1. Background:

This experiment consists of three main parts numerical modeling of the structure in the Slang software, performance of the first experimental test and finally performance of the second experimental test and processing of the data from these experiments in MACEC software. This model is a five story 3D frame structure with height of 1000 mm and dimension of 300x300.

We used 6 sensors for this experimental test and we defined the reference sensor at the top of the structural model and other sensors at different levels. We defined 4 setup in this test and 7 modes which first mode up to forth mode belongs to the first setup, mode 5 is for setup 2, mode 6 for setup 3 and mode 7 for setup 4.

At the end we realized that there was a mistake in the first experiment of the model that we did not defined any sensor at the base level in order to have data and idea about the first story members.

2. Objective:

The objective of this experiment is to develop knowledge of doing a structural dynamic test and comparison of the result from the laboratory test with the structural model by software.

There are two softwares which are used to measure frequencies for each experiment. MACEC is used to calculate the time histories which were taken from Sensors. The number of sensors for each setup is 6 sensors, therefore we did some combinations of sensor positions to have a lot of data from every point in the structure. After finding the time histories from each sensor, all data were compiled in the MACEC's software, where it calculates the data by stochastic approach.

Slang software is a powerful tool to measure frequency of the structure. We are assuming that all joints in the structure in the Slang is a really fix and rigid without considering the fact in the experiment that we were using screw to fix it. Slang is able to give us some output from the model, for instance Natural Frequencies, Eigenvectors, eigenvalues and mode shapes.

3. Equipments:

- *Sensors*

In the first experimental, we were using 6 sensors which were used to measure the displacement in the each point of structure where the sensors are put. For the second experimental, we also used the same sensors but we modify the position of sensors because we did some mistakes in previous experimental.

-Structural elements

All elements are made of steel, and the properties for these elements are:
Density = 8000 kg/m3
Poisson Ratio = 0.3
Modulus Young = 2e+11 N/m2
Sensor's Mass = 270 gr

- hammer

We were using hammer to give some small forces for the structure.

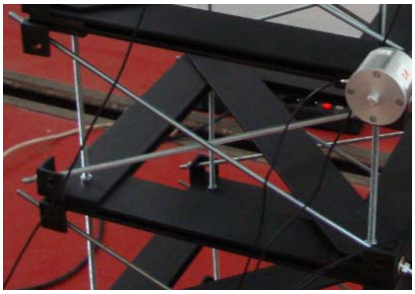
-Base excitation

It is allocated on the bottom of the structure. It was used to give some vibrations onto the structure.

-Bracings

These elements were assembled at the second experimental. We were installing these elements in Y direction because we want to the behavior of the structure in one direction.

Made of steel



4. Duration:

We started numerical modeling of the structure in Slang on May 2010 and we performed the first experimental test on 11 June 2010. Finally, we performed the second experimental test on 25 June 2010. During making the report, we were using MACEC and Slang software to investigate the result which was taken from the sensors. In the MACEC software, we just used the time histories which were given from sensor's number 1, 2, 3, 4, 5 and 6. We neglected the sensor's number 7 and 8, because it is the Force and Base Execution data.

5. Experimental tests:

5.1- First experimental test:

After doing the first modal test we need to process the data in MACEC which is powerful software for analyzing the data and determining the modal parameters such as damping ratio, eigen frequency and mode shapes. In the first experimental, we did 2 mistakes, where we did not consider the sensor in the basement and there is no additional sensor on the top. Therefore, the result for the first experimental is not correct. We could identify it by comparing the mode shape for each mode which will be described in the next page.

This is a table which describes the position of the sensor in the structure.

		Sensor					
Setup	Direction	I	II	III	IV	V	VI
		-Y	-Y	-Y	+X	-X	-X
1	Point	21	5	14	23	7	14
2	Point	21	9	18	23	11	18
3	Point	21	13	6	23	15	6
4	Point	21	17	10	23	19	10

The tables below are describing the node's number, the position of beam/column elements, and slave correlation.

node	x	y	z
1	0	0	0
2	0.3	0	0
3	0.3	0.3	0
4	0	0.3	0
5	0	0	0.2
6	0.3	0	0.2
7	0.3	0.3	0.2
8	0	0.3	0.2
9	0	0	0.4
10	0.3	0	0.4
11	0.3	0.3	0.4
12	0	0.3	0.4
13	0	0	0.6
14	0.3	0	0.6
15	0.3	0.3	0.6
16	0	0.3	0.6
17	0	0	0.8
18	0.3	0	0.8
19	0.3	0.3	0.8
20	0	0.3	0.8
21	0	0	1
22	0.3	0	1
23	0.3	0.3	1
24	0	0.3	1

beam/column	A	B
1	5	6
2	6	7
3	7	8
4	8	5
5	9	10
6	10	11
7	11	12
8	12	9
9	13	14
10	14	15
11	15	16
12	16	13
13	17	18
14	18	19
15	19	20
16	20	17
17	21	22
18	22	23
19	23	24
20	24	21
21	1	5
22	2	6
23	3	7
24	4	8
25	5	9
26	6	10
27	7	11
28	8	12
29	9	13
30	10	14
31	11	15
32	12	16
33	13	17
34	14	18
35	15	19
36	16	20
37	17	21
38	18	22
39	19	23
40	20	24
41	22	24
42	17	19
43	14	16
44	9	11
45	6	8

column	A	B
1	1	5
2	2	6
3	3	7
4	4	8
5	5	9
6	6	10
7	7	11
8	8	12
9	9	13
10	10	14
11	11	15
12	12	16
13	13	17
14	14	18
15	15	19
16	16	20
17	17	21
18	18	22
19	19	23
20	20	24

Slave I

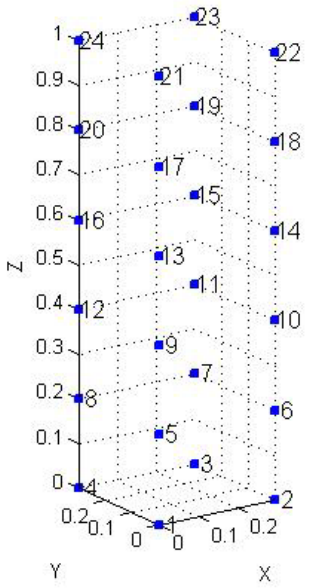
Master	X	Y	Z	Slave	X	Y	Z
6	0	1	0	7	0	1	0
6	1	0	0	5	1	0	0
7	1	0	0	8	1	0	0
5	0	1	0	8	0	1	0
10	0	1	0	11	0	1	0
10	1	0	0	9	1	0	0
11	1	0	0	12	1	0	0
9	0	1	0	12	0	1	0
14	0	1	0	15	0	1	0
14	1	0	0	13	1	0	0
15	1	0	0	16	1	0	0
13	0	1	0	16	0	1	0
18	0	1	0	19	0	1	0
18	1	0	0	17	1	0	0
19	1	0	0	20	1	0	0
17	0	1	0	20	0	1	0
23	1	0	0	24	1	0	0
21	0	1	0	24	0	1	0

Modified Slave I at due to less Information at the top storey							
Master	X	Y	Z	Slave	X	Y	Z
6	0	1	0	7	0	1	0
6	1	0	0	5	1	0	0
7	1	0	0	8	1	0	0
5	0	1	0	8	0	1	0
10	0	1	0	11	0	1	0
10	1	0	0	9	1	0	0
11	1	0	0	12	1	0	0
9	0	1	0	12	0	1	0
14	0	1	0	15	0	1	0
14	1	0	0	13	1	0	0
15	1	0	0	16	1	0	0
13	0	1	0	16	0	1	0
18	0	1	0	19	0	1	0
18	1	0	0	17	1	0	0
19	1	0	0	20	1	0	0
17	0	1	0	20	0	1	0
21	0	1	0	22	0	1	0
21	0	1	0	23	0	1	0
21	0	1	0	24	0	1	0
23	1	0	0	24	1	0	0
23	1	0	0	22	1	0	0
23	1	0	0	21	1	0	0

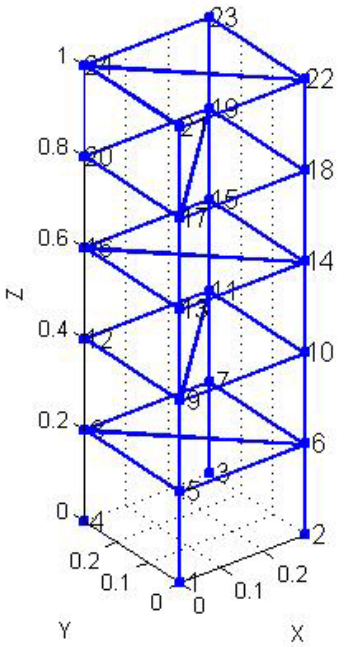
First Experimental Picture

Modal analysis of structures with MACEC:

First step:
The first step is to make the geometry of the model and in order to do it we defined the nodes and then connected the nodes to the beam to build the structural model. The model consists of 5 story and 24 nodes. The following figures show the grid and geometry of the model.

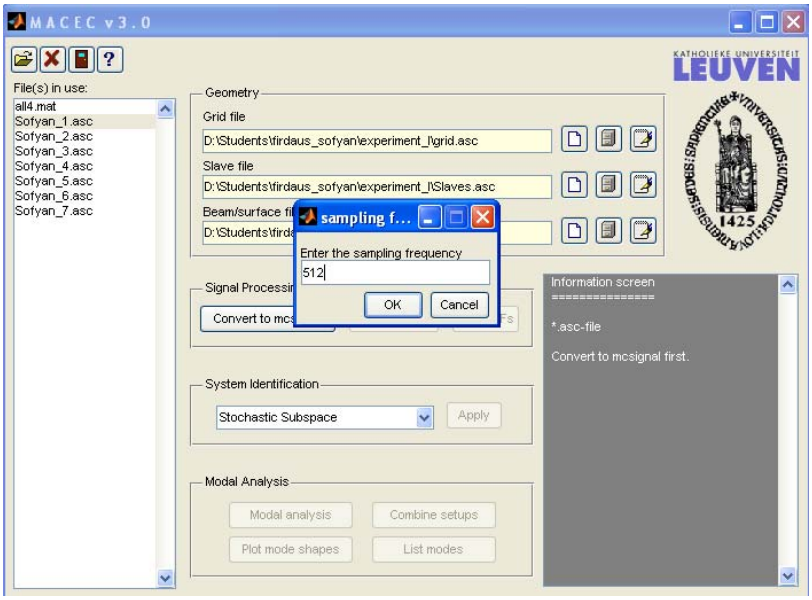


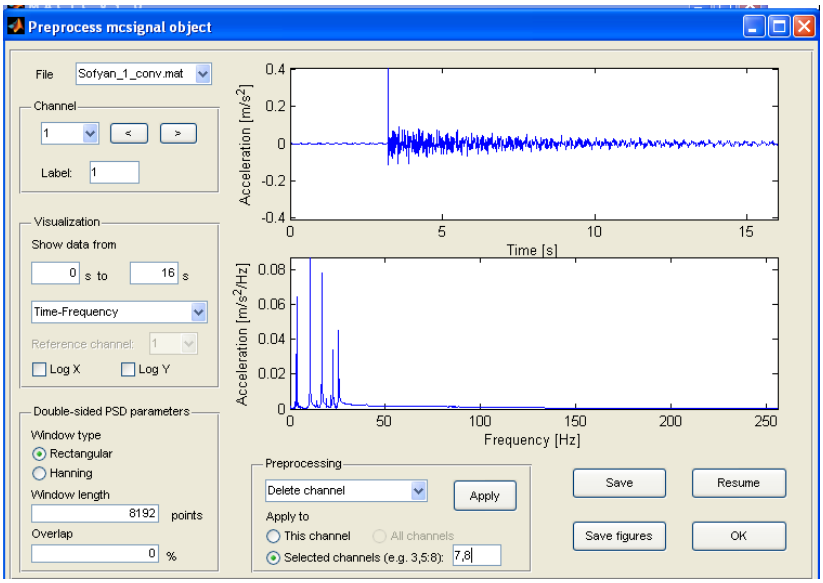
Defining the master and slave nodes



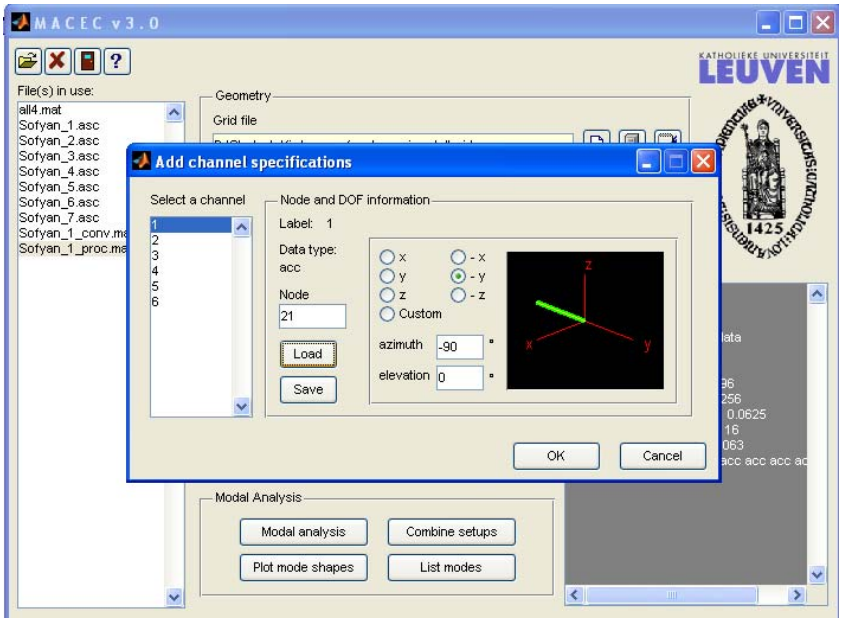
Geometry of the model by making link between nodes

Second step:
After defining the model geometry we should select the data to process it. The sampling frequency is 512.

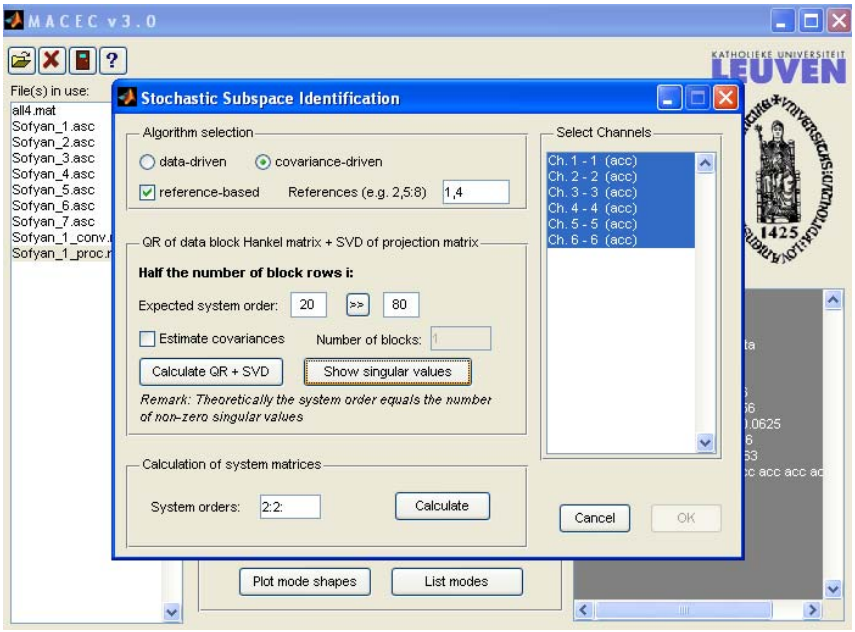




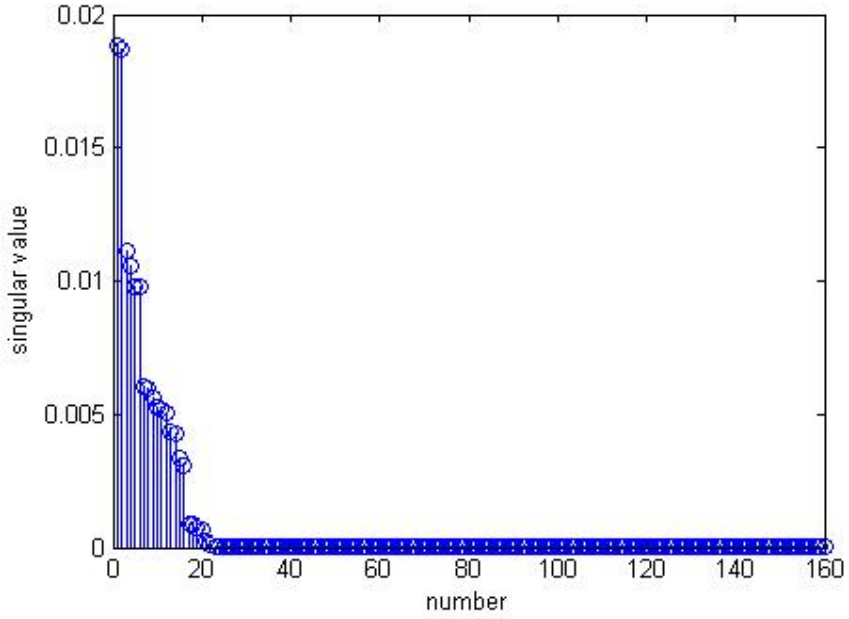
The above figure shows the signal processing of first mode of the model. And we deleted channel 7 and 8.



Providing the direction and node number for the different channels



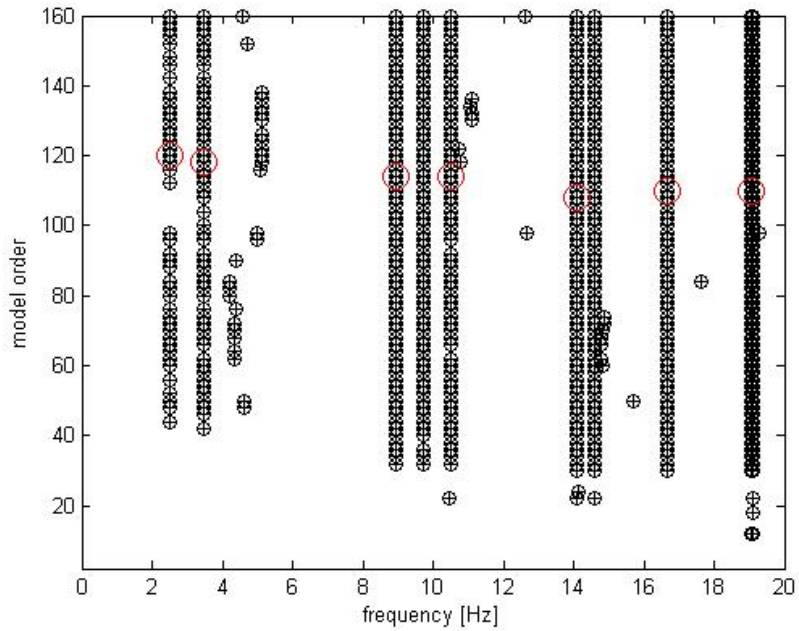
Selecting the Covariance-driven because of the availability of estimation of the variances on the identified system parameters (eigenfrequencies, damping ratios, mode shapes…)



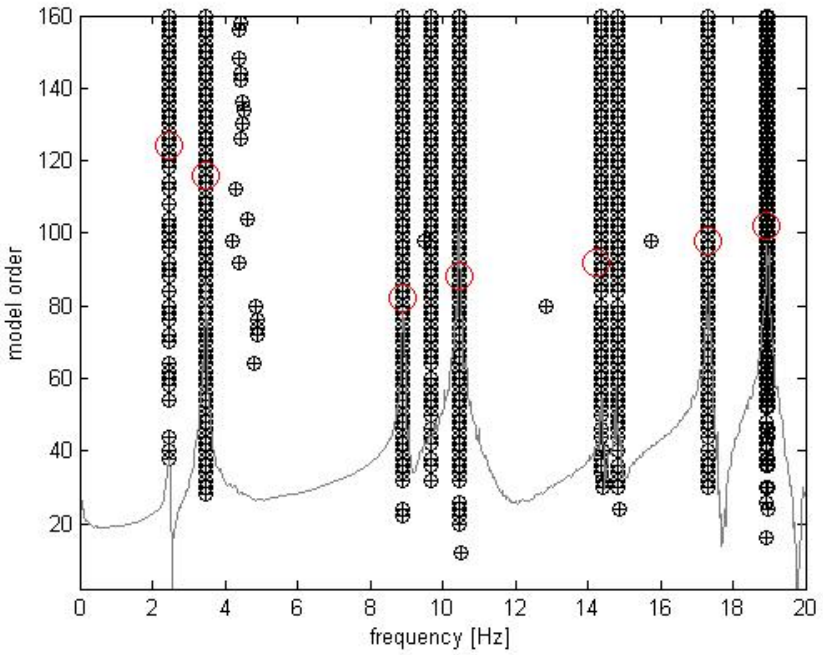
Singular values diagram which shows the maximum possible system order equals to 160[8]

Stabilization diagram

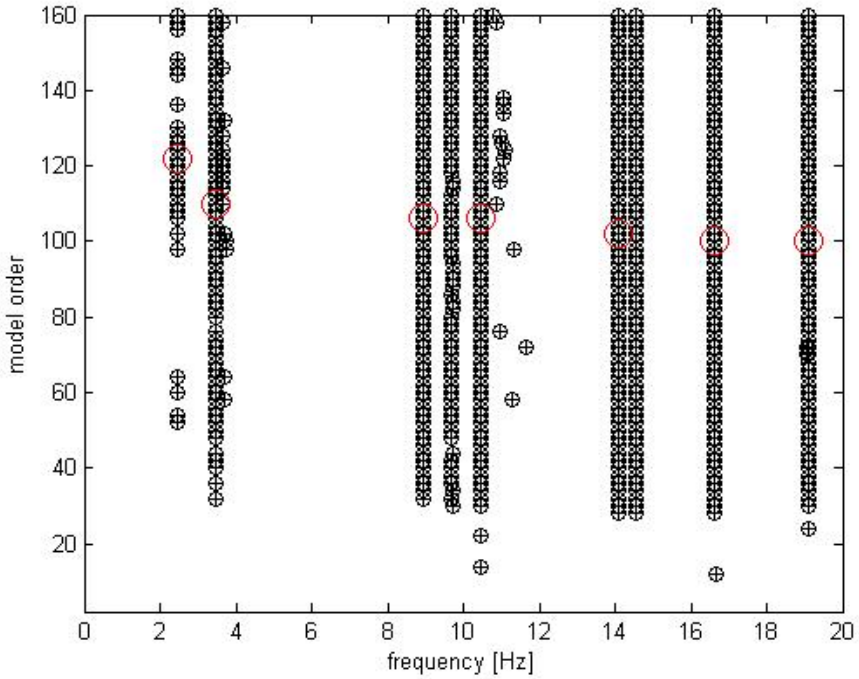
We decided to choose 7 dots to have eigen frequency for each setup. We want to predict the eigen frequency value compare to the slang's result.



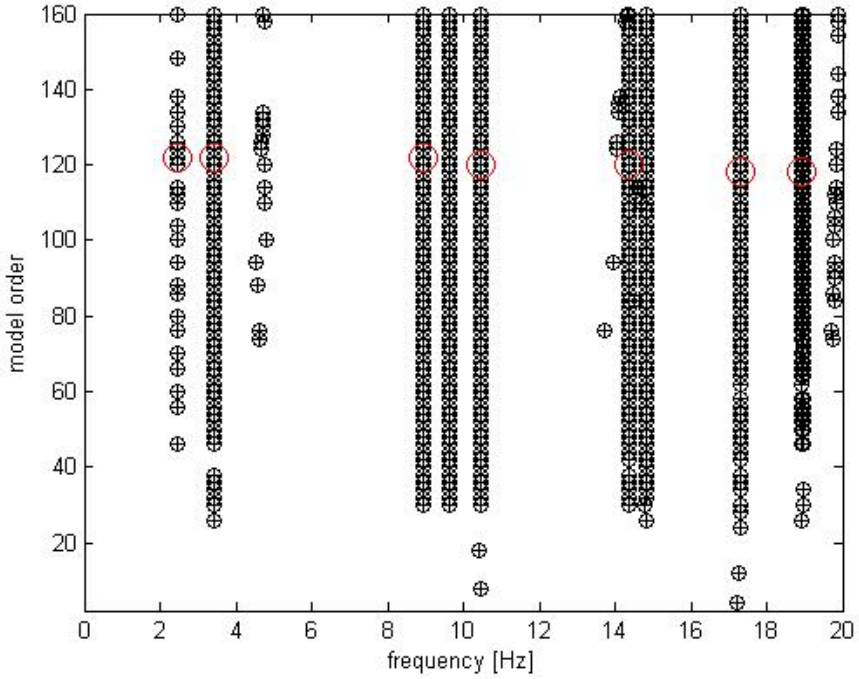
Stabilization diagram for setup 1



Stabilization diagram for setup 2



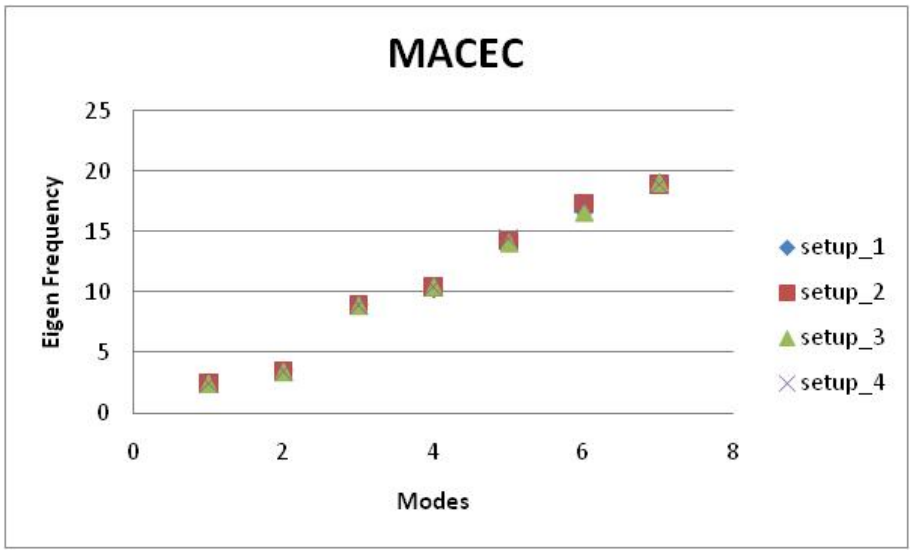
Stabilization diagram for setup 3



Stabilization diagram for setup 4

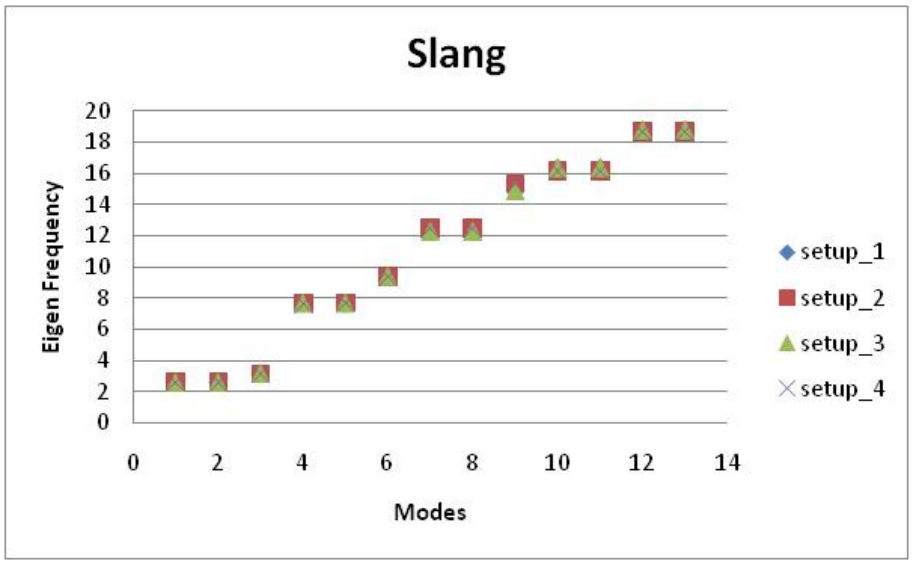
The result from MACEC is:

Macec					
	setup_1	setup_2	setup_3	setup_4	average
1	2.48542	2.46432	2.4765	2.45298	2.469805
2	3.47613	3.44908	3.46427	3.43236	3.45546
3	8.93475	8.90309	8.93277	8.93336	8.925993
4	10.2431	10.4452	10.481	10.4458	10.40378
5	14.1089	14.2257	14.1076	14.383	14.2063
6	16.6669	17.3259	16.6231	17.3169	16.9832
7	19.0842	18.9299	19.0809	18.9392	19.00855



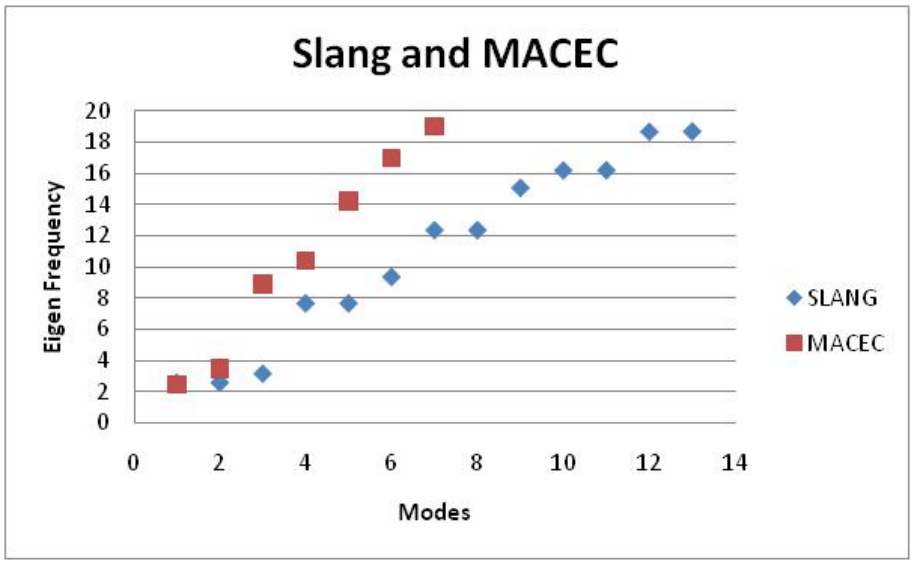
If we compare it to the slang result, the eigen frequencies distribution is:

Slang					
	setup_1	setup_2	setup_3	setup_4	average
1	2.6001	2.58609	2.60091	2.58739	2.593623
2	2.60102	2.58783	2.60102	2.58783	2.594425
3	3.1813	3.1551	3.17993	3.15273	3.167265
4	7.68978	7.68319	7.68502	7.67724	7.683808
5	7.69003	7.68338	7.69003	7.68338	7.686705
6	9.38804	9.37438	9.39015	9.38478	9.384338
7	12.2596	12.5088	12.2618	12.5095	12.38493
8	12.2692	12.5095	12.2692	12.5097	12.3894
9	14.8702	15.3333	14.8646	15.3517	15.10495
10	16.3194	16.1336	16.3194	16.1336	16.2265
11	16.3215	16.1489	16.3481	16.1343	16.2382
12	18.7473	18.6791	18.7452	18.6787	18.71258
13	18.7574	18.7096	18.7473	18.7096	18.73098



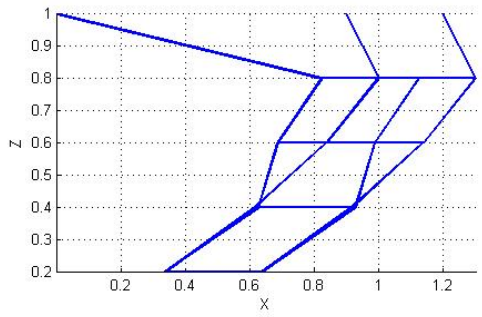
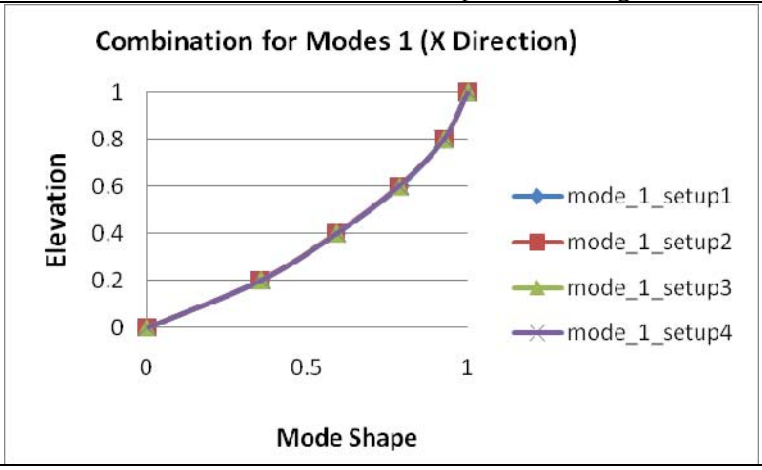
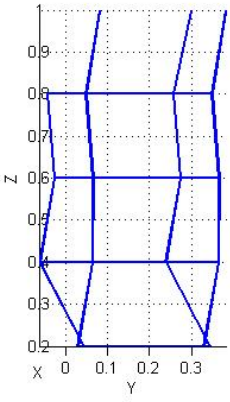
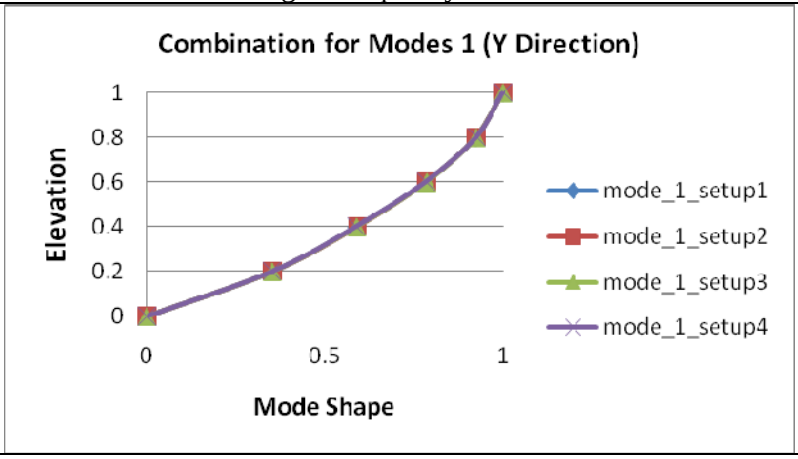
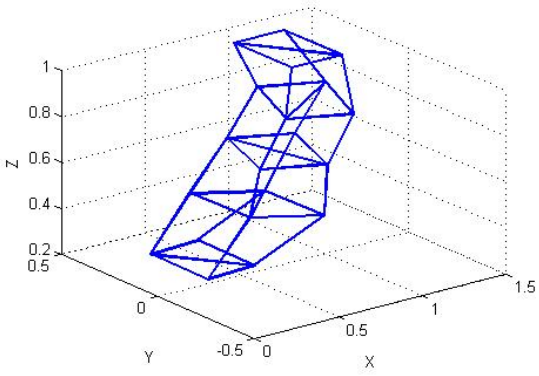
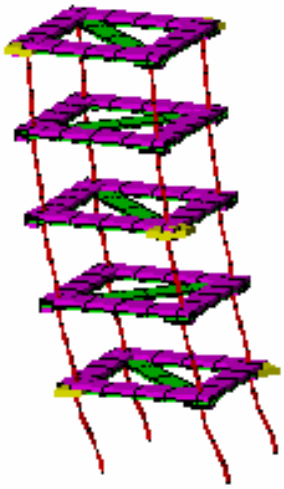
Overall Eigen frequencies from Slang for 6 setups

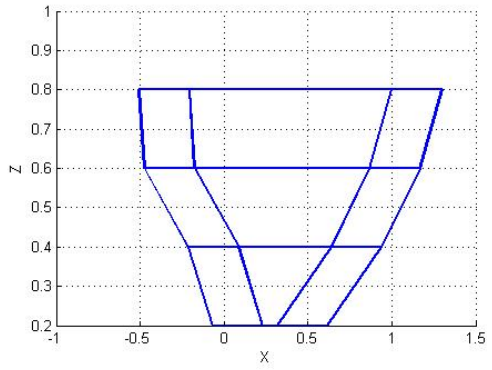
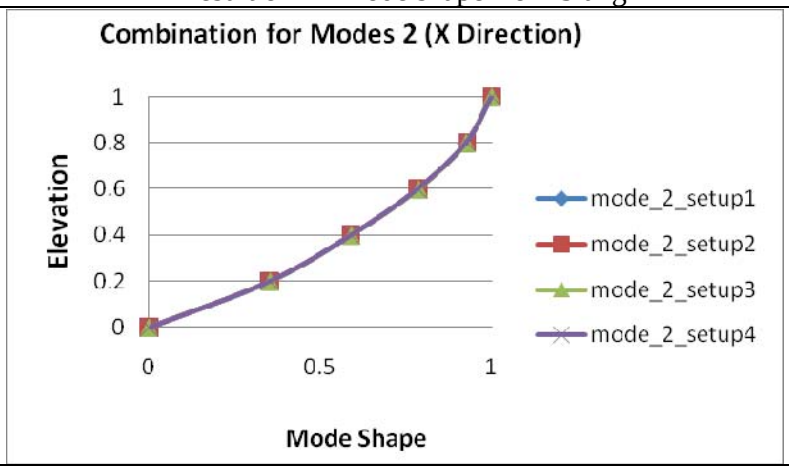
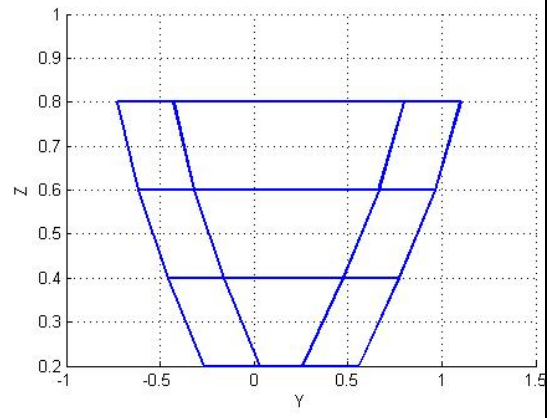
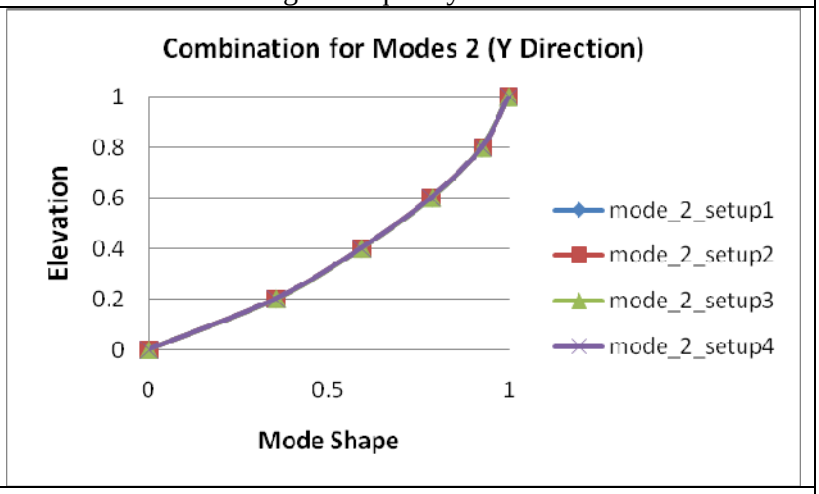
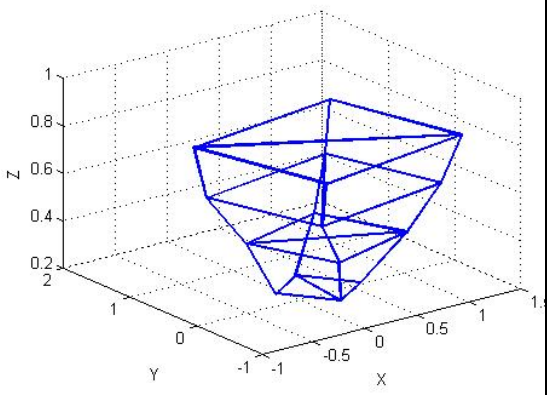
Because of the MACEC calculation is using stochastic method; we determined the eigen frequency value for each setup by using statistic method where we make average for each setup. The graph between MACEC and Slang is

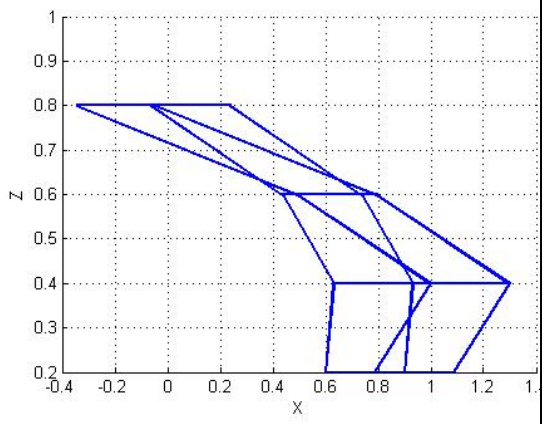
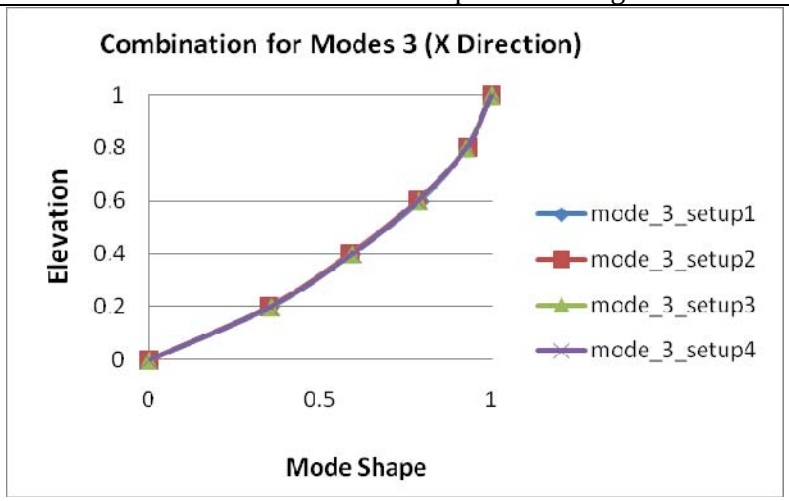
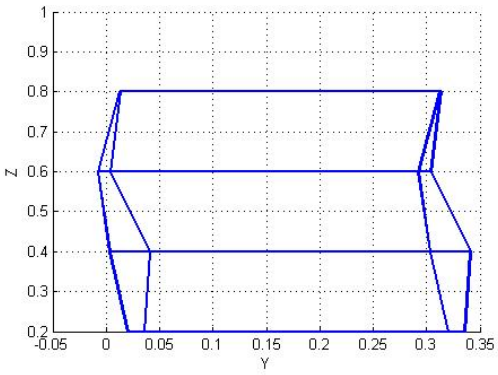
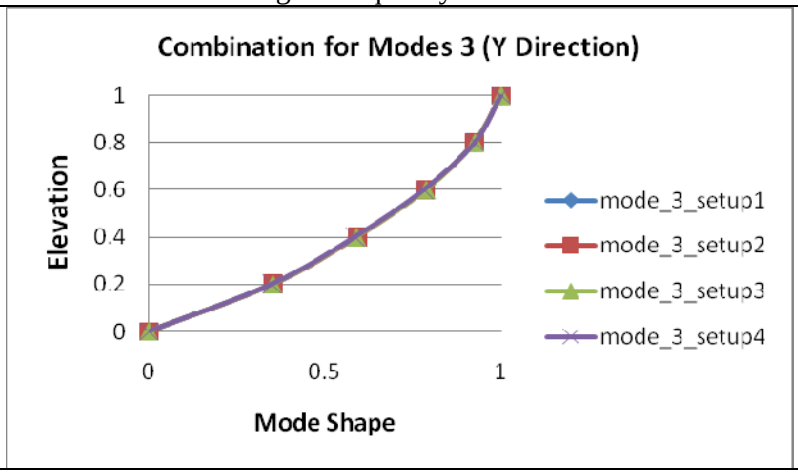
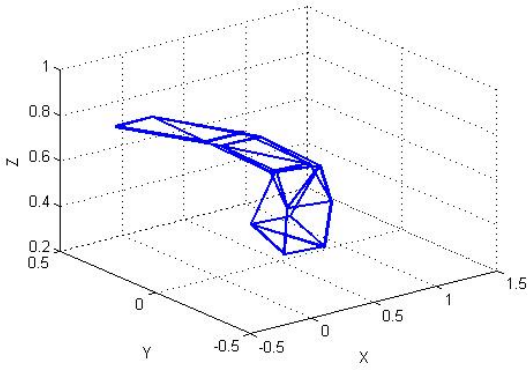


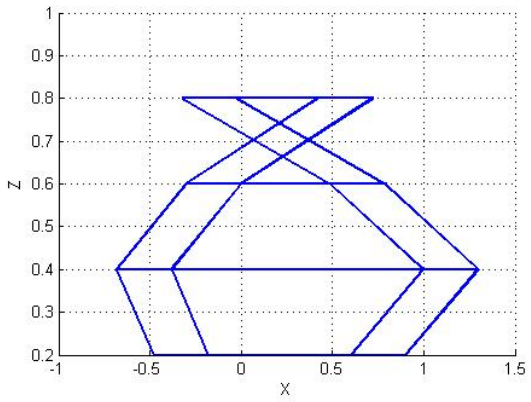
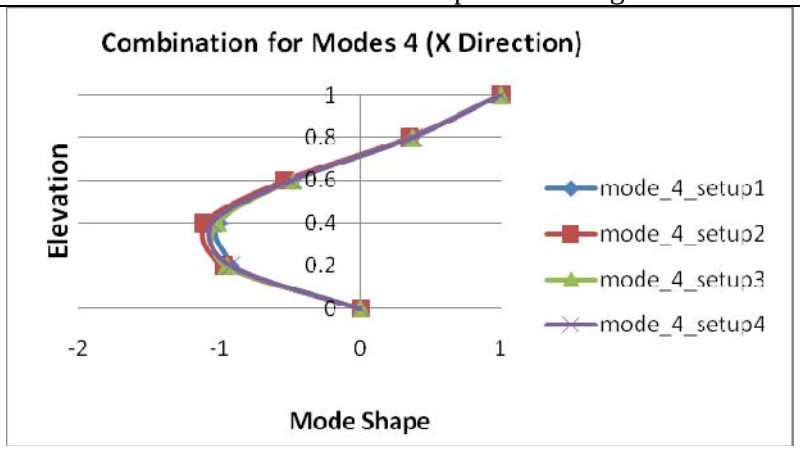
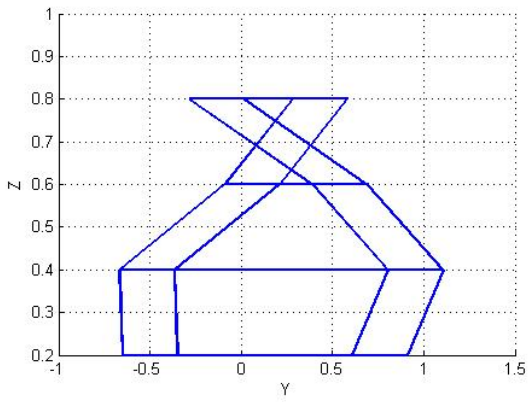
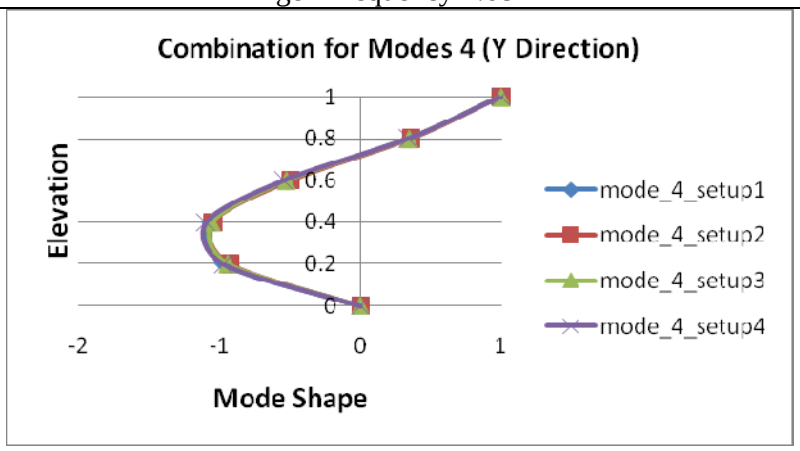
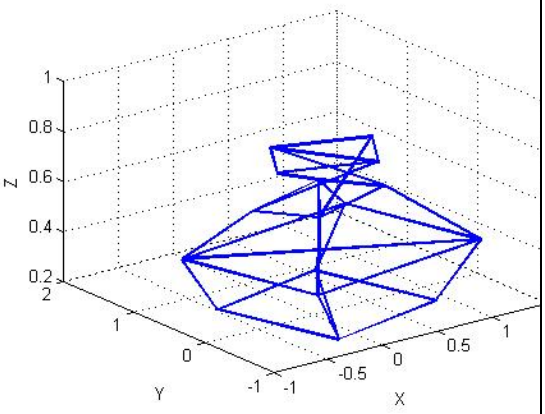
Overall frequencies from Macec

The result of Mode Shape for all Modes is:

Result of first Mode shape from MACEC	Result of first Mode shape from Slang
	
X Direction : Eigen frequency 2.47 Hz	Eigen Frequency 2.6 Hz
	
Y Direction : Eigen frequency 2.47 Hz	Eigen Frequency 2.6 Hz
	
3D view by MACEC	3D view by Slang

Result of 2nd Mode shape from MACEC	Result of 2nd Mode shape from Slang
	
X Direction : Eigen frequency 3.45 Hz	Eigen Frequency 2.6 Hz
	
Y Direction : Eigen frequency 3.45 Hz	Eigen Frequency 2.6 Hz
	
3D view by MACEC	3D view by Slang

Result of 3rd Mode shape from MACEC	Result of 3rd Mode shape from Slang
	
X Direction : Eigen frequency 8.9 Hz	Eigen Frequency 3.16 Hz
	
Y Direction : Eigen frequency 8.9 Hz	Eigen Frequency 3.16 Hz
	
3D view by MACEC	3D view by Slang

Result of 4th Mode shape from MACEC	Result of 4th Mode shape from Slang
	
X Direction : Eigen frequency 10.4 Hz	Eigen Frequency 7.68 Hz
	
Y Direction : Eigen frequency 10.4 Hz	Eigen Frequency 7.68 Hz
	
3D view by MACEC	3D view by Slang

There are mode shape above which were given by Slang. It was calculated by extracting the Eigen vector from the Slang and normalize it into same tables below:

Mode I:

	X Direction			
Normalisation	mode_1_setup1	mode_1_setup2	mode_1_setup3	mode_1_setup4
1	1	1	1	1
0.8	0.926032725	0.927218543	0.925282603	0.926428474
0.6	0.78929721	0.783907285	0.787151916	0.785694804
0.4	0.591724785	0.588490066	0.591253102	0.592158734
0.2	0.354285139	0.35105298	0.355086849	0.353381972
0	0	0	0	0

	Y Direction			
Normalisation	mode_1_setup1	mode_1_setup2	mode_1_setup3	mode_1_setup4
1	1	1	1	1
0.8	0.924514366	0.924774399	0.925287767	0.925606548
0.6	0.784179038	0.78516721	0.786373061	0.783469746
0.4	0.58919418	0.59083188	0.589676128	0.587277112
0.2	0.353098456	0.353120497	0.352320011	0.350862321
0	0	0	0	0

Mode II:

	X Direction			
Normalisation	mode_2_setup1	mode_2_setup2	mode_2_setup3	mode_2_setup4
1	1	1	1	1
0.8	0.925268402	0.925999013	0.925273646	0.925999013
0.6	0.786751807	0.784551413	0.786696604	0.784551413
0.4	0.590470844	0.589682148	0.59043643	0.589682148
0.2	0.353694478	0.352096695	0.353676677	0.352096695
0	0	0	0	0

	Y Direction			
Normalisation	mode_2_setup1	mode_2_setup2	mode_2_setup3	mode_2_setup4
1	1	1	1	1
0.8	0.925268402	0.925999013	0.925282603	0.925999013
0.6	0.786751807	0.784551413	0.787151916	0.784551413
0.4	0.590463827	0.589682148	0.591253102	0.589682148
0.2	0.353694478	0.352096695	0.355086849	0.352096695
0	0	0	0	0

Mode III

	X Direction			
Normalisation	mode_3_setup1	mode_3_setup2	mode_3_setup3	mode_3_setup4
1	1	1	1	1
0.8	0.92642539	0.928341489	0.925208762	0.927225229
0.6	0.792134479	0.78289982	0.788636089	0.786154133
0.4	0.593250957	0.587528972	0.592478519	0.593941656
0.2	0.355328357	0.349607262	0.356638025	0.35377869
0	0	0	0	0

	Y Direction			
Normalisation	mode_3_setup1	mode_3_setup2	mode_3_setup3	mode_3_setup4
1	1	1	1	1
0.8	0.923846456	0.924630404	0.9250595	0.925687705
0.6	0.783622773	0.785271967	0.787020375	0.782059381
0.4	0.588770865	0.591854951	0.589539676	0.585539539
0.2	0.353138875	0.35335007	0.351848842	0.349273531
0	0	0	0	0

Mode IV

	X Direction			
Normalisation	mode_4_setup1	mode_4_setup2	mode_4_setup3	mode_4_setup4
1	1	1	1	1
0.8	0.361039799	0.353599879	0.366162504	0.371855368
0.6	-0.490692004	-0.534671118	-0.480809005	-0.486576853
0.4	-1.00731445	-1.104696154	-1.018642279	-1.055353902
0.2	-0.918823951	-0.966239284	-0.952233556	-0.916515426
0	0	0	0	0

	Y Direction			
Normalisation	mode_4_setup1	mode_4_setup2	mode_4_setup3	mode_4_setup4
1	1	1	1	1
0.8	0.350653314	0.360777305	0.346152609	0.341372944
0.6	-0.513778265	-0.493641618	-0.522786846	-0.544654246
0.4	-1.066270245	-1.045710374	-1.054273539	-1.098439074
0.2	-0.971598466	-0.922878004	-0.938570395	-0.975662974
0	0	0	0	0

5.2. Second experimental test:

In the second test we made the model stiff by using the bracing elements in Y direction. It means we increased the stiffness and the natural period of the structure decreases and it result in increasing of the natural frequency of the model. We do not have displacement in y direction and only we have a displacement in x direction and we focus only in this direction, it means there is no close space.
We defined 4 setups and different sensors positions in the second test. We considered channel 1 and 4 as references at the top of the structure.

The table below describes the position of the sensor in the structure

		Sensor					
Setup	Direction	I	II	III	IV	V	VI
		-X	-X	-X	-Y	+Y	+Y
1	Point	21	24	13	21	22	13
2	Point	21	20	9	21	18	9
3	Point	21	16	5	21	14	5
4	Point	21	12	1	21	10	1
5	Point	21	8	17	21	6	17
6	Point	21	4	3	21	2	13

The tables below are describing the node's number, the position of beam/column elements, and slave correlation.

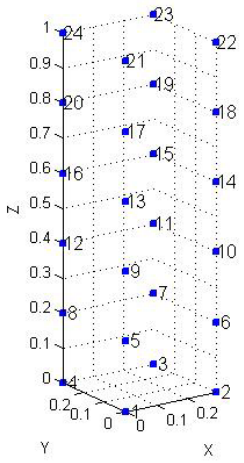
node	x	y	z
	[m]	[m]	[m]
1	0	0	0
2	0.3	0	0
3	0.3	0.3	0
4	0	0.3	0
5	0	0	0.2
6	0.3	0	0.2
7	0.3	0.3	0.2
8	0	0.3	0.2
9	0	0	0.4
10	0.3	0	0.4
11	0.3	0.3	0.4
12	0	0.3	0.4
13	0	0	0.6
14	0.3	0	0.6
15	0.3	0.3	0.6
16	0	0.3	0.6
17	0	0	0.8
18	0.3	0	0.8
19	0.3	0.3	0.8
20	0	0.3	0.8
21	0	0	1
22	0.3	0	1
23	0.3	0.3	1
24	0	0.3	1

Element	A	B	Remark
1	5	6	Beam
2	6	7	Beam
3	7	8	Beam
4	8	5	Beam
5	9	10	Beam
6	10	11	Beam
7	11	12	Beam
8	12	9	Beam
9	13	14	Beam
10	14	15	Beam
11	15	16	Beam
12	16	13	Beam
13	17	18	Beam
14	18	19	Beam
15	19	20	Beam
16	20	17	Beam
17	21	22	Beam
18	22	23	Beam
19	23	24	Beam
20	24	21	Beam
21	0	0	Column
22	0	0	Column
23	0	0	Column
24	0	0	Column
25	0	0	Column
26	0	0	Column
27	0	0	Column
28	0	0	Column
29	0	0	Column
30	0	0	Column
31	0	0	Column
32	0	0	Column
33	0	0	Column
34	0	0	Column
35	0	0	Column
36	0	0	Column
37	0	0	Column
38	0	0	Column
39	0	0	Column
40	0	0	Column
41	4	5	Bracing
42	8	9	Bracing
43	12	13	Bracing
44	16	17	Bracing
45	20	21	Bracing
46	1	8	Bracing
47	5	12	Bracing
48	9	16	Bracing
49	13	20	Bracing
50	17	24	Bracing
51	3	6	Bracing
52	7	10	Bracing
53	11	14	Bracing
54	15	18	Bracing
55	19	22	Bracing
56	2	7	Bracing
57	6	11	Bracing
58	10	15	Bracing
59	14	19	Bracing
60	18	23	Bracing
61	6	8	Bracing
62	9	11	Bracing
63	14	16	Bracing
64	17	19	Bracing
65	22	24	Bracing

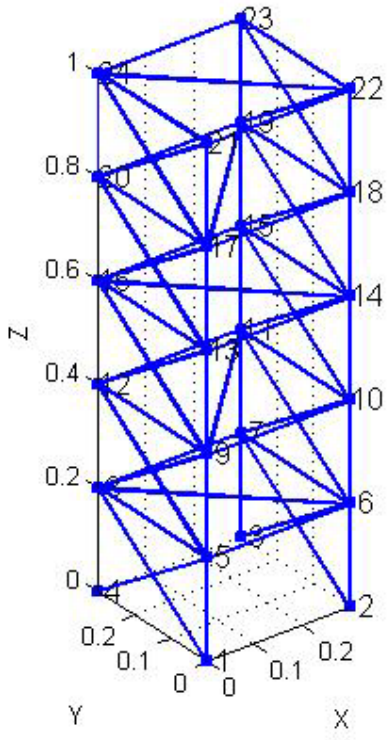
SLAVE II							
Master	X	Y	Z	Slave	X	Y	Z
1	1	0	0	2	1	0	0
1	0	1	0	4	0	1	0
2	0	1	0	3	0	1	0
4	1	0	0	3	1	0	0
5	1	0	0	6	1	0	0
5	0	1	0	8	0	1	0
6	0	1	0	7	0	1	0
8	1	0	0	7	1	0	0
9	1	0	0	10	1	0	0
9	0	1	0	12	0	1	0
10	0	1	0	11	0	1	0
12	1	0	0	11	1	0	0
13	1	0	0	14	1	0	0
13	0	1	0	16	0	1	0
14	0	1	0	15	0	1	0
16	1	0	0	15	1	0	0
17	1	0	0	18	1	0	0
17	0	1	0	20	0	1	0
18	0	1	0	19	0	1	0
20	1	0	0	19	1	0	0
21	1	0	0	22	1	0	0
21	0	1	0	24	0	1	0
22	0	1	0	23	0	1	0
24	1	0	0	23	1	0	0

Modal analysis of structures with MACEC:

First step:
The first step is to make the geometry of the model and in order to do it we defined the nodes and then connected the nodes to the beam to build the structural model. The model consists of 5 story and 24 nodes. The following figures show the grid and geometry of the model.



Defining the master and slave nodes



Geometry of the model by making link between nodes

Second step:
After defining the model geometry we should select the data to process it. The sampling frequency is 512. The procedure of the MACEC for the second experimental is the same with the first experimental. It was described in the previous paragraph.

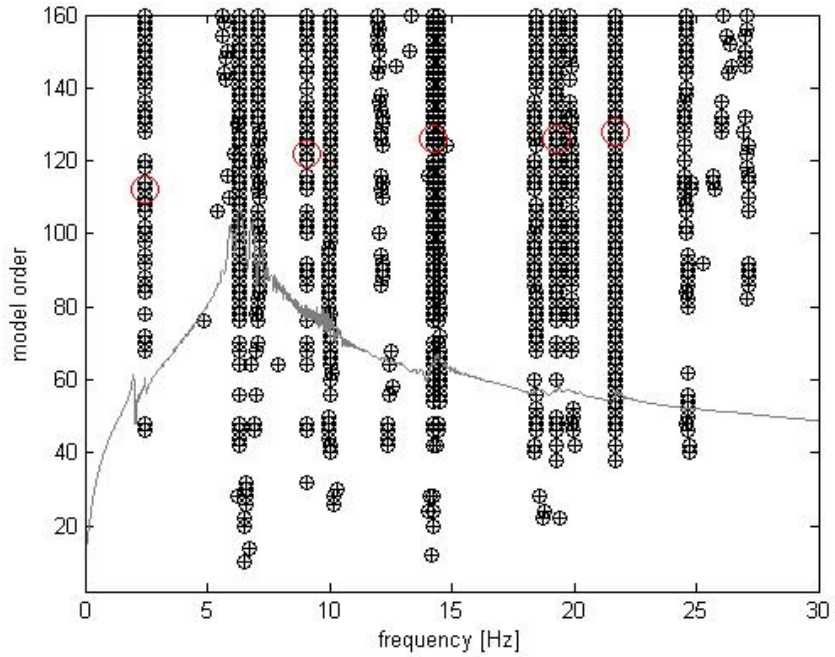
This figure shows the setup 3 which we used 2 sensor at the first level and 2 sensors at the third level and 2 constant position reference sensors at the top.

This figures show the setup 2 and setup 4.

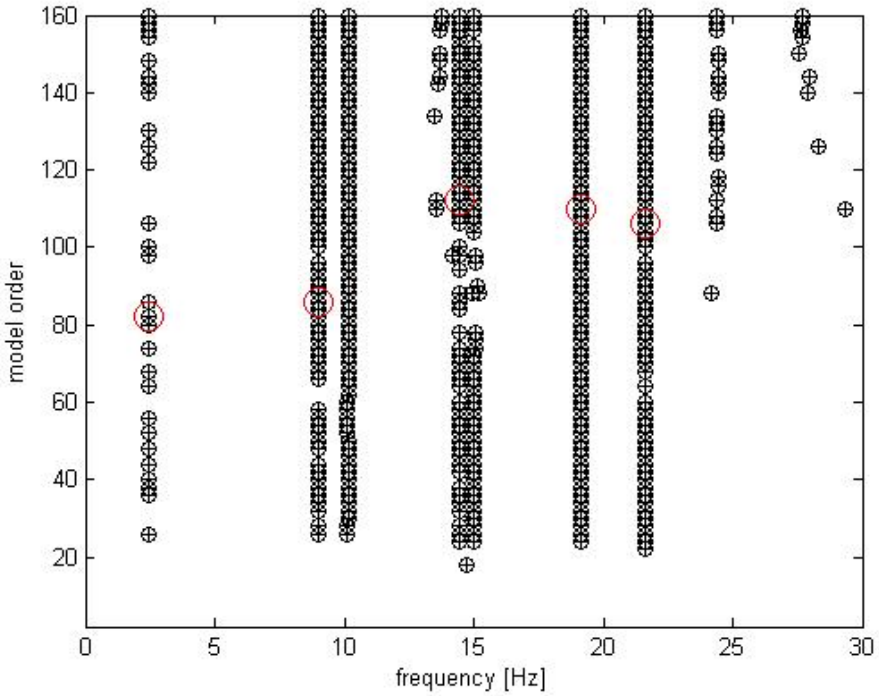
After performance of the second test we processed the data in MACEC software in order to get dynamic parameters of the model the same procedures like first test.

Stabilization diagram

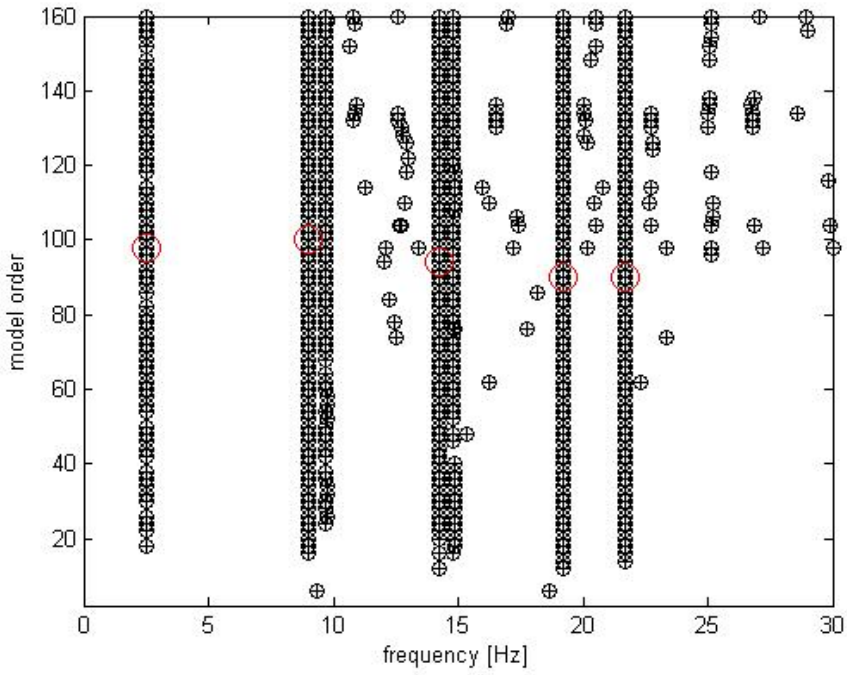
We decided to choose 5 dots to have eigen frequency for each setup. We want to predict the eigen frequency value compare to the slang's result.



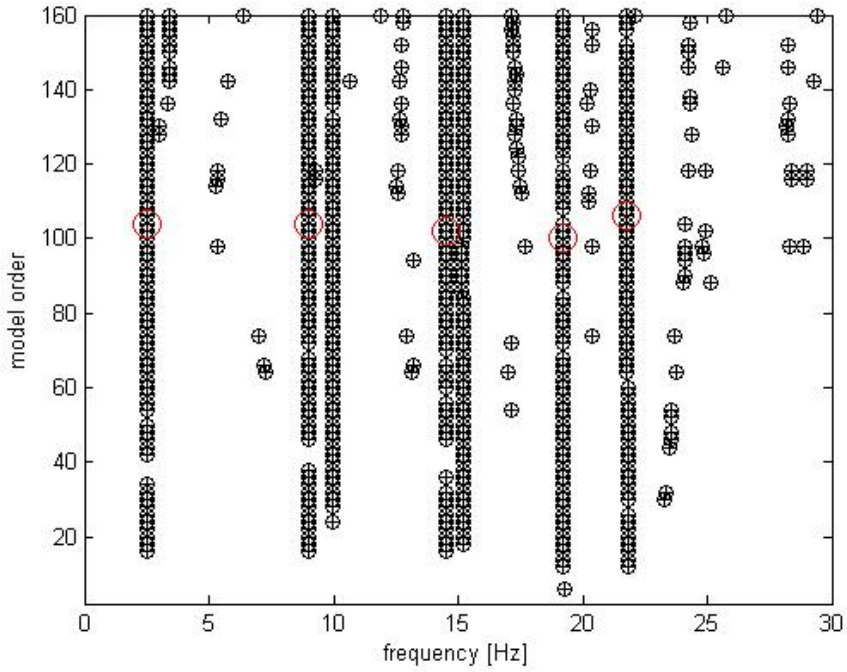
Stabilization diagram for setup 1



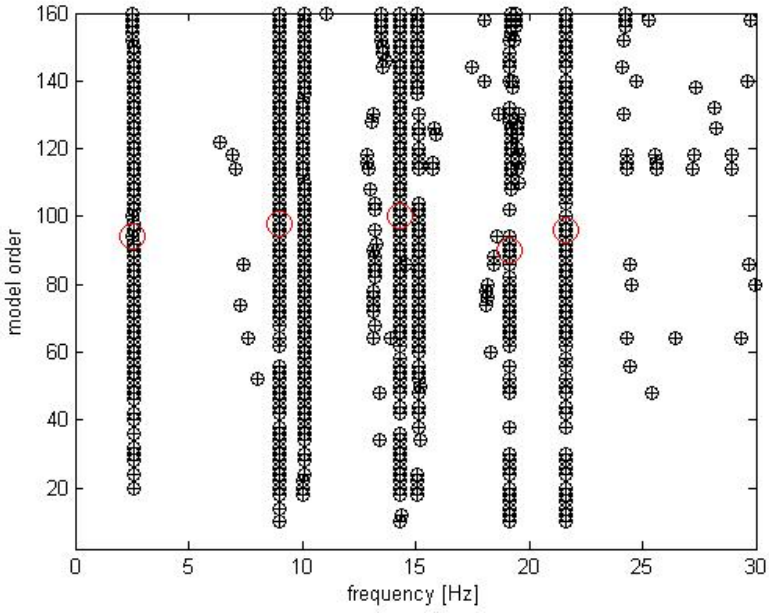
Stabilization diagram for setup 2



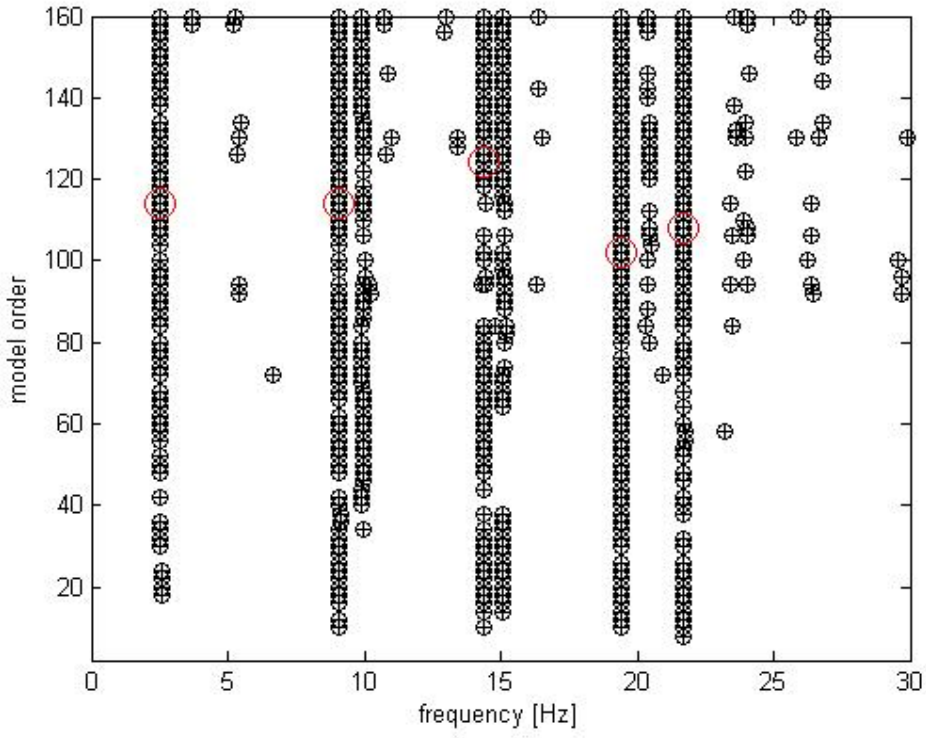
Stabilization diagram for setup 3



Stabilization diagram for setup 4



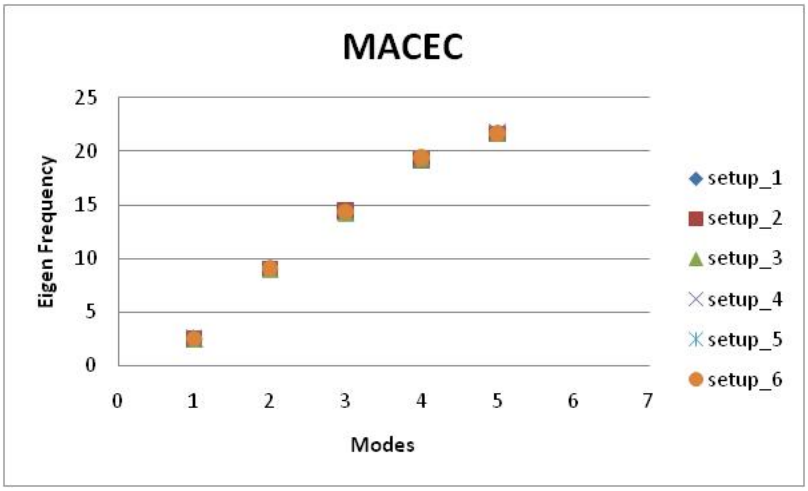
Stabilization diagram for setup 5



Stabilization diagram for setup 6

The result from MACEC is:

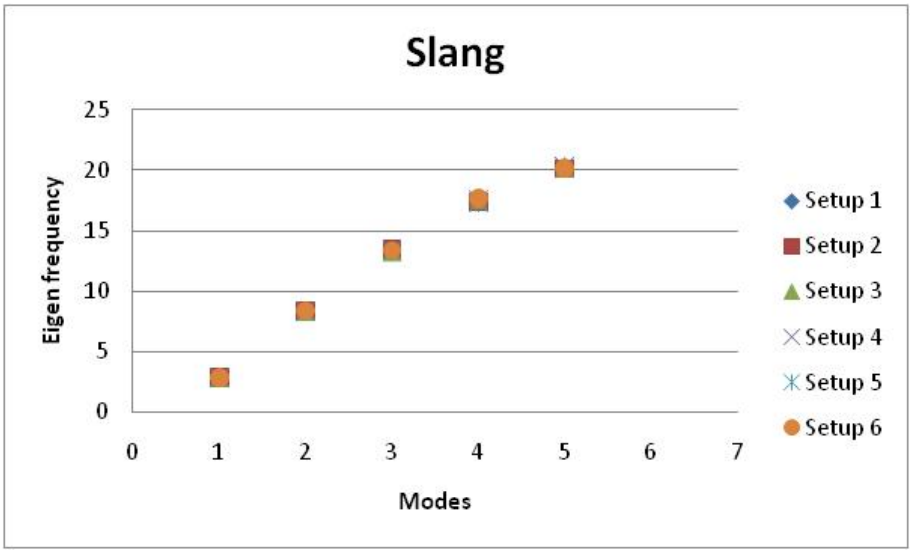
	setup_1	setup_2	setup_3	setup_4	setup_5	setup_6	average
1	2.47289	2.4554	2.49203	2.50398	2.55033	2.53612	2.520615
2	9.0362	9.02053	9.00489	9.01734	9.00948	9.09996	9.032918
3	14.3363	14.4605	14.2236	14.4907	14.3407	14.3944	14.36235
4	19.3495	19.1437	19.2315	19.2223	19.164	19.3952	19.25325
5	21.6892	21.6123	21.6597	21.777	21.6403	21.7155	21.69813



Overall frequencies from Macec

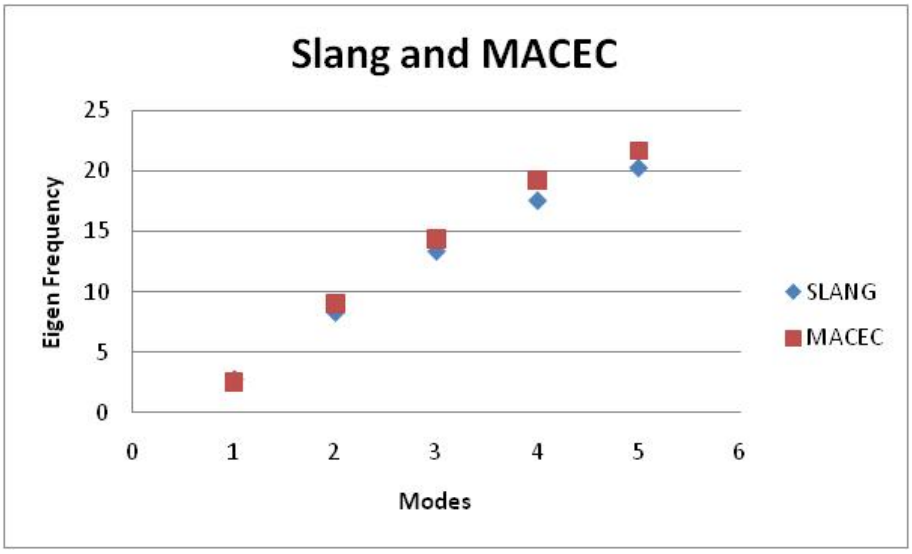
If we compare it to the slang result, the eigen frequencies distribution is:

	setup_1	setup_2	setup_3	setup_4	setup_5	setup_6	average
1	2.78909	2.80173	2.81594	2.82794	2.80847	2.81952	2.817968
2	8.29567	8.29785	8.30716	8.30749	8.31865	8.37495	8.327063
3	13.3023	13.4746	13.2228	13.5194	13.3252	13.3832	13.36265
4	17.6338	17.3657	17.5537	17.5553	17.3527	17.6921	17.53845
5	20.2007	20.1239	20.1628	20.2755	20.2661	20.2186	20.23075

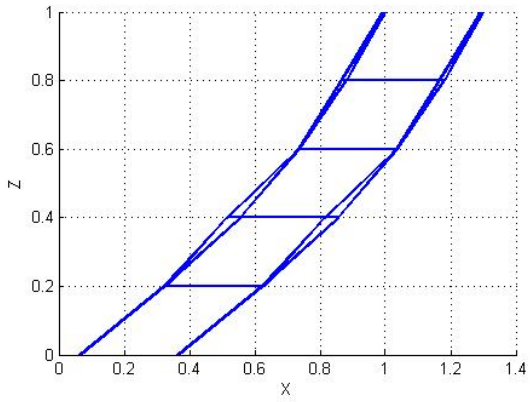
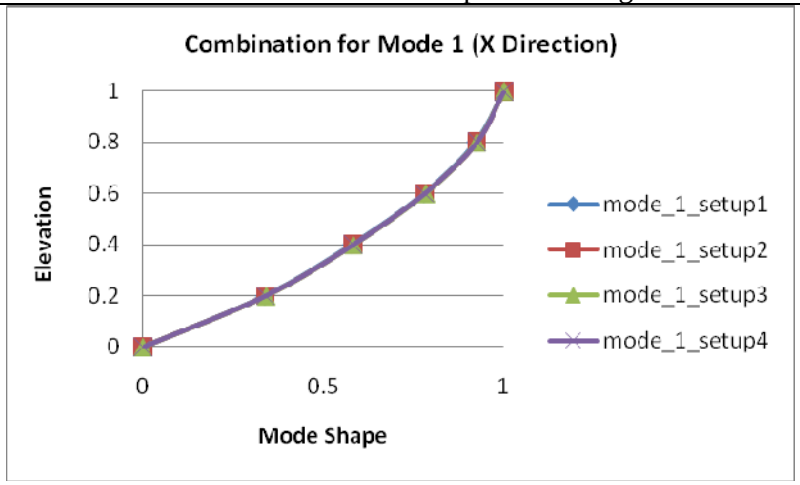
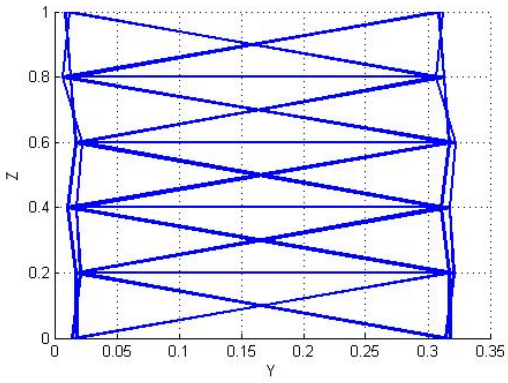
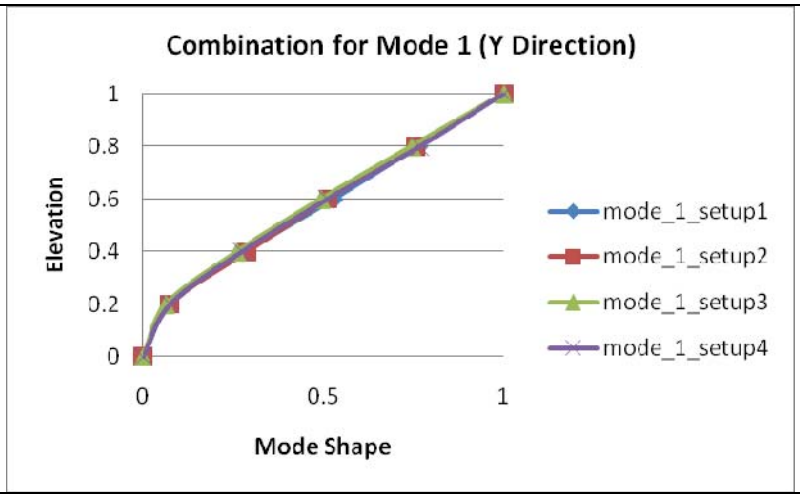
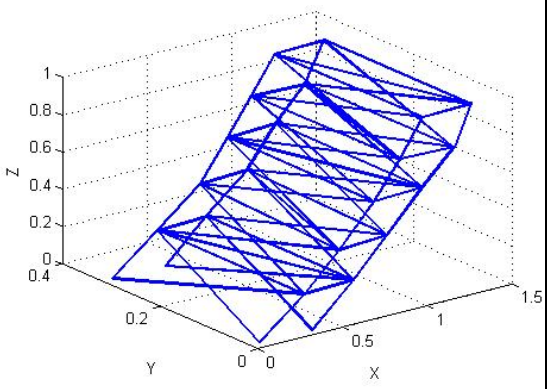
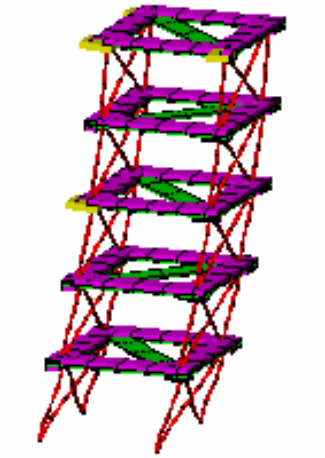


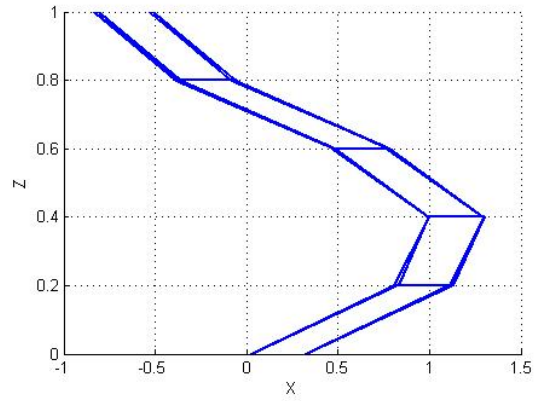
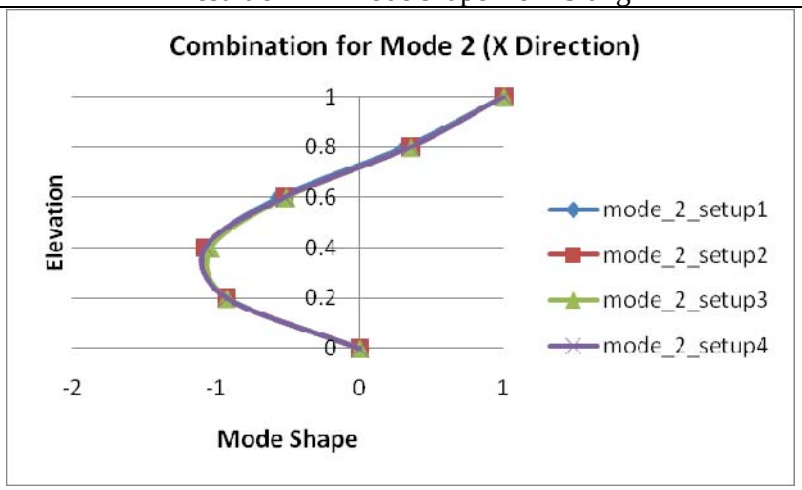
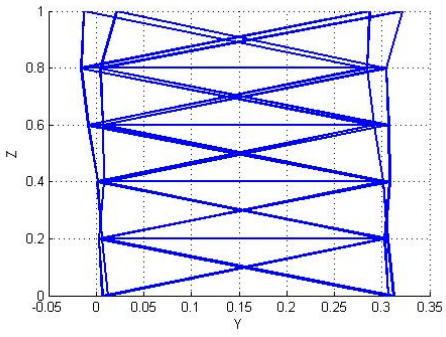
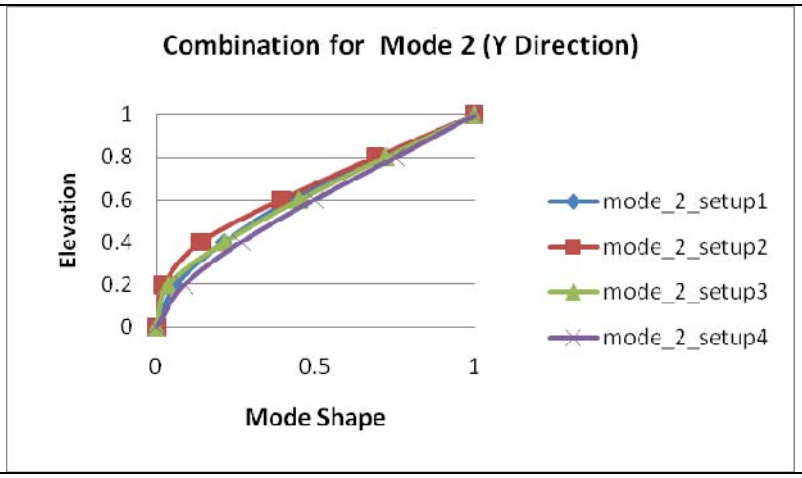
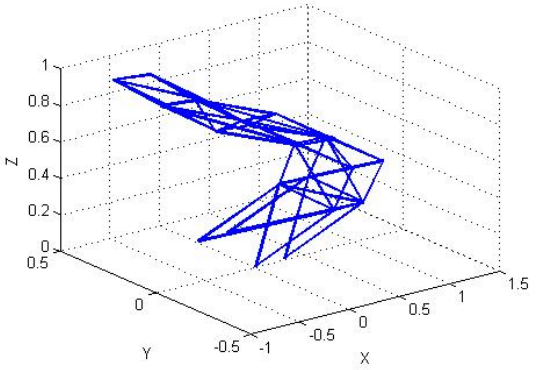
Overall Eigen frequencies from Slang for 6 setups

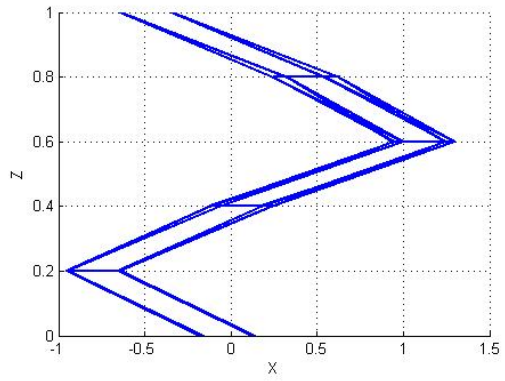
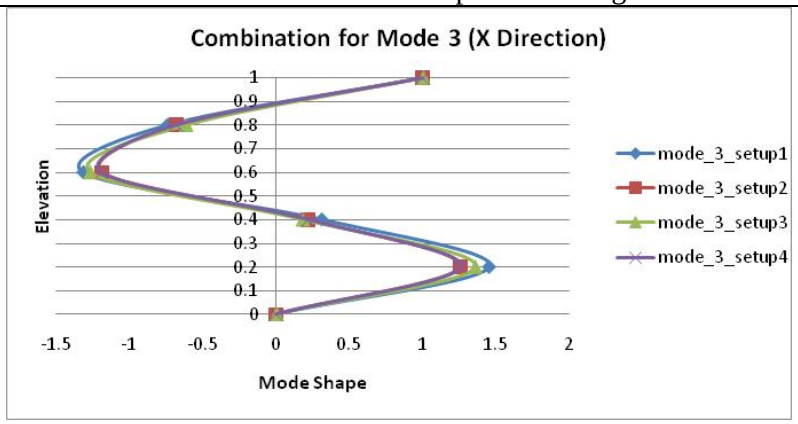
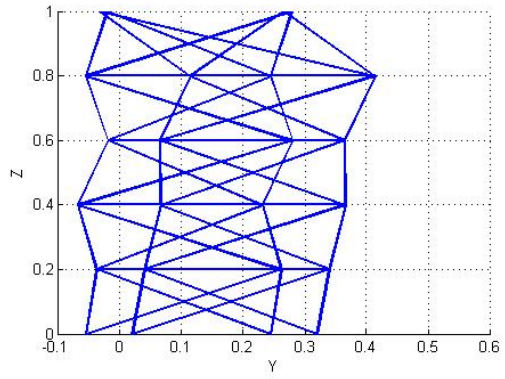
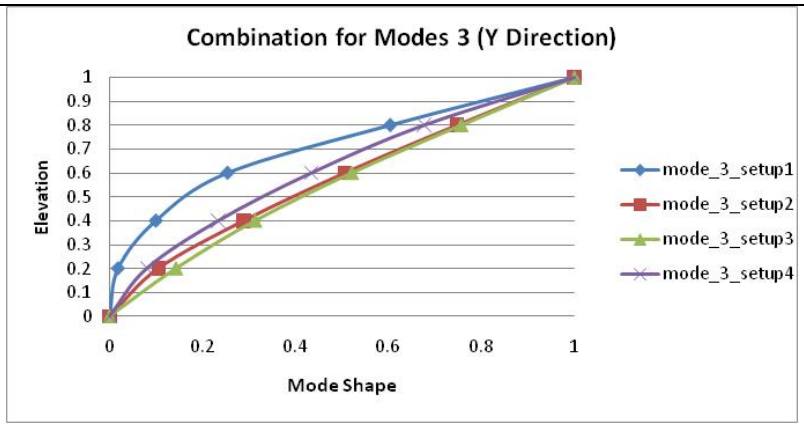
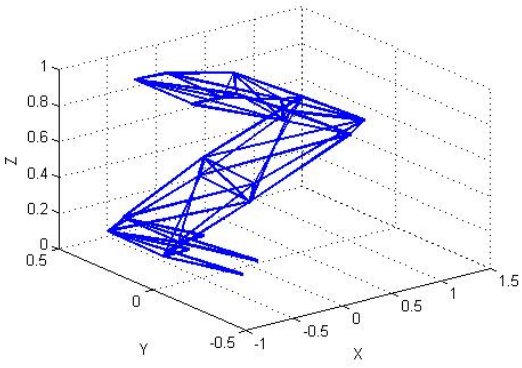
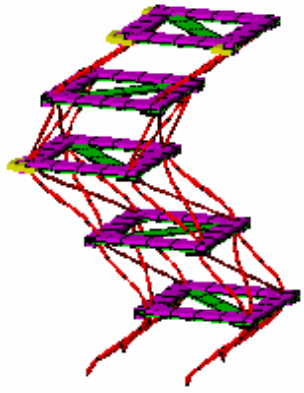
Because of the MACEC calculation is using stochastic method; we determined the eigen frequency value for each setup by using statistic method where we make average for each setup. The graph between MACEC and Slang is

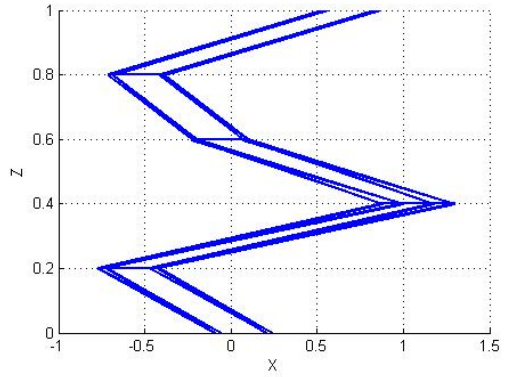
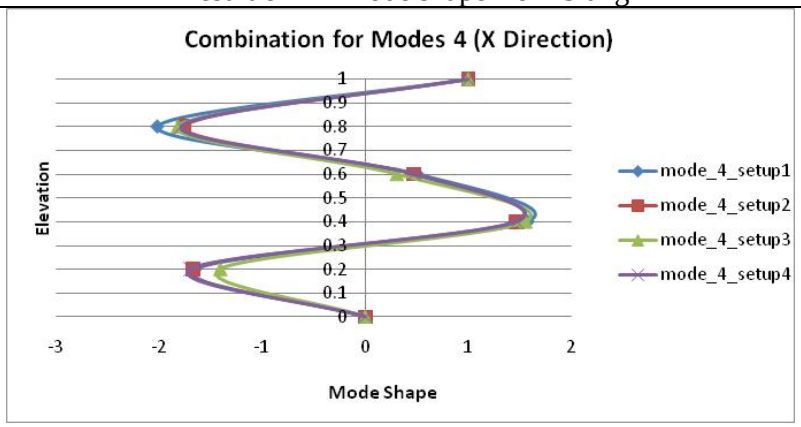
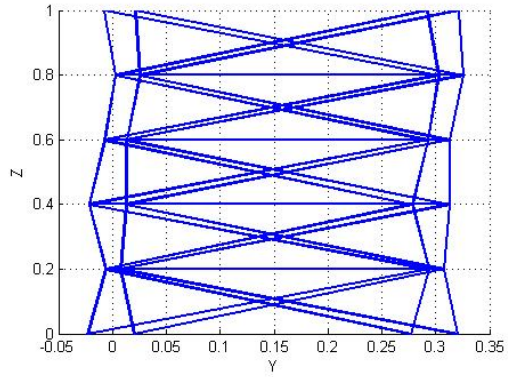
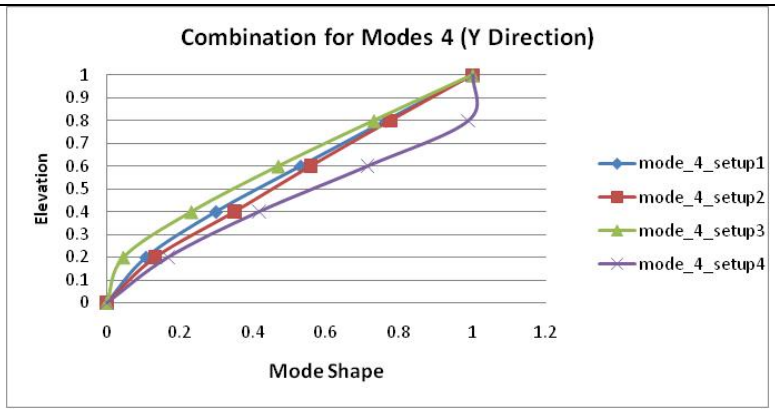
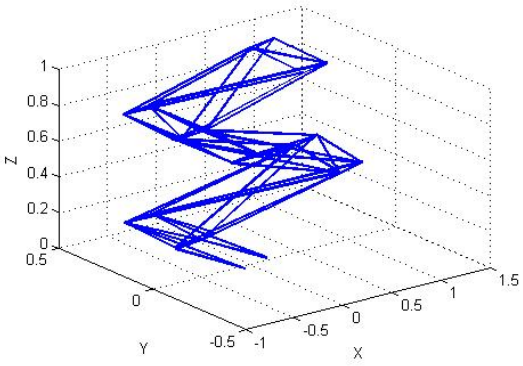
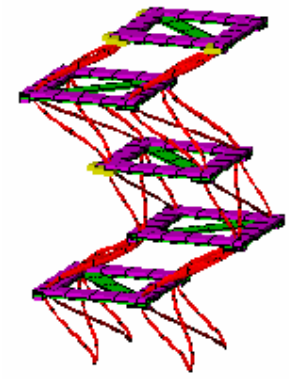


The result of Mode Shape for all Mode are:

Result of first Mode shape from MACEC	Result of first Mode shape from Slang
	
X Direction : Eigen frequency 2.52 Hz	Eigen Frequency 2.81 Hz
	
Y Direction : Eigen frequency 2.52 Hz	Eigen Frequency 2.81 Hz
	
3D view by MACEC	3D view by Slang

Result of 2nd Mode shape from MACEC	Result of 2nd Mode shape from Slang
	
X Direction : Eigen frequency 9.03 Hz	Eigen Frequency 8.32 Hz
	
Y Direction : Eigen frequency 9.03 Hz	Eigen Frequency 8.32 Hz
	
3D view by MACEC	3D view by Slang

Result of 3rd Mode shape from MACEC	Result of 3rd Mode shape from Slang
	
X Direction : Eigen frequency 14.36 Hz	Eigen Frequency 13.36 Hz
	
Y Direction : Eigen frequency 14.36 Hz	Eigen Frequency 13.36 Hz
	
3D view by MACEC	3D view by Slang

Result of 4th Mode shape from MACEC	Result of 4th Mode shape from Slang
	
X Direction : Eigen frequency 19.25 Hz	Eigen Frequency 17.53 Hz
	
Y Direction : Eigen frequency 19.25 Hz	Eigen Frequency 17.53 Hz
	
3D view by MACEC	3D view by Slang

There are mode shape above which were given by Slang. It was calculated by extracting the Eigen vector from the Slang and normalizes it into same tables below:

Mode 1

	X Direction			
Elevation	mode_1_setup1	mode_1_setup2	mode_1_setup3	mode_1_setup4
1	1	1	1	1
0.8	0.921080376	0.925001253	0.924278726	0.925005013
0.6	0.778151514	0.780869304	0.783018868	0.780830158
0.4	0.577739846	0.582092545	0.582859139	0.582113495
0.2	0.337426578	0.340116308	0.341619247	0.340099258
0	0	0	0	0

	Y Direction			
Elevation	mode_1_setup1	mode_1_setup2	mode_1_setup3	mode_1_setup4
1	1	1	1	1
0.8	0.764125782	0.757412471	0.744466922	0.769029628
0.6	0.528968779	0.514315586	0.493674326	0.513276038
0.4	0.284891409	0.28834915	0.260463782	0.27546096
0.2	0.076233274	0.073618037	0.063613032	0.075434043
0	0	0	0	0

Mode 2

	X Direction			
Elevation	mode_2_setup1	mode_2_setup2	mode_2_setup3	mode_2_setup4
1	1	1	1	1
0.8	0.313459357	0.353249419	0.351975749	0.353595724
0.6	-0.564299217	-0.523445519	-0.511381163	-0.522702732
0.4	-1.071725628	-1.07741343	-1.03807903	-1.076449627
0.2	-0.919956792	-0.925125601	-0.92437377	-0.92441421
0	0	0	0	0

	Y Direction			
Elevation	mode_2_setup1	mode_2_setup2	mode_2_setup3	mode_2_setup4
1	1	1	1	1
0.8	0.703258924	0.688948307	0.71975089	0.752035415
0.6	0.423019685	0.391228898	0.449711913	0.49633161
0.4	0.21309692	0.139661319	0.215196577	0.265860756
0.2	0.060567957	0.022830555	0.037882986	0.087611058
0	0	0	0	0

Mode 3

	X Direction			
Elevation	mode_3_setup1	mode_3_setup2	mode_3_setup3	mode_3_setup4
1	1	1	1	1
0.8	-0.742894322	-0.679089407	-0.617733351	-0.682099712
0.6	-1.318402849	-1.18829937	-1.272296508	-1.192064757
0.4	0.310649955	0.218322012	0.178300662	0.217980009
0.2	1.453736045	1.25347286	1.35538102	1.255963697
0	0	0	0	0

	Y Direction			
Elevation	mode_3_setup1	mode_3_setup2	mode_3_setup3	mode_3_setup4
1	1	1	1	1
0.8	0.603890223	0.747696949	0.756467838	0.676547831
0.6	0.253904004	0.506099972	0.520872427	0.434237933
0.4	0.099799189	0.28891753	0.313147937	0.234080961
0.2	0.018277356	0.104970782	0.142832313	0.080052525
0	0	0	0	0

Mode 4

	X Direction			
Elevation	mode_4_setup1	mode_4_setup2	mode_4_setup3	mode_4_setup4
1	1	1	1	1
0.8	-2.013948298	-1.754381306	-1.821015672	-1.783803132
0.6	0.501515715	0.472818198	0.306988096	0.470747204
0.4	1.572252185	1.460966543	1.558619508	1.472662192
0.2	-1.6458992	-1.670915206	-1.407895864	-1.69064877
0	0	0	0	0

	Y Direction			
Elevation	mode_4_setup1	mode_4_setup2	mode_4_setup3	mode_4_setup4
1	1	1	1	1
0.8	0.763840463	0.775830143	0.730102295	0.988034124
0.6	0.530002551	0.557437906	0.468887226	0.712818964
0.4	0.298766902	0.34950592	0.231387226	0.415936887
0.2	0.107645208	0.132725007	0.045603792	0.16726559
0	0	0	0	0

6. Conclusion

1. The result from the first experimental doesn't has sufficient data, for instance, there is no sensor on the bottom level and one additional sensor in the top storey. It causes the structure doesn't move properly and the structure is not complete due to less information.

2. After finding the problem in the first experimental, we did some modifications in the second experimental. The result of mode shapes is almost the same with the slang output.

3. Eigen Frequencies between Slang and Macec are different because in the Slang, we are assuming that the structure is perfect condition, on the other hand, the actual structure in each experimental is not perfect, for instance, connection by Screws and shape of rod has small banding.

4. We recommend to use 1 or 2 sensor as the slave's controller for each setup because we don't have enough sensor to measure all data at each point.

5. Bracings were used in the second experimental. We considered in the Y direction because we want to know the influence of the bracing in the structure. Because of this, the mode shapes of the structure is dominantly in X direction, whereas the mode shapes in Y direction is almost not moving.

6. In the first experimental, there are some modes which is really close to each other. Usually it is called "Close Space Mode". It occurs in the first experimental because the structure might move to X or Y direction. By using the bracing in the second experimental, we could reduce the "Close Space Mode" because we increased the stiffness and mass in Y Direction and the movement is dominantly in X direction.

7. Reference

1. Experimental Structural Dynamics, Dr.-Ing. Volkmar Zabel, Bauhaus University Weimar, 2010

2. Slang Manual, version 5.1.0, Institute of Structural Mechanics, Bauhaus University Weimar, November 2006

3. MACEC Manual, version 3.1, Matlab toolbox for experimental and Operational Modal analysis, Edwin Reyders, Mattias Schevenels and Guido De Roeck, Faculty of Engineering, Department of Civil Engineering, Structural Mechanics Division, Katholieke Universiteit Leuven, February 2010.

8. References

MACEC 3.1: A MATLAB TOOLBOX FOR EXPERIMENTAL AND OPERATIONAL MODAL ANALYSIS USER'S MANUAL Edwin REYNDERS, Mattias SCHEVENELS and Guido DE ROECK

Slang the structural language Version 5.1.0 Institute of Structural Mechanics – Bauhaus University Weimar November 23, 2006