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FINITE ELEMENT FOR SEISMIC ANALYSIS OF A PIPE LINE

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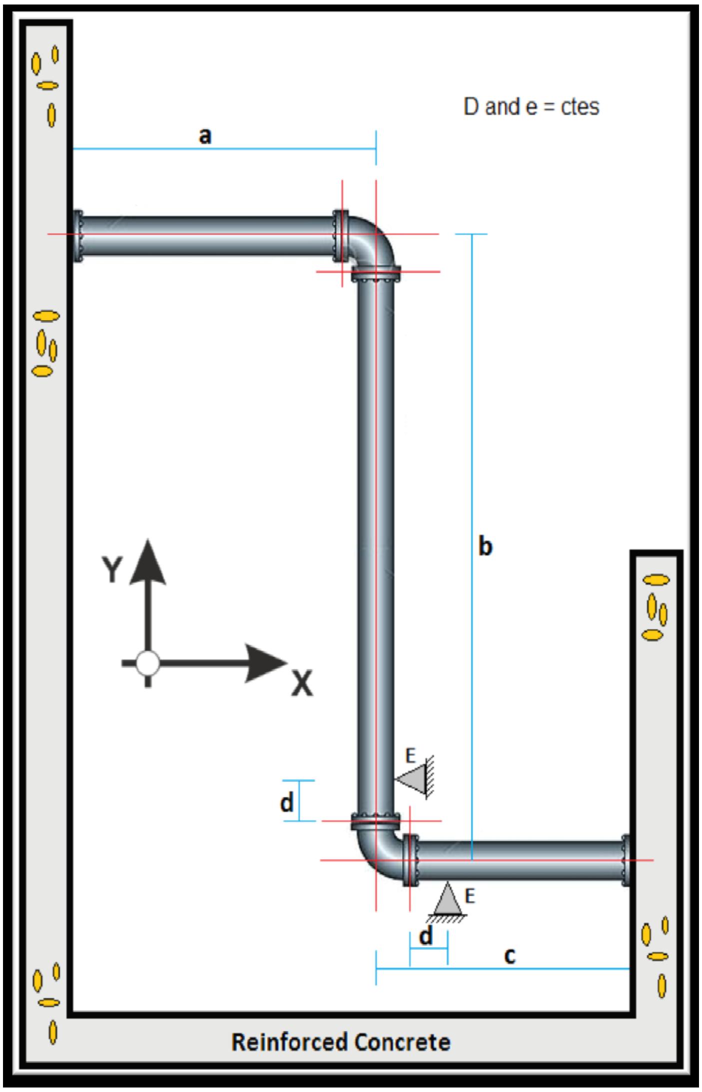
ABSTRACT

The target of this Study is to execute a a seismic analysis (response spectrum analysis) of a Pipe Line with the Performing of initially a static analysis of the pipe line considering its self-weight. Then Perform a modal analysis and obtain the natural frequencies and eigenvectors. Then Perform response spectrum analyses of the pipeline separately for the directions X, Y and Z. The solution is extended to perform Combine solution and Check Integrity & Sanity . The Analysis will be conducted with Patran Nastran.

.The System is presented as per Trailing



1. INTRODUCTION

Modal analysis is the process of identifying a system's natural frequencies, damping factors, and mode shapes in order to use them to create a mathematical model of the system's dynamic behavior. While Spectrum Analysis plot of the maximum response (maximum displacement, velocity, acceleration or any other quantity of interest) to a specified dynamic loading applied on all possible cases . The Dynamic behavior of piping systems is tremendously import specially when it is connected to high speed high value rotating equipment and the adjustment of the piping system dynamics is mandatory for smooth operation. In this study the Patran uses finite element analysis to calculate the dynamics of piping system from two prospectives Modal Analysis & Spectrum Analysis and the behaviors are compared as what is going to be detailed in this study

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2. SOLUTION METHODOLOGY

1. Perform a static analysis of the pipe line considering its self-weight.
2. Perform a modal analysis and obtain the natural frequencies and eigenvectors.
3. Perform response spectrum analyses of the pipe line separately for the directions X, Y and Z.
4. Combine step 1 and the three results of step 3 and obtain the combined result
5. Check if the pipe line maintains integrity
6. Sanity Checks

Data of interest

- The section has the following values for the defined parameters

Parameter	Value	Unit	Meaning
a	10	m	Distances delimited in the figure
b	20	m	
c	8	m	
d	1.5	m	
D	40	inch	Diameter of the pipe (*)
e	STD	-	Pipe wall thickness (*)

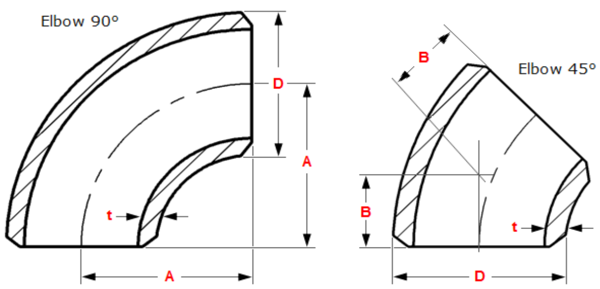
- **Modal damping in the spectrum analysis of 5%.**

Frequency (Hz)	Accelerations (g)
0.10	0.0035
0.25	0.0333
0.40	0.0801
1.00	0.3117
1.42	0.4157
2.00	0.5464
2.82	0.6646
3.98	0.7011
5.62	0.7852
7.94	0.7030
11.22	0.5639
15.84	0.4616
22.39	0.3929
31.62	0.3429
34.00	0.3423
100.00	0.3423

Sanity checks

- Compare the reactions of the own weight analysis done with Patran with analytical calculation of model mass.
- Compare the frequencies obtained in the modal analysis with the ones obtained in the response spectrum analysis. Are there differences.
- Perform a static analysis applying the high acceleration of the spectrum as an inertial load. Compare the results with the ones obtained at the response spectrum analysis. Justify the comparative.

3. GEOMETRY CREATION



- We Will Take the Long Radius with thickness 10mm D= 1015 & A=1500 mm and generate The curve and chain it as one curve

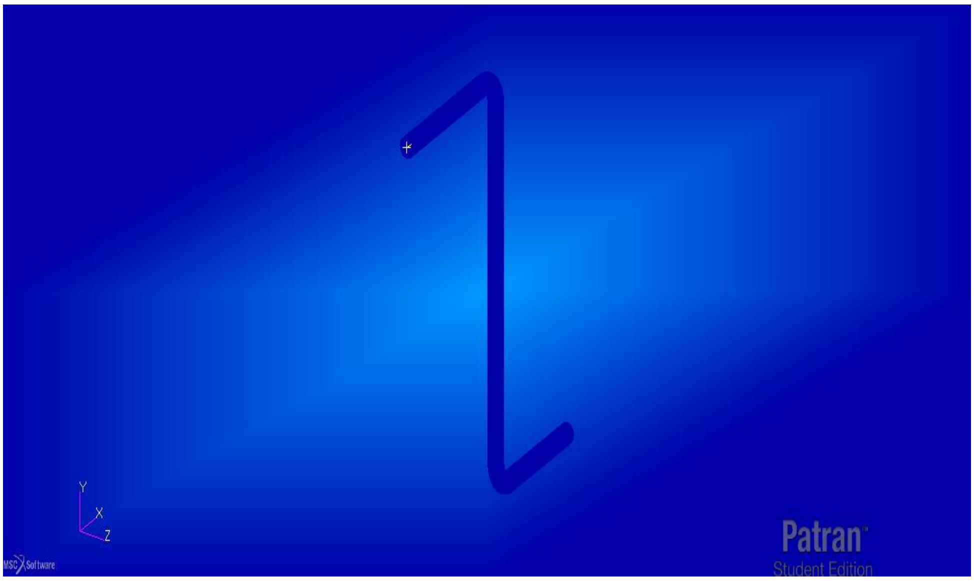
4. MATERIALS, PROPERTIES AND ELEMENTS

See the next table for materials, properties and element types used in the model.

Part	Material				Property	Element
	E	Poisson	Density	Damping Coeff.		
Pipe	2,00E+11	0,3	7850	0,05	1D Beam	Bar2

MESHING

As Indicated we will mesh the chained curve with the element Bar2 , with around 4800 Elements & Nodes.

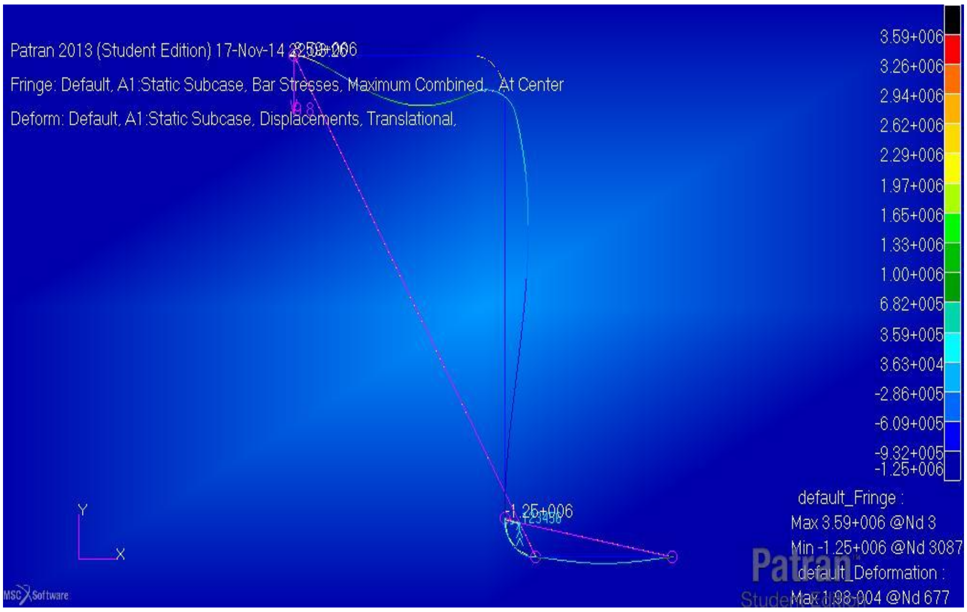


Loads And Boundary Conditions

Will create a RBE2 and set at the independent node an embedment. The Independent node will be a new node located at the intersection of lines connecting embedment and embedments as dependent nodes Then, let's create a fixed support at the independent node. Both inertial load and fixed support are stored at the "self-weight" load case.

5. SELF WEIGHT ANALYSIS

As it's said at the statement we have to solve the own-weight load case and then combine it with the spectral analysis. Therefore let's solve first the self-weight load case



Max Combined stress for self weight case

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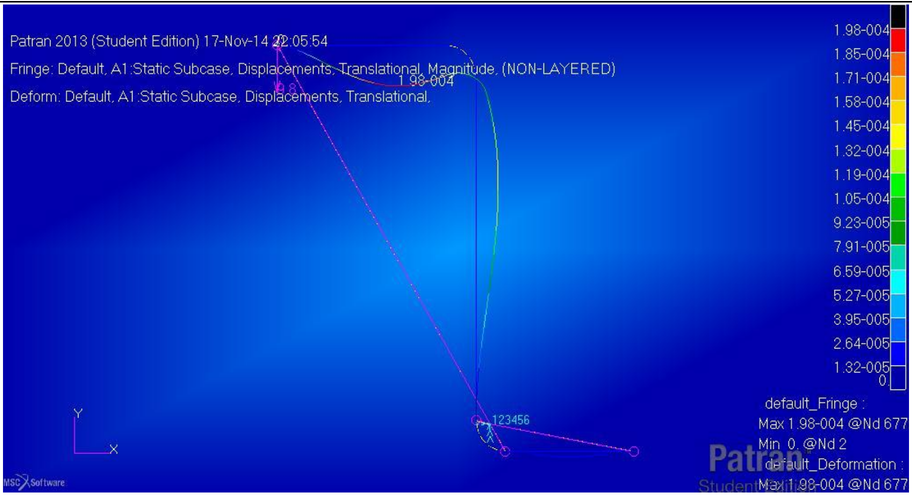


Displacement of the Self Weight Case

6. SPECTRUM ANALYSIS. CONFIGURATION

We have analyzed the self-weight load case, and the scope of the model has been fixed. We will study the spectrum analysis having in mind these results.

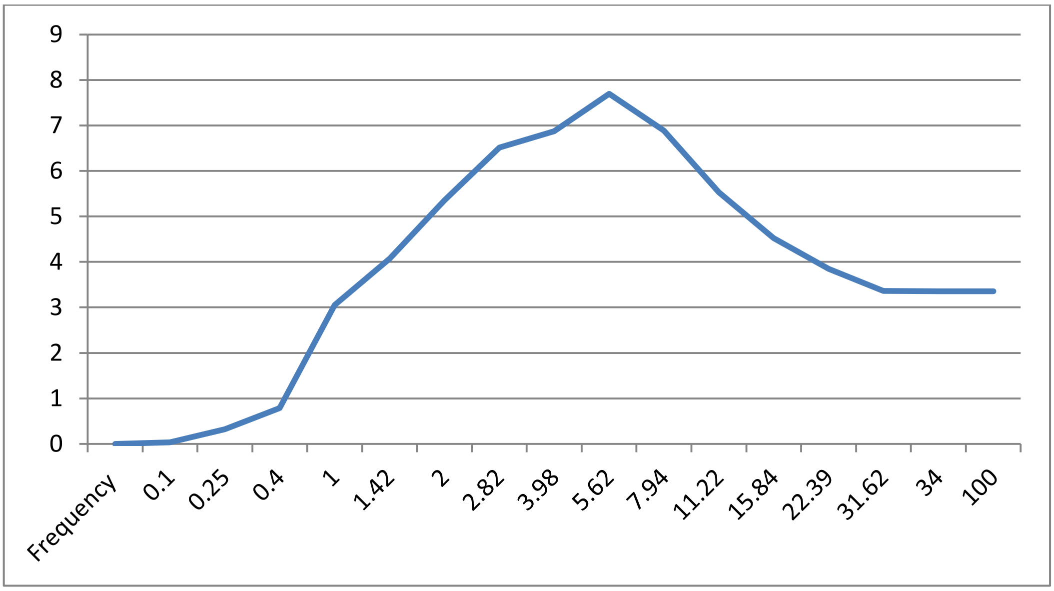
“TABLED1,2” This card defines the frequencies vs. acceleration spectrum.(It will change depending on Y , Z direction)

TABLED1, 2

+, 0.1, 0.0343, 0.25, 0.3263, 0.4, 0.7851, 1, 3.0547

+, 2, 5.3547, 3.98, 6.8708, 7.94, 6.8894, 11.22, 5.5262

+, 22.39, 3.3604, 34, 3.3545, 100, 3.3545, ENDT



The Frequency in X direction

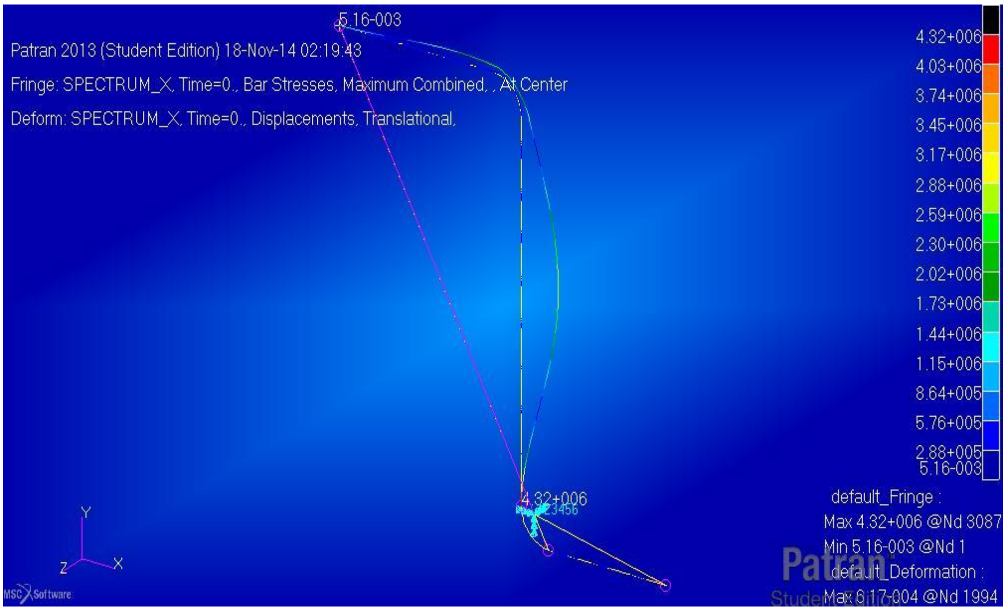
Table.1 For mt/Sec sq calculation for spectrum

Frequency	Acceleration	M/Sec sq...X & Z direction	Y direction
0.1	0.0035	0.0343	0.0137
0.25	0.0333	0.3263	0.1305
0.4	0.0801	0.785	0.314
1	0.3117	3.0547	1.2219
1.42	0.4157	4.0739	1.6296

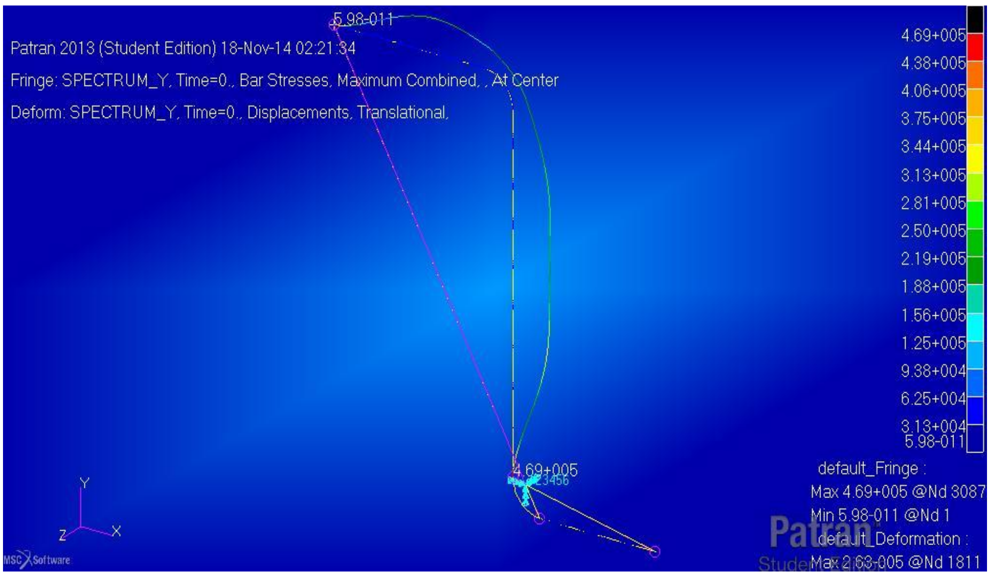
2	0.5464	5.3547	2.1419
2.82	0.6646	6.5131	2.6052
3.98	0.7011	6.8708	2.7483
5.62	0.7852	7.695	3.078
7.94	0.703	6.8894	2.7558
11.22	0.5639	5.5262	2.2105
15.84	0.4616	4.5237	1.8095
22.39	0.3929	3.8504	1.5402
31.62	0.3429	3.3604	1.3442
34	0.3423	3.3545	1.3418
100	0.3423	3.3545	1.3418

7. SPECTRUM ANALYSIS. SOLUTION ANALYSIS

The following plots are the results in terms of stress tensor and displacements for **Spectrum response in X, Y ,Z AND COMBINED** case.



Spectrum X direction



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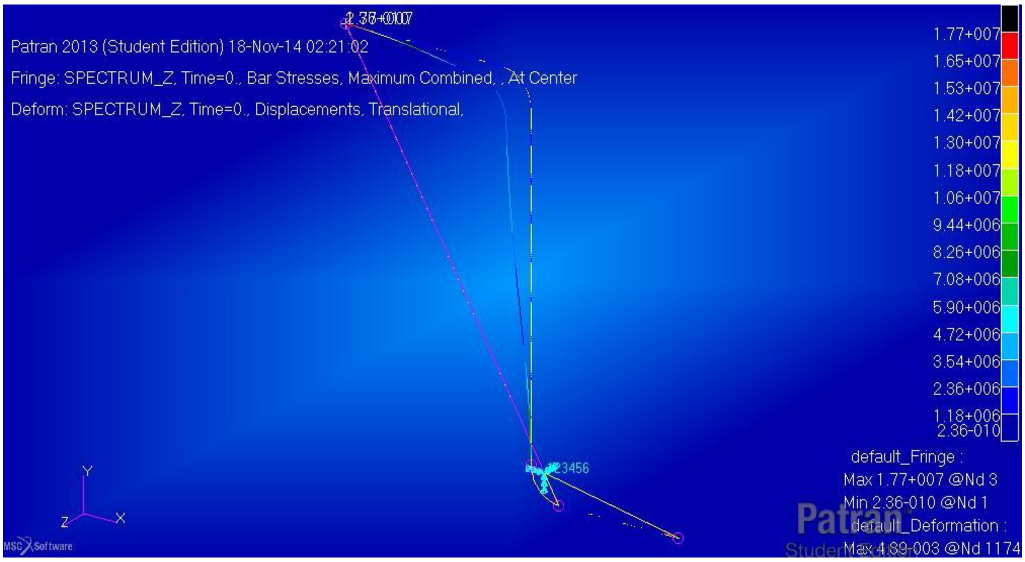
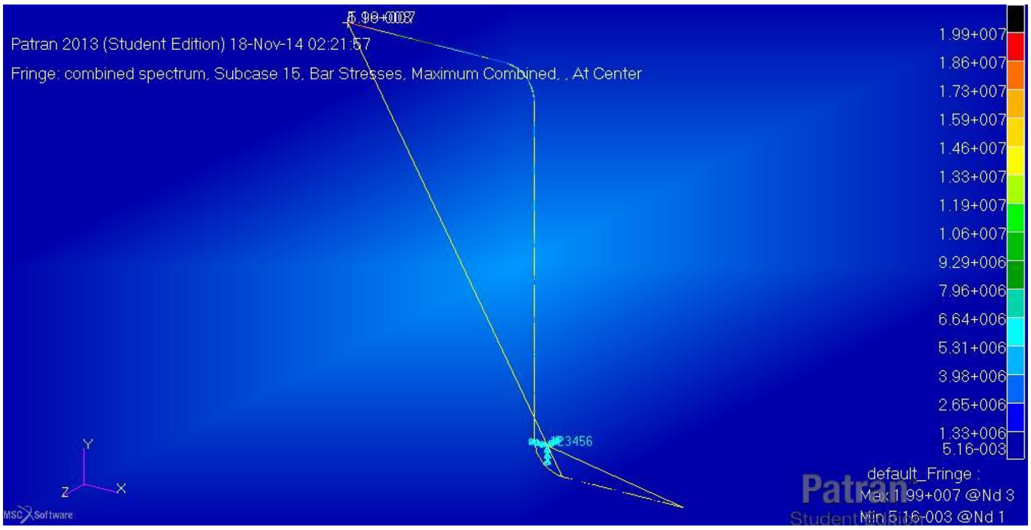
Spectrum Y Direction

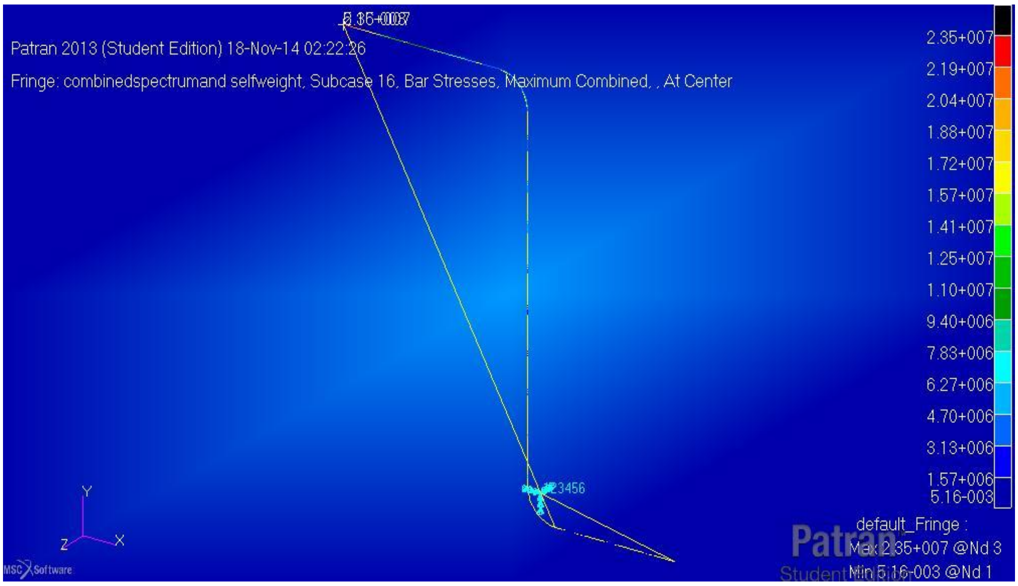


Spectrum Z Direction



Combined Spectrum

The combined spectrum combined with Self Weight



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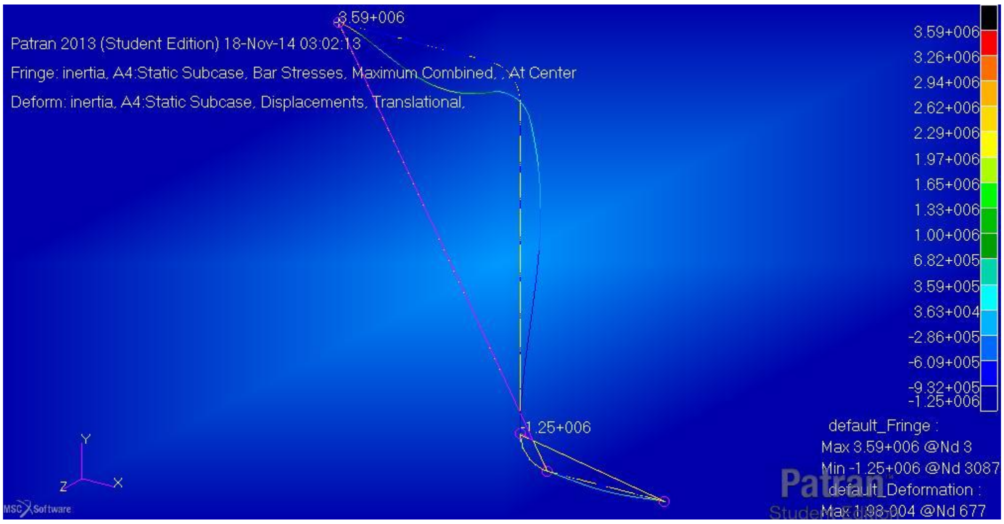
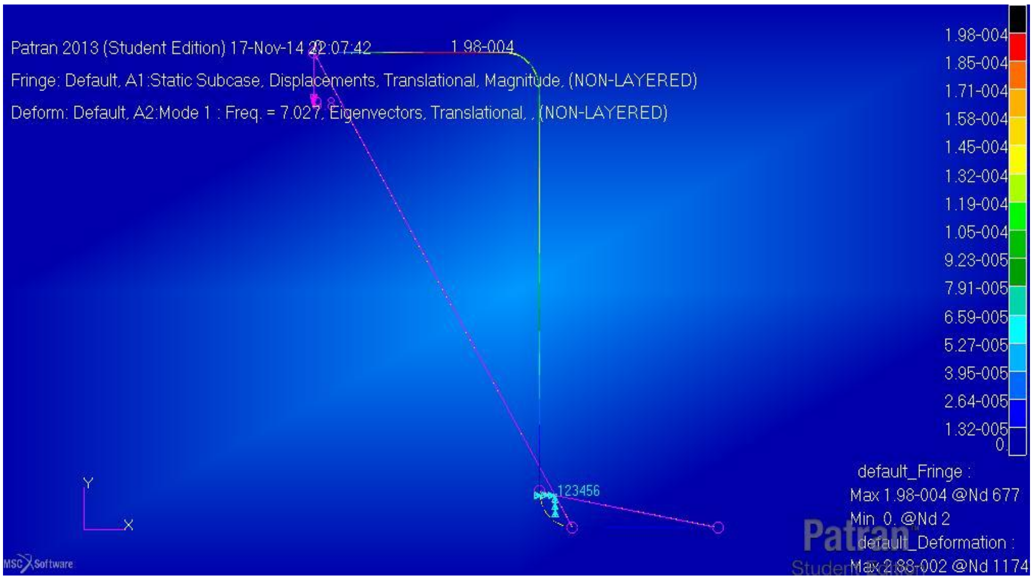
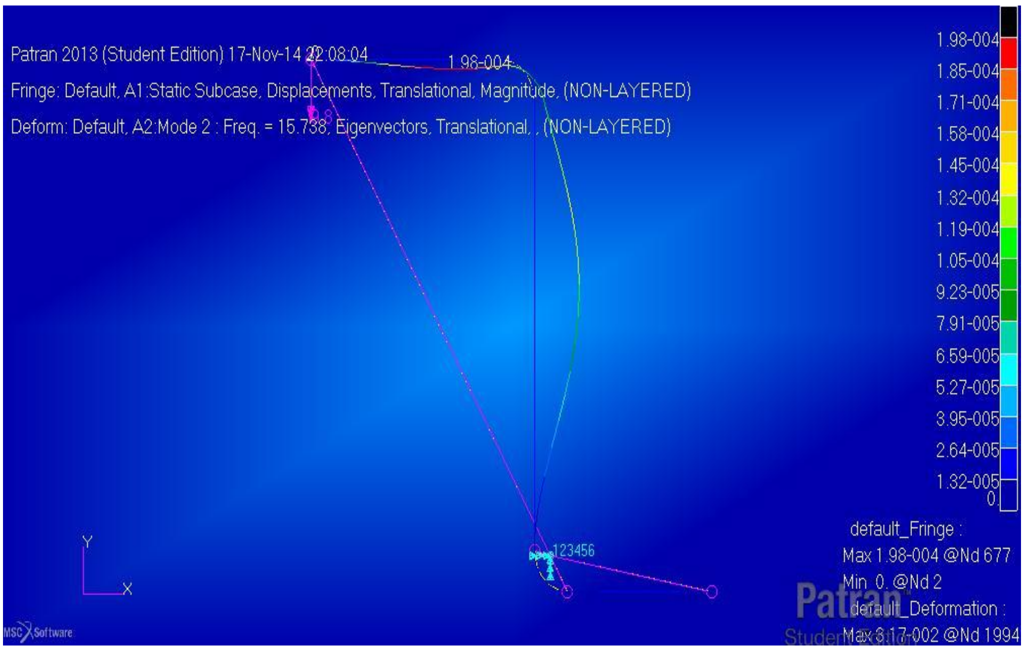
Inertia Case with the Highest value of Gravity acceleration



Modal Analysis Shape



Modal 1



Modal 2

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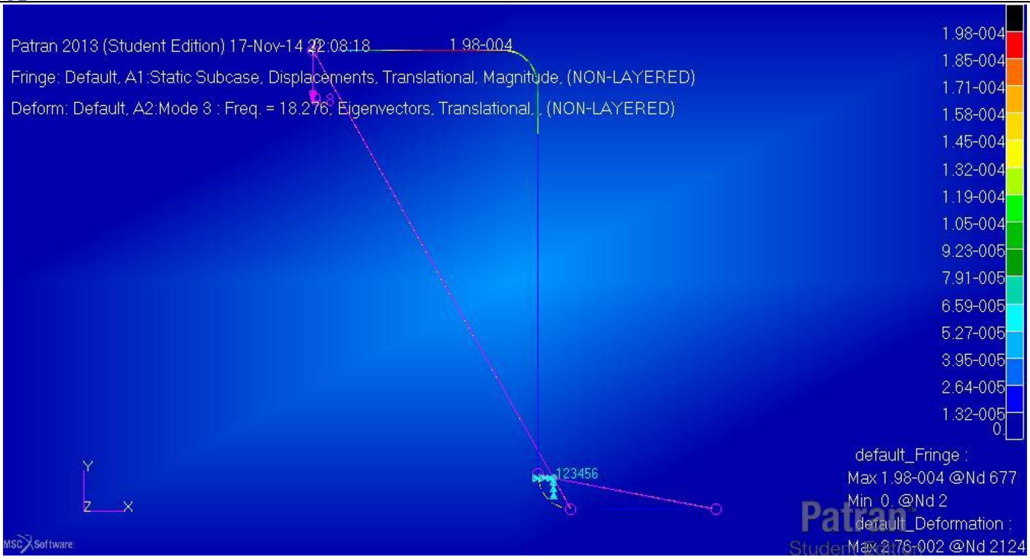
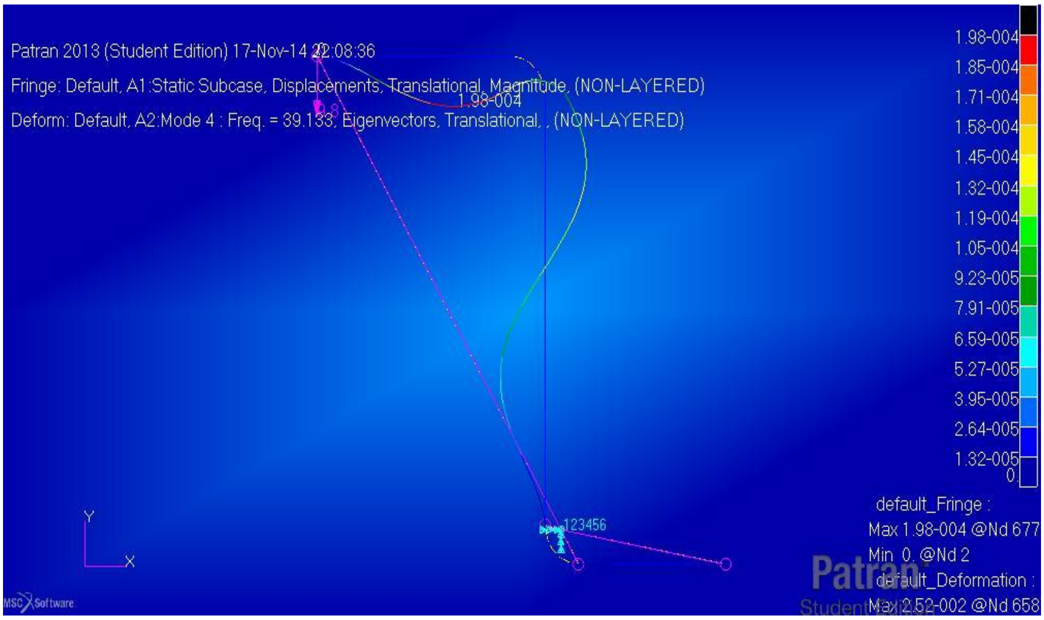
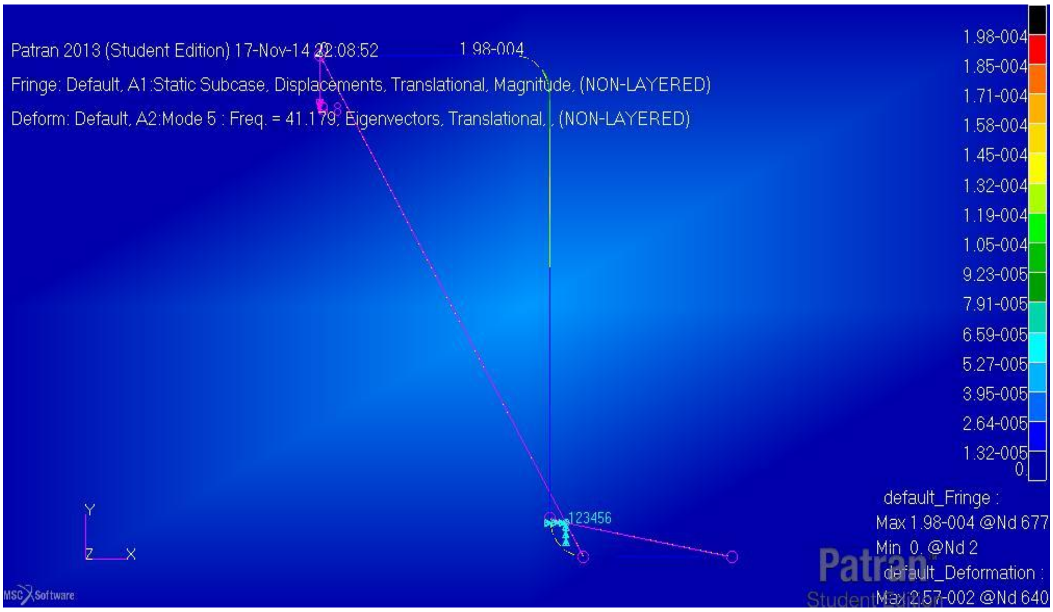


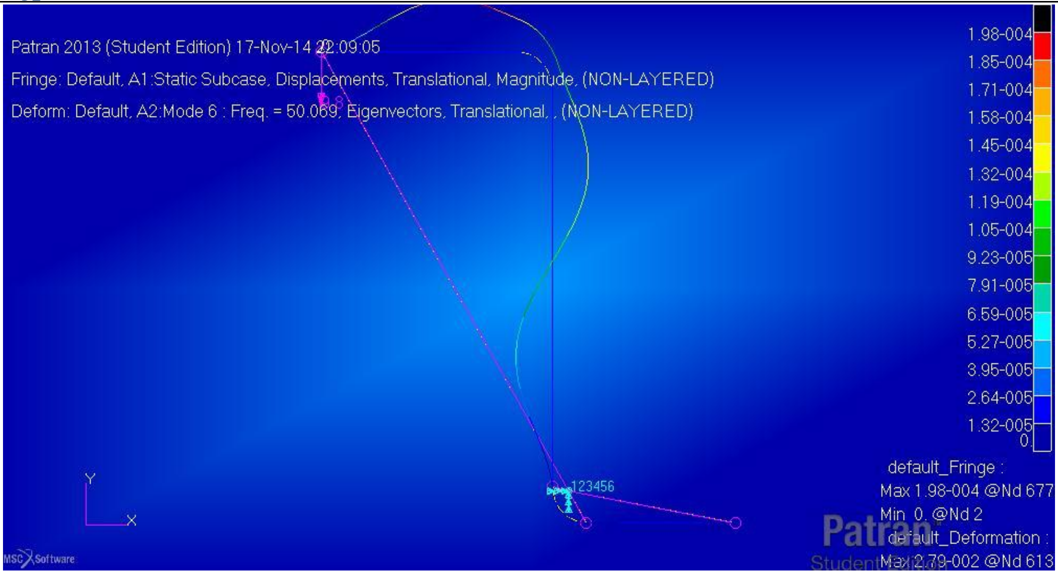
Modal3



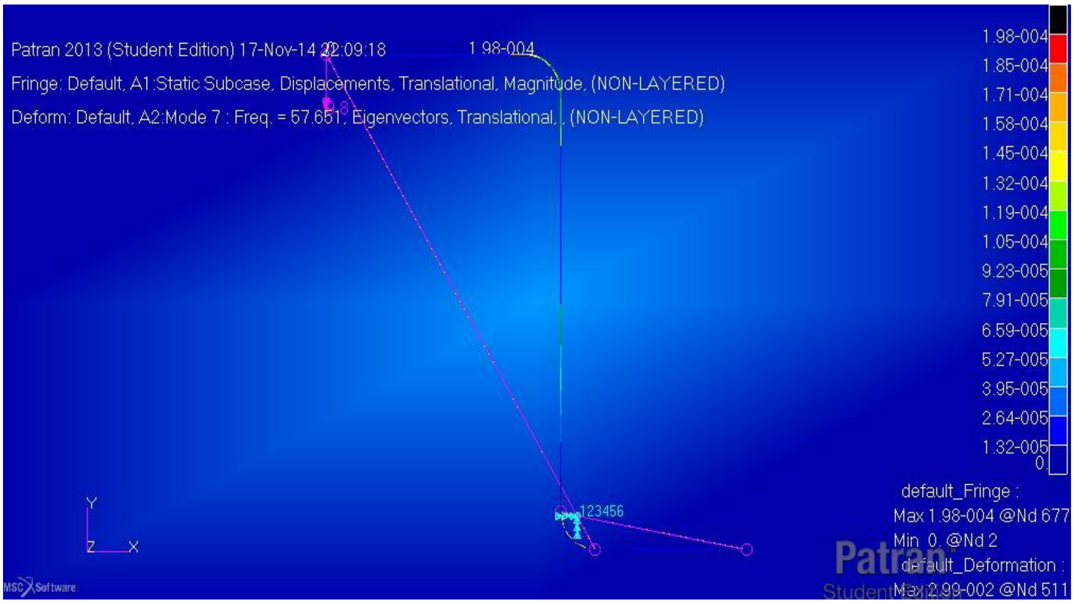
Modal 4



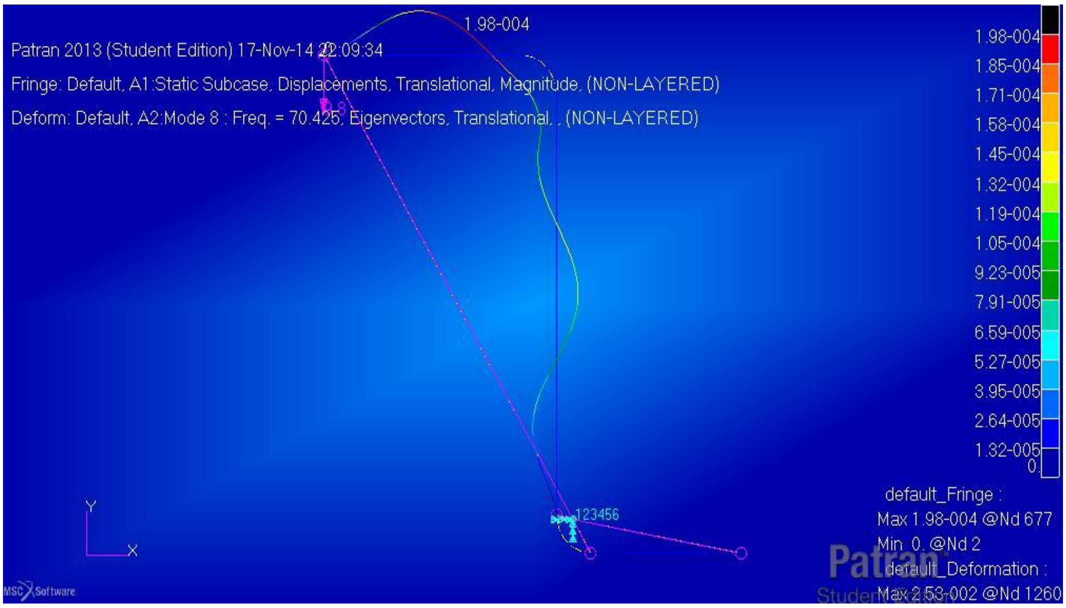
Modal 5



Modal 6



Modal 7



Modal 8

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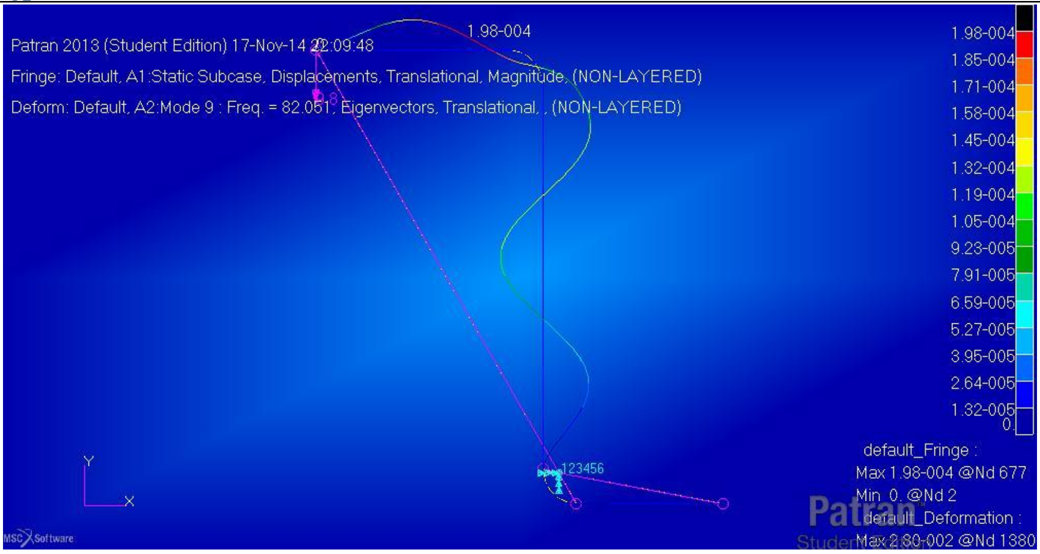
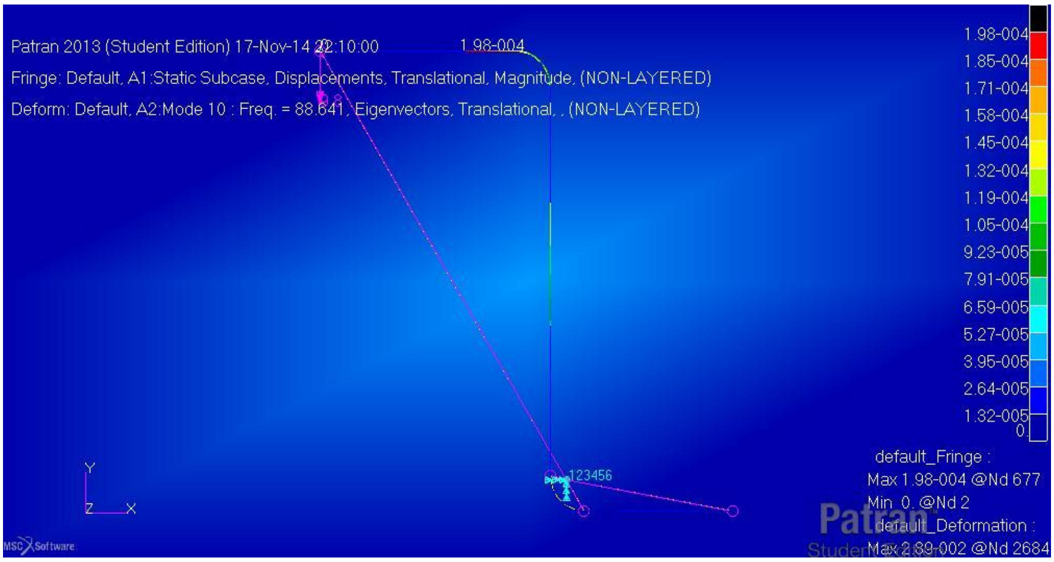


Modal 9



Modal 10

8. SANITY CHECKS

1.1. VERTICAL REACTIONS. SELF-WEIGHT LOAD CASE

We can check the reactions given by Nastran at the embedment of the independent node of the RBE2. Extracting the Same from F06 File

weight			
radius out	0.507	Radius......................................	0.80713386
radius in	0.502	Radius......................................	0.79129256
	difference in Area		0.0158413
	length	39	
	volume	0.6178107	
	mass	4850	
	weight	4.75E+04	Length 10+20+8+1 Mt for Elbows

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3
4081	G	-6.636314E-08	4.480734E+04	0.0

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9. CHECKING FREQUENCIES

Below, we include the comparison between the normal modes obtained at a modal analysis and the normal modes obtained at the spectrum analysis,

Spectrum Response frequency

MODE NO.	EXTRACTION ORDER	EIGENVALUE	RADIANS	CYCLES	GENERALIZED MASS	GENERALIZED STIFFNESS
1	1	0.0	0.0	0.0	1.000000E+00	0.0
2	2	1.949413E+03	4.415216E+01	7.027034E+00	1.000000E+00	1.949413E+03
3	3	9.778179E+03	9.888467E+01	1.573798E+01	1.000000E+00	9.778179E+03
4	4	1.318596E+04	1.148301E+02	1.827578E+01	1.000000E+00	1.318596E+04
5	5	6.045748E+04	2.458810E+02	3.913318E+01	1.000000E+00	6.045748E+04
6	6	6.694298E+04	2.587334E+02	4.117870E+01	1.000000E+00	6.694298E+04
7	7	9.896815E+04	3.145920E+02	5.006888E+01	1.000000E+00	9.896815E+04
8	8	1.312139E+05	3.622346E+02	5.765143E+01	1.000000E+00	1.312139E+05
9	9	1.957997E+05	4.424926E+02	7.042487E+01	1.000000E+00	1.957997E+05
10	10	2.657892E+05	5.155474E+02	8.205192E+01	1.000000E+00	2.657892E+05
11	11	3.101918E+05	5.569487E+02	8.864113E+01	1.000000E+00	3.101918E+05

Normal Modes

MODE NO.	EXTRACTION ORDER	EIGENVALUE	RADIANS	CYCLES	GENERALIZED MASS	GENERALIZED STIFFNESS
1	1	1.949413E+03	4.415216E+01	7.027034E+00	1.000000E+00	1.949413E+03
2	2	9.777880E+03	9.888316E+01	1.573774E+01	1.000000E+00	9.777880E+03
3	3	1.318596E+04	1.148301E+02	1.827578E+01	1.000000E+00	1.318596E+04
4	4	6.045748E+04	2.458810E+02	3.913318E+01	1.000000E+00	6.045748E+04
5	5	6.694298E+04	2.587334E+02	4.117870E+01	1.000000E+00	6.694298E+04
6	6	9.896814E+04	3.145920E+02	5.006887E+01	1.000000E+00	9.896814E+04
7	7	1.312139E+05	3.622346E+02	5.765143E+01	1.000000E+00	1.312139E+05
8	8	1.957996E+05	4.424924E+02	7.042486E+01	1.000000E+00	1.957996E+05
9	9	2.657864E+05	5.155447E+02	8.205149E+01	1.000000E+00	2.657864E+05
10	10	3.101918E+05	5.569486E+02	8.864112E+01	1.000000E+00	3.101918E+05

10. CONCLUSION

The study had compared the self-Weight case with Applied with this acceleration like an inertial load in a static load case, we obtain the results shown at above for value of Y direction the stresses is higher than the ones obtained at the spectral analysis (3.59e6 Pa the Static vs4.69e5 Pa the spectrum). This comparison verifies that the stress in the static inertial load case is higher than the spectrum case and the results of the spectral analysis are satisfactory. Also the Study had compared the Frequencies obtained from Spectrum Analysis & Modal Analysis with good match between values.

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