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Specific Cautions To Users e.g. **Enumerate/list specific incomplete content.** **Enumerate/list specific complete but unverified content.** **Enumerate/list key areas of technical uncertainty and parameters impacted.**	This report documents the Additional Oscillators for fully cracked model for RAI 3.7.2-14(f) Response for the North Anna Unit 3 (NA3) site-specific SSI analyses for Dominion NA 3 ESBWR project. The eigenvalue analysis of the RB/FB wall is revised to decouple in-plane and out-of-plane modes of vibration. The analysis conditions are provided by the following Design Inputs: 001N0332, Revision 1 (26A6642AL Revision 10) 26A6647, Revision 6 26A6648, Revision 4 26A7419, Revision 1
Cross-reference Information e.g. **eDRF or other useful data pointers**	

Shimizu Engineering Report

Project	GE-Hitachi Nuclear Energy Dominion NA3 ESBWR Project	Shimizu Document No.	SER-DMN-014
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NOTE:

This report documents the Additional Oscillators for Fully Cracked Model for RAI 3.7.2-14(f) Response for the North Anna Unit 3 (NA3) site-specific SSI analyses for Dominion NA 3 ESBWR project.

The input for the analysis presented in this report are obtained from the following sources:

001N0332, Revision 1 (26A6642AL Revision 10)
26A6647, Revision 6
26A6648, Revision 4
26A7419, Revision 1

NASTRAN version 2013 was obtained from MSC Software Corporation and implemented by Shimizu Corporation of Tokyo, Japan on PRIMERGY RX2011 S7 Workstation computer using Red Hat Enterprise Linux Server release 5.7 OS. Program validation documentation is available at Shimizu Corporation.

Rev.	Date	Note	Approve	Review	Prepare
1	3/13/15	Eigenvalue analysis of walls revised to decouple in-plane and out-of plane modes of vibration	Y. O.	S.O.	R. I.
0	2/6/15	Issue for Use	Y. O.	S.O.	R. I.

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1. SCOPE

In order to capture the effects of concrete cracking on out-of-plane vibration of flexible walls and slabs in response to RAI Question 3.7.2-14(f), this report documents the evaluations performed and results obtained for the following:

- 50% reduced concrete stiffness is applied to all existing single degree of freedom (SDOF) oscillators up to 50 Hz in the uncracked conditions, and
- Additional SDOF oscillators that are required to adequately capture all modes of vibrations with frequencies up to 50 Hz under fully cracked conditions.

This report describes the additional SDOF oscillators which are developed using the same methodology and eigenvalue analysis models that were used for standard design in References 2-b, 2-c and 2-d for the DCD (Reference 2-a). The only differences are that:

- The eigenvalues are extracted for all modes with frequencies up to 71 Hz. Since under the 50% reduced stiffness conditions, this corresponds to a modal frequency of $71/\sqrt{2}$ =50 Hz.
- Additional constrains are added to the RB/FB models used for extraction of additional modes of out-of-plane vibration of walls in order to decouple higher modes that represent coupled in-plane and out-of-plane vibration of walls.

2. REFERENCES

a. 001N0332, ESBWR DCD Tier 2 Chapter 3 Appendices 3A - 3F, Revision 1 (26A6642AL Revision 10)
b. 26A6647, ESBWR Seismic Analysis of Reactor/Fuel Building Complex, Revision 6
c. 26A6648, ESBWR Seismic Analysis of Control Building, Revision 4
d. 26A7419, ESBWR Seismic Analysis of Firewater Service Complex, Revision 1
e. ASCE/SEI 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities

3. EIGENVALUE ANALYSIS FOR EVALUATION OF OSCILLATORS

3.1 Oscillators for Vertical Frequency of Flexible Slab

The vertical vibration properties of slabs are different in each part of the slab which is bounded by beams and partition walls. Therefore, when the vertical eigenvalue analysis of a slab is performed, the effective weight and vertical stiffness are calculated for each mode of the slab, and the slab is modeled by using oscillators. This simulates the vertical frequency of the flexible slab. The added oscillators for out-of-plane vibration of fully cracked slabs for the RB/FB, CB and FWSC are shown in red in Figures 3.4.1-13, 3.4.2-5 and 3.4.3-2, respectively.

3.1.1 Analysis Model

The finite element (FE) model of floor slabs is developed based on the following assumptions.

- Analysis model of each floor consists of floor slab (including girders), seismic wall and partition wall.
- Degrees of freedom of each node are shown in Figure 3.1.1-1.
- Seismic walls, whose stiffness are considered in the vertical seismic model, are assumed to have infinite vertical stiffness in the slab FE model.

FE models of walls developed for standard design in References 2-b, 2- c. and 2-d based on the following assumptions.

- Analysis model of entire building is used.
- Degrees of freedom of each node are shown in Figure 3.1.1-2.
- Mass is assigned only to walls for which out-of-plane modes of vibration are extracted.

Boundary conditions of the FE model of RB/FB walls are revised from the model used in the standard design, Reference 2-b. It was observed from the eigenvalue analysis results that higher frequency modes with frequencies above 50 Hz under uncracked conditions besides the out-of-plane vibrations also captured the in-plane vibrations of the wall. As described in Appendix A, additional constrains are introduced in the model of RB/FB walls to decouple the out-of-plane vibrations from the in-plane vibrations. The additional wall oscillators are developed using only the modes representing only the out-of-plane wall vibrations.

3.1.2 Weight

Equipment Load (EL), Piping Load (PL), effective Live Load (LL), and Dead Load (DL) are considered in calculating slab weight. They are distributed evenly to the whole floor area. The weights of the box wall and inner wall are not considered.

3.1.3 Evaluation Method of Effective Mass

Effective mass of each mode is calculated from the following equation:

$$[{}_E M_i] = \frac{\left(\sum_{j=1}^{n} [m_j]\{u_{ji}\}\right)^2}{\sum_{j=1}^{n} [m_j]\{u_{ji}\}^2} = [{}_G M_i] \cdot \beta_i{}^2, \quad i = 1, Mode, \qquad j = 1, Mass$$

where,

$_E M_i$ = Effective mass of i-th mode $\left(tonf \cdot \sec^2 / cm\right)$

β_i = Participation factor of i-th mode

$_G M_i$ = Generalized mass off i-th mode $\left(tonf \cdot \sec^2 / cm\right)$

$\{u_i\}$ = Eigen vector $(u_{ij},\ i=1,\ Mode,\ j=1,\ Mass(n))$

$[M]$ = Mass matrix $(m_j,\ j=1,\ Mass(n))$

Generalized mass is obtained from NASTRAN analysis and described as follows:

$$[_G M_i] = \{u_{ji}\}^T [m_j] \{u_{ji}\} = \sum_{j=1}^{n} [m_j] \{u_{ji}\}^2, \quad i = 1, Mode, \qquad j = 1, Mass$$

Participation factor is also obtained from NASTRAN analysis and described as follows:

$$\beta_i = \frac{\{u_i\}^T [M] \{I\}}{\{u_i\}^T [M] \{u_i\}} = \frac{\sum_{j=1}^{n} m_j u_{ij}}{\sum_{j=1}^{n} m_j u_{ij}^{\ 2}}, \qquad i = 1, Mode,\ j = 1, Mass(n)$$

$\{I\}$: Exciter unit vector

3.1.4 Weight and Stiffness of Slab Oscillator

The eigenvalue analysis results are treated in accordance with the following principle:

- Modes above 71 Hz are considered as rigid modes.
- Modes whose frequencies are within about ±15% from certain frequency are classified into one group.

The vertical stiffness of slabs are obtained from the following equation by using the effective mass and average frequency:

$$_V K_i = (2.0 \cdot \pi \cdot {}_{Ave} f_i)^2 \cdot {}_E M_i, \qquad i = 1, Group\ Number$$

where,

$_V K_i$: Vertical Stiffness $\left(tonf / cm\right)$
$_{Ave} f_i$: Average Frequency $\left(Hz\right)$
$_E M_i$: Effective Mass $\left(tonf \cdot sec^2 / cm\right)$

3.1.5 Weight of Wall

The vertical weight of each node is calculated by the following equations:

$$ {}_{V}W = {}_{H}W - \sum_{i=1}^{Group} W_i $$

where,

W_i : Slab Weight $(tonf) = 980.7\,{}_{E}M_i$

${}_{E}M_i$: Effective Mass $(tonf \cdot \sec^2/cm)$

${}_{H}W$: Total Floor Weight $(tonf)$

${}_{V}W$: Rigid Weight of Wall $(tonf)$

3.2 Oscillators for Out-of-Plane Vibration of Walls

Oscillators for out-of-plane vibration of walls are evaluated by using the FE model in the same manner as the slab oscillators.

To obtain design loads of these walls and design Frequency Response Spectra (FRS) for the components attached to these walls, seismic analysis will be performed using wall oscillators calculated by the above analysis, in the same manner as floor oscillators. The added oscillators for out-of-plane vibration of fully cracked walls for RB/FB, CB and FWSC are shown in red in Figures 3.4.1-13, 3.4.2-5 and 3.4.3-2, respectively.

3.3 Results of Eigenvalue Analysis

3.3.1 Slabs

3.3.1.1 RB/FB

Overviews of the eigenvalue analysis model are shown in Figures 3.3.1.1-1 through 3.3.1.1-10, for RB/FB slabs.

Eigenvalue analysis results for RB/FB slab, weight and stiffness of oscillators, are shown in Tables 3.3.1.1-1 through 3.3.1.1-10. The shaded modes in these tables are neglected since their effective weights are negligibly small. Figures 3.3.1.1-11 through 3.3.1.1-20 show the typical vibration modes of floor slabs.

3.3.1.2 CB

Overviews of the eigenvalue analysis model are shown in Figures 3.3.1.2-1 through 3.3.1.2-4, for CB slabs.

Eigenvalue analysis results for CB slab, weight and stiffness of oscillators, are shown in Tables 3.3.1.2-1 through 3.3.1.2-4. The shaded modes in these tables are neglected since their effective weights are negligibly small. Figures 3.3.1.2-5 through 3.3.1.2-8 show the typical vibration modes of floor slabs.

3.3.1.3 FWSC

An overview of the eigenvalue analysis model is shown in Figure 3.3.1.3-1.

Eigenvalue analysis results for FWSC roofs, weight and stiffness of oscillators, are shown in Tables 3.3.1.3-1 and 3.3.1.3-2. The shaded modes in these tables are neglected since their effective weights are negligibly small. Figures 3.3.1.3-2 and 3.3.1.3-3 show the typical vibration modes of roofs.

3.3.2 Walls

3.3.2.1 RB/FB

As shown in Table 3.3.2.1-1, the calculated out-of-plane fundamental frequencies for the typical walls in the RB/FB are higher than the highest frequency of interest at 71 Hz. However, since the RB walls above the refueling floor at EL 34.0m and EL 27.0m and the FB walls at EL 4.65m have large heights to the upper floor, their frequencies are expected to be lower than 71 Hz.

Eigenvalue analysis results for RB/FB wall, weight and stiffness of oscillators, are shown in Tables 3.3.2.1-2 through 3.3.2.1-4. The shaded modes in these tables are neglected since their effective weights are negligibly small. Figures 3.3.2.1-1 through 3.3.2.1-3 show the typical vibration modes of walls.

3.3.2.2 CB

Eigenvalue analysis results for CB wall, weight and stiffness of oscillators, are shown in Tables 3.3.2.2-1 and 3.3.2.2-2. Since the effective masses are negligibly small, all nodes in these tables are neglected.

3.3.2.3 FWSC

It is confirmed that the calculated out-of-plane fundamental frequencies for the typical walls in the FPE are higher than the highest frequency of interest at 71 Hz. The lowest fundamental frequency for the FPE wall is 145.6 Hz.

3.4 Seismic Analysis Model Properties for Fully Cracked Model

3.4.1 RB/FB

Calculated results of structural properties for the RB/FB fully cracked reinforced concrete members and concrete-filled steel vent wall and diaphragm floor structures with 0% and 50% infill concrete stiffness are summarized in Tables 3.4.1-1 and 3.4.1-2, respectively. The properties for the RB/FB uncracked reinforced concrete members and concrete-filled steel vent wall and diaphragm floor structures with 100% infill concrete stiffness can be found in Reference 2-b.

In accordance with ASCE 43-05 in Reference 2-e, the effect of concrete cracking on the shear, flexural and axial stiffness of the reinforced concrete walls are captured by reducing the section properties for the shear areas, torsional moment of inertia and flexural moments of inertia of the stick elements by 50% and using full 100% axial area. The overall stiffness of the shell elements modeling the below grade exterior walls and basemats are also reduced by 50%.

Frequencies of slab oscillators for RB/FB models based on the crack state and infill concrete stiffness contribution of vent wall and diaphragm floor are shown in Tables 3.4.1-3. Properties and frequencies of wall oscillators are shown in Table 3.4.1-4.

7% SSE damping is used in conjunction with reduced (cracked concrete) stiffness properties for reinforced concrete members. For consistency, the SSE damping values are also used for concrete-filled steel structures, steel structures and RPV components coupled with cracked reinforced structures in the RB/FB. For uncracked models, the OBE damping values are applicable. The damping values for various structures and RPV components are shown in Table 3.4.1-5.

The regions of floor slab vertical responses and out-of-plane wall responses for RB/FB are shown in Figures 3.4.1-1 through 3.4.1-12. The non-shaded areas in these figures are rigid regions. The ’rigid’ region of a ‘flexible’ slab or wall panel is taken to be over a distance D from the face of the supporting wall or slab as ‘D = L/4 or 4t whichever is smaller’ where L is the clear span of the slab or wall panel and t is the panel thickness. The response of the rigid region of the slab or wall is the same as the response of the closest supporting wall or slab.

Figure 3.4.1-13 shows RB/FB stick model with additional oscillators used for fully cracked model which are shown in red portions in the figure.

3.4.2 CB

Calculated results of structural properties for the CB seismic analysis model are summarized in Table 3.4.2-1.

In accordance with ASCE 43-05, the effect of concrete cracking on the shear, flexural and axial stiffness of the reinforced concrete walls are captured by reducing the section properties for the shear areas, torsional moment of inertia and flexural moments of inertia of the stick elements by 50% and using full 100% axial area. The overall stiffness of the shell elements modeling the below grade exterior walls and basemats are also reduced by 50%.

Frequencies of slab oscillators for CB model based on the crack state are shown in Table 3.4.2-2 and compared to the uncracked state documented in Reference 2-c.

7% SSE damping is used in conjunction with reduced (cracked concrete) stiffness properties for reinforced concrete members.

The regions of floor slab vertical responses for CB are shown in Figures 3.4.2-1 through 3.4.2-4. The non-shaded areas in these figures are rigid regions. The 'rigid' region of a 'flexible' slab panel is taken to be over a distance D from the face of the supporting wall as 'D = L/4 or 4t whichever is smaller' where L is the clear span of the slab panel and t is the slab panel thickness. The vertical response of the rigid region of the slab is the same as the vertical response of the closest supporting wall.

Figure 3.4.2-5 shows CB stick model with additional oscillators used for fully cracked model which are shown in red in the figure.

3.4.3 FWSC

Calculated results of structural properties for the FWSC seismic analysis model are summarized in Tables 3.4.3-1.

In accordance with ASCE 43-05, the effect of concrete cracking on the shear, flexural and axial stiffness of the reinforced concrete walls are captured by reducing the section properties for the shear areas, torsional moment of inertia and flexural moments of inertia of the stick elements by 50% and using full 100% axial area. The overall stiffness of the shell elements modeling the basemats are also reduced by 50%.

Frequencies of roof oscillators for FWSC model based on the crack state are shown in Table 3.4.3-2.

7% SSE damping is used in conjunction with reduced (cracked concrete) stiffness properties for reinforced concrete members.

The regions of floor slab vertical responses for FWSC are shown in Figure 3.4.3-1. The non-shaded areas in these figures are rigid regions. The 'rigid' region of a 'flexible' slab panel is taken to be over a distance D from the face of the supporting wall as 'D = L/4 or 4t whichever is smaller' where L is the clear span of the slab panel and t is the slab panel thickness. The vertical response of the rigid region of the slab is the same as the vertical response of the closest supporting wall.

Figure 3.4.3-2 shows FWSC stick models with additional oscillators used for fully cracked model which are shown in red portions in the figures.

4. CONCLUSION

In order to capture the effect of concrete cracking on out-of-plane vibrations of flexible walls and slabs and respond to RAI Questions 3.7.2-14(f), additional SDOF oscillators used for fully cracked model are developed using the same methodology as presented in the standard plant seismic analyses for the DCD. The fully cracked seismic analysis models including additional SDOF oscillators are presented.

Table 3.3.1.1-1 RB/FB Slab Eigenvalue Analysis Results EL -6.40 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	22.28	3.70	1	22.28	3.70 (3.1%)	7.403E+03	RCCV-Pedestal
2	23.29	0.00					
3	25.15	0.67	2	26.31	3.62 (3.0%)	1.009E+04	RCCV-Pedestal
4	26.34	2.64					
5	27.05	0.11					
6	27.73	0.00					
7	28.90	0.13					
8	30.73	0.06					
9	32.45	0.00					
10	34.65	0.00	3	34.65	4.42 (3.7%)	2.138E+04	RB-RCCV
11	34.65	4.42					
12	34.98	0.00					RCCV-Pedestal
13	37.70	0.00	4	39.79	0.00 (0.0%)	2.998E+01	RCCV-Pedestal
14	41.00	0.00					
15	42.57	1.08	5	42.57	1.08 (0.9%)	7.915E+03	FB
16	44.67	0.00					To Group No. 4
17	48.80	0.00					
18	50.68	0.71	6	53.24	3.38 (2.8%)	3.853E+04	FB
19	52.50	0.70					
20	53.18	0.00					To Group No. 4
21	54.10	0.00	7	59.64	9.81 (8.2%)	1.405E+05	RB-RCCV
22	54.10	0.01					
23	54.28	1.36					To Group No. 6
24	54.72	0.61					
25	55.04	0.88					To Group No. 7
26	55.06	0.95					
27	57.79	0.02	8	61.18	0.17 (0.1%)	2.583E+03	RCCV-Pedestal
28	58.02	1.61					To Group No. 7
29	58.04	0.03					To Group No. 8
30	58.94	0.01					
31	58.97	0.11	9	66.07	1.07 (0.9%)	1.885E+04	FB
32	60.99	0.09					To Group No. 8
33	61.00	1.38					To Group No. 7
34	61.09	1.68					
35	61.09	1.95					
36	61.34	0.80					
37	61.34	0.39					
38	62.74	0.00					To Group No. 8
39	63.95	0.00					
40	66.11	0.78					To Group No. 9
41	67.48	0.00					To Group No. 8
42	68.06	0.00					
43	68.62	0.02					
44	69.53	0.00					
45	70.30	0.18					To Group No. 9
46	70.67	0.18					To Group No. 7
47	70.76	0.00					To Group No. 9
Slab Weight at Seismic Analysis 120.06 MN			Total		27.27 MN	(22.7%)	

Table 3.3.1.1-2 RB/FB Slab Eigenvalue Analysis Results EL -1.00 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	20.34	3.62	1	20.38	3.66 (3.1%)	6.110E+03	FB
2	22.83	0.00	2	22.84	11.00 (9.3%)	2.309E+04	RB-RCCV
3	22.83	5.34					
4	22.84	2.70					
5	22.86	2.96					
6	24.10	0.04					To Group No. 1
7	27.31	2.66	3	27.81	5.99 (5.1%)	1.866E+04	RCCV-Pedestal
8	27.82	1.76					
9	27.88	0.52					
10	28.24	0.22					
11	28.43	0.50					
12	28.63	0.01					
13	29.40	1.09	4	29.40	1.09 (0.9%)	3.777E+03	FB
14	29.47	0.00					To Group No. 3
15	30.00	0.24					
16	30.40	0.04					
17	31.52	0.00					
18	31.77	0.00					
19	33.02	0.01					
20	33.60	0.02					
21	35.05	0.00					
22	35.33	0.01					
23	42.19	1.18	5	42.27	4.68 (4.0%)	3.370E+04	RB-RCCV
24	42.27	1.17					
25	42.31	0.00					
26	42.31	2.33					
27	43.44	1.05	6	45.80	2.78 (2.4%)	2.350E+04	FB
28	43.67	0.06	7	46.42	8.14 (6.9%)	7.064E+04	RCCV-Pedestal
29	44.43	0.28					
30	45.29	0.07					To Group No. 6
31	46.12	3.77					To Group No. 7
32	46.37	0.03					
33	46.60	2.29					
34	46.74	0.04					To Group No. 6
35	46.75	1.24					To Group No. 7
36	47.13	0.07					
37	47.26	1.57					To Group No. 6
38	47.87	0.01					To Group No. 7
39	48.28	0.12					
40	48.52	0.01					
41	49.06	0.27					
42	49.17	0.05					To Group No. 6

Table 3.3.1.1-2 RB/FB Slab Eigenvalue Analysis Results EL -1.00 m (Continued)

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
43	50.28	0.00	8	60.65	0.07 (0.1%)	1.105E+03	RCCV-Pedestal
44	50.82	0.00					
45	51.08	0.01					
46	51.44	0.01					
47	52.34	0.35	9	53.34	2.21 (1.9%)	2.528E+04	RB-RCCV
48	53.10	0.01					
49	53.10	0.84					
50	53.34	0.46					
51	53.89	0.00					To Group No. 8
52	53.99	0.00					
53	54.09	0.00					
54	54.30	0.20					To Group No. 9
55	54.35	0.02					
56	54.36	0.24					
57	54.47	0.09					
58	56.16	0.00					To Group No. 8
59	57.26	0.00	10	63.90	2.49 (2.1%)	4.094E+04	FB
60	57.95	0.00					To Group No. 8
61	58.27	0.00					
62	58.33	0.00					
63	59.16	0.00					
64	59.38	0.74					To Group No. 10
65	60.51	0.00					
66	60.95	0.00					
67	63.07	0.00					To Group No. 8
68	63.79	0.00					
69	64.01	0.00					
70	64.23	0.34	11	65.14	1.64 (1.4%)	2.799E+04	RB-RCCV
71	64.29	1.32					To Group No. 10
72	64.52	0.24					To Group No. 11
73	64.52	0.49					
74	64.62	0.03					To Group No. 8
75	64.67	0.32					To Group No. 11
76	65.21	0.01					To Group No. 10
77	67.06	0.00					To Group No. 8
78	67.75	0.01					
79	68.32	0.02					To Group No. 11
80	68.59	0.00					
81	68.59	0.15					
82	69.09	0.00	12	70.81	0.02 (0.0%)	3.704E+02	RCCV-Pedestal
83	69.51	0.07					To Group No. 11
84	69.56	0.00					To Group No. 12
85	70.59	0.00					
86	70.64	0.00					
87	70.76	0.41					To Group No. 10
88	70.90	0.02					To Group No. 12
Slab Weight at Seismic Analysis		117.72 MN		Total	43.76 MN	(37.2%)	

Table 3.3.1.1-3 RB/FB Slab Eigenvalue Analysis Results EL 4.65 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	22.15	17.95	1	22.79	52.62 (28.1%)	1.101E+05	RB-RCCV
1	22.15	32.99	2	22.16	33.05 (17.7%)	6.533E+04	RCCV-Pedestal
2	22.52	0.27					To Group No. 1
3	22.57	0.00					
4	22.94	0.10					
5	23.13	34.24					
6	23.19	0.00					
7	23.21	0.06					
8	24.51	0.03					To Group No. 2
9	24.65	0.01					
10	25.70	8.97	3	26.38	11.02 (5.9%)	3.089E+04	FB
11	28.40	0.02					To Group No. 2
12	28.46	0.00					
13	28.48	1.59					To Group No. 3
14	32.44	0.46					
15	38.38	3.81	4	40.00	5.41 (2.9%)	3.483E+04	FB
16	41.26	0.89					
17	42.34	0.00	5	42.64	5.58 (3.0%)	4.084E+04	RB-RCCV
18	42.37	0.01					
19	42.59	1.88					
20	42.66	1.94					
21	42.67	1.11					
22	42.69	0.64					
23	47.19	0.71					To Group No. 4

Table 3.3.1.1-3 RB/FB Slab Eigenvalue Analysis Results EL 4.65 m (Continued)

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
24	51.23	0.00	6	56.33	1.31 (0.7%)	1.671E+04	RCCV-Pedestal
25	51.28	0.00					
26	51.48	0.01	7	66.23	0.49 (0.3%)	8.620E+03	FB
27	52.76	0.33	8	53.74	2.12 (1.1%)	2.462E+04	RB-RCCV
28	53.32	0.73					
29	53.32	0.00					
30	53.79	0.50					
31	54.77	0.20					
32	54.79	0.00					
33	54.80	0.30					
34	54.96	0.07					
35	55.42	0.07					To Group No. 7
36	56.31	1.26					To Group No. 6
37	56.91	0.04					
38	57.04	0.00					
39	58.99	0.00					
40	59.11	0.00					
41	60.71	0.00					
42	60.74	0.00					
43	61.73	0.00					To Group No. 7
44	62.81	0.00					To Group No. 6
45	62.92	0.00					
46	64.77	0.45	9	65.61	2.12 (1.1%)	3.680E+04	RB-RCCV
47	64.98	0.00					
48	64.98	0.90					
49	65.24	0.50					
50	68.21	0.41					To Group No. 7
51	68.44	0.00	10	69.92	0.00 (0.0%)	3.023E+01	RCCV-Pedestal
52	68.53	0.00					
53	68.94	0.03					To Group No. 9
54	69.06	0.00					To Group No. 7
55	69.30	0.00					To Group No. 9
56	69.31	0.06					
57	69.73	0.07					
58	70.17	0.12					
59	70.46	0.00					To Group No. 10
60	70.48	0.00					
Slab Weight at Seismic Analysis 187.09 MN				Total	113.72 MN	(60.8%)	

Table 3.3.1.1-4 RB/FB Slab Eigenvalue Analysis Results EL 9.06 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	22.41	0.03	1	22.44	11.09 (21.3%)	2.247E+04	RB-RCCV
2	22.41	5.51					
3	22.44	2.77					
4	22.49	2.78					
5	35.77	0.02	2	41.65	4.82 (9.3%)	3.363E+04	RB-RCCV
6	35.77	0.00					
7	35.78	0.01					
8	35.82	0.01					
9	41.66	1.24					
10	41.71	1.15					
11	41.71	0.70					
12	41.71	1.69					
13	51.55	0.32	3	52.58	2.04 (3.9%)	2.270E+04	RB-RCCV
14	52.13	0.00					
15	52.13	0.70					
16	52.53	0.39					
17	53.58	0.20					
18	53.61	0.07					
19	53.61	0.25					
20	53.76	0.11					
21	63.39	0.34	4	64.13	1.51 (2.9%)	2.493E+04	RB-RCCV
22	63.63	0.00					
23	63.63	0.66					
24	63.92	0.35					
25	67.41	0.02					
26	67.95	0.00					
27	67.96	0.05					
28	68.87	0.08					
Slab Weight at Seismic Analysis 52.04 MN				Total	19.45 MN	(37.4%)	

Table 3.3.1.1-5 RB/FB Slab Eigenvalue Analysis Results EL 13.57 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	23.55	2.25	1	23.58	10.04 (20.3%)	2.248E+04	RB-RCCV
2	23.55	2.76					
3	23.61	2.50					
4	23.62	2.52					
5	37.60	0.01	2	43.81	4.33 (8.7%)	3.348E+04	RB-RCCV
6	37.60	0.01					
7	37.60	0.02					
8	37.84	0.00					
9	43.79	1.05					
10	43.83	1.02					
11	43.83	1.11					
12	43.97	1.12					
13	54.12	0.29	3	55.28	1.90 (3.8%)	2.334E+04	RB-RCCV
14	54.89	0.11					
15	54.89	0.57					
16	55.16	0.35					
17	56.30	0.13					
18	56.30	0.13					
19	56.43	0.10					
20	56.59	0.21					
21	66.36	0.30	4	66.86	1.32 (2.7%)	2.370E+04	RB-RCCV
22	66.84	0.55					
23	66.84	0.12					
24	67.07	0.32					
25	70.70	0.03					
Slab Weight at Seismic Analysis 49.52 MN				Total	17.59 MN	(35.5%)	

Table 3.3.1.1-6 RB/FB Slab Eigenvalue Analysis Results EL 17.50 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	12.05	5.80	1	12.05	5.80 (8.5%)	3.389E+03	RB
2	23.64	2.44	2	23.80	9.71 (14.2%)	2.213E+04	RB-RCCV
3	23.81	2.41					
4	23.82	2.41					
5	23.92	2.45					
6	27.90	0.00	3	32.15	1.46 (2.1%)	6.096E+03	RB
7	32.15	1.46					
8	36.53	0.02	4	43.96	3.88 (5.7%)	3.016E+04	RB-RCCV
9	38.24	0.01					
10	38.74	0.09					
11	38.93	0.09					
12	42.39	1.12					
13	44.28	1.10					
14	45.72	0.74					
15	45.73	0.71					
16	51.13	0.02	5	56.42	1.34 (2.0%)	1.719E+04	RB-RCCV
17	52.83	0.54	6	52.83	0.54 (0.8%)	6.043E+03	RB
18	55.27	0.29					To Group No. 5
19	56.13	0.22					
20	56.16	0.28					
21	56.30	0.25					
22	56.30	0.18					
23	61.67	0.06	7	66.18	0.55 (0.8%)	9.700E+03	RB
24	62.62	0.05					To Group No. 5
25	62.79	0.05					
26	66.37	0.21	8	68.30	1.01 (1.5%)	1.898E+04	RB-RCCV
27	66.75	0.49					To Group No. 7
28	67.51	0.28					To Group No. 8
29	69.50	0.25					
30	69.54	0.27					
31	70.45	0.00					
32	70.67	0.00					To Group No. 7
Slab Weight at Seismic Analysis 68.38 MN				Total	24.28 MN	(35.5%)	

Table 3.3.1.1-7 RB/FB Slab Eigenvalue Analysis Results EL 22.50 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	5.22	19.58	1	5.23	20.02 (44.0%)	2.206E+03	FB
2	5.74	0.44					
3	6.72	2.61	2	6.76	2.68 (5.9%)	4.932E+02	FB
4	8.35	0.07					
5	12.25	0.70	3	12.29	0.71 (1.6%)	4.299E+02	FB
6	15.37	0.01					
7	15.65	0.00					
8	16.48	0.00					
9	17.16	0.00					
10	17.58	0.00					
11	18.53	0.91	4	23.09	3.44 (7.6%)	7.387E+03	FB
12	20.47	0.00					
13	21.93	0.07					
14	24.80	2.46					
15	25.09	0.01					
16	26.80	0.18	5	28.74	1.20 (2.6%)	3.979E+03	FB
17	27.26	0.29					
18	27.87	0.09					
19	28.95	0.04					
20	29.22	0.20					
21	30.70	0.39					
22	32.65	0.00					
23	33.23	0.01	6	35.93	0.32 (0.7%)	1.671E+03	FB
24	34.90	0.26					
25	36.35	0.00					
26	36.98	0.00					
27	39.01	0.00					
28	39.09	0.02					
29	39.54	0.00					
30	39.84	0.00					
31	40.68	0.00					
32	42.33	0.00					
33	43.13	0.00					
34	43.77	0.03					

Table 3.3.1.1-7 RB/FB Slab Eigenvalue Analysis Results EL 22.50 m (Continued)

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
35	44.97	0.16	7	53.42	1.58 (3.5%)	1.820E+04	FB
36	46.96	0.00					
37	50.20	0.08					
38	50.42	0.01					
39	51.83	0.00					
40	52.71	0.00					
41	53.18	0.00					
42	53.57	0.13					
43	53.64	0.30					
44	54.42	0.00					
45	54.45	0.03					
46	54.86	0.64					
47	55.64	0.04					
48	55.68	0.18					
49	56.66	0.00					
50	57.83	0.00					
51	59.06	0.01					
52	62.25	0.07	8	65.74	0.24 (0.5%)	4.231E+03	FB
53	63.69	0.00					
54	63.93	0.00					
55	64.12	0.01					
56	65.18	0.00					
57	66.29	0.12					
58	68.77	0.00					
59	70.61	0.01					
60	70.67	0.03					
Slab Weight at Seismic Analysis 45.5 MN				Total	30.2 MN	(66.4%)	

Table 3.3.1.1-8 RB/FB Slab Eigenvalue Analysis Results EL 27.00 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	25.26	19.84	1	26.42	39.04 (13.2%)	1.097E+05	RCCV
2	27.62	19.20					
3	33.61	0.05	2	41.59	52.53 (17.7%)	3.658E+05	RCCV
4	38.72	9.57					
5	41.47	0.00					
6	42.24	42.86					
7	43.46	0.00	3	43.48	8.77 (3.0%)	6.673E+04	RB-RCCV
8	43.48	8.77					
9	43.63	9.16	4	43.63	9.16 (3.1%)	7.021E+04	RB
10	44.05	0.05					To Group No. 2
11	46.19	0.01	5	46.58	5.41 (1.8%)	4.727E+04	RCCV
12	46.55	3.85					
13	46.63	1.55					
14	49.02	0.00					
15	49.07	0.00					
16	50.98	0.00	6	59.64	18.50 (6.2%)	2.648E+05	RCCV
17	52.15	0.46					
18	52.58	0.00					
19	53.07	0.03	7	57.11	20.43 (6.9%)	2.682E+05	RB-RCCV
20	53.07	4.86					
21	57.07	1.58					To Group No. 6
22	57.37	1.61					To Group No. 7
23	57.37	0.21					
24	57.40	9.91					
25	57.40	0.00					
26	57.72	10.22					To Group No. 6
27	58.75	0.00					
28	59.66	0.00	8	59.66	0.00 (0.0%)	4.959E-04	RB
29	60.08	1.90					To Group No. 7
30	60.08	0.00					
31	60.40	0.00					
32	60.40	0.00					
33	61.81	4.62					To Group No. 6
34	62.07	0.07					To Group No. 7
35	62.07	1.35					
36	62.73	0.00					
37	62.73	0.24					
38	63.47	0.00					
39	63.47	0.00					
40	64.40	0.00					To Group No. 6
41	65.33	0.07					To Group No. 7
42	65.33	0.05					
43	67.03	0.04					
44	67.03	0.00					
45	67.06	0.00					
46	68.35	0.01					To Group No. 6
47	68.55	0.00					To Group No. 7
48	68.55	0.00					
49	69.53	0.11					To Group No. 6
50	70.22	0.09					
51	70.36	1.39					
52	70.93	0.07					To Group No. 7
Slab Weight at Seismic Analysis 296.4 MN				Total	153.84 MN	(51.9%)	

Table 3.3.1.1-9 RB/FB Slab Eigenvalue Analysis Results EL 34.00 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	38.78	2.52	1	38.78	4.92 (6.4%)	2.977E+04	RB-RCCV
2	38.78	2.40					
3	41.56	0.02	2	49.18	9.16 (12.0%)	8.924E+04	RCCV
4	49.13	4.44					
5	49.26	4.64					
6	49.58	0.04					
7	49.76	0.02					
8	53.00	0.15	3	60.69	9.58 (12.6%)	1.420E+05	RCCV
9	53.40	0.17					
10	54.69	0.14					
11	57.12	0.58					
12	57.26	0.49					
13	57.83	0.67					
14	59.06	1.06					
15	59.18	0.96					
16	60.06	0.21					
17	60.11	0.09					
18	61.96	0.00					
19	62.39	1.69					
20	62.42	1.56					
21	63.35	0.24					
22	63.56	0.46					
23	63.62	0.25					
24	63.89	0.33					
25	63.90	0.34					
26	64.78	0.01					
27	64.89	0.01					
28	70.53	0.09					
29	70.55	0.08					
Slab Weight at Seismic Analysis 76.26 MN				Total	23.66 MN	(31.0%)	

Table 3.3.1.1-10 RB/FB Slab Eigenvalue Analysis Results EL 52.40 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	2.75	29.39	1	2.75	29.39 (58.0%)	8.948E+02	RB
2	3.58	0.00					
3	5.23	4.40	2	5.23	4.41 (8.7%)	4.858E+02	RB
4	6.38	0.00					
5	6.91	0.00					
6	7.80	0.00					
7	8.10	0.00					
8	10.21	0.00					
9	10.23	0.00					
10	10.40	3.75	3	10.75	5.86 (11.6%)	2.725E+03	RB
11	10.78	0.00					
12	11.33	1.89					
13	11.74	0.22					
14	11.93	0.00					
15	13.41	0.00					
16	14.48	0.00					
17	14.88	0.00					
18	15.03	0.00					
19	15.16	0.00					
20	15.99	0.00					
21	17.24	0.00					
22	17.37	0.00					
23	18.82	0.08	4	19.89	2.73 (5.4%)	4.339E+03	RB
24	19.86	1.52					
25	19.99	1.12					
26	20.20	0.00					
27	20.83	0.00					
28	20.95	0.00					
29	21.93	0.00					
30	21.97	0.00					
31	22.19	0.00					
32	23.84	0.00					
33	24.87	0.00					
34	25.04	0.18	5	25.14	0.19 (0.4%)	4.731E+02	RB
35	25.24	0.00					
36	25.65	0.00					
37	25.95	0.00					
38	26.61	0.00					
39	26.76	0.00					
40	27.48	0.00					
41	28.15	0.00					
42	28.50	0.00					
43	28.74	0.00					
44	29.01	0.00					
45	29.33	0.04	6	30.83	1.21 (2.4%)	4.632E+03	RB
46	29.49	0.00					
47	30.02	0.61					
48	30.30	0.00					
49	31.53	0.01					
50	31.78	0.53					
51	32.10	0.00					
52	32.76	0.02					
53	33.06	0.00					

Table 3.3.1.1-10 RB/FB Slab Eigenvalue Analysis Results EL 52.40 m (Continued)

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
54	33.62	0.05	7	35.90	0.82 (1.6%)	4.275E+03	RB
55	33.66	0.00					
56	33.84	0.01					
57	33.99	0.50					
58	35.59	0.00					
59	35.77	0.02					
60	36.12	0.00					
61	36.28	0.00					
62	36.82	0.00					
63	37.15	0.00					
64	37.30	0.00					
65	38.22	0.00					
66	38.63	0.00					
67	38.80	0.00					
68	38.94	0.03					
69	39.07	0.00					
70	39.67	0.00					
71	39.76	0.00					
72	39.82	0.00					
73	40.35	0.20					
74	40.60	0.00					
75	41.32	0.00					
76	41.44	0.00					
77	41.57	0.00					
78	41.66	0.00					
79	41.95	0.00					
80	42.11	0.00					
81	44.18	0.00					
82	44.27	0.00					
83	44.58	0.01					
84	45.18	0.19	8	46.36	0.91 (1.8%)	7.866E+03	RB
85	45.61	0.01					
86	45.72	0.28					
87	46.07	0.16					
88	46.46	0.05					
89	46.68	0.05					
90	47.00	0.00					
91	47.09	0.01					
92	47.58	0.00					
93	48.24	0.00					
94	48.29	0.00					
95	48.31	0.03					
96	48.46	0.00					
97	48.71	0.00					
98	49.36	0.10					
99	49.56	0.02					
100	49.88	0.00					

Table 3.3.1.1-10 RB/FB Slab Eigenvalue Analysis Results EL 52.40 m (Continued)

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
101	50.44	0.00	9	67.61	1.48 (2.9%)	2.714E+04	RB
102	51.12	0.00					
103	51.25	0.00					
104	51.61	0.00					
105	52.50	0.01					
106	52.69	0.00					
107	52.97	0.00					
108	53.17	0.00					
109	53.35	0.00					
110	53.58	0.00					
111	54.06	0.00					
112	54.36	0.00					
113	55.08	0.00					
114	55.41	0.00					
115	55.57	0.00					
116	55.85	0.00					
117	55.97	0.00					
118	56.10	0.00					
119	56.20	0.01					
120	56.42	0.00					
121	56.64	0.00					
122	57.73	0.08					
123	57.88	0.00					
124	58.34	0.04					
125	58.52	0.00					
126	58.66	0.00					
127	58.90	0.00					
128	59.15	0.00					
129	59.65	0.03					
130	59.89	0.01					
131	60.25	0.00					
132	60.78	0.00					
133	61.25	0.04					
134	61.83	0.00					
135	62.01	0.05					
136	62.04	0.00					
137	62.30	0.00					
138	62.46	0.00					
139	62.72	0.00					
140	62.79	0.00					
141	63.34	0.00					
142	63.92	0.00					
143	64.54	0.10					
144	64.89	0.02					
145	65.23	0.00					
146	65.56	0.01					
147	66.02	0.00					
148	66.56	0.03					
149	66.77	0.01					
150	67.06	0.00					
151	68.24	0.00					
152	68.46	0.00					
153	68.61	0.00					
154	68.89	0.08					
155	69.27	0.01					
156	70.01	0.01					
157	70.08	0.00					
158	70.53	0.40					
159	70.64	0.01					
160	70.83	0.50					
161	70.91	0.01					
Slab Weight at Seismic Analysis 50.69 MN				Total	46.99 MN	(92.7%)	

Table 3.3.1.2-1 CB Slab Eigenvalue Analysis Results EL -2.00 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)
1	35.70	1.08	1	39.63	4.32 (34.2%)	2.735E+04
2	39.46	1.57				
3	40.83	0.46				
4	41.40	0.05				
5	41.78	0.44				
6	43.06	0.01				
7	43.67	0.72				
8	53.14	0.10	2	58.89	1.61 (12.7%)	2.247E+04
9	55.16	0.30				
10	56.07	0.18				
11	56.98	0.32				
12	57.74	0.02				
13	60.85	0.00				
14	62.07	0.42				
15	64.07	0.26				
16	66.68	0.02				
Slab Weight at Seismic Analysis 12.64MN			Total 5.93MN (46.9%)			

Table 3.3.1.2-2 CB Slab Eigenvalue Analysis Results EL 4.65 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)
1	32.18	5.29	1	35.08	8.02 (56.9%)	3.975E+04
2	33.33	0.01				
3	36.66	0.04				
4	37.07	0.02				
5	39.91	0.04				
6	39.98	1.48				
7	41.69	0.62				
8	42.36	0.52				
9	44.42	0.20	2	45.03	0.23 (1.6%)	1.856E+03
10	46.25	0.00				
11	49.58	0.03				
12	50.87	0.04	3	56.64	2.65 (18.8%)	3.420E+04
13	51.75	0.09				
14	53.11	1.32				
15	55.33	0.39				
16	55.58	0.17				
17	58.76	0.21				
18	59.57	0.00				
19	66.33	0.02				
20	67.84	0.00				
21	68.05	0.00				
22	70.27	0.40				
Slab Weight at Seismic Analysis 14.1MN			Total 10.9MN (77.3%)			

Table 3.3.1.2-3 CB Slab Eigenvalue Analysis Results EL 9.06 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)
1	15.85	1.35	1	16.46	3.49 (24.4%)	3.808E+03
2	16.83	2.15				
3	21.04	0.02		21.84	0.02 (0.2%)	4.442E+01
4	25.76	0.00				
5	33.66	0.67	2	37.56	4.91 (34.3%)	2.786E+04
6	36.39	0.43				
7	37.69	1.03				
8	38.50	2.54				
9	39.49	0.19				
10	40.38	0.00				
11	41.17	0.02				
12	43.60	0.02				
13	45.44	0.31	3	47.12	0.85 (5.9%)	7.593E+03
14	45.98	0.11				
15	48.08	0.09				
16	48.52	0.00				
17	48.69	0.34				
18	53.76	0.91	4	55.08	1.61 (11.2%)	1.960E+04
19	53.85	0.00				
20	55.67	0.59				
21	59.80	0.03				
22	60.78	0.00				
23	61.83	0.00				
24	62.41	0.01				
25	63.34	0.02				
26	64.43	0.01				
27	65.33	0.00				
28	65.55	0.00				
29	66.07	0.04				
Slab Weight at Seismic Analysis 14.3MN			Total 10.88MN (76.1%)			

Table 3.3.1.2-4 CB Slab Eigenvalue Analysis Results EL 13.80 m

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)
1	17.92	0.01	1	18.38	5.48 (38.6%)	7.453E+03
2	18.38	5.47				
3	25.75	0.00		26.54	0.12 (0.8%)	3.322E+02
4	26.55	0.12				
5	33.45	6.30	2	33.49	6.39 (45.0%)	2.886E+04
6	34.95	0.01				
7	36.74	0.07				
8	37.44	0.01				
9	40.45	0.00				
10	40.98	0.00				
11	43.50	0.40	3	45.80	0.78 (5.5%)	6.592E+03
12	45.49	0.00				
13	46.36	0.07				
14	46.63	0.02				
15	48.25	0.06				
16	48.78	0.24				
17	52.97	0.68	4	56.55	1.06 (7.5%)	1.362E+04
18	54.65	0.01				
19	54.77	0.01				
20	57.52	0.00				
21	57.89	0.05				
22	59.38	0.00				
23	62.54	0.02				
24	63.25	0.00				
25	63.38	0.21				
26	64.10	0.01				
27	67.51	0.02				
28	67.80	0.05				
Slab Weight at Seismic Analysis		14.2MN	Total		13.83MN (97.4%)	

Table 3.3.1.3-1 FWSC Roof Eigenvalue Analysis Results (FWS)

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	35.75	0.00					
2	35.75	0.00					
3	35.75	0.00					
4	35.76	1.34	1	35.76	1.34 (62.7%)	6.895E+03	
5	46.04	0.00					
6	46.04	0.00					
7	46.04	0.00					
8	50.02	1.74	2	50.02	1.74 (51.7%)	1.756E+04	
9	57.86	0.00					
10	57.86	0.00					
11	57.86	0.00					
12	57.86	0.00					
13	64.72	0.00					
14	64.72	0.00					
15	64.72	0.00					
16	64.72	0.00					
Roof Weight at Seismic Analysis for Group No.1: 2.14 MN				Total	1.34 MN	(62.7%)	
Roof Weight at Seismic Analysis for Group No.2: 3.37 MN				Total	1.74 MN	(51.7%)	

Table 3.3.1.3-2 FWSC Roof Eigenvalue Analysis Results (FPE)

Mode No.	Frequency (Hz)	Effective Weight (MN)	Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
1	48.36	0.00					
2	54.02	0.76	1	54.02	0.76 (32.4%)	8.904E+03	
3	64.59	0.02					
Roof Weight at Seismic Analysis 2.34 MN				Total	0.76 MN	(32.5%)	

Table 3.3.2.1-1 Out-of-plane Fundamental Frequencies for Typical Walls for RB/FB

Building	Elevation (m)	Wall Thickness (m)	Frequency (Hz)
RBFB	EL -11.5 to EL -6.4	2.0	224
RBFB	EL -4.65 to EL -9.06	1.5	183
MS Tunnel	EL 17.5 to EL 27.0	1.3	484
Pool Girder	EL 27.0 to EL 34.0	1.6	992

Table 3.3.2.1-2 Eigenvalue Analysis Results for RB Walls above EL 34.0 m

Mode No.	Frequency (Hz)	Effective Weight (MN)		Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
		R1	RB					
1	14.14	0.00	4.56	1-RB	14.14	4.56 (33.6%)	3.666E+03	RB
2	15.14	7.16	0.00	1-R1	15.87	8.13 (80.0%)	8.238E+03	R1
3	17.23	0.00	0.00					
4	21.22	0.97	0.01					R1 (to 1-R1)
5	21.88	0.00	1.41	2-RB	24.51	5.10 (37.6%)	1.233E+04	RB
6	25.29	0.00	2.44					
7	25.95	0.00	1.25					
8	26.99	0.00	0.01					
9	30.63	0.00	0.00					
10	35.22	0.54	0.01	2-R1	35.22	0.54 (5.3%)	2.714E+03	R1
11	38.07	0.01	0.56	3-RB	43.36	2.28 (16.8%)	1.723E+04	RB
12	39.44	0.01	0.00					
13	40.40	0.00	0.01					
14	40.88	0.00	0.00					
15	41.73	0.00	0.02					
16	42.51	0.00	0.00					
17	43.61	0.01	0.01					
18	44.12	0.00	0.37					RB (to 3-RB)
19	45.59	0.00	0.02					
20	47.49	0.02	0.02					
21	48.01	0.00	1.30					RB (to 3-RB)
22	51.32	0.00	0.06	4-RB	63.99	1.42 (10.5%)	2.338E+04	RB
23	53.36	0.09	0.00	3-R1	67.20	1.37 (13.5%)	2.487E+04	R1
24	56.33	0.00	0.00					
25	57.00	0.02	0.00					R1 (to 3-R1)
26	57.80	0.09	0.01					
27	58.39	0.01	0.08					RB (to 4-RB)
28	60.88	0.00	0.62					
29	62.89	0.00	0.02					
30	65.33	0.05	0.00					R1 (to 3-R1)
31	65.78	0.00	0.00					
32	68.54	0.05	0.52					RB (to 4-RB)
33	68.68	7.56	0.00					
34	68.72	0.68	0.11					R1 (to 3-R1)
35	69.86	0.28	0.02					
36	70.59	0.17	0.00					
37	70.59	0.00	0.12					RB (to 4-RB)
	R1 Total	10.16 MN			Total	10.09 (99.3%)		
	RB Total		13.57 MN		Total	13.31 (98.1%)		

Note : Mode No. 33 is in-plane vibration and neglected.

Table 3.3.2.1-3 Eigenvalue Analysis Results for FB Walls above EL 4.65 m

Mode No.	Frequency (Hz)	Effective Weight (MN)		Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
		F3	FA					
1	12.73	8.09	0.01	1-F3	12.73	8.09 (64.8%)	5.278E+03	F3
2	13.27	0.01	4.93	1-FA	13.27	4.93 (74.7%)	3.493E+03	FA
3	15.98	0.60	0.00	2-F3	18.34	2.38 (19.1%)	3.225E+03	F3
4	19.14	1.78	0.00					
5	23.65	0.00	0.00					
6	25.75	0.03	0.00					
7	29.23	0.00	0.00					
8	33.32	0.04	0.00	3-F3	35.36	0.23 (1.9%)	1.170E+03	F3
9	35.79	0.19	0.00					
10	36.55	0.01	0.00					
11	37.55	0.00	0.00					
12	37.69	0.01	0.00					
13	40.73	0.00	0.86	2-FA	40.73	0.86 (13.0%)	5.733E+03	FA
14	42.50	0.20	0.00	4-F3	42.50	0.21 (1.7%)	1.522E+03	F3
15	49.87	0.01	0.00					
16	52.33	0.00	0.00					
17	54.28	0.00	0.80	3-FA	54.30	0.80 (12.2%)	9.520E+03	FA
18	56.54	0.04	0.00	5-F3	63.00	1.51 (12.1%)	2.410E+04	F3
19	59.57	0.01	0.00					
20	60.62	0.00	0.00					FA (to 3-FA)
21	61.09	0.16	0.00					F3 (to 5-F3)
22	61.25	0.00	0.00					FA (to 3-FA)
23	61.91	0.44	0.00					F3 (to 5-F3)
24	63.89	0.77	0.00					
25	66.75	0.10	0.00					
26	69.56	0.00	9.51					
27	70.47	0.00	0.00					FA (to 3-FA)
	F3 Total	12.48 MN			Total	12.42 (99.5%)		
	FA Total		6.61 MN		Total	6.59 (99.9%)		

Note : Mode No. 26 is in-plane vibration and neglected.

Table 3.3.2.1-4 Eigenvalue Analysis Results for RB Walls above EL 27.0 m

Mode No.	Frequency (Hz)	Effective Weight (MN)		Group No.	Average Frequency (Hz)	Total Weight (MN)	Stiffness (MN/m)	Note
		R1	RB					
1	44.37	0.00	3.98	1-RB	45.27	4.77 (98.6%)	3.937E+04	RB
2	45.58	0.00	0.00					
3	47.51	0.00	0.60					RB (to 1-RB)
4	51.35	0.00	0.00					
5	56.84	0.00	0.19					RB (to 1-RB)
6	59.71	3.51	0.00	1-R1	59.71	3.51 (100%)	5.038E+04	R1
7	59.73	0.00	0.00					
8	63.38	0.00	0.00					
9	70.79	0.00	0.06					
	R1 Total	3.51 MN			Total	3.51 (100%)		
	RB Total		4.84 MN		Total	4.77 (98.6%)		

Table 3.3.2.2-1 Eigenvalue Analysis Results for CB Walls above EL 9.06 m

Mode No.	Frequency (Hz)	Effective X	Effective Y	Group No.	Average Frequency	Total Weight (MN)	Stiffness (MN/m)	Note
1	67.80	0.00	0.00					
2	69.60	0.05	0.00					
	C1 Total	0.05 MN						
	CA Total		0 MN					

Table 3.3.2.2-2 Eigenvalue Analysis Results for CB Walls above EL 4.65 m

Mode No.	Frequency (Hz)	Effective X	Effective Y	Group No.	Average Frequency	Total Weight (MN)	Stiffness (MN/m)	Note
1	68.29	0.00	0.00					
2	69.98	0.00	0.00					
	C1 Total	0 MN						
	CA Total		0 MN					

Table 3.4.1-1a Seismic Model Properties of RBFB (Cracked Model) -0% Infill Concrete Stiffness of VW and DF-

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{3}]]

[[**Table 3.4.1-1b Seismic Model Properties of RCCV (Cracked Model) -0% Infill Concrete Stiffness of VW and DF-**

{3}]]

[[**Table 3.4.1-1c Seismic Model Properties of Pedestal (Cracked Model) -0% Infill Concrete Stiffness of VW and DF-**

{3}]]

Table 3.4.1-1d Seismic Model Properties of VW and RSW (Cracked Model)
-0% Infill Concrete Stiffness of VW and DF-

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{3}]]

Table 3.4.1-1e RB/FB Slab Node Properties and Spring Constants (Cracked Model)
-0% Infill Concrete Stiffness of VW and DF-

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{3}]]

Table 3.4.1-1e RB/FB Slab Node Properties and Spring Constants (Cracked Model)
[[-0% Infill Concrete Stiffness of VW and DF- (Continued)

{3}]]

Table 3.4.1-2a Seismic Model Properties of RCCV (Cracked Model) -50% Infill Concrete Stiffness of VW and DF-

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{3}]]

Table 3.4.1-2b Seismic Model Properties of VW and RSW (Cracked Model)
-50% Infill Concrete Stiffness of VW and DF-

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{3}]]

Table 3.4.1-2c RB/FB Slab Node Properties and Spring Constants (Cracked Model)
-50% Infill Concrete Stiffness of VW and DF-

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Table 3.4.1-2c RB/FB Slab Node Properties and Spring Constants (Cracked Model) -50% Infill Concrete Stiffness of VW and DF-(Continued)

{3}]]

Table 3.4.1-3 Frequency of RB/FB Slab Oscillator -0%, 50% and 100% Infill Concrete Stiffness of VW and DF-

EL (m)	Node	Infill Concrete Stiffness of VW and DF	Uncracked Frequency (Hz)	Cracked Frequency (Hz)
52.40	9101		2.75	1.95
	9102		5.23	3.70
	9103		10.75	7.60
	9104		19.89	14.06
	9105		25.14	17.78
	9106		30.83	21.80
	9107		35.90	25.39
	9108		46.36	32.78
	9109		67.61 (N/A)	47.80
34.00	9091		38.78	27.42
	9092		49.18	34.78
	9093		60.69 (N/A)	42.91
27.00	9081		26.42	18.68
	9082		41.59	29.41
	9083		43.48	30.74
	9084		43.63	30.85
	9085		46.58	32.94
	9086		59.64 (N/A)	42.17
	9087		57.11 (N/A)	40.38
22.50	9071		5.23	3.70
	9072		6.76	4.78
	9073		12.29	8.69
	9074		23.09	16.33
	9075		28.74	20.33
	9076		53.42 (N/A)	37.77
17.50	9061		12.05	8.52
	9062		32.15	22.73
	9063		23.80	16.83
	9064	0%	12.69	12.69
		50%	17.00	17.00
		100%	18.29	18.29
	9065		43.96	31.08
	99064	0%	47.84	47.84
		50%, 100%	-	-
	9066		56.42 (N/A)	39.90
	9067		68.30 (N/A)	48.30
13.57	9051		23.58	16.67
	9052		43.81	30.98
	9053		55.28 (N/A)	39.09
	9054		66.86 (N/A)	47.28

EL (m)	Node	Infill Concrete Stiffness of VW and DF	Uncracked Frequency (Hz)	Cracked Frequency (Hz)
9.06	9041		22.44	15.87
	9042		41.65	29.45
	9043		52.58 (N/A)	37.18
	9044		64.13 (N/A)	45.35
4.65	9031		26.38	18.66
	9032		22.79	16.11
	9033		22.16	15.67
	9034		40.00	28.28
	9035		42.64	30.15
	9036		53.74 (N/A)	38.00
	9037		65.61 (N/A)	46.39
-1.00	9021		20.38	14.41
	9022		29.40	20.79
	9023		22.84	16.15
	9024		27.81	19.66
	9025		42.27	29.89
	9026		45.80	32.39
	9027		46.42	32.83
	9028		53.34 (N/A)	37.72
	9029		63.90 (N/A)	45.19
	9030		65.14 (N/A)	46.06
-6.40	9011		22.28	15.76
	9012		26.31	18.60
	9013		34.65	24.50
	9014		53.24 (N/A)	37.64
	9015		59.64 (N/A)	42.17

Note 1: Values of frequency except for oscillator nodes 9064 and 99064 are applicable to models with all 0%, 50% and 100% of infill concrete stiffness of vent wall and diaphragm floor.

Note 2: Values of frequency higher than 50 Hz for uncracked model described N/A are not used.

Table 3.4.1-4a RB/FB Wall Node Properties and Spring Constants (Cracked Model)

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Table 3.4.1-4b Frequency of RB/FB Wall Oscillator {3}]]

EL (m)	Node	Uncracked Frequency (Hz)	Cracked Frequency (Hz)
52.40	99981	15.87	11.22
to 34.00	99982	35.22	24.90
	99983	14.14	10.00
	99984	24.51	17.33
	99985	43.36	30.66
	99986	67.20 (N/A)	47.52
	99987	63.99 (N/A)	45.25
34.00	99991	59.71 (N/A)	42.22
to 27.00	99992	45.27	32.01
13.57	99971	12.73	9.00
	99972	18.34	12.97
	99973	35.36	25.00
	99974	42.50	30.05
	99977	63.00 (N/A)	44.55
	99975	13.27	9.39
	99976	40.73	28.80
	99978	54.30 (N/A)	38.40

Note: Values of frequency higher than 50 Hz for uncracked model described N/A are not used.

Table 3.4.1-5 Damping Values for Dynamic Analysis

Components	Percent of Critical Damping (%)	
	SSE damping for cracked models	OBE damping for uncracked models
Reinforced concrete structures	7.0	4.0
Vent Wall / Diaphragm Floor		
― 0% Concrete Stifness Contribution	4.0	-
― 50% Concrete Stifness Contribution	5.0	-
― 100% Concrete Stifness Contribution	-	3.0
Reactor Shield Wall	4.0	3.0
Reactor Pressure Vessel (RPV)	4.0	2.0
Separator / Chimney / Shroud	4.0	2.0
Fuel		
― horizontal	6.0	6.0
― vertical	6.0	4.0
Control Rod Drive Housing (CRDH)	2.0	1.0
RPV and Shroud support	4.0	2.0
CRDH support (CRD restraint)	4.0	2.0
Shroud support	4.0	2.0

[[

Table 3.4.2-1a Seismic Model Properties of CB (Cracked Model)

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Table 3.4.2-1b CB Slab Node Properties and Spring Constants (Cracked Model)

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Table 3.4.2-2 Frequency of CB Slab Oscillator

EL (m)	Node	Uncracked Frequency (Hz)	Cracked Frequency (Hz)
13.80	9001	18.38	13.00
	9002	33.49	23.68
	9003	45.80	32.38
	9004	56.55 (N/A)	39.99
9.06	9101	16.46	11.64
	9102	37.56	26.56
	9103	47.12	33.32
	9104	55.08 (N/A)	38.95
4.65	9201	35.08	24.81
	9202	45.03	31.84
	9203	56.64 (N/A)	40.05
-2.00	9301	39.63	28.02
	9302	58.89 (N/A)	41.64

Note: Values of frequency higher than 50 Hz for uncracked model described N/A are not used.

Table 3.4.3-1a Seismic Model Properties of FWS (Cracked Model)

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{3}]]

Table 3.4.3-1b Seismic Model Properties of FPE (Cracked Model) (Half Model)

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Table 3.4.3-1c FWSC Roof Node Properties and Spring Constants (Cracked Model)

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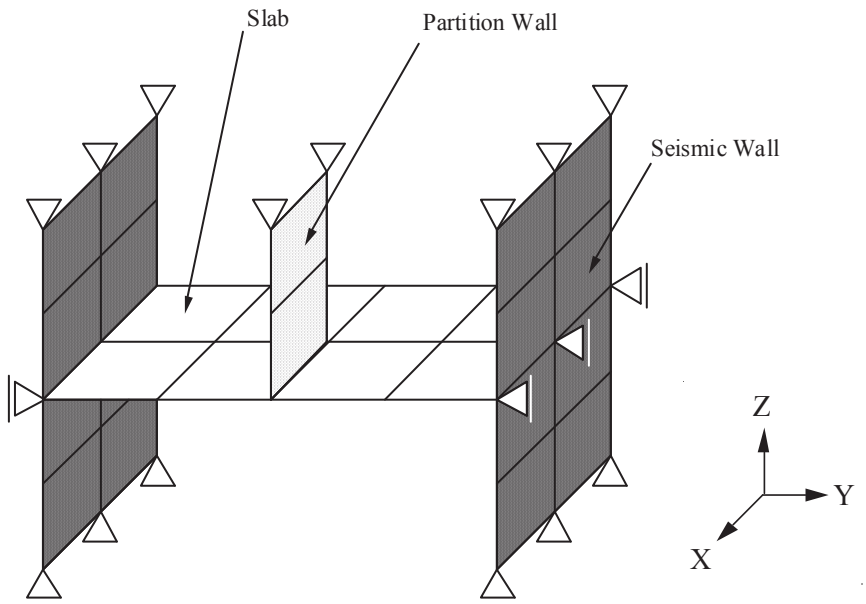
Table 3.4.3-2 Frequency of FWSC Roof Oscillator

EL (m)	Node	Uncracked Frequency (Hz)	Cracked Frequency (Hz)
19.70	11	35.76	25.29
	12	50.22 (N/A)	35.51
8.25	13	54.02 (N/A)	38.20

Note: Values of frequency higher than 50 Hz for uncracked model described N/A are not used.



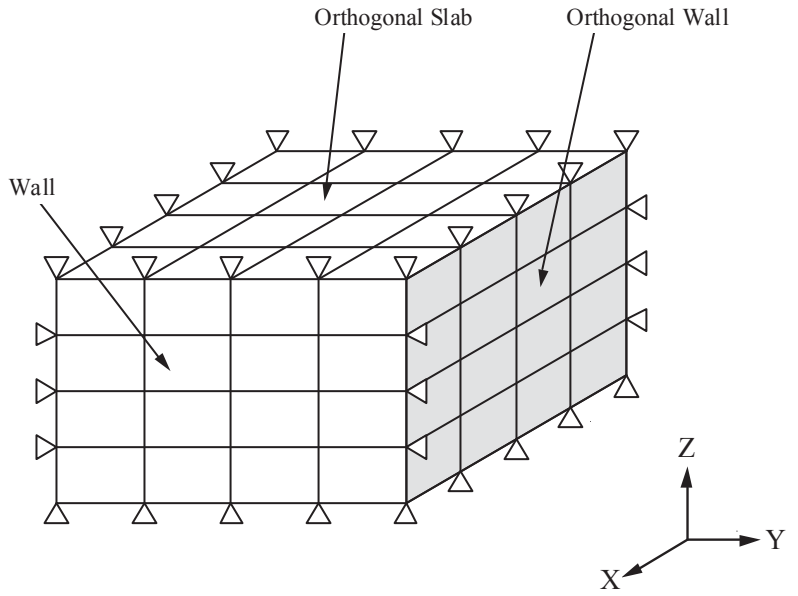
Boundary Condition

	Translation X	Y	Z	Rotation θxx	θyy	θzz	
▽ △	fixed	fixed	fixed	free	free	free	nodes of wall elements at the upper and lower floor levels
▷ ◁	fixed	fixed	free	free	free	free	all nodes of slab elements

Note:
1) Equivalent unit weight is applied on slab elements. Seismic walls and partition walls have no weight.

2) Young's modulus for in-plane deformation of seismic wall is increased by 10 times to neglect their vertical deformation. While, their out-of -plane bending deformation is taken into consideration.

Figure 3.1.1-1 Principal of Model for Slab Vertical Flexibility



Boundary Condition

	Translation			Rotation		
	X	Y	Z	θxx	θyy	θzz
△ ▽	fixed	fixed	fixed	free	free	free

Note:
1) Equivalent unit weight is applied on two target orthogonal walls in X and Y directions. The other walls and slabs and partition walls have no weight.

2) Young's modulus for all portions is not changed.

Figure 3.1.1-2 Principal of Model for Wall Horizontal Flexibility

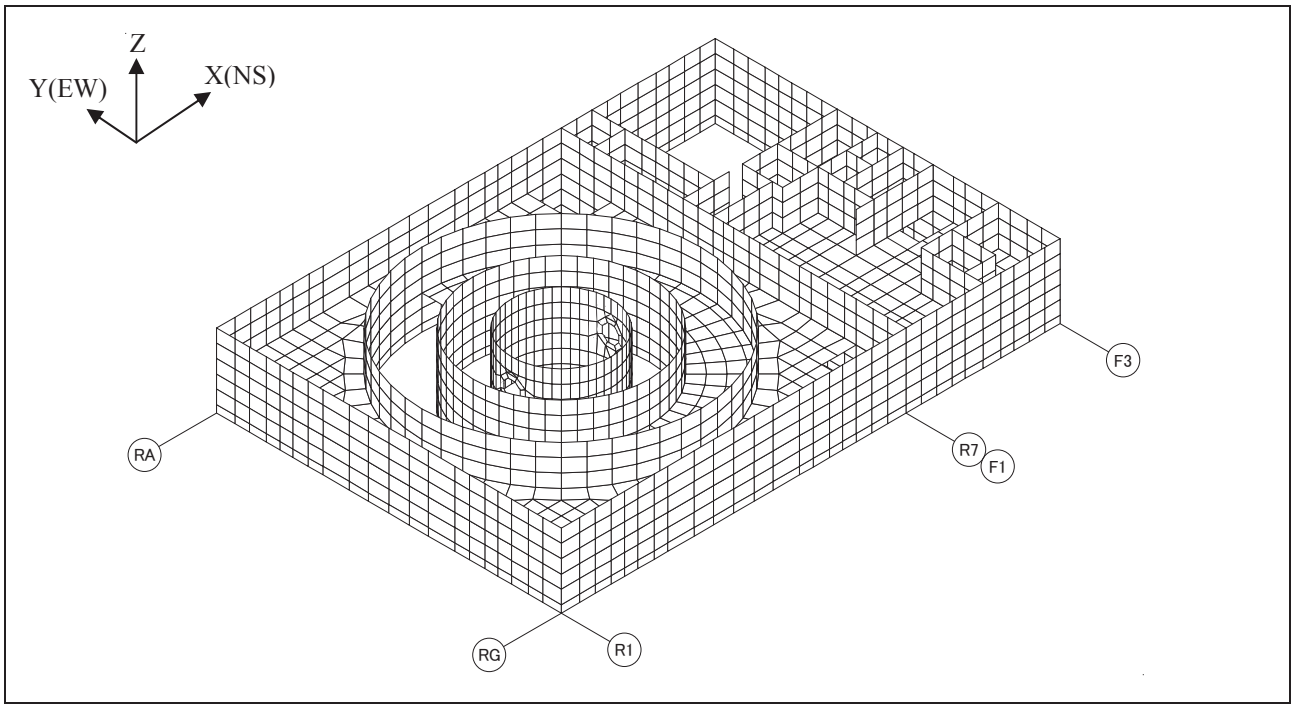


Figure 3.3.1.1-1 FE Model for RB/FB Slab Eigenvalue Analysis EL -6.40m

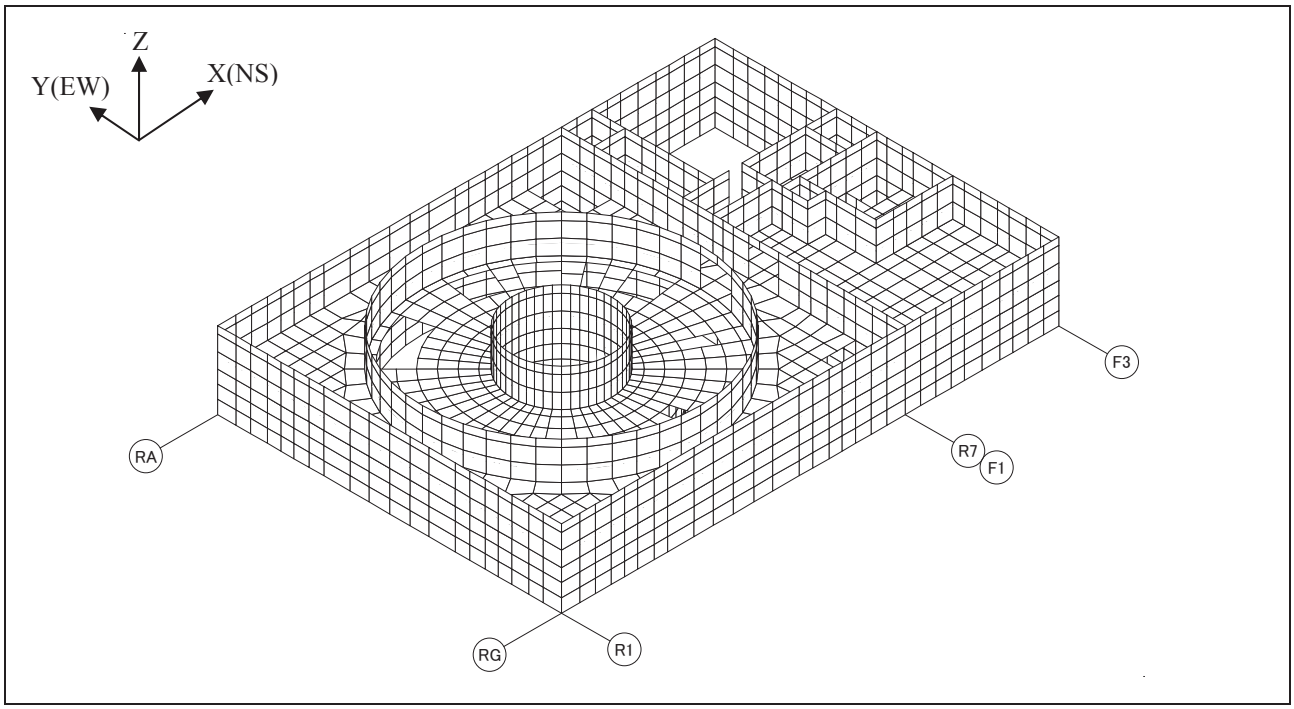


Figure 3.3.1.1-2 FE Model for RB/FB Slab Eigenvalue Analysis EL -1.00m

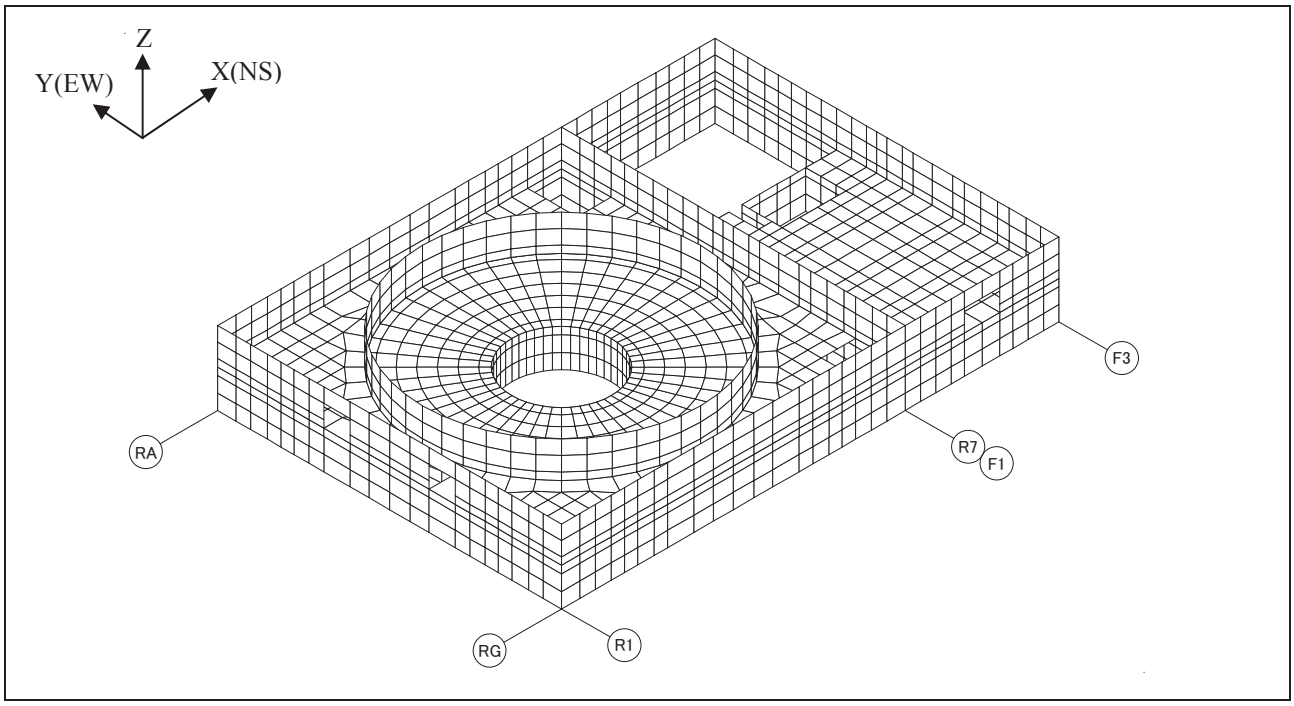


Figure 3.3.1.1-3 FE Model for RB/FB Slab Eigenvalue Analysis EL 4.65m

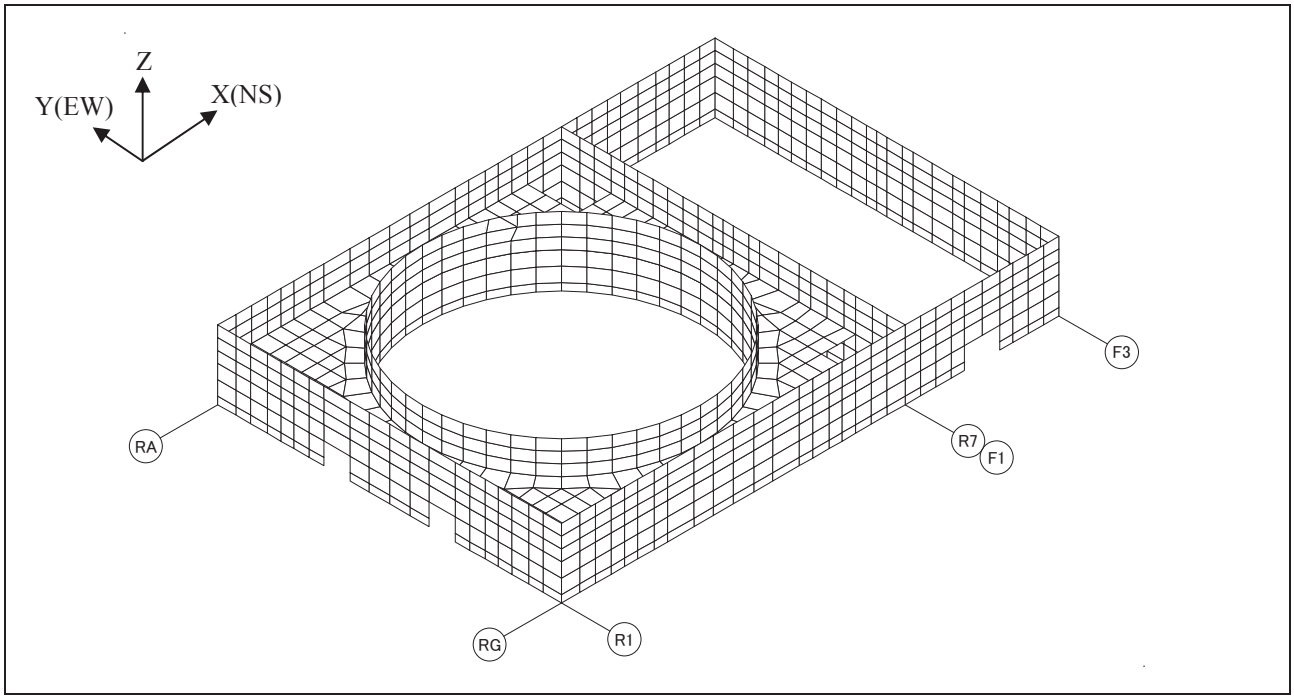


Figure 3.3.1.1-4 FE Model for RB/FB Slab Eigenvalue Analysis EL 9.06m

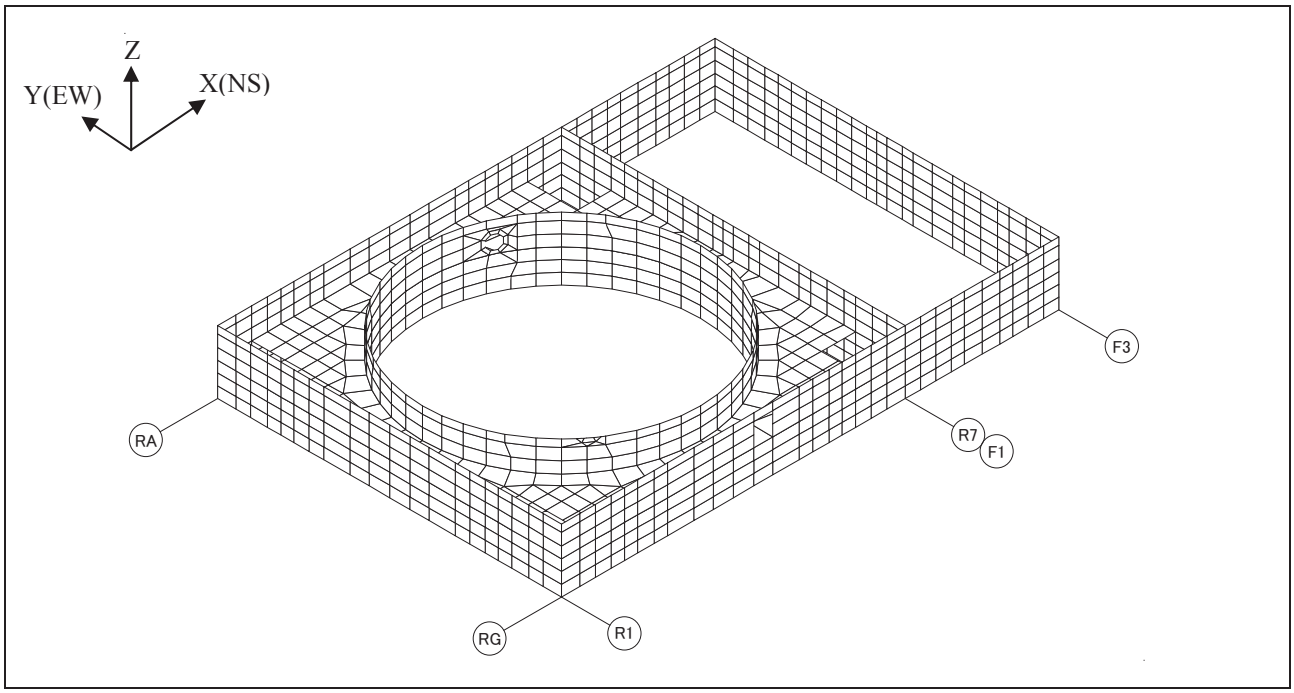


Figure 3.3.1.1-5 FE Model for RB/FB Slab Eigenvalue Analysis EL 13.57m

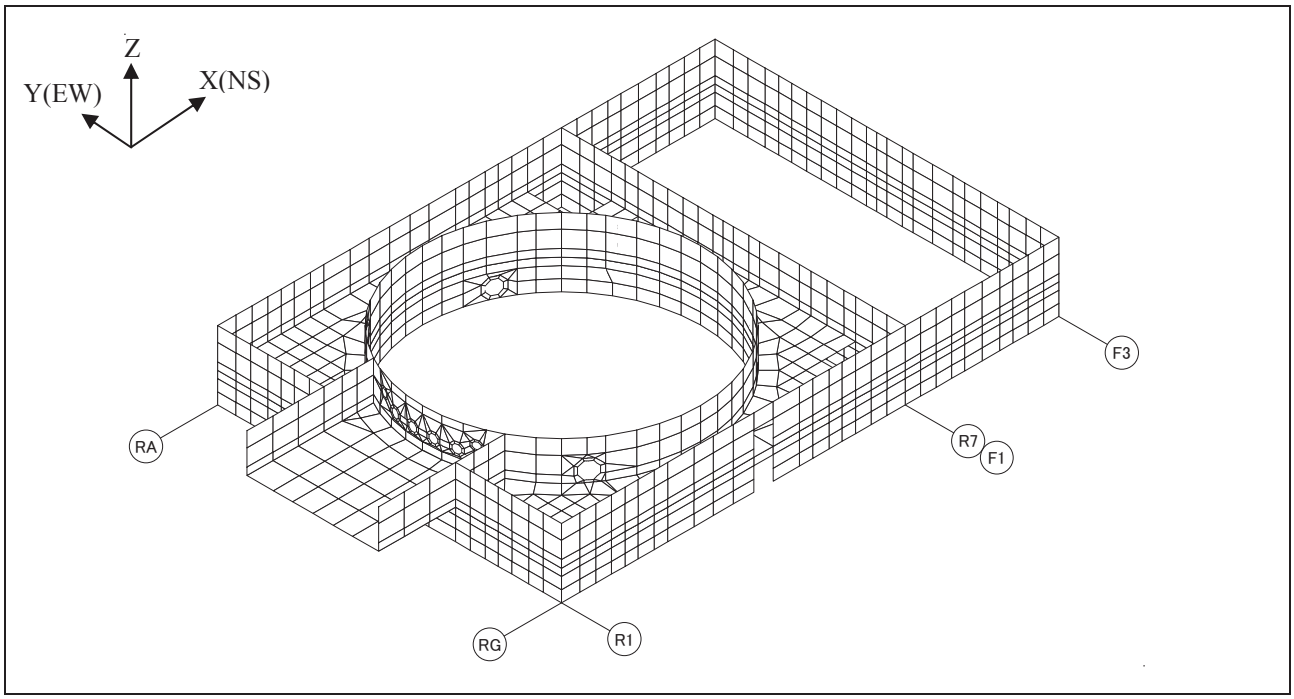


Figure 3.3.1.1-6 FE Model for RB/FB Slab Eigenvalue Analysis EL 17.50m

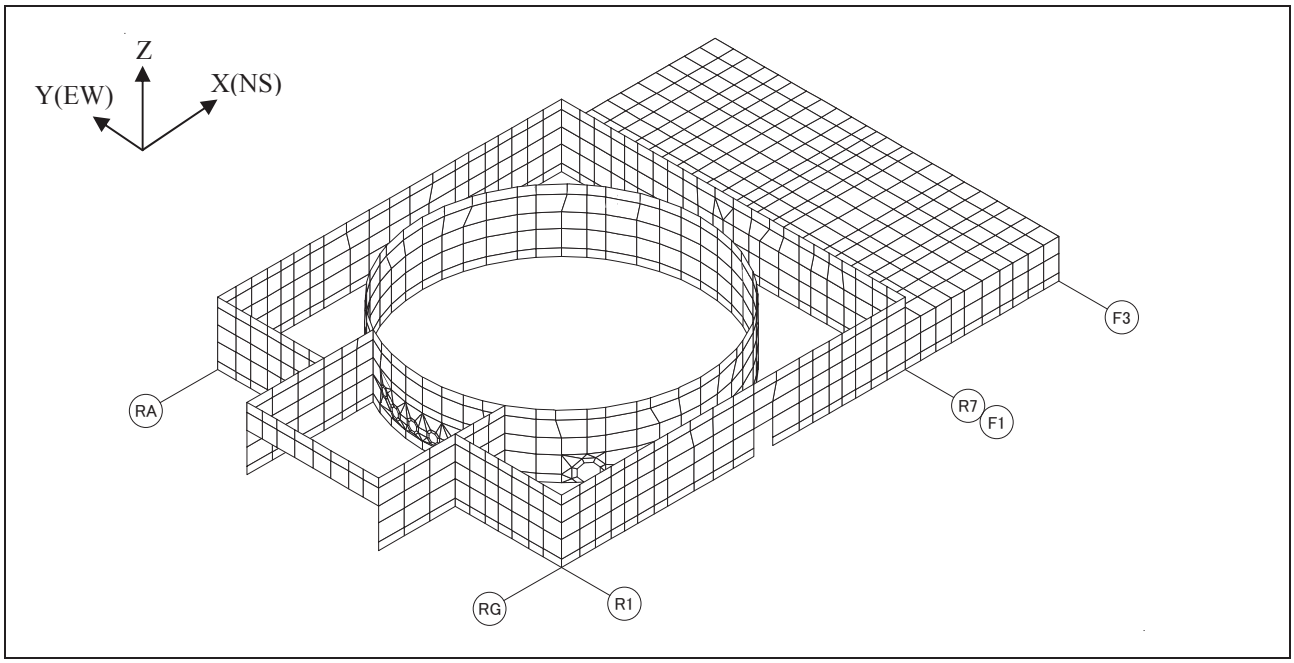


Figure 3.3.1.1-7 FE Model for RB/FB Slab Eigenvalue Analysis EL 22.50m

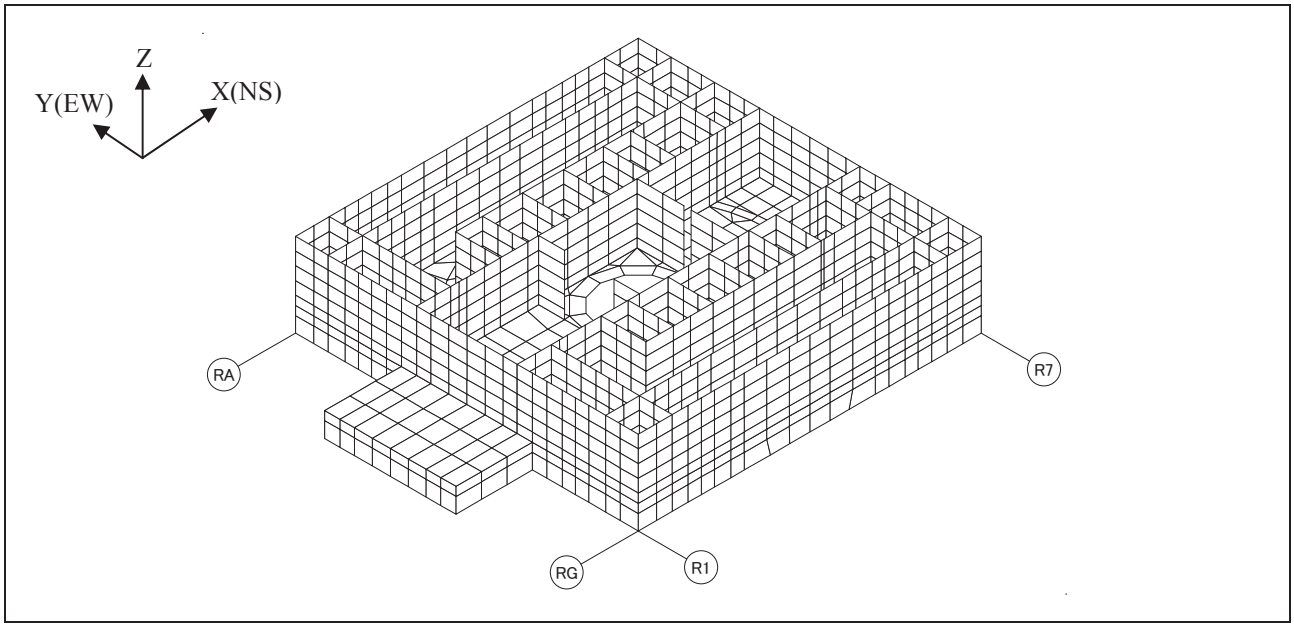


Figure 3.3.1.1-8 FE Model for RB/FB Slab Eigenvalue Analysis EL 27.00m

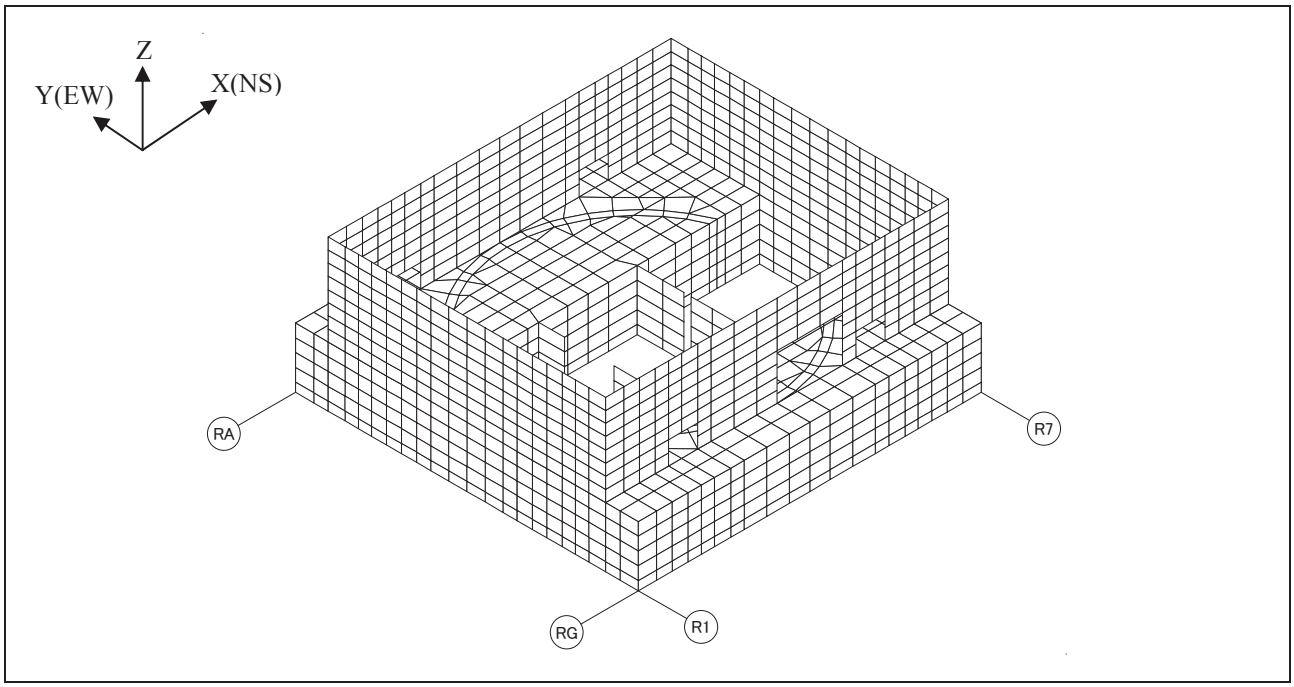


Figure 3.3.1.1-9 FE Model for RB/FB Slab Eigenvalue Analysis EL 34.00m

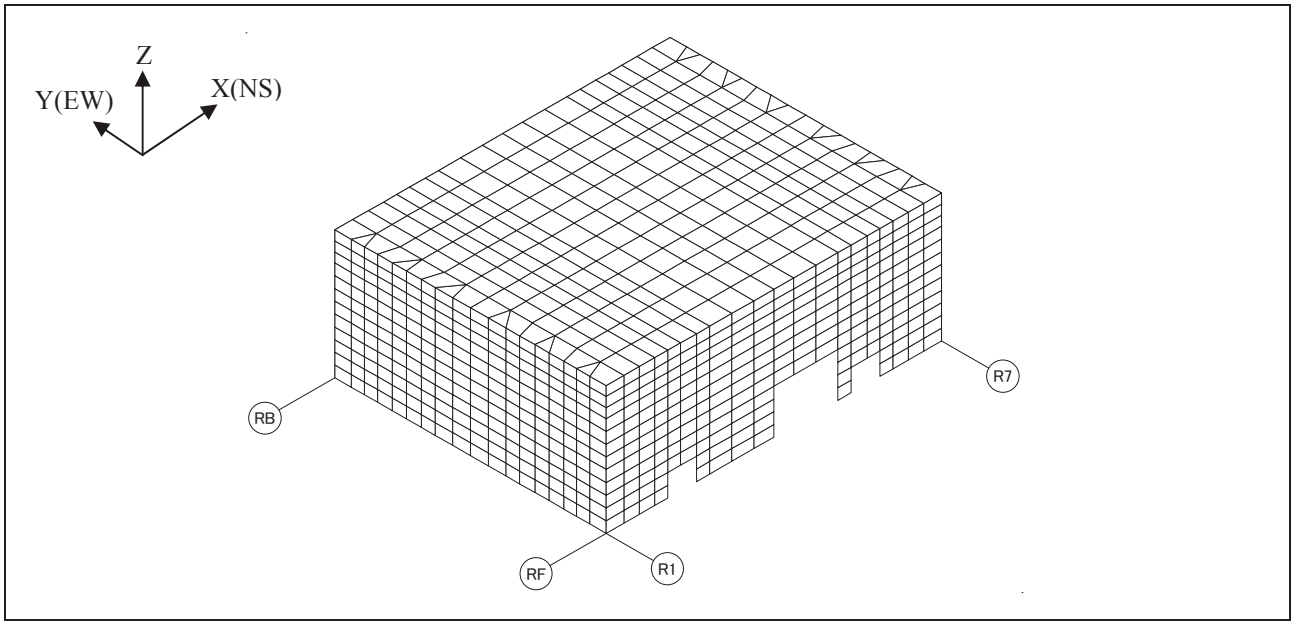


Figure 3.3.1.1-10 FE Model for RB/FB RB/FB Slab Eigenvalue Analysis EL 52.40m

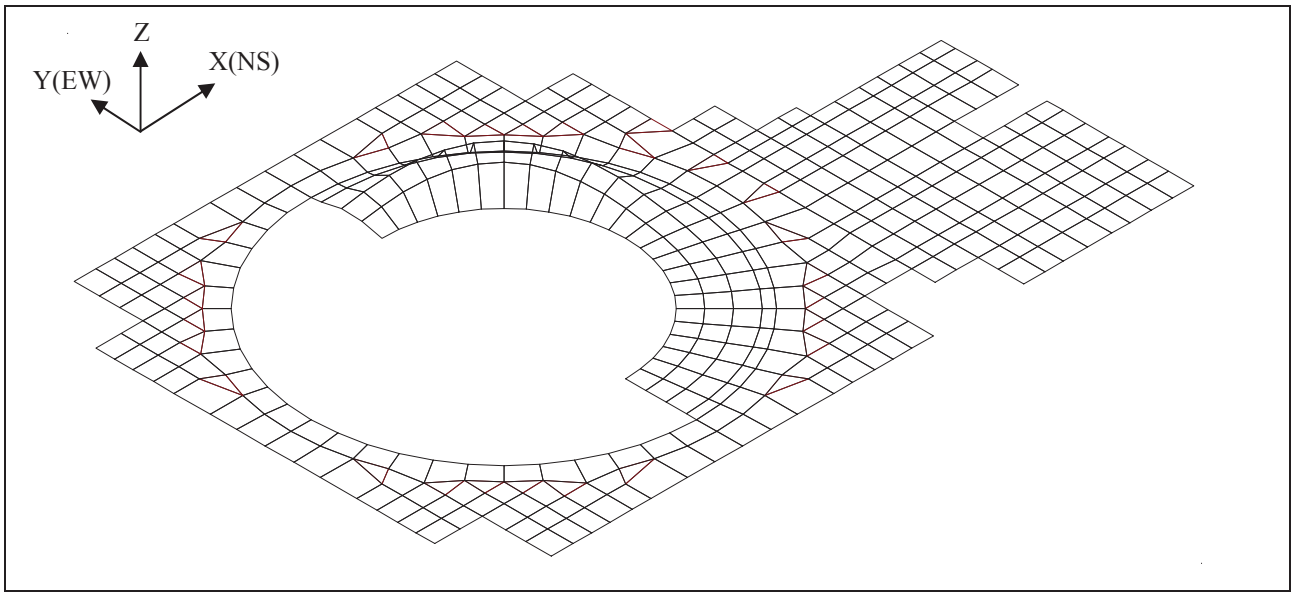


Figure 3.3.1.1-11a RB/FB Slab Eigenvalue Analysis Result EL -6.40m 1st Mode 22.28Hz

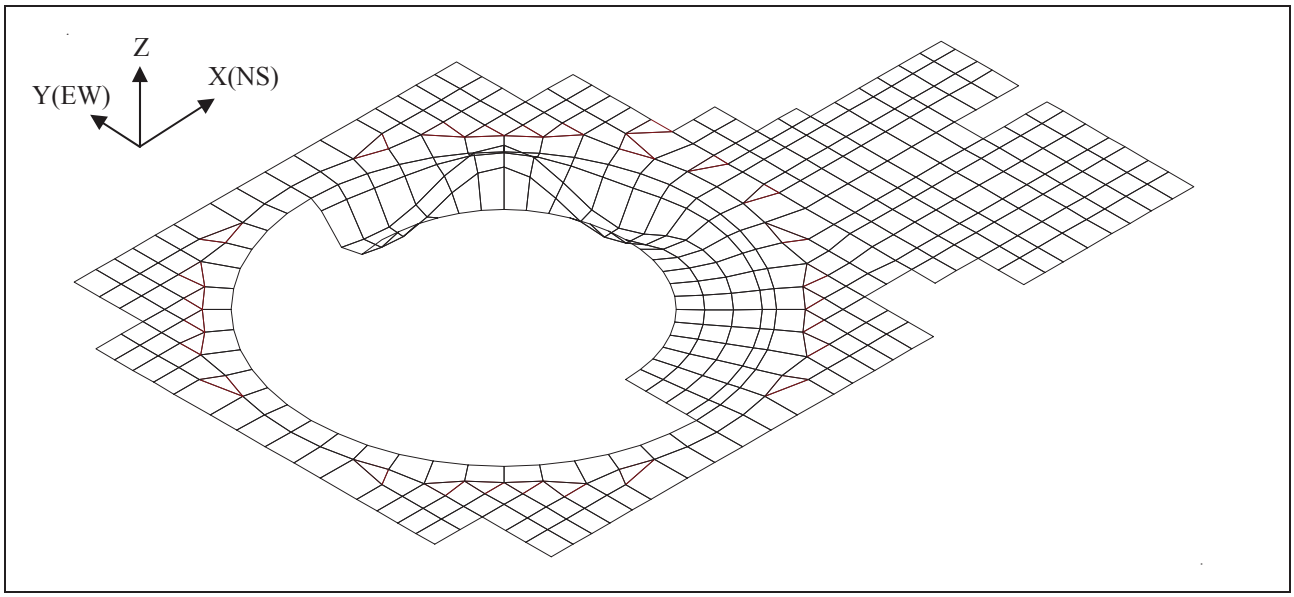


Figure 3.3.1.1-11b RB/FB Slab Eigenvalue Analysis Result EL -6.40m 3rd Mode 25.15Hz

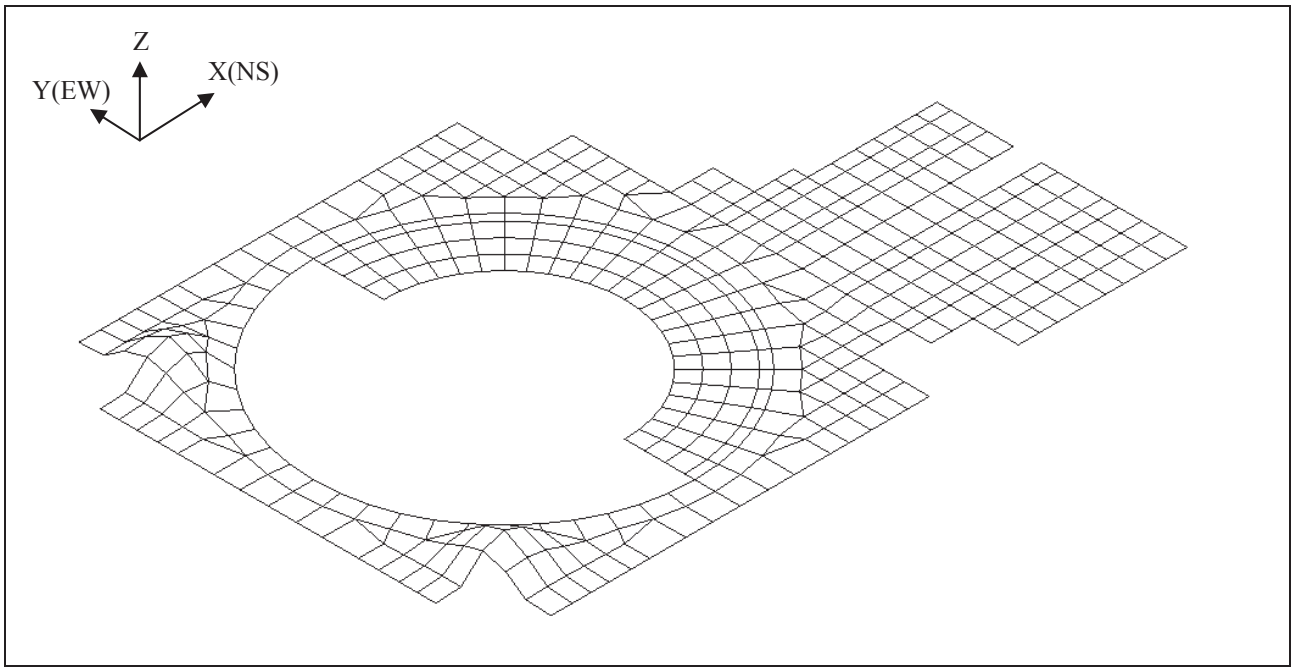


Figure 3.3.1.1-11c RB/FB Slab Eigenvalue Analysis Result EL -6.40m 11th Mode 34.65Hz

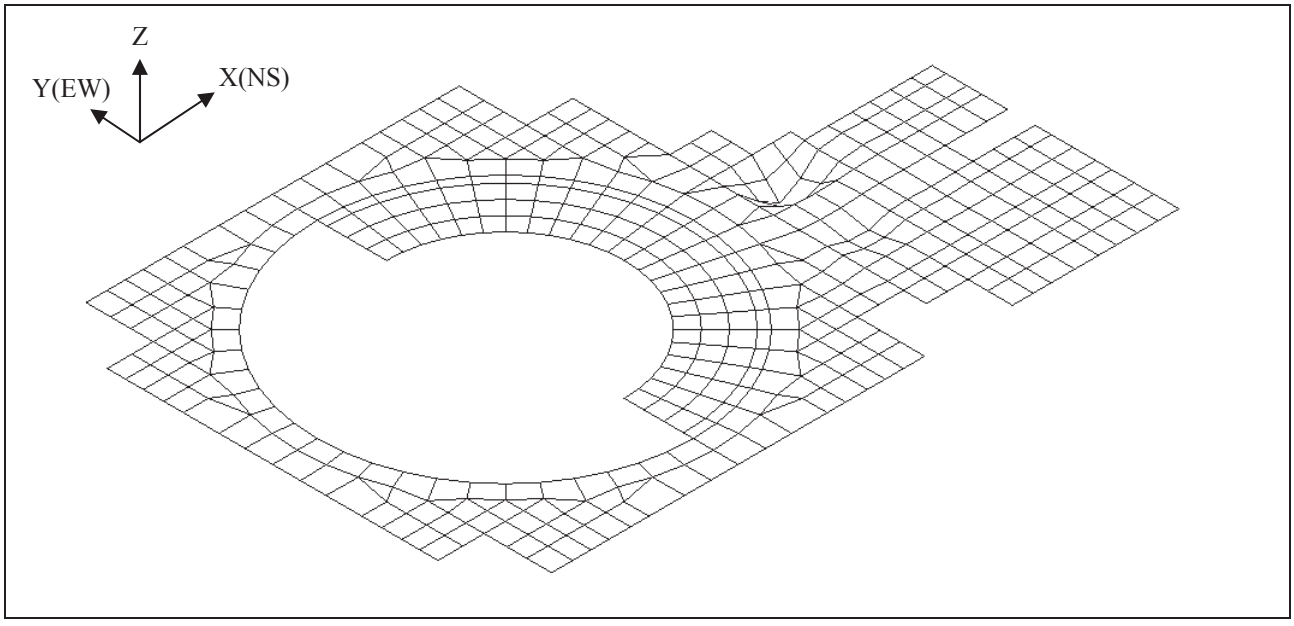


Figure 3.3.1.1-11d RB/FB Slab Eigenvalue Analysis Result EL -6.40m 23rd Mode 54.28Hz

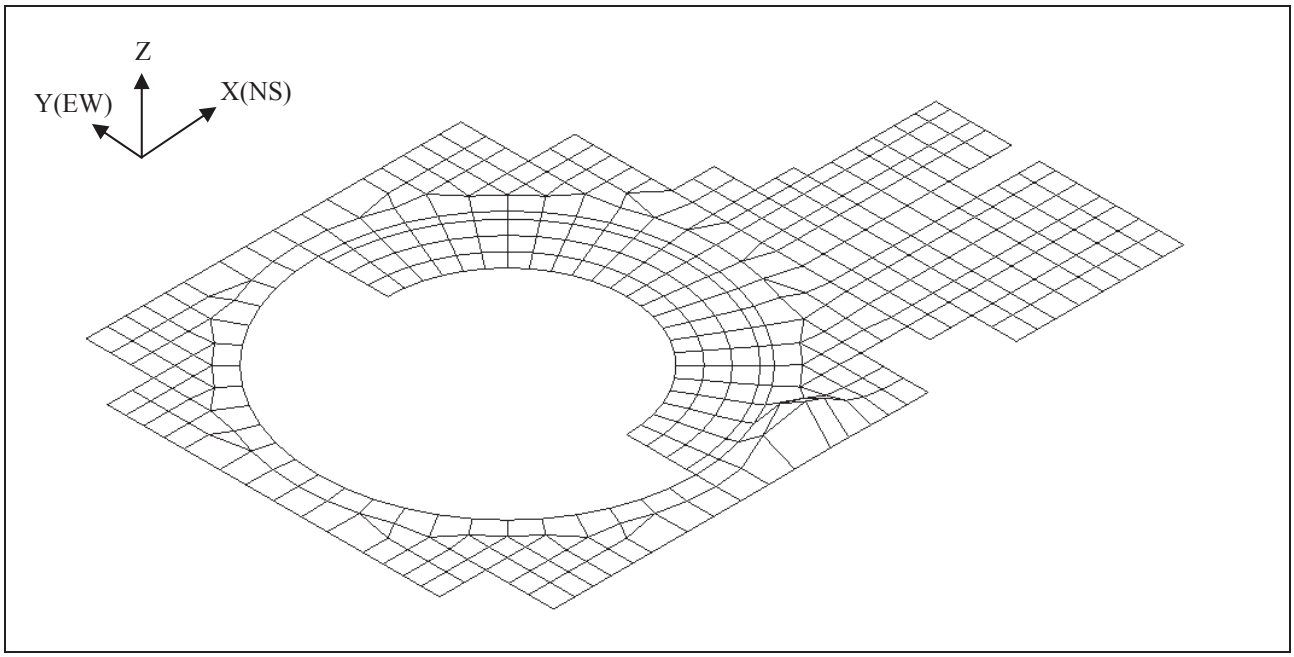


Figure 3.3.1.1-11e RB/FB Slab Eigenvalue Analysis Result EL -6.40m 35th Mode 61.09Hz

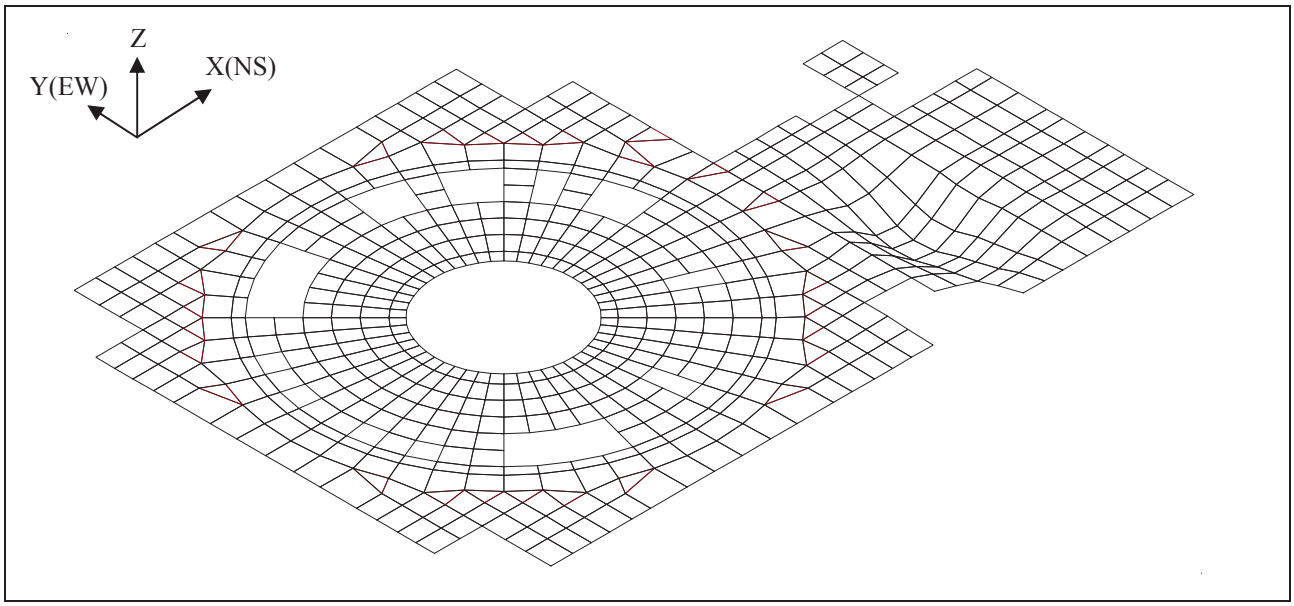


Figure 3.3.1.1-12a RB/FB Slab Eigenvalue Analysis Result EL -1.00m 1st Mode 20.34Hz

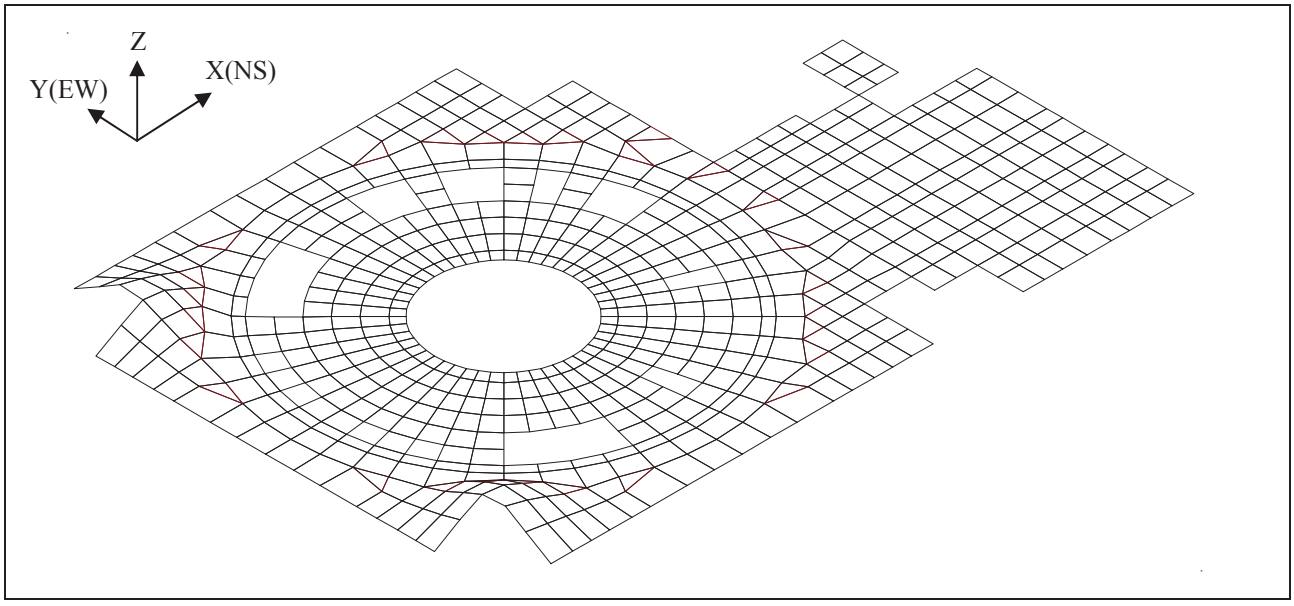


Figure 3.3.1.1-12b RB/FB Slab Eigenvalue Analysis Result EL -1.00m 3rd Mode 22.83Hz

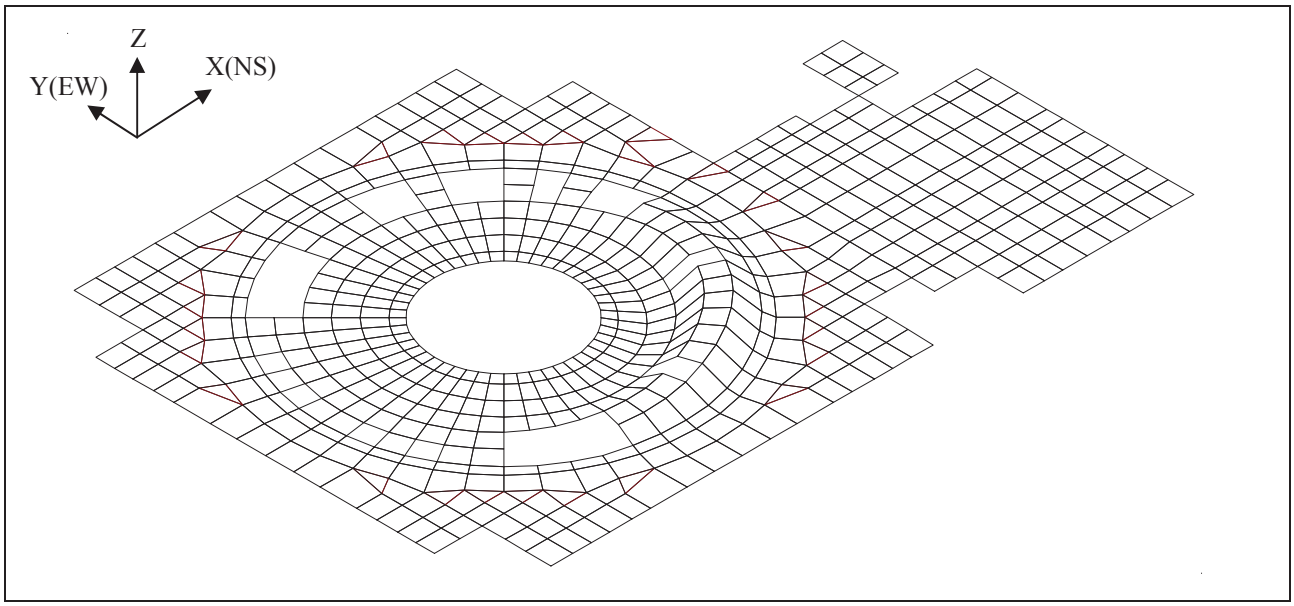


Figure 3.3.1.1-12c RB/FB Slab Eigenvalue Analysis Result EL -1.00m 7th Mode 27.31Hz

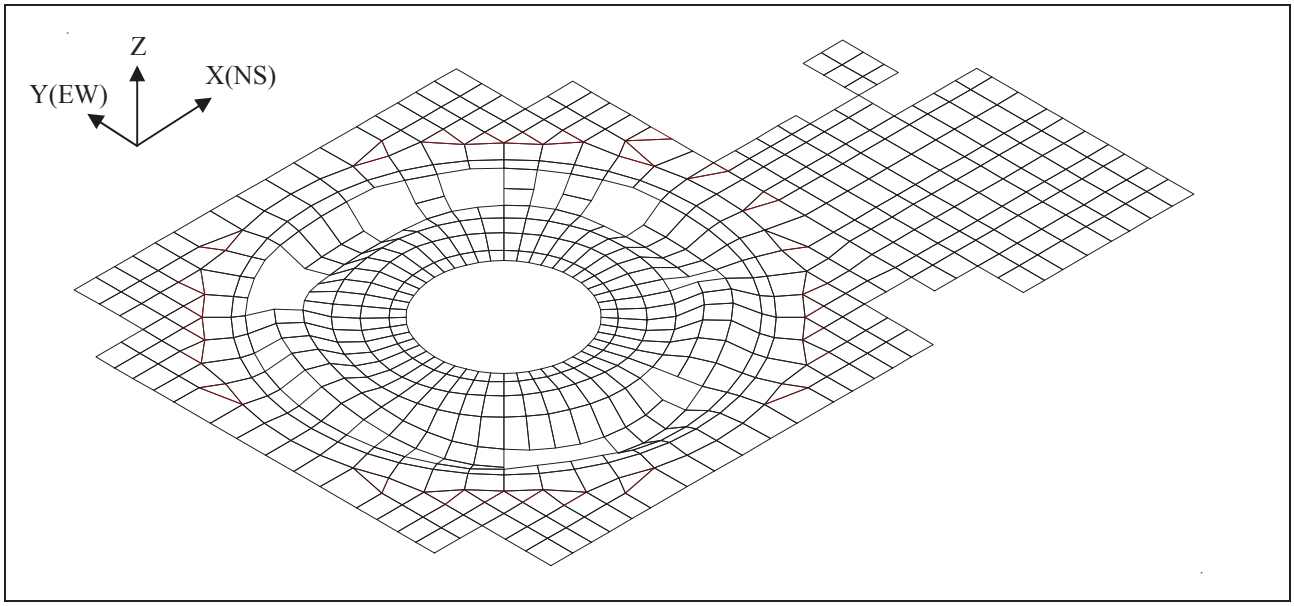


Figure 3.3.1.1-12d RB/FB Slab Eigenvalue Analysis Result EL -1.00m 11th Mode 28.43Hz

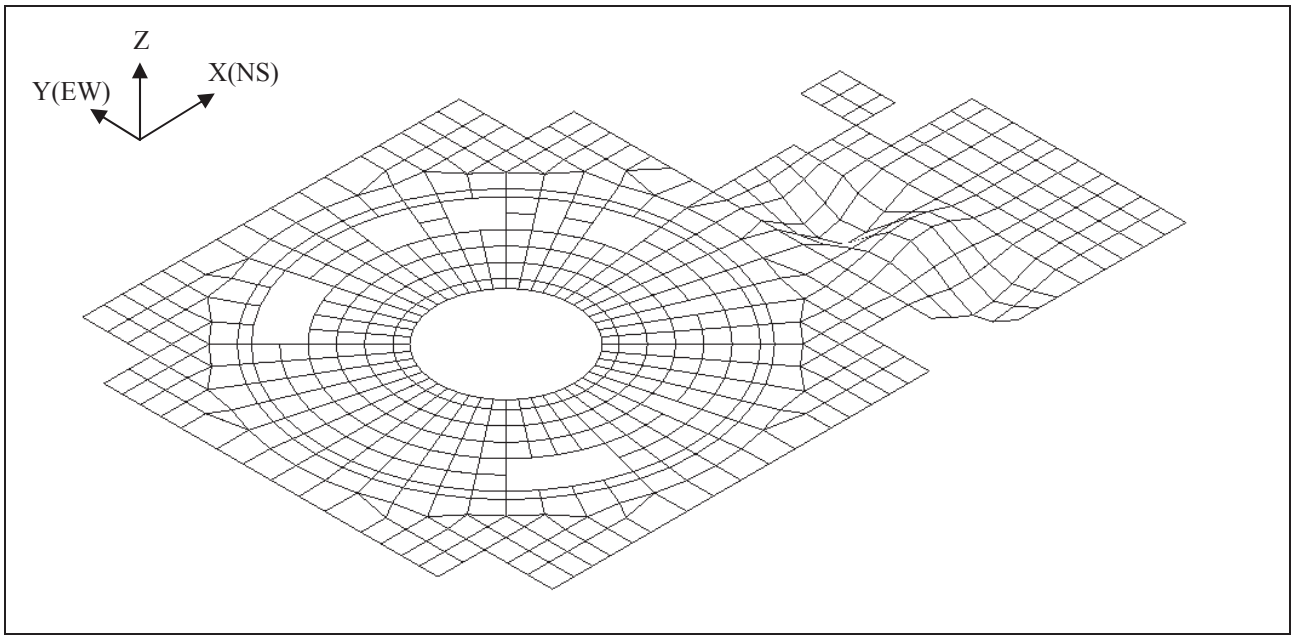


Figure 3.3.1.1-12e RB/FB Slab Eigenvalue Analysis Result EL -1.00m 13th Mode 29.40Hz

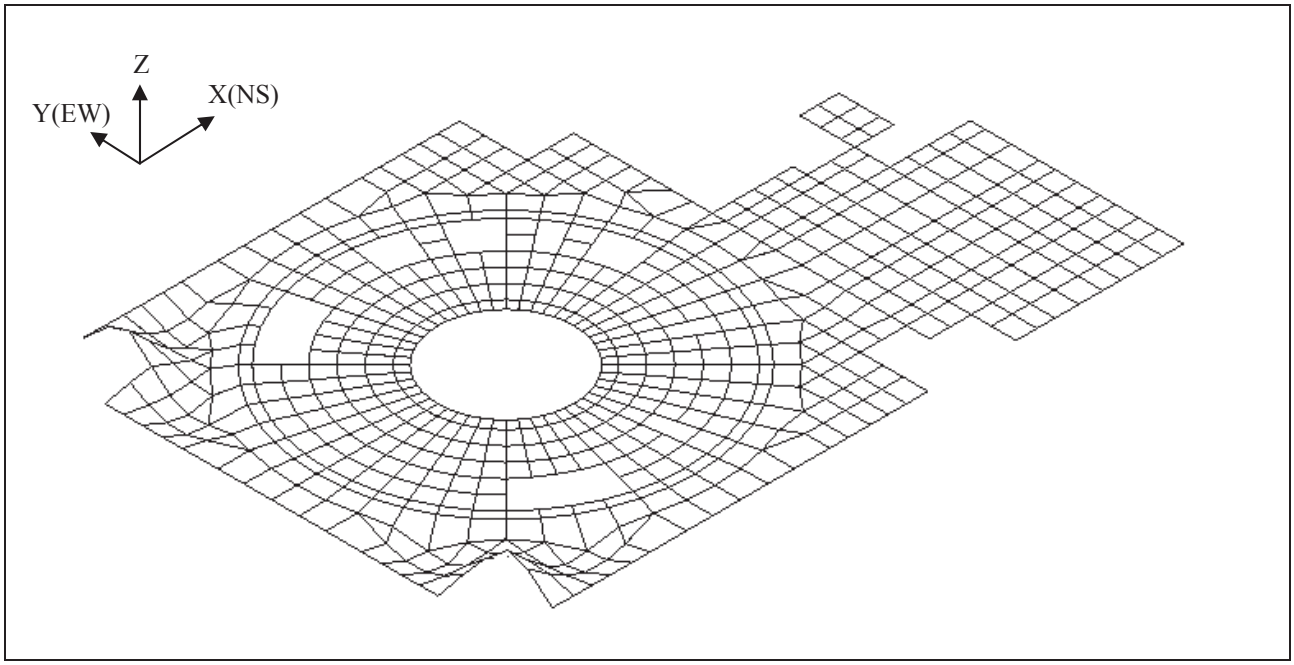


Figure 3.3.1.1-12f RB/FB Slab Eigenvalue Analysis Result EL -1.00m 35th Mode 42.31Hz

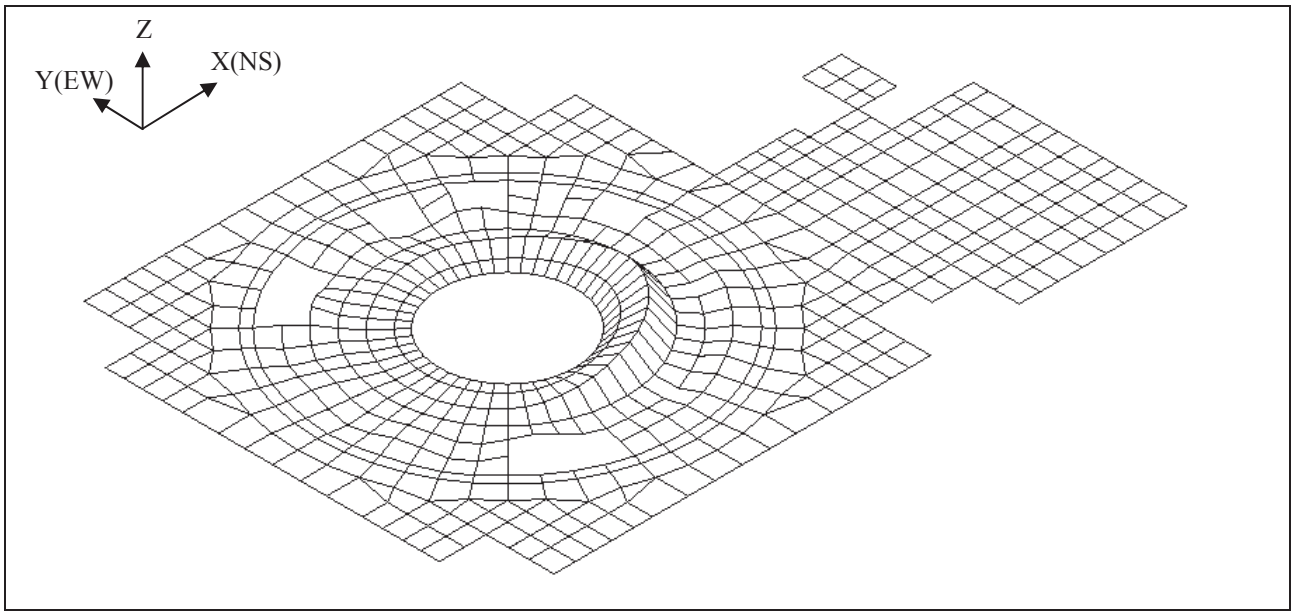


Figure 3.3.1.1-12g RB/FB Slab Eigenvalue Analysis Result EL -1.00m 40th Mode 46.12Hz

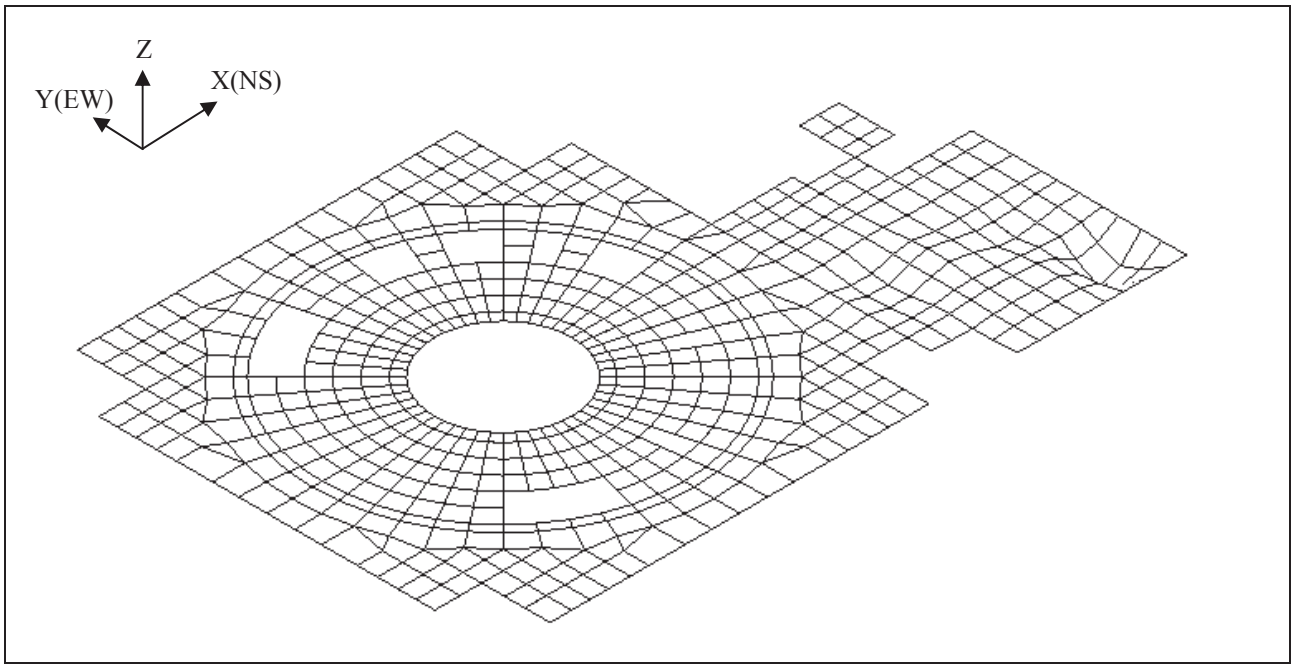


Figure 3.3.1.1-12h RB/FB Slab Eigenvalue Analysis Result EL -1.00m 46th Mode 47.26Hz

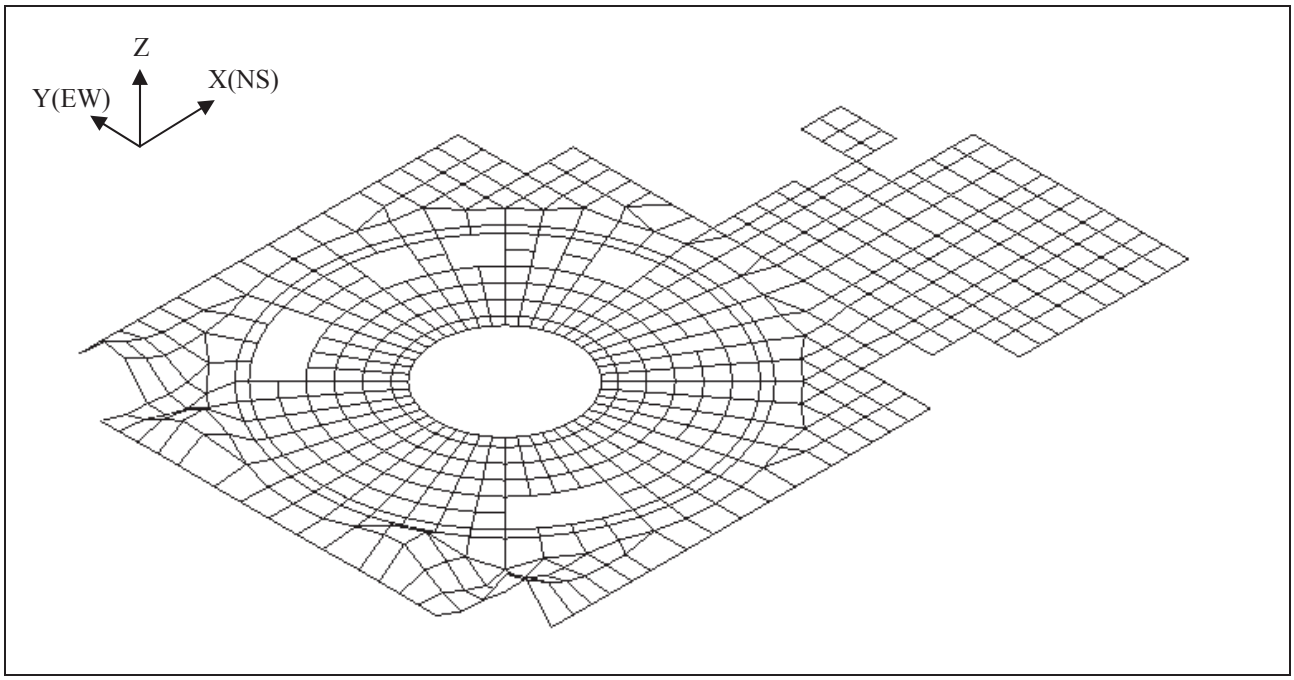


Figure 3.3.1.1-12i RB/FB Slab Eigenvalue Analysis Result EL -1.00m 58th Mode 53.10Hz

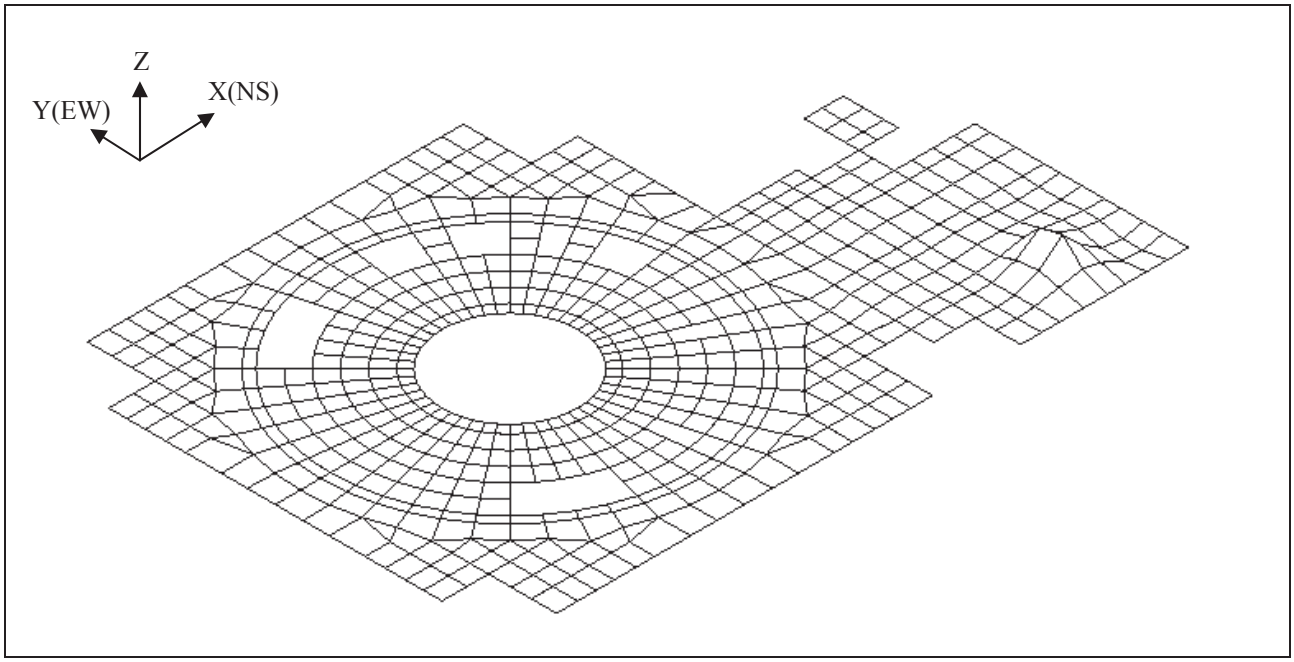


Figure 3.3.1.1-12j RB/FB Slab Eigenvalue Analysis Result EL -1.00m 80th Mode 64.29Hz

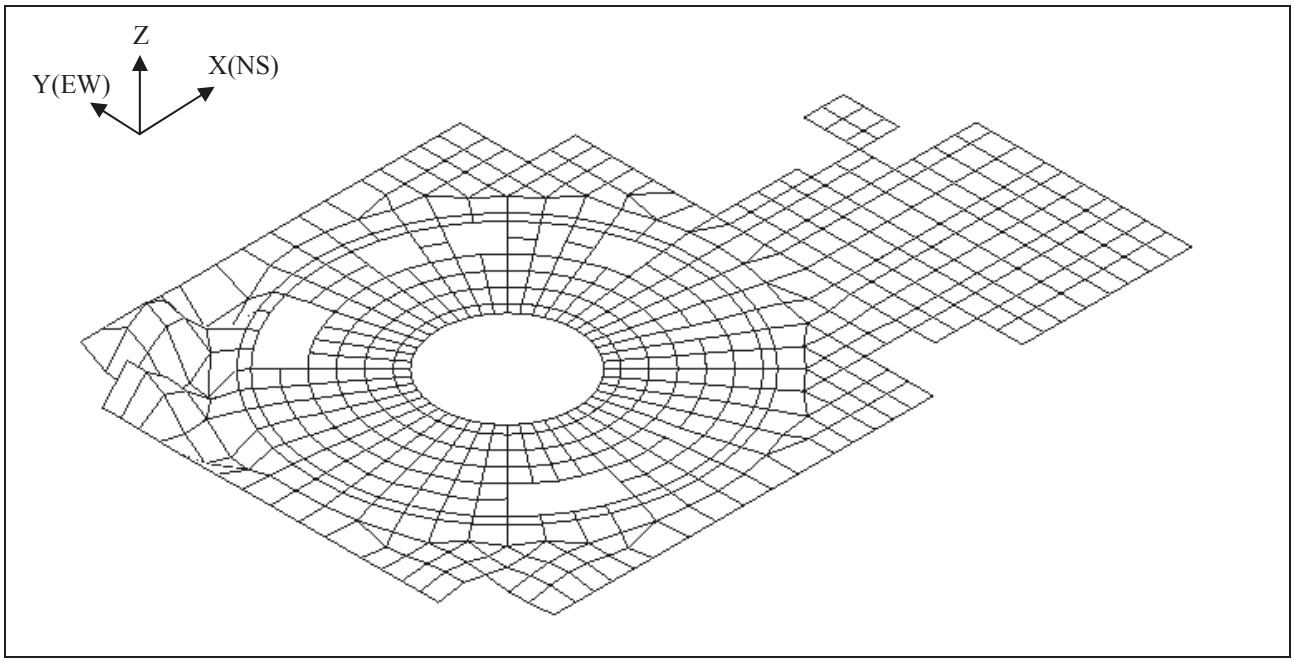


Figure 3.3.1.1-12k RB/FB Slab Eigenvalue Analysis Result EL -1.00m 82nd Mode 64.52Hz

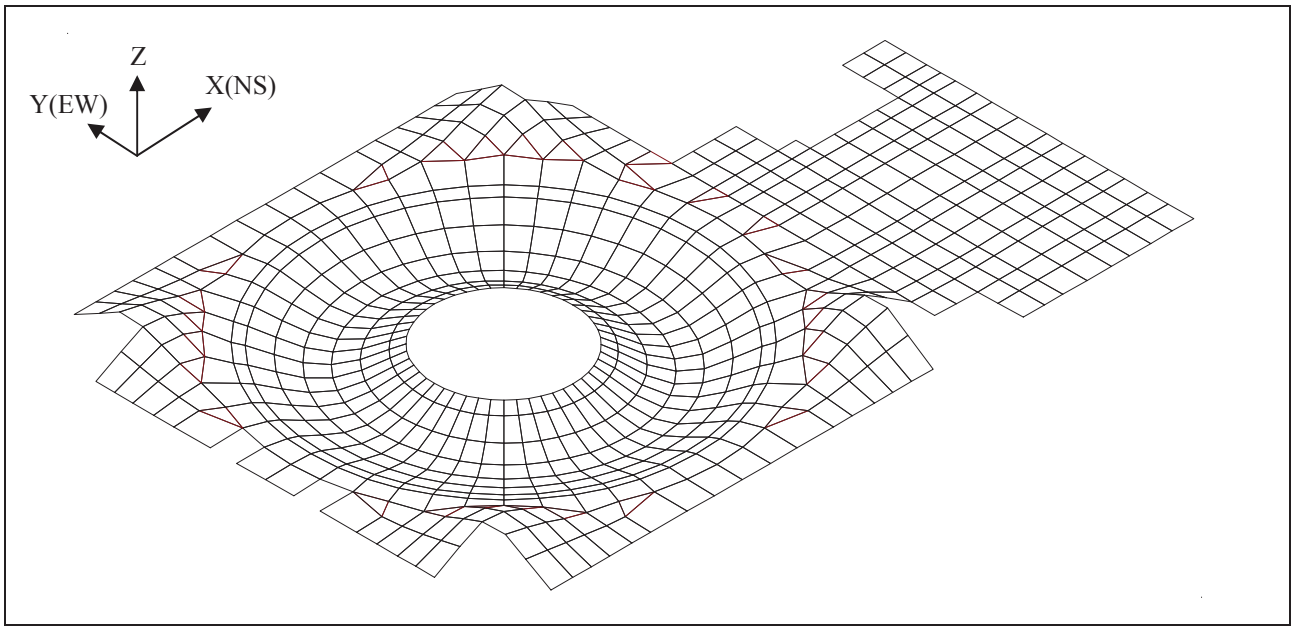


Figure 3.3.1.1-13a RB/FB Slab Eigenvalue Analysis Result EL 4.65m 1st Mode 22.15Hz

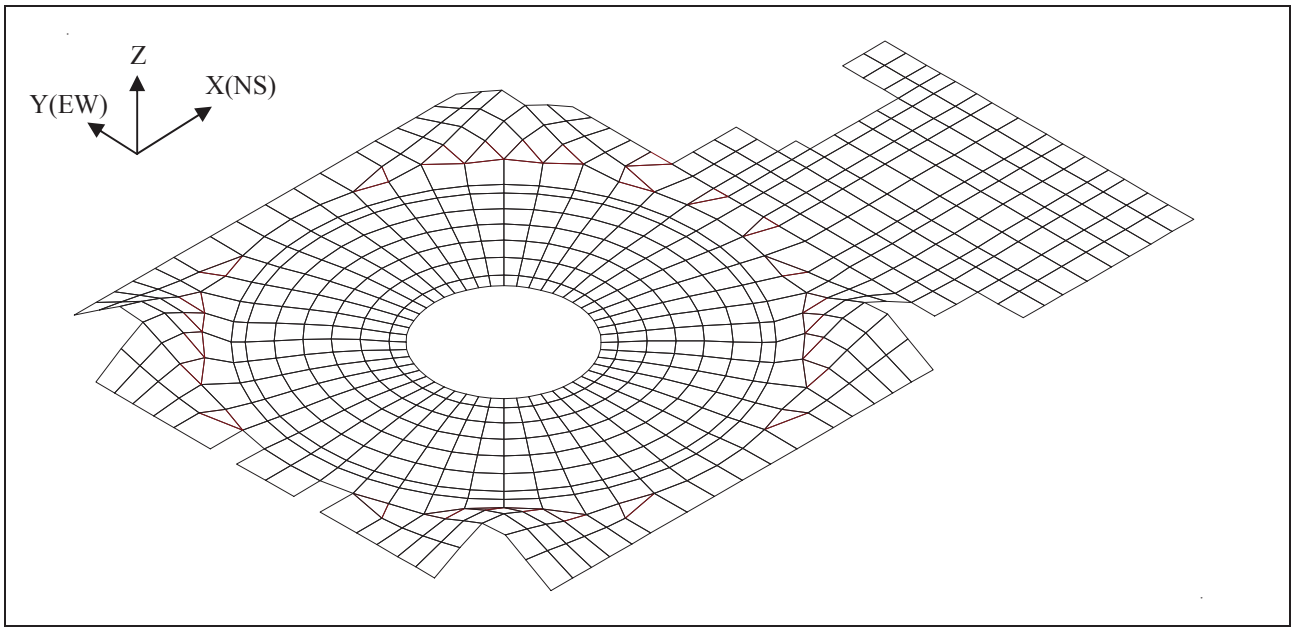


Figure 3.3.1.1-13b RB/FB Slab Eigenvalue Analysis Result EL 4.65m 5th Mode 23.13Hz

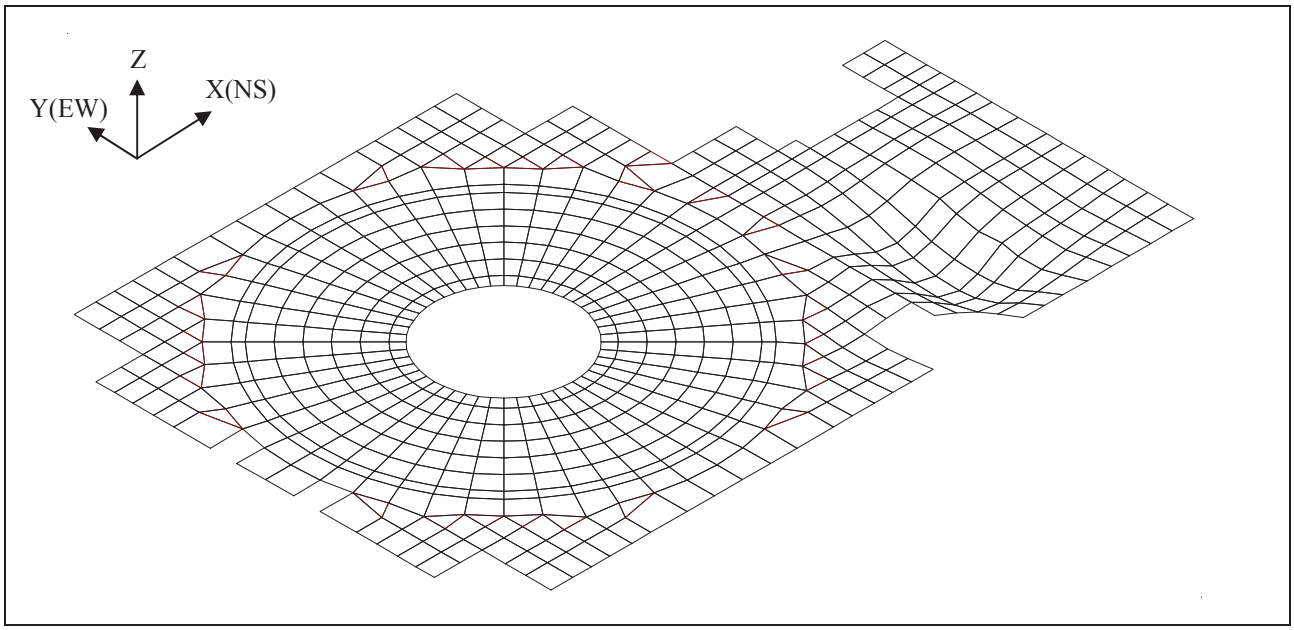


Figure 3.3.1.1-13c RB/FB Slab Eigenvalue Analysis Result EL 4.65m 10th Mode 25.70Hz

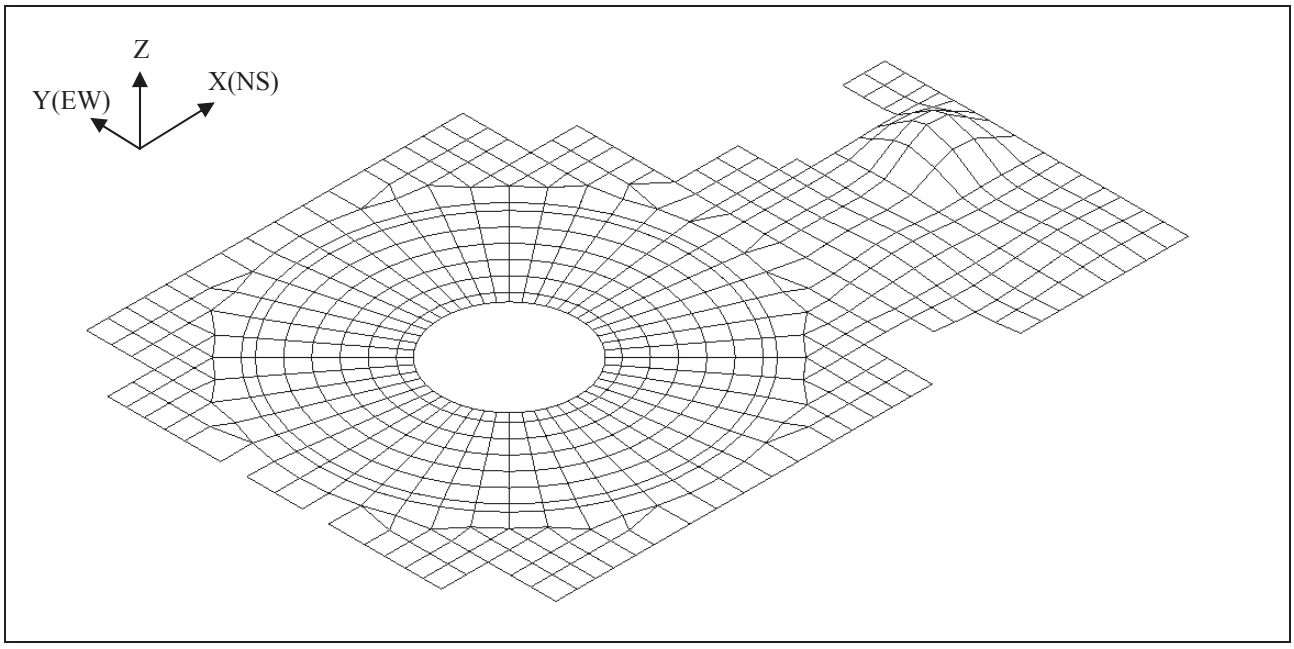


Figure 3.3.1.1-13d RB/FB Slab Eigenvalue Analysis Result EL 4.65m 15th Mode 38.38Hz

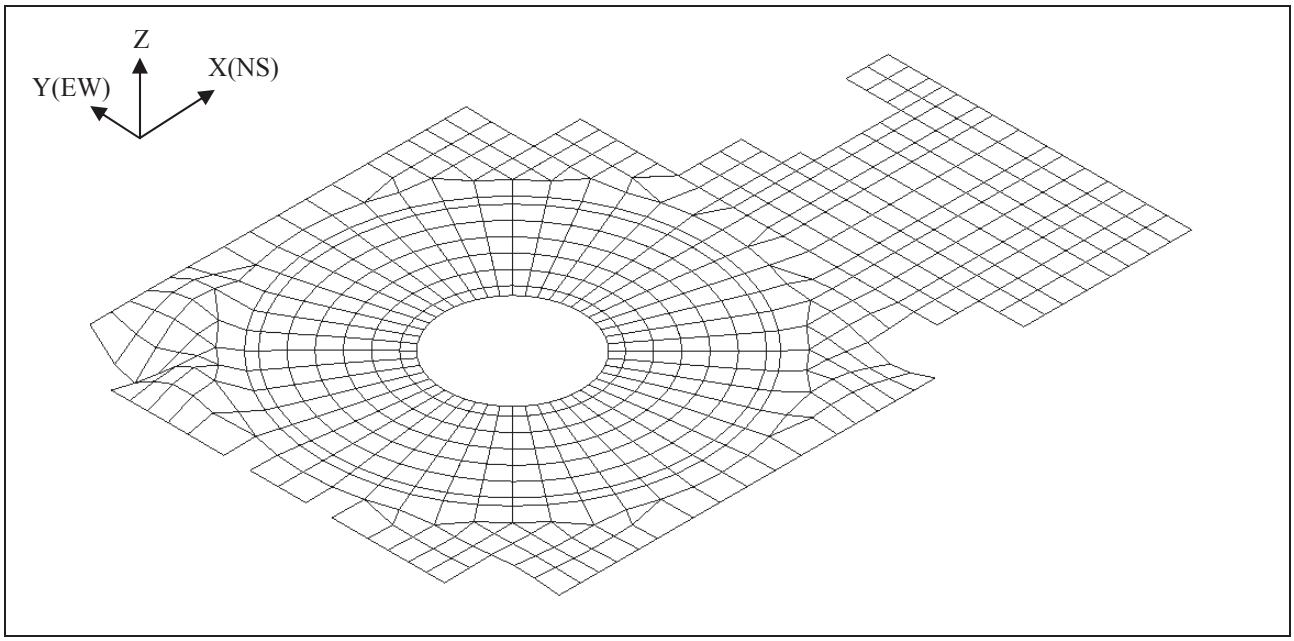


Figure 3.3.1.1-13e RB/FB Slab Eigenvalue Analysis Result EL 4.65m 20th Mode 42.66Hz

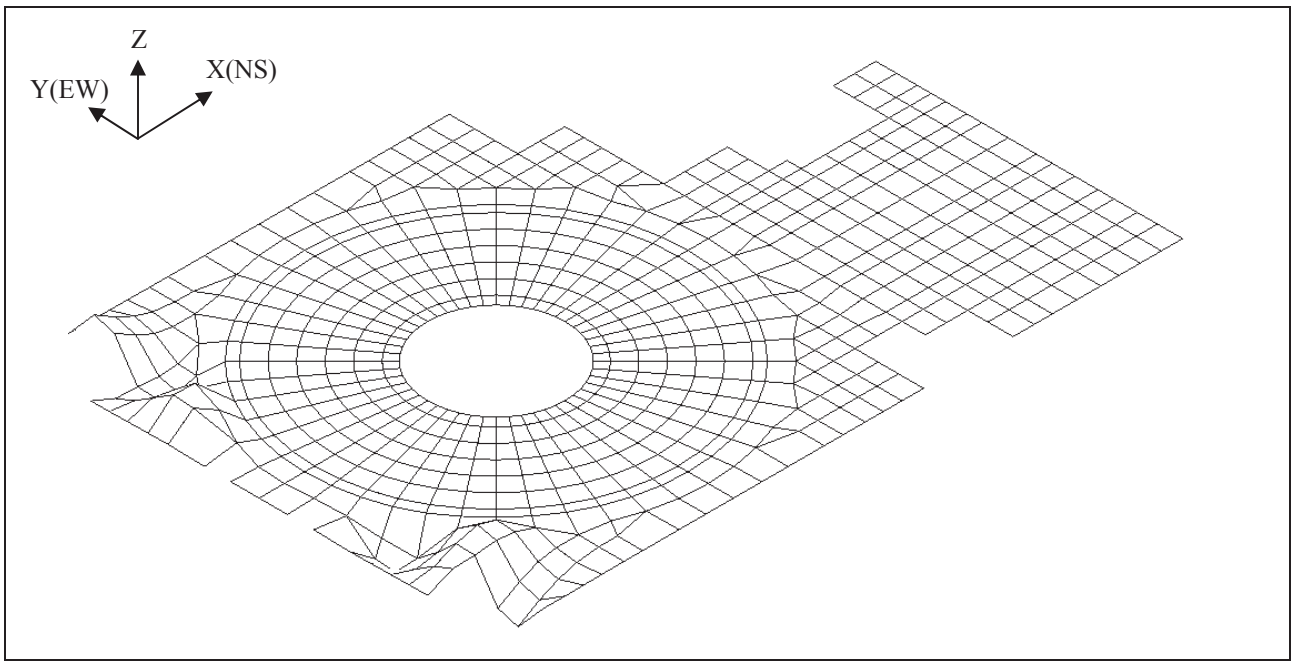


Figure 3.3.1.1-13f RB/FB Slab Eigenvalue Analysis Result EL 4.65m 28th Mode 53.32Hz

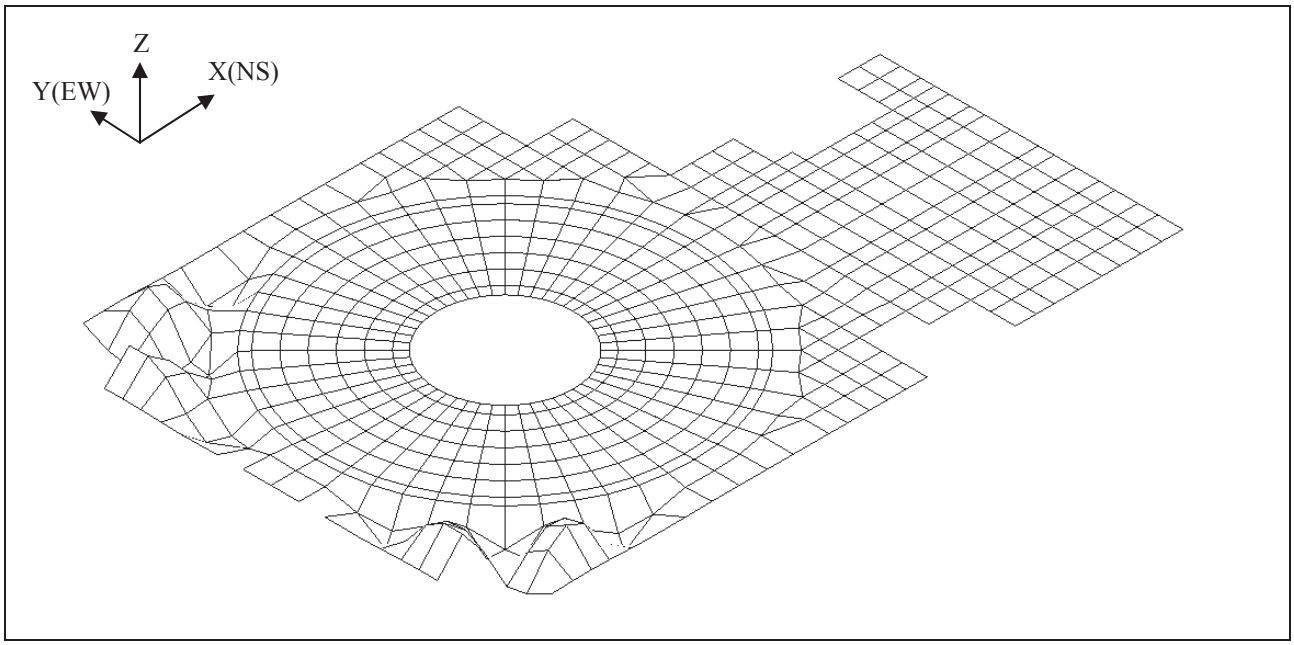


Figure 3.3.1.1-13g RB/FB Slab Eigenvalue Analysis Result EL 4.65m 48th Mode 64.98Hz

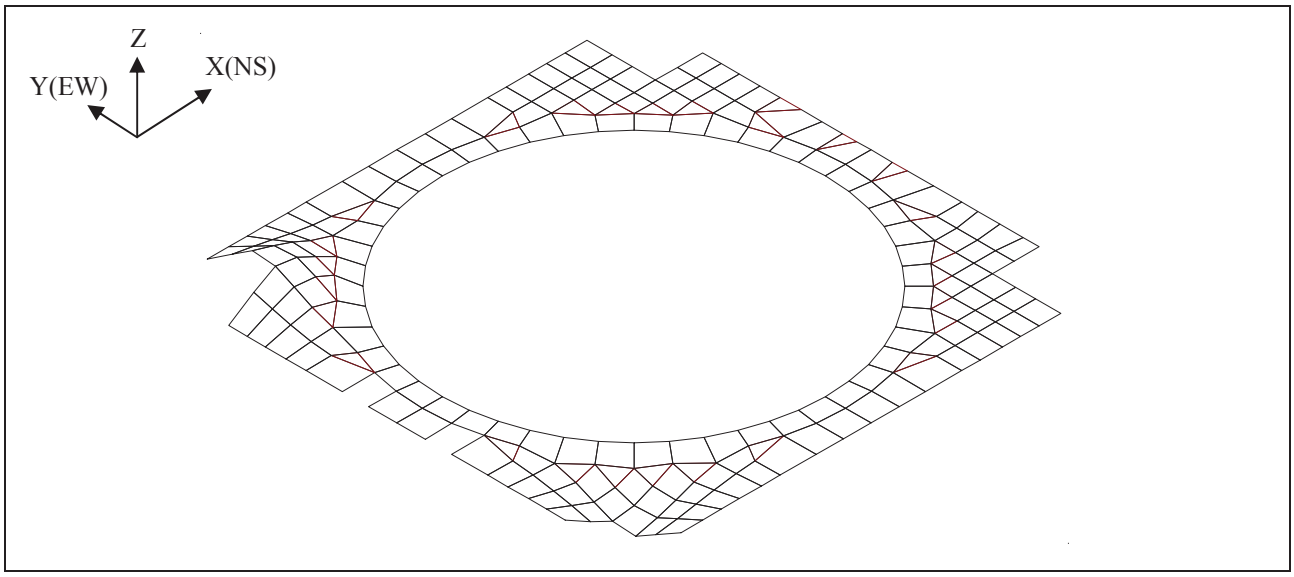


Figure 3.3.1.1-14a RB/FB Slab Eigenvalue Analysis Result EL 9.06m 1st Mode 22.41Hz

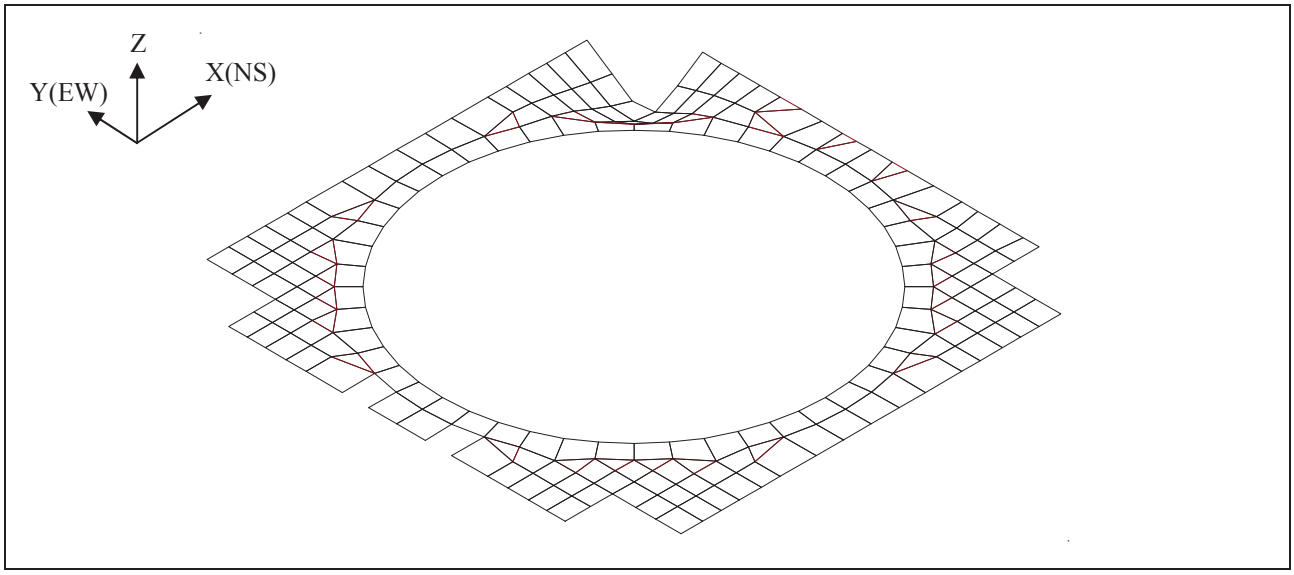


Figure 3.3.1.1-14b RB/FB Slab Eigenvalue Analysis Result EL 9.06m 3rd Mode 22.44Hz

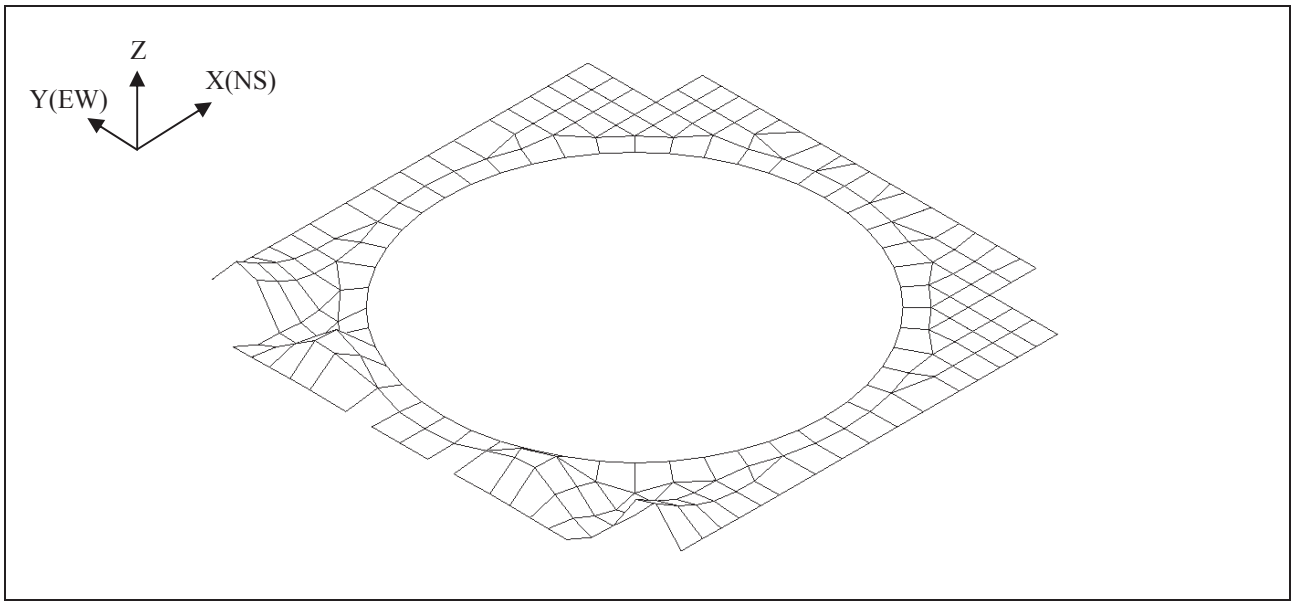


Figure 3.3.1.1-14c RB/FB Slab Eigenvalue Analysis Result EL 9.06m 15th Mode 52.13Hz

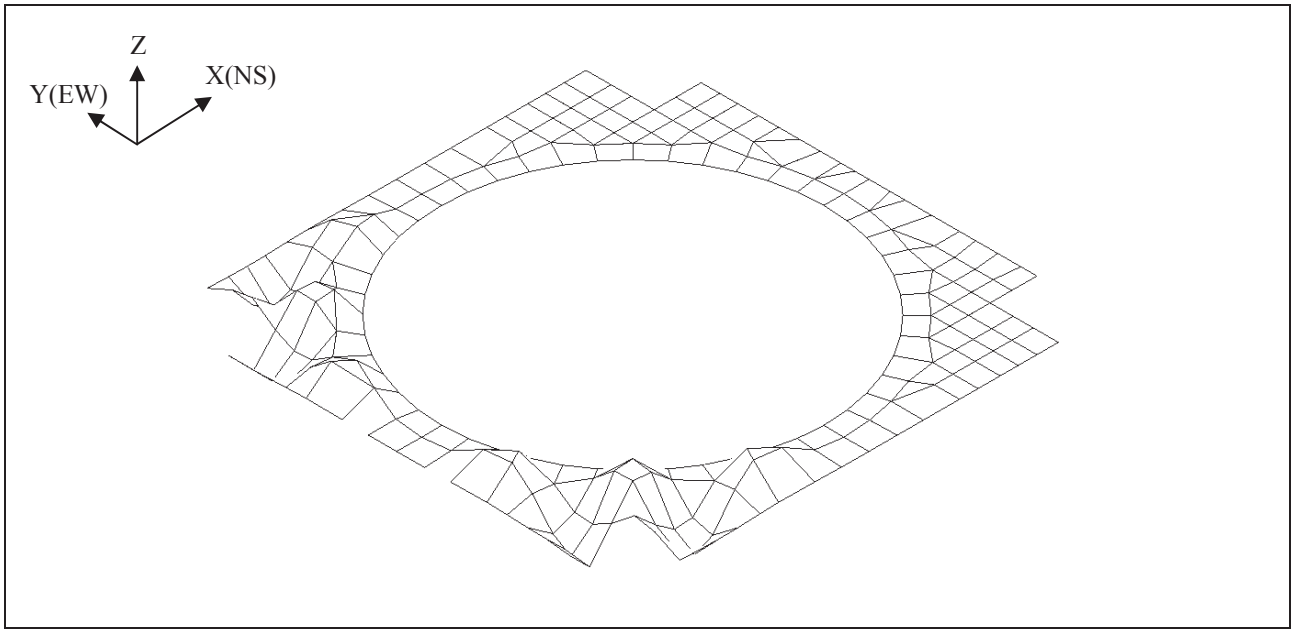


Figure 3.3.1.1-14d RB/FB Slab Eigenvalue Analysis Result EL 9.06m 23rd Mode 63.63Hz

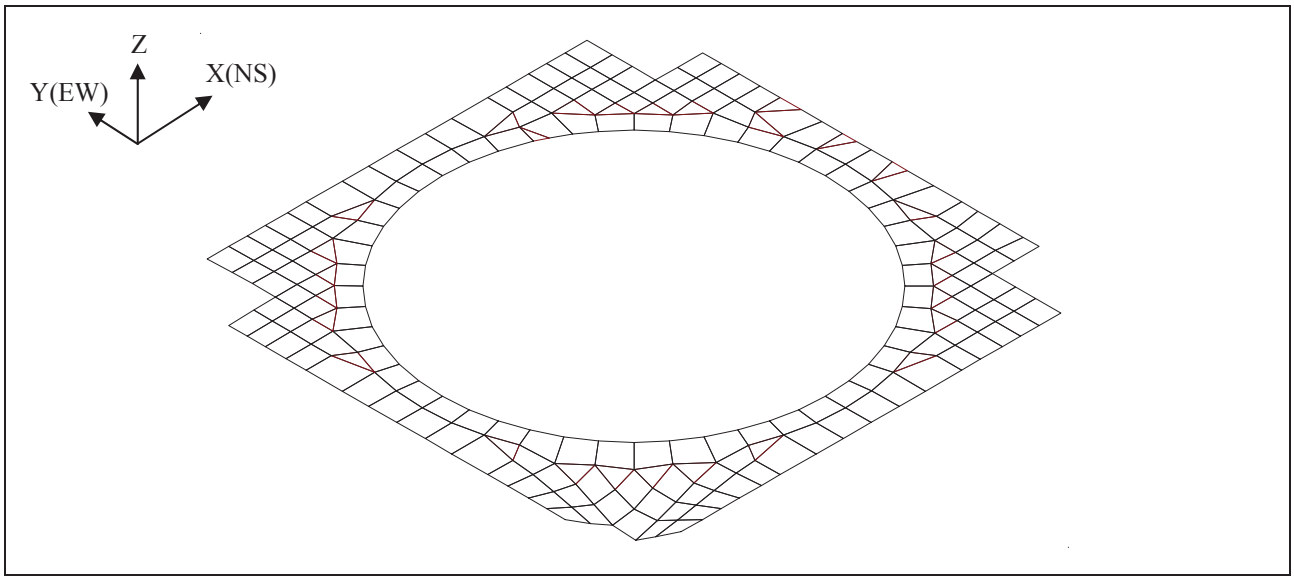


Figure 3.3.1.1-15a RB/FB Slab Eigenvalue Analysis Result EL 13.57m 1st Mode 23.55Hz

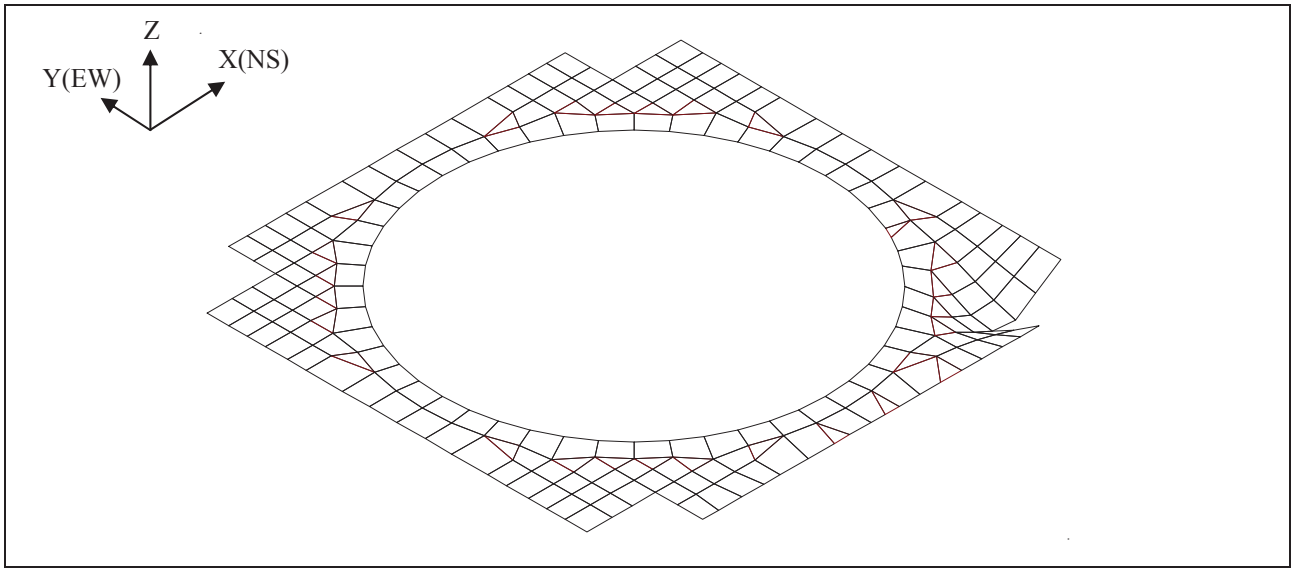


Figure 3.3.1.1-15b RB/FB Slab Eigenvalue Analysis Result EL 13.57m 3rd Mode 23.61Hz

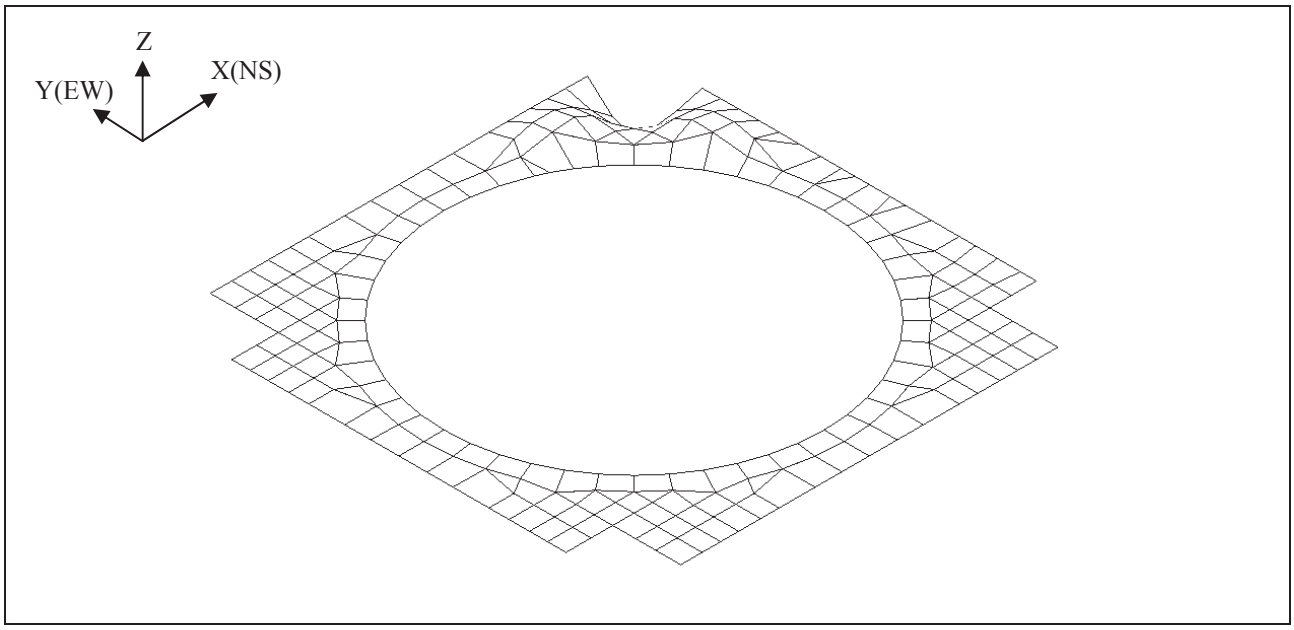


Figure 3.3.1.1-15c RB/FB Slab Eigenvalue Analysis Result EL 13.57m 12th Mode 43.97Hz

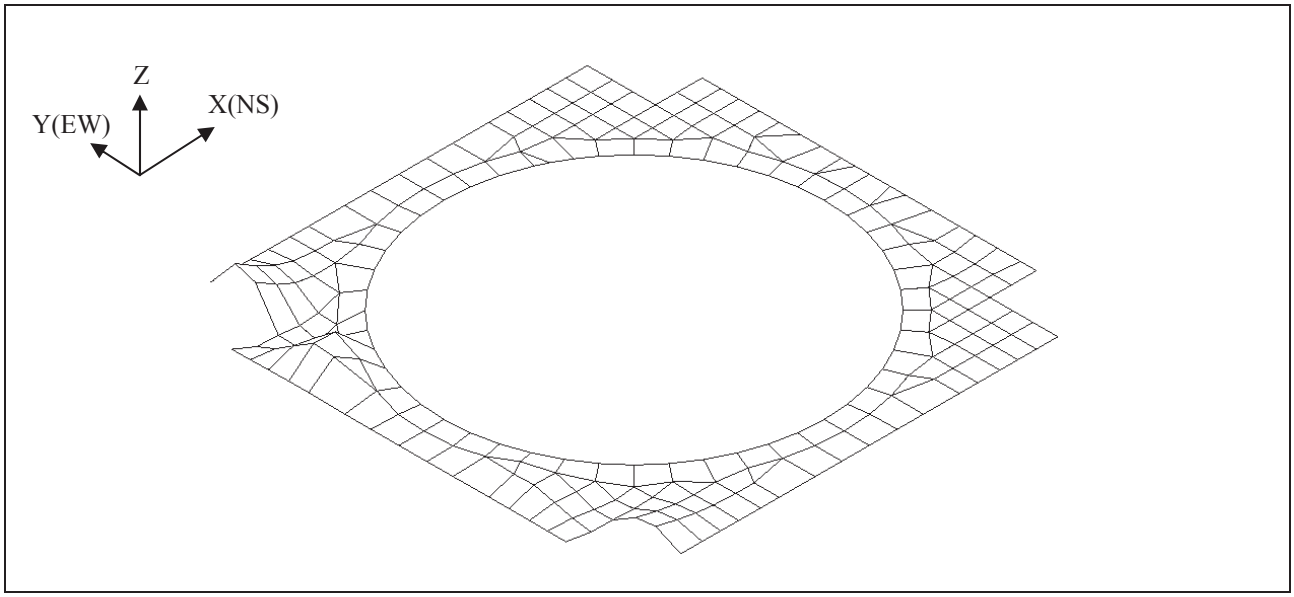


Figure 3.3.1.1-15d RB/FB Slab Eigenvalue Analysis Result EL 13.57m 15th Mode 54.89Hz

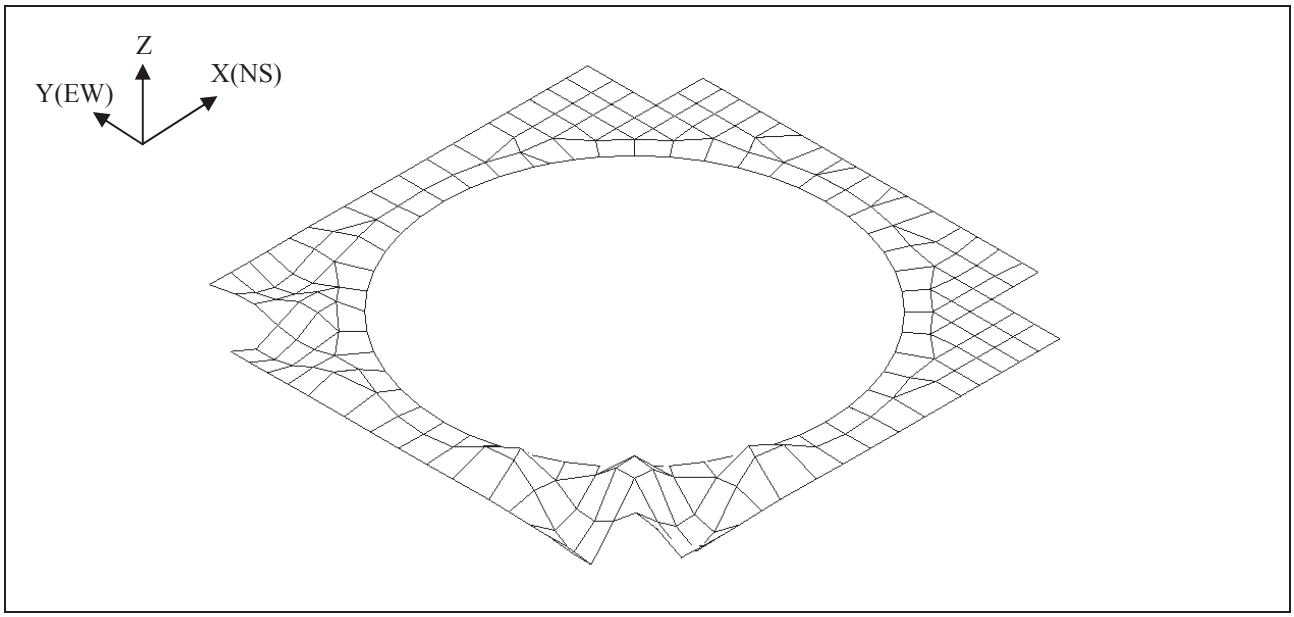


Figure 3.3.1.1-15e RB/FB Slab Eigenvalue Analysis Result EL 13.57m 22nd Mode 66.84Hz

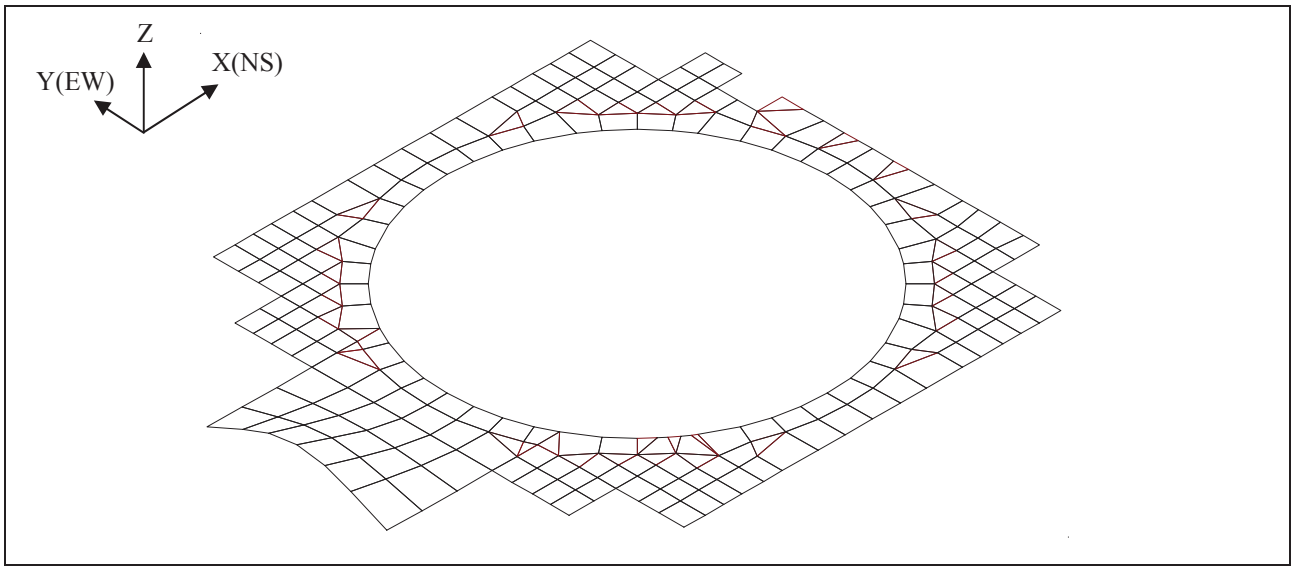


Figure 3.3.1.1-16a RB/FB Slab Eigenvalue Analysis Result EL 17.50m 1st Mode 12.05Hz

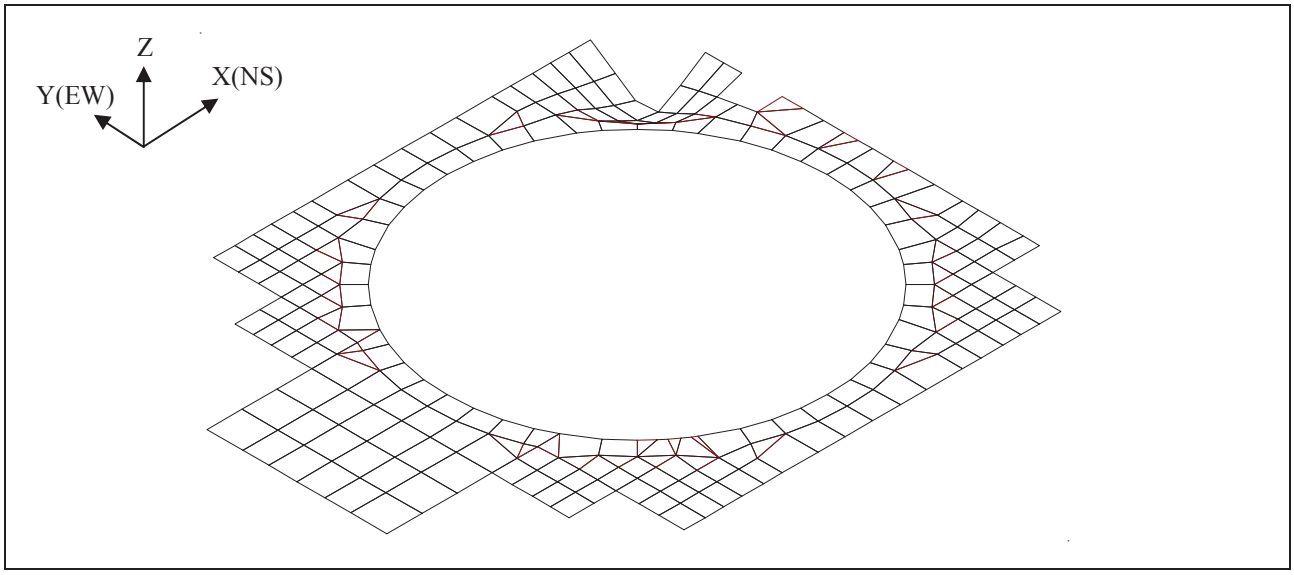


Figure 3.3.1.1-16b RB/FB Slab Eigenvalue Analysis Result EL 17.50m 2nd Mode 23.64Hz

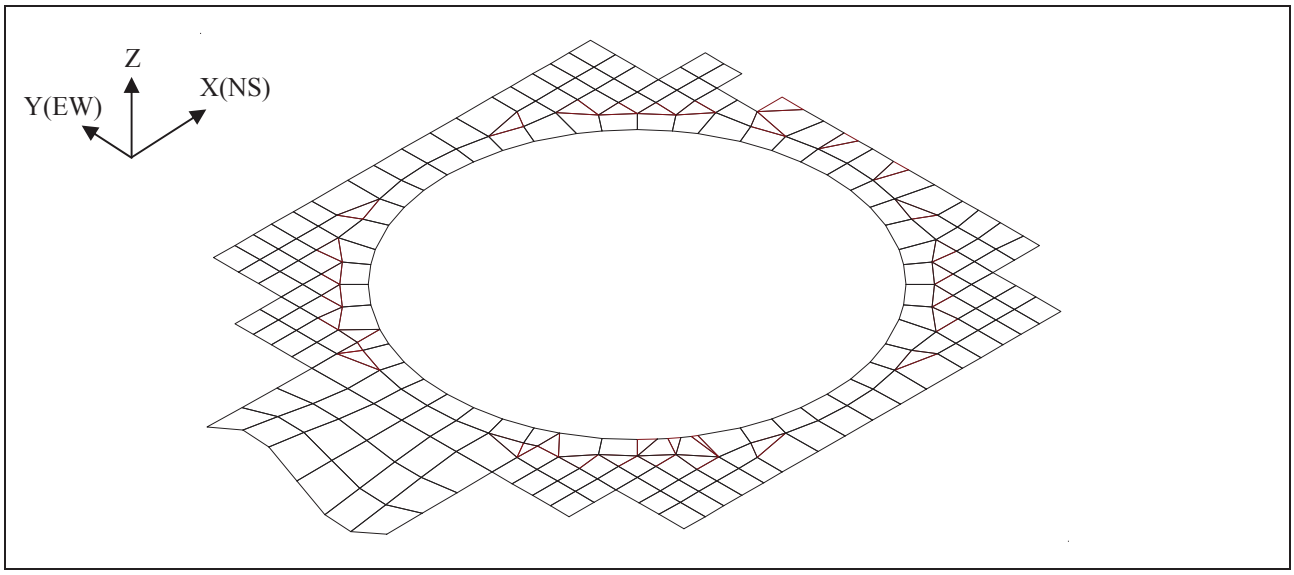


Figure 3.3.1.1-16c RB/FB Slab Eigenvalue Analysis Result EL 17.50m 6th Mode 27.90Hz

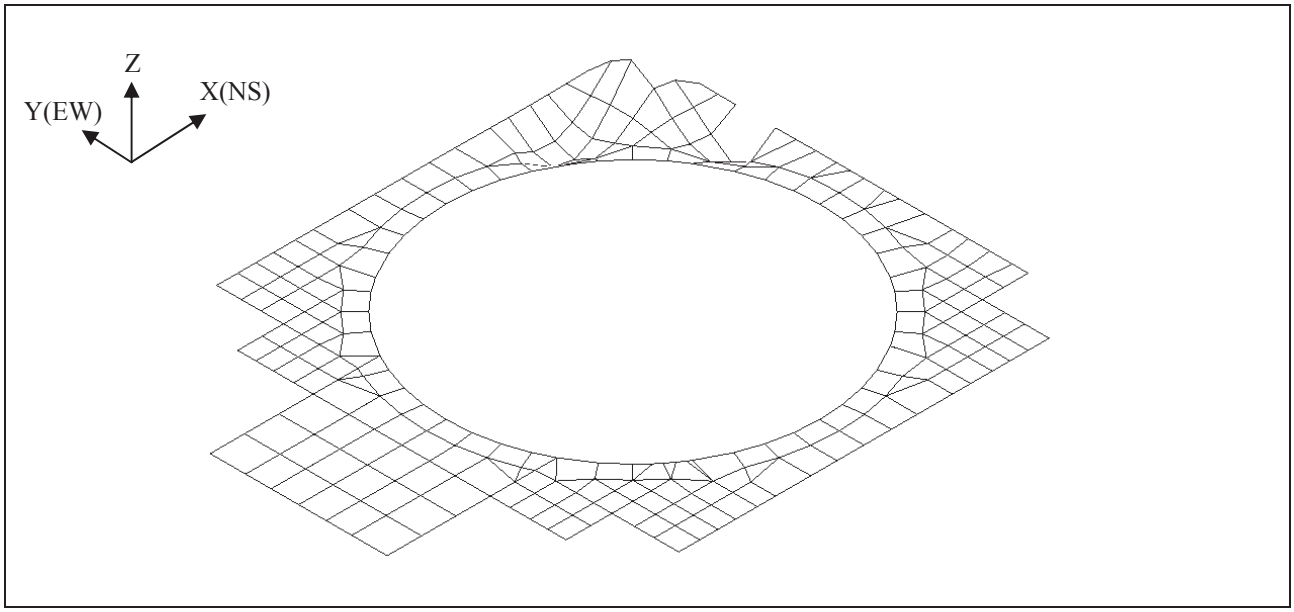


Figure 3.3.1.1-16d RB/FB Slab Eigenvalue Analysis Result EL 17.50m 12th Mode 42.39Hz

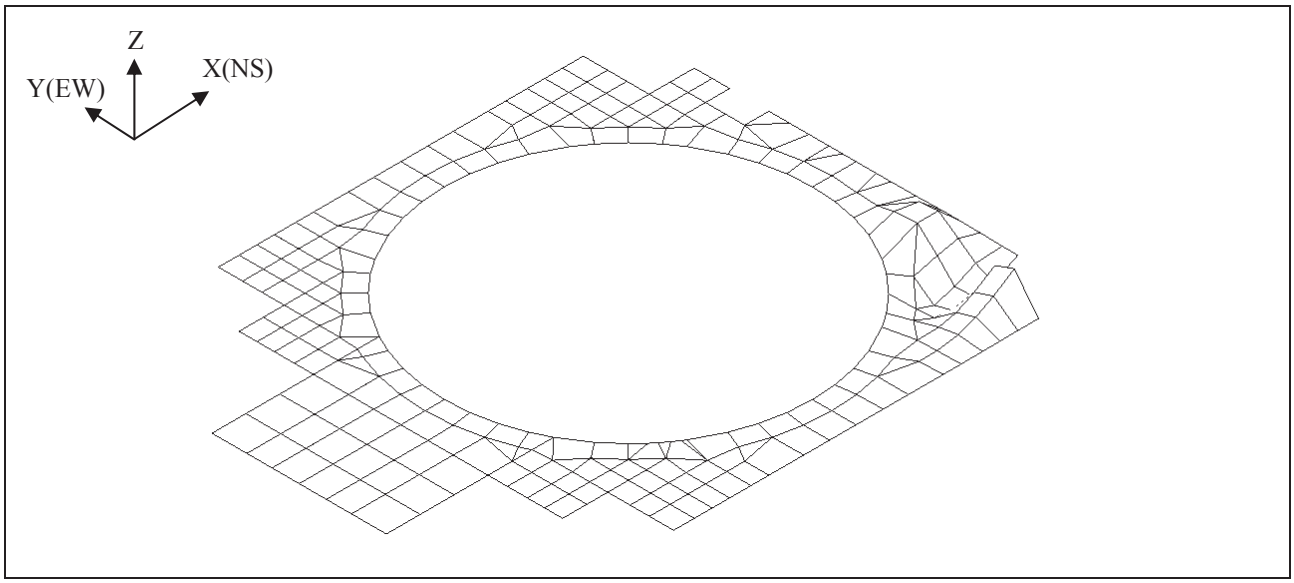


Figure 3.3.1.1-16e RB/FB Slab Eigenvalue Analysis Result EL 17.50m 18th Mode 55.27Hz

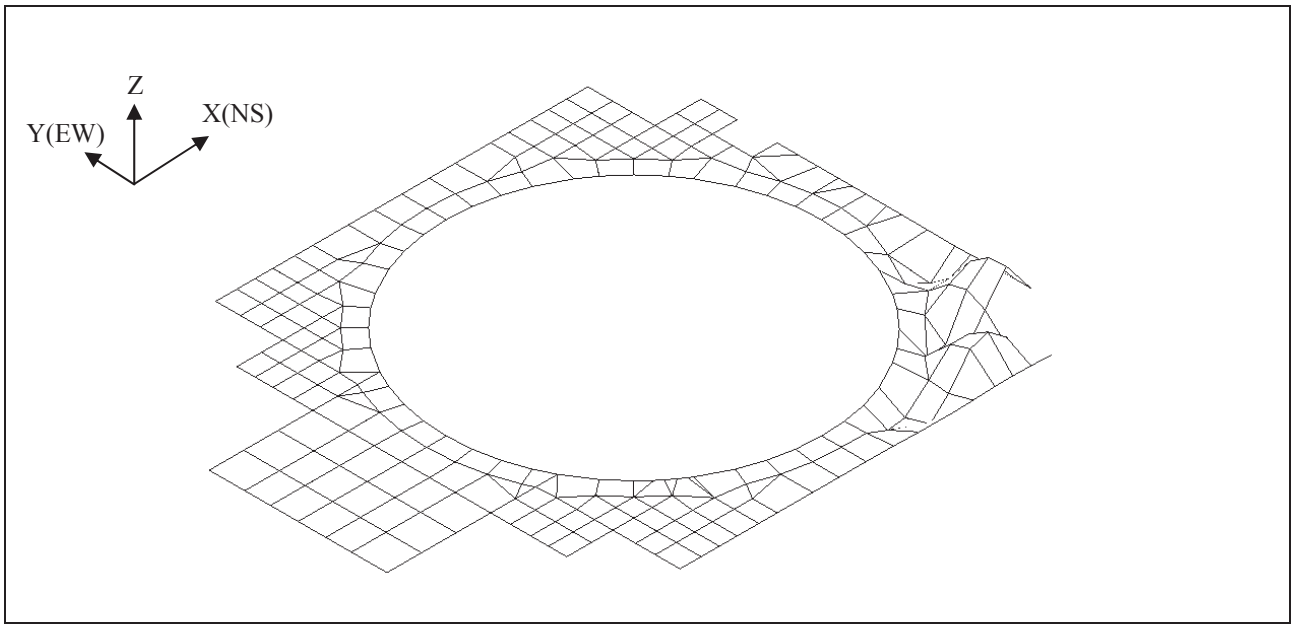


Figure 3.3.1.1-16f RB/FB Slab Eigenvalue Analysis Result EL 17.50m 28th Mode 67.51Hz

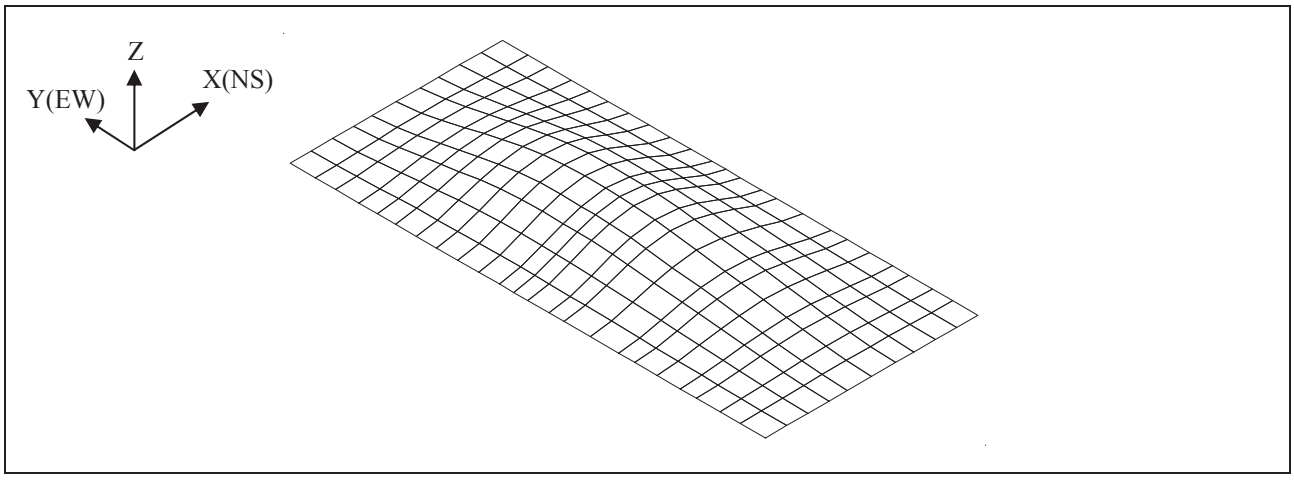


Figure 3.3.1.1-17a RB/FB Slab Eigenvalue Analysis Result EL 22.50m 1st Mode 5.22Hz

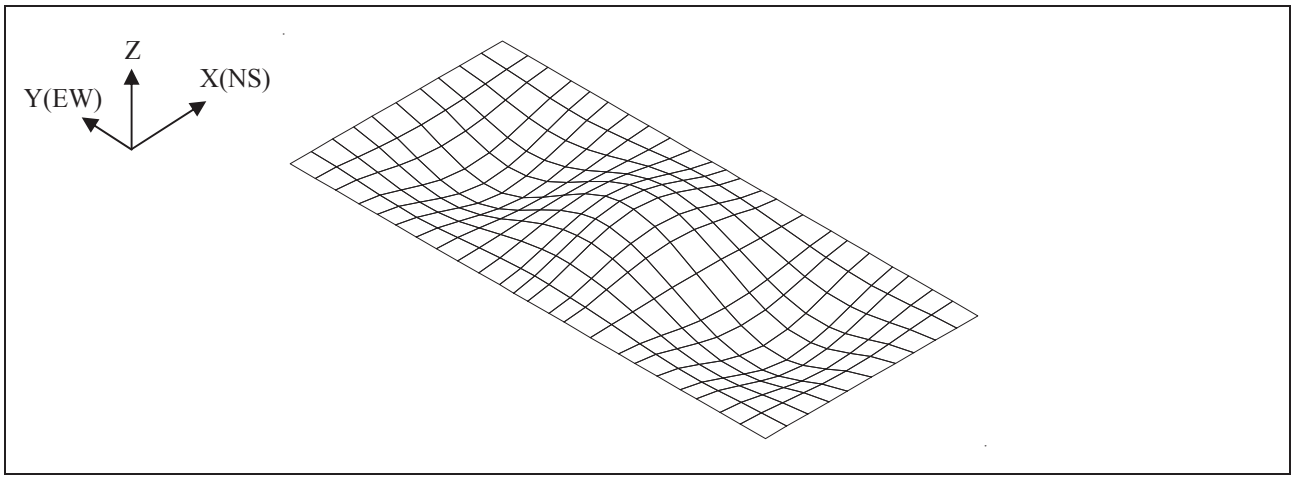


Figure 3.3.1.1-17b RB/FB Slab Eigenvalue Analysis Result EL 22.50m 3rd Mode 6.72Hz

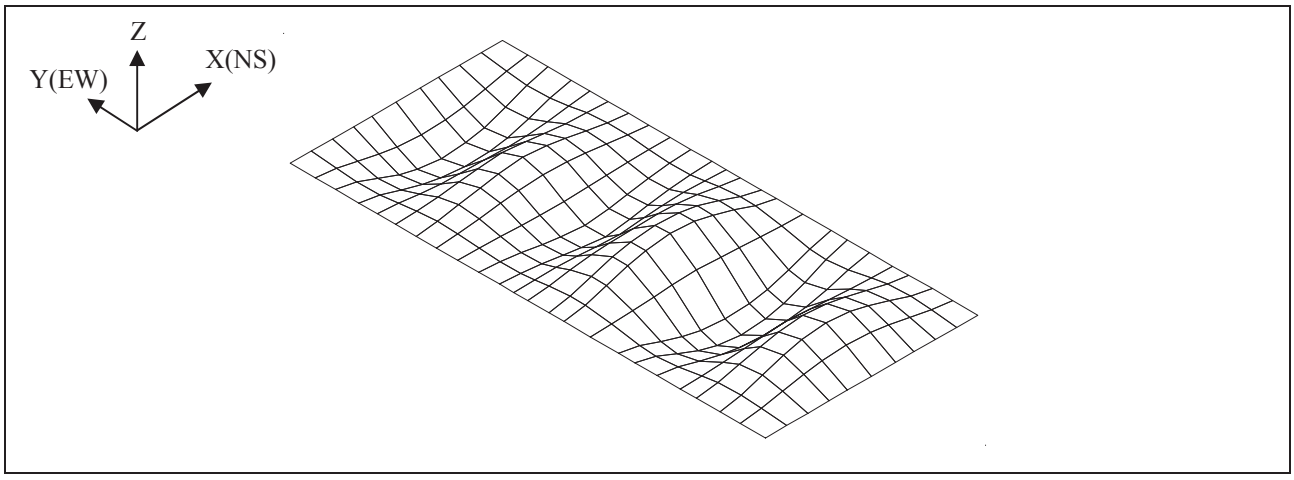


Figure 3.3.1.1-17c RB/FB Slab Eigenvalue Analysis Result EL 22.50m 6th Mode 15.37Hz

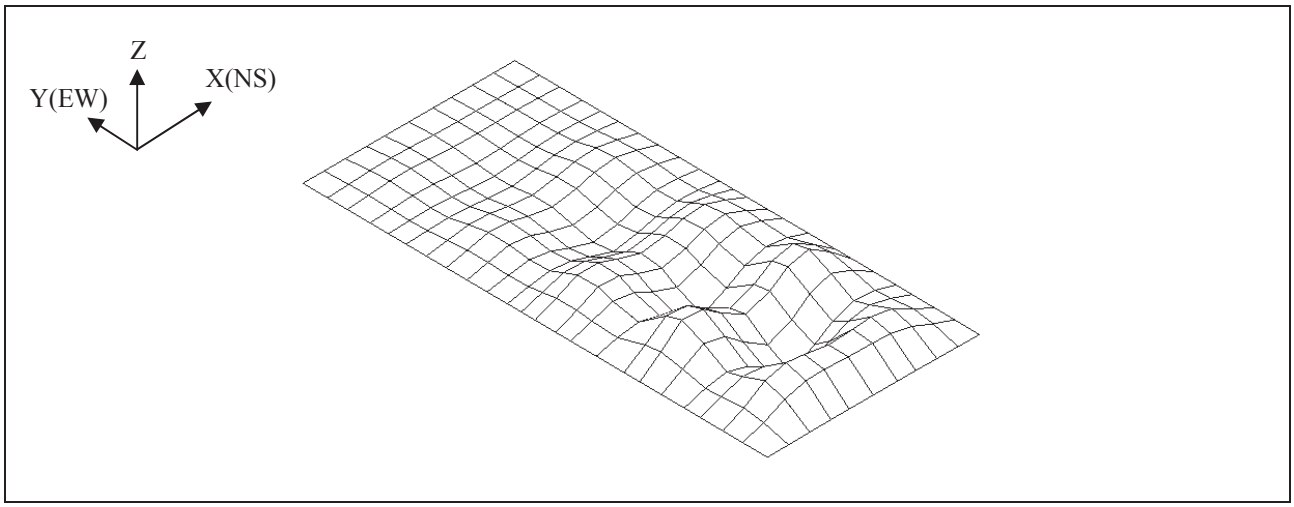


Figure 3.3.1.1-17d RB/FB Slab Eigenvalue Analysis Result EL 22.50m 14th Mode 24.80Hz

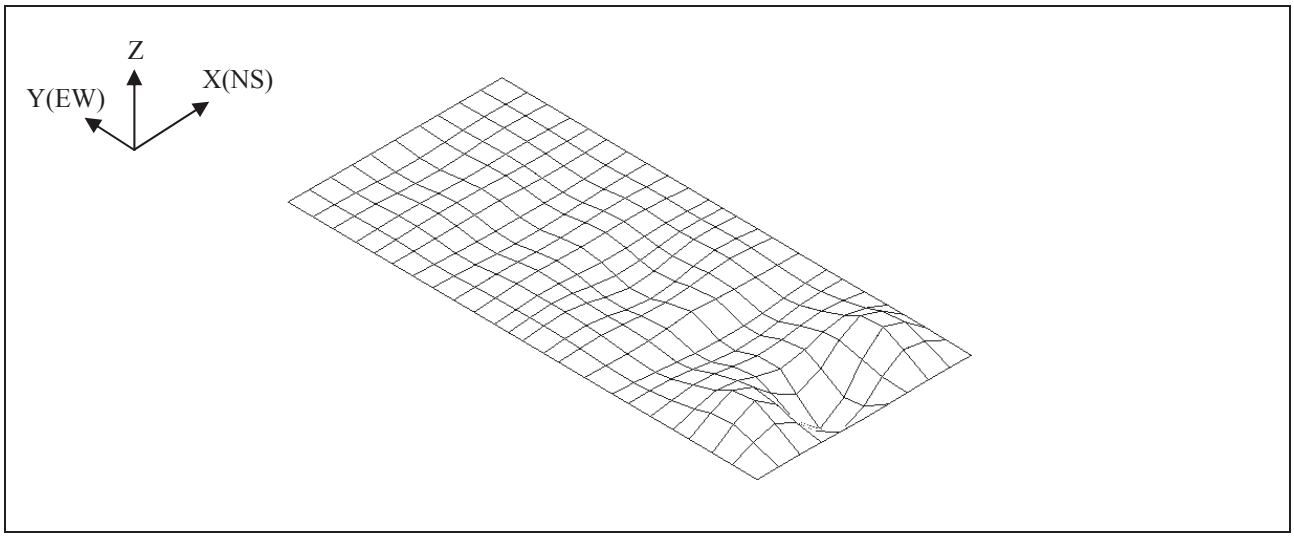


Figure 3.3.1.1-17e RB/FB Slab Eigenvalue Analysis Result EL 22.50m 21st Mode 30.70Hz

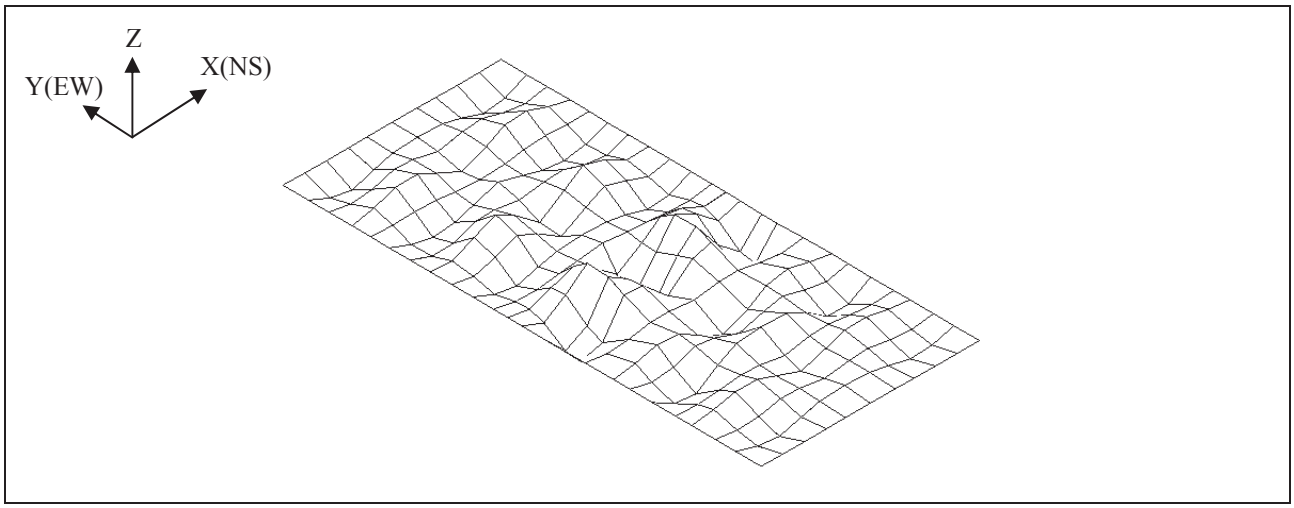


Figure 3.3.1.1-17f RB/FB Slab Eigenvalue Analysis Result EL 22.50m 46th Mode 54.86Hz

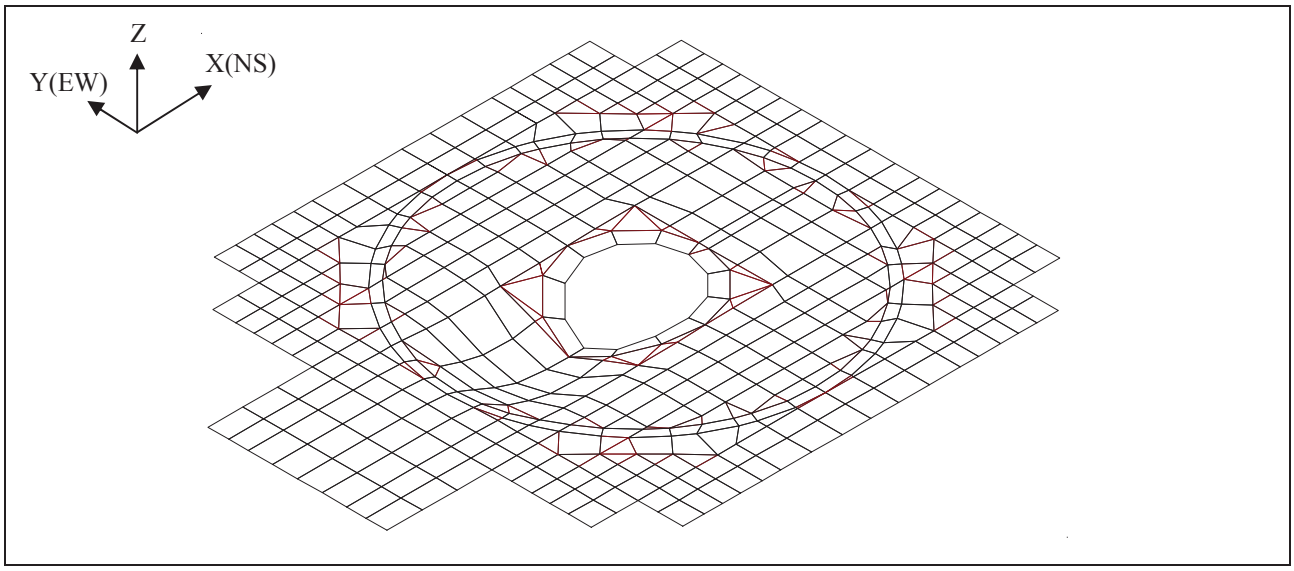


Figure 3.3.1.1-18a RB/FB Slab Eigenvalue Analysis Result EL 27.00m 1st Mode 25.26Hz

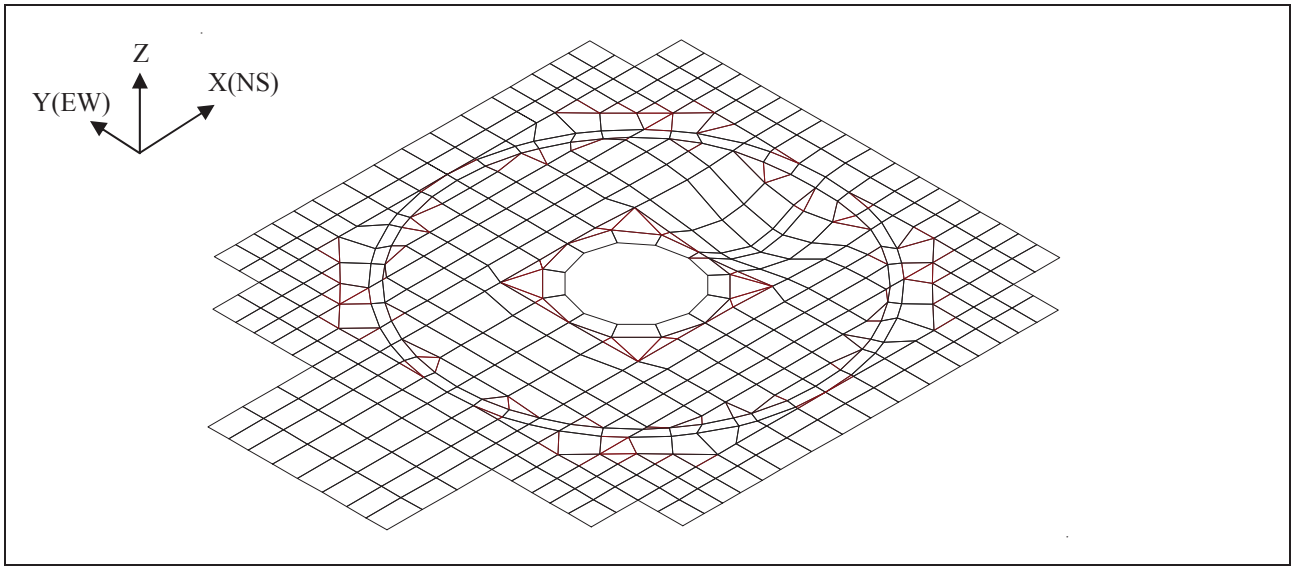


Figure 3.3.1.1-18b RB/FB Slab Eigenvalue Analysis Result EL 27.00m 2nd Mode 27.62Hz

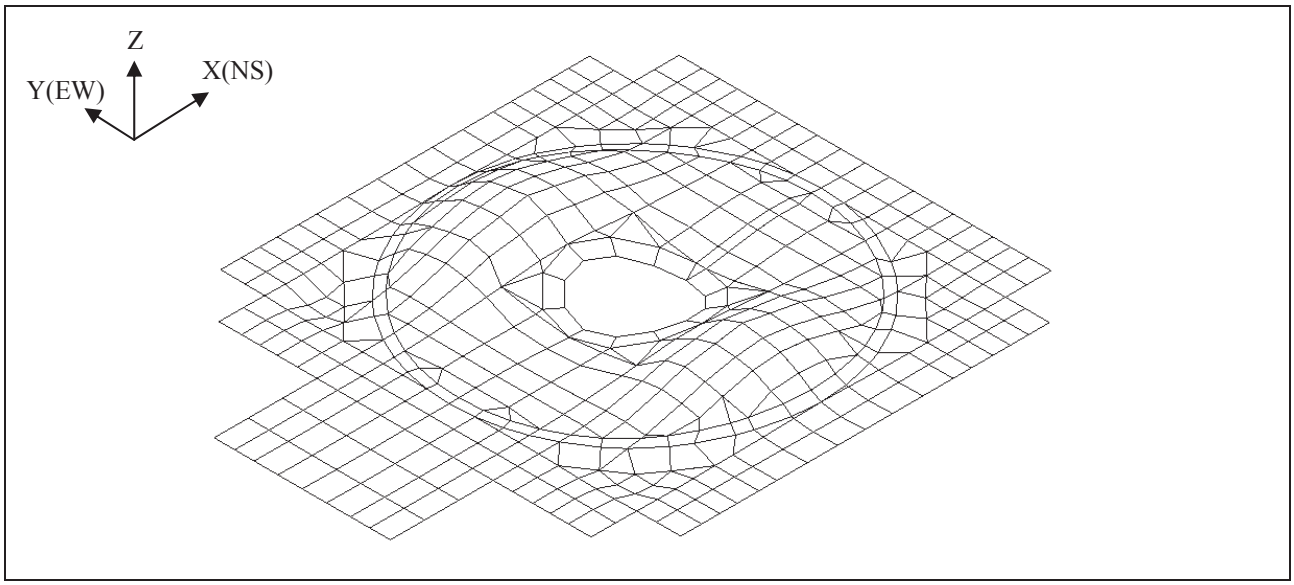


Figure 3.3.1.1-18c RB/FB Slab Eigenvalue Analysis Result EL 27.00m 6th Mode 42.24Hz

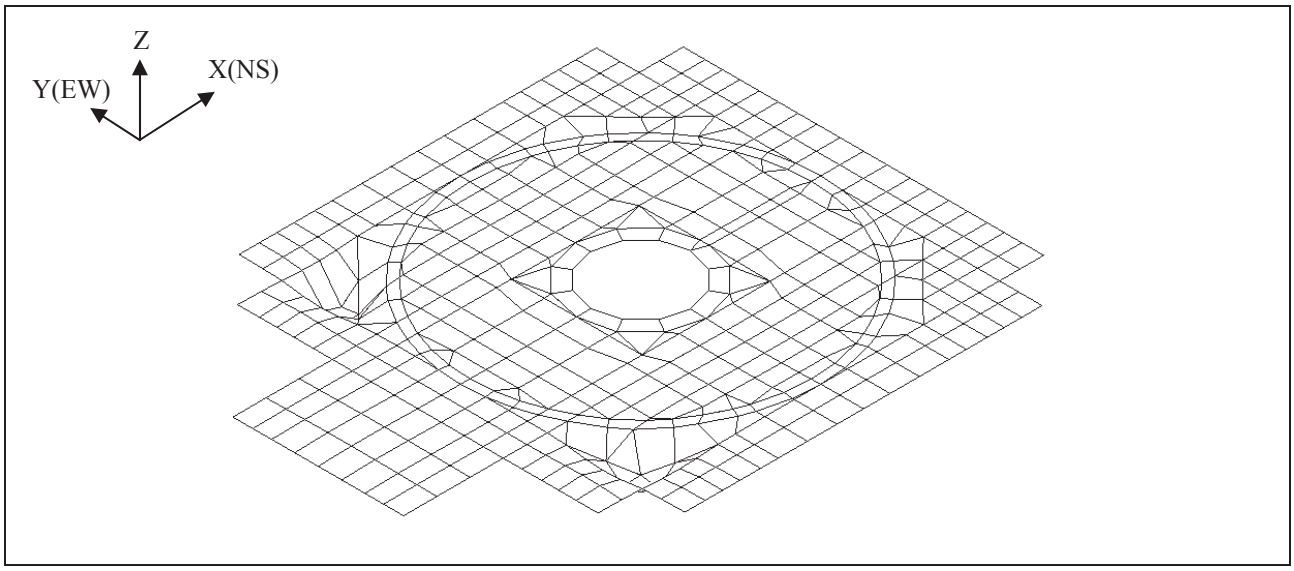


Figure 3.3.1.1-18d RB/FB Slab Eigenvalue Analysis Result EL 27.00m 8th Mode 43.48Hz

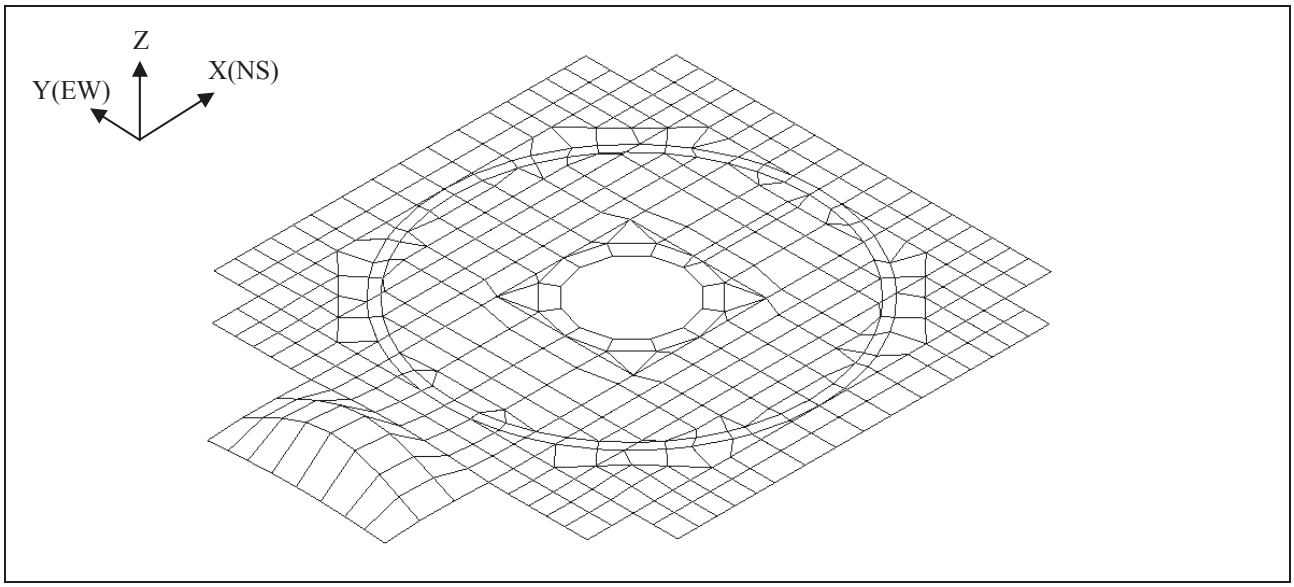


Figure 3.3.1.1-18e RB/FB Slab Eigenvalue Analysis Result EL 27.00m 9th Mode 43.63Hz

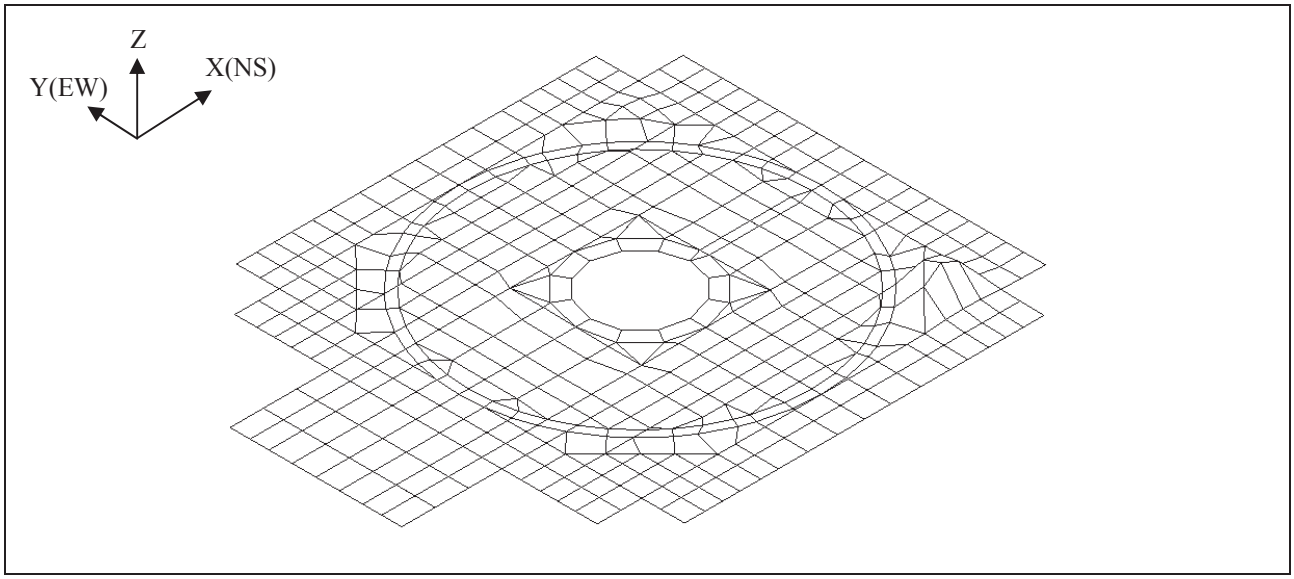


Figure 3.3.1.1-18f RB/FB Slab Eigenvalue Analysis Result EL 27.00m 12th Mode 46.55Hz

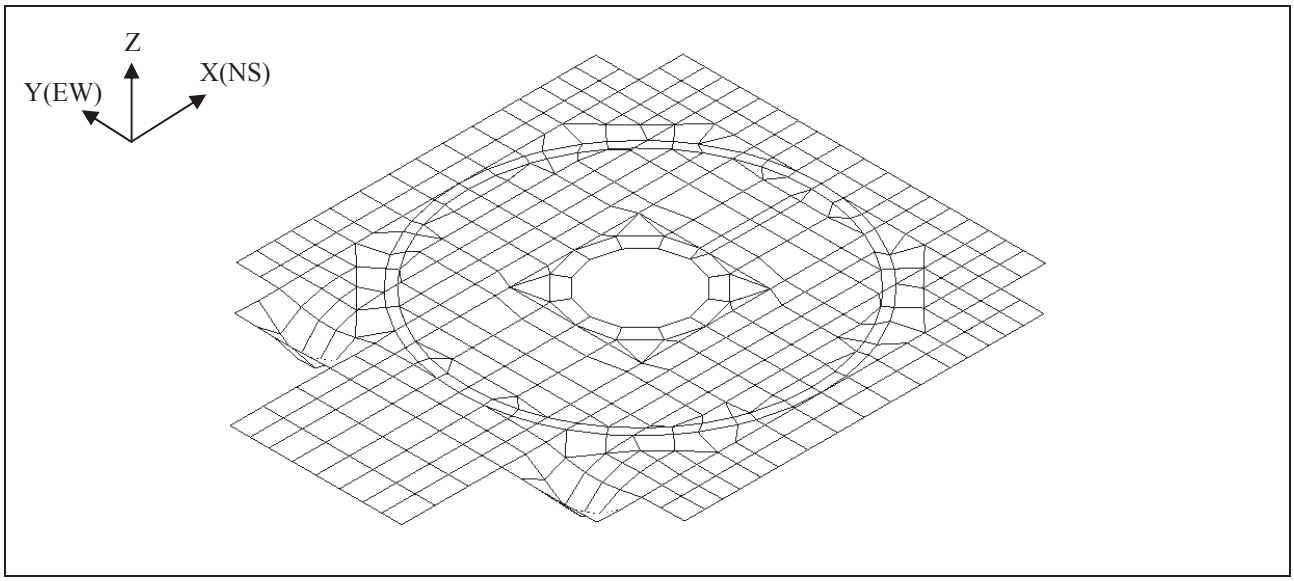


Figure 3.3.1.1-18g RB/FB Slab Eigenvalue Analysis Result EL 27.00m 20th Mode 53.07Hz

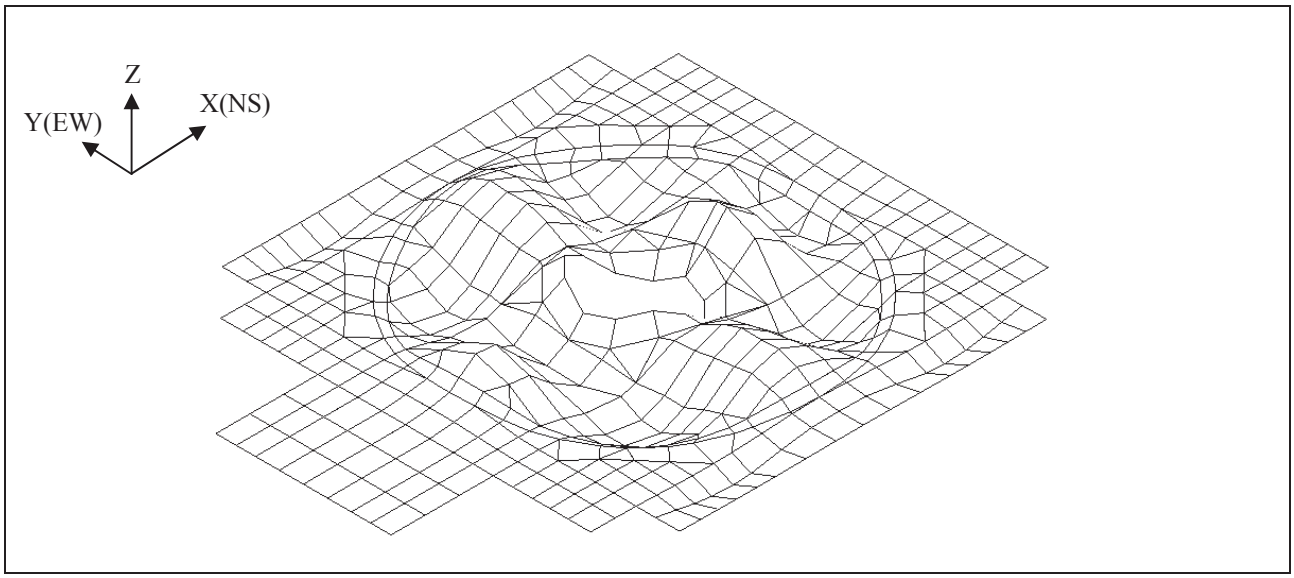


Figure 3.3.1.1-18h RB/FB Slab Eigenvalue Analysis Result EL 27.00m 26th Mode 57.72Hz

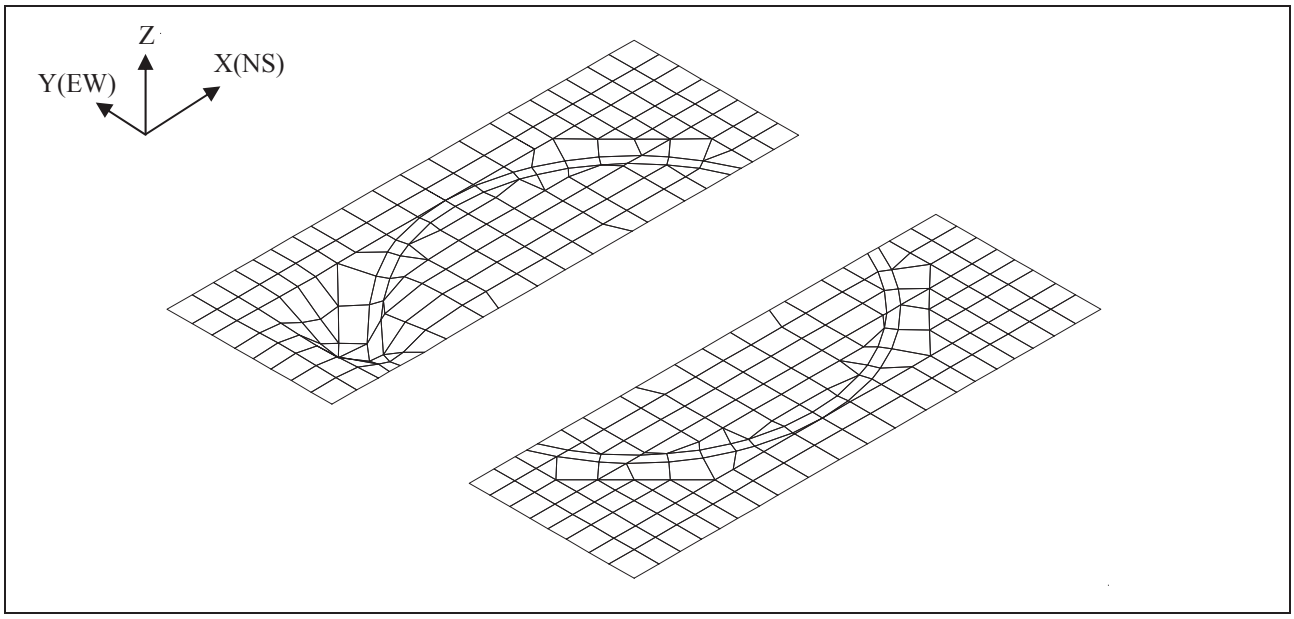


Figure 3.3.1.1-19a RB/FB Slab Eigenvalue Analysis Result EL 34.00m 1st Mode 38.78Hz

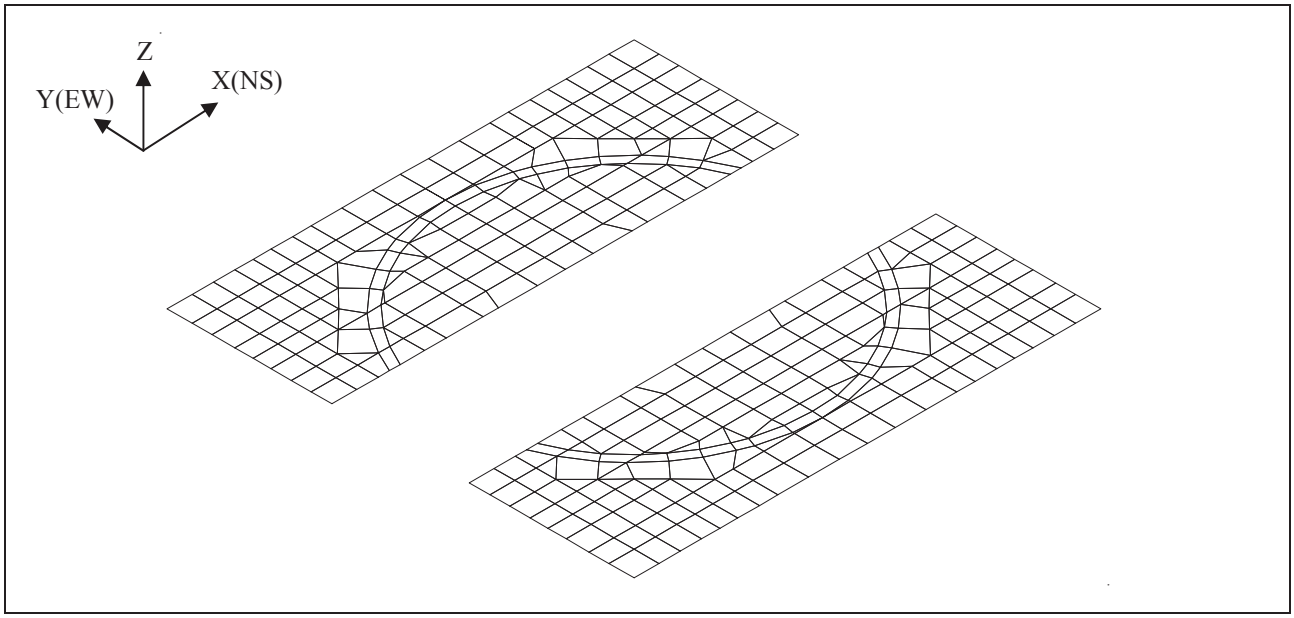


Figure 3.3.1.1-19b RB/FB Slab Eigenvalue Analysis Result EL 34.00m 3rd Mode 41.56Hz

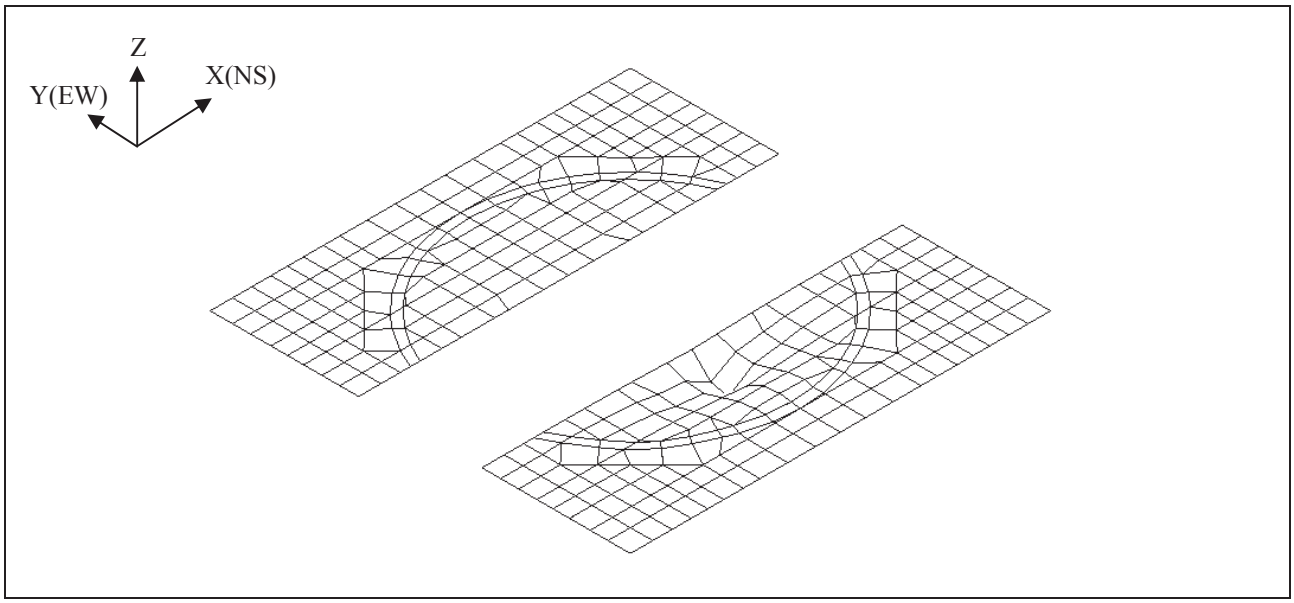


Figure 3.3.1.1-19c RB/FB Slab Eigenvalue Analysis Result EL 34.00m 19th Mode 62.39Hz

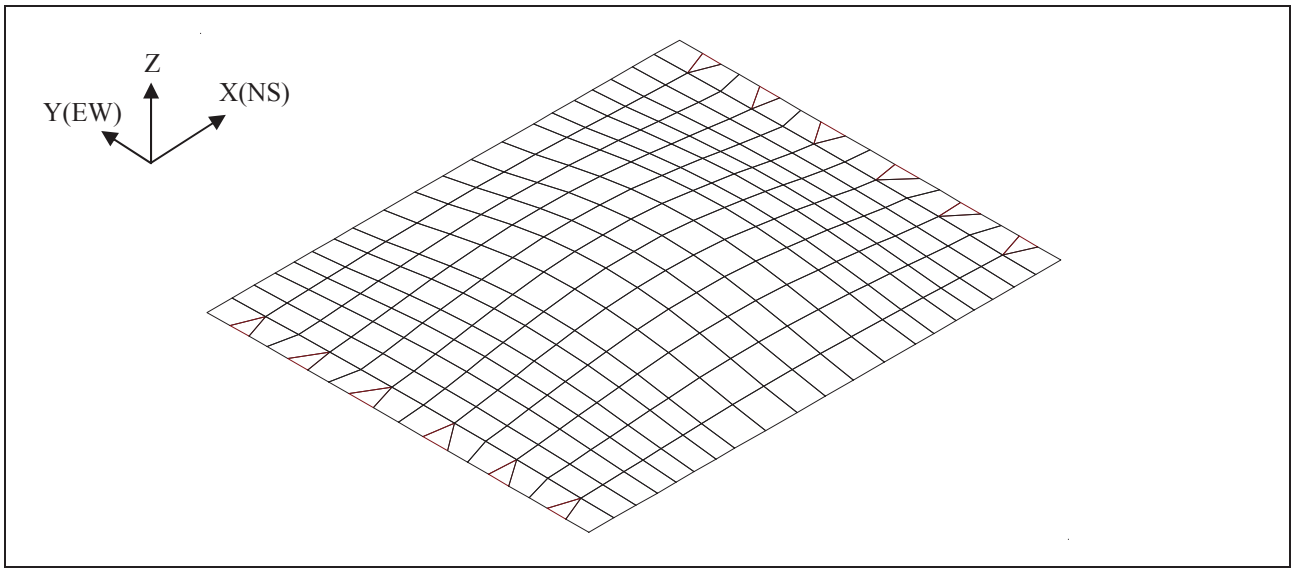


Figure 3.3.1.1-20a RB/FB Slab Eigenvalue Analysis Result EL 52.40m 1st Mode 2.75Hz

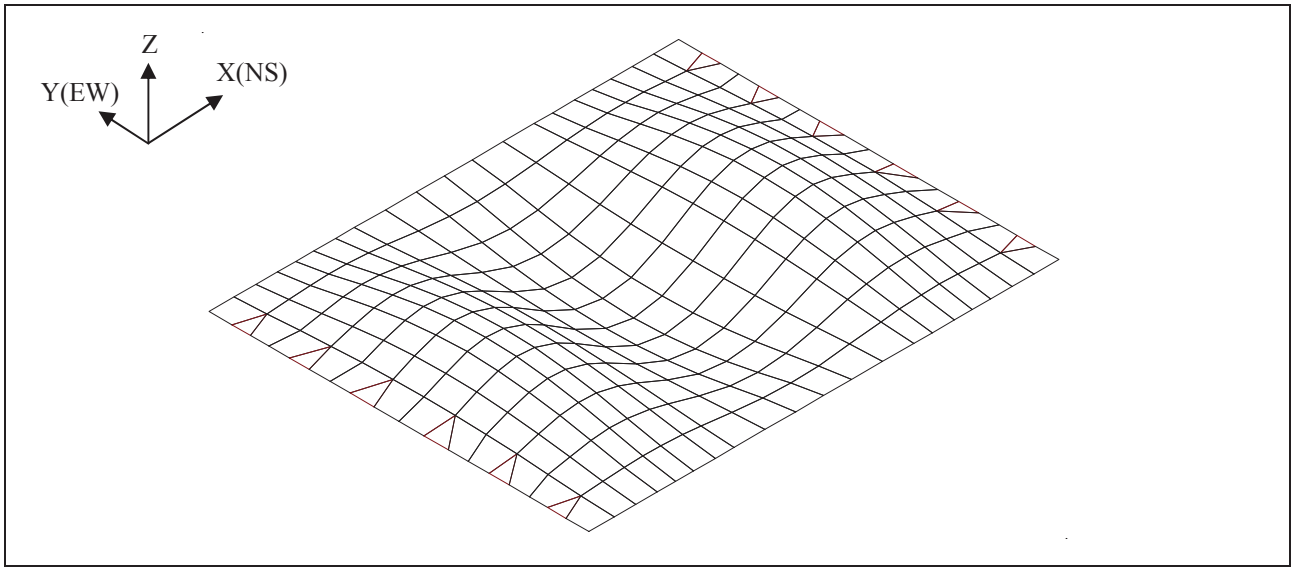


Figure 3.3.1.1-20b RB/FB Slab Eigenvalue Analysis Result EL 52.40m 3rd Mode 5.23Hz

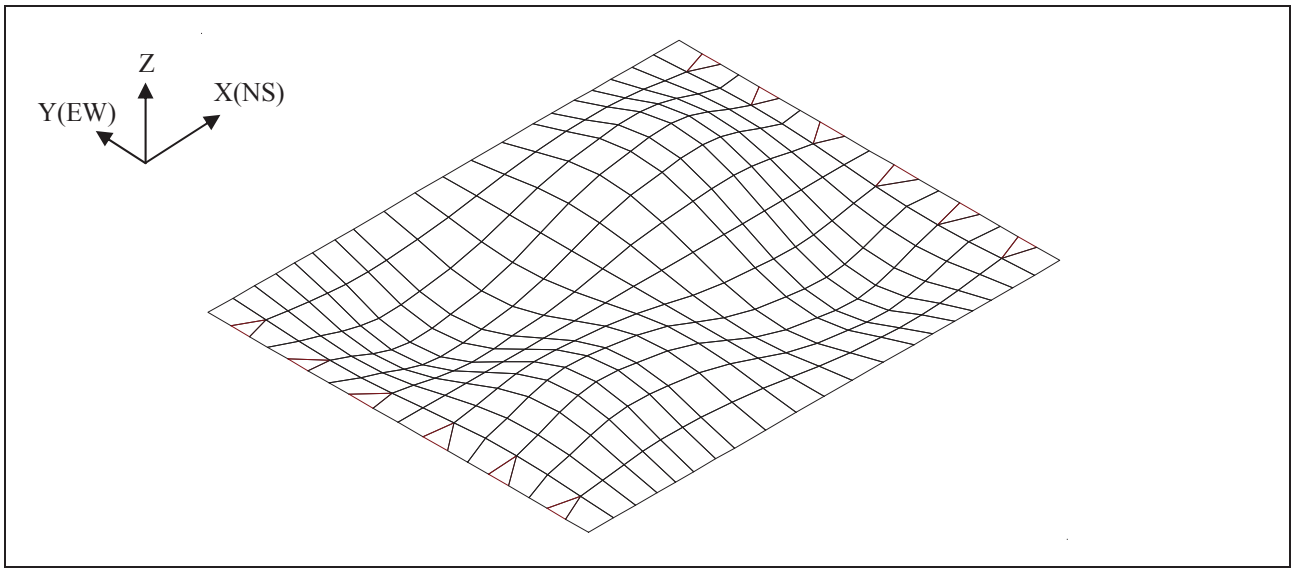


Figure 3.3.1.1-20c RB/FB Slab Eigenvalue Analysis Result EL 52.40m 5th Mode 6.91Hz

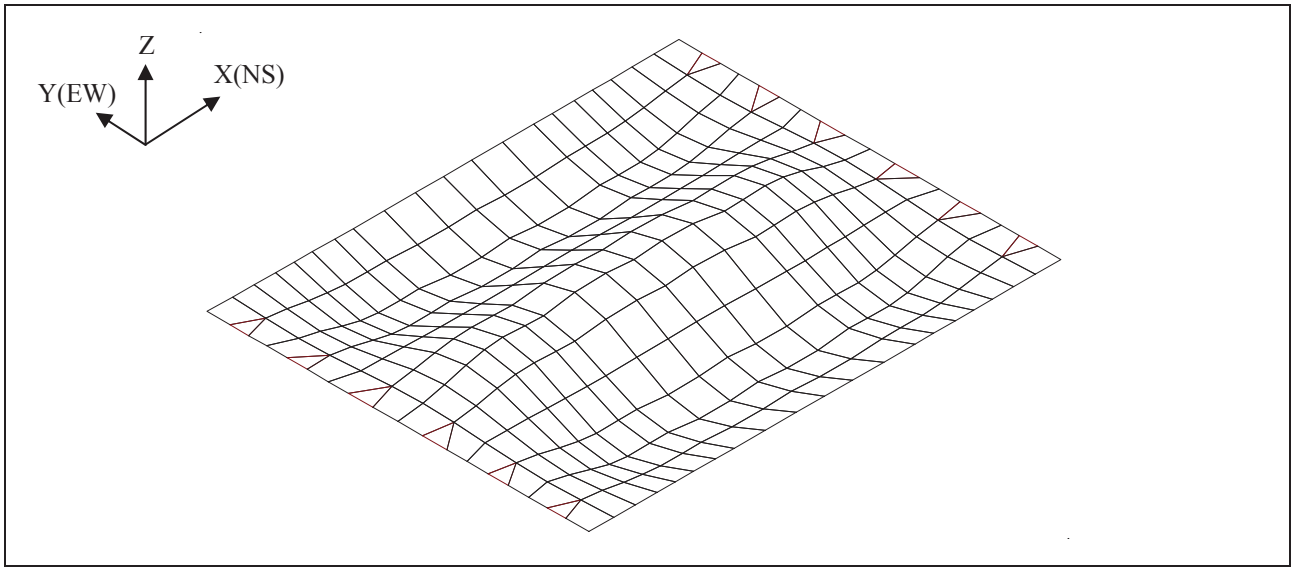


Figure 3.3.1.1-20d RB/FB Slab Eigenvalue Analysis Result EL 52.40m 10th Mode 10.40Hz

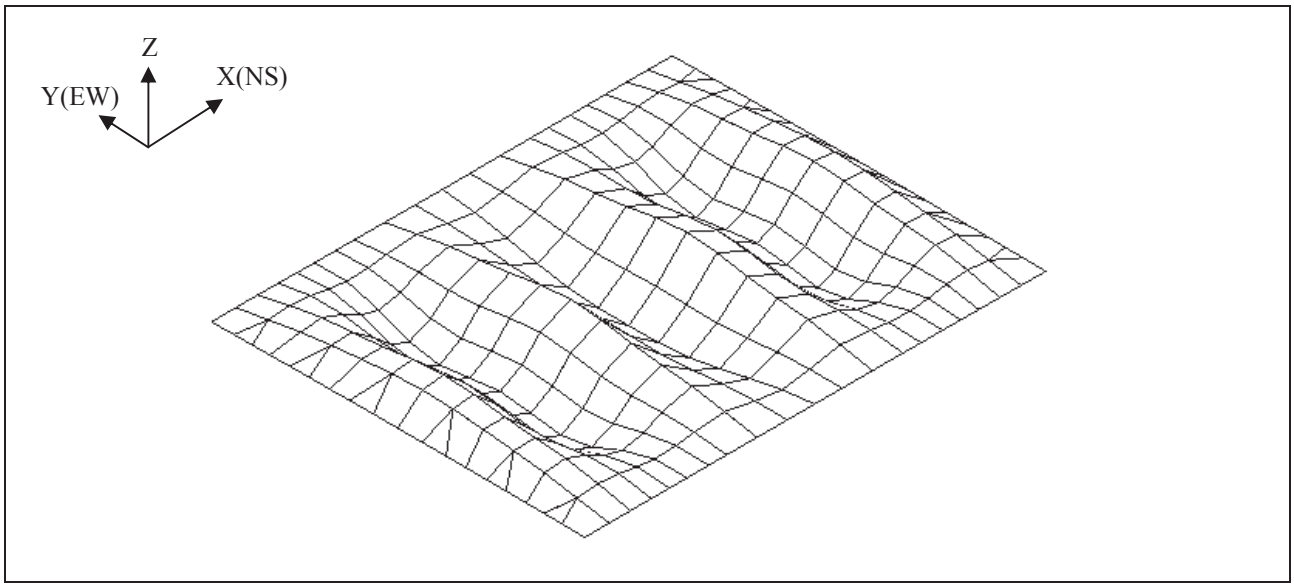


Figure 3.3.1.1-20e RB/FB Slab Eigenvalue Analysis Result EL 52.40m 24th Mode 19.86Hz

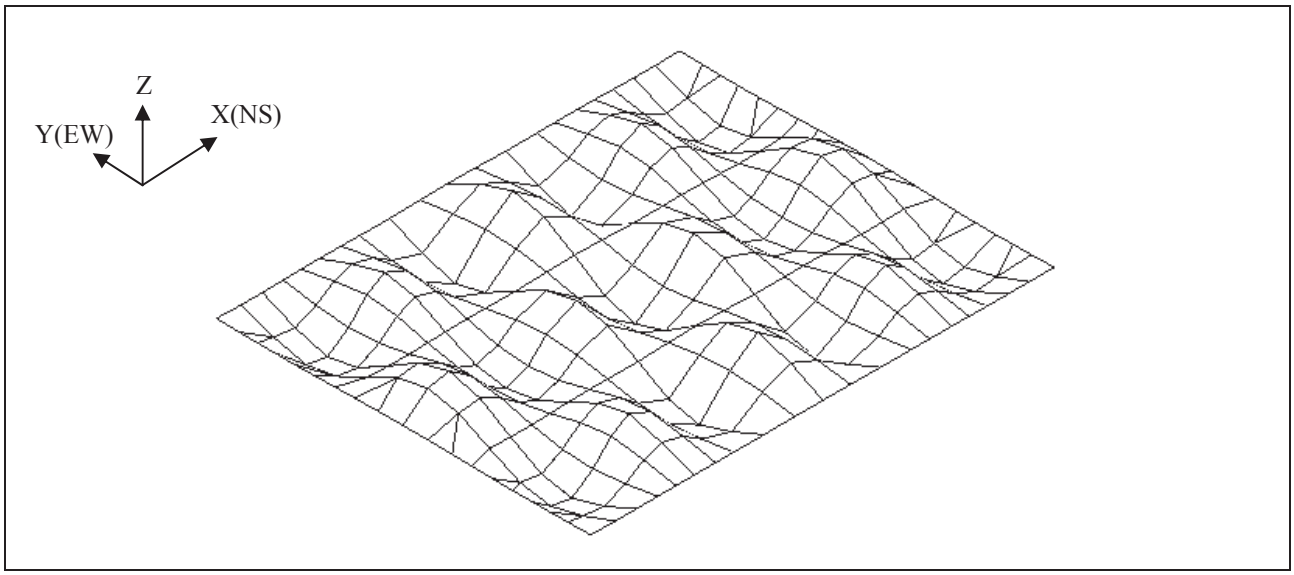


Figure 3.3.1.1-20f RB/FB Slab Eigenvalue Analysis Result EL 52.40m 34th Mode 25.04Hz

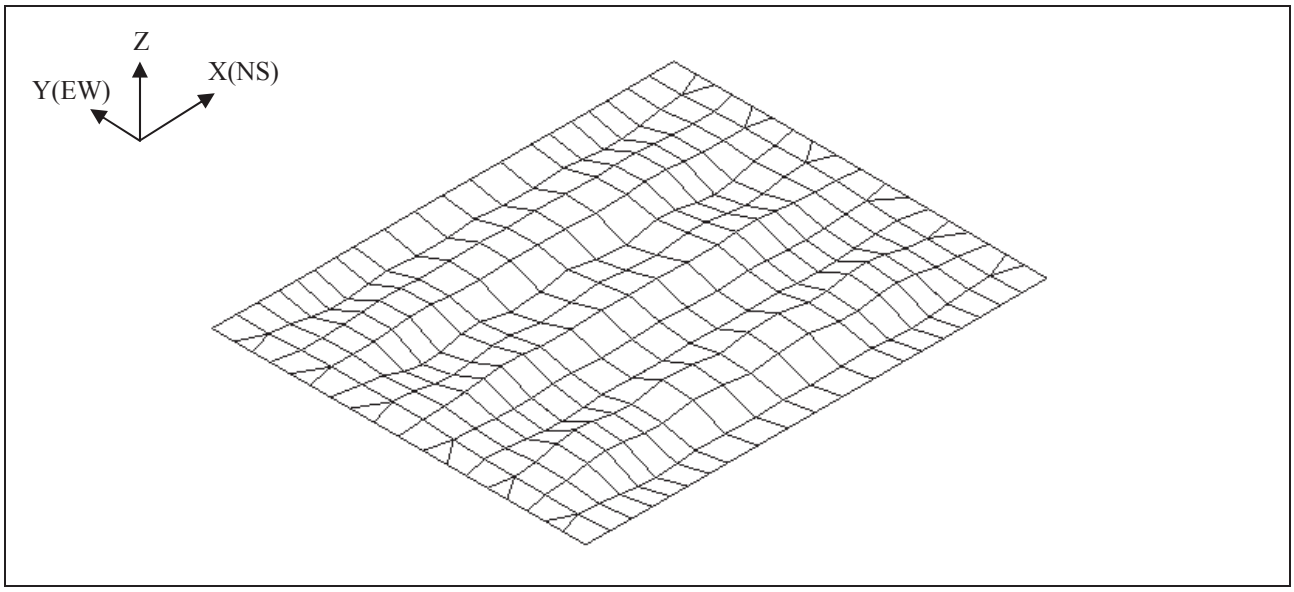


Figure 3.3.1.1-20g RB/FB Slab Eigenvalue Analysis Result EL 52.40m 50th Mode 31.78Hz

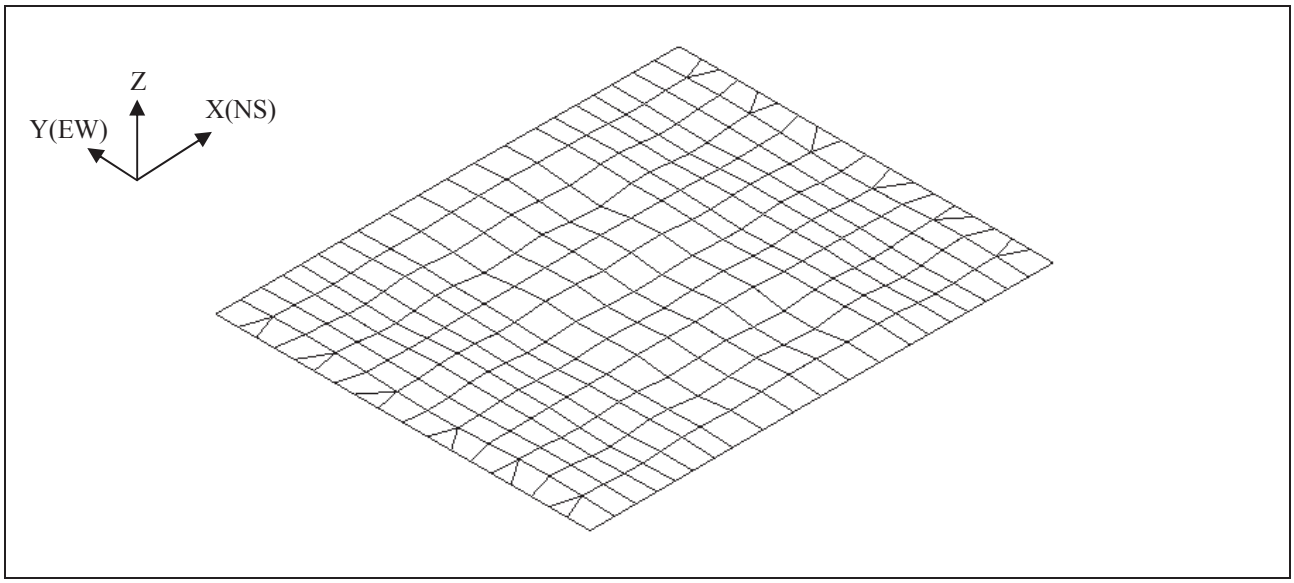


Figure 3.3.1.1-20h RB/FB Slab Eigenvalue Analysis Result EL 52.40m 57th Mode 33.99Hz

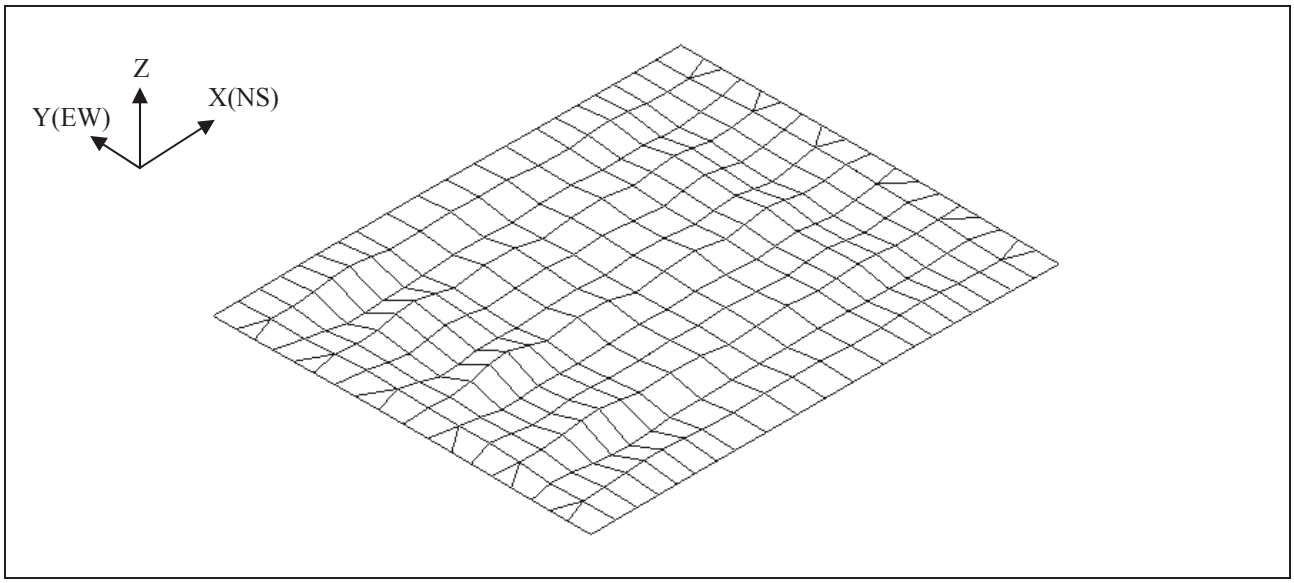


Figure 3.3.1.1-20i RB/FB Slab Eigenvalue Analysis Result EL 52.40m 86th Mode 45.72Hz

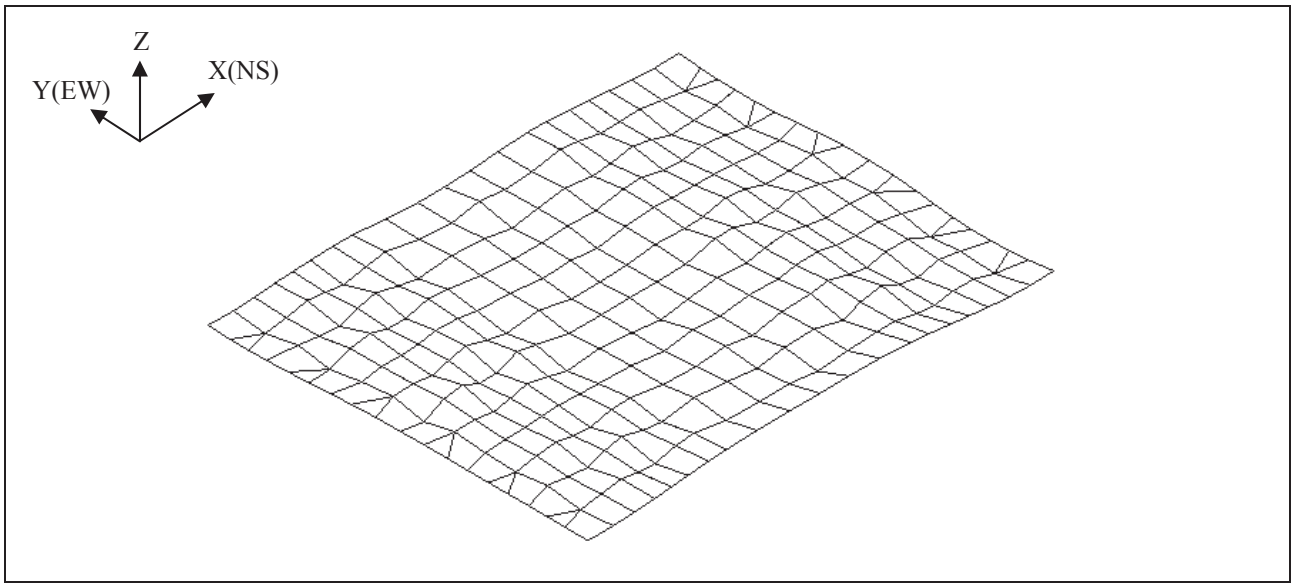


Figure 3.3.1.1-20j RB/FB Slab Eigenvalue Analysis Result EL 52.40m 160th Mode 70.83Hz

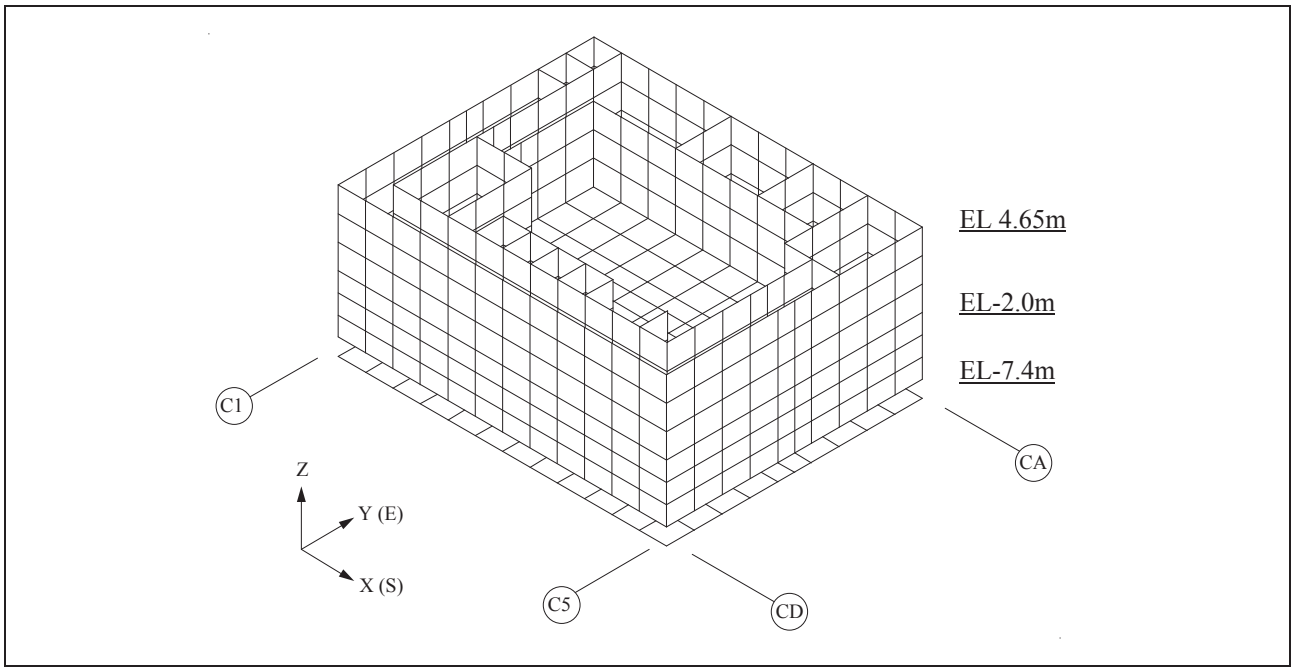


Figure 3.3.1.2-1 FE Model for CB Slab Eigenvalue Analysis EL -2.00m

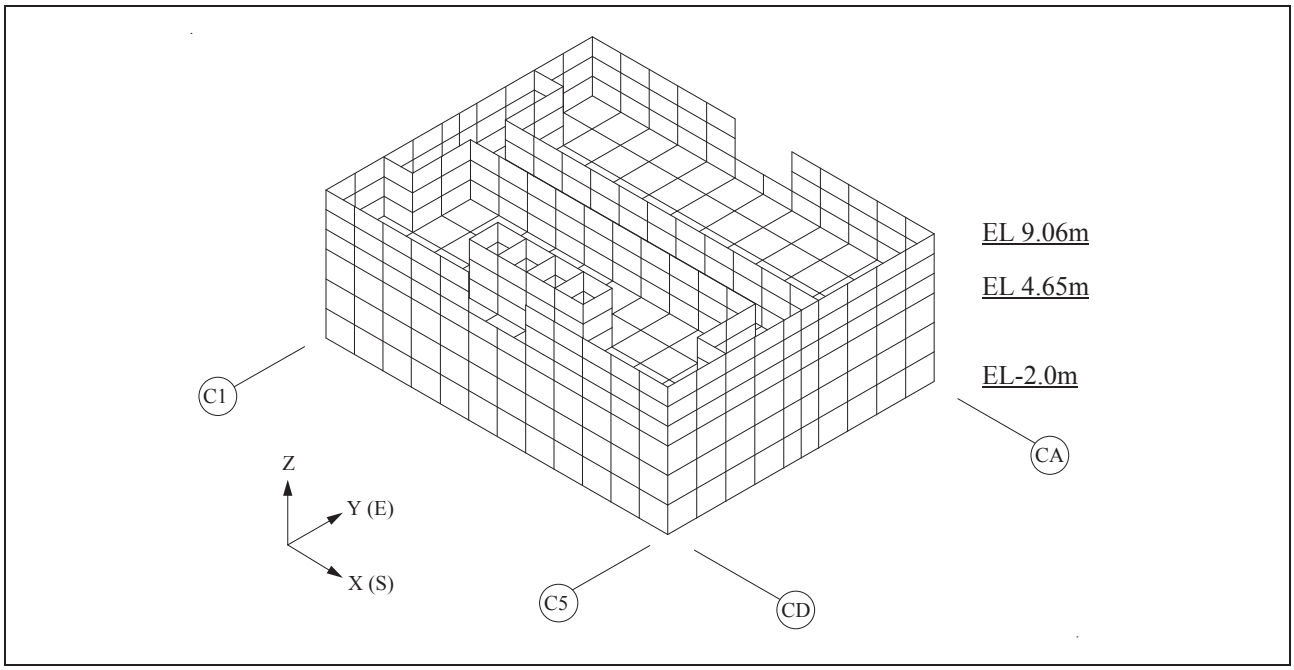


Figure 3.3.1.2-2 FE Model for CB Slab Eigenvalue Analysis EL 4.65m

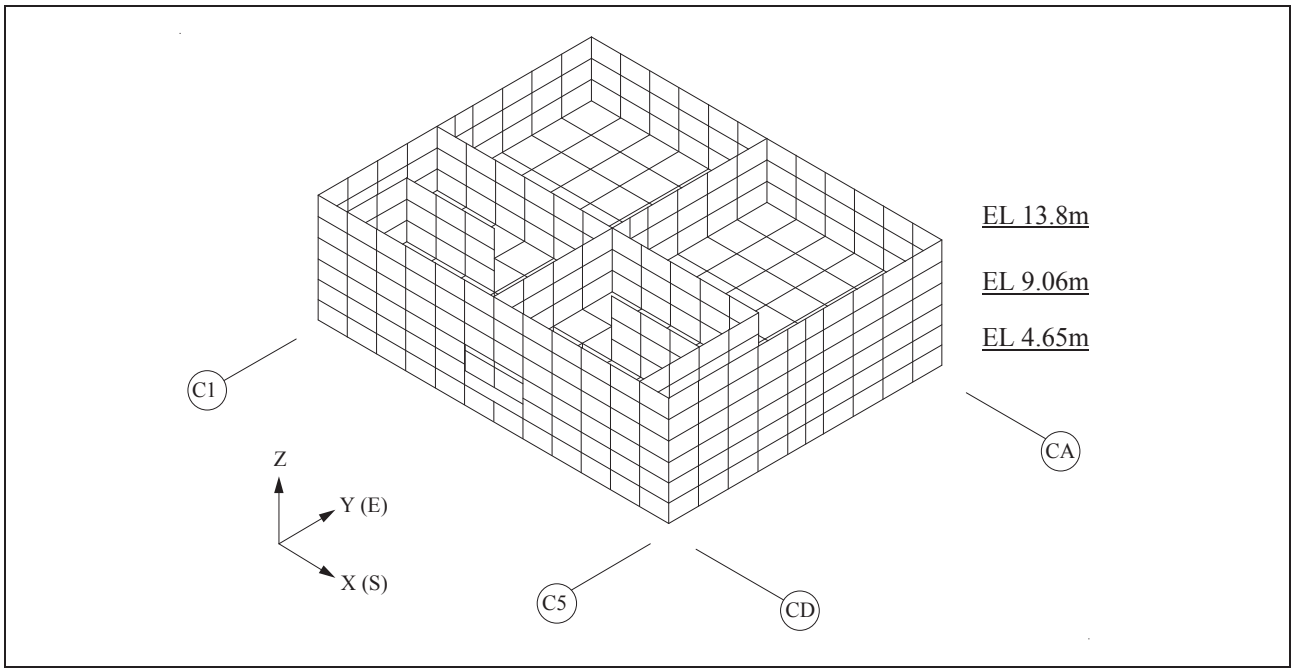


Figure 3.3.1.2-3 FE Model for CB Slab Eigenvalue Analysis EL 9.06m

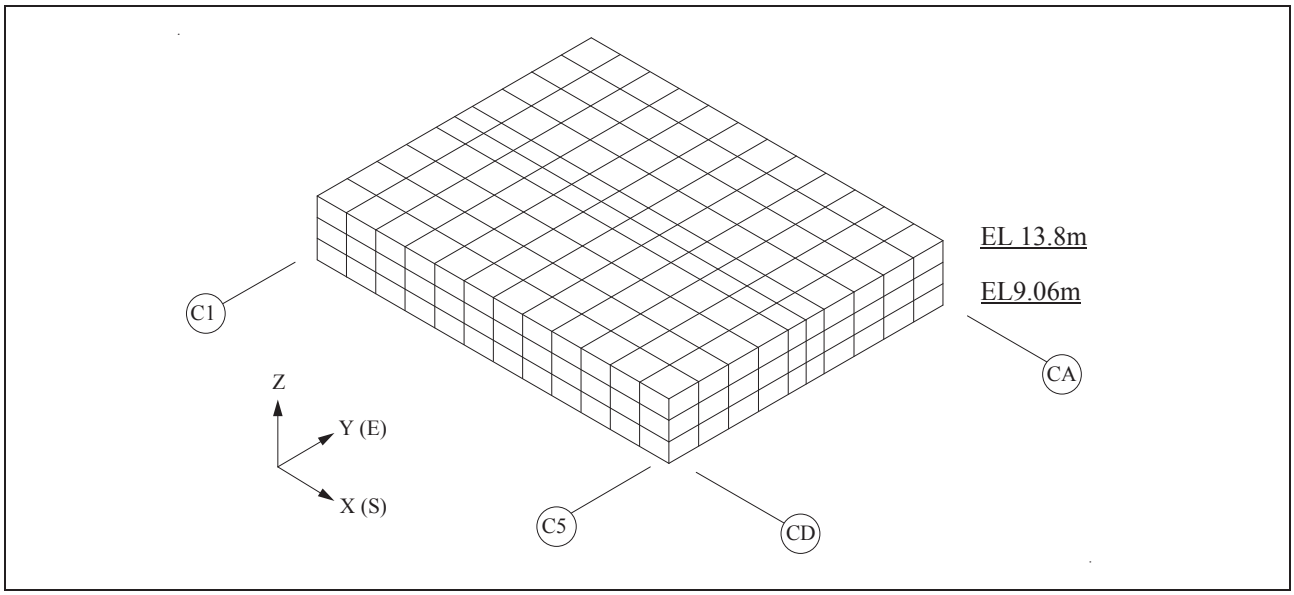


Figure 3.3.1.2-4 FE Model for CB Slab Eigenvalue Analysis EL 13.80m

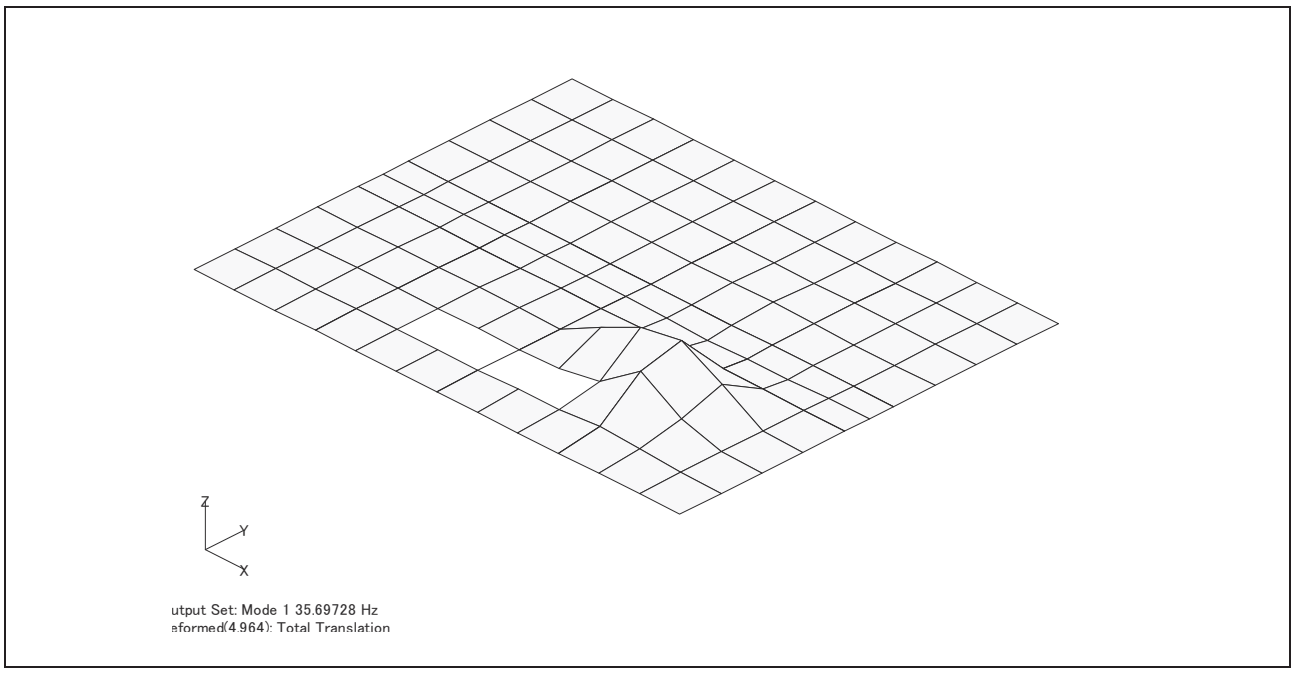


Figure 3.3.1.2-5a CB Slab Eigenvalue Analysis Result EL -2.00m 1st Mode 35.70 Hz

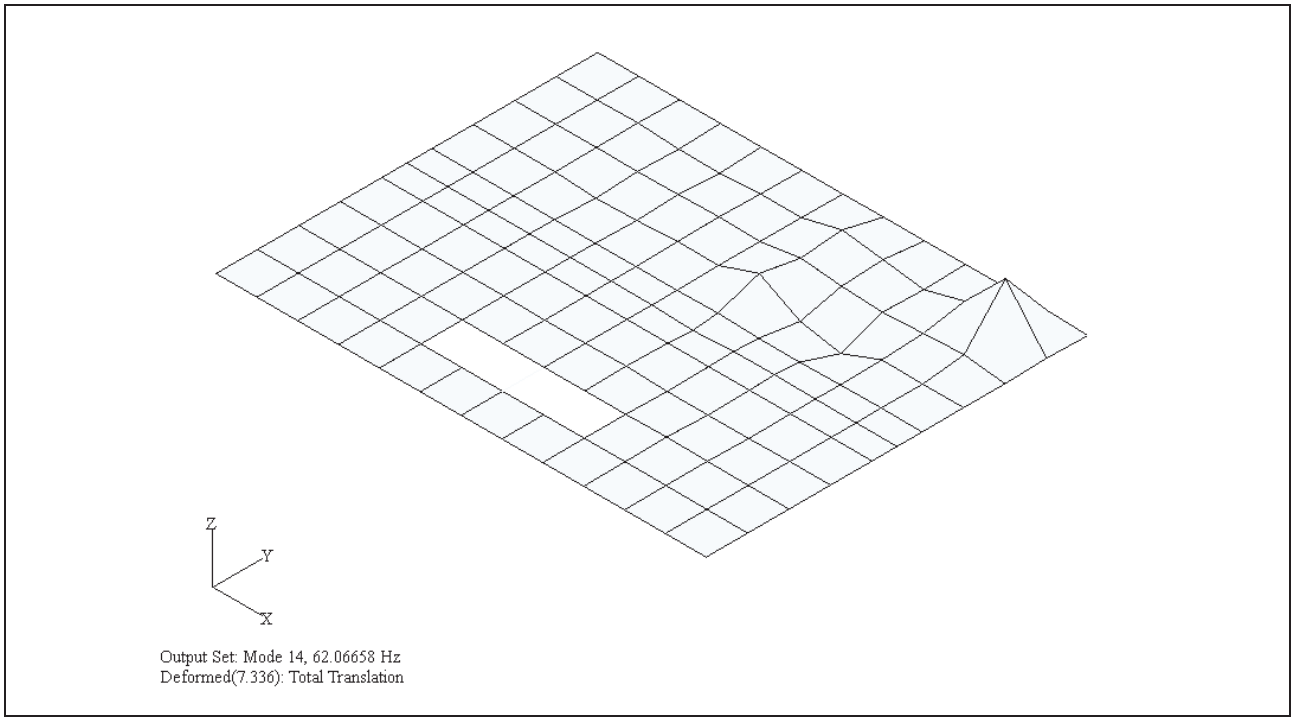


Figure 3.3.1.2-5b CB Slab Eigenvalue Analysis Result EL -2.00m 14th Mode 62.07 Hz

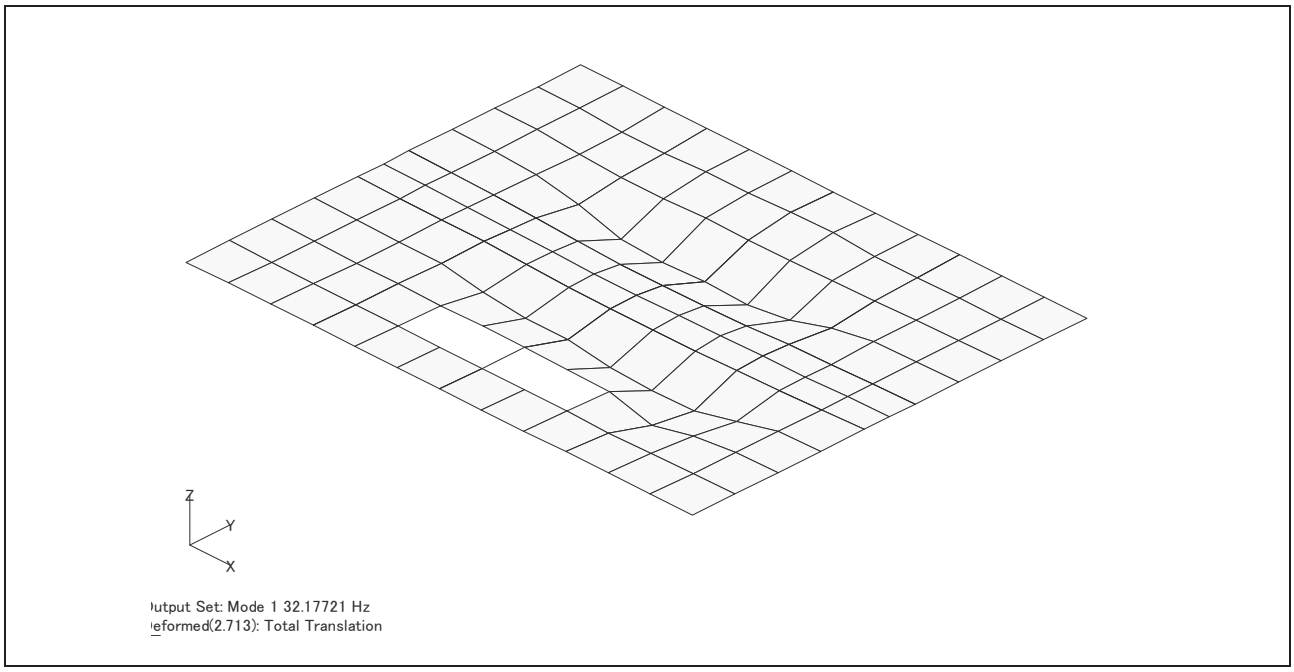


Figure 3.3.1.2-6a CB Slab Eigenvalue Analysis Result EL 4.65m 1st Mode 32.18 Hz

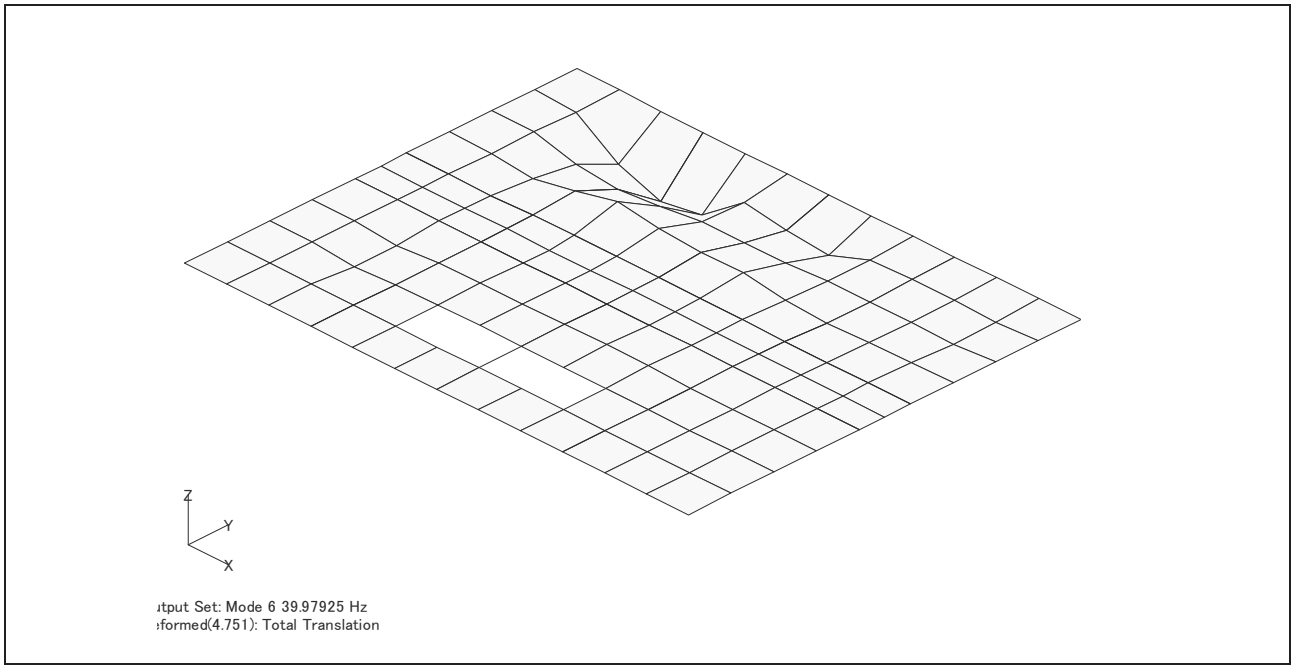


Figure 3.3.1.2-6b CB Slab Eigenvalue Analysis Result EL 4.65m 6th Mode 39.98 Hz

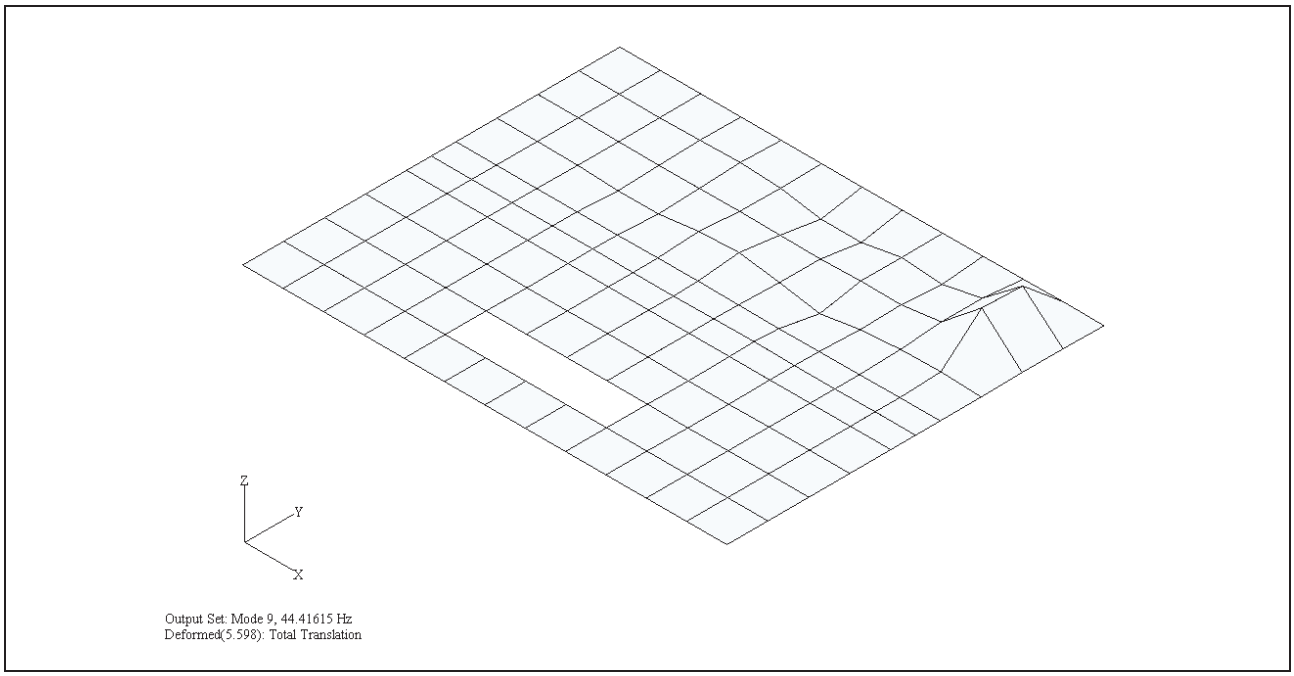


Figure 3.3.1.2-6c CB Slab Eigenvalue Analysis Result EL 4.65m 9th Mode 44.42 Hz

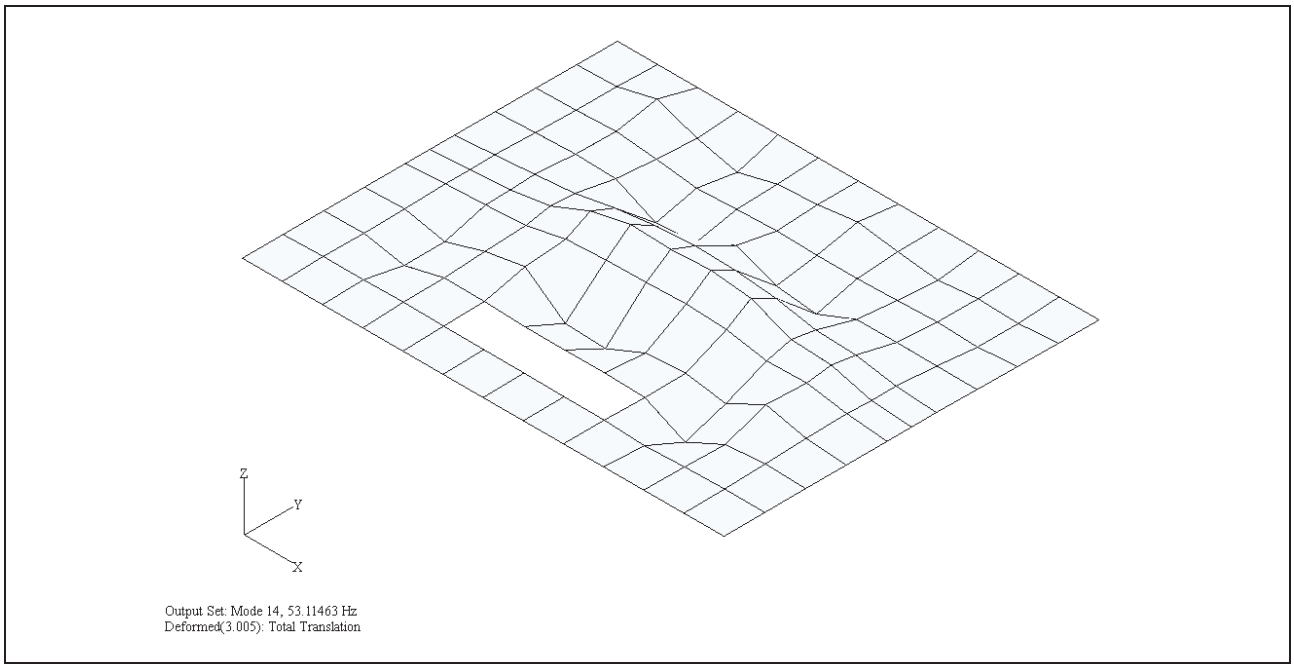


Figure 3.3.1.2-6d CB Slab Eigenvalue Analysis Result EL 4.65m 14th Mode 53.11 Hz

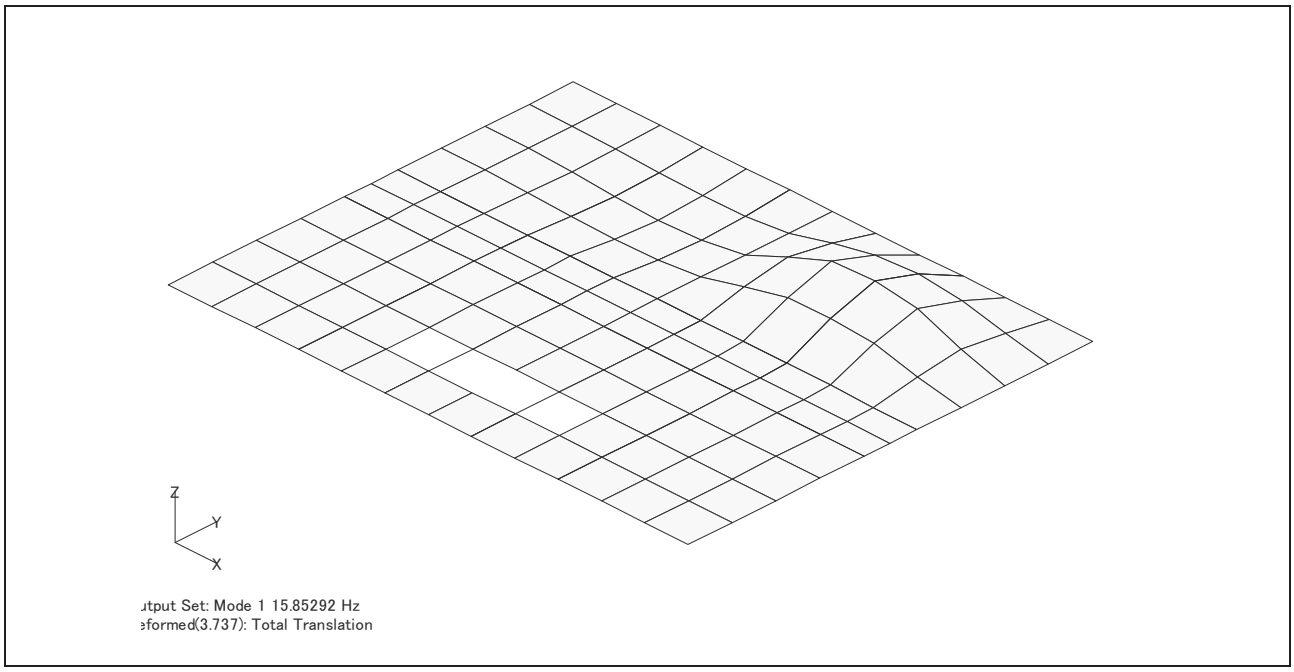


Figure 3.3.1.2-7a CB Slab Eigenvalue Analysis Result EL 9.06m 1st Mode 15.85 Hz

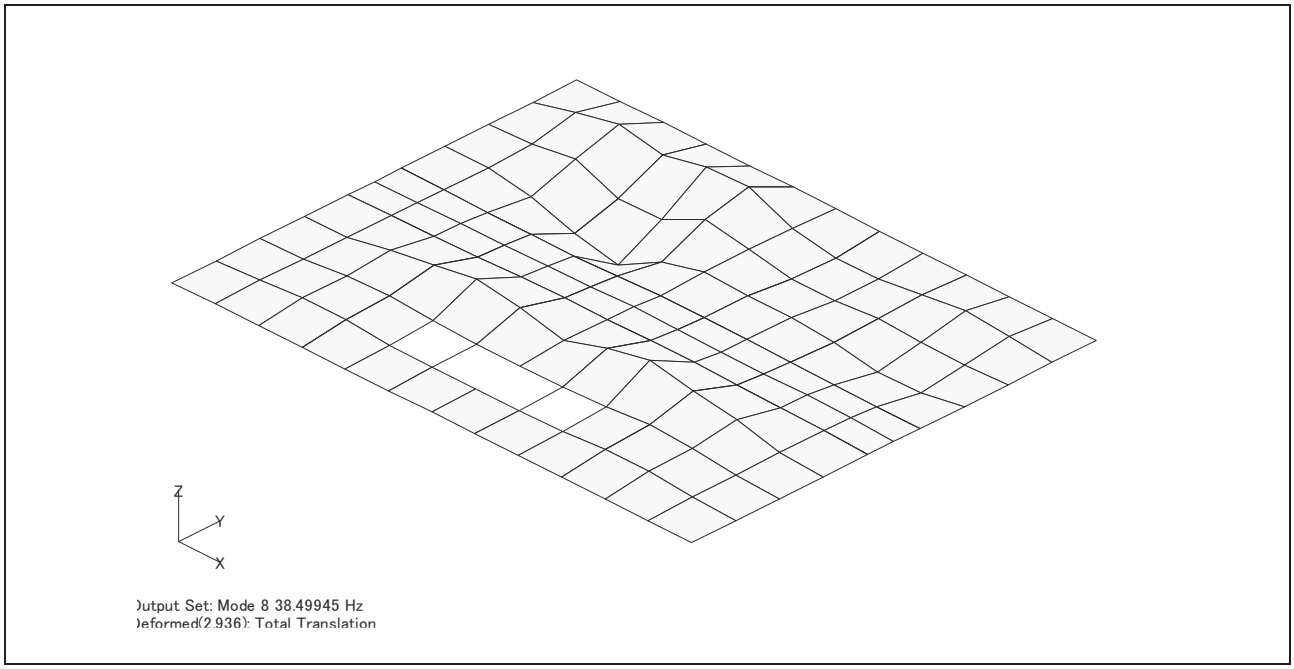


Figure 3.3.1.2-7b CB Slab Eigenvalue Analysis Result EL 9.06m 8th Mode 38.50 Hz

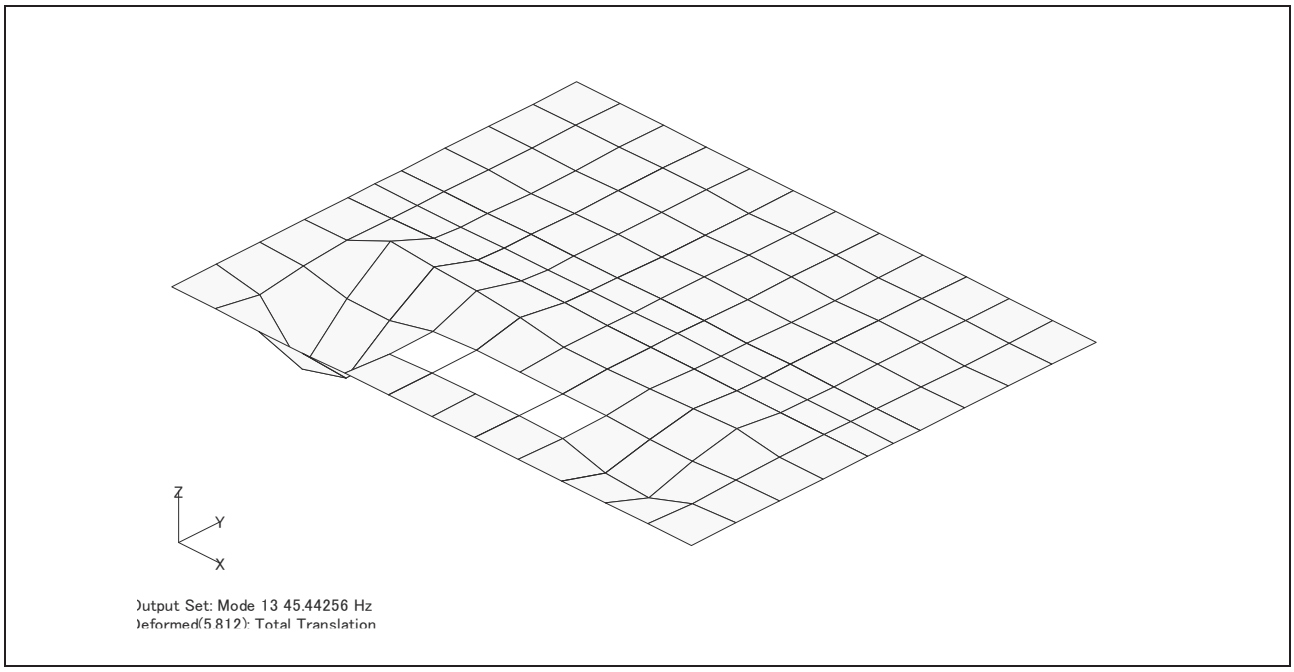


Figure 3.3.1.2-7c CB Slab Eigenvalue Analysis Result EL 9.06m 13th Mode 45.44 Hz

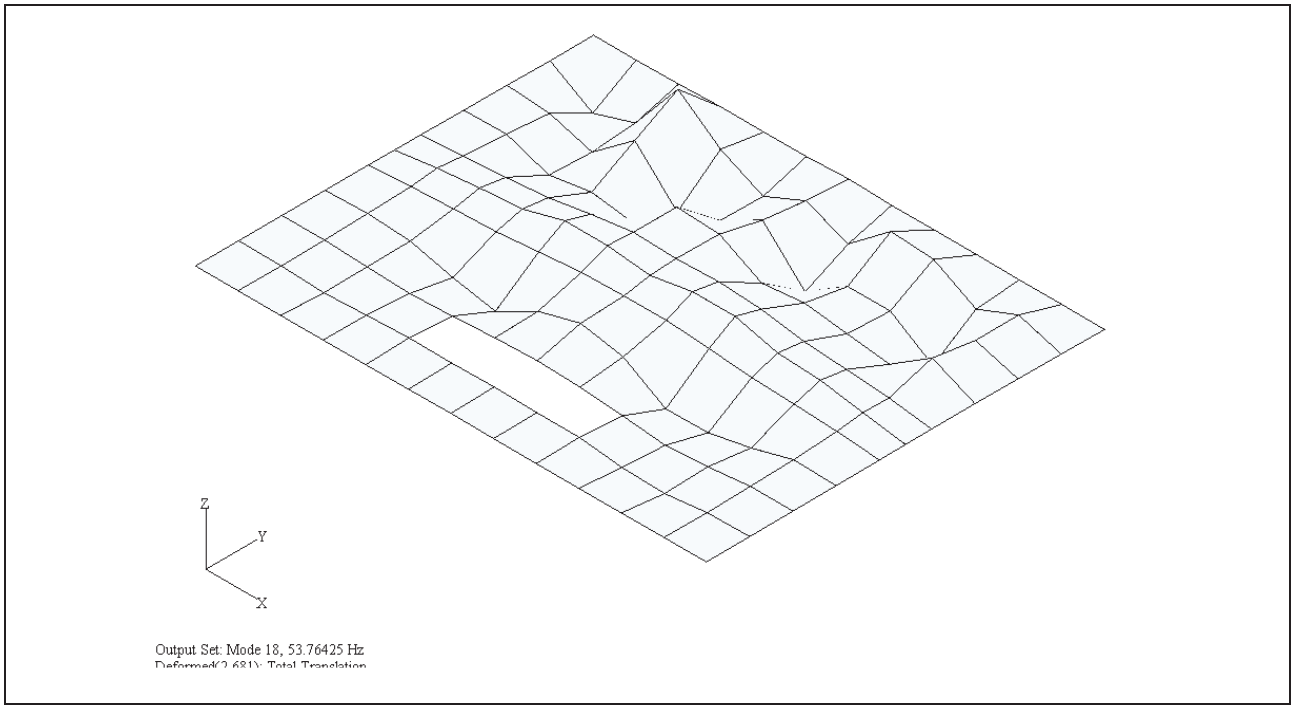


Figure 3.3.1.2-7d CB Slab Eigenvalue Analysis Result EL 9.06m 18th Mode 53.76 Hz

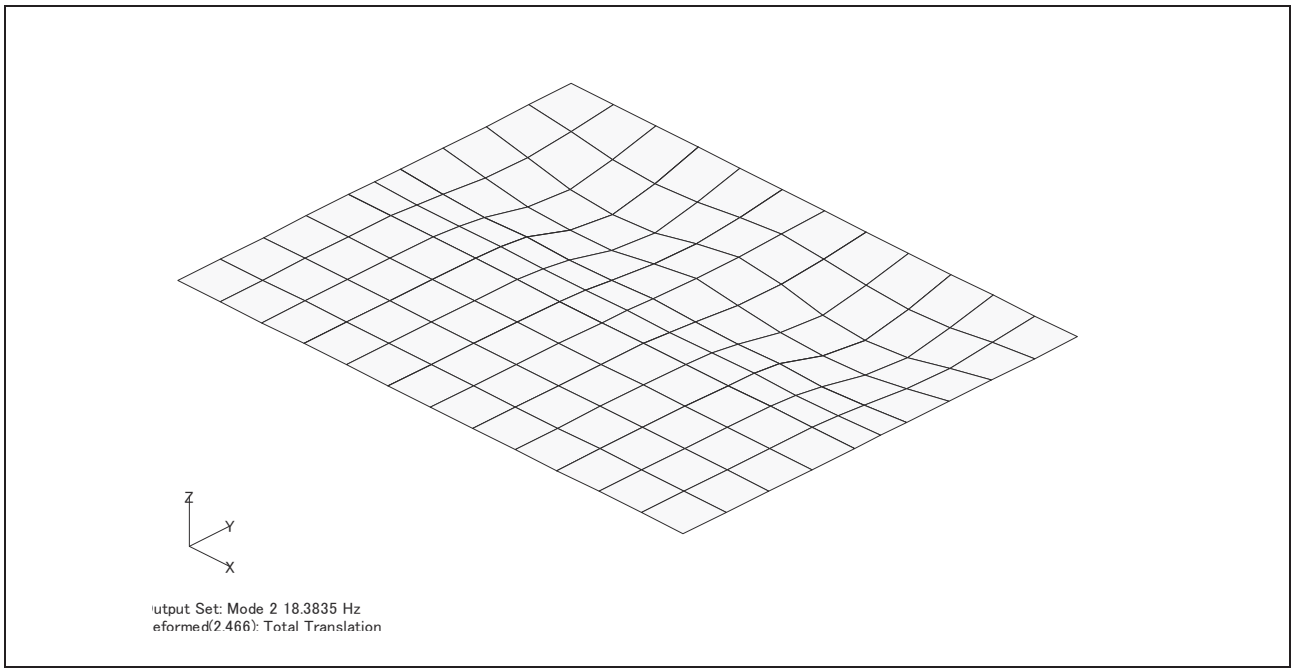


Figure 3.3.1.2-8a CB Slab Eigenvalue Analysis Result EL 13.80m 2nd Mode 18.38 Hz

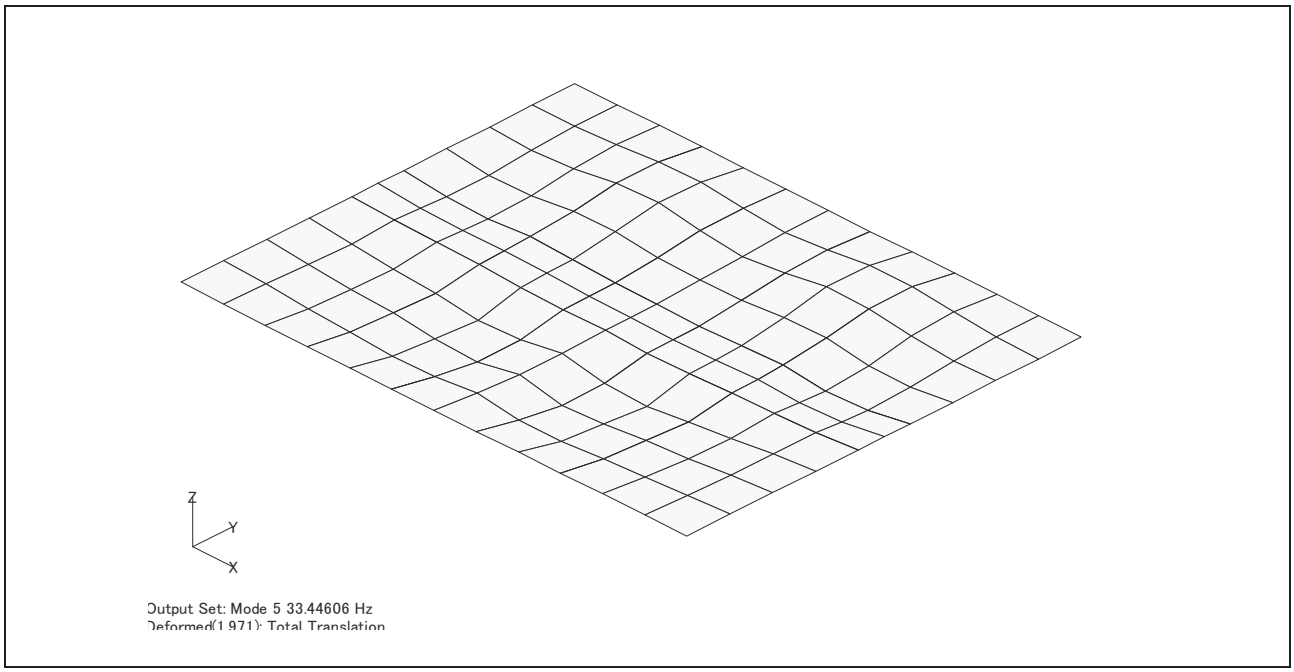


Figure 3.3.1.2-8b CB Slab Eigenvalue Analysis Result EL 13.80m 5th Mode 33.45 Hz

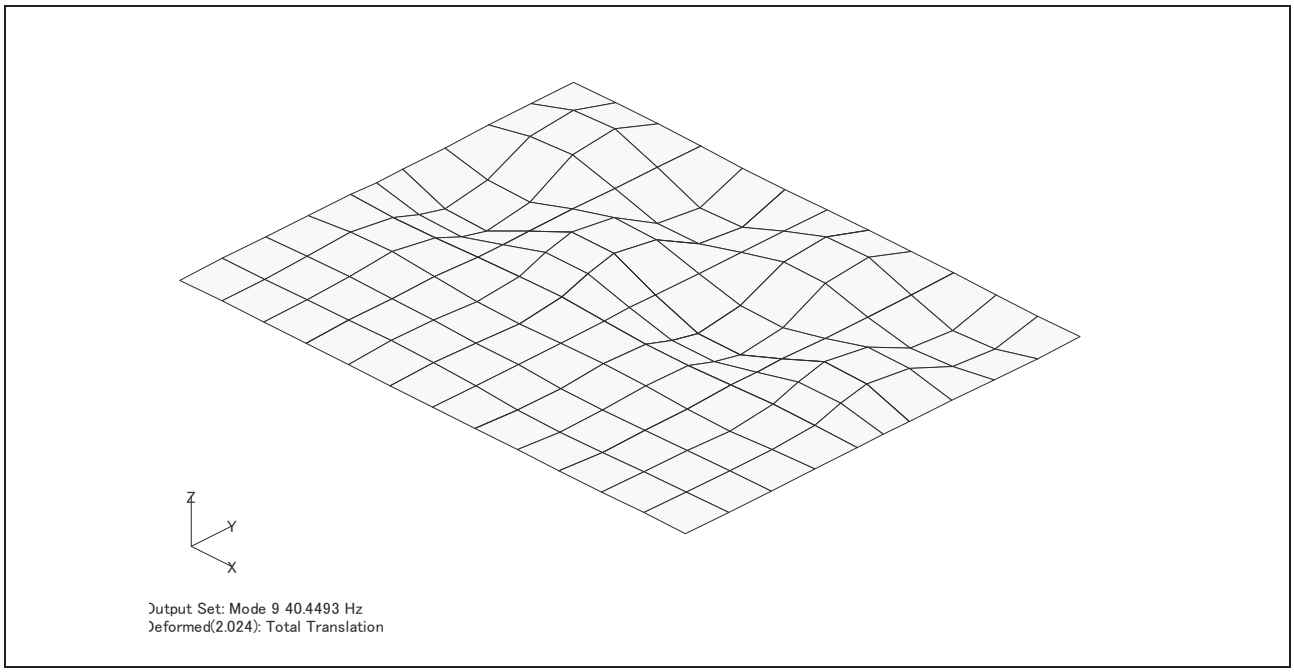


Figure 3.3.1.2-8c CB Slab Eigenvalue Analysis Result EL 13.80m 9th Mode 40.45 Hz

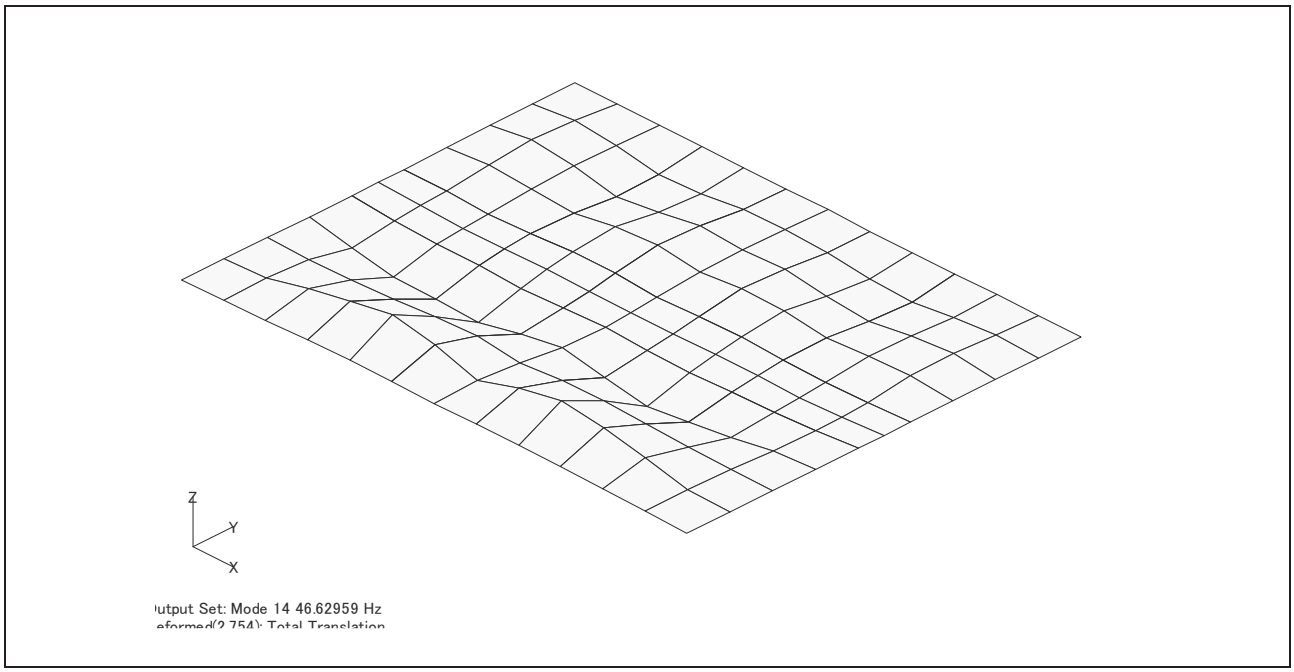


Figure 3.3.1.2-8d CB Slab Eigenvalue Analysis Result EL 13.80m 14th Mode 46.63 Hz

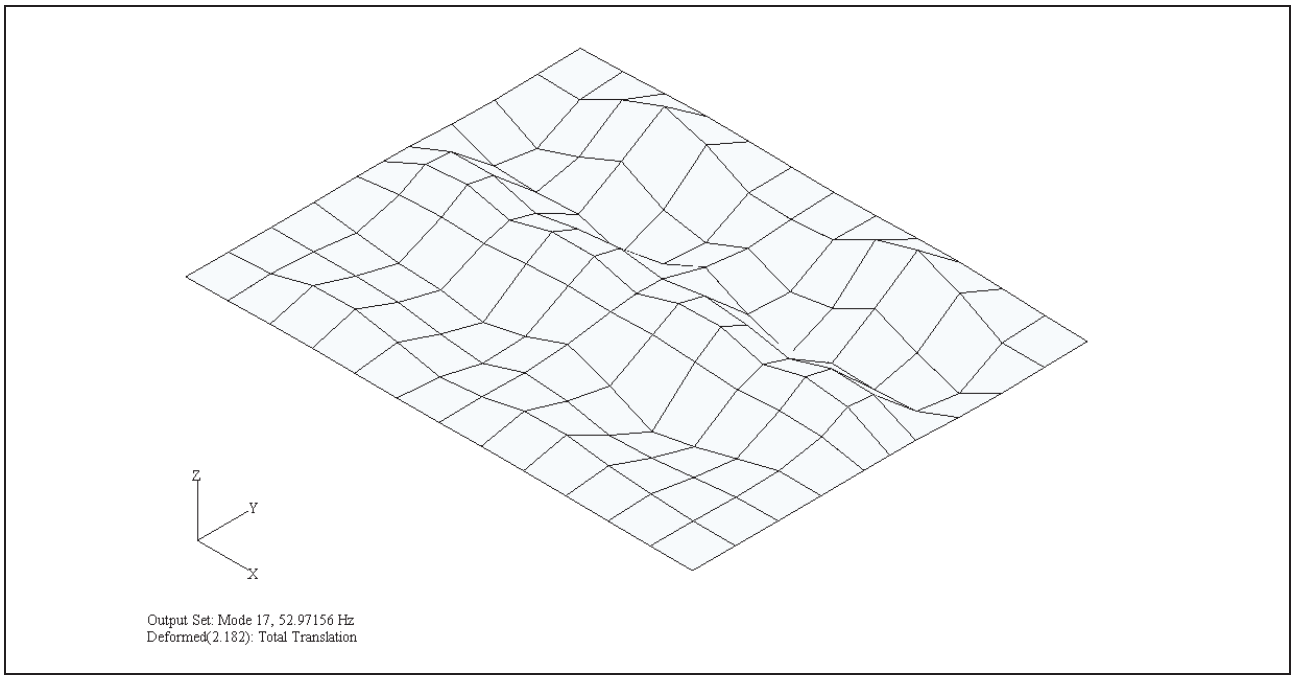


Figure 3.3.1.2-8e CB Slab Eigenvalue Analysis Result EL 13.80m 17th Mode 52.97 Hz

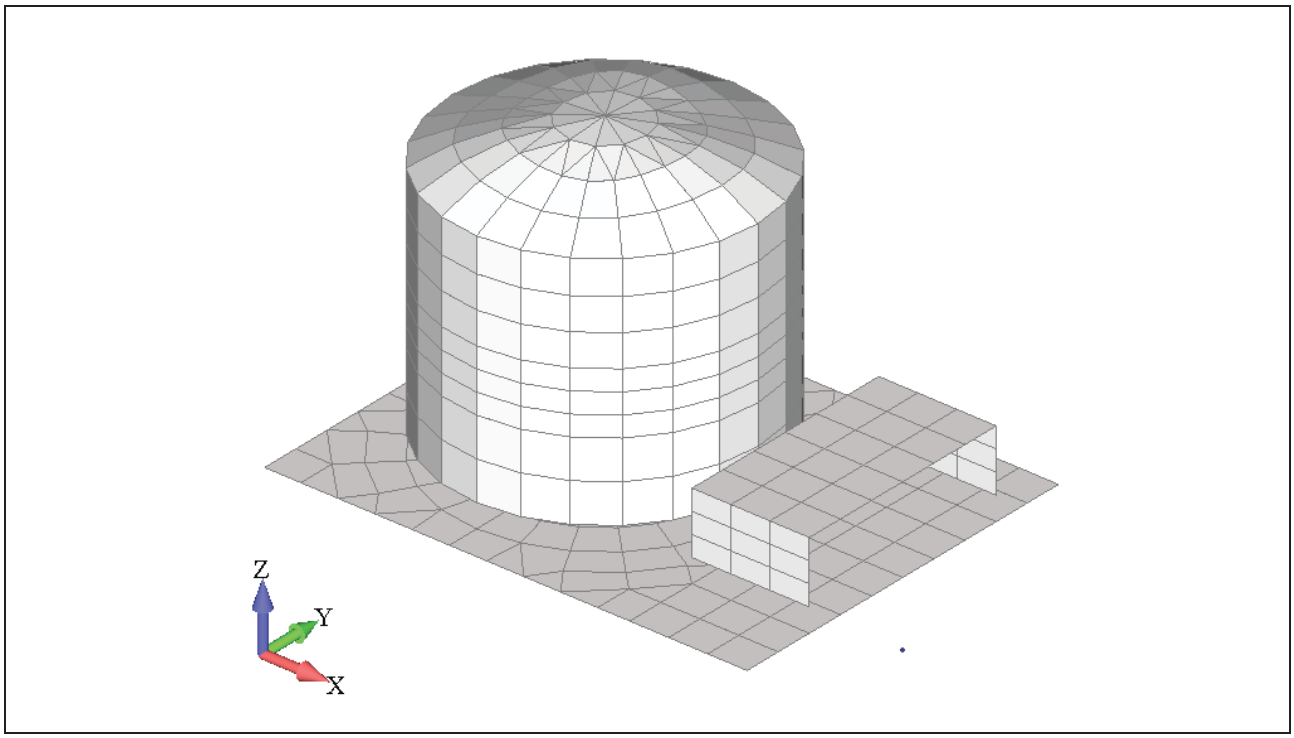


Figure 3.3.1.3-1 FE Model for Roof FWSC Roof Eigenvalue Analysis

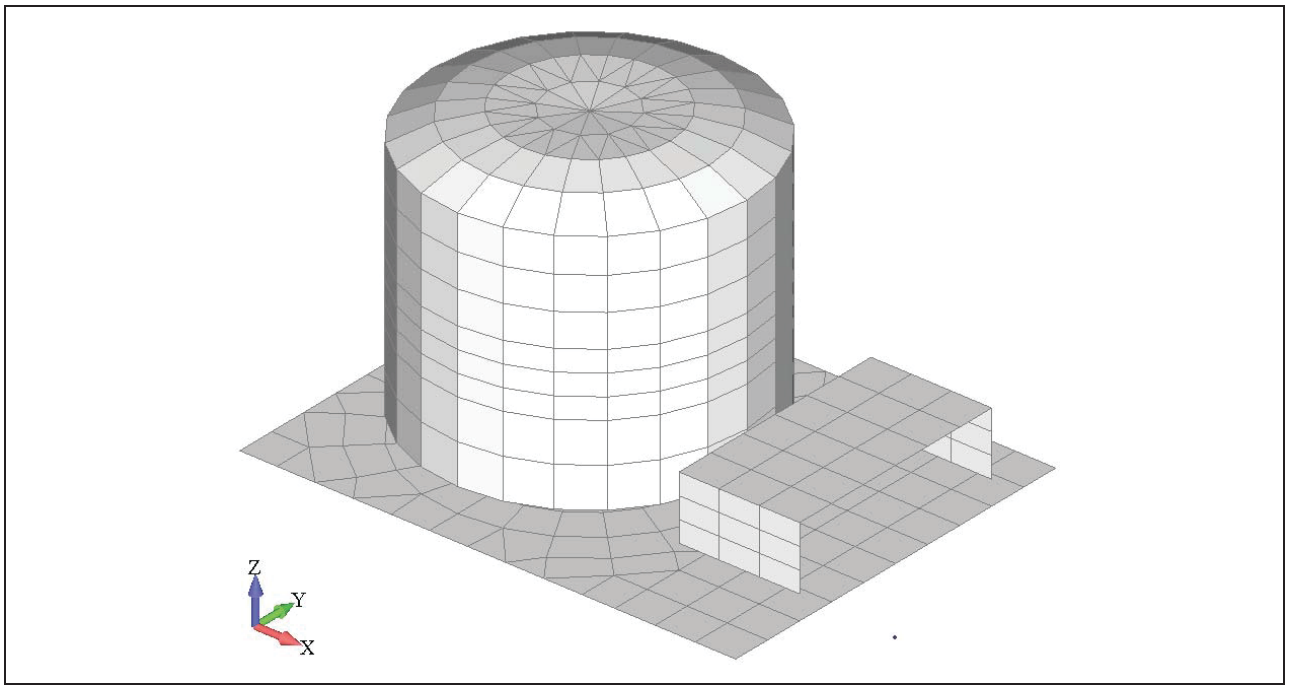


Figure 3.3.1.3-2a FWSC Roof Eigenvalue Analysis Result 4th Mode 35.76Hz (FWS)

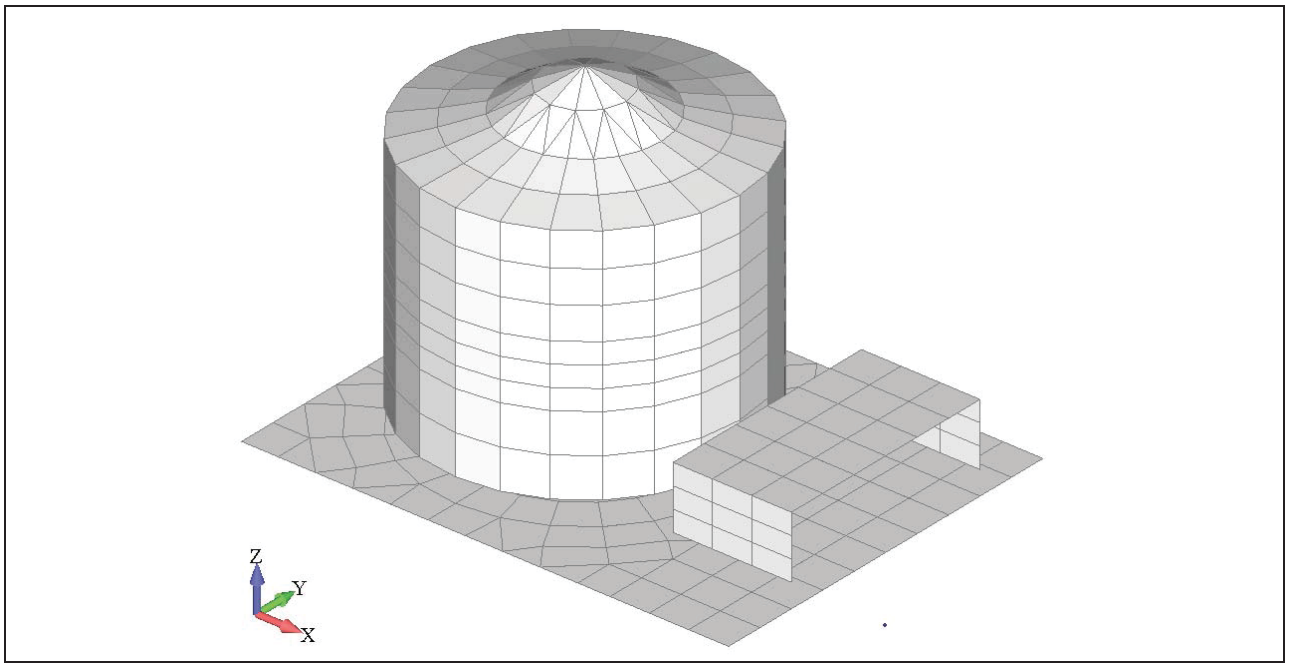


Figure 3.3.1.3-2b FWSC Roof Eigenvalue Analysis Result 8th Mode 50.02Hz (FWS)

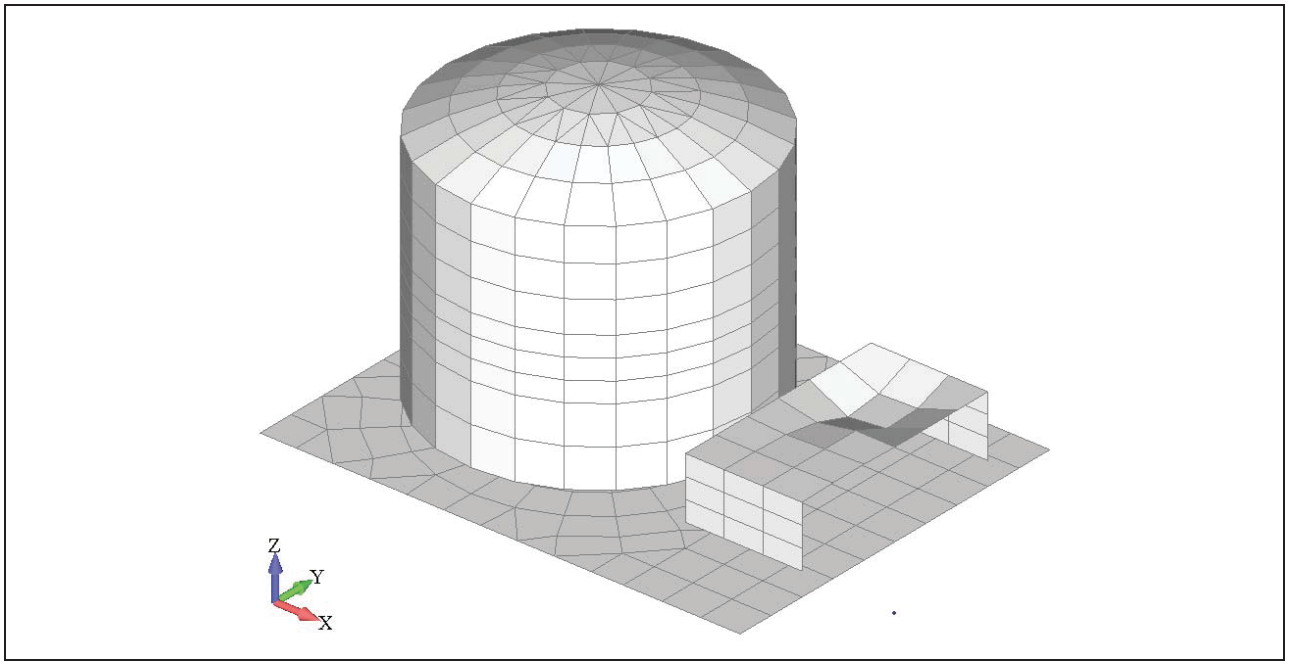


Figure 3.3.1.3-3 FWSC Roof Slab Eigenvalue Analysis Result 2nd Mode 54.02Hz (FPE)

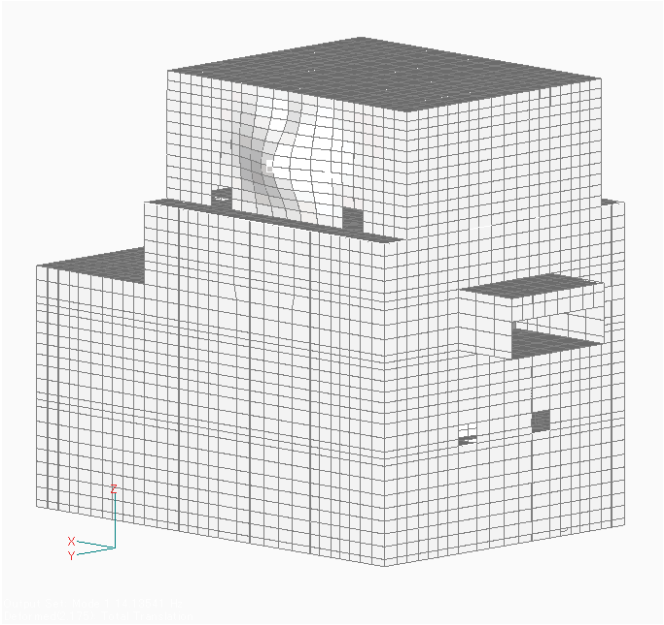


Figure 3.3.2.1-1a Eigenvalue Analysis Result for RB Walls above EL 34.00m 1st Mode 14.14Hz

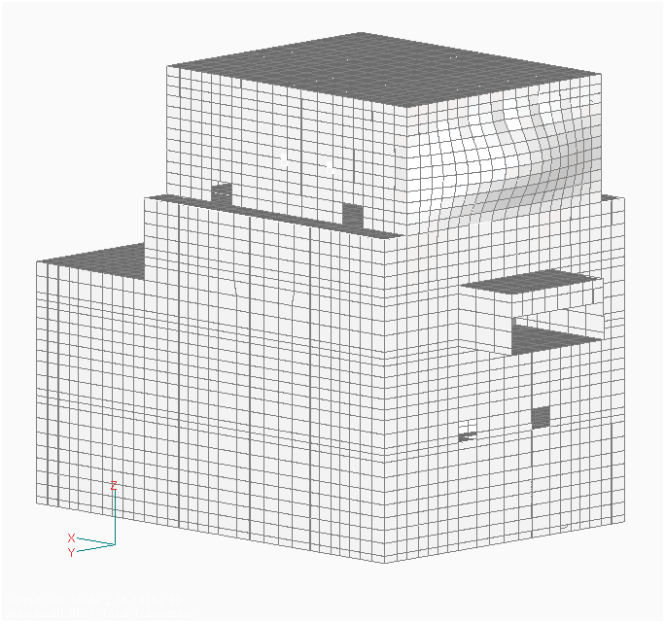


Figure 3.3.2.1-1b Eigenvalue Analysis Result for RB Walls above EL 34.00m 2nd Mode 15.14Hz

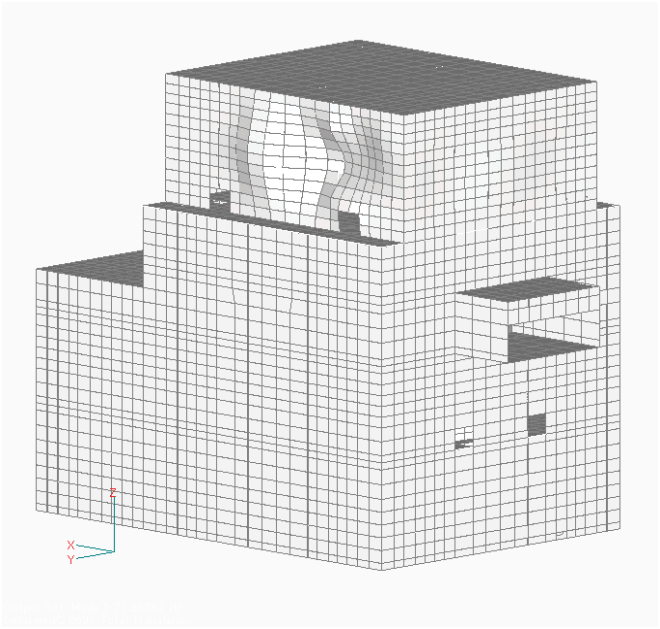


Figure 3.3.2.1-1c Eigenvalue Analysis Result for RB Walls above EL 34.00m 5th Mode 21.88Hz

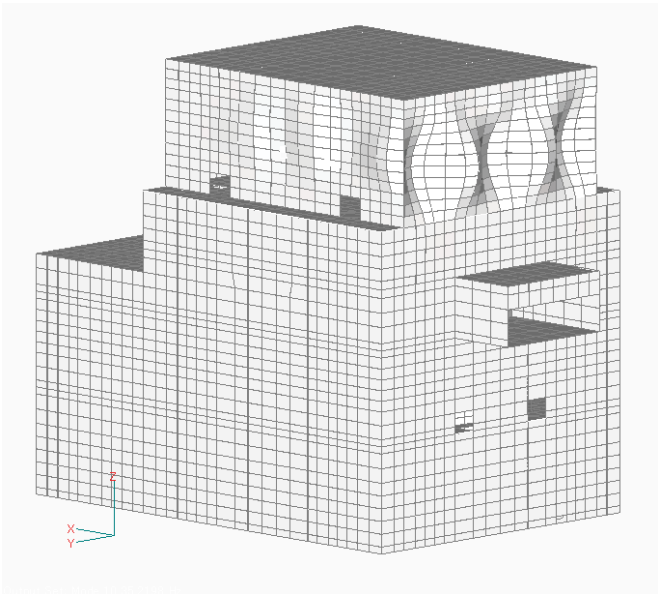


Figure 3.3.2.1-1d Eigenvalue Analysis Result for RB Walls above EL 34.00m 10th Mode 35.22Hz

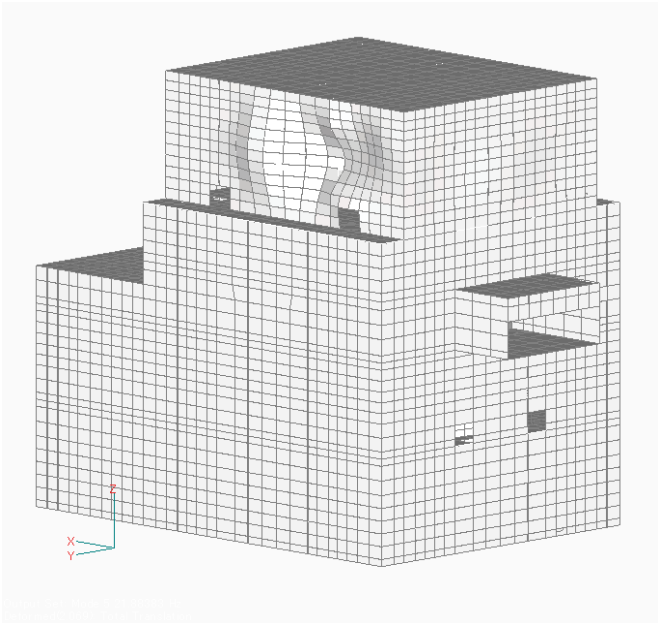


Figure 3.3.2.1-1e Eigenvalue Analysis Result for RB Walls above EL 34.00m 21st Mode 48.01Hz

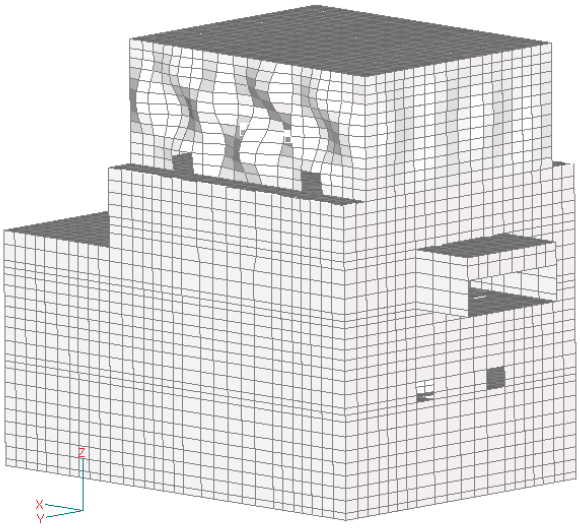


Figure 3.3.2.1-1f Eigenvalue Analysis Result for RB Walls above EL 34.00m 28th Mode 60.88Hz

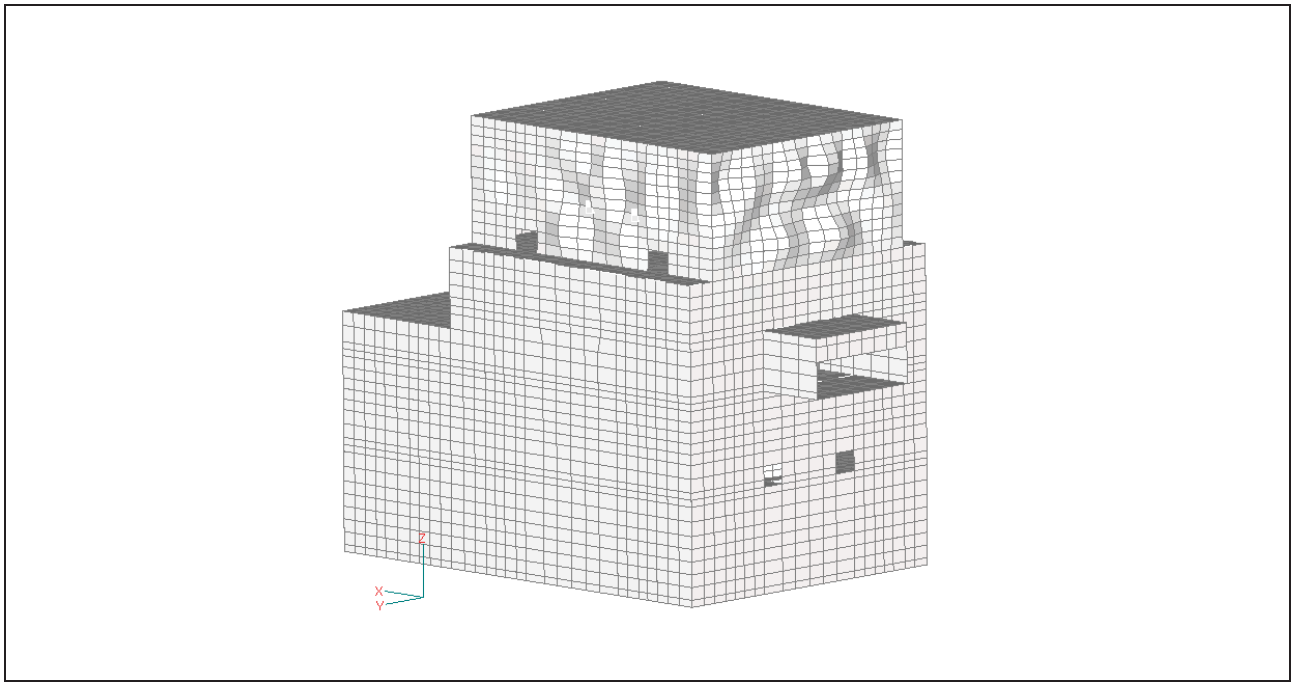


Figure 3.3.2.1-1g Eigenvalue Analysis Result for RB Walls above EL 34.00m 34st Mode 68.72Hz

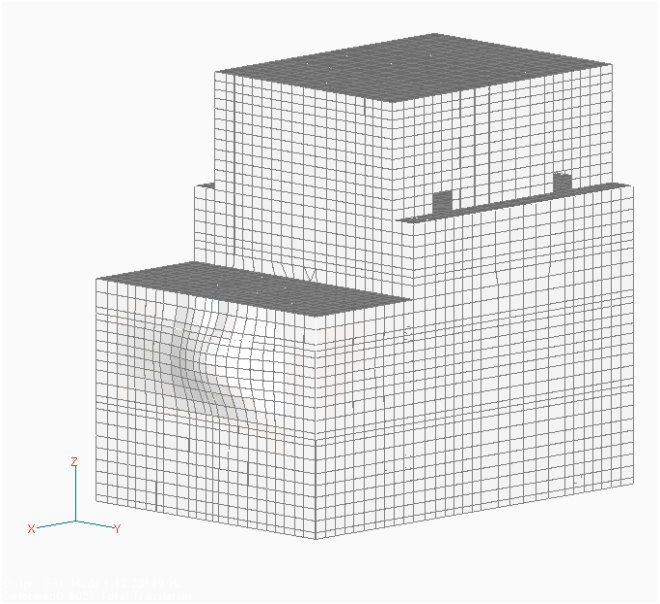


Figure 3.3.2.1-2a Eigenvalue Analysis Result for FB Walls above EL 4.65m 1st Mode 12.73Hz

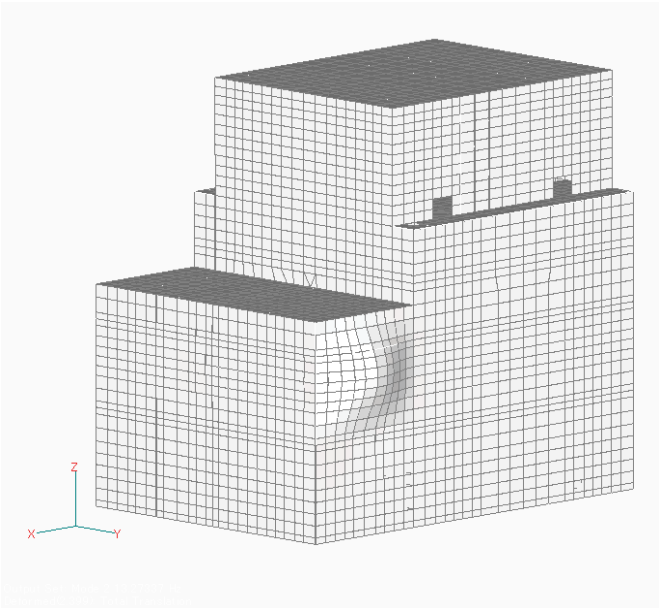


Figure 3.3.2.1-2b Eigenvalue Analysis Result for FB Walls above EL 4.65m 2nd Mode 13.27Hz

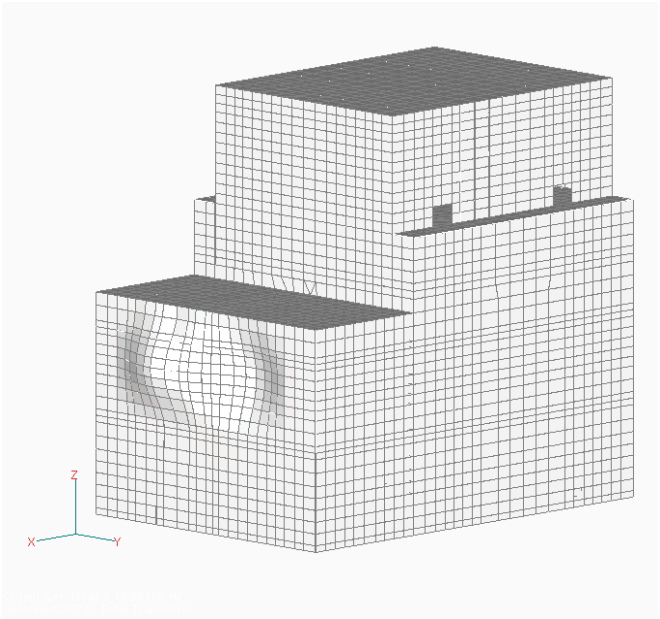


Figure 3.3.2.1-2c Eigenvalue Analysis Result for FB Walls above EL 4.65m 3rd Mode 15.98Hz

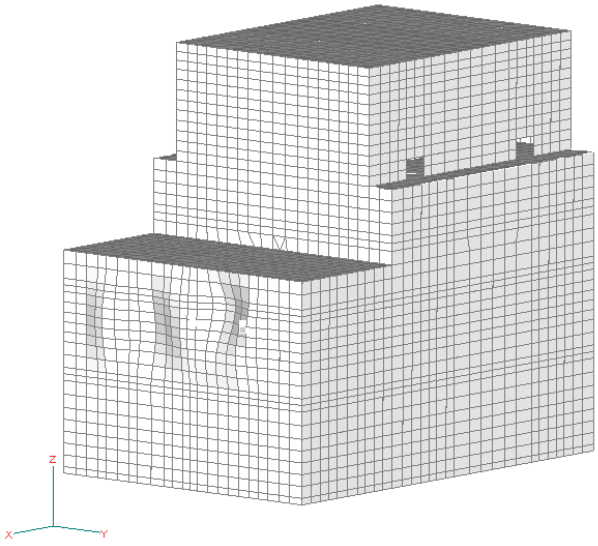


Figure 3.3.2.1-2d Eigenvalue Analysis Result for FB Walls above EL 4.65m 9th Mode 35.79Hz

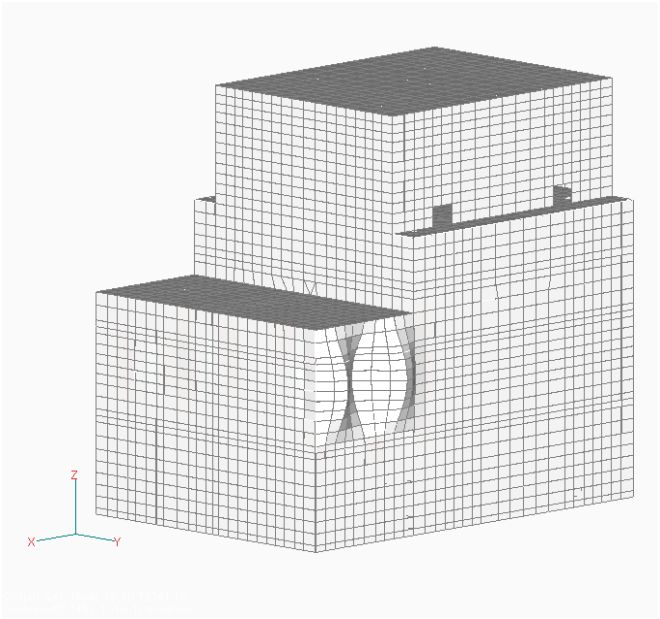


Figure 3.3.2.1-2e Eigenvalue Analysis Result for FB Walls above EL 4.65m 13th Mode 40.73Hz

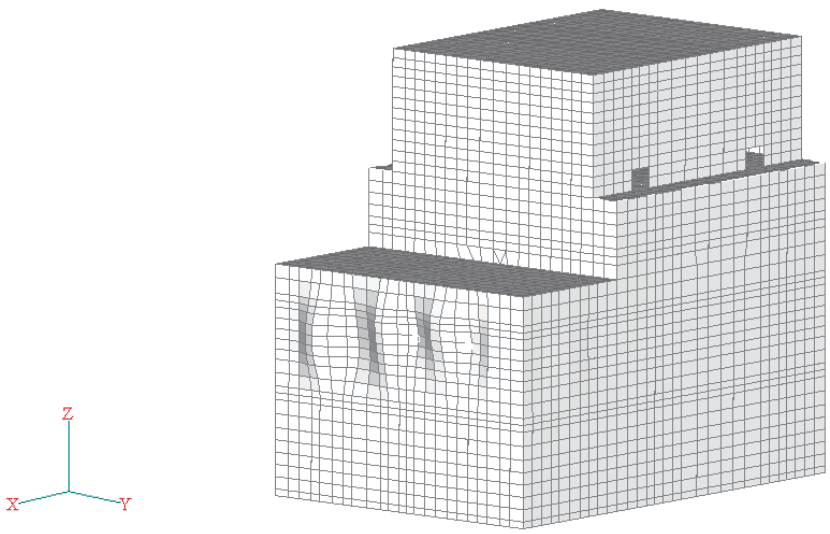


Figure 3.3.2.1-2f Eigenvalue Analysis Result for FB Walls above EL 4.65m 14th Mode 42.50Hz

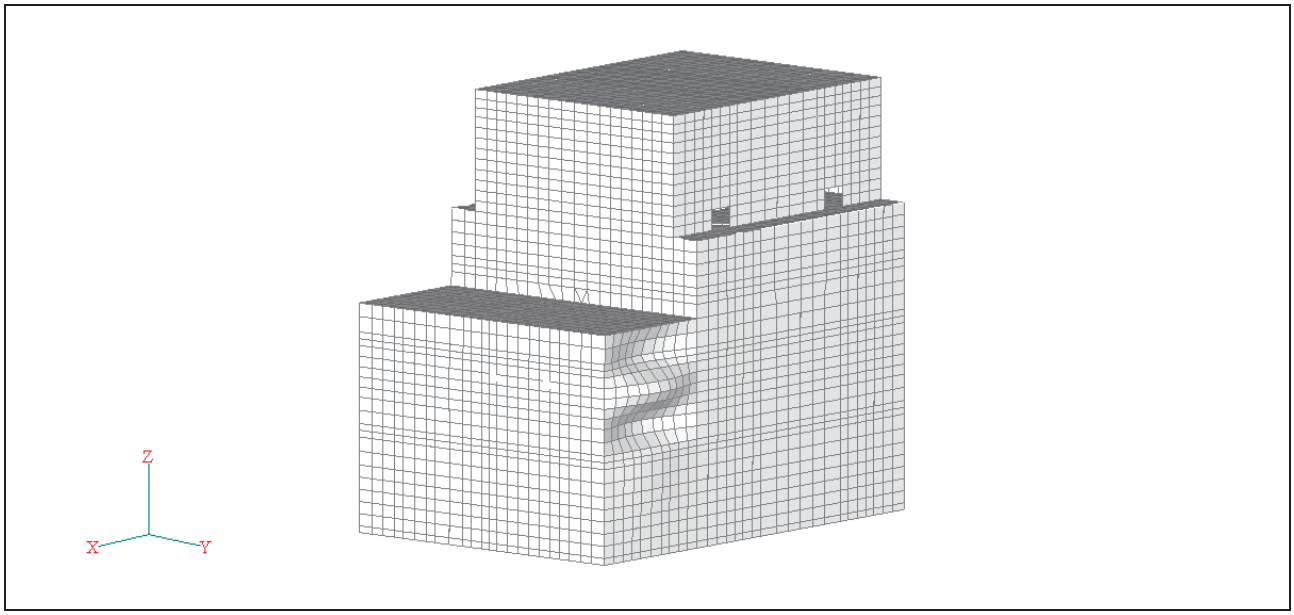


Figure 3.3.2.1-2g Eigenvalue Analysis Result for FB Walls above EL 4.65m 17th Mode 54.20Hz

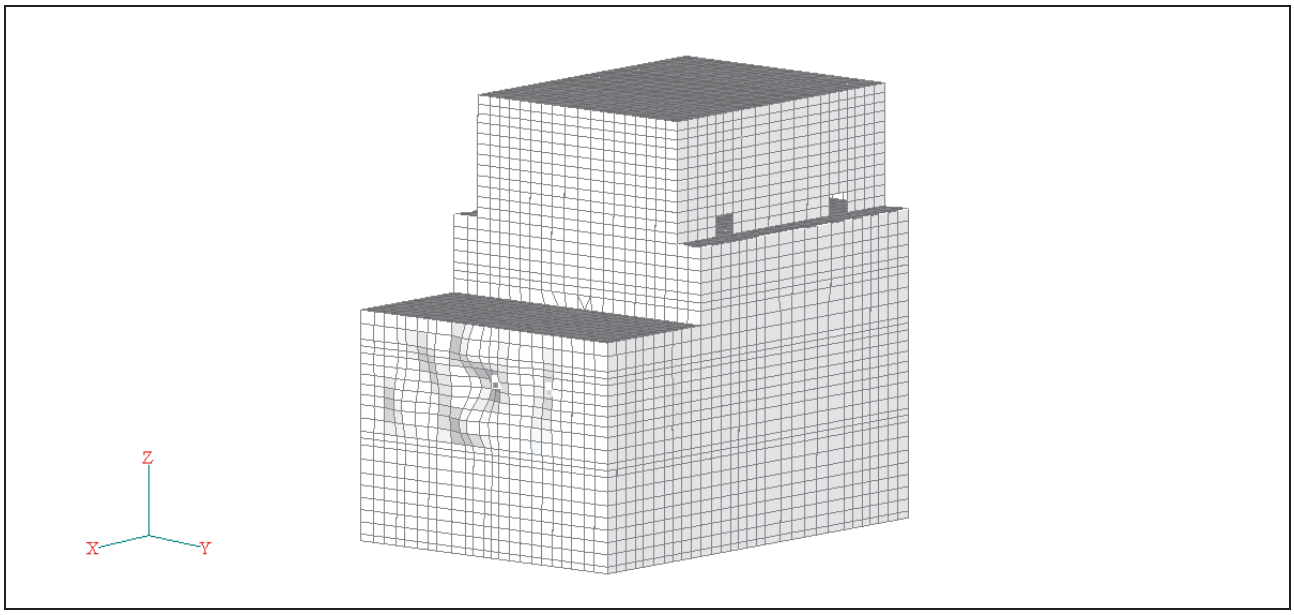


Figure 3.3.2.1-2h Eigenvalue Analysis Result for FB Walls above EL 4.65m 24th Mode 63.86Hz

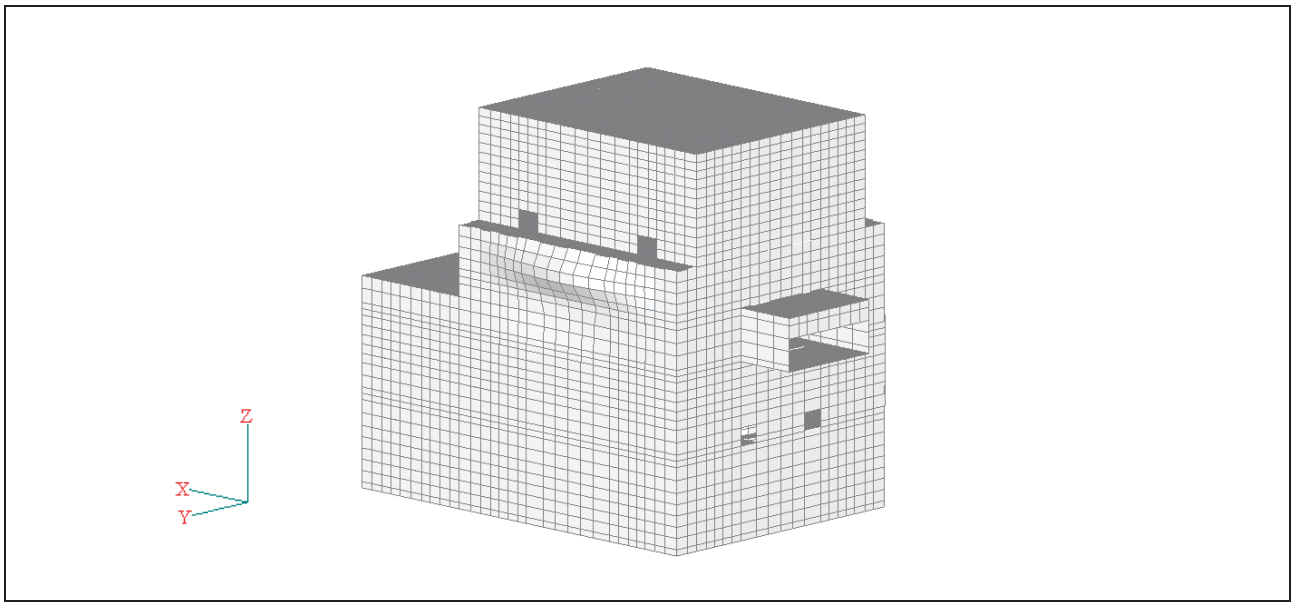


Figure 3.3.2.1-3a Eigenvalue Analysis Result for FB Walls above EL 27.00m 1st Mode 44.37Hz

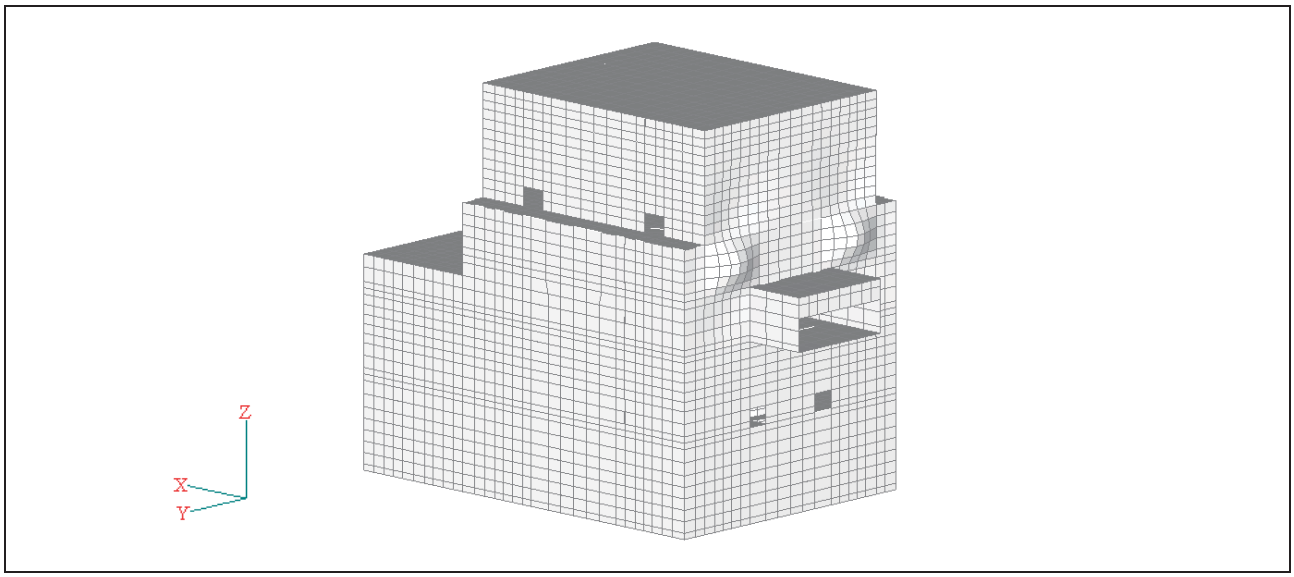


Figure 3.3.2.1-3b Eigenvalue Analysis Result for FB Walls above EL 27.00m 6th Mode 59.71Hz

Figure 3.4.1-1 Region of Floor Slab Vertical Responses EL -6.40m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-2 Region of Floor Slab Vertical Responses EL -1.00m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-3 Region of Floor Slab Vertical Responses EL 4.65m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-4 Region of Floor Slab Vertical Responses EL 9.06m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-5 Region of Floor Slab Vertical Responses EL 13.57m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-6 Region of Floor Slab Vertical Responses EL 17.50m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-7 Region of Floor Slab Vertical Responses EL 22.50m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-8 Region of Floor Slab Vertical Responses EL 27.00m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-9 Region of Floor Slab Vertical Responses EL 34.00m

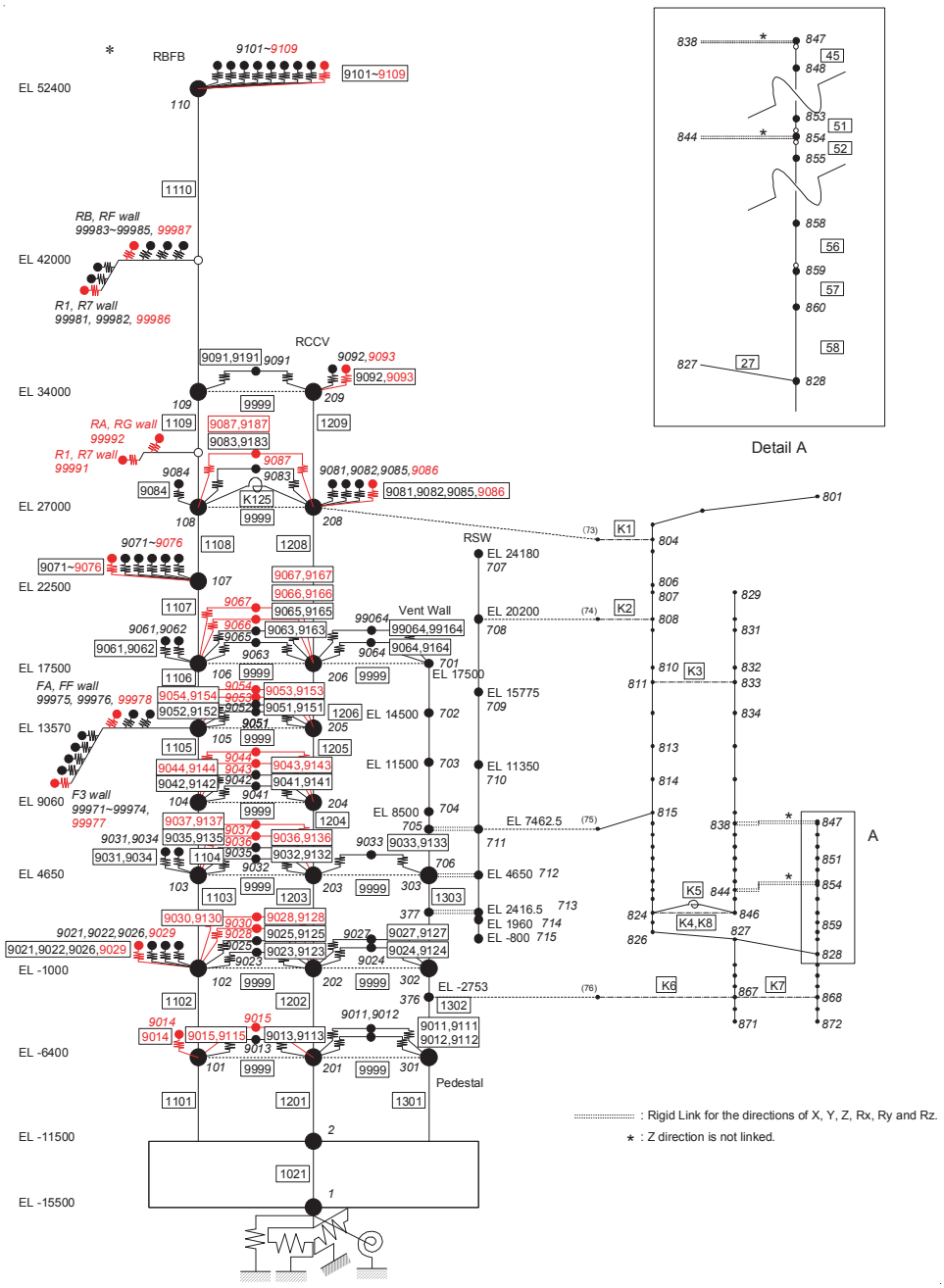
{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-10 Region of Floor Slab Vertical Responses EL 52.40m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.1-11 Region of Out-of-Plane Wall Responses South Elevation

Figure 3.4.1-12 Region of Out-of-Plane Wall Responses East Elevation



*: The difference between the modeled elevation 52.4 m and the actual elevation 52.7 m at the RB roof is negligibly small.

Note: Slab oscillator node 99064 is only for the model considering 0% of infill concrete stiffness of the vent wall and diaphragm floor.

Figure 3.4.1-13 RB/FB Seismic Analysis Stick Model

Figure 3.4.2-1 Region of Floor Slab Vertical Responses EL -2.00m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.2-2 Region of Floor Slab Vertical Responses EL 4.65m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.2-3 Region of Floor Slab Vertical Responses EL 9.06m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

Figure 3.4.2-4 Region of Floor Slab Vertical Responses EL 13.80m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}

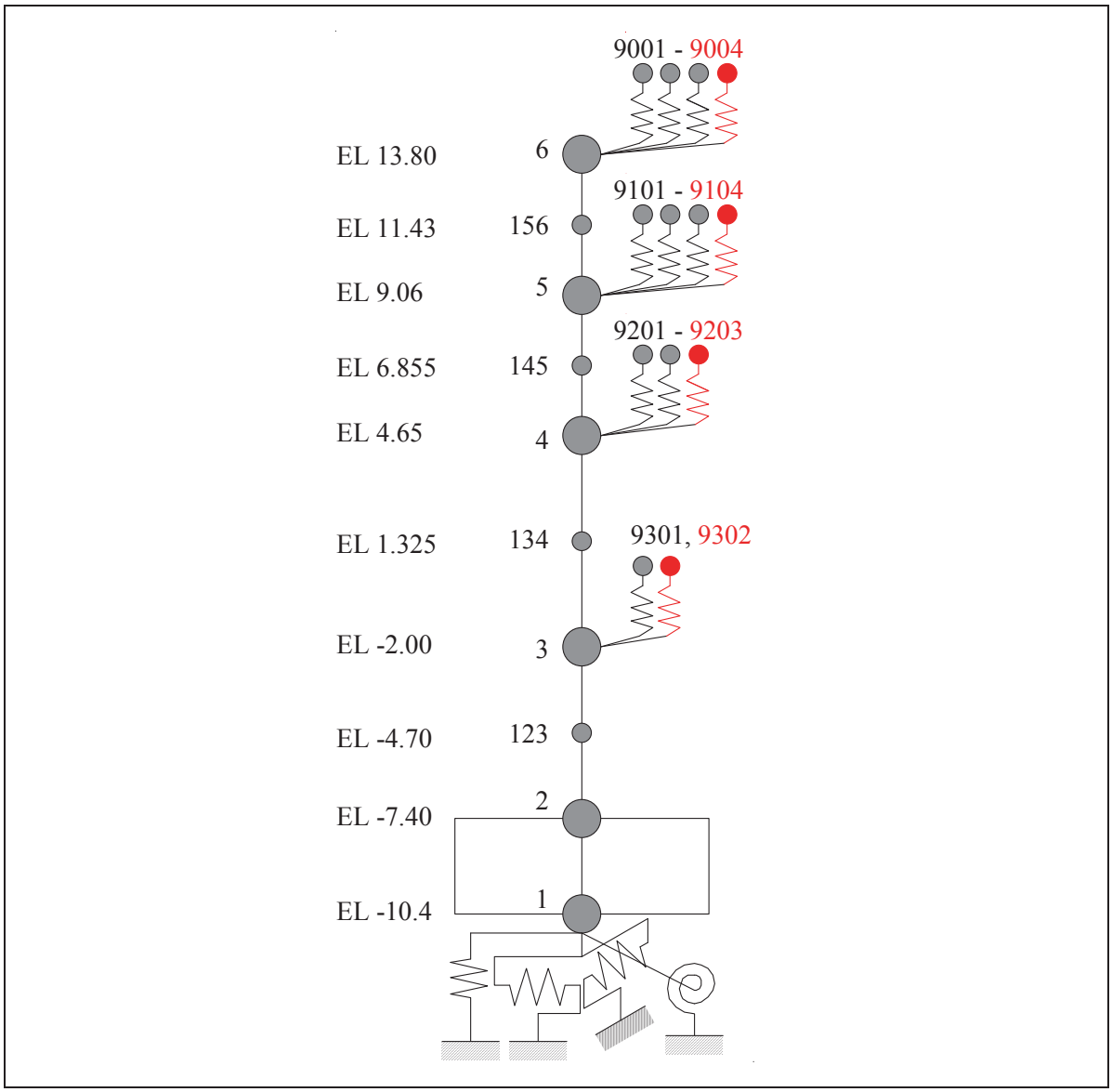
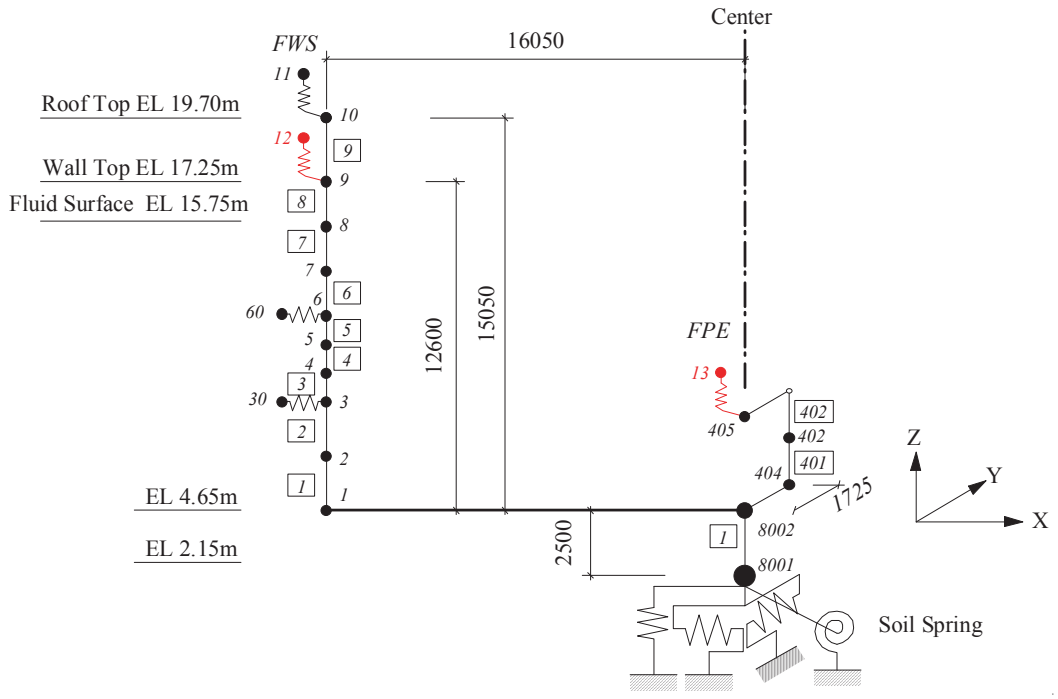


Figure 3.4.2-5 CB Seismic Analysis Stick Model

Figure 3.4.3-1 Region of Floor Slab Vertical Responses EL 13.80m

{{{Security Related Information - withheld Under 10 CFR 2.390}}}



Mass at Node 30 represents the impulsive mode.
Mass at Node 60 represents the fundamental sloshing (convective) mode.
The model is assumed to be symmetric about YZ-plane including the center line.

Figure 3.4.3-2 FWSC Seismic Analysis Stick Model

APPENDIX A
Additional Boundary Conditions in RB/FB Wall Eigenvalue Analysis Model

TABLE OF CONTENTS

LIST OF FIGURES

A.1 SCOPE

This Appendix describes the boundary conditions of RB/FB FE model added to the model used for standard design, Reference 2-b in order to decouple out-of-plane vibrations of the walls from the in-plane vibrations.

A.2 ADDITIONAL BOUNDARY CONDITIONS

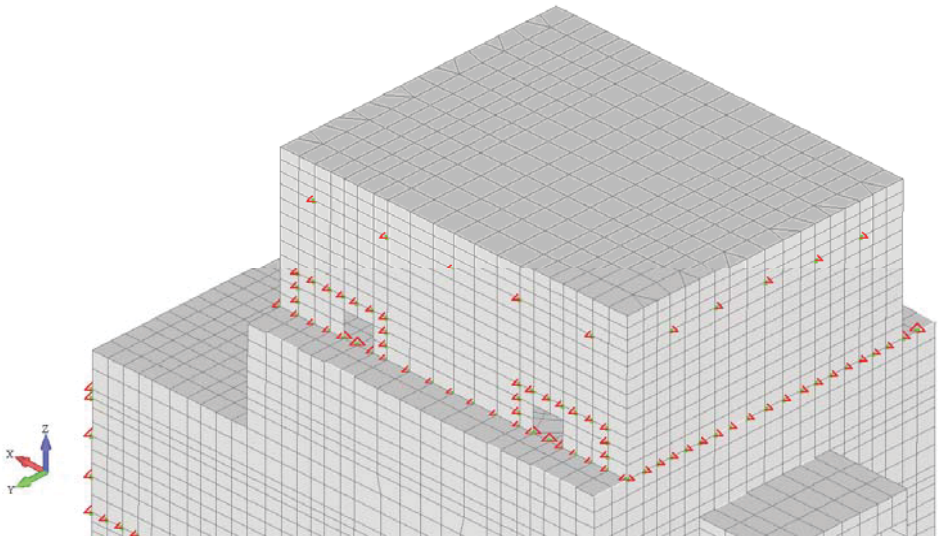
Boundary conditions assigned to the FE models used for eigenvalue analysis of RB/FB walls in standard design, Reference 2-b are shown in Figure A.2-1. As shown in Figure A.2-1, the walls are fixed only at the point of beam support and the bottom of walls. As shown in Figure A.2-2, the model with these boundary conditions yielded modes with frequencies higher than 50 Hz that besides the out-of-plane vibration of the particular wall also excite the in-plane vibrations of slabs and walls orthogonal to the wall of interest capturing the mass of the wall otherwise associated with rigid-body motion of the wall.

For NA3, to capture only out-of-plane vibrations of interest wall, constrains are added to the FE model of RB/FB walls. The revised FE models for the eigenvalue analysis of RB/FB walls presented in this calculation are shown in Figure A.2-3. As shown in Figure A.2-4, for frequencies higher than 50 Hz, in-plane vibrations of orthogonal slab and orthogonal wall are decoupled from the out-of-plane wall vibrations.

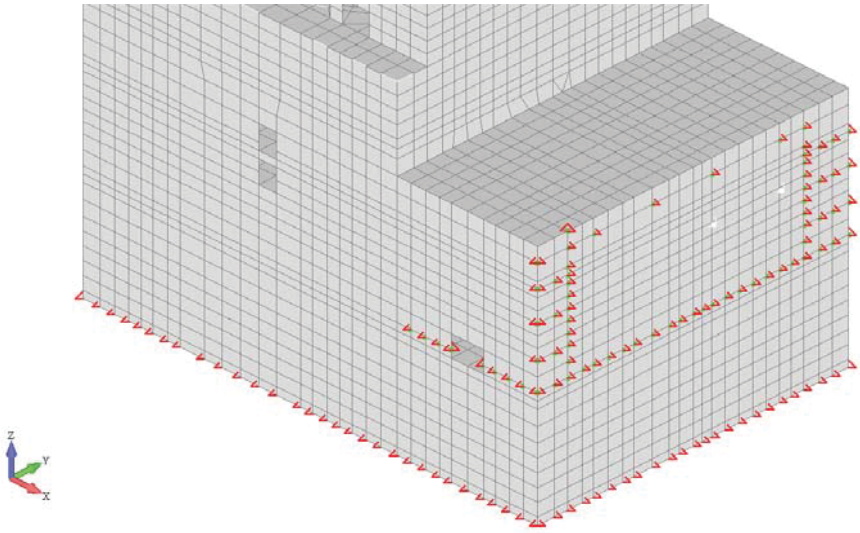
A.3 EFFECT OF ADDITIONAL BOUNDARY CONDITIONS ON MODAL EFFECTIVE MASS

For RB/FB wall oscillators which represent the out-of-wall vibration below 50 Hz, same properties as described in standard design, Reference 2-b, are applied for NA3. Figures A.2-5 and A.2-6 show the comparisons of the cumulative mass participation between the presence and absence of the additional boundary conditions for RB wall above EL 34.0m and FB wall above 4.65m, respectively.

As shown in Figures A.2-5 and A.2-6, revised models with additional boundary conditions for NA3 yields results for modes up to 50 Hz close to those obtained from the original model for standard design. Since the differences become obvious for modes after 50 Hz, in-plane vibrations of RB/FB wall for the original models for standard design affect the modes above 50 Hz.



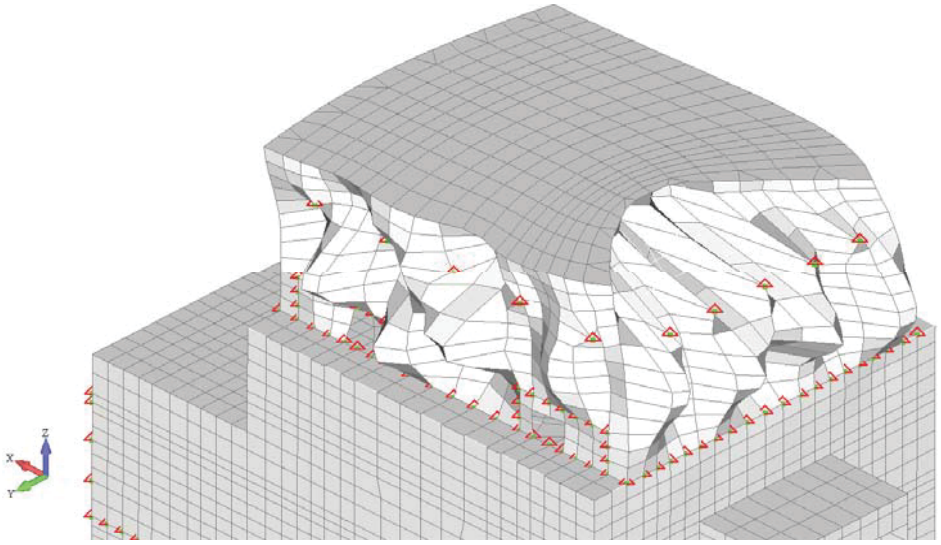
(a) RB Walls above EL 34.0 m



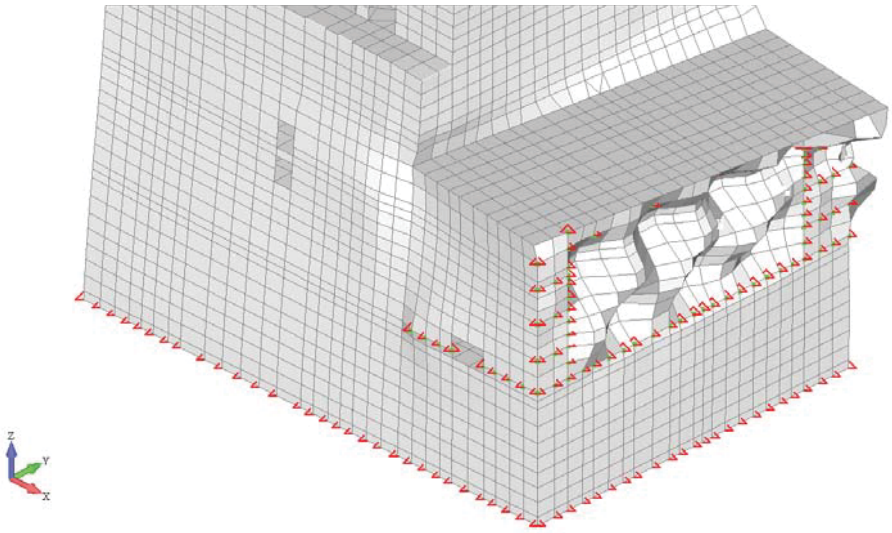
(b) FB Walls above EL 4.65 m

Note: Triangular symbols represent pin support (X, Y and Z translational displacements are fixed but XX, YY and ZZ rotations are not fixed) except for basemat. For basemat, displacement for all directions including rotation are fixed.

Figure A.2-1 Boundary Condition of FE Model of RB/FB Wall for Standard Design



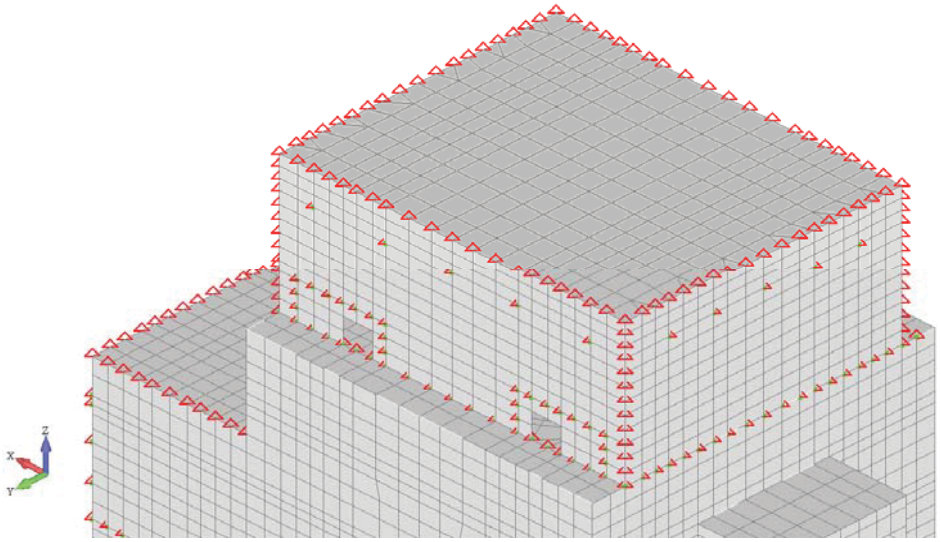
(a) RB Walls above EL 34.0 m (x10 of Scale Factor) at 59.01 Hz



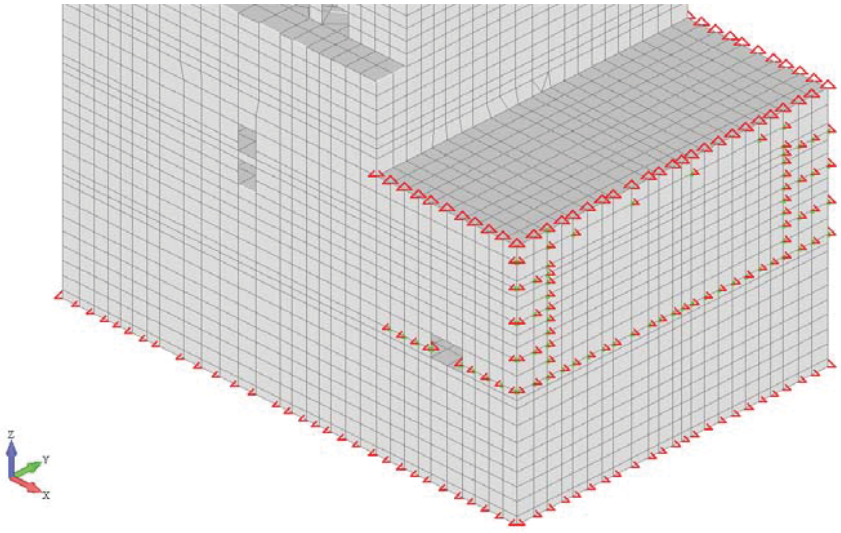
(b) FB Walls above EL 4.65 m (x5 of Scale Factor) at 66.88 Hz

Note: Triangular symbols represent pin support (X, Y and Z translational displacements are fixed but XX, YY and ZZ rotations are not fixed) except for basemat. For basemat, displacement for all directions including rotation are fixed.

Figure A.2-2 Mode Shape of FE Model of RB/FB Wall for Standard Design



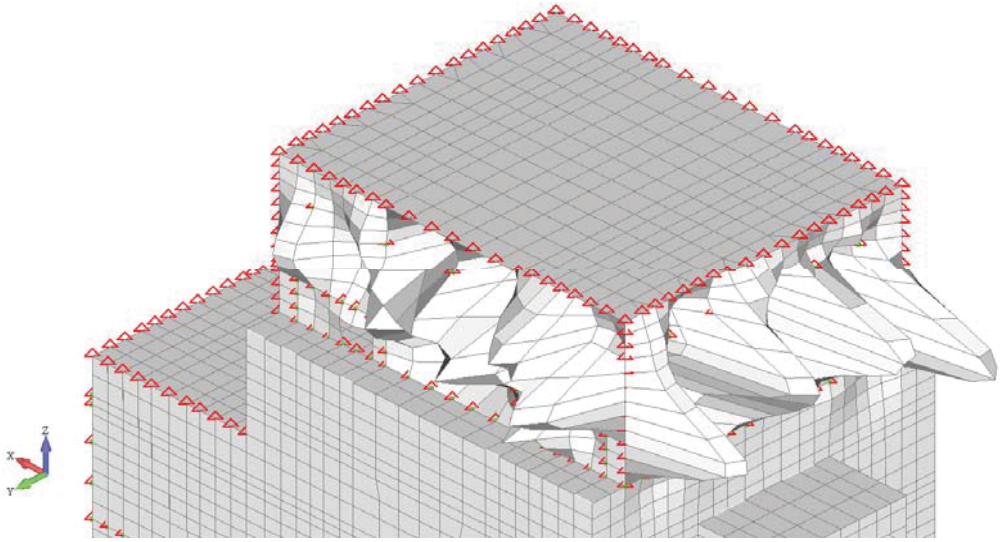
(a) RB Walls above EL 34.0 m



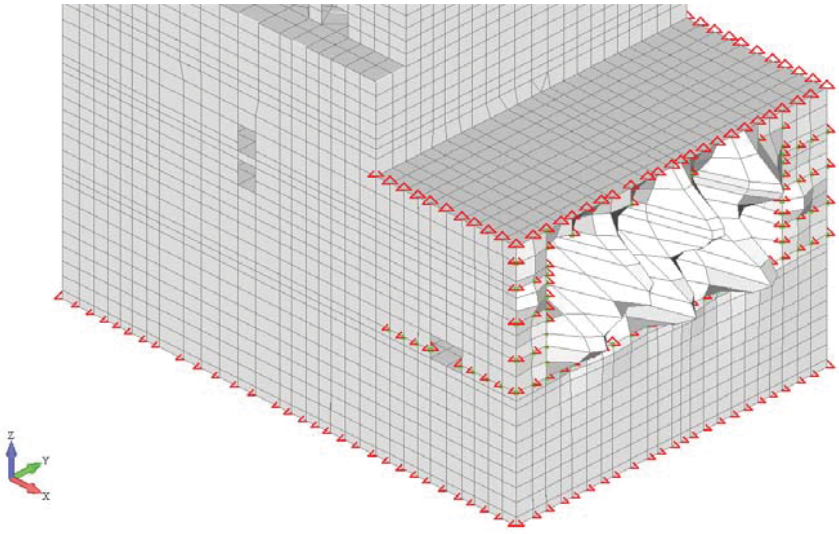
(b) FB Walls above EL 4.65 m

Note: Triangular symbols represent pin support (X, Y and Z translational displacements are fixed but XX, YY and ZZ rotations are not fixed) except for basemat. For basemat, displacement for all directions including rotation are fixed.

Figure A.2-3 Boundary Condition of FE Model of RB/FB Wall for NA3



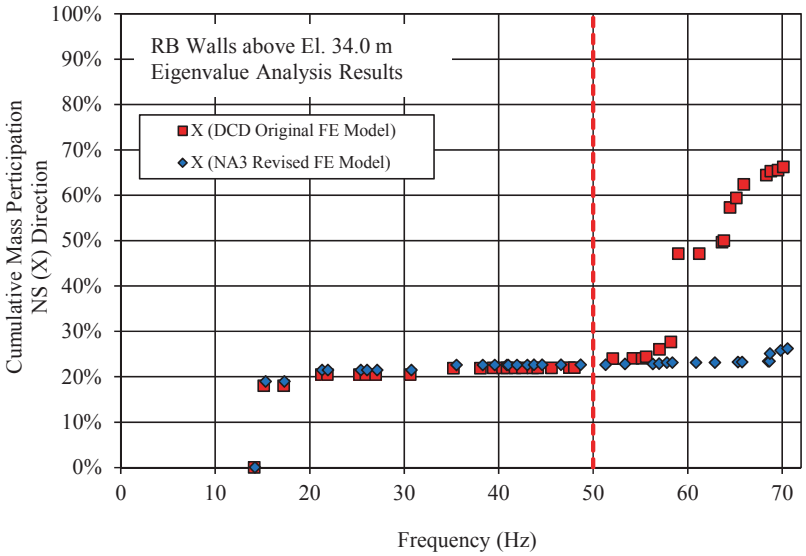
(a) RB Walls above EL 34.0 m (x10 of Scale Factor) at 57.8 Hz



(b) FB Walls above EL 4.65 m (x5 of Scale Factor) at 66.75 Hz

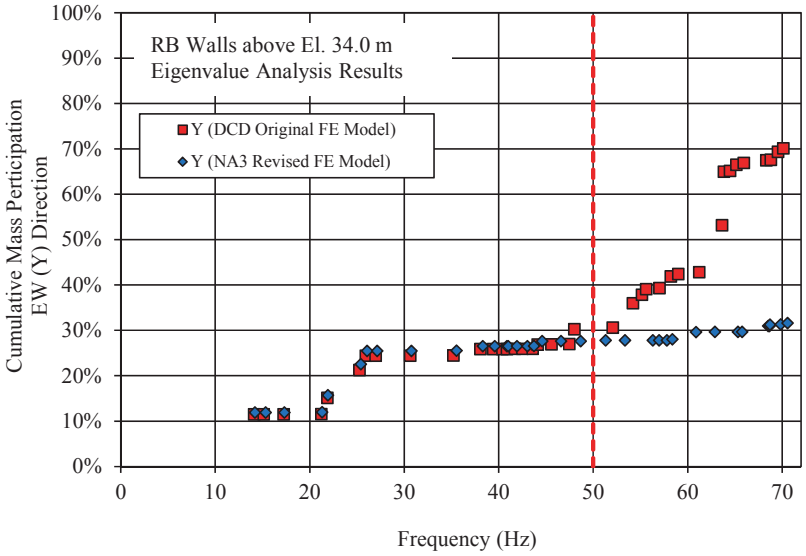
Note: Triangular symbols represent pin support (X, Y and Z translational displacements are fixed but XX, YY and ZZ rotations are not fixed) except for basemat. For basemat, displacement for all directions including rotation are fixed.

Figure A.2-4 Mode Shape of FE Model of RB/FB Wall for NA3



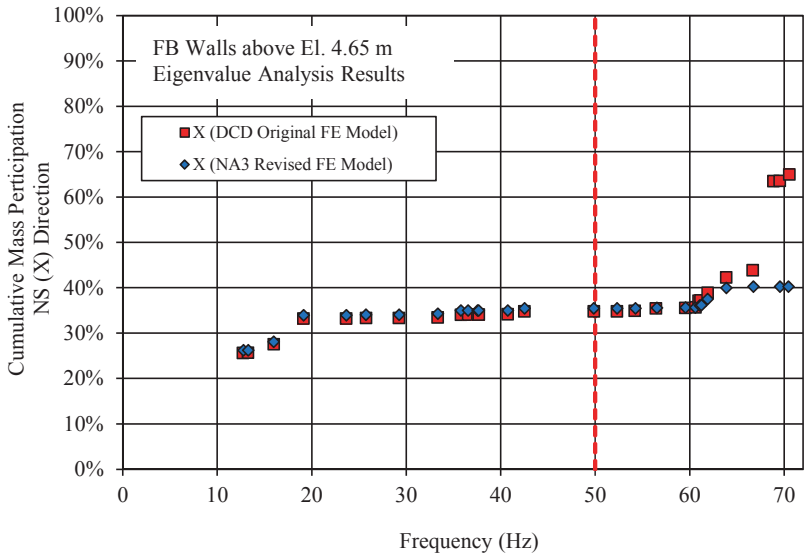
Note: Mass incited only by in-plane vibration at 68.7 Hz for NA3 revised model is neglected.

(a) NS-direction (X-dir.)

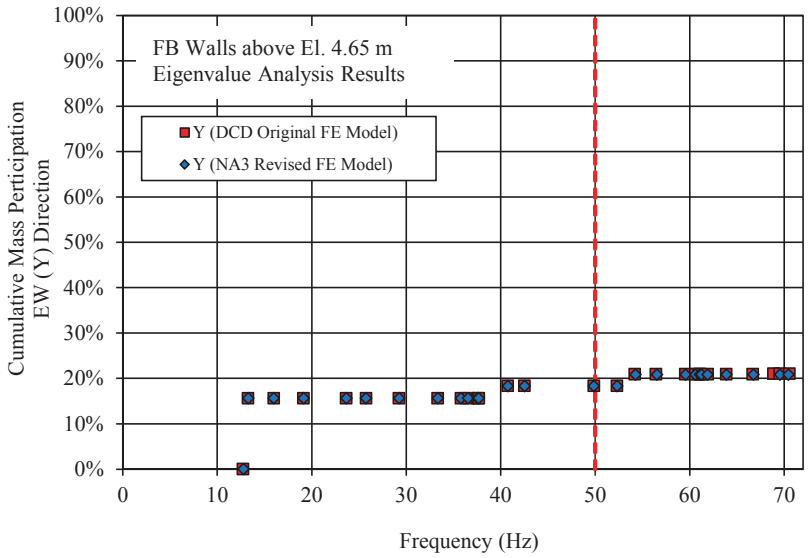


(b) EW-direction (Y-dir.)

Figure A.2-5 Comparison of Cumulative Mass Participation for RB Wall above EL 34.0 m



(a) NS-direction (X-dir.)



Note: Mass incited only by in-plane vibration at 69.5 Hz for DCD original and NA3 revised model are neglected.

(b) EW-direction (Y-dir.)

Figure A.2-6 Comparison of Cumulative Mass Participation for FB Wall above EL 4.65 m