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Dynamic Response of Beam Under Moving Load

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ABSTRACT

This paper is about the analytical study of linear dynamic response a structure (Euler-Bernoulli beam) under a moving load. The moving load is constant in magnitude and moves at constant velocity. The dynamic analysis of beam is done by taking two different cases. In the first case effects of inertia of the load were neglect and in second case effects of the beam inertia were also not considered. The study of the moving load is a great importance in the field of transportation. Examples of the structural elements which support the moving masses are bridges, guide ways, overhead cranes, cable ways, railway, roadways, runways, tunnels and pipelines etc. In the first phase, dynamic equation of motion with the moving load for simply supported beam is solved by analytical method is given. In the present work, effect of moving load on both simply supported and cantilever beam for two different materials is investigated. The effect of variation of parameters on dynamic response of Euler- Bernoulli beam is studied. The beam is divided into 3 and 5 points and the deflection of beam at span is recorded while load moves at constant velocity through different points. The deflection at span for different point is taken with the help of analytical method. The result obtained will be plotted in the form of graphs for different velocities of load and will be validated using ANSYS Software.

Index Terms: Beams, Euler-Bernoulli, Moving Load, Dynamic amplification

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I. INTRODUCTION

The moving load problem is a unavoidable difficulty in structural dynamics. A lot of hard work has been accounted during the last 100 years conducting with the dynamic response of railway bridges and later on highway bridges under the effect of moving loads. Beam type structures are widely used in many fields of engineering like civil, mechanical and aerospace. In the past, the moving load problems are about railway bridges excited by travelling trains with moving structures travel in straight line. Taking an example of computer disc drive system where the magnetic reader or writer head maintain a moving load in circumferential direction and adopts circular path. The most general type of moving loads in structural studies is a constant or harmonic pure force. so it is said that a structure under moving pure load is equal to non-moving load vibration problem. so a moving load problem can be defined by using beam subjected to moving point wise mass which is also called moving mass problem. Advances in transport technology and automobile engineering resulting high speed and heaviness of vehicles and other moving bodies' as a result corresponding structures have been subjected to vibration and dynamic stress much higher than ever before. This analytical work is concerned with the dynamic behavior of an Euler-Bernoulli beam subjected to a moving load. The dynamic analysis of the vibrating beam is done by neglecting the disconnection of the moving load from the beam during the motion and result is given by considering mass moving at constant speed and in one direction.

Dynamic Response of Beam Structure

The problem of moving loads on structures was first considered in the early Nineteenth century when the traversing of bridges by locomotives was analyzed, this has been followed by a considerable amount of research on this topic. The purpose of dynamic analysis is to know the structural behavior under the influence of various loads and to get the necessary information for design such as deformation, moments and dynamic forces etc. Structural analysis is classified in to static and dynamic. Static analysis deals with load which is time independent. But in dynamic analysis magnitude, direction and position of mass change with respect to time. Important dynamic loads for vibration analysis of bridge structure are vehicle motion and wave actions i.e. earthquake, stream flow and winds. The effect of a moving body travelling over a bridge can be solved with various assumptions such as

- The bridge has in significant mass compared to the moving body.
- The moving body mass is slight compared to the bridge.
- The whole system can be dynamically analyzed in full when considering the effects of the masses of both the bridge and body.

I made different beam structures having 1m in length and 5mm in thick, such as simply supported beam and cantilever beam. I had divided the methodology in two steps as below.

1) In the step 1, I have found the maximum deflection of beam increasing with increase in velocity of mass and also position of maximum deflection deviates of beam. I have use four materials is St, Al, St-Al and St-FRP-Al for this stage.

2) In the step 2, I have found the deflection of beam at free end decrease with increase in velocity of mass. I have use four materials is St, Al, St-Al and St-FRP-Al for this stage.

II. BEAM STRUCTURE

Stage	Type of Structure	Beam Material			
I	Simply Supported Beam	Ms	Al	Ms-Al	Ms-FRP-Al
II	Cantilever Beam	Ms	Al	Ms-Al	Ms-FRP-Al

BEAM SPECIFICATION

Specifications: 1) Length of plate: 1000 mm
2) Width of plate: 50 mm
3) Total Thickness of joint: 5 mm
4) C-Block = 0.9kg & 1.3kg

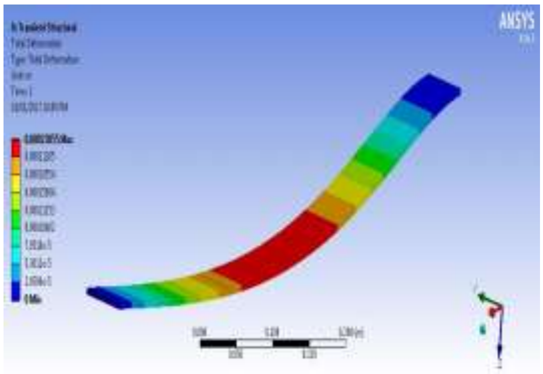
SOFTWARE ANALYSIS BY USING ANSYS

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.).

Condition 1 (Using 0.9kg moving load)

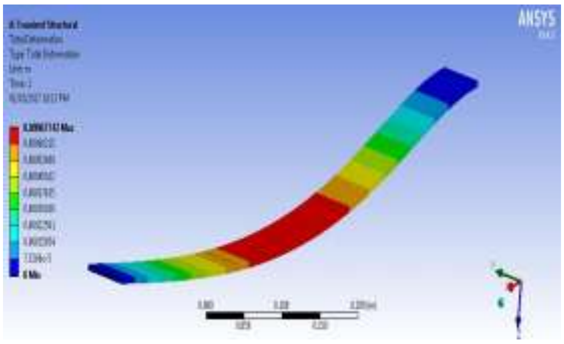
Simply Supported Beam at velocity 0.33m/s for 3s

Ms Beam



Point 1

Al Beam



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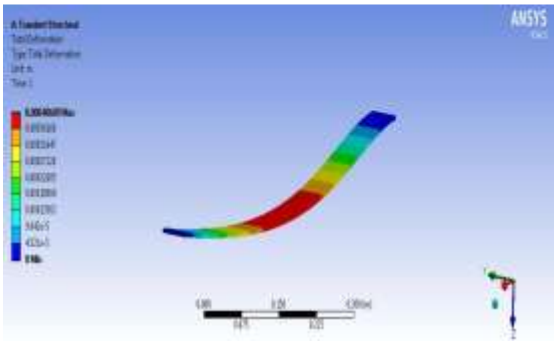
Ms-Al



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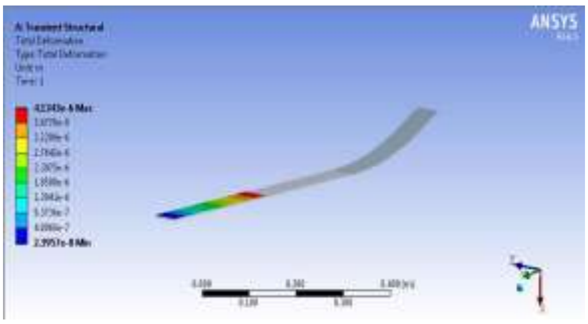
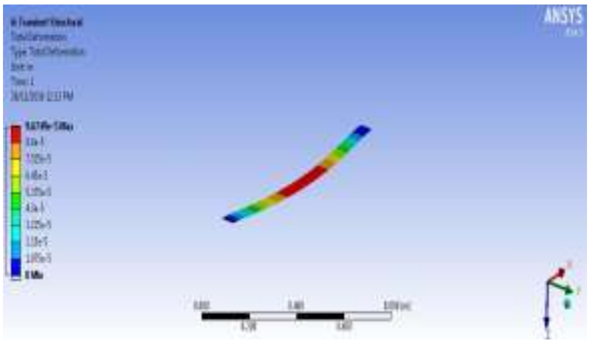
Ms-FRP-Al Beam



Point 1

Simply Supported Beam at velocity 0.19m/s for 5s

Ms Beam



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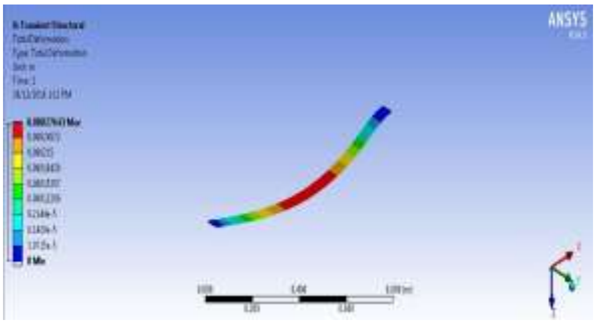
Al Beam



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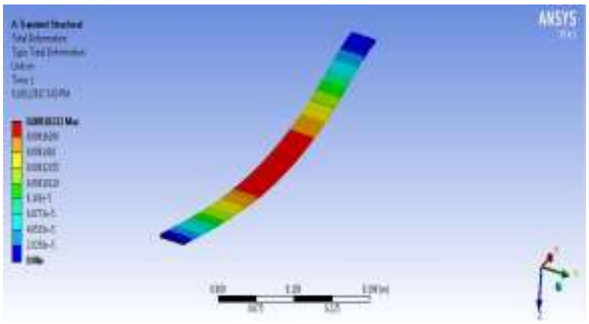

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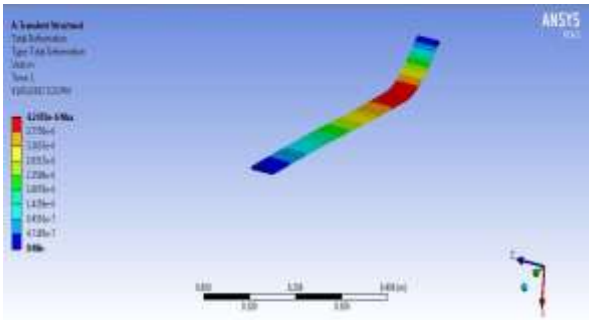
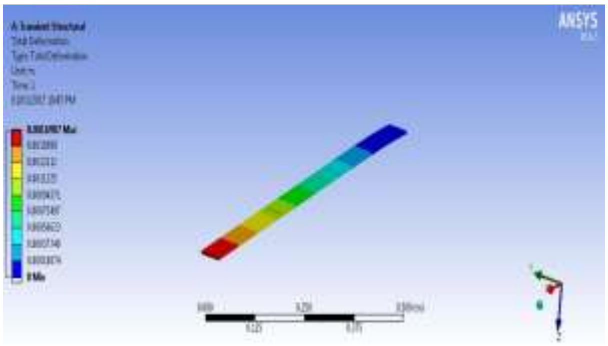
Ms-FRP-Al Beam



Point 1

Cantilever Beam at velocity 0.33m/s for 3s

Ms Beam



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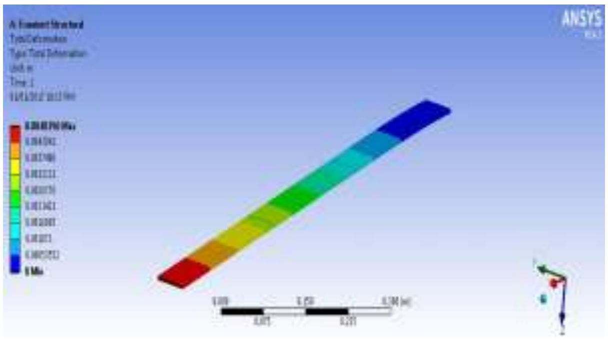
Al Beam



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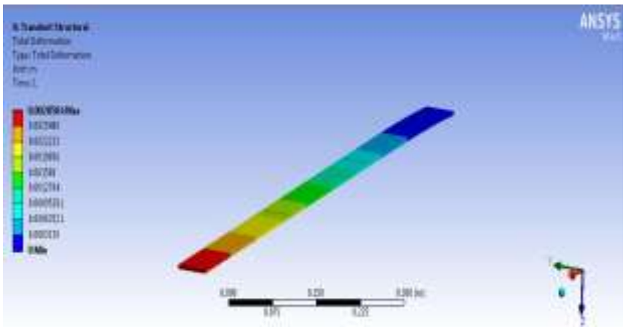

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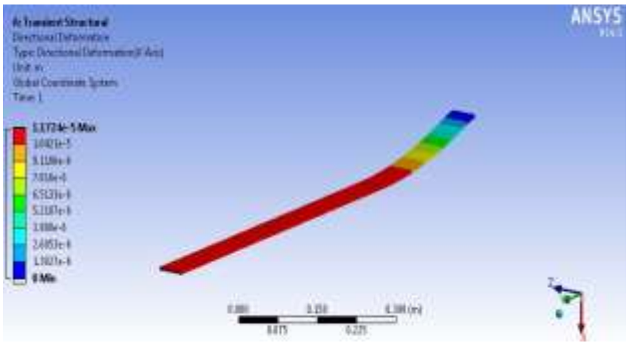

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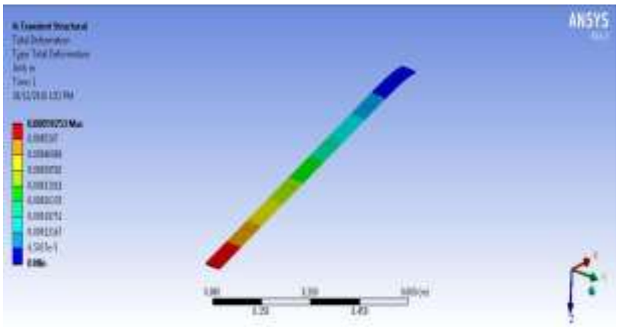
Cantilever Beam at velocity 0.19m/s for 5s

Ms Beam



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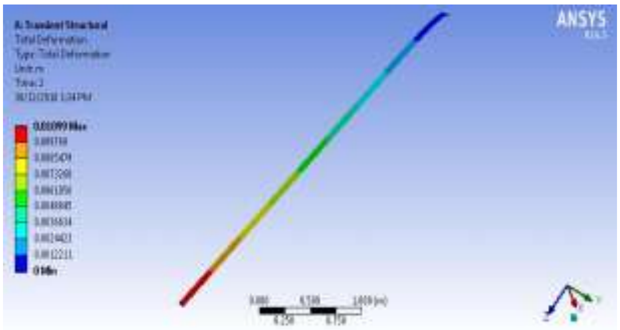

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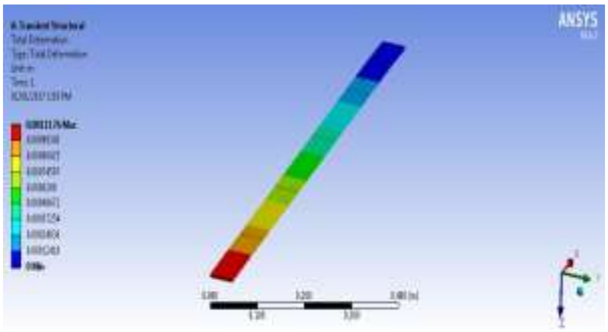

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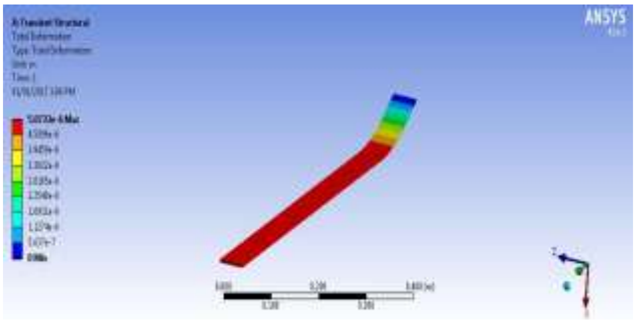

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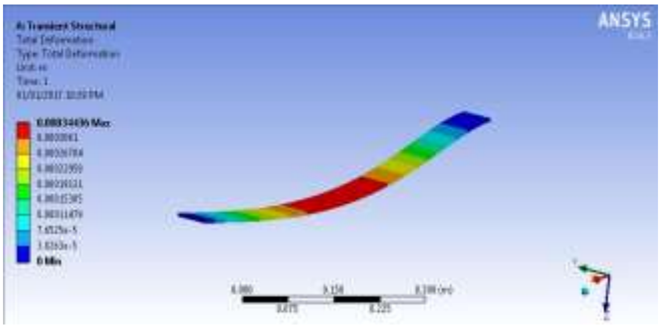
Condition 2 (Using 1.3kg moving load)

Simply Supported Beam at velocity 0.33m/s for 3s

Ms Beam



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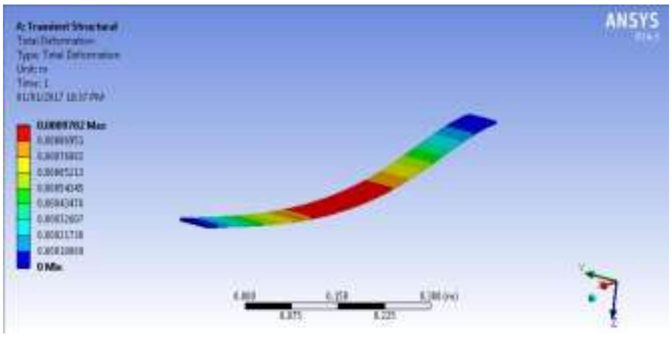

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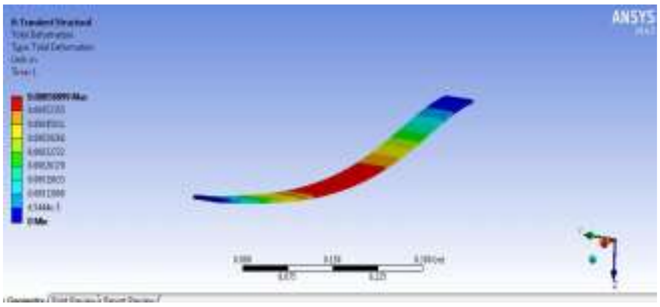

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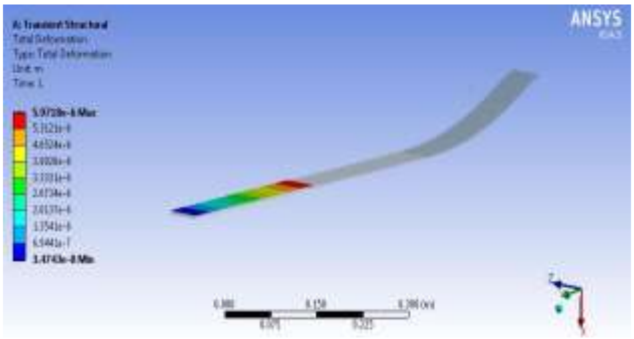

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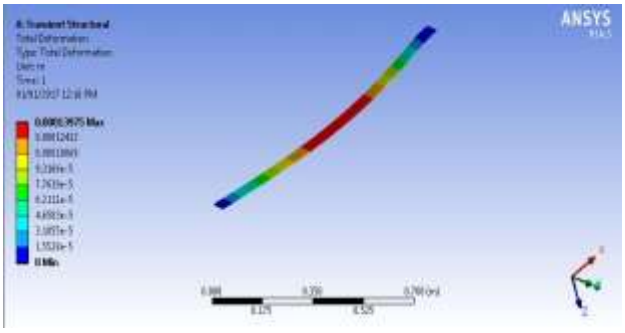
Simply Supported Beam at velocity 0.19m/s for 5s

Ms Beam



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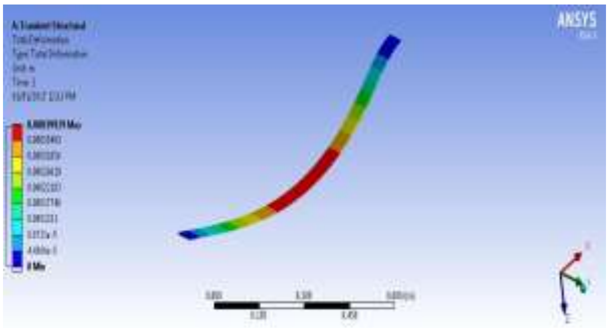
Al Beam



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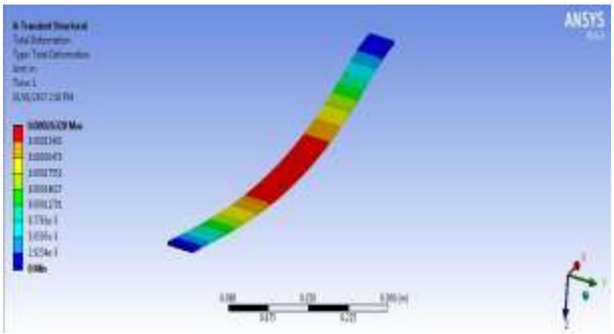

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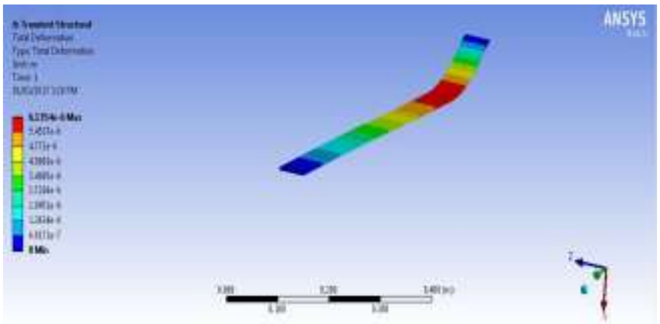

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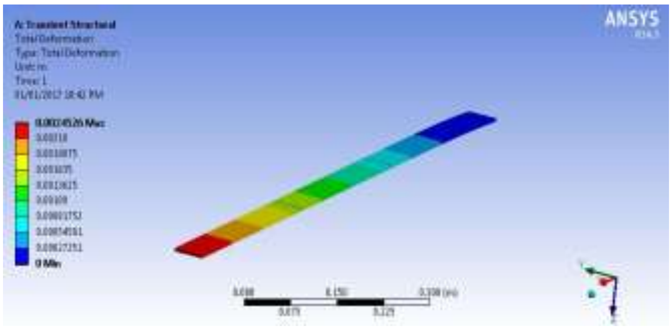
Cantilever Beam at velocity 0.33m/s for 3s

Ms Beam



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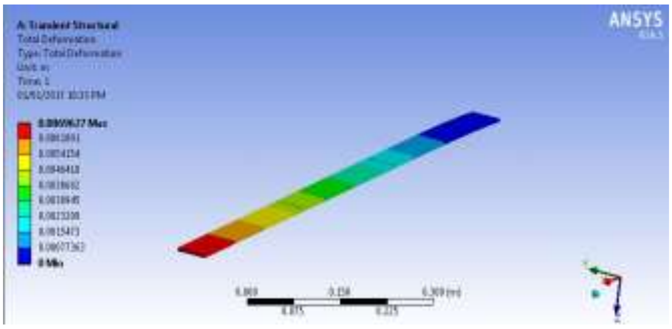
Al Beam



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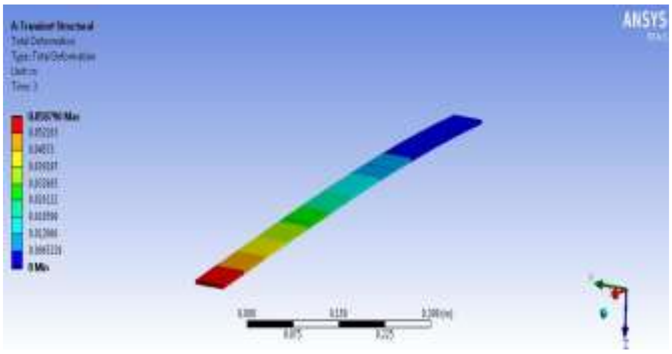
Ms-Al Beam



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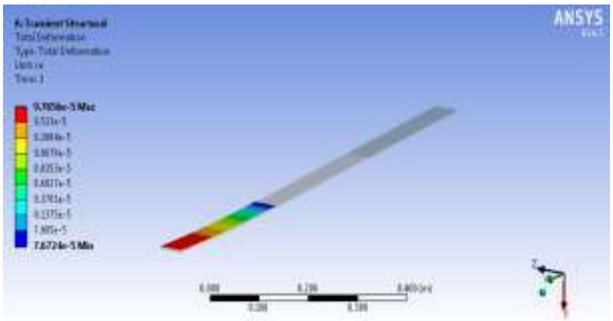
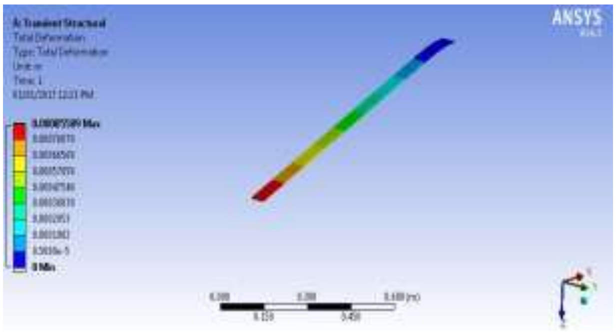
Ms-FRP-Al Beam



Point 1

Cantilever Beam at velocity 0.19m/s for 5s

Ms Beam



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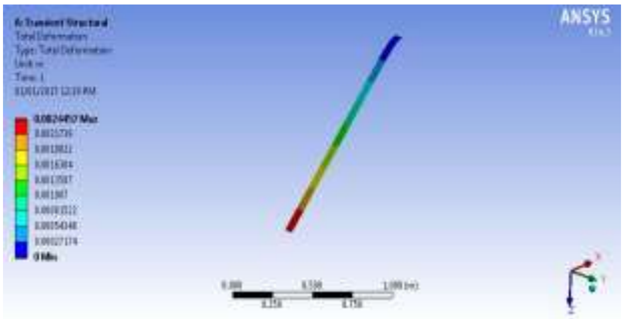
Al Beam



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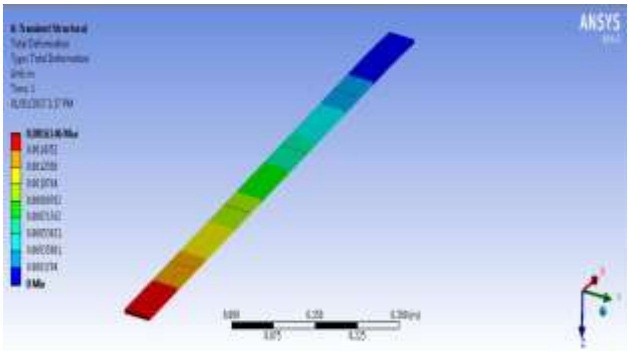

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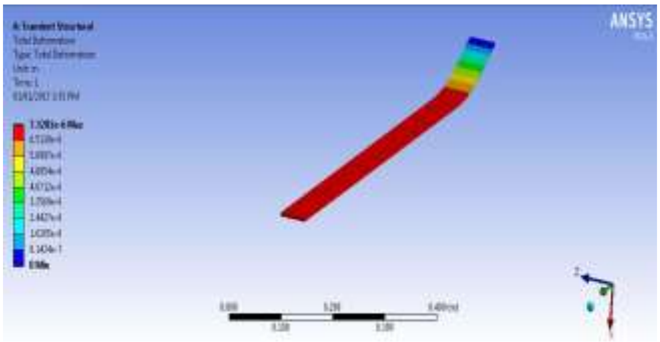
Ms-FRP-Al Beam

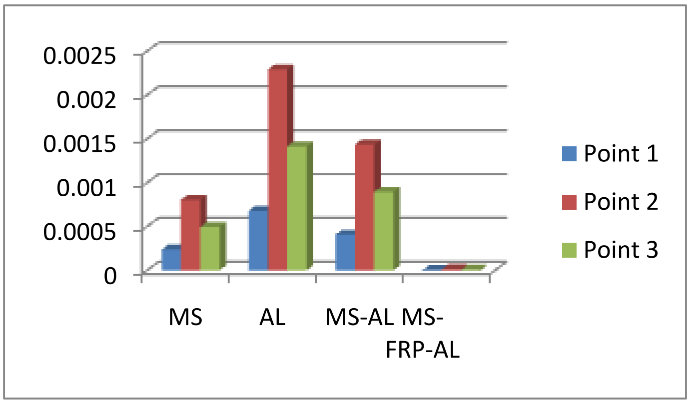


Point 1

Result Table with Graph of Condition 1 (Load 0.9kg)

Simply Supported Beam at velocity 0.33m/s for 3s

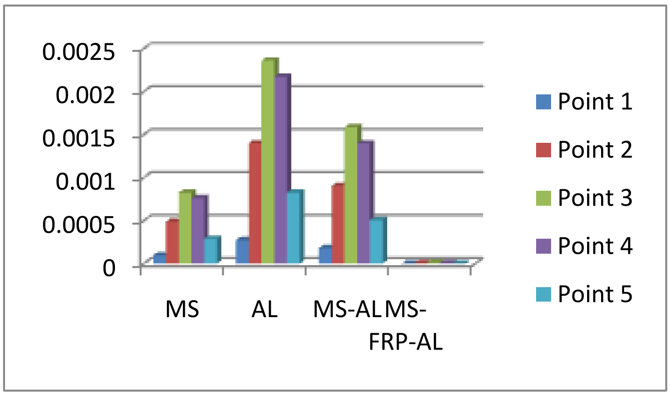
Beam	Point 1	Point 2	Point 3
Ms	0.00023855	0.0008056	0.0004957
Al	0.00067742	0.0022927	0.0014129
Ms-Al	0.00040689	0.0014335	0.00089526
Ms-FRP-Al	0.00000413	0.0000136	0.00000978



Graphical representation of Simply Supported Beam at velocity 0.33m/s for 3s

Simply Supported Beam at velocity 0.19m/s for 5s

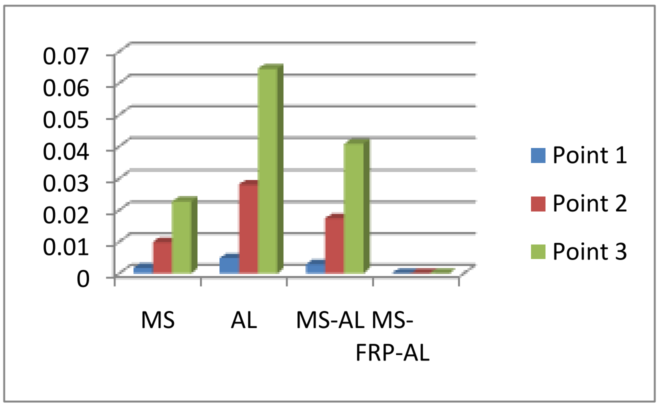
Beam	Point 1	Point 2	Point 3	Point 4	Point 5
Ms	0.000096	0.00048	0.00082	0.00076	0.000289
Al	0.000276	0.00139	0.00236	0.00217	0.000827
Ms-Al	0.000182	0.00090	0.00158	0.00139	0.000508
Ms-FRP-Al	0.000004	0.00001	0.00001	0.00001	0.000004



Graphical representation of Simply Supported Beam at velocity 0.19m/s for 5s

Cantilever Beam at velocity 0.33m/s for 3s

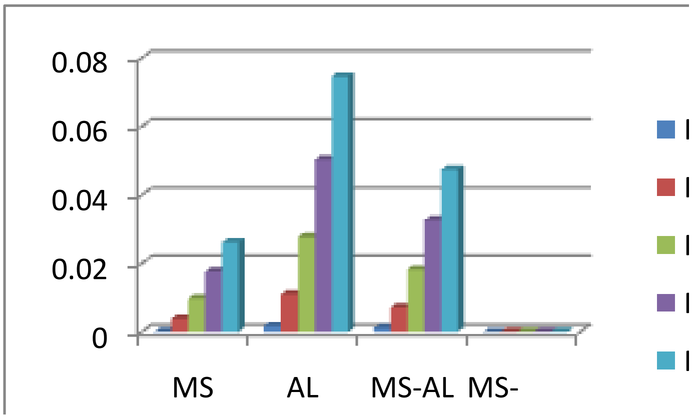
Beam	Point 1	Point 2	Point 3
Ms	0.0016987	0.0098552	0.022698
Al	0.004819	0.028049	0.064528
Ms-Al	0.0028584	0.017323	0.040786
Ms-FRP-Al	0.0000117	0.0000387	0.0000676



Graphical representation of Cantilever Beam at velocity 0.33m/s for 3s

Cantilever Beam at velocity 0.19m/s for 5s

Beam	Point 1	Point 2	Point 3	Point 4	Point 5
Ms	0.0000592	0.003846	0.0096823	0.01763	0.026165
Al	0.00169313	0.01099	0.0277	0.050305	0.07450
Ms-Al	0.0011176	0.007177	0.018199	0.032611	0.04738
Ms-FRP-Al	0.00000507	0.0000172	0.0000335	0.0000497	0.0000608

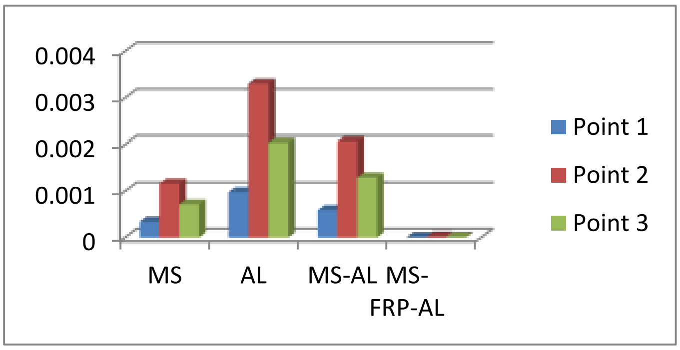


Graphical representation of Cantilever Beam at velocity 0.19m/s for 5s

Result Table with Graph of Condition 2 (Load 1.3kg)

Simply Supported Beam at velocity 0.33m/s for 3s

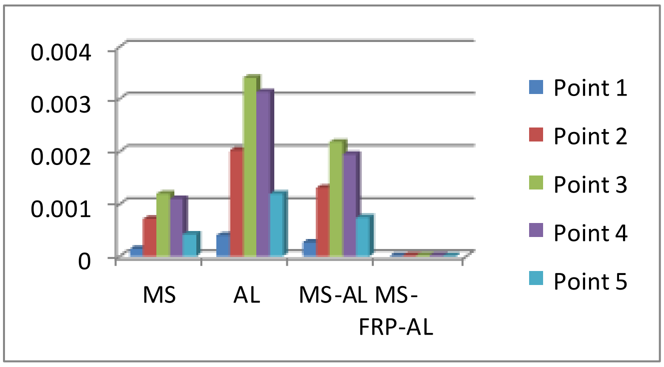
Beam	Point 1	Point 2	Point 3
Ms	0.0003443	0.0011634	0.0007132
Al	0.0009782	0.0033067	0.0020376
Ms-Al	0.0005889	0.0020693	0.0012925
Ms-FRP-Al	0.0000059	0.0000197	0.0000141



Graphical representation of Simply Supported Beam at velocity 0.33m/s for 3s

Simply Supported Beam at velocity 0.19m/s for 5s

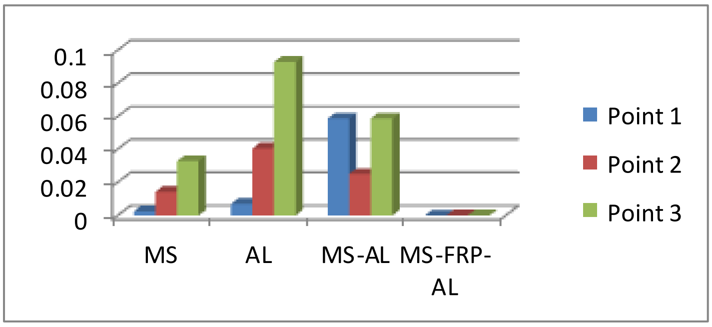
Beam	Point 1	Point 2	Point 3	Point 4	Point 5
Ms	0.000139	0.00070	0.001195	0.0011008	0.0004184
Al	0.000399	0.00202	0.003407	0.0031312	0.001194
Ms-Al	0.000263	0.00130	0.002176	0.0019459	0.0007337
Ms-FRP-Al	0.000006	0.00001	0.000020	0.0000155	0.0000057



Graphical representation of Simply Supported Beam at velocity 0.19m/s for 5s

Cantilever Beam at velocity 0.33m/s for 3s

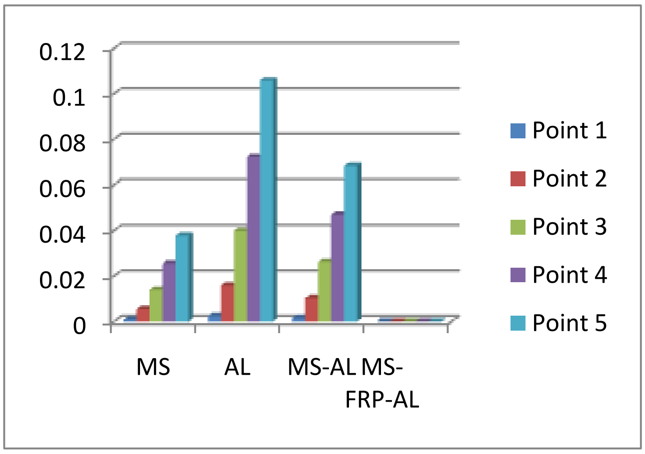
Beam	Point 1	Point 2	Point 3
Ms	0.0024526	0.014232	0.032768
Al	0.0069627	0.040488	0.092928
Ms-Al	0.058769	0.025022	0.058796
Ms-FRP-Al	0.000016935	0.000055978	0.000097656



Graphical representation of Cantilever Beam at velocity 0.33m/s for 3s

Cantilever Beam at velocity 0.19m/s for 5s

Beam	Point 1	Point 2	Point 3	Point 4	Point 5
Ms	0.0008558	0.0055554	0.013986	0.025467	0.037791
Al	0.0024457	0.01588	0.039936	0.072264	0.10584
Ms-Al	0.0016146	0.010362	0.026287	0.047075	0.068342
Ms-FRP-Al	0.0000073	0.0000249	0.0000484	0.0000718	0.0000878



Graphical representation of Cantilever Beam at velocity 0.19m/s for 5s

III.CONCLUSION

Dynamic analysis of a simply supported and cantilever beam subjected to moving load at constant speed is investigated. The influence of variation of parameters i.e. velocity of load and increase in weight of moving load on dynamic response is studied. From the above results and discussion it can be concluded that the minimum amplitude is occurred in composite beam (Ms-FRP-Al) and maximum amplitude is occurred in Al beam. The dynamic response of beam is more influenced by change in speed of load as compared to change in load ratio of system. The effect of changing the material on dynamic behavior of beam for both cantilever and simply support is same.

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