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Study into vibration characteristic of isotropic hyper composite material beam with various supported conditions

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Abstract
The composite materials are very impartment materials. Since, many structures are using its materials, because, its materials have higher strength and low weight. Therefore, in this paper selected the vibration objected for beam of studying. There, the vibration characterization as natural frequency was investigation in this work with various volume fraction effects, for hyper composite materials beam. The composite material is combined from material of polyester resin and two type's reinforcements, first short reinforcement fibre and second powder reinforcement. The different of volume fraction reinforcement of powder effect on the natural frequency of isotropic hype composite material beam is investigation. Where, the study is investigated by experimental and numerical techniques. The experimental work included calculated the natural frequency of hyper composite beam with different volume fraction of reinforcement powder, and also, evaluated the mechanical properties of composite materials beam to using in numerical work. After this, is evaluating the natural frequency of hyper composite beam by numerical technique, and then, the results has been compared with the experimental results. Where, the comparison of the results has submit a good matching between the results of natural frequency experimentally and numerically with a maximum error of about (10.2%). Finally, the results of natural frequency beam are shown that the powder reinforcement is increase the strength of composite materials, then, the beam frequency was increased with increasing the volume fraction of the reinforcement powder.

Keywords: Beam vibration; Finite element vibration; Isotropic composite materials; Isotropic composite vibration; Beam supported.

1. Introduction
The composite materials in nowadays is using with more application, due to the higher strength to weight ratio it has and due to low cost needed to production it. The study of composite materials taking many ranges, dependent on the application of composite structure, as behavior of static, dynamic, thermal and buckling. Therefore, one of impartment subject is dynamic behaviors of composite structure, then, the vibration characterization as natural frequency is one of the very impartment properties it is must be evaluated to structure. Thus, many researchers are investigation the effect of reinforcement on many properties and behaviors of composite structure. Then, the following review shown summery of researchers about the subject as, at (2013), [1], presented the investigation of composite materials plates it is combined from Glass-Carbon/Epoxy materials. Where, the investigation included evaluated the reinforcement fiber

effect on the vibration and buckling characterization. Where, the investigation included experimental and numerical techniques. Also, researcher has been show that the comparison of results produce a very good agreement to the result that obtained experimentally and numerically. After this, at (2014), [2], present the effects of the blast load on the nonlinear behavior of hybrid composite plate. Where, the composite material plate is studying combined from different reinforcement fiber and materials of epoxy resin. Thus, the investigation included evaluated of the dynamic response of simply supported plate with damping influence. The results are evaluating by solution the equation of motion with finite different method and evaluated the effect of different parameters, as, aspect ratio, ratio of damping, and pressure peak.
Also, at (2016), [3], is present investigation of the free vibration of composite plate by using numerical technique with finite element method. Where, the results are given the natural frequency and the mode shape for different reinforcement fiber effect of composite materials structure. Therefore, the conclusion of the paper is show that the volume fraction of reinforcement fiber is effect on the natural frequency of plate and mode shape, and, the various of laminated layers and orientation of fiber are more effect on the frequency from fiber reinforcement volume fraction
And, at same year, [4], is present the effect of impact on the buckling and vibration behavior of composite beams structure. Where, the study of vibration included evaluating the effect of different impact energy on the various mode of hybrid composite beam. Also, the study found by using experimental technique. In addition, the results took into account the effect of span length of beam.
Finally, Muhannad Al-Waily et. al. presented many paper to investigation the effect of powder reinforcement on vibration characterization and other characterization for hyper composite structure, plate and beam. Where, in (2013), [5], is presented theoretical investigation of vibration analysis for isotropic hyper composite plate with different effect of powder reinforcement types and volume fraction. After this, in (2014), [6], is investigation the effect of powder reinforcement types and volume fraction on vibration characterization for orthotropic hyper composite plate structure. At, (2015), [7, 8] are presented effect of buckling behavior for isotropic and orthotropic composite plate, with different powder reinforcement effect, where the investigation is presented by theoretical and numerical techniques. Also, at same year, [9], is presented experimental investigation for powder reinforcement effect on vibration characterization of isotropic hyper composite plate structure. After that, in (2016), [10], is presented the theoretical analysis of boundary condition effect on the natural frequency of isotropic hyper composite plate structure. Also, at same year, [11], is presented investigation of natural reinforcement powder effect on vibration characterization of hyper composite plate structure, where, the powder reinforcement used is date palm nuts powder. Finally, at (2017), [12], is investigation experimentally the effect of Nanotube (MWCNTs) reinforcement powder on vibration characterization of hyper composite plate structure. Then, the papers showed that the reinforcement by powder materials is increasing the strength and the mechanical properties of composite structure. And the influence of fiber on mechanical characteristics, dynamic behaviors, and static behaviors are more than the effect of powder reinforcement on same parameters .
Therefore, the different between this work and presented researchers was presenting experimental technique to calculate the effect of volume fraction of reinforcement powder of beam structure on natural frequency for isotropic hyper composite beam. Also, this work, presented the investigation of supported types effect on natural frequency for beam structure. In addition, the investigation presented comparison of experimental results with numerical results of natural frequency that evaluated by finite element method with using Ansys Program.

2. Experimental work

The experimental work is dividing to two parts, the first, calculate the mechanical properties of composite plate, combined from glass powder; glass short fiber; and polyester resin materials, by testing the composite materials sample, shows in Figure 1, with tensile test machine, shown in Figure 2. Where, the tensile sample shown in Figure 1 are made dependent on the ASTM stander (D3039/D03039M), [13], with dimension as shown in the figure, and, the number of tensile sample are five sample for each test to evaluated the modulus of elasticity. Then, by evaluated the average values for five test for each volume fraction reinforcement sample, the elasticity modulus of composite materials can be calculated with various volume fraction of reinforcement short fiber and powder, as shows in Table 1. After this, the second part of experimental work is evaluating the natural frequency of hyper composite beam with various volume fraction of reinforcement powder and short fiber. Where, the beam sample, shown in Figure 3, testing by vibration rig with vibration machine, as shown in Figure 4, to evaluating the natural frequency of beam with various beam supported, simply supported and clamped beam supported.

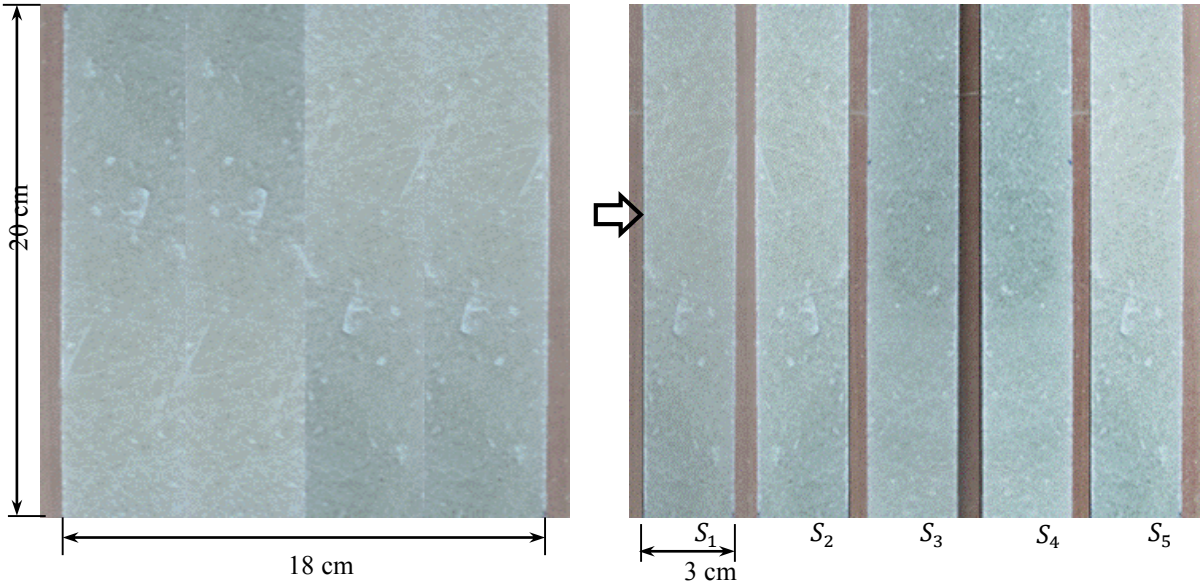

Figure 1. Tensile test sample.

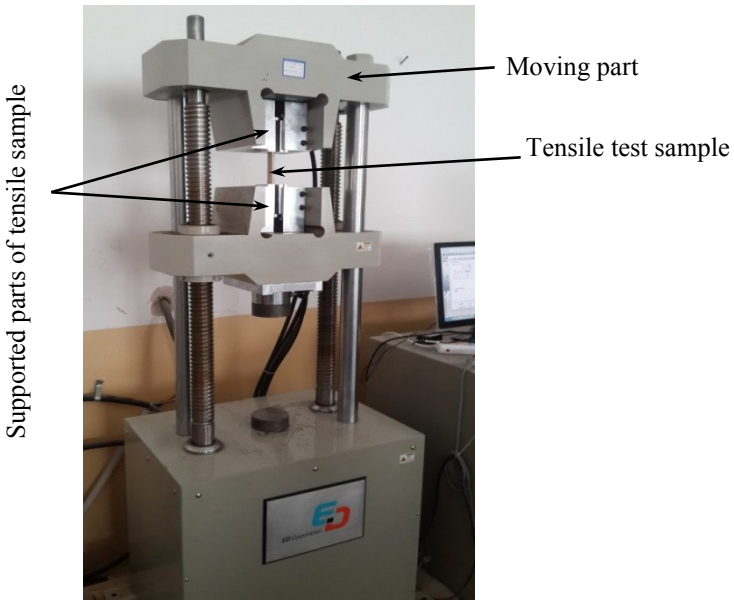

Figure 2. Tensile test machine.

Table 1. Modulus of Elasticity for hyper composite materials with different volume fraction (GPa).

No	Reinforcement volume fraction	Powder reinforcement $\forall_p$	Short fiber reinforcement $\forall_{sh}$	Modulus of Elasticity
1	30%	0%	30%	14.28
2		5%	25%	13.37
3		10%	20%	12.24
4		15%	15%	11.18
5	40%	10%	30%	16.34
6		15%	25%	15.23
7		20%	20%	14.48
8		25%	15%	13.25
9	50%	20%	30%	18.93
10		25%	25%	17.82
11		30%	20%	16.64
12		35%	15%	15.87

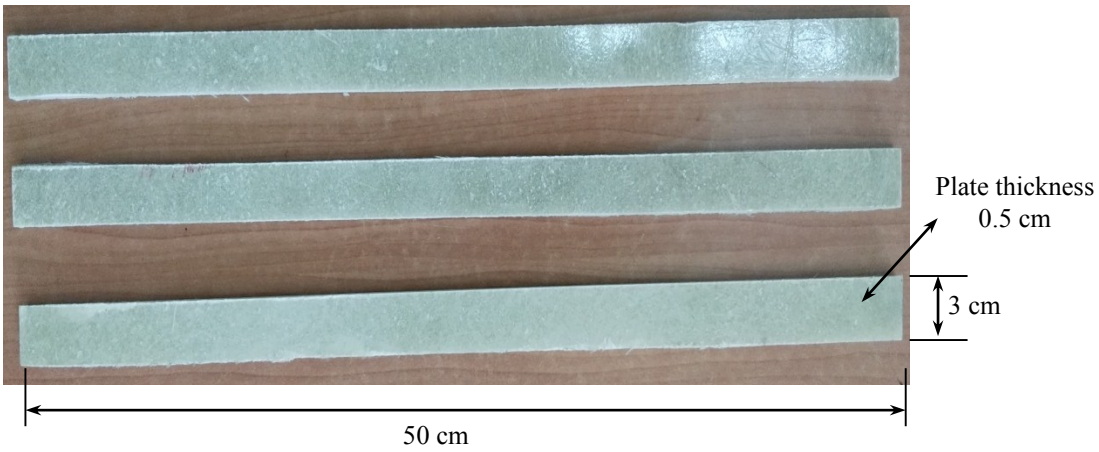

Figure 3. Dimensions of vibration beam sample.

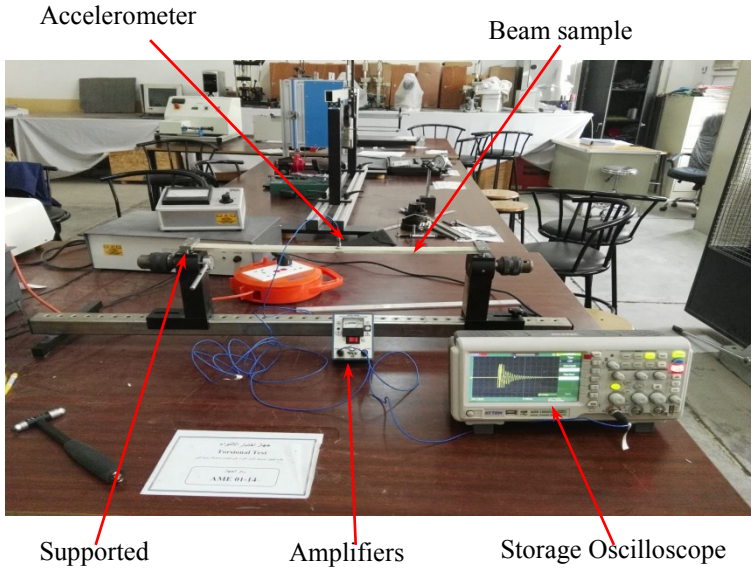

Figure 4. Vibration test machine.

Therefore, the testing of vibration sample, by vibration rig, given the response of plate as a function of acceleration-time (evaluated by accelerometer sensor), and then, by analysis the output signal with Fast Fourier Transfer (FFT) by using sig view program, get the natural frequency of hyper composite beam, as shown in Figure 5. Where, the natural frequency is the value at the x-axis in sig view programs it's give the maximum peak at the figure. Therefore, the natural frequency evaluating by experimental work of hyper composite beam is comparison with the numerical natural frequency results evaluating by using finite element method, with using Ansys program, to shown the agreement of experimental frequency results.

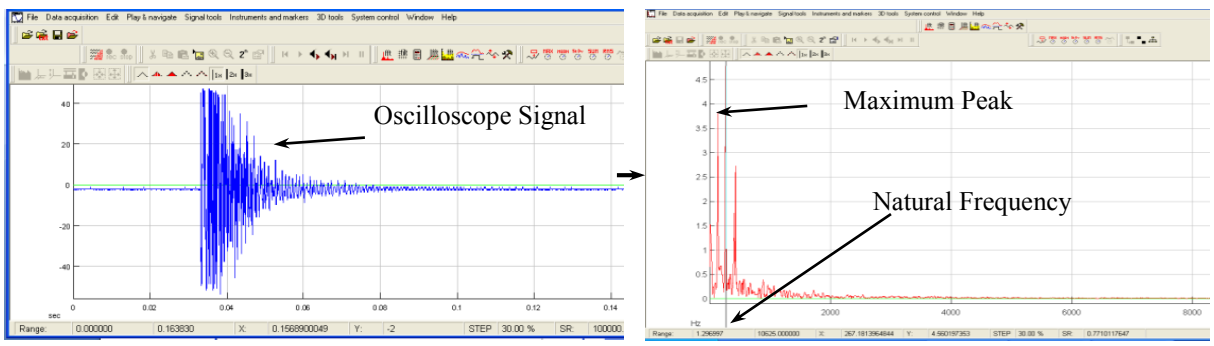

Figure 5. Analysis of storage oscilloscope signal by FFT.

3. Numerical study

The numerical part included using Ansys program to evaluate hyper composite beam natural frequency with various fractions of volume of powder and fiber reinforcement and different beam supported. The beam dimensions beam used in the numerical part is as the dimensions of beam testing in the experimental part. Therefore, to calculating the natural frequency by Ansys program must be using the mechanical properties of bam, thus, the mechanical properties used in the numerical part are same the mechanical properties evaluated by experimental part, shown in the Table 1. In addition, the mechanical properties needed in the numerical part are density; Poisson's ratio; and the shear modulus of rigidity, then, its properties used shown in Table 2, [8]. The numerical work by Ansys program needed selected the element type used to modeling the beam structure. Therefore, the element types selecting is beam 189-3 node, as shown in Figure 6. Where, it' element is give the best results of thin composite beam.

Table 2. Mechanical Properties for hyper composite materials with different volume fraction, [8].

No	Reinforcement volume fraction	$\forall_p$	$\forall_{sh}$	Elasticity Modulus (GPa)	Rigid modulus of rigidity (GPa)	Poisson's Ratio
1	30%	0%	30%	14.28	5.01	0.40
2		5%	25%	13.37	4.70	0.39
3		10%	20%	12.24	4.37	0.38
4		15%	15%	11.18	4.01	0.37
5	40%	10%	30%	16.34	5.82	0.39
6		15%	25%	15.23	5.49	0.38
7		20%	20%	14.48	5.14	0.37
8		25%	15%	13.25	4.78	0.36
9	50%	20%	30%	18.93	6.85	0.37
10		25%	25%	17.82	6.50	0.36
11		30%	20%	16.64	6.16	0.35
12		35%	15%	15.87	5.80	0.34

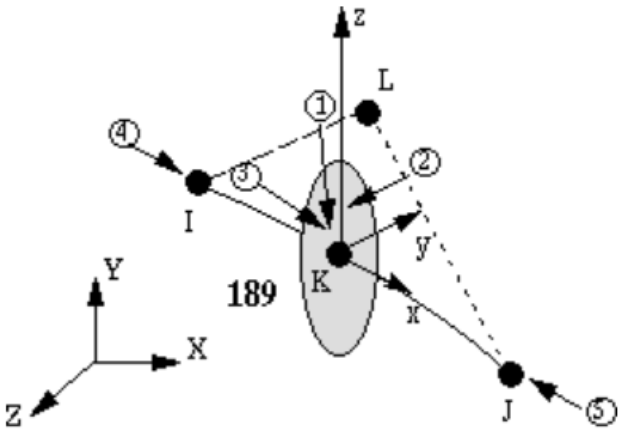

Figure 6. Element 189-3-node quadratic finite strain beam.

Where, the best of element 189-3-node is Timoshenko beam theory. Also, it's element have 6-degree of freedom 6-DOF at each beam node. The each degree from the six degree of freedom include three translations degree of freedom in x, y, and z direction, and also, three rotations degree of freedom about the x, y, and z direction. The application can be studding by its element are large rotation, linear, large strain and nonlinear problem.

4. Results and discussion

The investigation of vibration beam included evaluated the natural frequency of beam is combined form three materials, powder and short reinforcement fiber in addition to polyester resin material. Therefore, the results included the influence of volume fraction of reinforcement (powder and short fiber) on the natural frequency of beam supported with various boundary conditions. Thus, the results are measuring by

experimental technique and comparison with numerical investigation to shown the results match it's evaluated by experimental and numerical work. Where, the Figures 7 to 18 are shown the comparison between the experimental and numerical results of natural frequency of beam with different reinforcement powder and fiber, and various beam boundary conditions. Thus, the volume fractions of reinforcement are variable from 30% to 50%, with different short fiber from 15% to 30%.

Where, Figures 7 to 10 are shown the comparison between experimental and numerical results for simply supported beam, also, Figures 11 to 14 for fixed beam from the two opposite ends, and the Figures 15 to 18 for cantilever beam. Therefore, the figures are shown that comparison between the two techniques used are produced a good agreement with about (10.2%) maximum error.

After the results comparison, shown in Figures 19 to 24 the effect of increase short reinforcement fiber on the natural frequency of simply supported, fixed, and cantilever beam, for various reinforcement. Where, it's shown that the natural frequencies are increase when increasing the short reinforcement fiber (with same powder reinforcement). Since, the increase of fiber and decrease of polyester resin materials cause increasing of materials strength and mechanical properties, therefore, increasing the dynamic characterizations of composite beam. Also, the Figures 25 to 27 are shown the effect of reinforcement powder on the natural frequency beam with same volume fraction of reinforcement powder and short fiber (with decreasing of short fiber and increasing of powder reinforcement), for various boundary condition of composite beam. From this figures are shows that the natural frequency of beam is decreasing with increasing the powder reinforcement and decreasing the short fiber reinforcement with same volume fraction, since the effect of short fiber more than the effect of powder on the strength of materials. Finally, also Figures 28 to 30 have shown the influence of reinforcement powder on the beam frequency with same short fiber reinforcement volume fraction and different beam boundary condition. From these figures can be seeing that the natural frequency of beam is increase with increasing the reinforcement powder (with same short reinforcement fiber) due to increasing of strength of composite materials used in beam.

Then, from the presented result scan be seeing that the increasing of powder reinforcement (with same short reinforcement fiber) and decreasing of resin materials are given improvement of mechanical properties and dynamic characterizations of isotropic hyper composite materials structure. Also, it can be seeing that the effect of short reinforcement fiber is more than the effect of reinforcement powder on the strength, mechanical properties and dynamic characterizations of hyper composite materials structure.

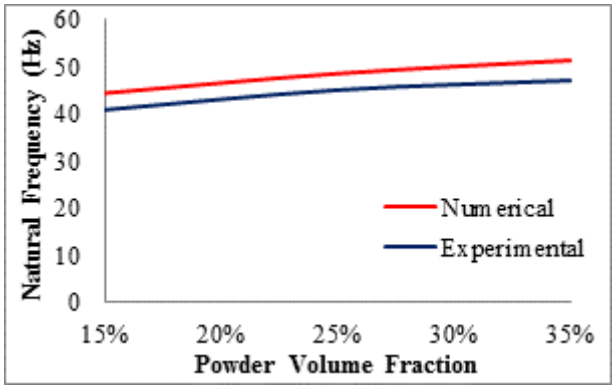

Figure 7. 15% reinforcement fiber for SS beam.

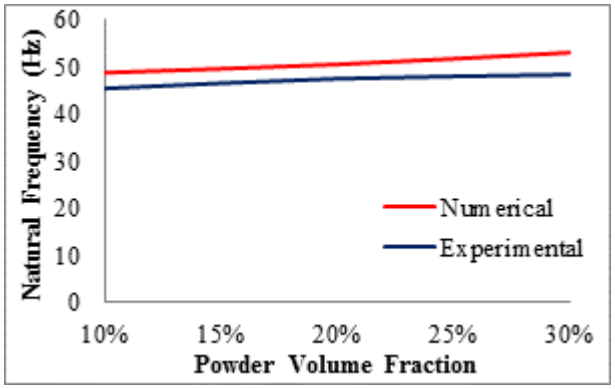

Figure 8. 20% reinforcement fiber for SS beam.

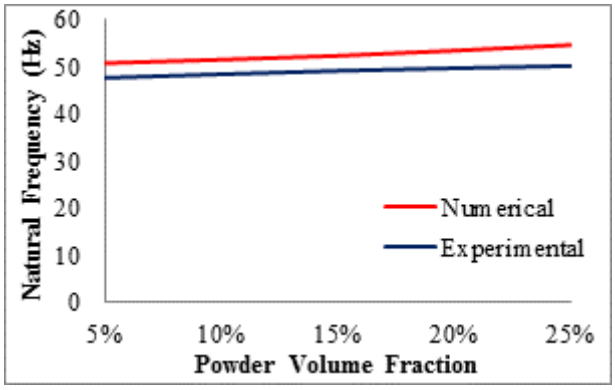

Figure 9. 25% reinforcement fiber for SS beam.

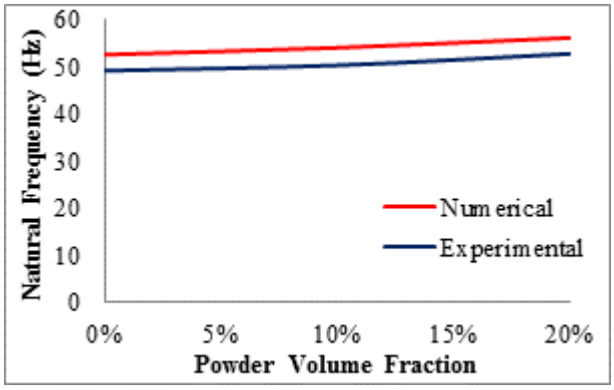

Figure 10. 30% reinforcement fiber for SS beam.

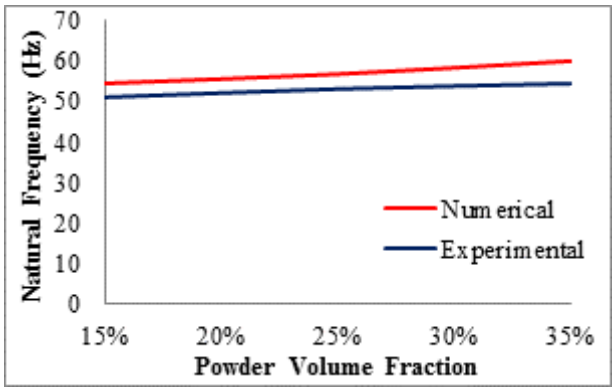

Figure 11. 15% reinforcement fiber for CC beam.

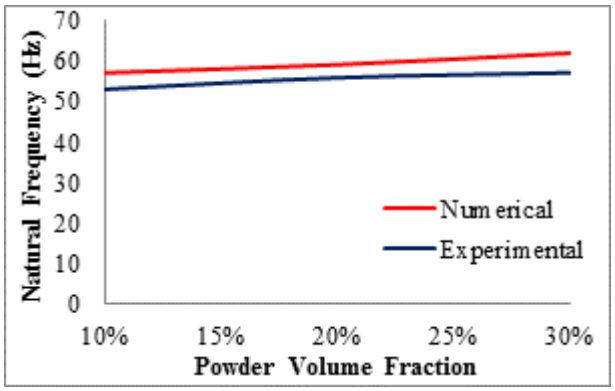

Figure 12. 20% reinforcement fiber for CC beam.

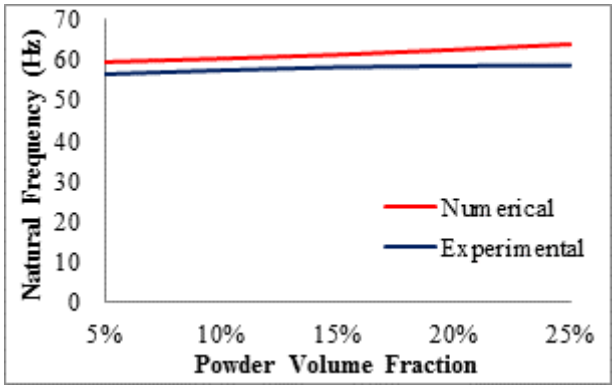

Figure 13. 25% reinforcement fiber for CC beam.

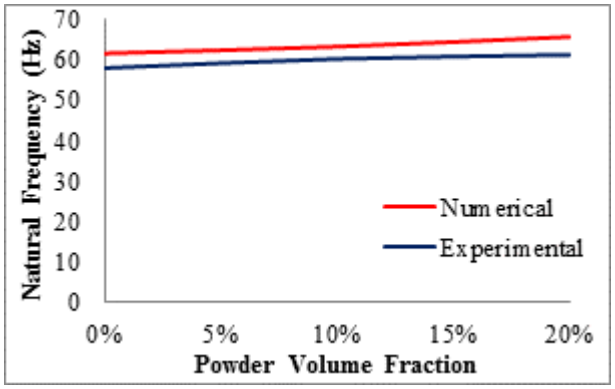

Figure 14. 30% reinforcement fiber for CC beam.

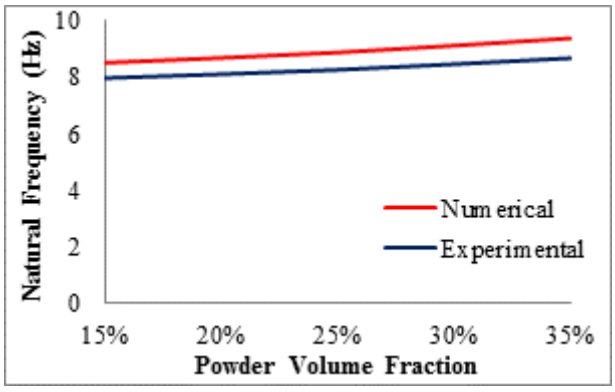

Figure 15. 15% reinforcement fiber for CF beam.

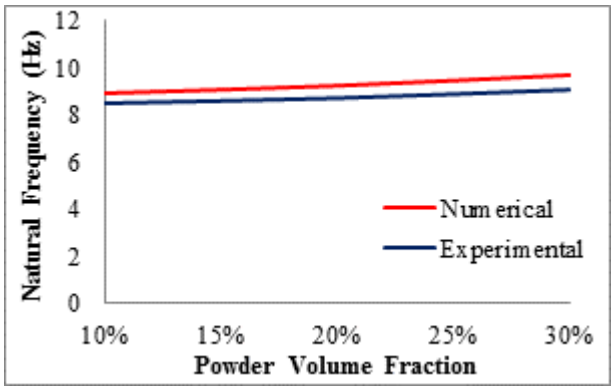

Figure 16. 20% reinforcement fiber for CF beam.

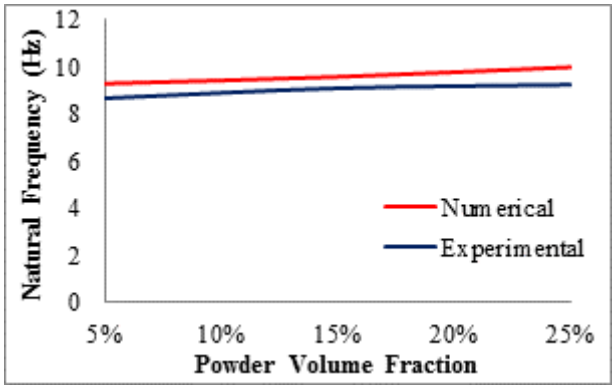

Figure 17. 25% reinforcement fiber for CF beam.

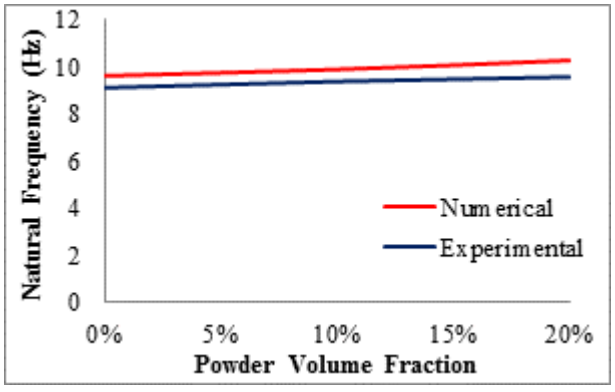

Figure 18. 30% reinforcement fiber for CF beam.

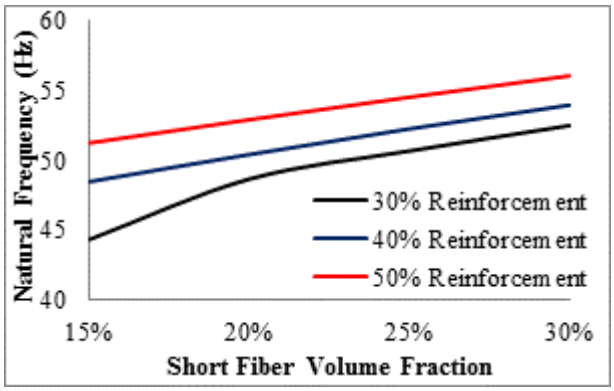

Figure 19. SS hyper composite beam.

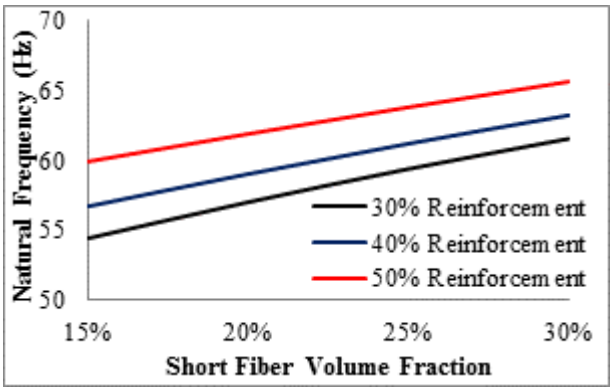

Figure 20. CC hyper composite beam.

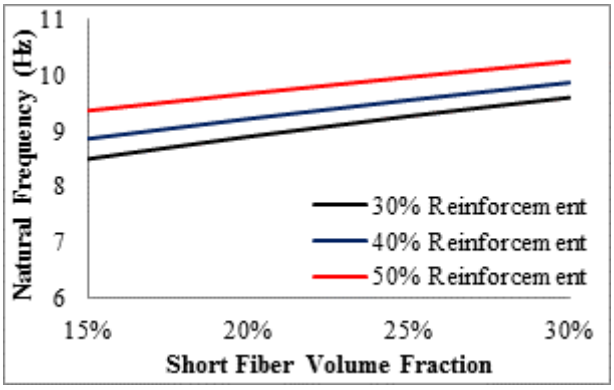

Figure 21. CF hyper composite beam.

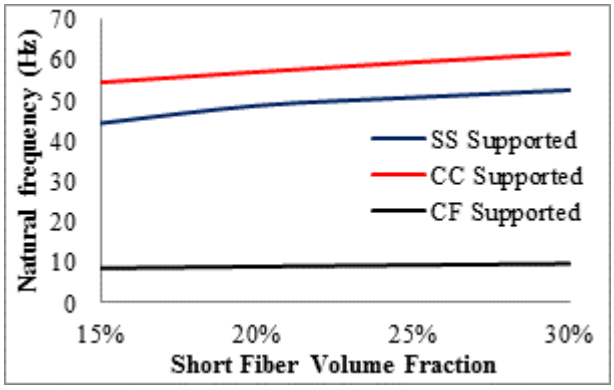

Figure 22. 30% Reinforcement powder and fiber.

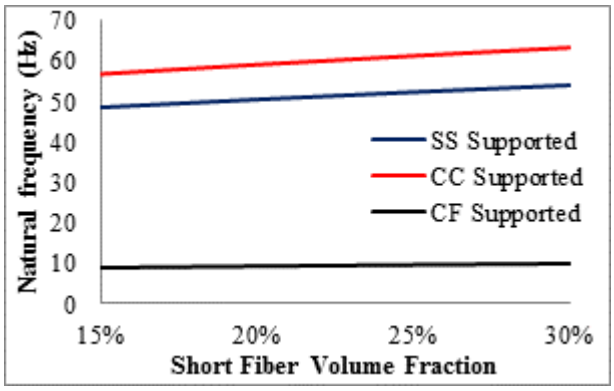

Figure 23. 40% Reinforcement powder and fiber.

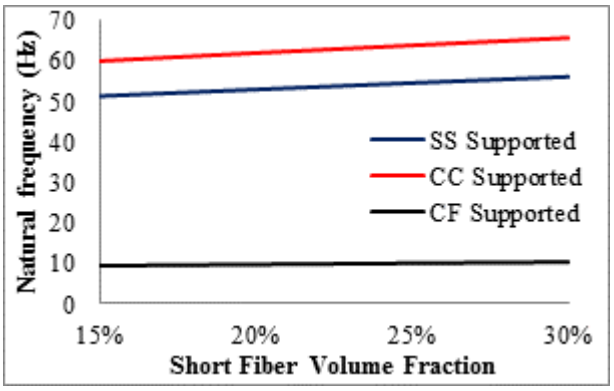

Figure 24. 50% Reinforcement powder and fiber.

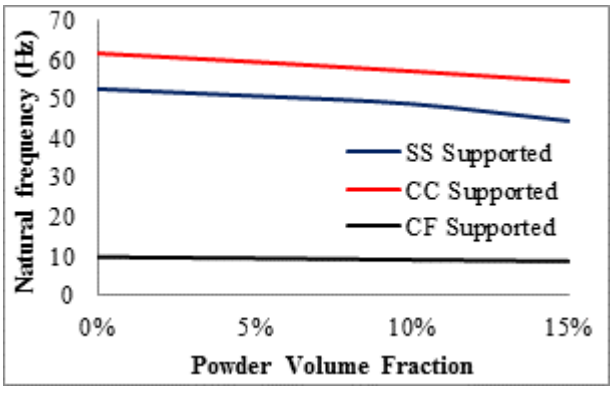

Figure 25. 30% powder and fiber Reinforcement.

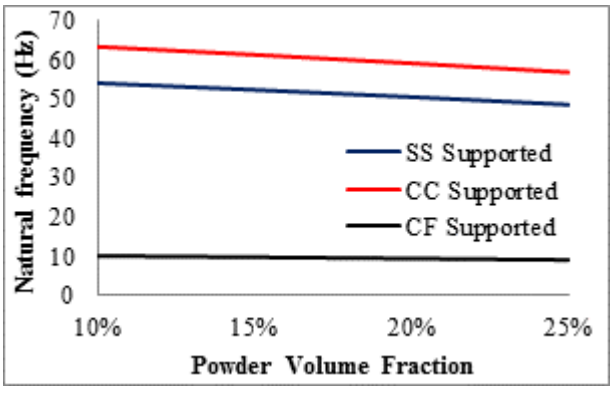

Figure 26. 40% powder and fiber Reinforcement.

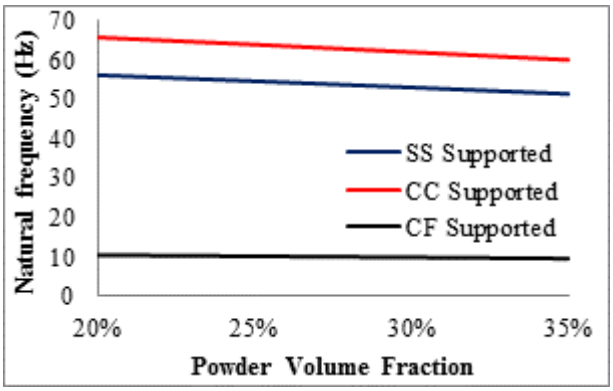

Figure 27. 50% powder and fiber Reinforcement.

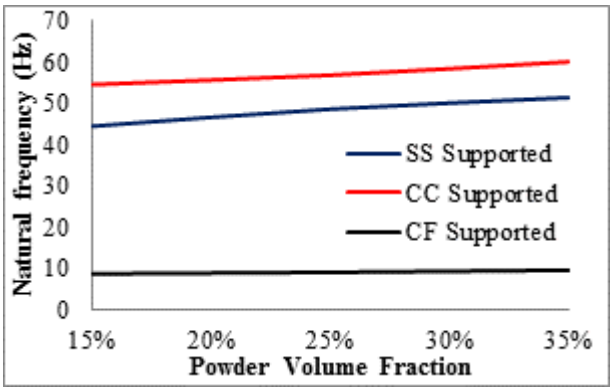

Figure 28. 15% short reinforcement fiber.

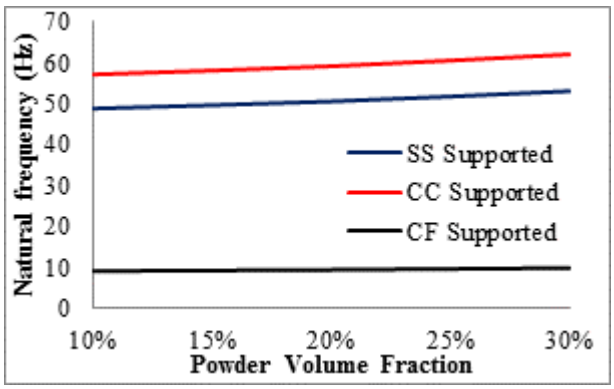

Figure 29. 20% short reinforcement fiber.

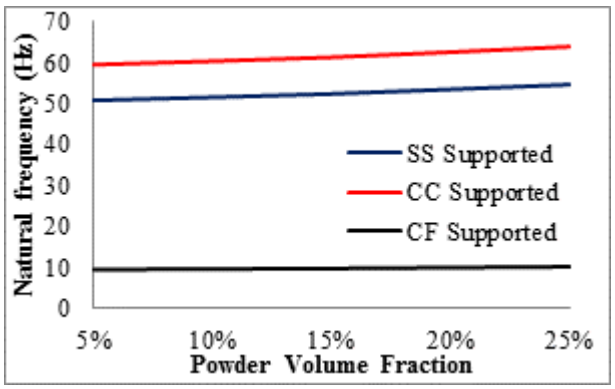

Figure 30. 25% short reinforcement fiber.

5. Conclusion

The results presented in the paper are showed that the influence of reinforcement of powder on the natural frequency of hyper composite beam. Therefore, can be conclusion many impartment points, as,

1. The experimental work is a perfect tool can be used to measure the natural frequency of beam supported with various boundary conditions. Where, the experimental results work were compares with numerical results and found that the maximum error about (10.2%.(
2. The powder reinforcement is increasing the strength and the mechanical characteristics of hyper composite materials. Where, the increasing of reinforcement powder brought out an increasing at the mechanical properties of composite materials, with same volume of fraction of short reinforcement fiber.
3. As shown in the point (2), since the increasing reinforcement powder was cause increasing of materials mechanical properties, then, the beam frequency is increasing with the reinforcement powder increasing.
4. The effect of reinforcement short fiber more than the effect of reinforcement powder on mechanical and dynamic characterization of isotropic hyper composite beam. Thus, the mechanical properties and dynamic characterization are increase with increasing of reinforcement short fiber more than it is increasing due to reinforcement powder.

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