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Experimental and Finite Element Analysis of Jointed Structure for Evaluation of Damping

[1]Sachin Shashikant Patil, [2]H .D. Chaudhari

[1]Sachinptl93@gmail.com
[2]hdchaudhari@rediffmaill.com

[#1]ME Student, Dept. of Mechanical Engineering
[#2]Asst. Prof. Dept. of Mechanical Engineering

J. T. Mahajan College of Engineering, Faizpur

ABSTRACT

Light weight structures commonly have low connate structural damping. The damping mechanism of various jointed structures can be explained by considering the energy loss due to friction and the dynamic slip produced at the interfaces. The frictional damping is evaluated from the relative slip between the jointed interfaces and is considered to be the most useful method for inspect the structural damping. The damping characteristics in jointed structures are influenced by the intensity of pressure distribution, micro-slip kinematic coefficient of friction and logarithmic decrement at the interfaces and natural frequency of the structure. The effects of all these parameters on the mechanism of damping have been extensively studied. All the above basic parameters are largely influenced by the thickness ratio of the beam and thereby affect the damping capacity of the structures. In addition to this, beam length of the structures and diameter of connecting rivet and bolt also play key roles on the damping capacity of the jointed structures is assessable.

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***Index Terms*- Finite Element Method, Dynamic Slip Introduction.**

I. INTRODUCTION

With accelerated growth and development of disenchanted contrive structures, efforts have been made by engineers and technologists to improve their capabilities by checking disastrous effects of vibration transmitted through foundation and chatter of fabricated structures. Problems involving vibration occur in many areas of mechanical, civil and aerospace engineering. Engineering structures are generally fabricated using a variety of connections such as bolted, riveted, Clamped and Adhesive joints etc. The dynamics of mechanical joints is a topic of special interest due to their strong influence in the performance of the structure. The contact pressure between the surfaces is generated by the clamping action of the joints and plays a vital role in the joint properties. Due to uneven pressure distribution, a local relative motion termed as micro-slip occurs at the interfaces of the connecting members. The energy dissipated in most real structures is often very small, so that an undamped analysis is sometimes realistic. When the damping is significant, its effect must be included in the analysis particularly when the dynamic study of a structure is required. The energy of the vibrating system is dissipated by various mechanisms and often more than one mechanism may be present at the same time. Although the knowledge on the friction joint is limited, efforts have been put in the present investigation to study the damping aspect of the friction joints in built-up structures

Vibration: Any Motion which repeats itself after an interval of the time is called vibration or oscillation.

Causes of Vibrations: The main reasons of vibration are as follows

1) Unbalanced centrifugal force in the system which is caused because of non-uniform material distribution in a rotating machine elements.
2) Elastic nature of the system.
3) External excitation applied on the system.
4) Winds may cause vibrations of certain systems such as electricity lines, telephone lines.

Damping: Damping is the energy dissipation properties of a material or system under cyclic stress. When a structure is subjected to an excitation by an external force then it vibrates in certain amplitude of vibration, it reduces as the external force is removed.

Structural Damping at Joints and Interfaces

Since the damping in the structural material is not significant, most of the damping in real fabricated structures arises in the joints and interfaces. It is the result of energy dissipation caused by rubbing friction resulting from relative motion between components and by intermittent contact at the joints in a mechanical system. However, the energy dissipation mechanism in a joint is a complex phenomenon being largely influenced by the interface pressure and degree of slip at the interfaces. It is this slip phenomenon occurring in the presence of friction at the joint interface that causes the energy dissipation and nonlinearity in the joints.

Jointed Structure

Stage	No. of plates	Material	Joints

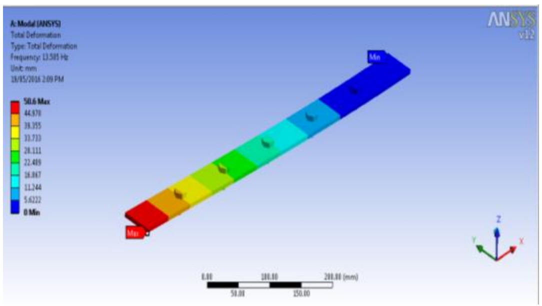
II. BEAM SPECIFICATION

Specifications: 1) Length of plate: 600 mm
2) Width of plate: 50 mm
3) Total Thickness of joint: 6 mm

III. SOFTWARE ANALYSIS BY USING ANSYS

The simulation of plates can be done in ANSYS 12.0 (Student License) software. The software is compatible with 60,000 nodes and having 6 degree of freedom (D.O.F.).

For MS-MS Bolted Beam
For Fixed-Free Condition



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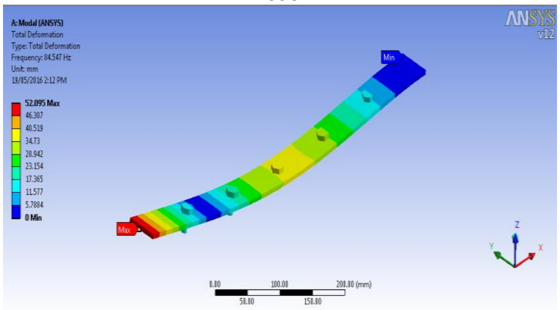

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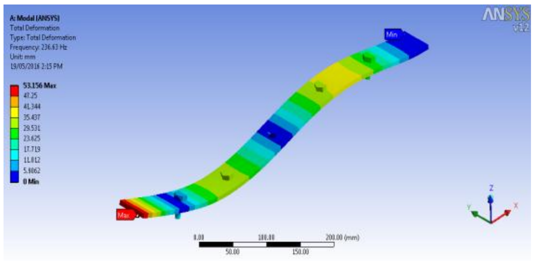

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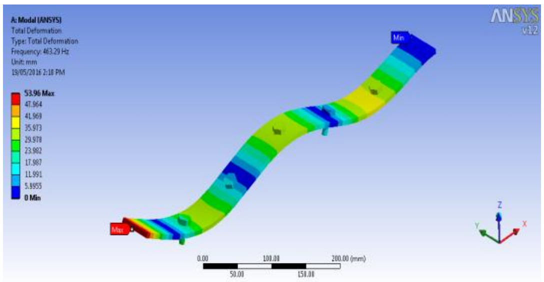

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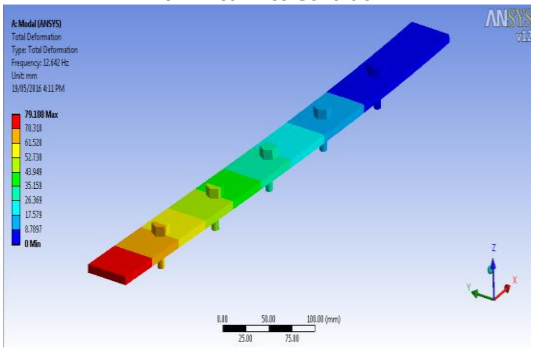
For Al-Al Bolted Beam
For Fixed-Free Condition



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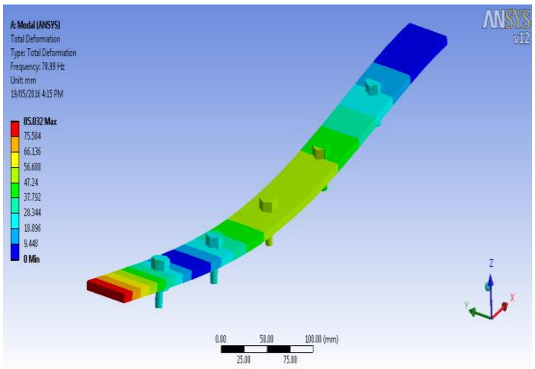

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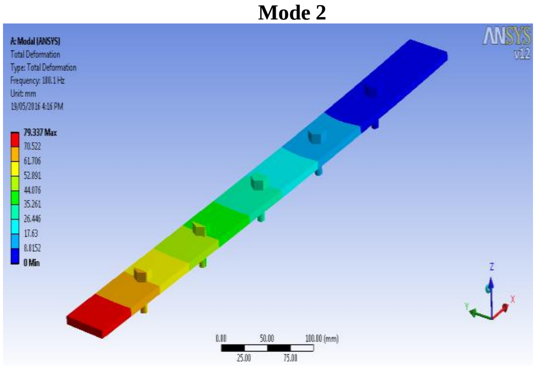

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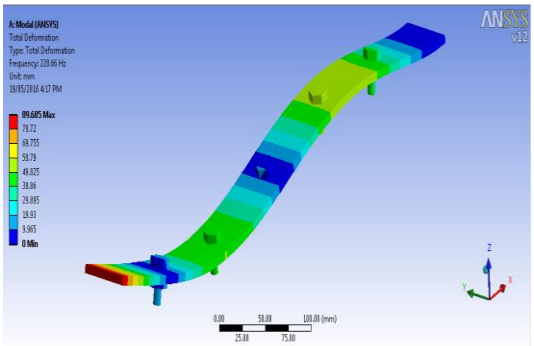

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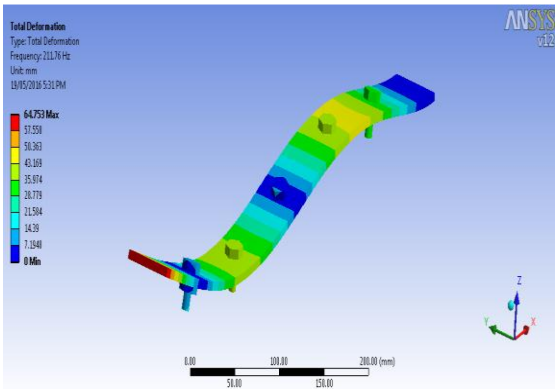

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For MS-Al Bolted Beam
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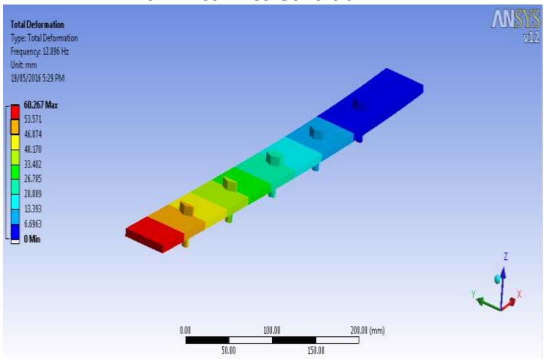

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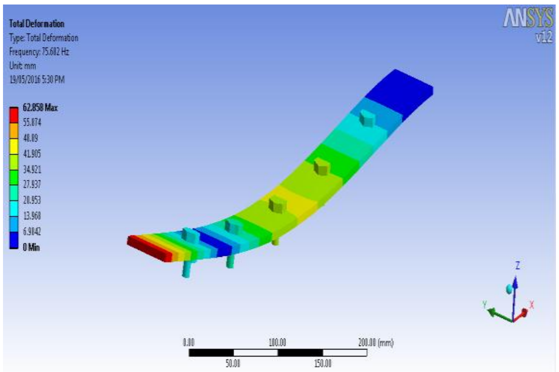

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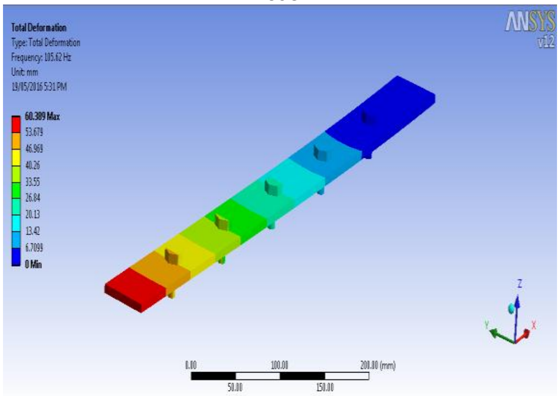

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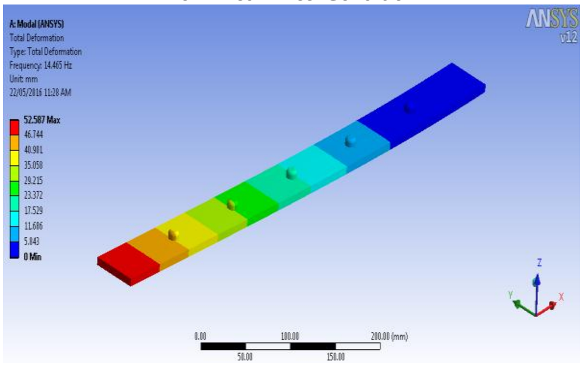

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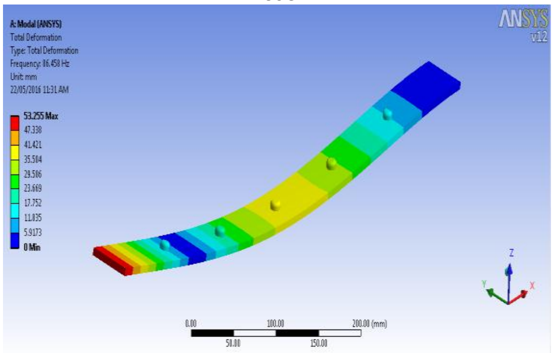

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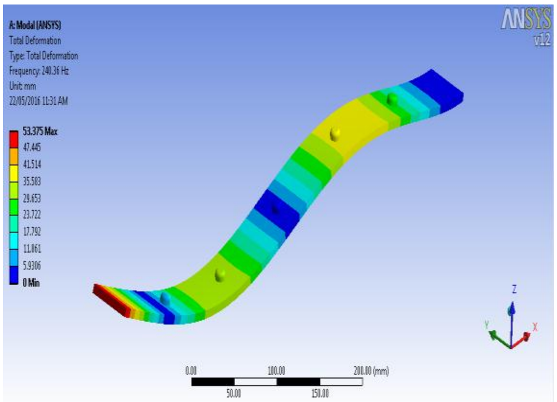

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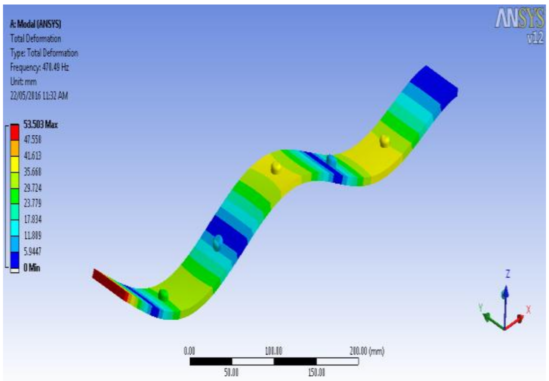

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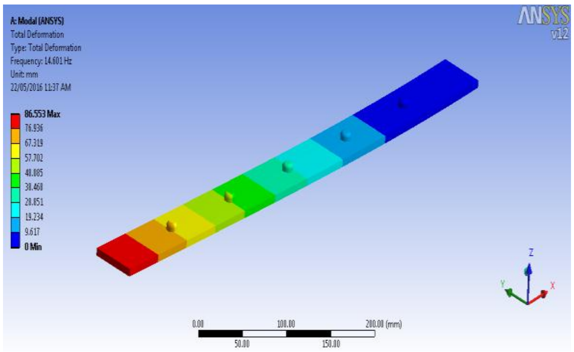

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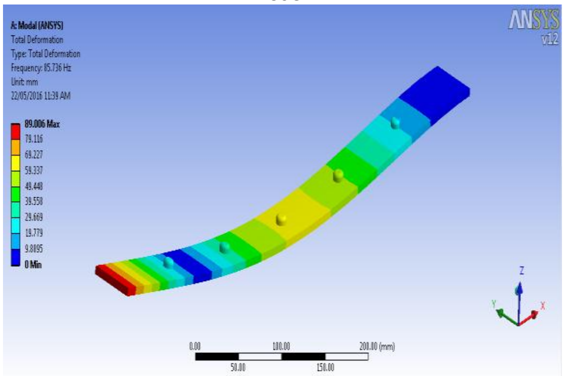

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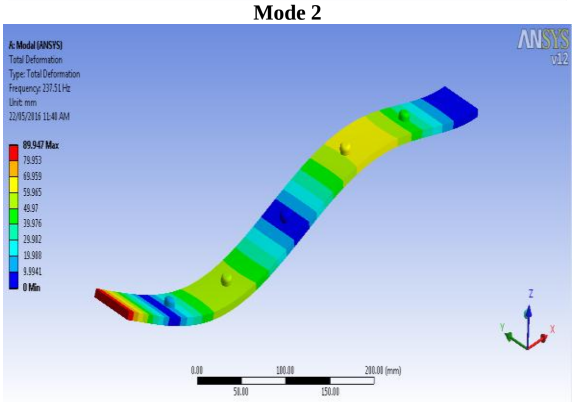

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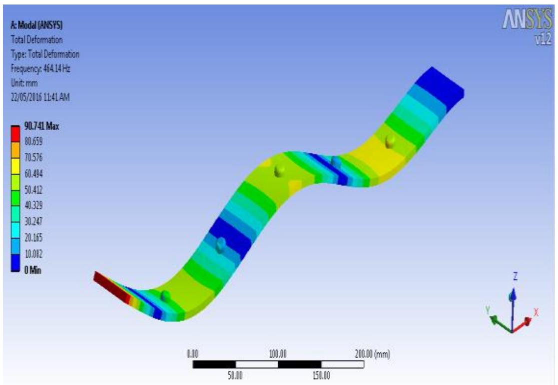

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For MS-Al Riveted Beam
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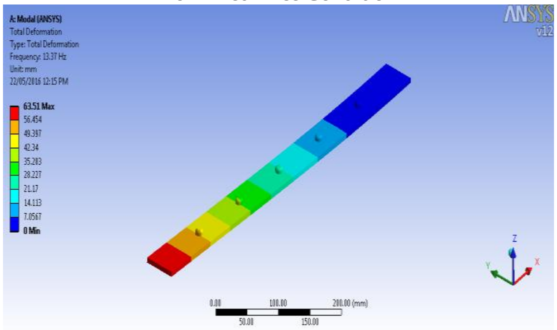

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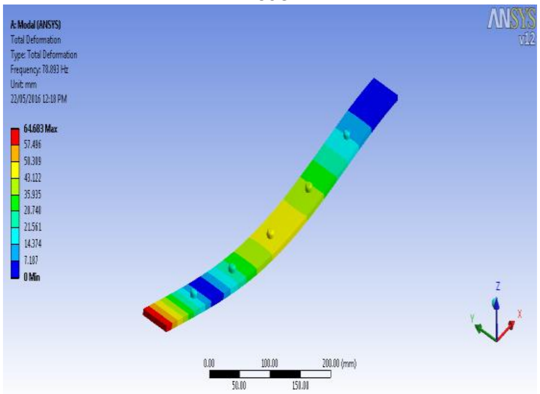

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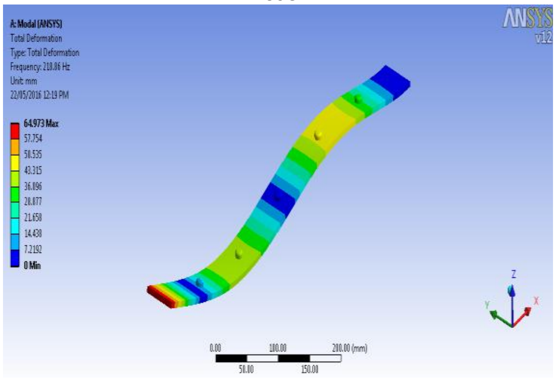

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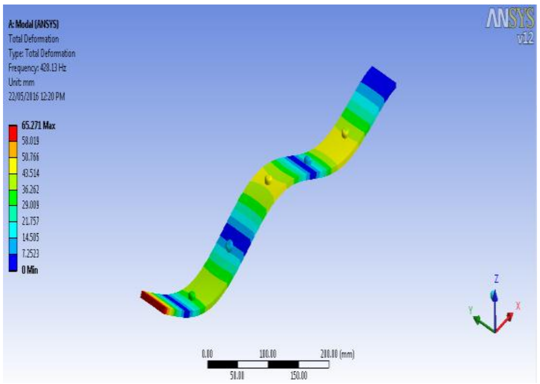

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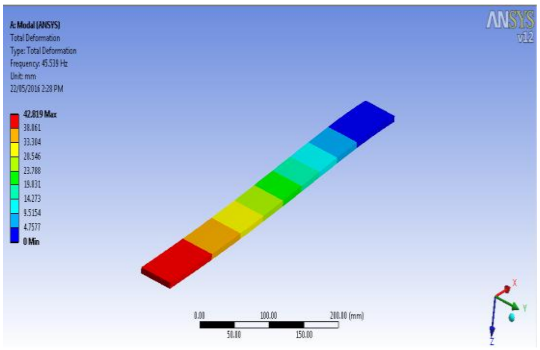
For MS-MS Adhesive Beam
For Fixed-Free Condition



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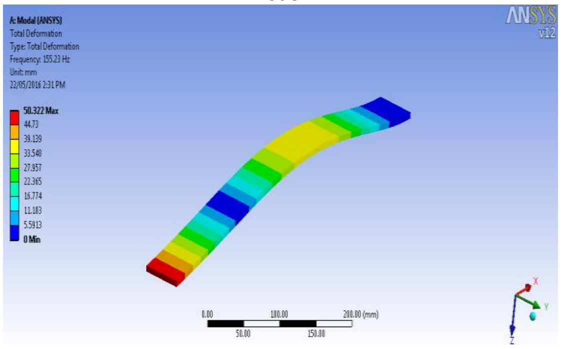

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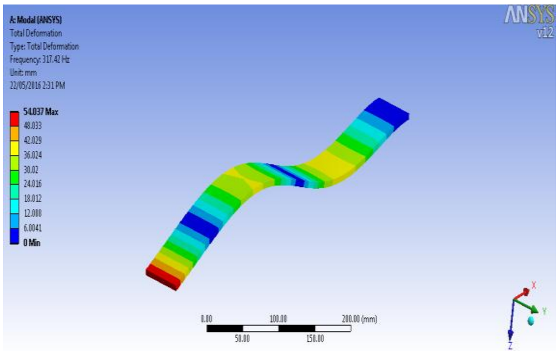

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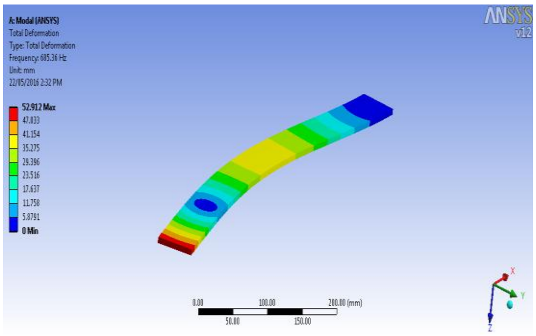

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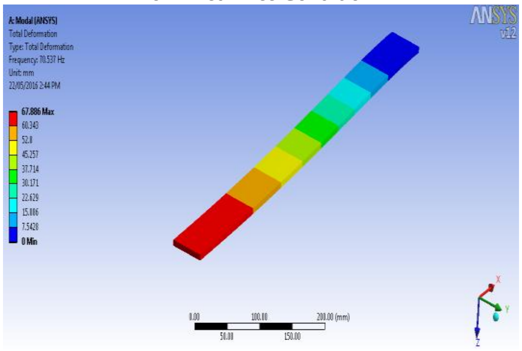

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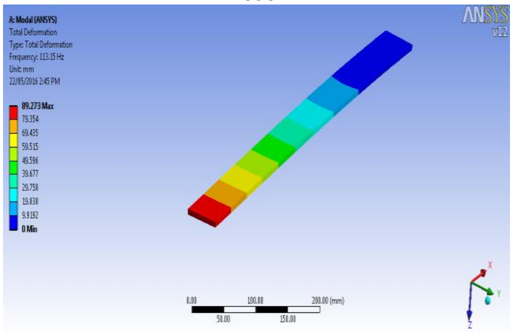

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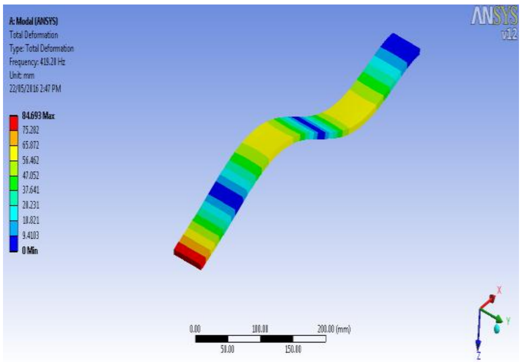

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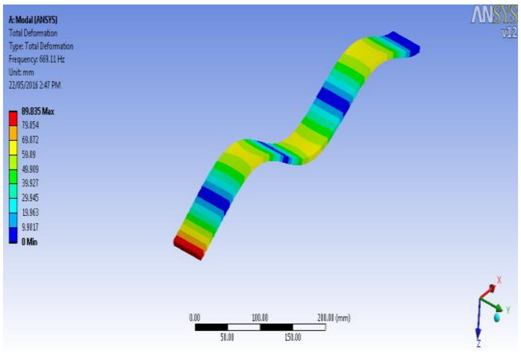

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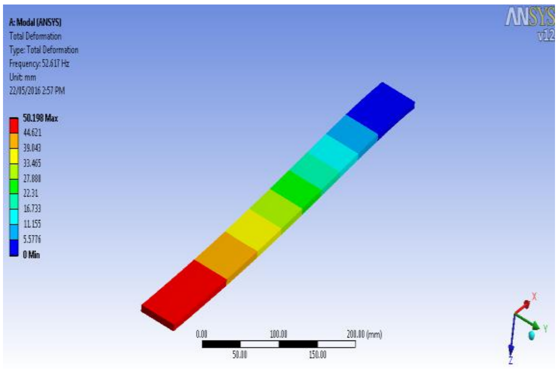
For Fixed-Free Condition



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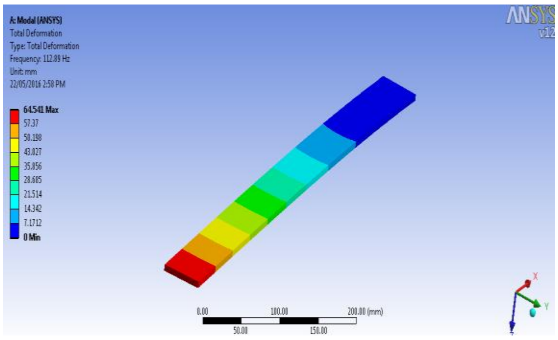

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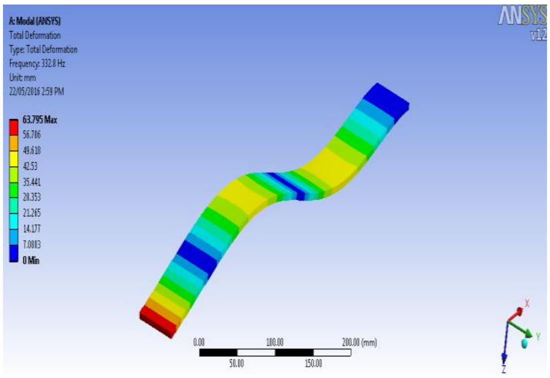

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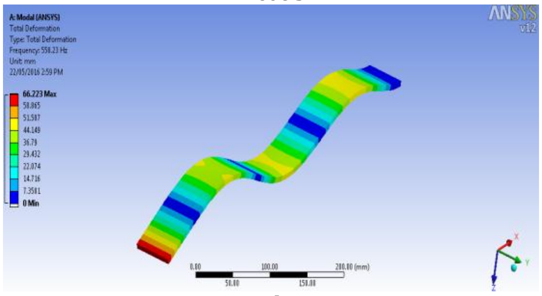

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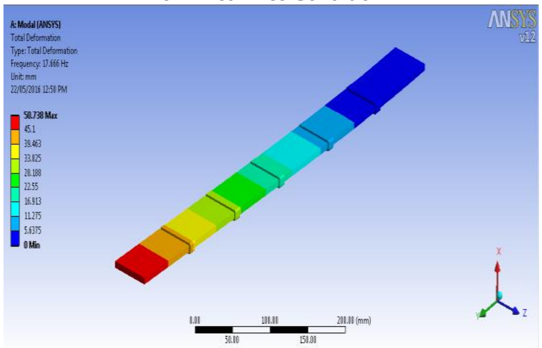
For MS-MS Clamped Beam
For Fixed-Free Condition



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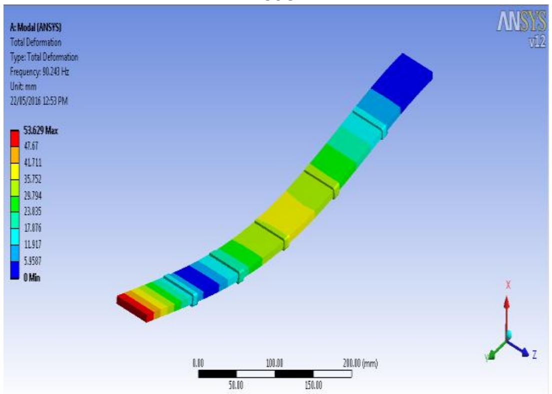

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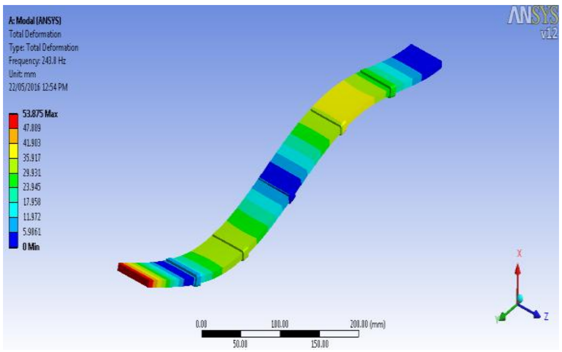

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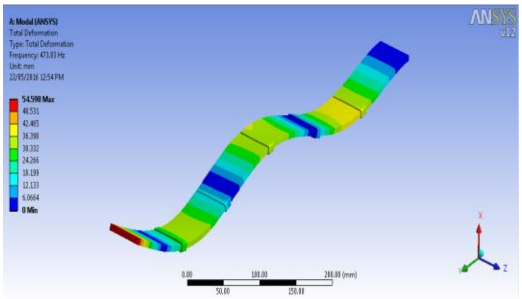

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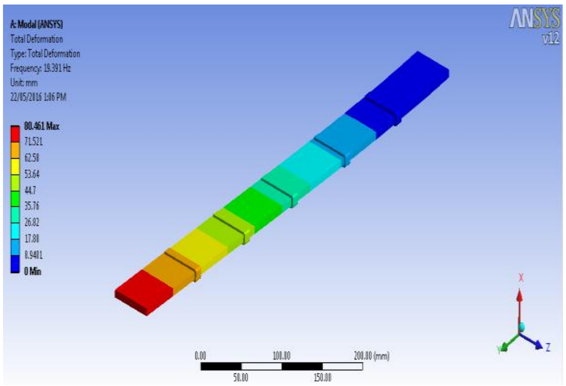

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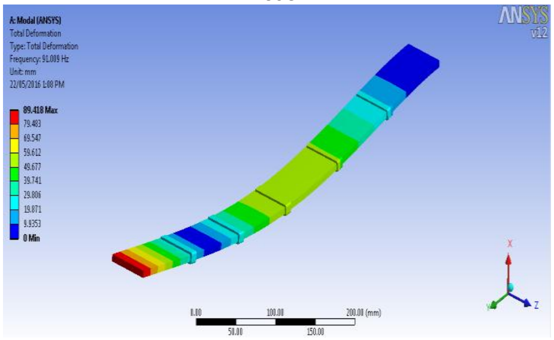

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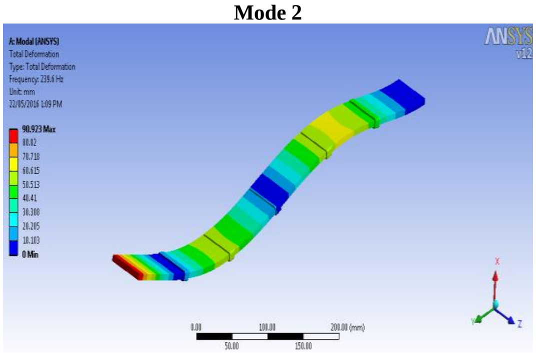

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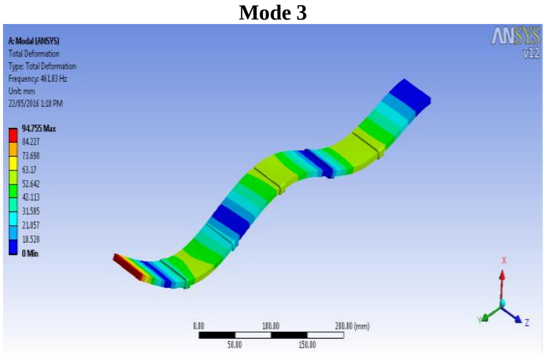

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For MS-Al Clamped Beam
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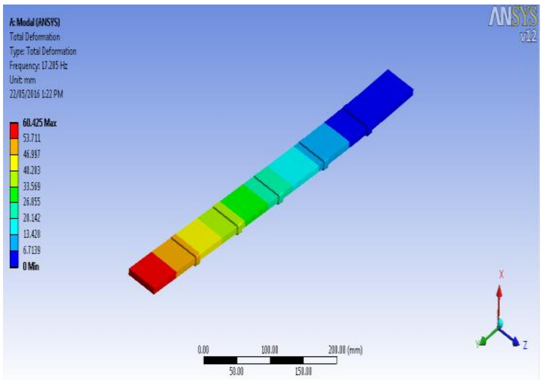

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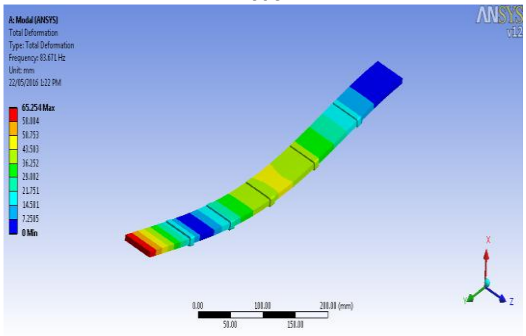

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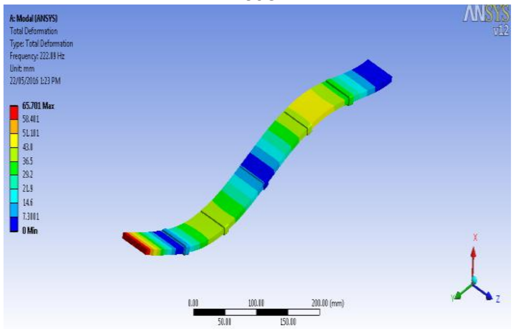

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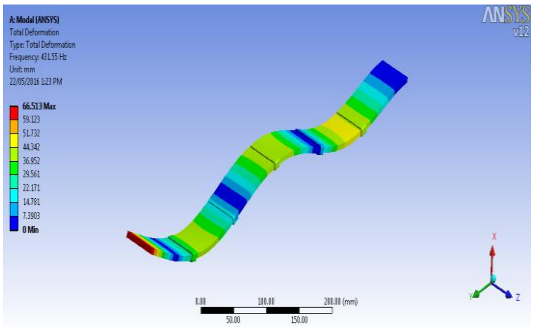

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IV. EXPERIMENAL ANALYSIS

The PULSE software analysis was used to measure the frequency ranges to which the foundations of various machines are subjected to when the machine is running with no load and full load. This will help us in designing the foundations of various machines in such a way that they are able to resist the vibration caused in them. The block diagram for Vibration Measurement is given below.

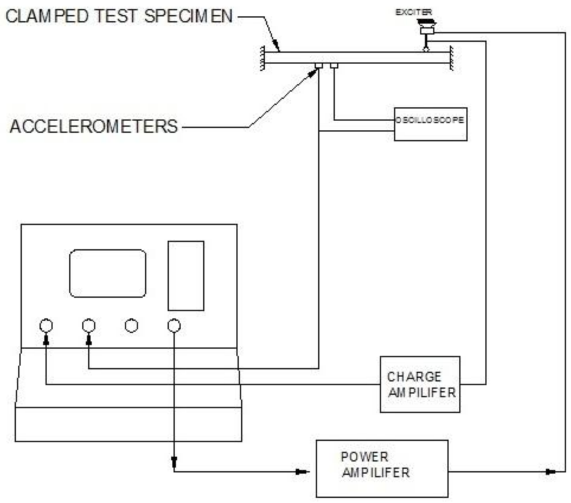


Fig: Schematic diagram of experimental setup

Impact hammer

The model hammer exits the structure with a constant force over a frequency range of interest. Three interchange tips are provided which determine the width of the input pulse and thus the band width the hammer structure is acceleration compensated to avoid glitches in the spectrum due to hammer structure resonance.

Figure: 5.2 Impact Hammer

FFT Analyser

FFT Analyser is used to measure the frequency ranges to which the foundation various machines are subjected to when the machine is running with no load and full load. This will help us in designing the foundations of various machines on such a way that they are able to resist the vibration caused in them.

Results of Experimental Work For Impact Hammer Test

For Simply Supported Condition

For Fixed-Free Condition

Ms-Ms Bolted Beam (6 mm thickness)

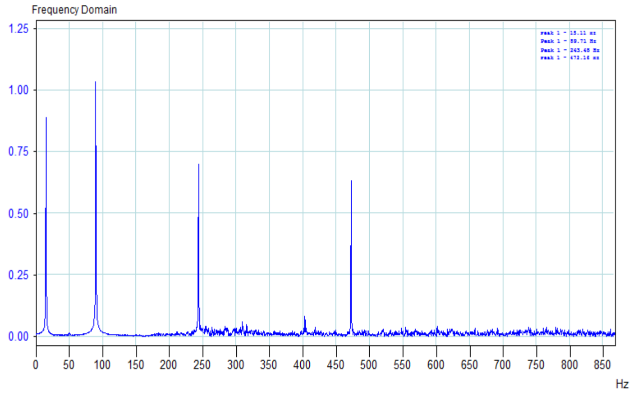


Fig: Frequency Response Curve for Ms-Ms Bolted Beam in Fixed-Free Condition

Al-Al Bolted Beam (6 mm thickness)

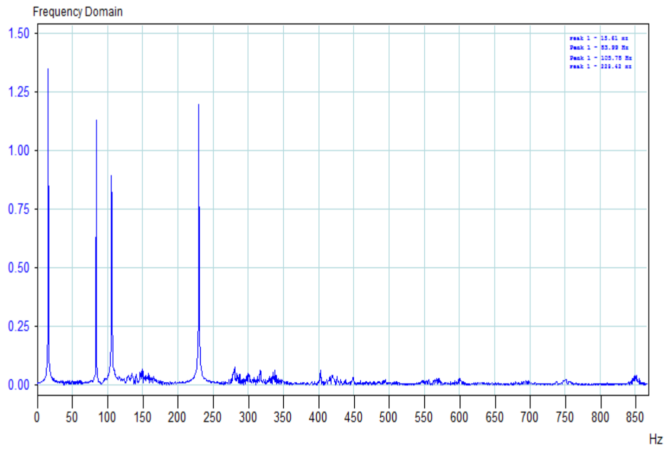


Fig: Frequency Response Curve for Al-Al Bolted Beam in Fixed-Free Condition

MS-Al Bolted Beam (6 mm thickness)

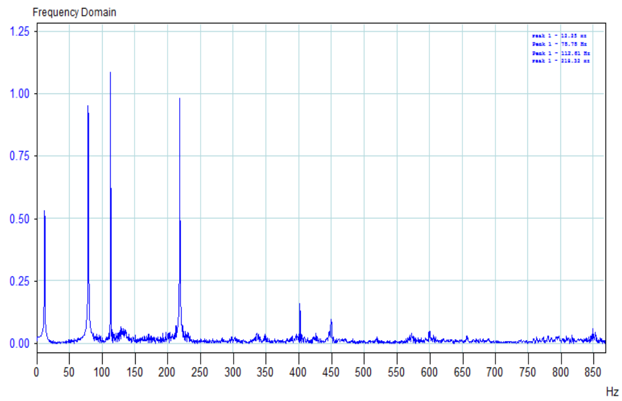


Fig: Frequency Response Curve for Ms-Al Bolted Beam in Fixed-Free Condition

For Fixed-Free Condition Ms-Ms Riveted Beam (6 mm thickness)

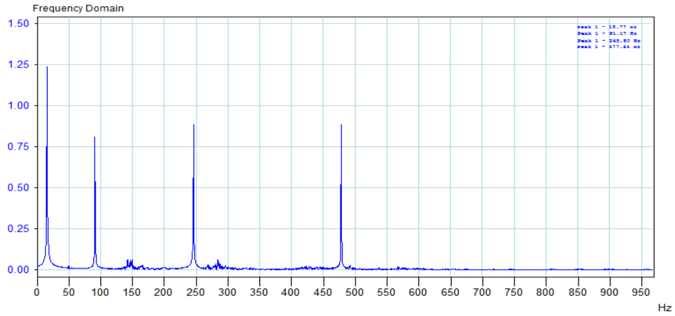


Fig: Frequency Response Curve for Ms-Ms Riveted Beam in Fixed-Free Condition

Al-Al Riveted Beam (6 mm thickness)

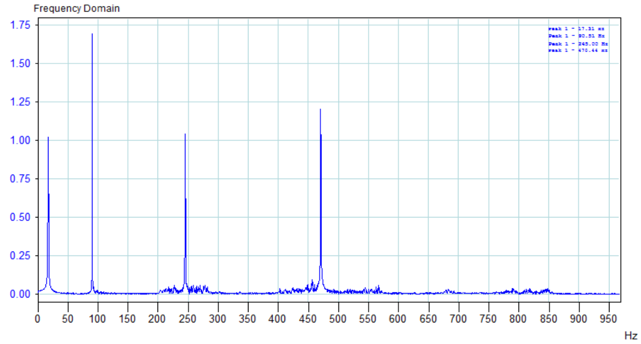


Fig: Frequency Response Curve for Al-Al Riveted Beam in Fixed-Free Condition

Ms-Al Riveted Beam (6 mm thickness)

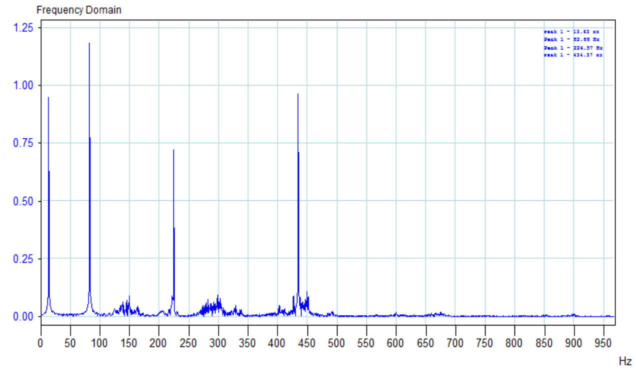


Fig: Frequency Response Curve for Ms-AlRiveted Beam in Fixed-Free Condition

For Fixed-Free Condition
Ms-Ms Clamped Beam (6 mm thickness)

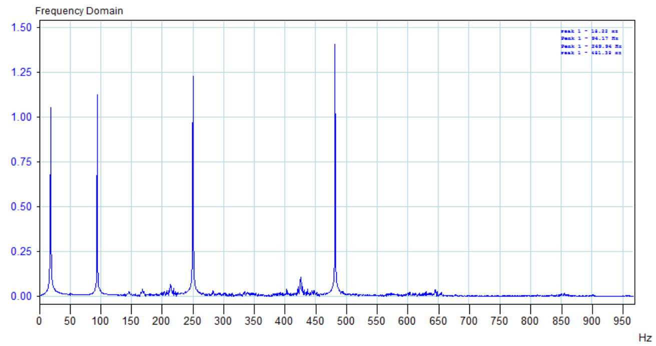


Fig: Frequency Response Curve for Ms-MsClamped Beam in Fixed-Free Condition

For Fixed-Free Condition
Al-Al Clamped Beam (6 mm thickness)

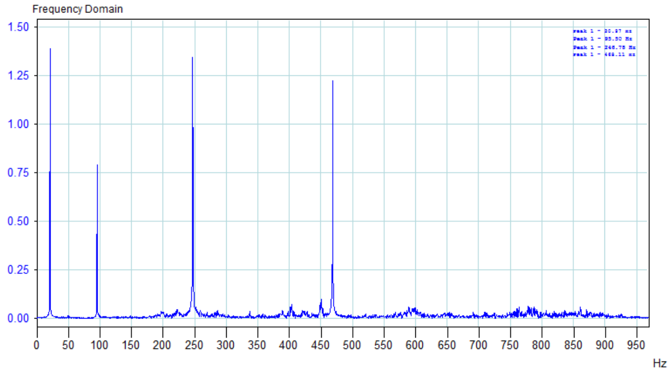


Fig: Frequency Response Curve for Al-Al Clamped Beam in Fixed-Free Condition

For Fixed-Free Condition
Ms-Al Clamped Beam (6 mm thickness)

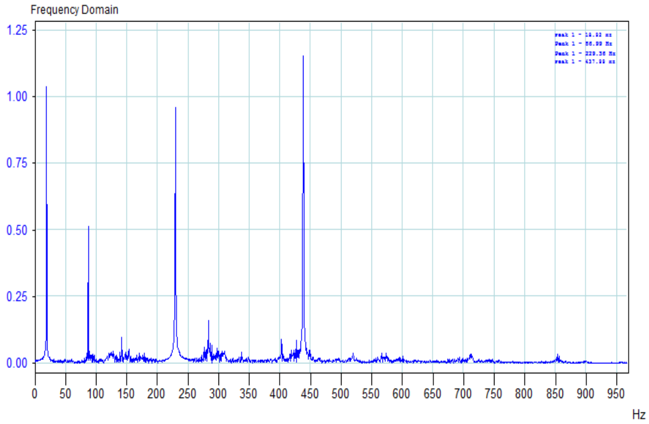


Fig: Frequency Response Curve for Ms-Al Clamped Beam in Fixed-Free Condition

For Fixed-Free Condition
Ms-Ms Adhesive Beam (6 mm thickness)

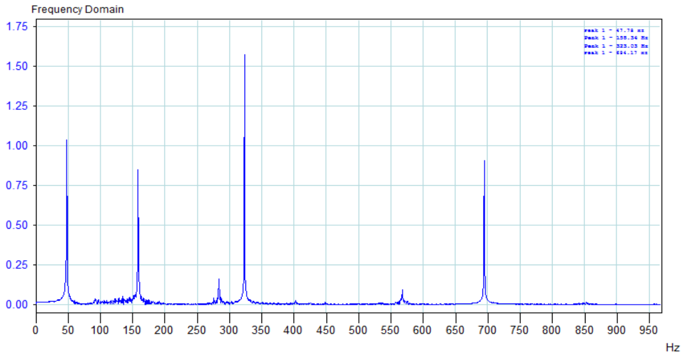


Fig: Frequency Response Curve for Ms-Ms Adhesive Beam in Fixed-Free Condition

For Fixed-Free Condition
Al-Al Adhesive Beam (6 mm thickness)

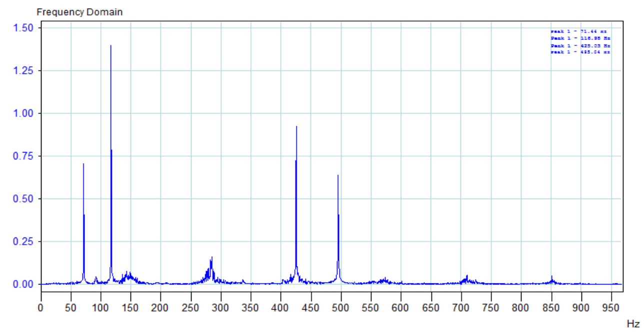


Fig: Frequency Response Curve for Al-Al Adhesive Beam in Fixed-Free Condition

For Fixed-Free Condition

Ms-Al Adhesive Beam (6 mm thickness)

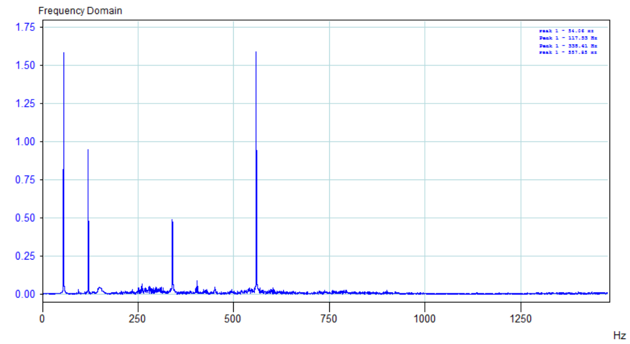


Fig: Frequency Response Curve for Ms-Al Adhesive Beam in Fixed-Free Condition

Result Table for Sandwich beam under Fixed-Free Condition for MS-MS

	Bolted		Riveted		Clamped		Adhesive	
	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result
I	13.50	15.11	14.46	15.77	17.66	18.22	45.54	47.78
II	84.54	89.71	86.45	97.17	90.24	94.17	155.23	158.34
III	236.63	243.48	240.36	245.80	243.8	249.94	317.42	323.03
IV	463.29	472.16	470.49	477.84	473.88	481.39	685.36	694.17

Result Table for Sandwich beam under Fixed-Free Condition

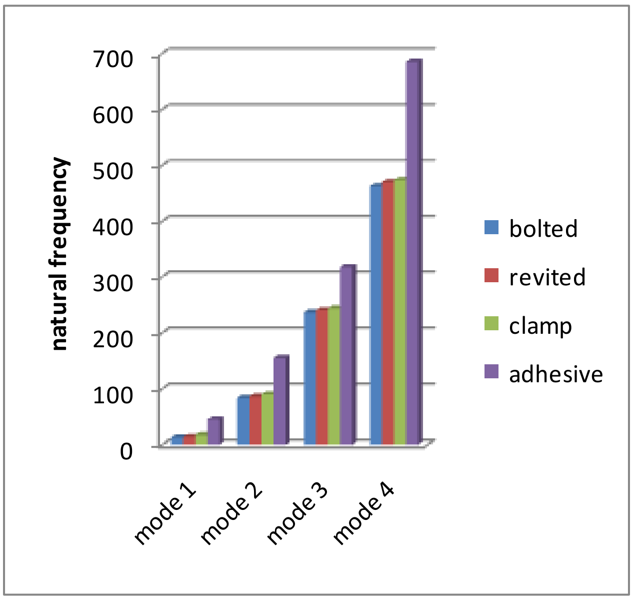
for Al-Al

Mode	Bolted		Riveted		Clamped		Adhesive	
	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result
I	12.64	15.14	14.601	17.31	19.39	20.97	70.537	71.44
II	78.99	83.99	85.736	90.51	91.009	95.50	113.15	116.98
III	100.1	105.78	237.51	245	239.6	246.78	419.28	425.03
IV	220.66	229.42	464.14	470	461.83	468.11	487.28	495.04

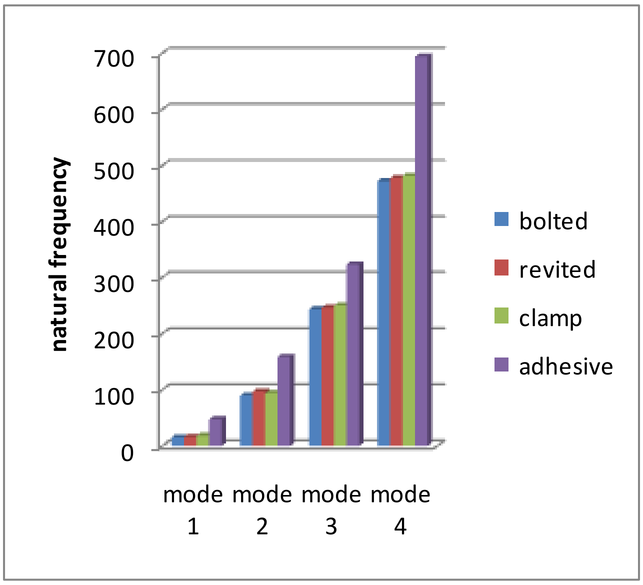
Result Table for Sandwich beam under Fixed-Free Condition

Mode	Bolted		Riveted		Clamped		Adhesive	
	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result	ANSYS Result	Exp. Result
I	12.096	12.25	13.37	13.63	17.28	18.92	52.617	54.06
II	75.68	78.78	78.893	82.66	83.671	86.99	112.89	117.53
III	105.62	112.61	218.86	224.57	222.89	229.36	332.8	338.41
IV	211.76	218.32	428.13	434.13	431.55	437.99	550.23	557.85

Result Table for Sandwich beam under Fixed-Free Condition for MS-Al



Comparison graph of finite element analysis between different joints.



Comparison graph of experimental analysis between different joints .

V. CONCLUSION

From above experimental and software work and its results clears that damping characteristics for Bolted beam has significant effect when compared with other joints . Finally the frequency responses of the modeled jointed structure have been plotted for the fixed-free boundary conditions. Results show that the bolted beam structure damping treatment has a great significance in controlling the vibration of structures like beams, plates, etc.

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