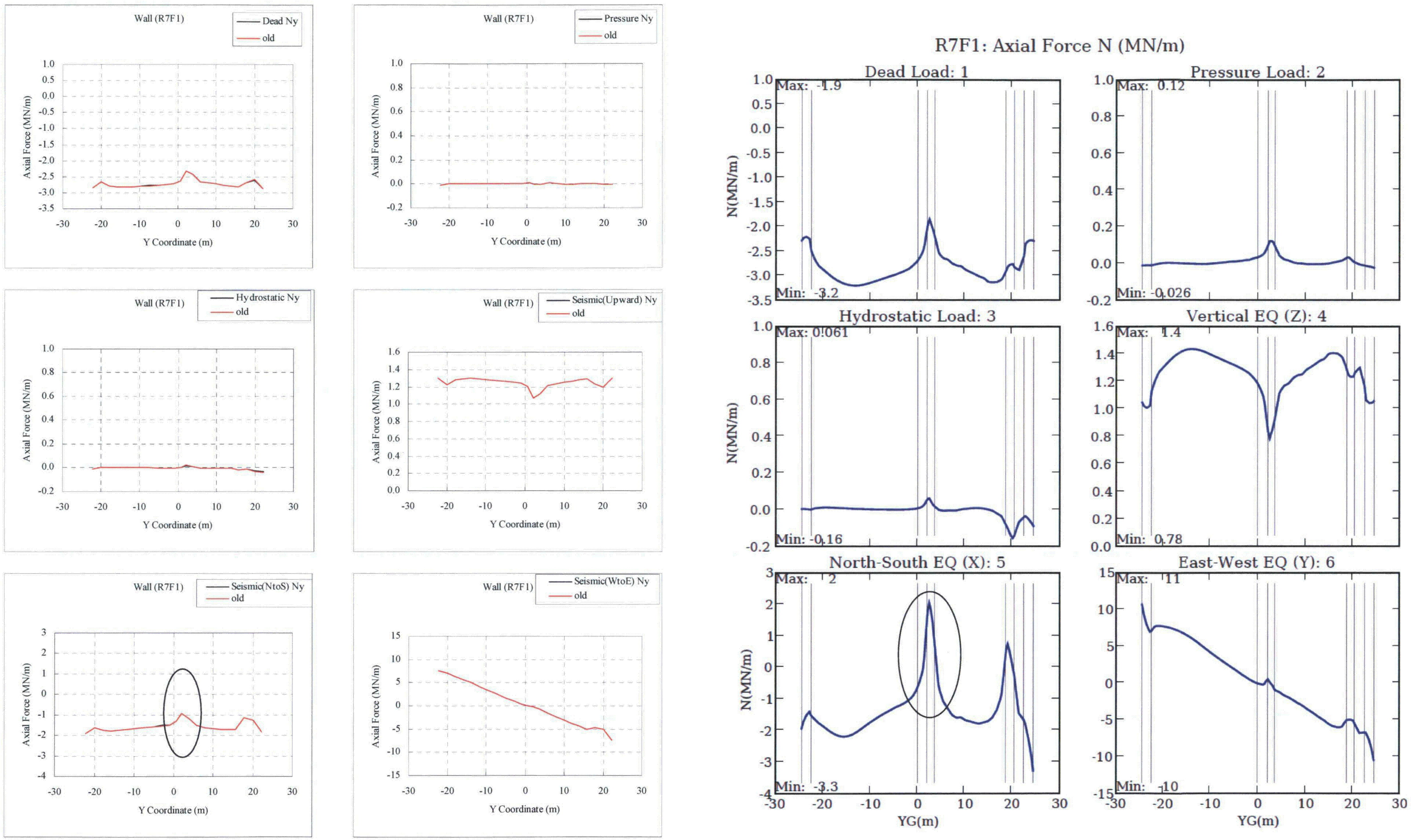


Figure C-13 Element Forces Comparison NASTRAN to ANSYS (R7 F1 Wall: Axial Force [MN/m])

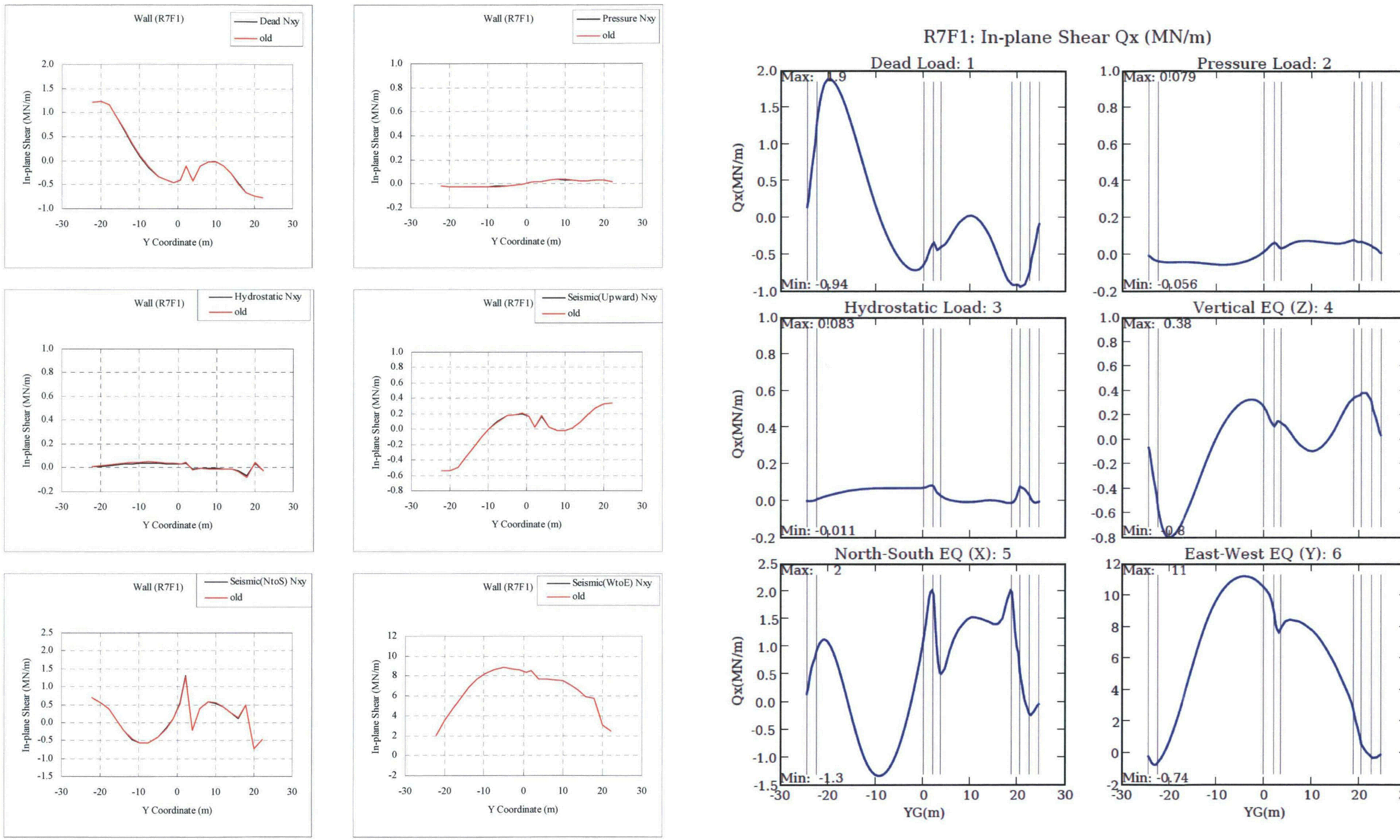


Figure C-14 Element Forces Comparison NASTRAN to ANSYS (R7 F1 Wall: In-plane Shear [MN/m])

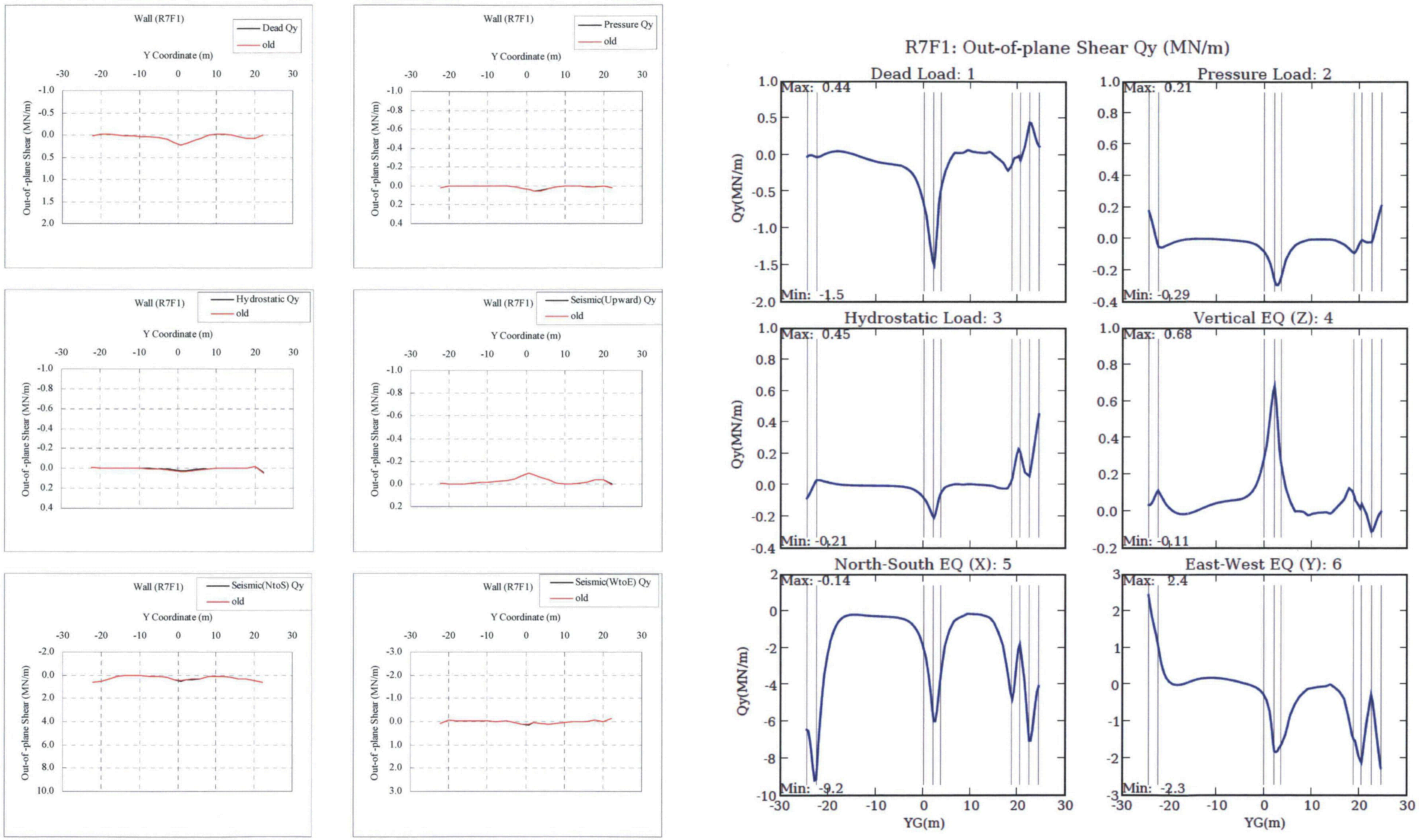
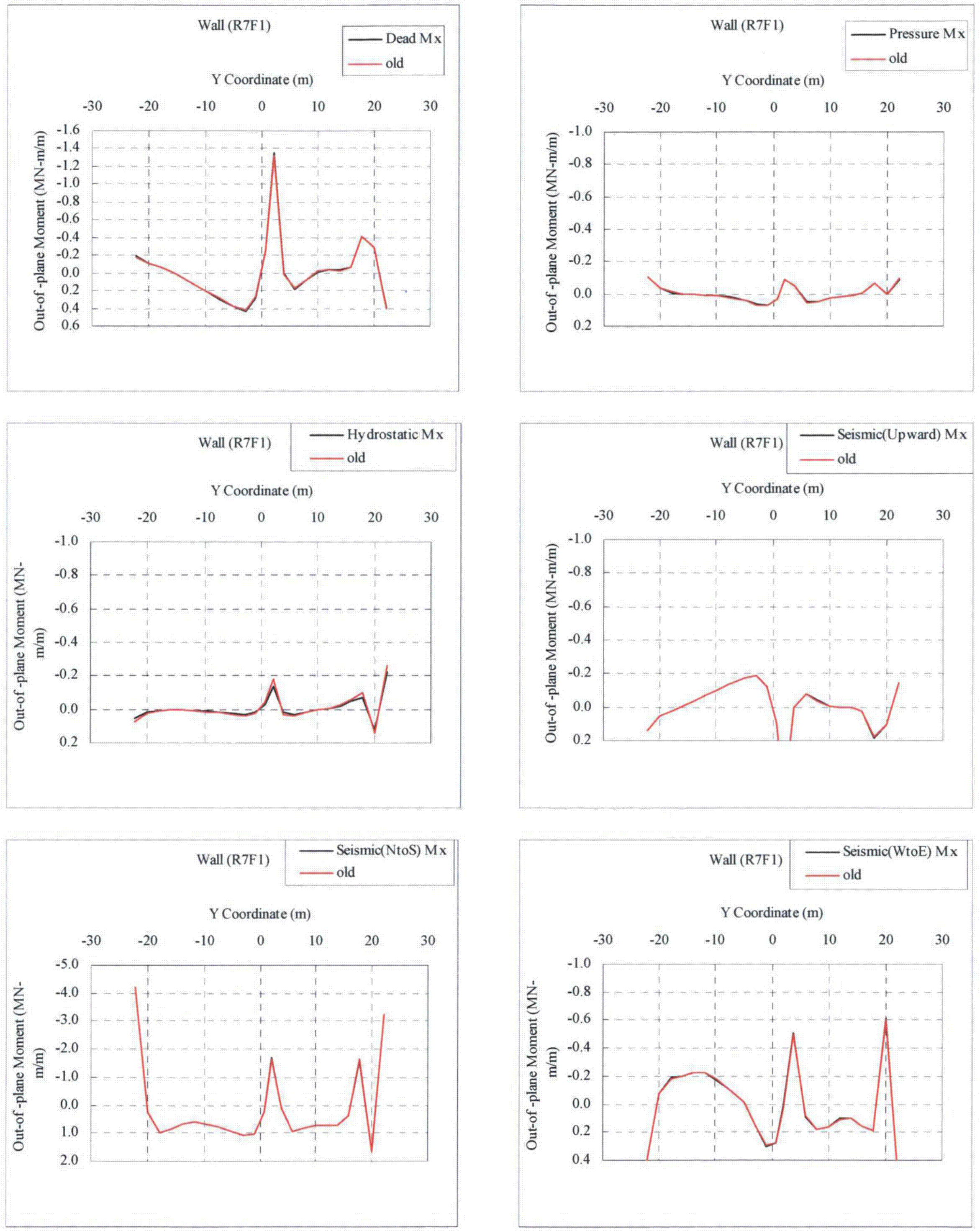


Figure C-15 Element Forces Comparison NASTRAN to ANSYS (R7 F1 Wall: Out-of-plane Shear [MN/m])



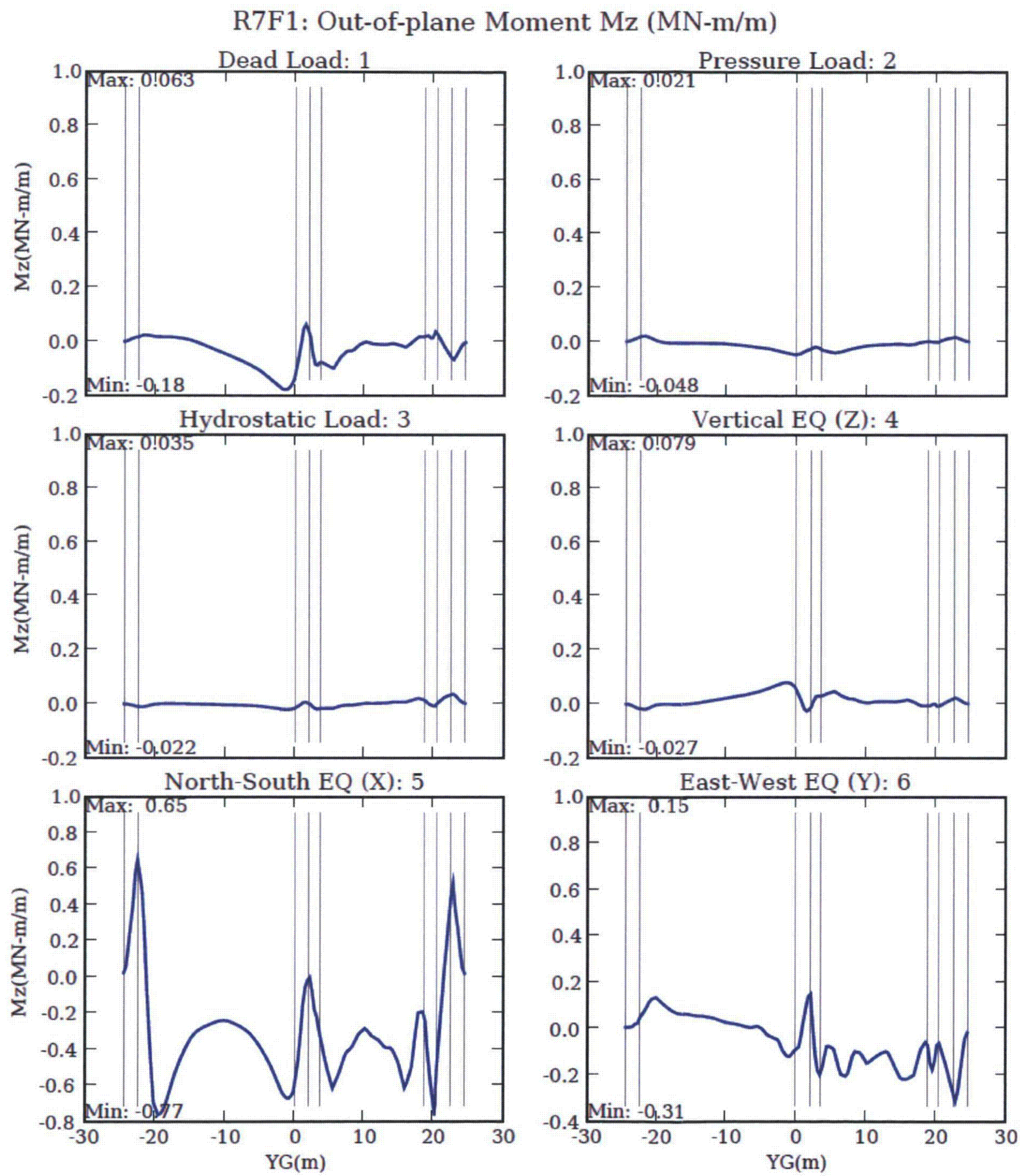


Figure C-16 Element Forces Comparison NASTRAN to ANSYS (R7 F1 Wall: Out-of-plane Moment [MN/m])

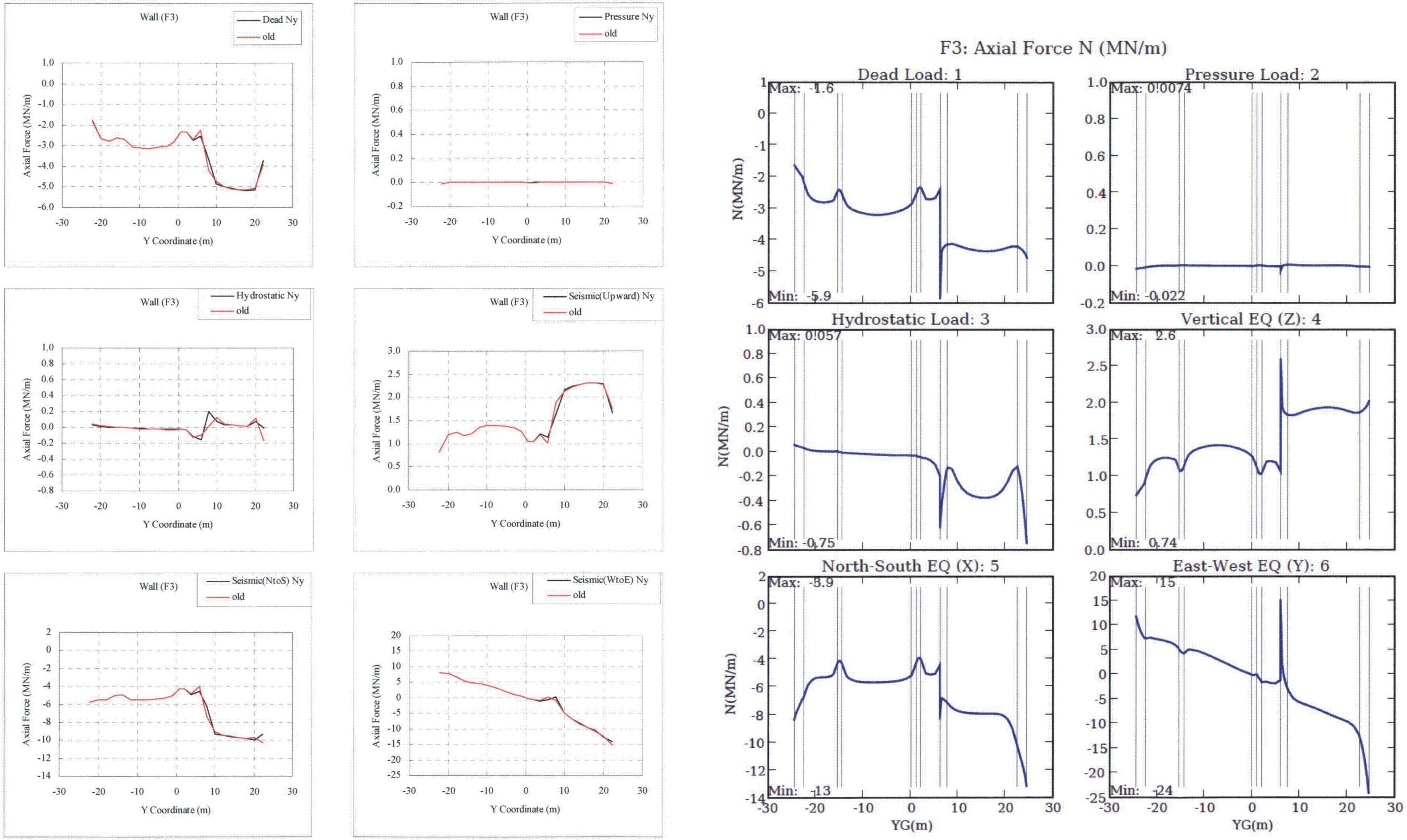


Figure C-17 Element Forces Comparison NASTRAN to ANSYS (F3 Wall: Axial Force [MN/m])

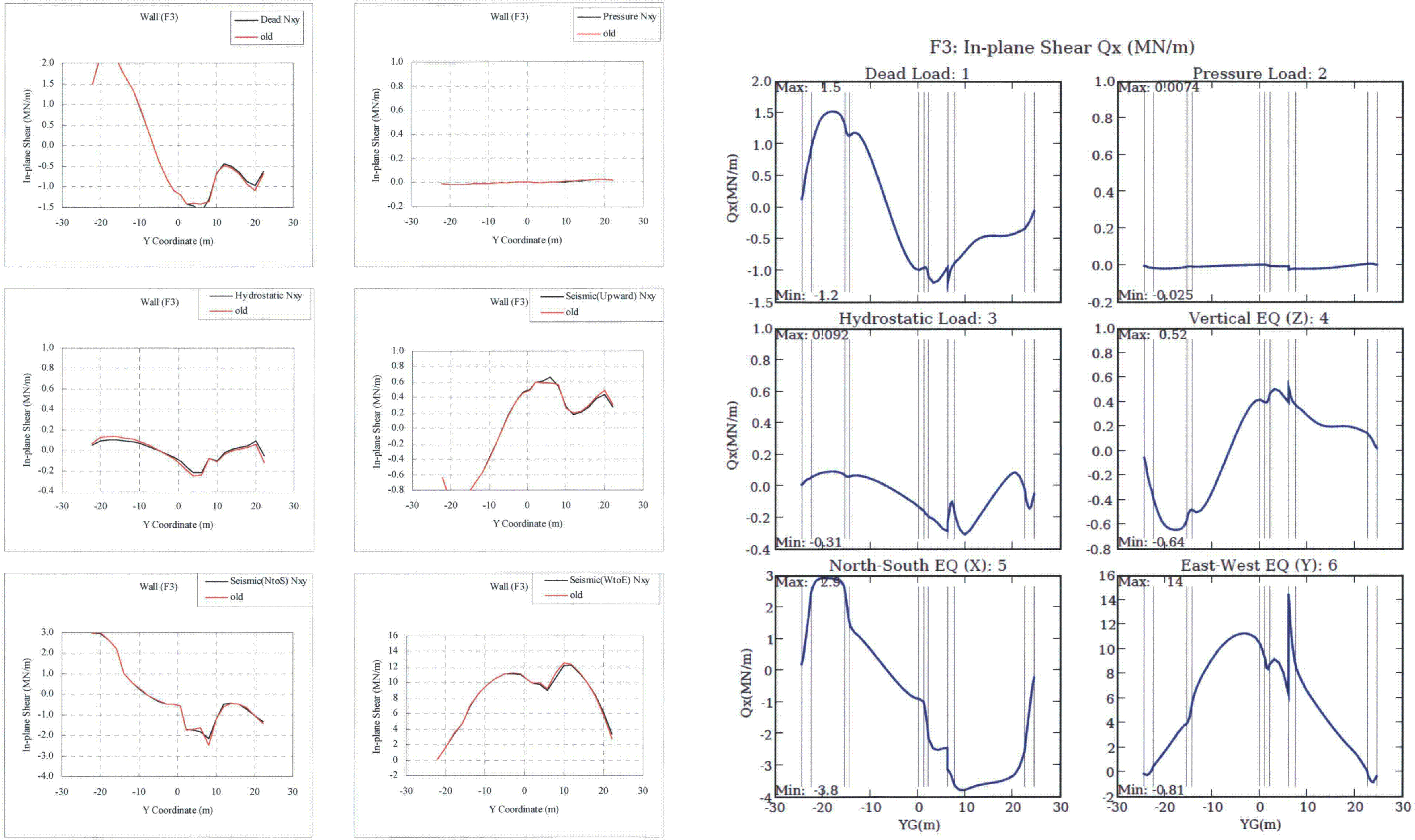


Figure C-18 Element Forces Comparison NASTRAN to ANSYS (F3 Wall: In-plane Shear [MN/m])

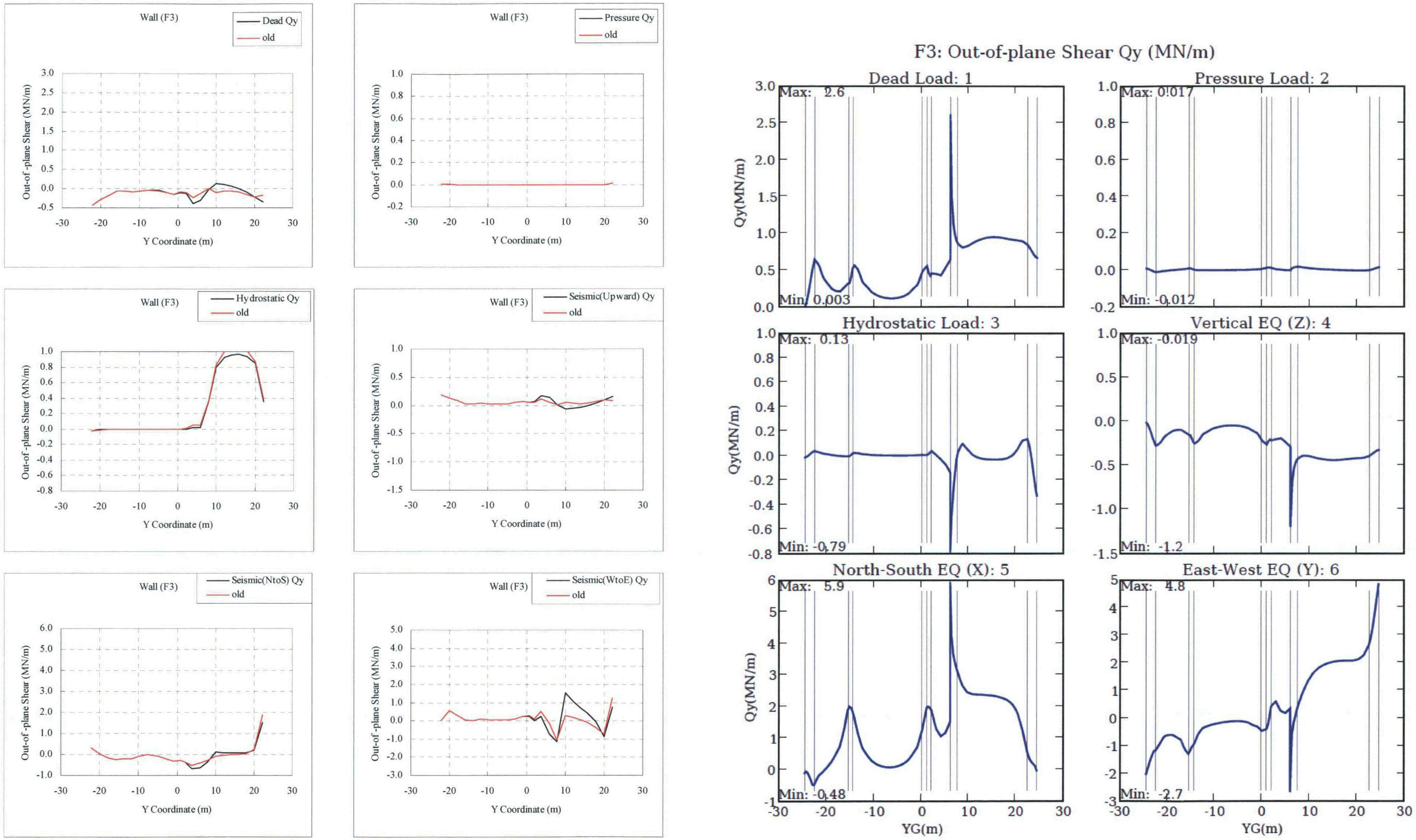


Figure C-19 Element Forces Comparison NASTRAN to ANSYS (F3 Wall: Out-of-plane Shear [MN/m])

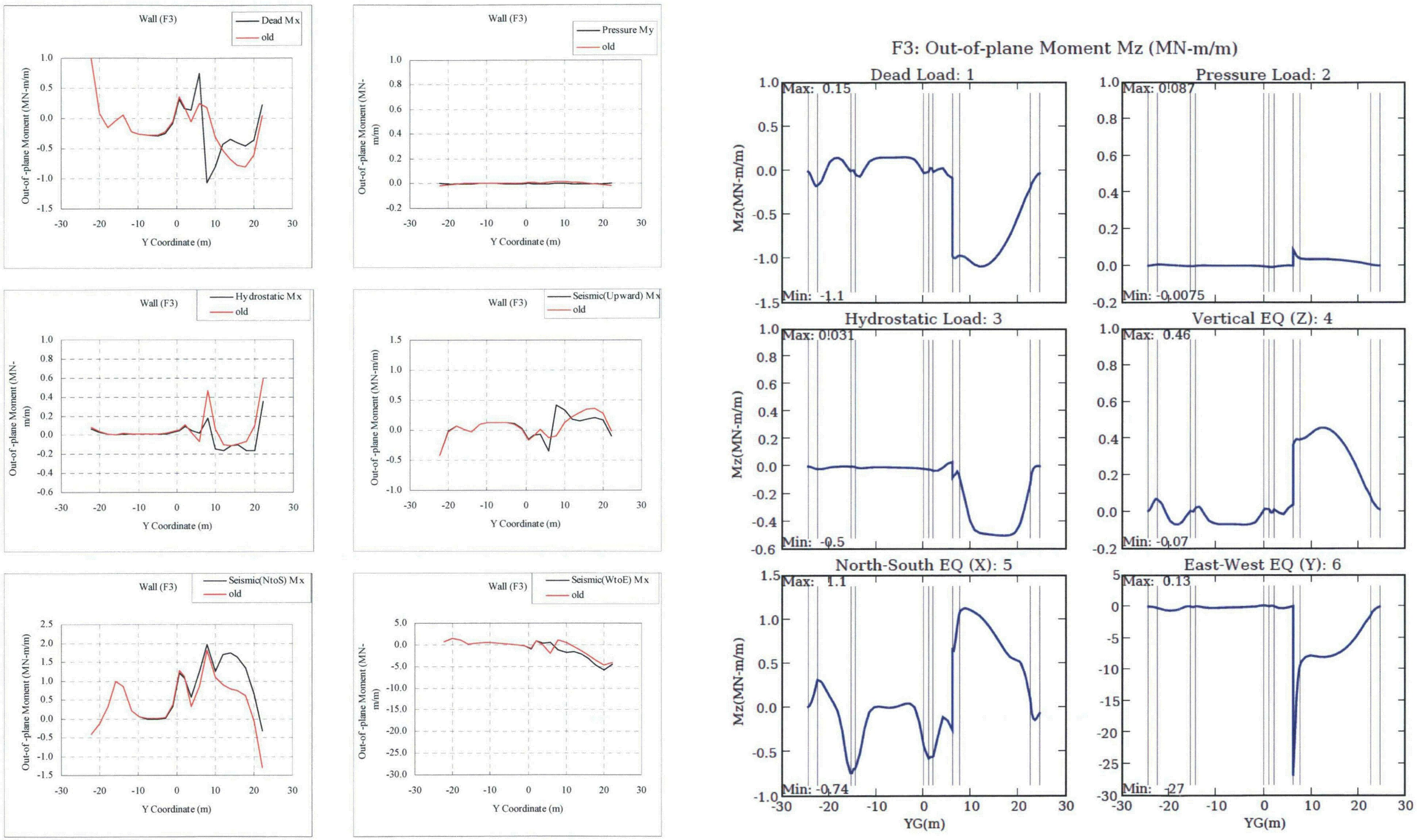


Figure C-20 Element Forces Comparison NASTRAN to ANSYS (F3 Wall: Out-of-plane Moment [MN-m/m])

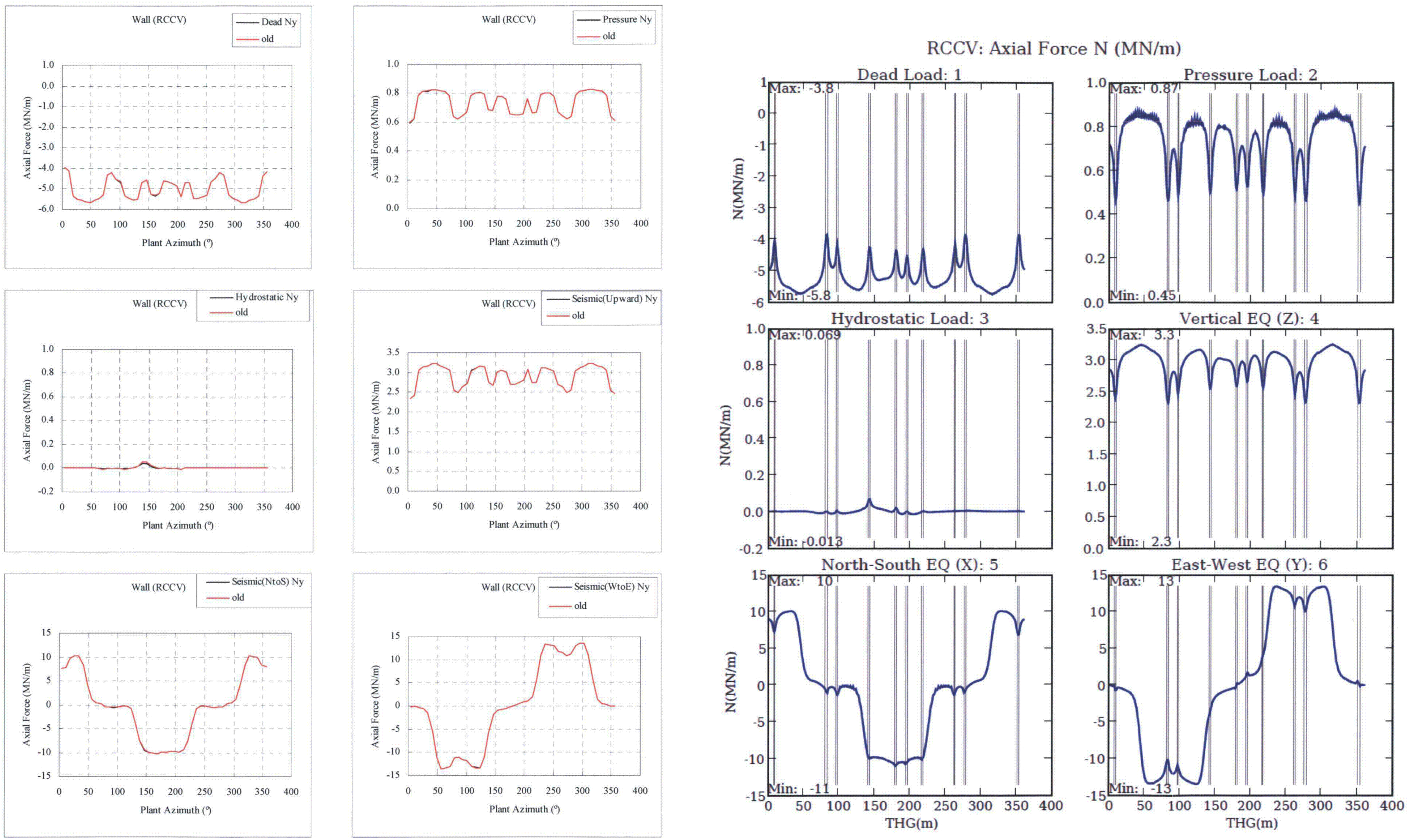


Figure C-21 Element Forces Comparison NASTRAN to ANSYS (RCCV: Axial Force [MN/m])

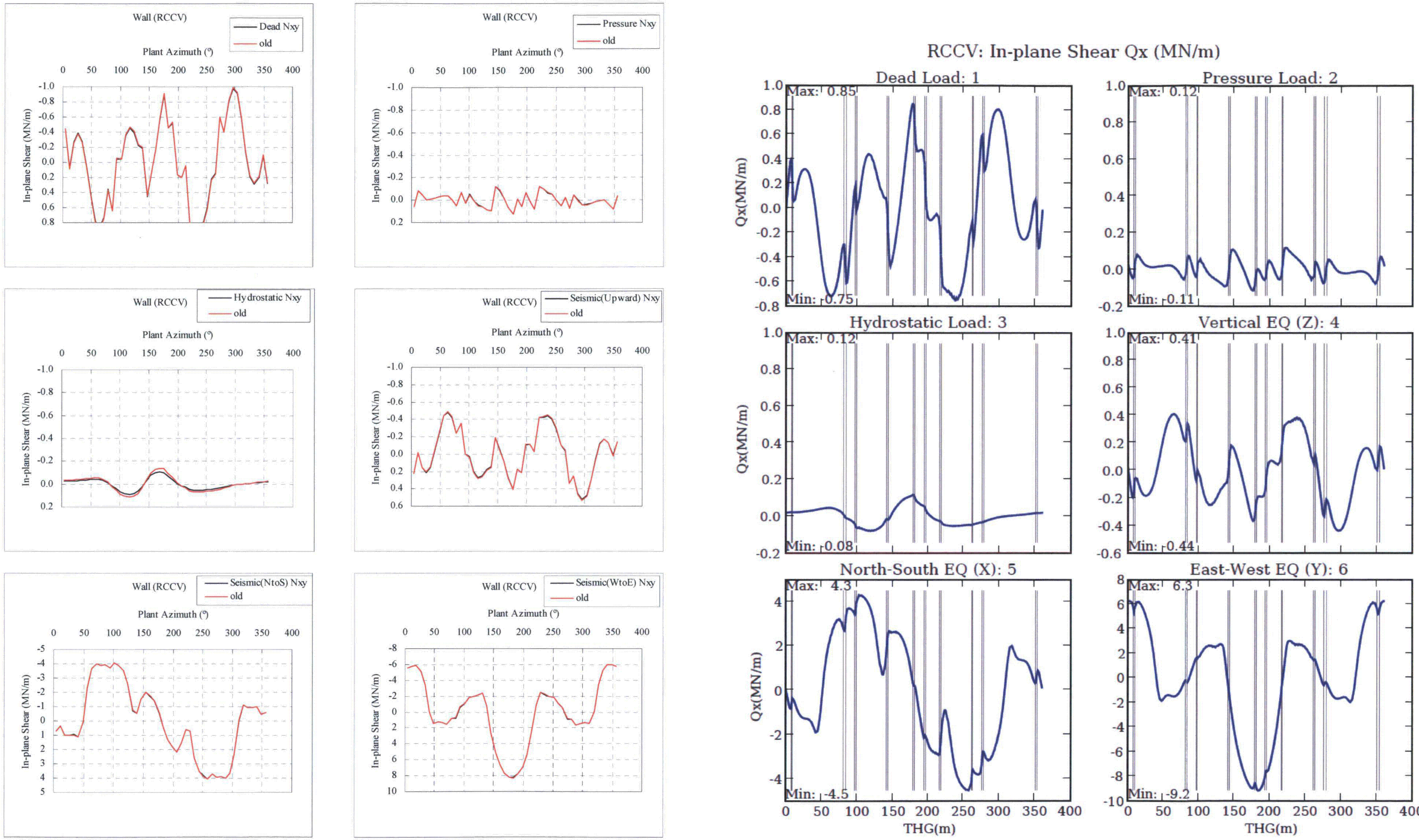


Figure C-22 Element Forces Comparison NASTRAN to ANSYS (RCCV: In-plane Shear [MN/m])

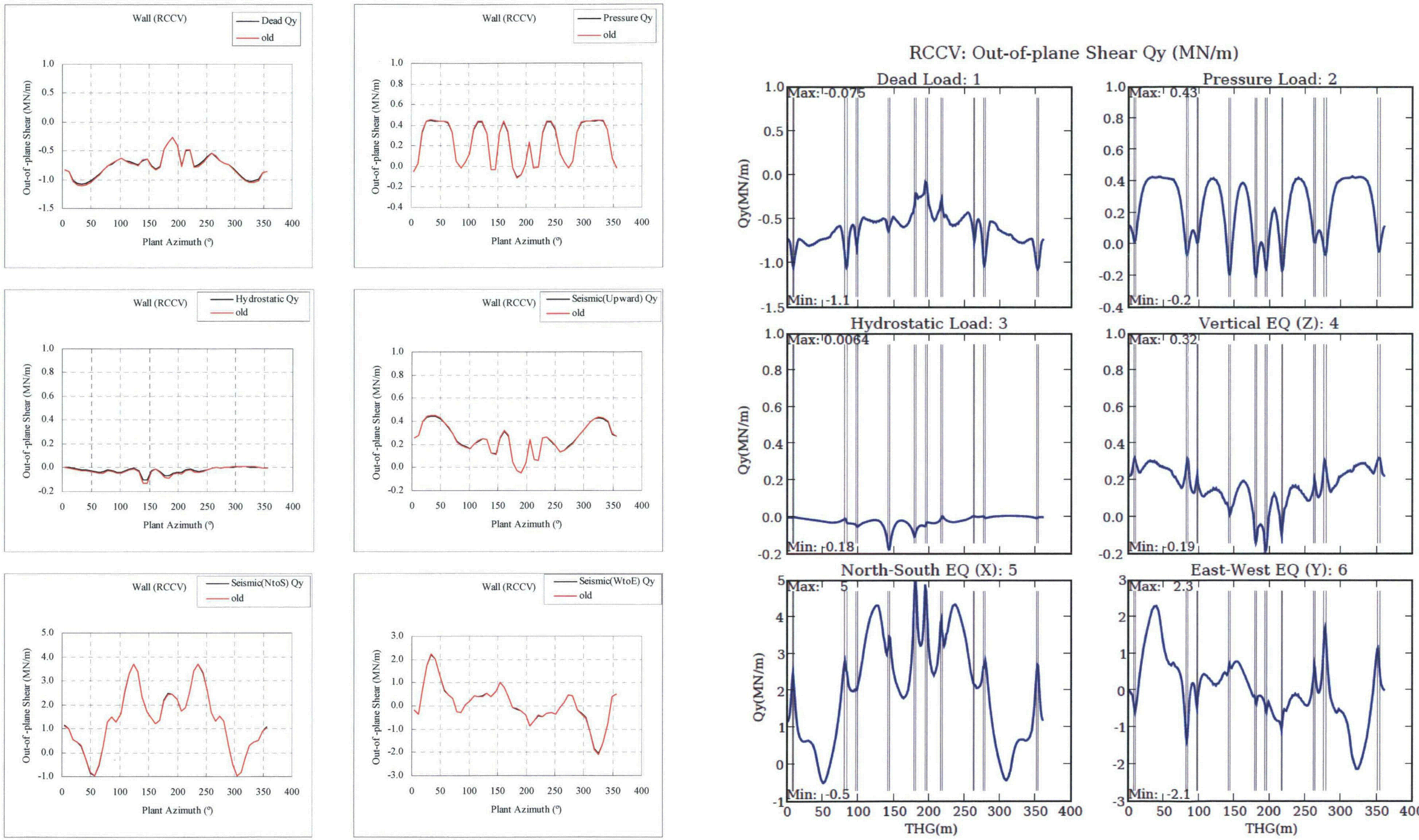


Figure C-23 Element Forces Comparison NASTRAN to ANSYS (RCCV: Out-of-plane Shear [MN/m])

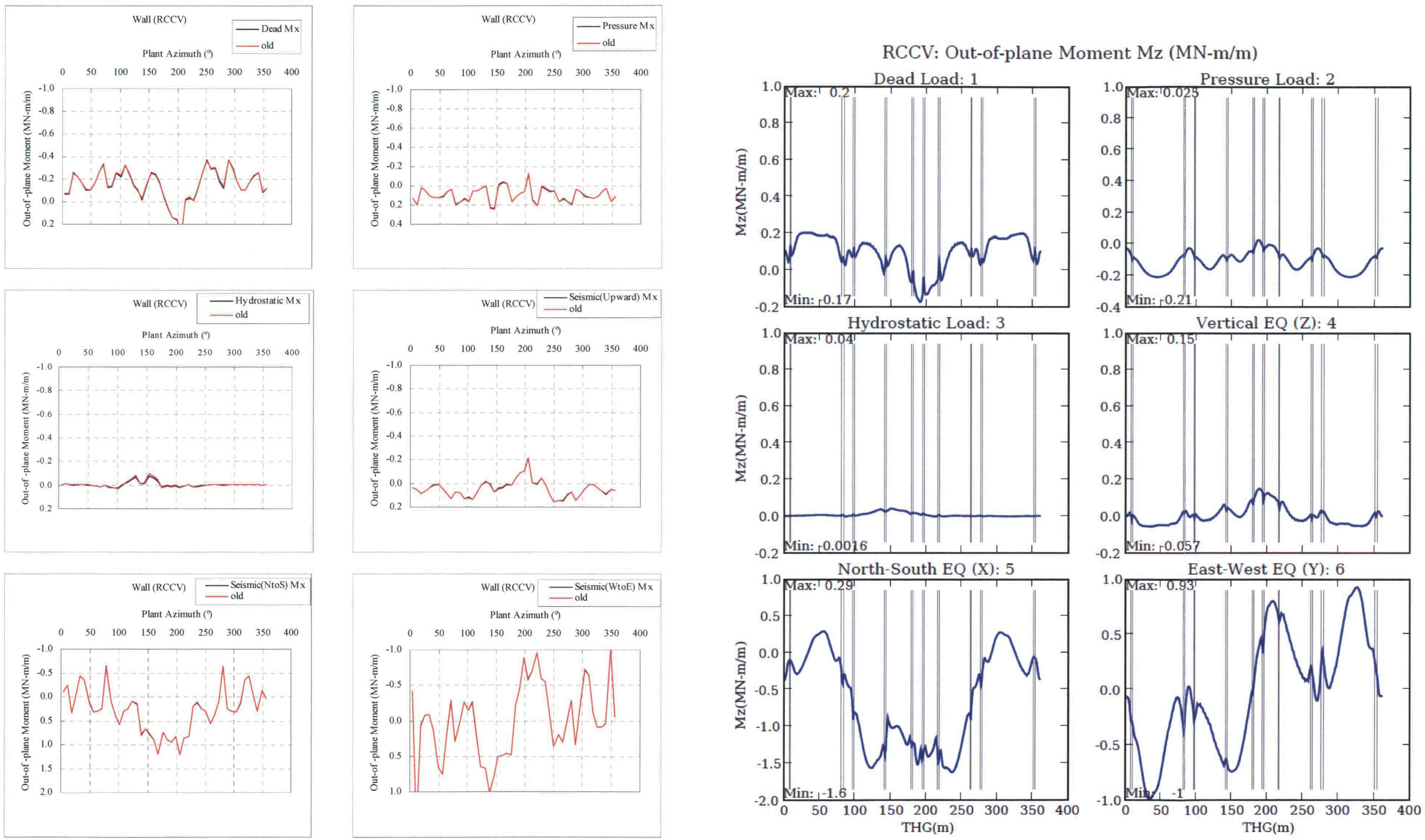


Figure C-24 Element Forces Comparison NASTRAN to ANSYS (RCCV: Out-of-plane Moment [MN-m/m])

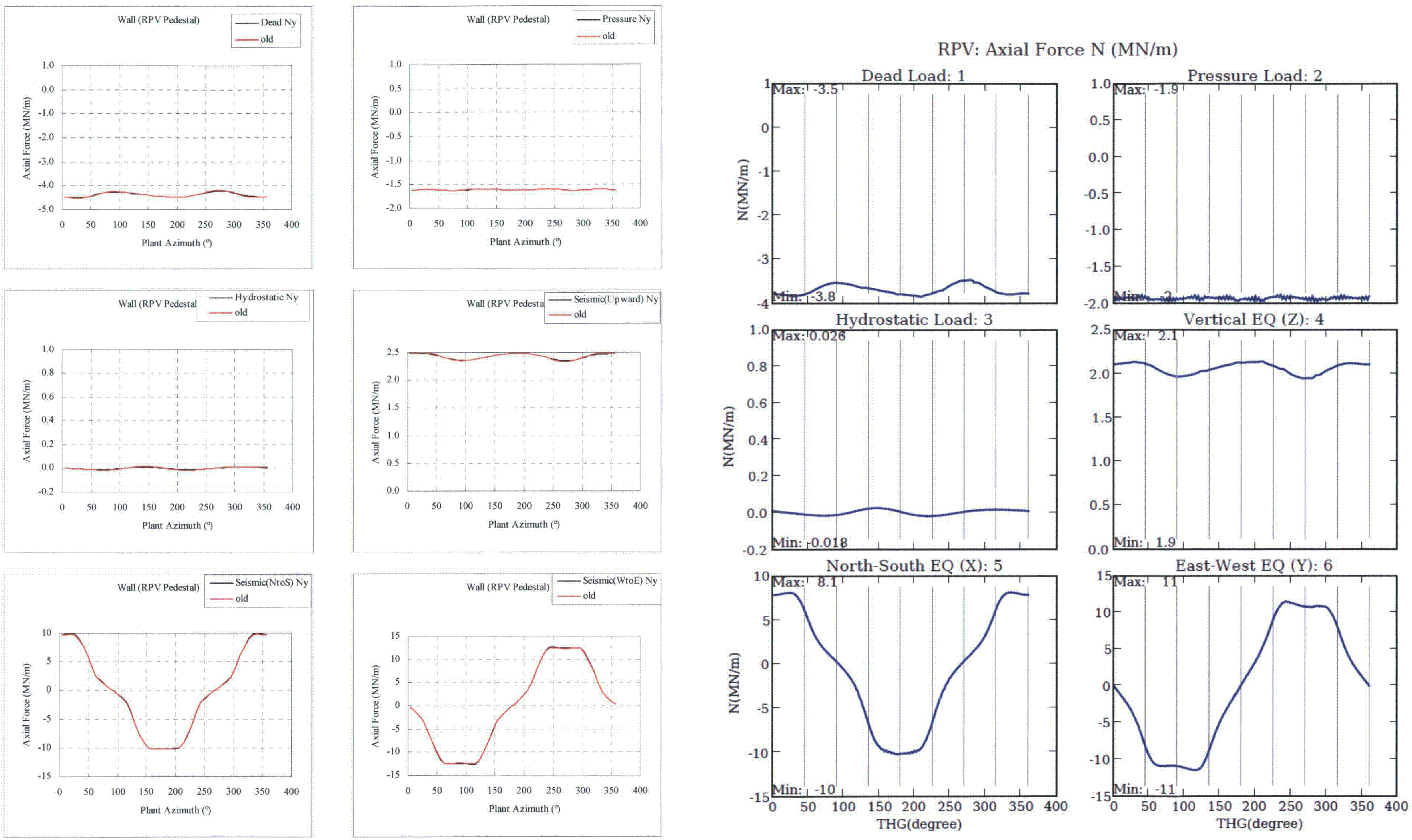


Figure C-25 Element Forces Comparison NASTRAN to ANSYS (RPV Pedestal: Axial Force [MN/m])

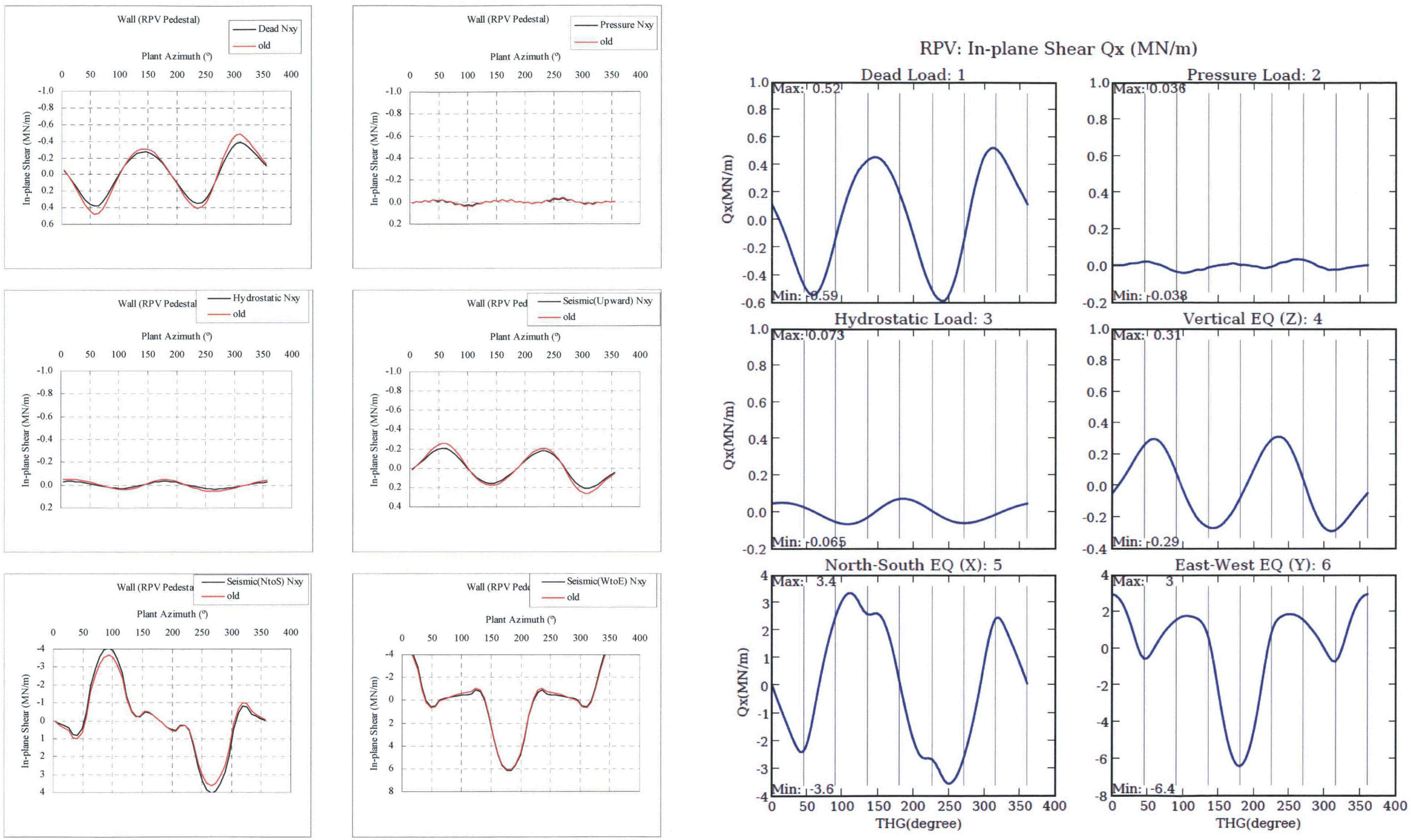


Figure C-26 Element Forces Comparison NASTRAN to ANSYS (RPV Pedestal: In-plane Shear [MN/m])

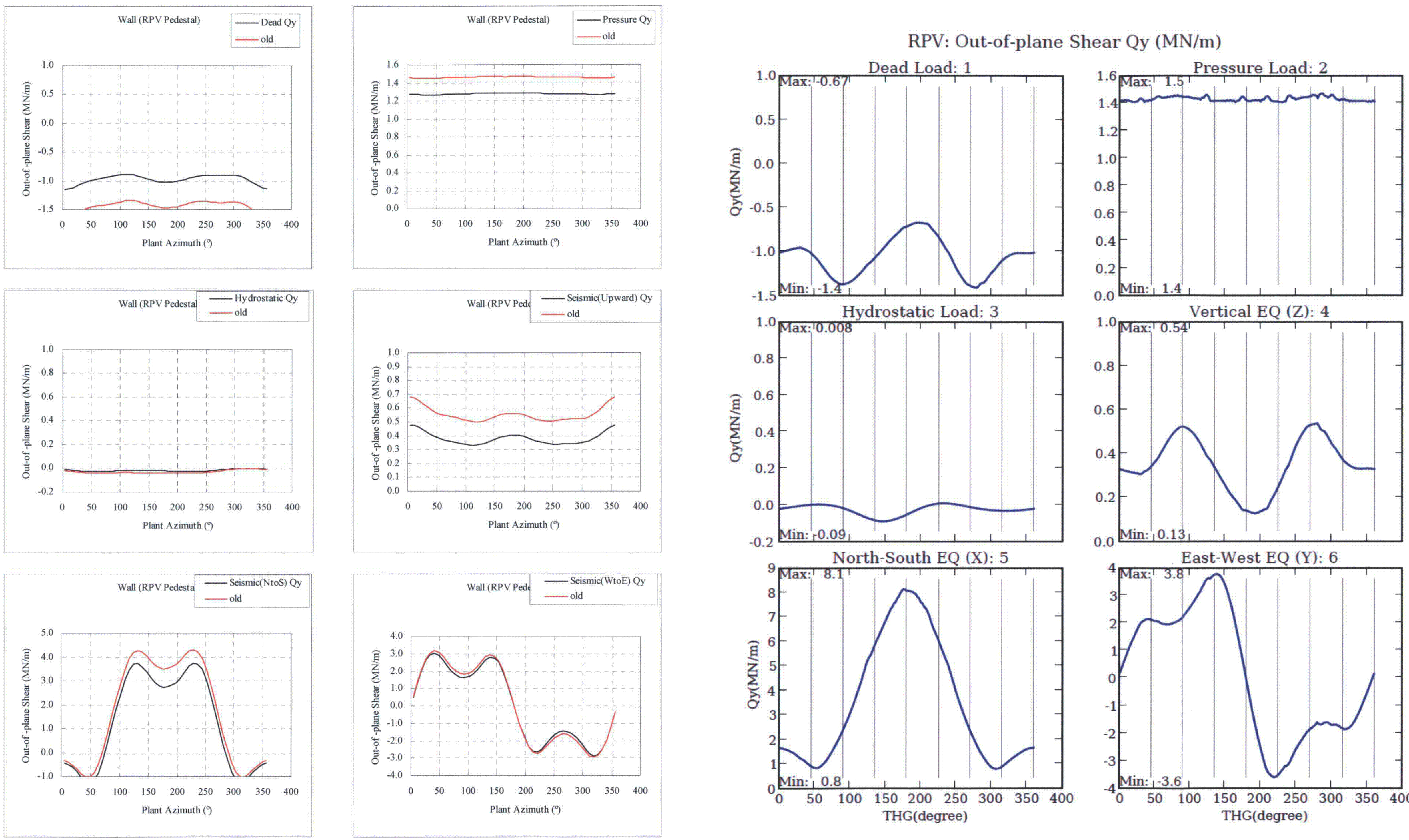


Figure C-27 Element Forces Comparison NASTRAN to ANSYS (RPV Pedestal: Out-of-plane Shear [MN/m])

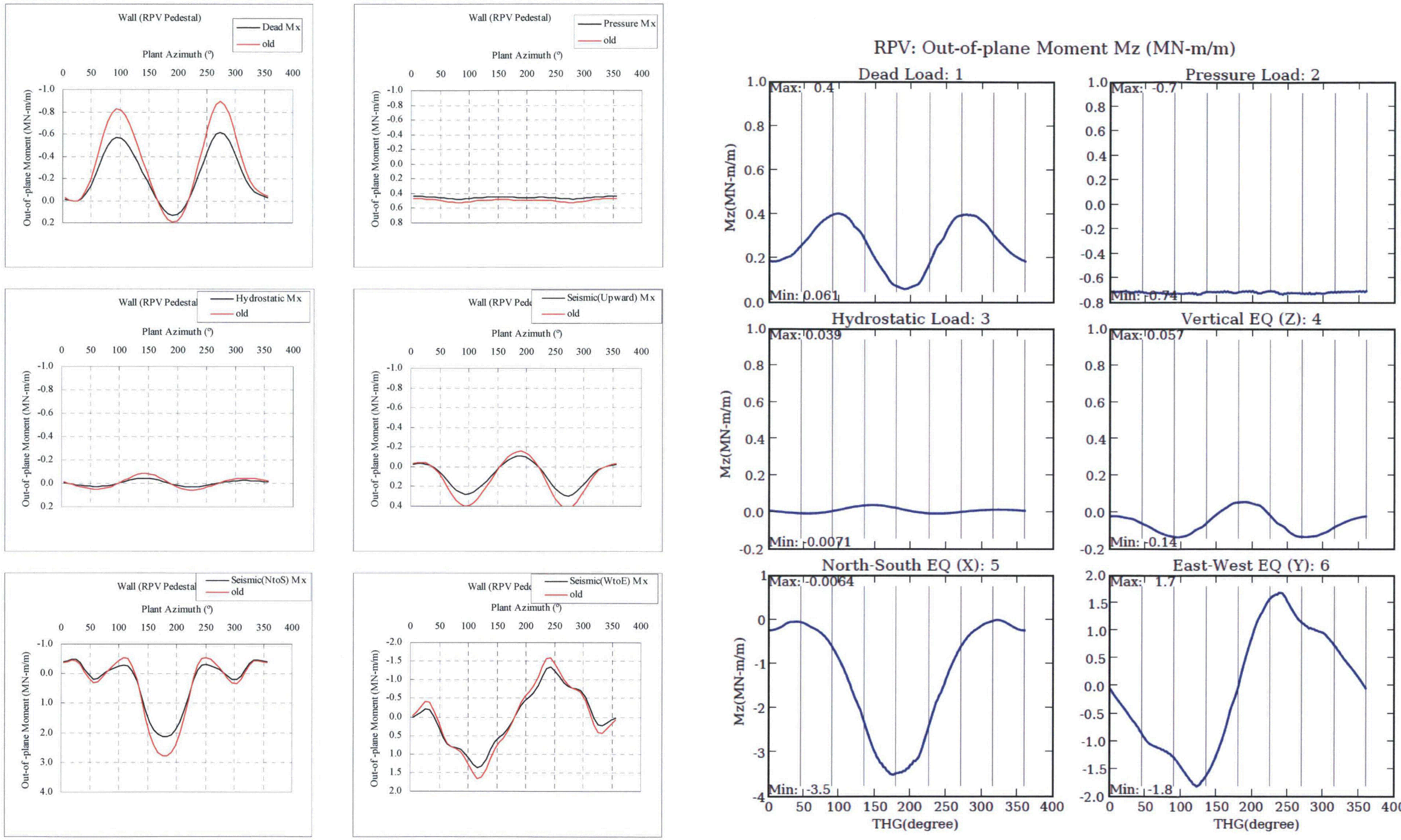


Figure C-28 Element Forces Comparison NASTRAN to ANSYS (RPV Pedestal: Out-of-plane Moment [MN-m/m])

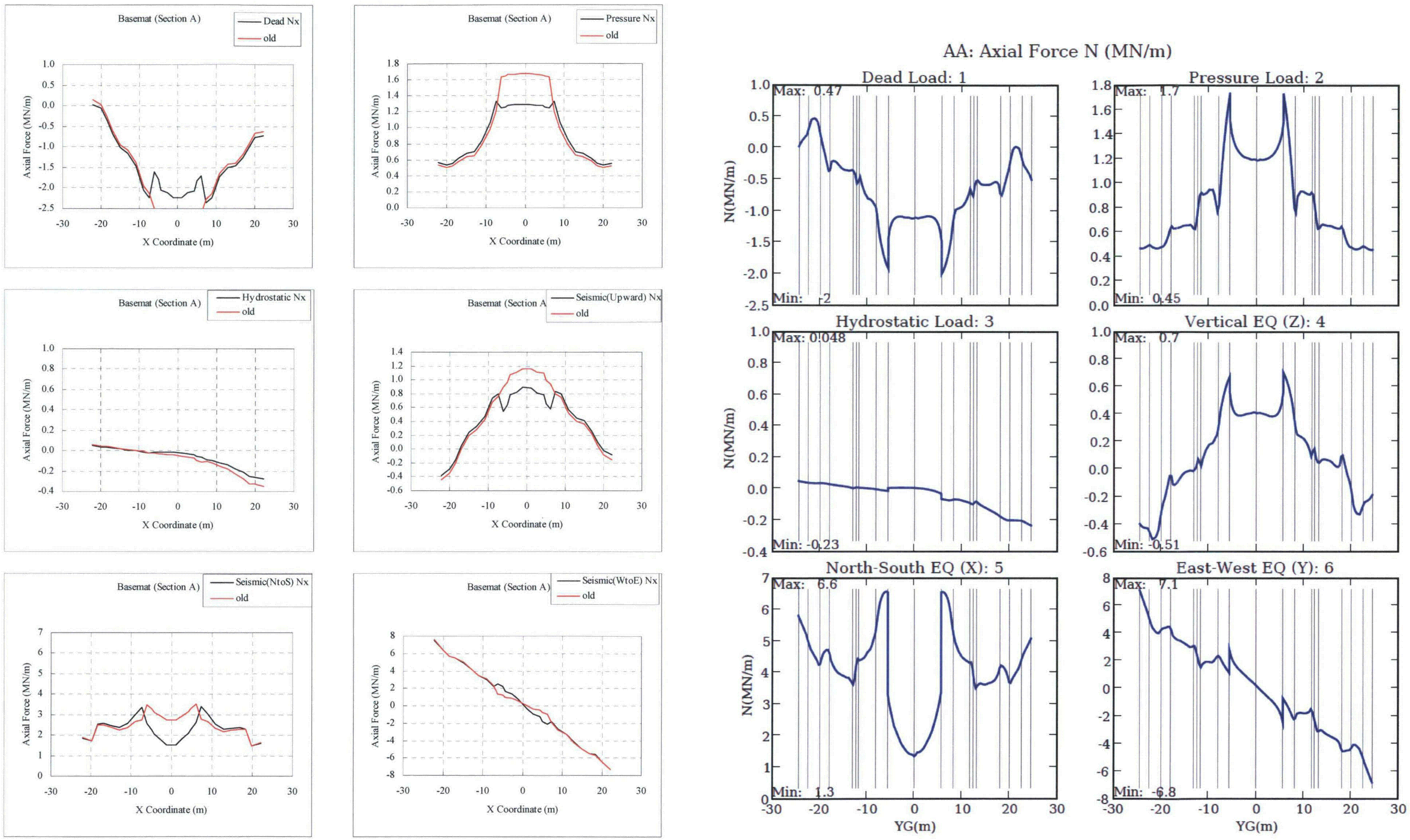


Figure C-29 Element Forces Comparison NASTRAN to ANSYS (Basemat Section A-A: Axial Force [MN/m])

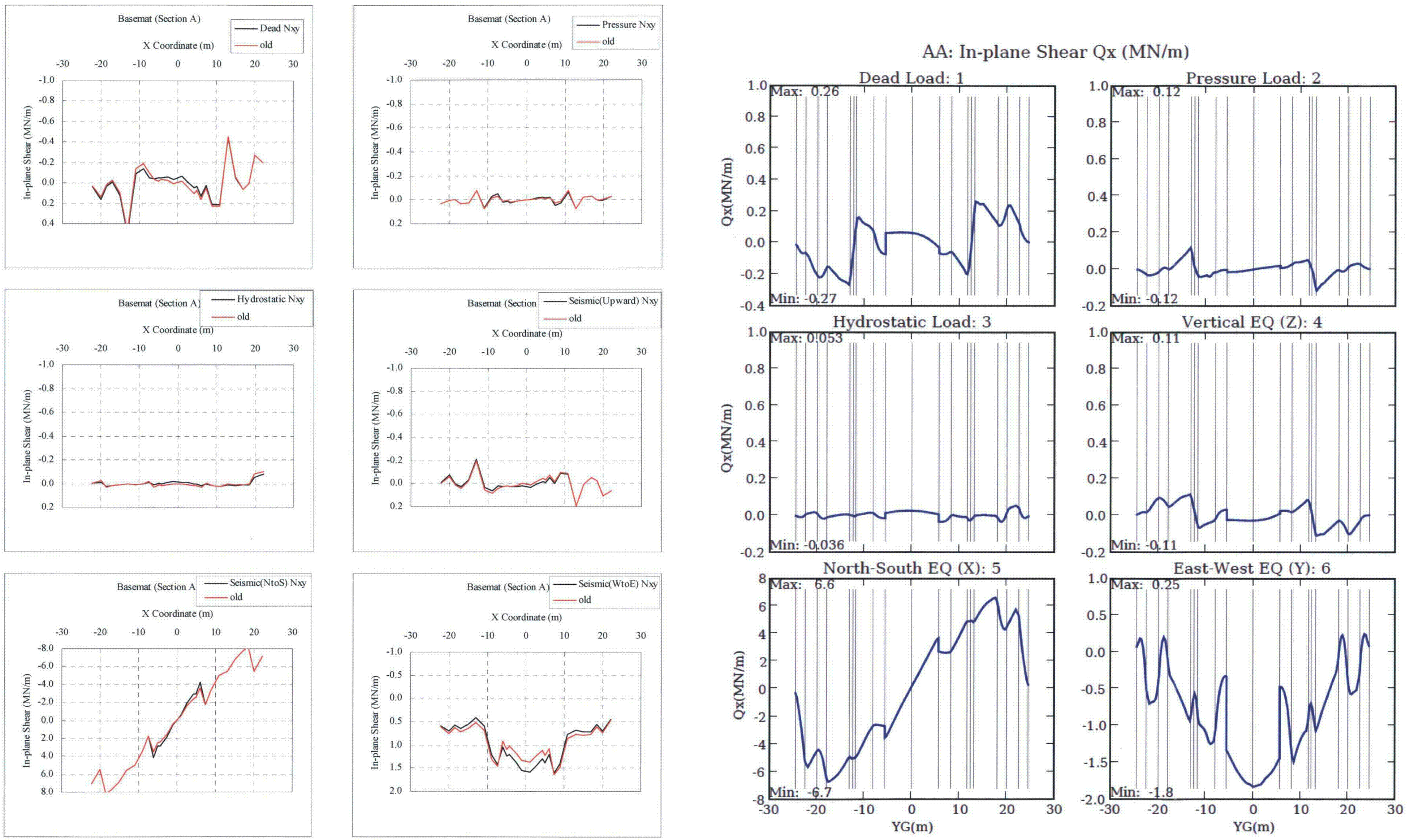


Figure C-30 Element Forces Comparison NASTRAN to ANSYS (Basemat Section A-A: In-plane Shear [MN/m])

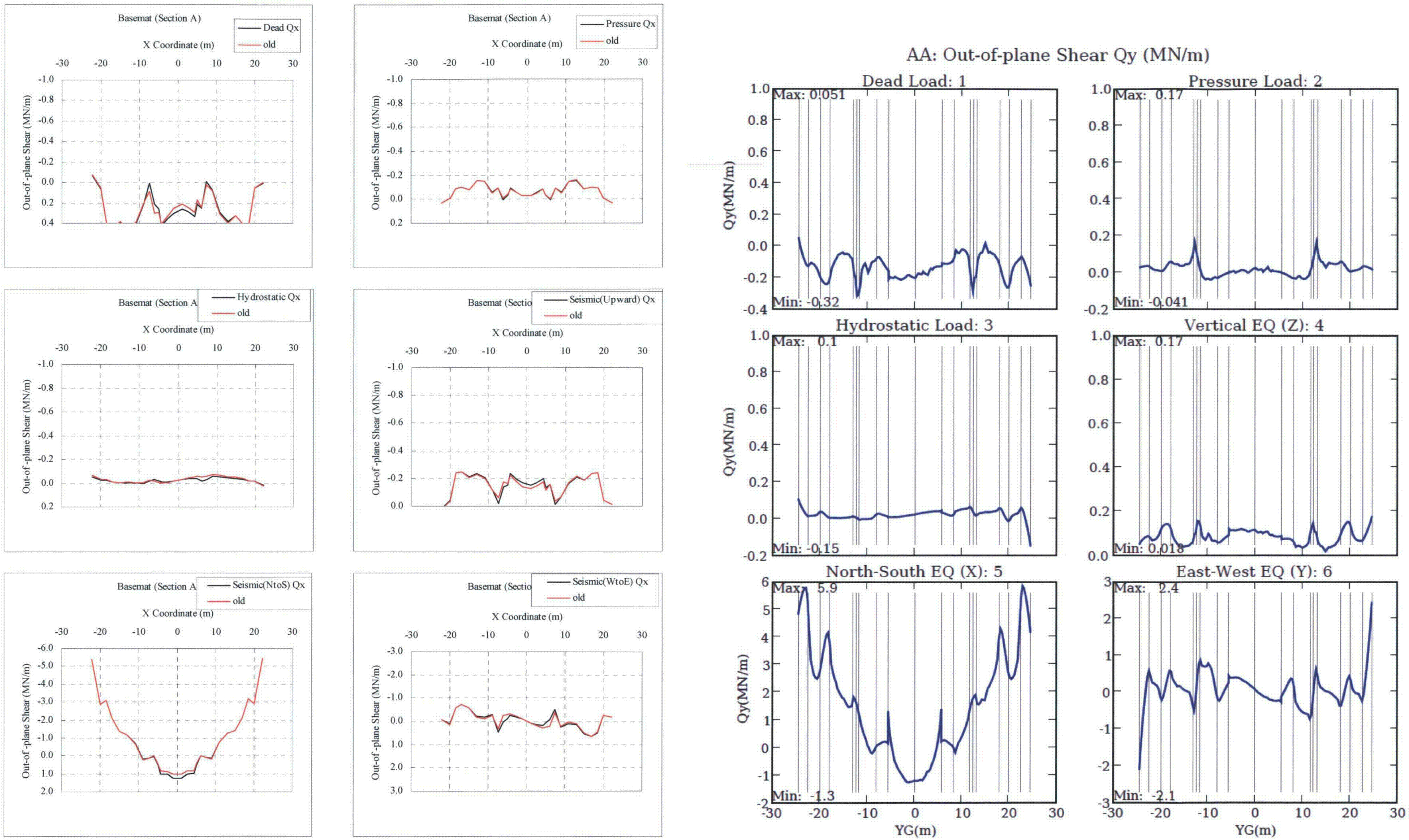


Figure C-31 Element Forces Comparison NASTRAN to ANSYS (Basemat Section A-A: Out-of-plane Shear [MN/m])

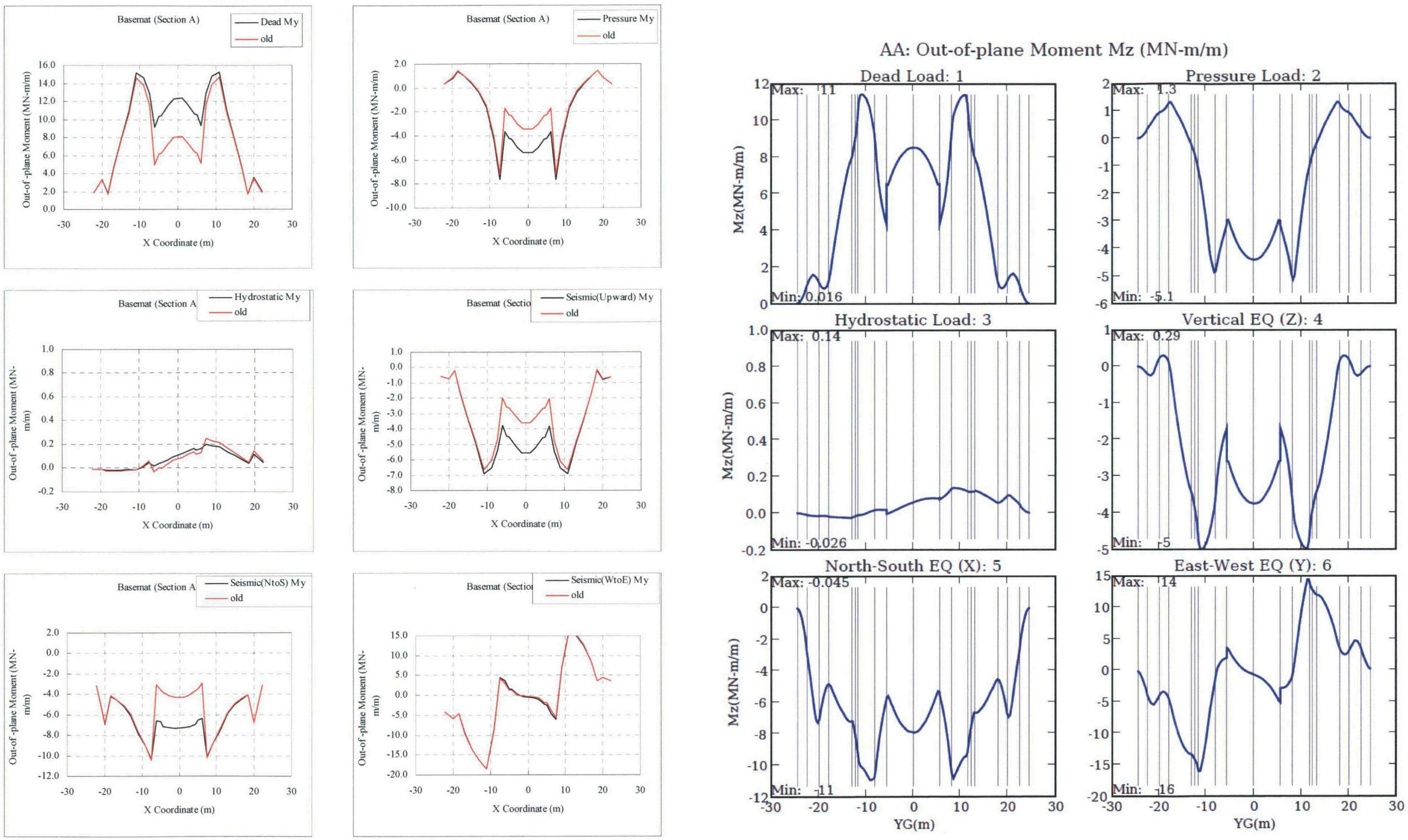


Figure C-32 Element Forces Comparison NASTRAN to ANSYS (Basemat Section A-A: Out-of-plane Moment [MN-m/m])

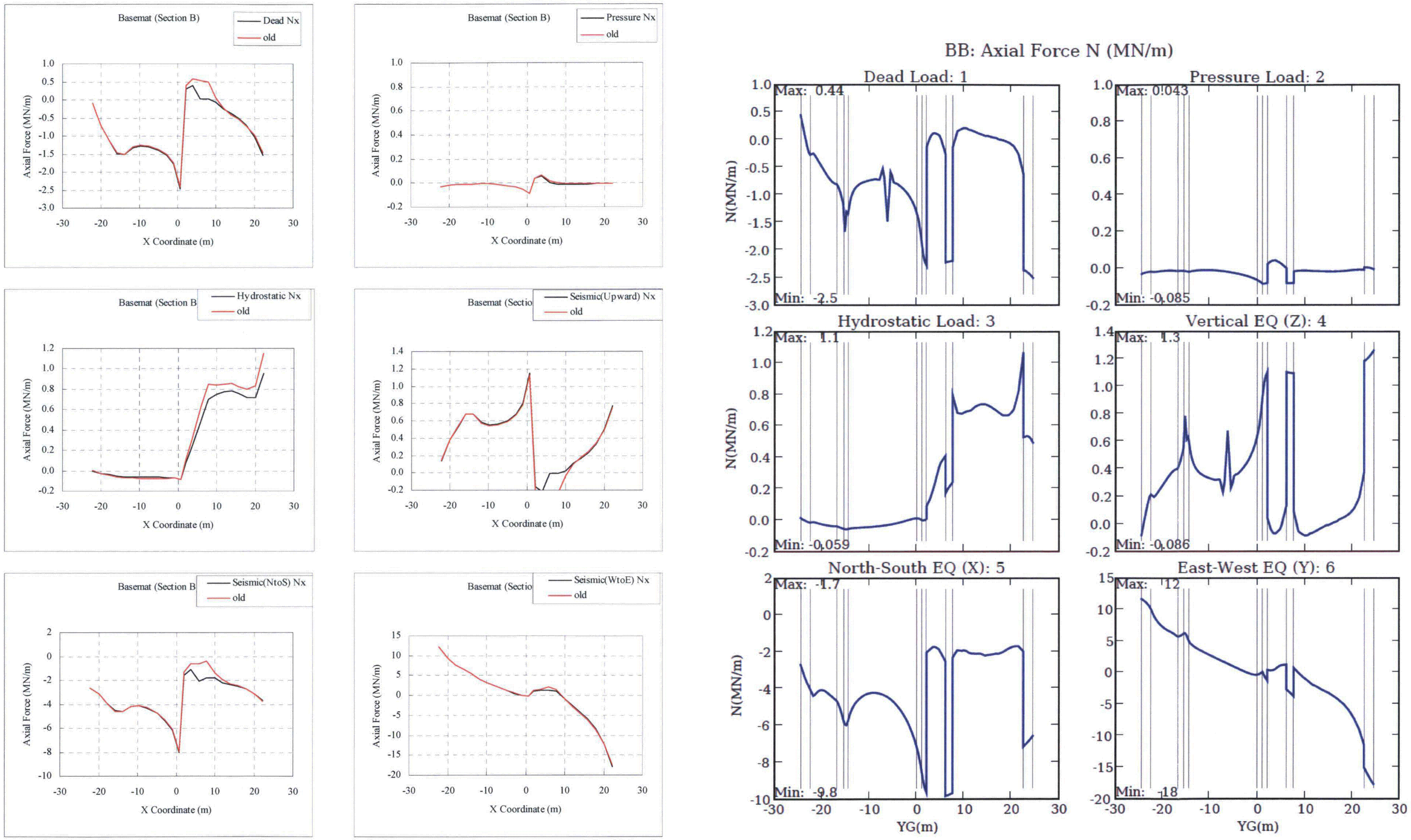


Figure C-33 Element Forces Comparison NASTRAN to ANSYS (Basemat Section B-B: Axial Force [MN/m])

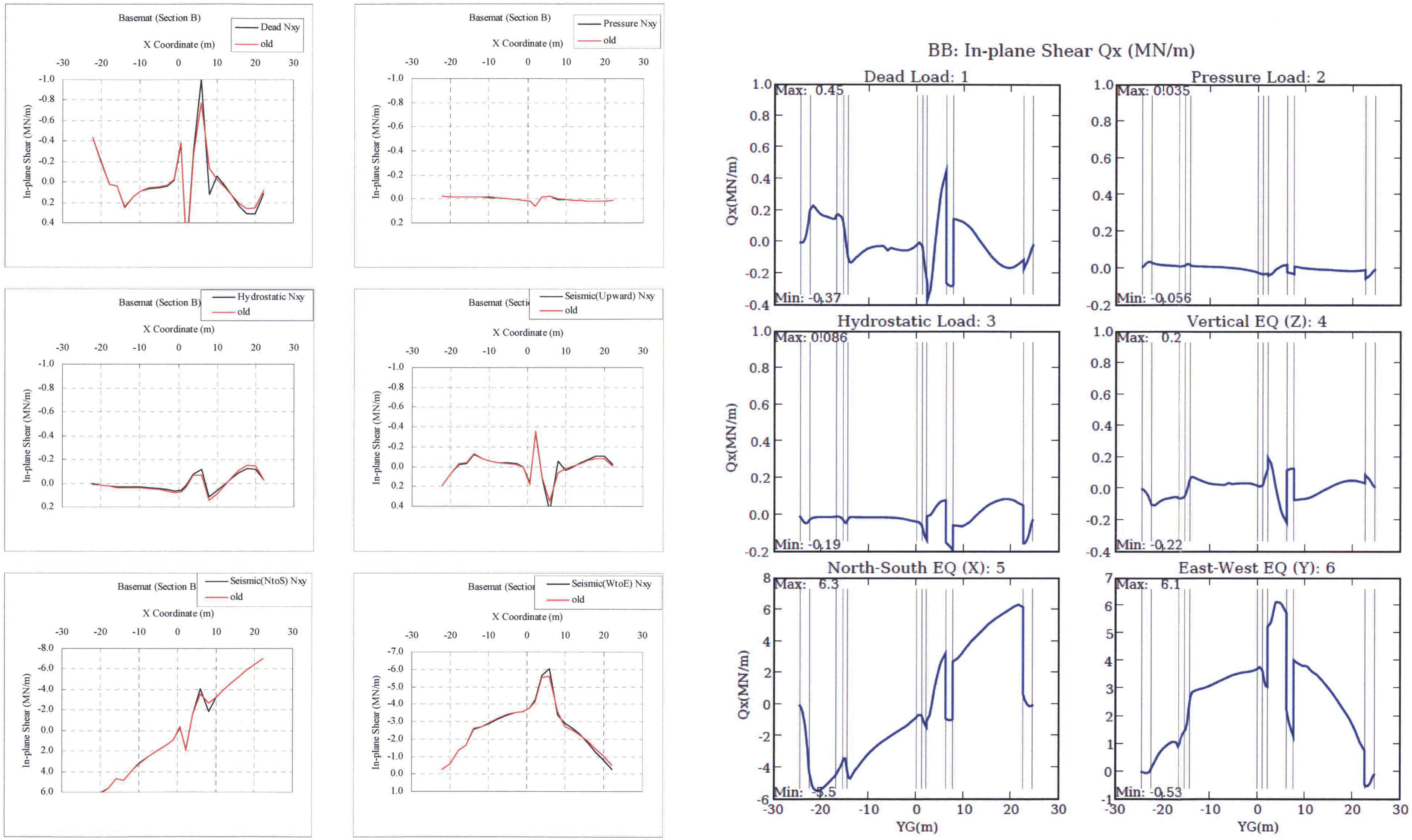


Figure C-34 Element Forces Comparison NASTRAN to ANSYS (Basemat Section B-B: In-plane Shear [MN/m])

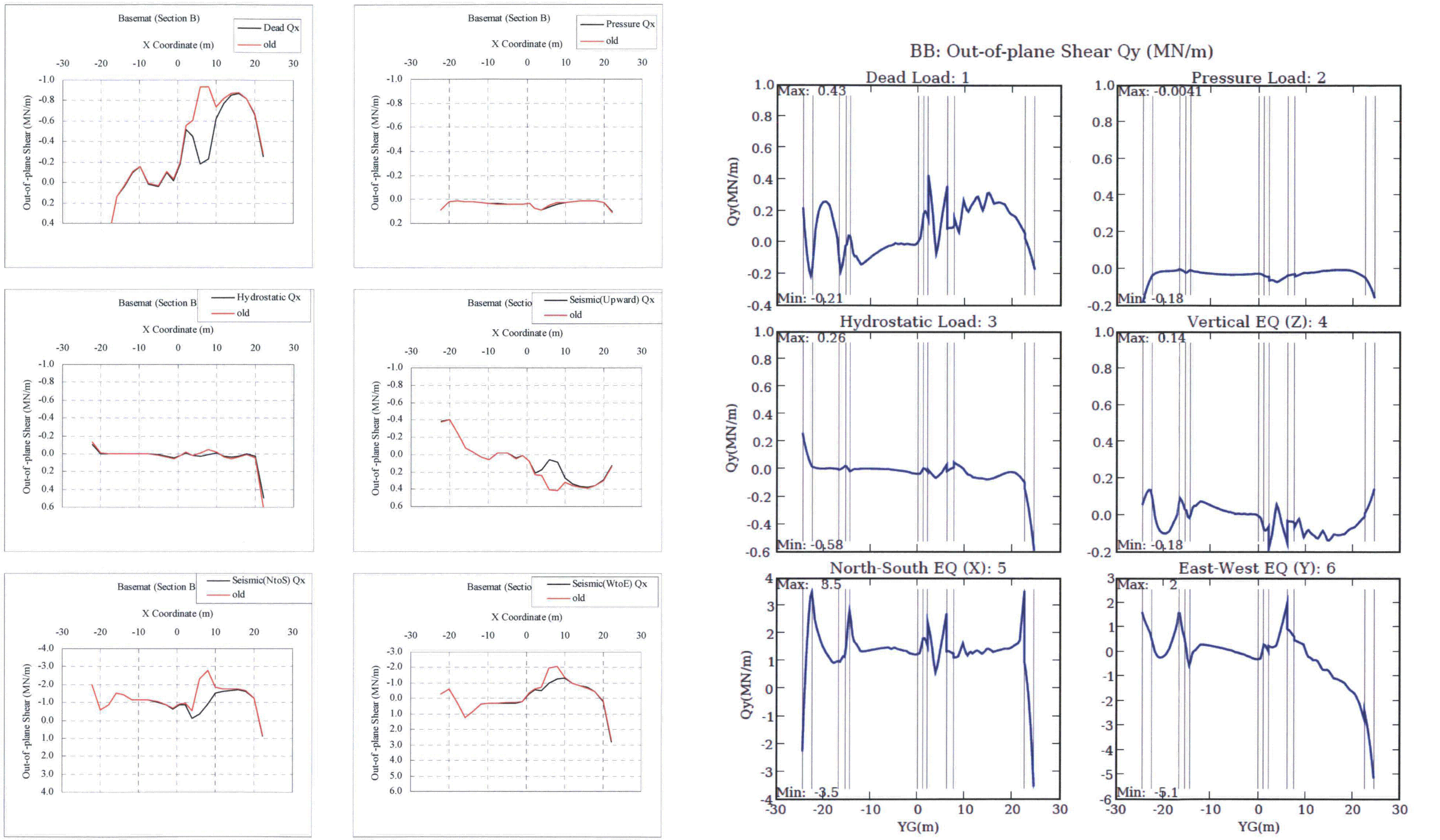


Figure C-35 Element Forces Comparison NASTRAN to ANSYS (Basemat Section B-B: Out-of-plane Shear [MN/m])

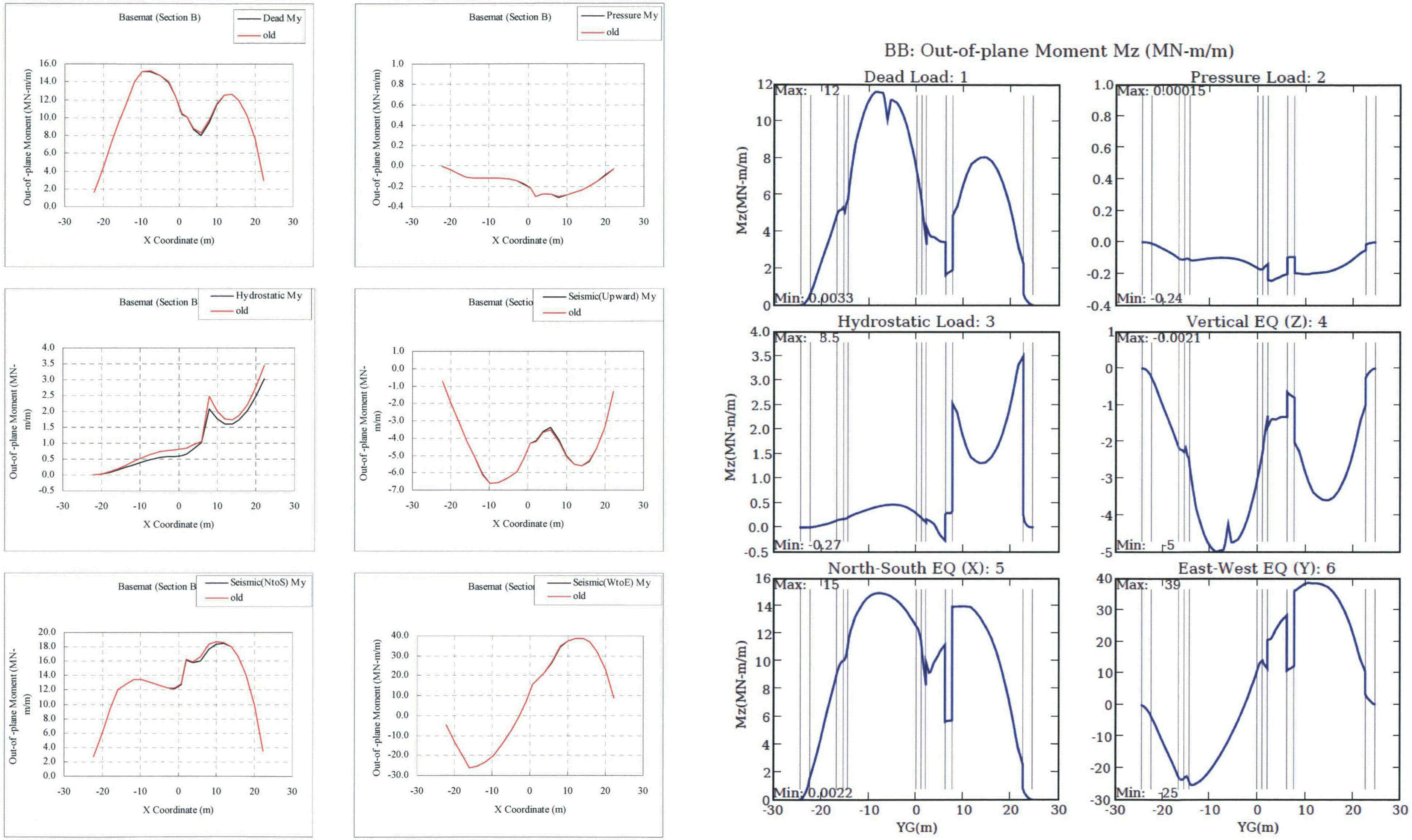


Figure C-36 Element Forces Comparison NASTRAN to ANSYS (Basemat Section B-B: Out-of-plane Moment [MN-m/m])

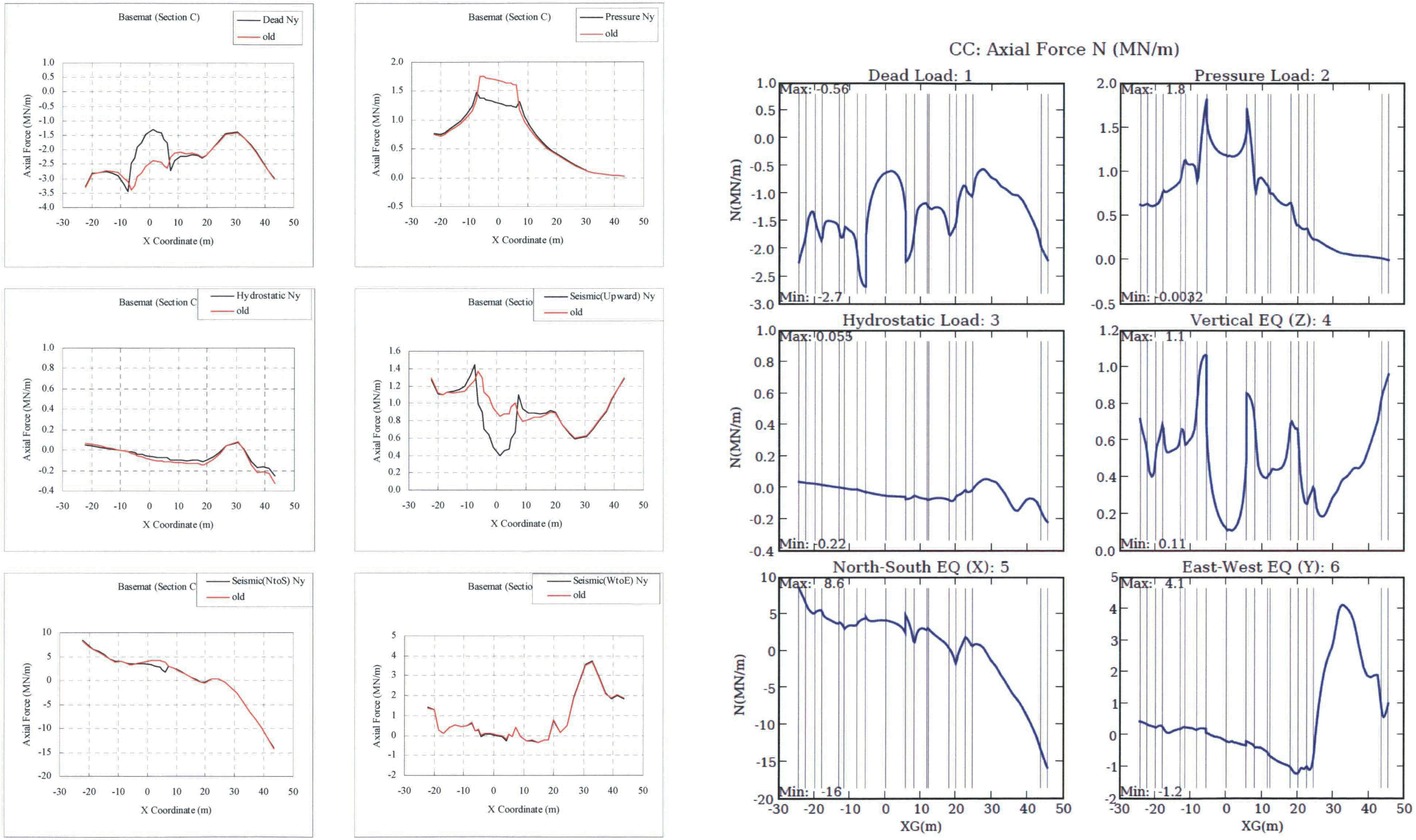


Figure C-37 Element Forces Comparison NASTRAN to ANSYS (Basemat Section C-C: Axial Force [MN/m])

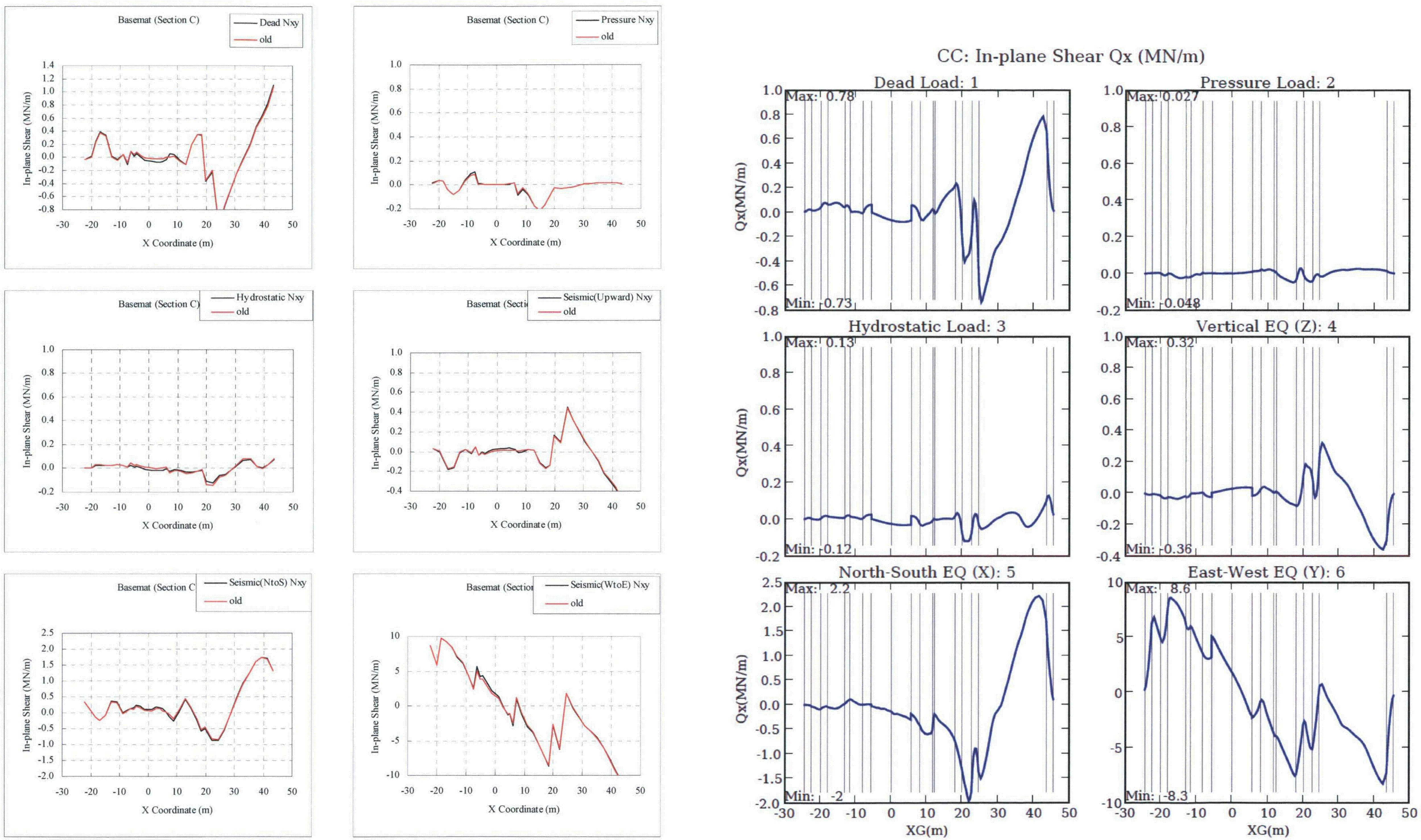


Figure C-38 Element Forces Comparison NASTRAN to ANSYS (Basemat Section C-C: In-plane Shear [MN/m])

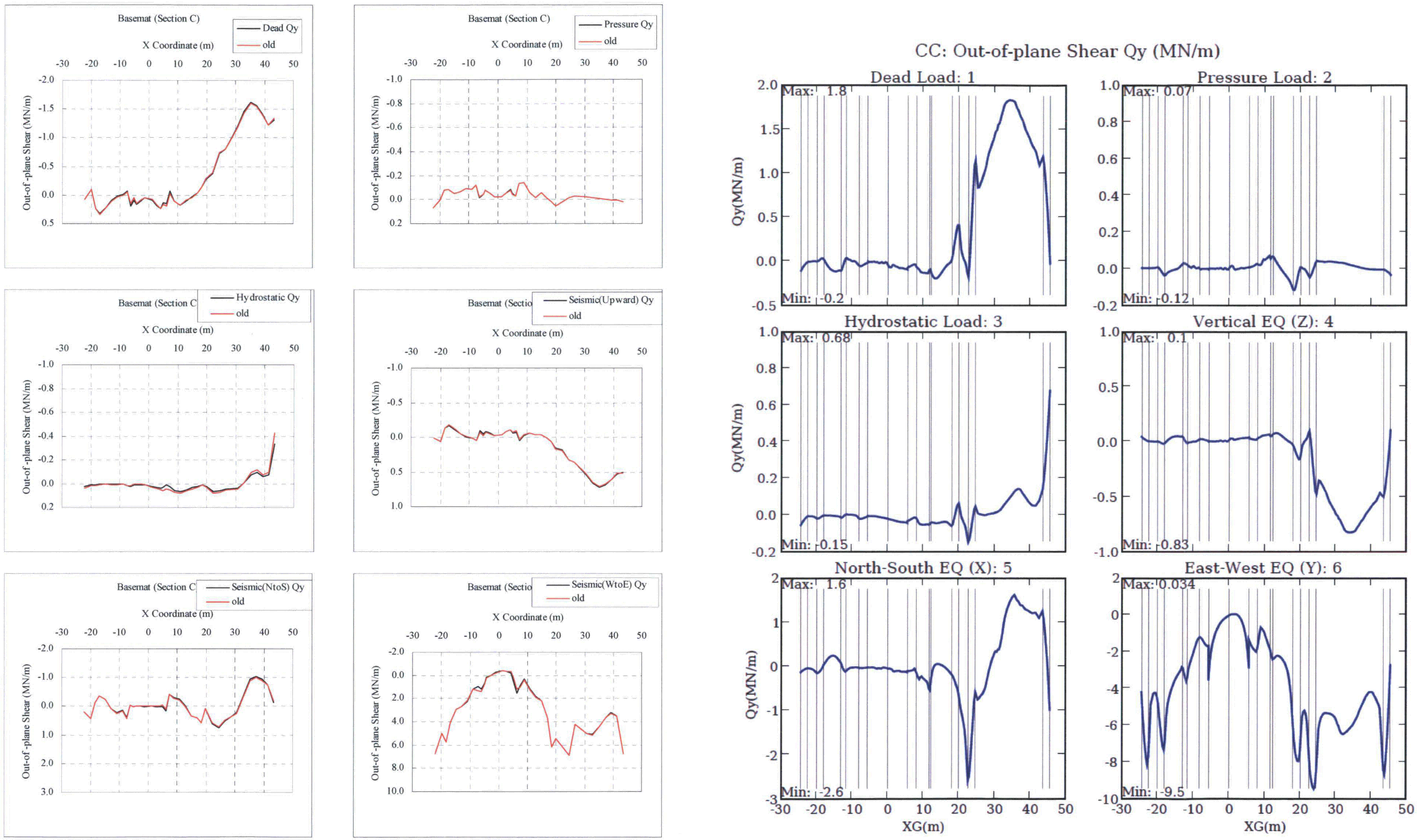


Figure C-39 Element Forces Comparison NASTRAN to ANSYS (Basemat Section C-C: Out-of-plane Shear [MN/m])

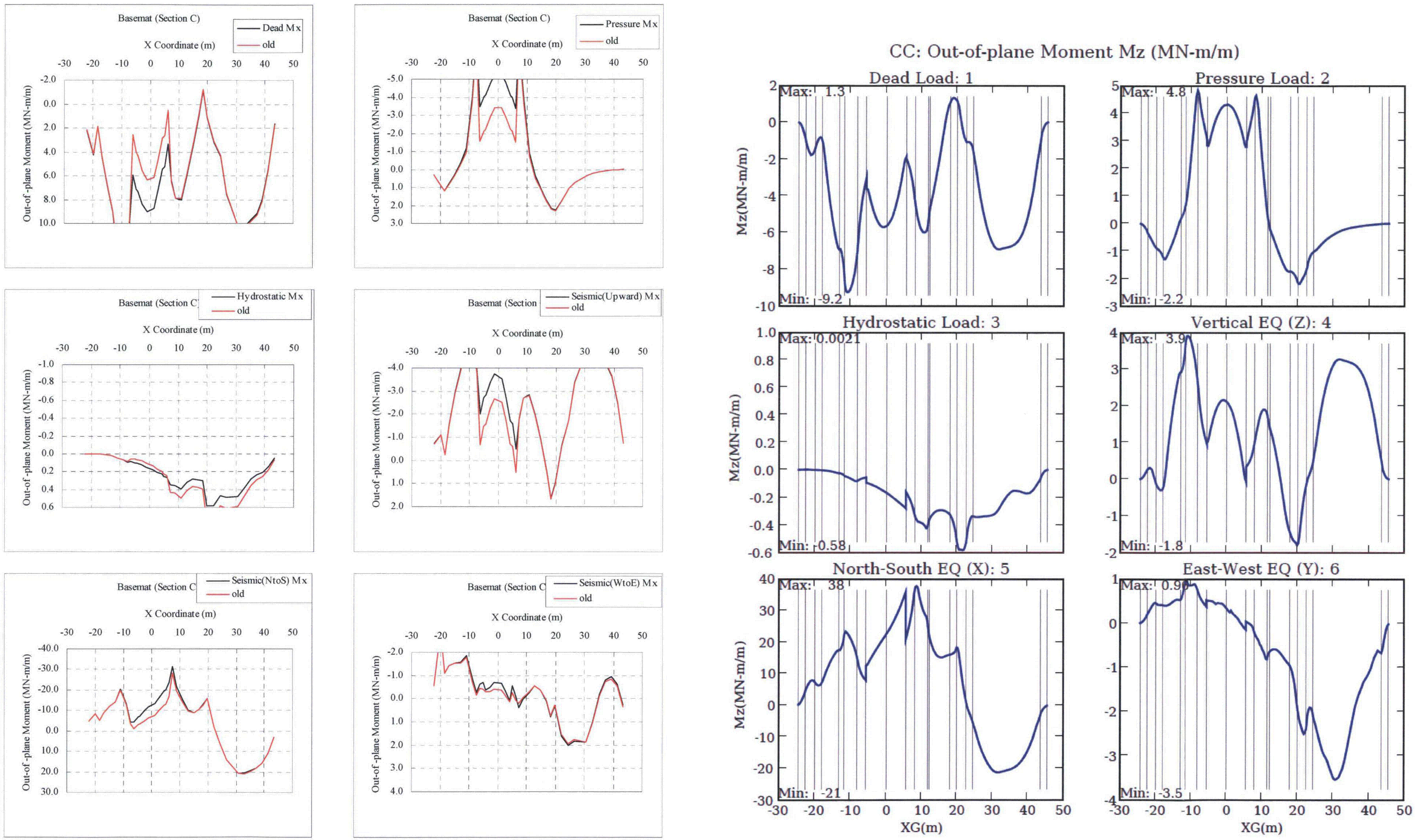


Figure C-40 Element Forces Comparison NASTRAN to ANSYS (Basemat Section C-C: Out-of-plane Moment [MN-m/m])

ENCLOSURE 2

MFN 06-262
Supplement 4

NASTRAN Analysis Input Data and

NASTRAN Analysis Results