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SHAKE TABLE SEISMIC PERFORMANCE OF BAMBOO FRAME AND STEEL FRAME

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Abstract: Seismic performance is an evaluation of building structures ability to sustain its due functions such as safety and serviceability at and after a particular earthquake. The study of the generation, propagation and recording of elastic waves in the earth is termed as seismology. Earthquakes are part of this environment. Apart from these, destruction of life and property, they can have serious indirect consequences. The exact simulation of earthquake motion has been a serious challenge to researchers and engineers. To overcome these problems caused by earthquakes various test have conducted on models before the construction of the full structure. We are making an attempt to evaluate the best frame system for resisting earthquakes. The models are analysed in ETABS software and experimentally analysed using shake table. Shake table are used in many research work as it produces the same effects that earthquake produces. Shake table are used to study the dynamic effects like frequency, drift and displacement of different frames. Based on this studies the performance of the bamboo frame over steel frame is evaluated and optimized the best frame effectively to withstand seismic activity.

***Keywords*: seismic performance, Etabs, bamboo frame, dynamic effects, shake table.**

I. INTRODUCTION

Seismic performance is an evaluation of building structures ability to sustain its due functions such as safety and serviceability at and after a particular earthquake. The subset of seismic analysis is the structural analysis and is the calculation of the response of a building structure to earthquakes.

The infrastructure is developing at a rapid pace with the growing needs of the community and the losses experienced by the earthquake hazards are increasing tremendously with time. From the past few decades, earthquake experiences all over the world have become major concern for the researchers and engineers. Several physical (full scale and reduced scale) and numerical models are developed and are being developed to study various problems related to seismic related basic soil mechanics problems and geotechnical structures.

In the northeast Indian hill region, the recent 2004 Sikkim earthquake demonstrated the vulnerability of existing and newly constructed masonry and concrete structures. India has Witnessed significant and damaging impacts of several medium and high intensity earthquakes in the past years.

Out of these, the Bhuj earthquake (2001), which has severely affected Ahmedabad city and surroundings, is the very recent one which attracted the attention of the most of the engineers, scientists and also professional practitioners working in the area of earthquake engineering. To minimize the damage caused due to earthquake on various structures, performance assessment of these structures under seismic loading is required, which can be acquired through physical model tests. One of the purposes of the physical modelling is to generate data which can be used to validate numerical and analytical procedures which can be used for simulation and then extrapolating from model to the prototype scale. There are several experimental techniques that can be used to test the response of structures and soil or rock slopes to verify their seismic performance, one of which is the use of an earthquake shaking table. Shake table are an essential tool for assessing the behaviour of structural components, the whole system works similar to those induced in real earthquake.

II. OBJECTIVE

The objective of this study:

1. To determine the various seismic parameters like drift, frequency and displacement for the two frame systems (bamboo frame and steel frames)
2. To evaluate the performance of the bamboo frame over steel frame.
3. To optimize the best frame system effectively to withstand seismic activity.

III. METHODOLOGY

Methodology steps follows:

1. Literature Review
2. Similitude Study
3. Seismic analysis of models using Etabs software
4. Preparation of model using Bamboo and MS steel
5. Testing models in shake table
6. Studying parameters like frequency, displacement...etc.

7. Comparison of results obtained from bamboo frame steel frame.
8. Conclusion

IV. MODEL PREPARATION

I. MODELLING IN ETABS

A simple steel frame of size 300mm*150mm single bay was modelled in Etabs, the details of the models are described below

Table I

Number of storey	G+2
Column size	25mm*5mm
Plate size	150mm*10mm
Plate dimensions	300mm*150mm
Storey height	500mm
Material	MS Steel

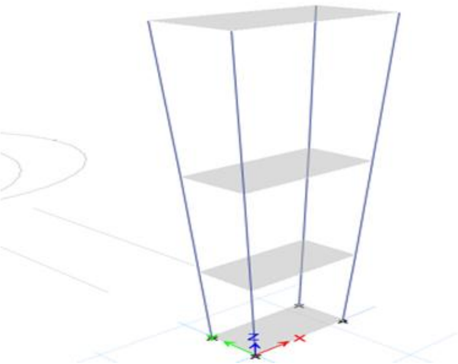

Fig 1. Steel frame

The seismic details of the steel frame

Seismic details:
Referring to IS code - 1893 (part 1):2002
Seismic zone factor, Z – 0.36
Seismic zone - V
Importance factor - I – 1
Reduction factor - R – 5

II. BAMBOO MODEL PREPARATION

After deciding the scaling factor the preparation of the scaled model is done. The model is prepared as follows,

1. At first the prototype building is considered.
2. The scaling of prototype building is done then the model with precise and required sizes is obtained.
3. Once the model size is been decided we moved to the preparation of model using bamboo.

The following fig shows the dimensions of prototype and model.

Fig 2: Cross section of bamboo column

4. The main components of model are columns, base and storey plates, steel nails, bamboo (in case of bamboo model) and steel (in case of steel model)
5. We searched for the bamboo's and collected required amount of bamboo and cleaned it.
6. Then the bamboo is cut into desired shape and size.
7. The columns prepared using bamboo is of height-500 mm (each storey height), thickness-5mm, and width-25mm, are formed using bamboo.
8. The plates of length-300 mm, width-150 mm, and thickness-10 mm, are made. Here as the thickness and width of plate is more we attached two bamboo strips to achieve the thickness and 5 bamboo strips of 30 mm width to achieve width of 150 mm. To attach the bamboo strips we used glue and steel wires.

Fig 3: Elements of plate

9. In the base plate the holes of 12mm diameter are made to fit the model safely on to the shake table (here 12mm diameter bolts are used).

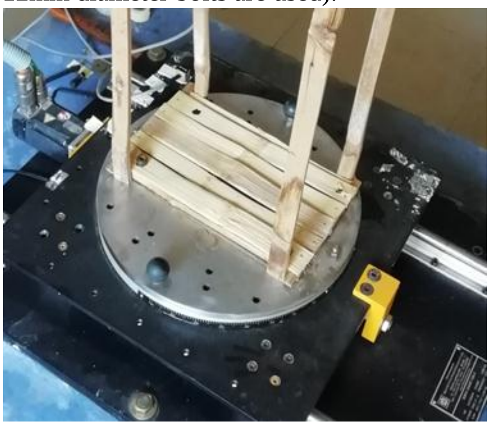

Fig 4: Connection of model with shake table

10. Once the individual elements of model are prepared they are joined and made into a 3 storey single bay replica of a building. Here the steel nails are used to join the individual elements.

Fig 5: Final Bamboo model

III. STEEL MODEL PREPARATION

After deciding the scaling factor the preparation of the scaled model is done. The model is prepared as follows,

1. At first the prototype frame is considered.
2. The scaling of prototype frame is done then the model with precise and required sizes is obtained.
3. Once the model size is been decided we moved to the preparation of model using mild steel.

The following fig shows the dimensions of steel frame

Fig 6: Cross section of Steel columns

The main components of model are steel columns, base and storey plates, nuts and screws.

The columns made from steel which are of height-500 mm (each storey height), thickness-5mm, and width-25mm, are formed.
The plates of length-300 mm, width-150 mm, and thickness-10mm, are made. To attach the steel plate we used screws and nuts.

Fig 7: plate connected to column using bolts (6mm dia)

Fig 8: steel plate of thickness 10mm

In the base plate the holes of 12mm diameter are made to fit the model safely on to the shake table (here 12mm diameter bolts are used).

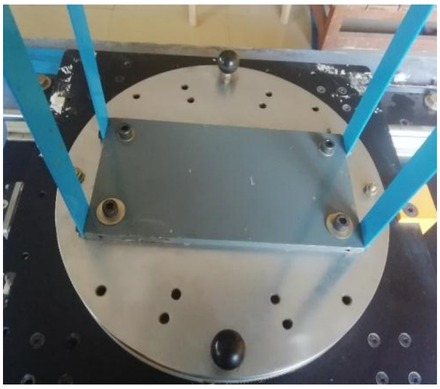

Fig 9: Bottom plate connected to shake table

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Once the individual elements of model are prepared they are joined and made into a 3 storey single bay

Fig 10 : Steel frames

IV. TESTING USING SHAKE TABLE

The testing procedure using shake table is as follows. It works on two soft-wares.

1. Launch the Kampana Vibration Analyser Software by clicking the Icon on the on the Desktop.
2. After the application launches, click on setting and select the appropriate port in the com port tab, also select the channels and grid settings.
3. Press the start button and let the time domain data get plotted.
4. Verify the frequency value. (Any change in frequency should have a minimum of 20 second off-time margin, half a minute could be taken as reference).
5. Use the keys to scale the time and voltage scale for the display windows.
6. Click Filter ON, then filter settings to select the filter parameters, edit the values as required and click apply.
7. You can see the change in the time domain waveform.
8. Similarly corresponding change will be visible in frequency domain.
9. Check the vibration parameters displayed on the control window.
10. Change the frequency to a different value and follow the steps from step 4 to step 10.
11. Repeat the procedure from step 4 to step 10 for further experiment.
12. Stop the experiment by clicking on the stop button.
13. Browse the files that are saved by default, verify the date and time of file creation.
14. Read the data and plot the data in offline mode for verification.
15. Export the acceleration data and verify the generated file by checking the time histories of acceleration, velocity and displacement.

V. RESULTS AND DISCUSSIONS

An experiment was carried on shake table for bamboo frame and Steel frame where the frequency ranges from 1 to 8 Hz of 50 cycles. The results are obtained in excel sheets. Graphs are plotted for respective values.

A.BAMBOO FRAME

Table 1- Displacement in ‘mm’ for X direction

	X Direction			
Frequency	CH 1	CH 2	CH 3	CH 4
1	19.974	33.952	56.256	52.489
2	43.403	33.952	56.256	54.251
3	7.087	23.019	11.235	23.039
4	32.564	50.79	11.239	74.226
5	26.984	31.339	43.273	46.554
6	86.136	93.178	144.621	84.254
7	86.136	93.178	144.621	161.083
8	86.136	93.178	144.621	161.083

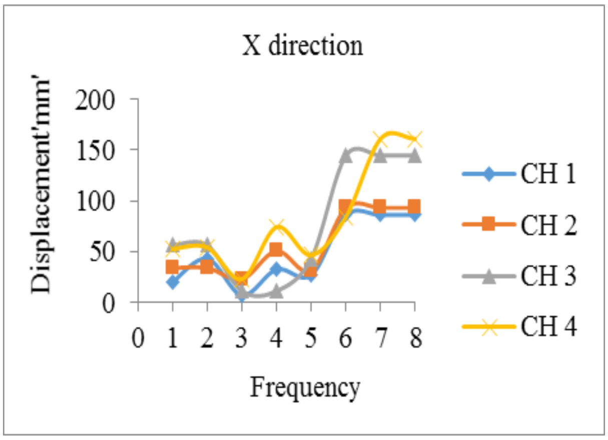

Fig 11: Displacement vs. frequency graph

Table 2 - Displacement in ‘mm’ for Y direction

	Y Direction			
Frequency	CH 1	CH 2	CH 3	CH 4
1	38.551	43.163	33.952	20.859
2	41.038	43.163	33.952	43.339
3	3.456	2.681	23.019	27.31
4	7.028	15.06	50.79	6.16
5	16.484	29.899	31.399	41.535
6	41.536	99.372	93.178	82.146
7	41.536	99.372	93.178	241.384
8	41.536	99.372	93.178	241.384

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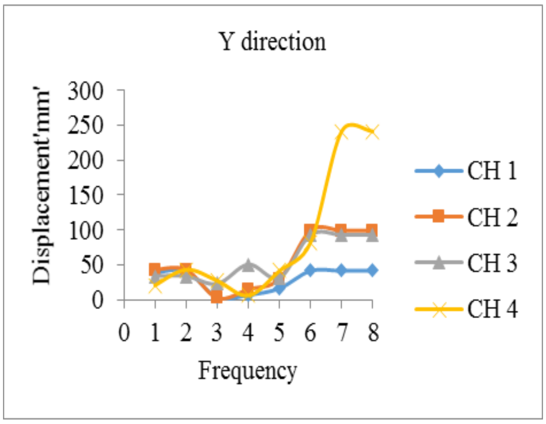

Fig 12: Displacement vs. frequency graph

Table 3- Displacement in 'mm' for Z direction

	Z Direction			
Frequency	CH 1	CH 2	CH 3	CH 4
1	2.837	16.158	0.587	40.222
2	3.591	42.955	39.226	40.222
3	5.34	2.439	1.813	6.558
4	6.036	7.724	7.724	6.726
5	7.785	10.796	39.178	36.997
6	8.158	10.796	133.756	54.498
7	8.158	15.026	133.756	321.347
8	8.158	15.026	133.756	321.347

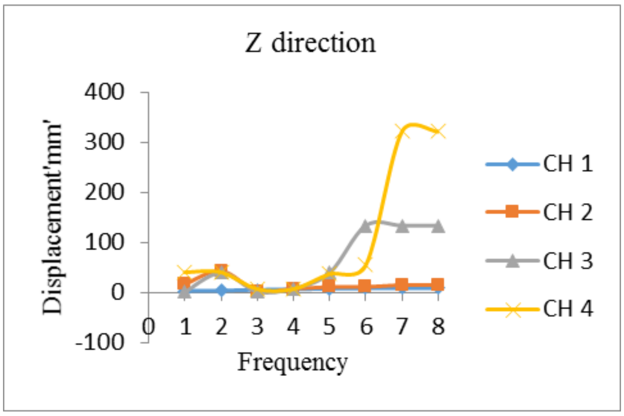

Fig 13: Displacement vs. frequency graph

The figure shows the Displacement vs Frequency variation graph. The above graph is drawn using the values of displacement obtained for varying frequencies for X,Y and Z direction of CH 1, 2, 3 and 4. Here the variation of frequency is between 1-6Hz. While doing the test using shake table for frequency 8Hz, the displacement values for CH 1,2,3,4 was maximum.

B. STEEL FRAME

Table 4- Displacement in 'mm' for X direction

	X Direction			
Frequency	CH 1	CH 2	CH 3	CH 4
1	12.059	20.752	10.566	41.274
2	40.469	80.792	49.047	36.486
3	40.469	80.792	49.047	36.486
4	50.583	42.96	45.464	274.607
5	51.45	40.551	50.324	274.604
6	51.45	40.551	50.324	274.607

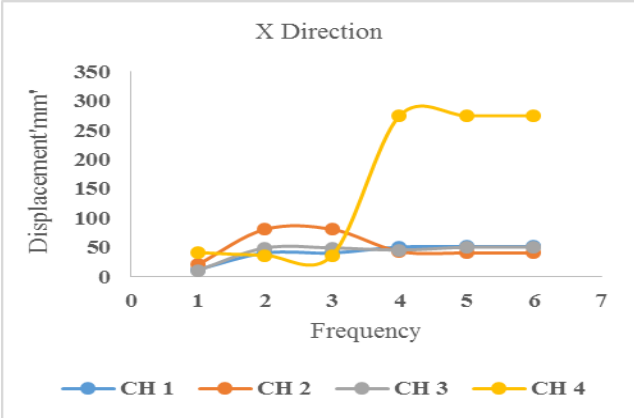

Fig 14: Displacement vs. frequency graph

Table 5- Displacement in 'mm' for Y direction

	Y Direction			
Frequency	CH 1	CH 2	CH 3	CH 4
1	24.277	22.663	39.475	3.074
2	65.774	26.207	106.901	42.864
3	65.774	26.207	106.901	43.99
4	41.003	7.753	40.952	338.869
5	9.599	9.753	38.112	338.869
6	27.017	9.753	38.112	338.869

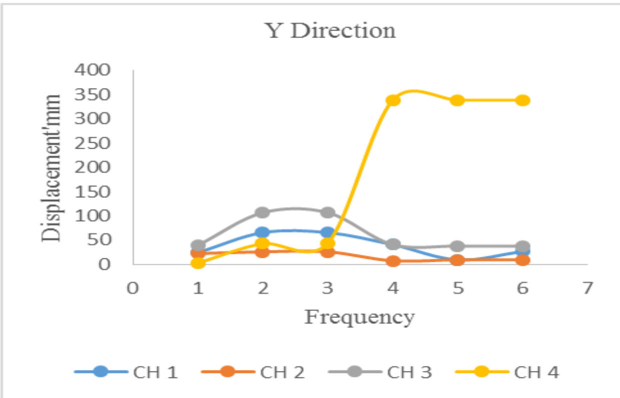

Fig 15: Displacement vs. frequency graph

Table 6- Displacement in 'mm' for Z direction

	Z Direction			
Frequency	CH 1	CH 2	CH 3	CH 4
1	2.808	11.979	30.516	37.331
2	2.808	57.599	63.179	40.116
3	2.808	57.599	63.179	40.116
4	2.678	5.699	18.723	158.056
5	8.678	6.147	19.843	158.056
6	10.849	6.678	20.033	158.056

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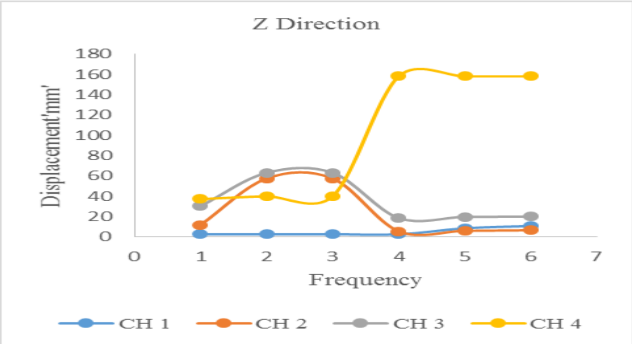

Fig 16: Displacement vs. frequency graph

.The figure shows the Displacement vs Frequency variation graph. The above graph is drawn using the values of displacement obtained for varying frequencies for X,Y and Z direction of CH 1, 2, 3 and 4. Here the variation of frequency is between 1-6Hz. While doing the test using shake table for frequency 4Hz, the displacement values for CH 1,2,3,4 was maximum.

Based on the results, it is observed that the bamboo framed structure was resisted the seismic loads safely till the frequency 8Hz whereas the steel framed structure was till the frequency 4Hz

C.BAMBOO FRAMED STRUCTURE (FREQUENCY 8HZ)

An experiment was carried on shake table for bamboo frame, where the frequency ranges from 1 to 8 Hz of 50 cycles. For time interval of 10seconds and 30seconds the displacement values were obtained. The results are obtained in excel sheets. Graphs are plotted for respective values.

Table 7- Displacement in ‘mm’ X Direction

	X Direction			
Time(S)	CH1	CH2	CH3	CH4
0	0	0	0	0
30	0.032	0.034	-0.047	-0.095
60	1.143	1.045	1.633	1.232
90	3.261	3.05	5.147	3.291
120	0.089	0.026	0.051	0.041
150	-9.817	-0.063	6.242	-0.404
180	1.4	-0.052	-0.018	0.004

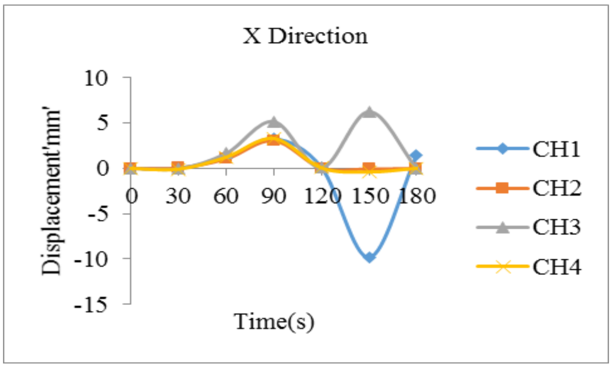

Fig 17: Displacement vs. Time graph

Table 8- Displacement in ‘mm’ Y Direction

	Y Direction			
Time(s)	CH1	CH2	CH3	CH4
0	0	0	0	0
30	0.373	-0.017	-0.015	0.121
60	1.1	1.25	0.711	0.657
90	3.084	3.63	1.563	1.861
120	0.041	0.028	0.049	0.196
150	-1.111	-4.083	-1.867	0.547
180	-4.254	0.025	0.003	-0.054

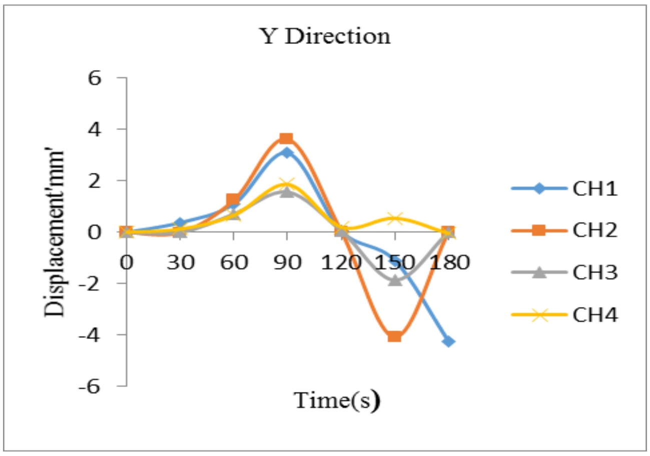

Fig 18: Displacement vs. Time graph

Table 9- Displacement in ‘mm’ Z Direction

	Z Direction			
Time(s)	CH1	CH2	CH3	CH4
0	0	0	0	0
30	-0.412	-0.068	-0.084	-0.049
60	0.806	-0.403	1.573	0.25
90	1.931	-0.232	5.015	0.099
120	0.15	-0.093	-0.236	-0.221
150	0.654	-2.109	3.58	-2.07
180	1.717	-0.067	0.073	-0.329

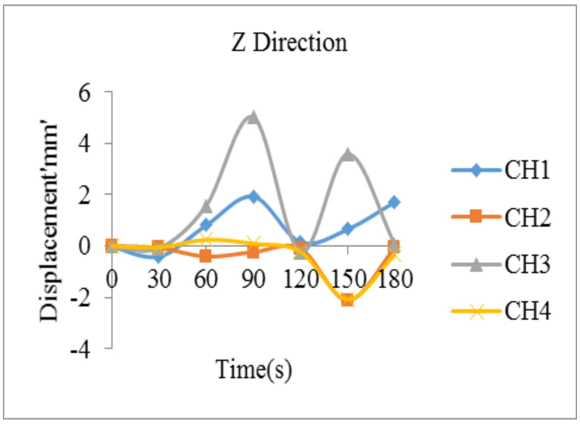

Fig 19: Displacement vs. Time graph

D. STEEL FRAMED STRUCTURE (FREQUENCY 4HZ)

Table 10- Displacement in 'mm' X Direction

	X Direction			
Time(s)	CH 1	CH 2	CH 3	CH 4
0	0	0	0	0
30	-1.104	0.475	0.381	-0.443
60	-0.637	-0.618	0.629	-0.827
90	2.549	1.295	-0.015	-0.362
120	0.06	-0.13	0.002	-0.632
150	-2.697	11.238	-20.126	28.63
180	-0.241	-0.107	0.221	-0.629

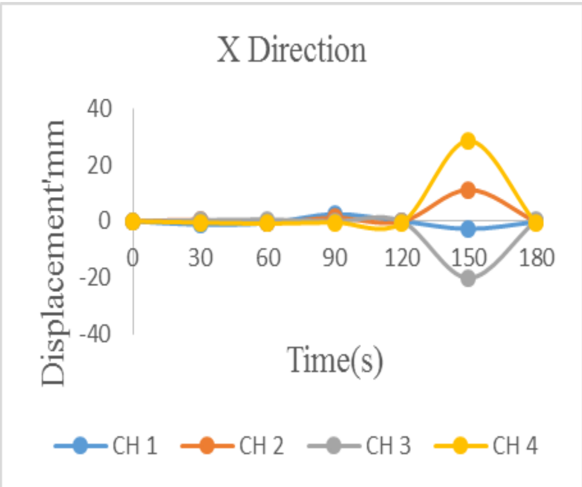

Fig 20: Displacement vs. Time graph

Table 11- Displacement in 'mm' Y Direction

	Y Direction			
Time(s)	CH 1	CH 2	CH 3	CH 4
0	0	0	0	0
30	-1.019	0.093	0.007	0.024
60	-1.586	0.086	-0.099	-0.166
90	3.896	-0.014	0.212	-0.088
120	0.243	0.017	0.158	-0.061
150	-4.323	0.132	-0.391	3.85
180	0.03	0.096	-0.097	-0.018

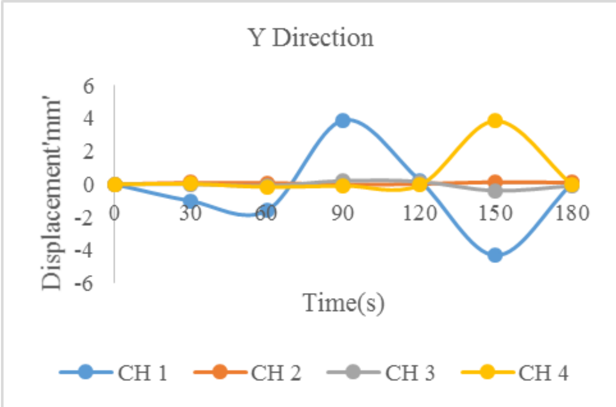

Fig 21: Displacement vs. Time graph

Table 12- Displacement in 'mm' Z Direction

	Z Direction			
Time(s)	CH 1	CH 2	CH 3	CH 4
0	0	0	0	0
30	1.028	-0.206	-0.089	-0.335
60	1.448	0.123	-0.231	-0.063
90	-5.241	0.322	-0.046	-0.151
120	0.247	-0.09	-0.19	-0.053
150	5.994	2.186	1.563	6.107
180	-0.068	-0.173	0.036	-0.246

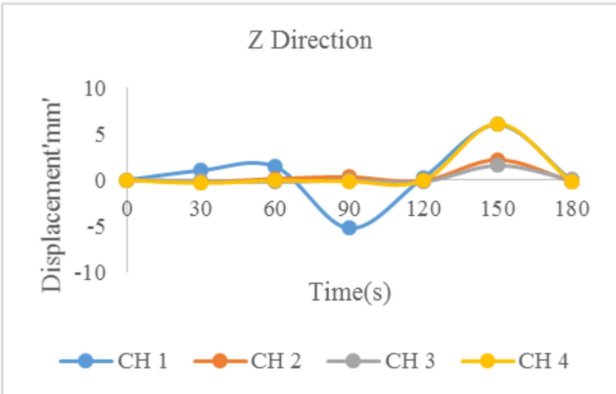

Fig 22: Displacement vs. Time graph

These figures show the Displacement vs Time variation graph. The above graph is drawn using the values of displacement obtained for frequencies 4Hz of X, Y and Z direction for CH1, 2, 3 and 4. While doing the test using shake table the displacement values for CH 1, 2, 3 and 4 at 60sec was minimum later at 150sec the displacement was maximum.

VI. CONCLUSION

Based on the results, the bamboo framed structure was resisted the seismic loads safely till the frequency 8Hz whereas the steel framed structure was till the frequency 4Hz . The maximum displacement was at channel 4 of X,Y and Z direction (161.083mm,241.384mm and 321.347mm) at frequency 8Hz for bamboo framed structure and for steel framed structure the maximum displacement was at channel 4 of X,Y and Z direction (274.607mm 3 38.869mm and 158.056) at frequency 4Hz.

The maximum displacement (0.654mm, -2.109mm, 3.58mm and -2.07mm) was at time 150sec for frequency 8Hz for bamboo framed structure, whereas the maximum displacement (5.994mm, 2.186mm,1.563mm,6.107mm) was at time 150sec for frequency 4Hz for steel framed structure

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