Vibration Analysis of Cracked Composite Laminated Plate and Beam Structures

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Abstract: - The composite structures usually experiences vibration during service. Presence of delamination in a structure not only significantly impacts the stiffness of the structure with declining trends but also affect their vibration properties. The purpose of this paper is to review the literature studies on the effect of vibration on composite delamianted structures. The literature studies have been classified on the basis of methodology i.e experimental, analytical and finite element methods. In this review, particular attention has been given to the study of results, comparison with the work conducted by other researchers in the field of the free and forced vibration behavior of the composite laminates subjected to delamination or crack.

Keywords: - Vibration testing; delamination; composite structure; cracked composite; finite element analysis; analytical technique; simulation

1. INTRODUCTION

Fiber-reinforced composites have gained wide use in many aspects of engineering applications. For example, they have been applied in ship building, mechanical, aerospace, etc. They are preferred because of the advantages they have such as superior mechanical characteristics, high-strength, their stiffness ratio to weight is excellent [1-3].

The characteristics of the CFRP formed depend on the Reinforcement and the particular Matrix used. The reinforcement components like elasticity and stress determines the rigidity and strength of the CFRP. This is why the property strength of Carbon-fiber-reinforced polymers (CFRP) is usually described as directional and distinct from isotropic structures like aluminum. It must not be forgotten that the carbon-fiber layout also has the ability to influence the CFRP properties [4-5].

Laminates are formed by stacking different laminates (usually two or more) with different or similar fiber orientation under global direction [6]. Different or similar composite materials with varying thicknesses can be used to form the laminate under any stacking sequence. Stacking sequence optimization of composite laminates requires the use of least amount of layers, highest fiber quality and highest possible thickness for each of the layers [7]. The composite structures usually experiences vibration during service. The consequences of vibration have a wide impact range from minor issue, such as development of noise in an automobile component, to significant damage occurrences to the structure or its parts [8-9].

Experiments showed that presence of delamination in composite structures is one of the major causes of failures in laminated structures. Presence of delamination in a structure affects the stiffness of the composite structure and also vibration properties. Delamination length and size decrease the natural frequencies and therefore to find effect of delamination on vibration characteristics is quite important for highly sensitive applications [10-11]. Experiments proved that in the presence of delamination, mode shapes of the composite materials were changed [12-13].

2. VIBRATION OF COMPOSITE WITH CRACK OR DELAMINATION

2.1. Analytical techniques

Ghoneam [14] analyzed effects of the crack depths, crack locations and boundary constraints on the dynamic (non-linear) properties of composite beams using mathematical model and experimental techniques. Shape function was derived to express kinetic energy and elastic potential energy of the cracked elements. The test beam was constructed using handy layup technique. It was analyzed that the fundamental frequency showed the declining trends if the crack depth value was increased. It was also concluded that at the specific value of crack depth, fundamental frequency decreased if the location of the crack was near to the center of the beam. The composite beam with C-C boundary conditions has higher natural frequency than other constraints.

Shu et al [15] investigated the free vibration impact of composite beams subjected to multiple delaminations. Classical Euler-Bernoulli was used as governing equation. It was concluded that primary and secondary frequencies decreases as the length of the delamination increased however reduction of primary frequency is not significant. No effect on frequency for short delamination was observed contrary to large delamination that reduced the natural frequency significantly. It was also observed that natural frequency and mode shapes are largely dependent of the assumed constraints. Multiple delamination effect was also conducted by Parhi et al [16]

Della et al [17] also did an analysis to find the vibration characteristics of beams with double delamination. Classical Euler's Bernoulli theorem was used as governing equation for free mode. Free mode along with partially constrained mode and fully constrained modes of beam were analyzed analytically. Two equal delamination lengths were considered. It was concluded that double delamination further reduced the value of natural frequencies. The mode shapes of the composite laminated beam structure were also reduced. It was also observed that second delamination with less than 25% delaminated area of the beam length had an insignificant impact on the natural frequency values and also on mode shapes. This behavior was also reported by [18-20]. Another analytical solution were also conducted with multiple delamination by Lestari et al [21]. They conducted dynamic analysis on composite beams for multiple delamination.

Chattopadhyay et al [22] conducted the vibration analysis and analyzed the vibration characteristics of delaminated composite plate structure subjected to piezoelectric actuators. Modified Higher order shear deformation theory was utilized to model dynamic behavior of smart composite laminated structures. Results from higher order shear deformation theory concluded from this research work were compared with Shen et al [23] and both results were in excellent agreement. When the delamination size is small, insignificant variations in the natural frequency are observed. The deviations of the results from classical laminate theory (CLT), first order shear deformation theory (FSDT) and third order shear deformation theory (TSDT) increases as the delamination length decreases. For a delaminated composite plate with crack size having L/T ratio of 15.7, results obtained of all three theories i.e classical laminate theory (CLT), first order shear deformation theory (FSDT) and third order shear deformation theory (TSDT) are in close agreement to each other for first frequency. For the second bending frequency, results obtained from both FSDT and TSDT have values closer to each other but deviate from TSDT however this difference of FSDT and TSDT decreases upon increase in the the size of delamination.

Lee et al [24] conducted the vibration analysis and analyzed the effect of multi-delamination on the vibration properties of multi-delaminated composite beam columns. Loading was axial compressive. Bernoulli-Euler beam theory obtained from [25] was used as governing equation. It was shown that effect of multi delaminations are more significant than those for single delamination.

Kim et al [26] investigated the influence of delamination. They found that the natural frequencies and vibration mode shapes in honeycomb sandwich beams. Delamination was embedded between the face layers of carbon/epoxy laminates and Nomex-aramid honeycomb cores. Equation of motion of the split sandwich beam was used for debonded honeycomb sandwich beam. An increase in value of debonding or delamination. They observed that value of natural frequency reduced. At delamination length of 50mm, a critical debonding point was observed at beyond which response of natural frequencies was unpredictable or disproportional. Also mode shapes become smaller for the increase in debonding size. The theoretical results obtained in this analysis were close to the experimental measurements. Other investigation have been done by Burlayenko et al [27] for dynamic behavior was partially delaminated honeycomb core sandwich plates.

Shu [28] investigated vibration analysis in composite beam with single and double delamination. Shu used the Classical Euler-Bernoulli beam theory as the starting base for the development of governing equation. For a clamped-clamped isotropic beam analysis, the value of primary frequency decreases as the length of delamination increases subjected to single delamination. Significant decrease in frequency was observed for incorporation of another delamination. It is observed that constrained mode model shows a decreasing frequency trends. It was also observed that if the delamination was located near the mid-plane, then the frequency decreases. It was obvious that free mode and constrained had identical results at mid plane delamination due to equal thickness of delaminated layers.

Dey et al [29] conducted vibration analysis on the graphite-epoxy composite shells using Lagrange's equation of motion. On an increase in twist angle of fiber orientation, its frequency values tend to decrease. The fundamental frequencies increases for twisted shells proportional to the delamination towards free end subjected to the stationary condition. However values of fundamental frequencies of stationary twisted shells depends upon the delamination location and its value decreases as the location of delamination is near free end. When a delamination is incorporated at the mid plane, non-dimensional fundamental frequencies have minimal values and second natural frequencies are attained.

Non-dimensional fundamental frequencies decreases as the twist angle from 0^0 to 45^0 is increased. Irrespective of twist angle, on the changes in the location of delamination, it affects the NDFF values and NDFF value gradually decreases to minimal if it is located at the vertical mid-plane and its value at the bottom surface gradually increases with location.

Marjanovic [30] did an investigation to find the mode shapes, fundamental frequencies and critical buckling loads. They developed the numerical model for the delaminated sandwich composite plate. However for free cantilevered plate, shear deformation does not affect the natural frequencies however shear deformation has considerable effect on the simply supported or clamped plate.

Luigi et al [31] conducted analysis to find the free vibration characteristics of beam-type composite structures subjected to delamination with proposed analytical solution using the Mid-plane delamination and Constrained model assumptions. They considered it Homogeneous material and shear deformations were neglected.

It has been observed that opening mode continues to disappear as the transversal longitudinal spring stiffness tends to increase from zero to higher values.

Luo et al [32] did an investigation to find the non-linear vibration properties of the composite beam subjected to variation in sizes and positions of the delamination.

Since the amplitude is small, larger value of frequency would be observed with greater length of delamination. Frequency increases relatively slow with an increase in length of the delamination. As the value of amplitude is increased, the influence of the positions or locations of delamination gets clearer. The influence by transverse shear deformation has significant importance and cannot be considered as no impact for non-linear vibration characteristics of composite beam.

Chen [33] did an investigation to find the effect of circular delamination on circular composite laminated plate. It was analyzed that the radius and depth of delamination has a considerable effect on the vibration characteristics of delaminated composite plate. Boundary conditions were formulated using Reissner Variational Principle. First order shear deformation was used for formulation of governing equation. It was concluded that an increase in delamination radius rapidly decreased the value of natural frequency of the composite laminated plate. However the value of natural frequency of laminated circular composite plate decreased with decrease in the delamination depth.

Lee [34] conducted free vibration analysis using layer wise theory approach to find the vibration properties of delaminated composite beam. Hamilton's principle was used to determine the equations of motion and the analytical results were compared with Wang [35]. Both the theories predicted that frequency values decreased as the delamination length increased as shown in [35].

Hirwani et al [36] did an investigation to analyze the effect of presence of delamination on the vibration characteristics of spherical structure, cylindrical structure, elliptical structure, hyperboloid structure and flat structures of laminated curved composites. Higher order shear deformation theory (HSDF) was taken to develop the model. The frequency responses were obtained using ANSYS and mode shapes were obtained using MATLAB. The experimental, analytical and ANSYS results were compared for delamination area of 6.25%, 11.11%, 25% and 56.25% of the total area. Result of first six mode shapes are evaluated. It was concluded that the results obtained from analytical method are in close agreement to the experimental results.

Nanda et al [37] find the vibration response of delaminated composite shell using first order shear deformation theory subjected to Cylindrical, Spherical and Hyperboloid shells. The value of linear frequency showed increasing trend with reduction of number of layers. This frequency difference continues to increase after the six number of layers. Moreover, higher modes were more influenced by the delamination.

Yam et al [38] analyzed the dynamic behavior of composite plate with multi-layered structure subjected internal delamination. Eight-node rectangular thin element was used for Finite element formulation. It was concluded that local internal delamination had slight or negligible influence on the natural frequencies of laminated composite plate with multi-layers. Moreover it was also found that natural frequency decreases if the area of delamination is increased. On the other hand, natural frequency increases if the mode numbers increased. Results obtained using FEM method conducted by Yam were then compared with experimental results concluded by Lin [39]. This proposed model was validated and incorporated by Wei et al [40] to determine the internal delamination for multi-layer composite plates. Similar influence of internal delamination for vibration analysis in fiber reinforced composite plate was also observed by Alnefaie [41]

PM Mujumdar and S Suryanarayan [19] did an investigation on the Delaminated Composite Beam by Numerical Solution using Euler beam theory. Size, boundary conditions, modes and location of delamination largely influence the frequencies. Delamination with shorter length have little impact on fundamental and second mode frequencies subjected to all boundary conditions. However Delamination with larger length have huge impact on fundamental and second mode frequencies subjected to boundary conditions. There is large difference in second mode if compared experimental results. It was also observed that a delamination located nearer to the mid plane caused more reduced natural frequency. This behavior of delamination location was also reported by [42-46]

Shen et al [23] conducted vibration analysis to find the effect of delamination on Composite Beam subjected to delamination. They used Timoshenko Beam Theory and local Rayleigh Ritz Method. Fundamental resonant frequencies showed declining trend by the increase of delamination sizes.

Kim et al [45] found the effect of delamination and without delamination on Cross-ply laminates with various delamination at multiple places as shown in Figure 5. They used Layer-wise composite laminate theory. It was observed that Natural frequencies decreased with delminations and there is significant difference between delaminated and without delaminated structure. Ju et al [47] investigated effect of multiple delamination. They used Composite beam and first order shear deformation Timoshenko Beam Theory. They concluded that the Effect of the first three delamination in lower modes is about uniform however it has significant effect for higher modes.

Kitipornchai et al [48] find the effect of crack depth on Functionally graded materials cracked beam using Ritz Method. Crack depth has no significance influence of non-linear frequencies however linear frequencies are greatly reduced and the both linear and non-linear frequencies are more sensitive for cracks at mid span as shown in Figure 1

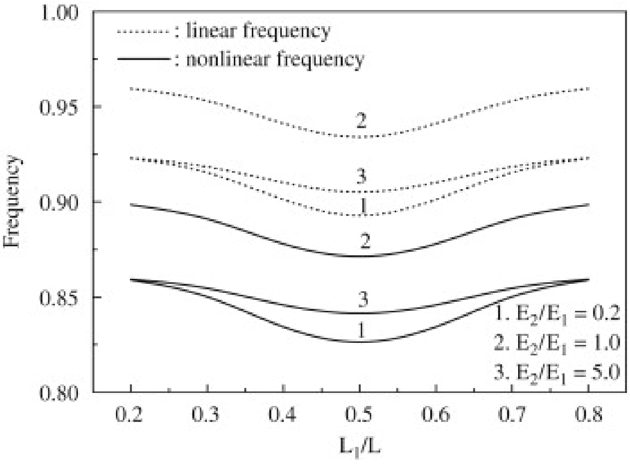

Figure 1. Effect of crack length on linear and non-linear frequencies [48]

Qu et al [49] investigated Piezoelectric composite plate with cracks using Classical laminated theory. Systematic reduced values of natural frequencies of composite plate would happen in the presence of cracks however this decrease of natural frequencies is in small amounts. Chang et al [50] find the influence of delamination size on Delaminated composite plate subjected to axial load using classical plate theory. It was concluded that as the delamination size increases, fundamental natural frequency value gets smaller as shown in Figure 7. This behavior was also predicted by [34, 51-52]. Talookolaei et al [53] did an investigation on Composite beam with single delamination using Hamilton's principle. They concluded that an increase in delamination length significantly reduced the natural frequencies. Natural frequencies increased with an increase in the rotating speed. Kulkarni and Frederick [54] investigated the Clamped circular cylindrical shell with circumferential central crack using Linear thin shell theory and Kirchhoff-Love's theorem. The delamination region was considered as reduced bending stiffness. No any specific conclusion was provided inspite of the well-written theory.

2.2. Experimental Techniques

Hammami et al [55] conducted experiments to find the linear and nonlinear vibration characteristics of composite structures with delamination. Interlaminated Delaminated Glass fiber reinforced plastic (GFRP) was used. Specimens were developed using hand lay-up method and were analyzed using resonance method. Natural frequencies decreased with delamination lengths. Increase in Non-linearity in composite was observed on delamination length. Linear parameters are not much sensitive to the parameter of delamination than nonlinear parameters.

Jian et al [56] found the effect of delamination. They used circular delamination on thin unidirectional glass-fiber composite plates. They conducted the analysis using finite element code and experimental setup. It was concluded that the mid-plane delamination having 0.34% of the total plate area significantly affected the first seven frequencies. Fundamental frequencies decreases as the delamination diameter tends to increase. This behavior was also observed by [45, 51, 57-59].

However, Penn et al [60] investigated through experiments that if the area of delamination is less than 13% of the plate area then first six natural frequencies have very small effect of delamination presence. On the other hand, investigations done by Hou et al [61] on circular composite plates concluded that significant increase in natural frequencies observed with an impact induced delamination however experiments conducted by Hou et al [62] showed that increase in the bending stiffness caused an increase in the frequency.

Babu et al [63] conducted vibration analysis of tapered delaminated composite plate. Classical laminated plate theory has been incorporated to find the governing equations of rotating non-uniform composite plates. Natural frequency of delaminated tapered composite plates decreased with an increase in size of delaminated area.On the other hand, Natural frequency of delaminated tapered composite plates had no influence by the variation in the location of the delamination. Furthermore, natural frequencies showed increasing trend with increased in the case of TM 1, TM 2, TM 3 and uniform composite plate.

Hirwani et al [64] conducted experiments on woven glass epoxy and found the delamination effect on the vibration behavior of woven glass/epoxy composite plate. Numerical results were compared with ANSYS results along with experimental results. The governing equation was derived using Hamilton's principle. Model was developed by using Teflon of 6.25% as delamination of total laminate area. It was concluded that natural frequency decreased upon an increase in the thickness ratio and natural frequencies increased with an increase in constrained modes as shown in Figure 2.

Mohanty et al [65] investigated free vibrations of woven fiber glass/epoxy composite plate with delamination. They used first order shear deformation theory as governing equation to develop an eight-noded two-dimensional quadratic iso-parametric element.

Mid plane square sized delamination was incorporated at 6.25%, 25% and 56.25% of the composite plate area and was concluded that presence of delamination reduced the natural frequencies by 10%, 14% and 22% as compared with the natural frequencies without delamination.

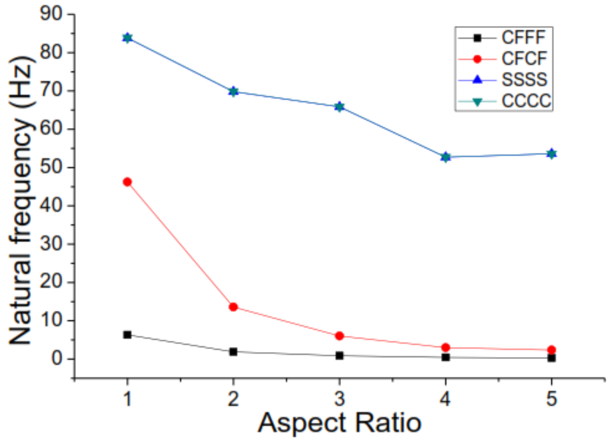

Figure 2. Natural frequency with central delamination for varying support conditions [64]

For large delamination area of 56.25%, natural frequency was less impacted subjected to cantilever boundary conditions. It was concluded that increasing the aspect ratio by 1.0 also increases the natural frequency. But the fundamental natural frequencies increased two times and four times with aspect ratio of 1.5 and 2.0 respectively. These results were compared with analytical solution and found good agreement.

Luo et al [66] did an analytical and experimental investigation to find the dynamic behavior of delaminated composite beam. Piecewise linear model incorporated to find the analytical results for delamination length of 3cm, 10cm and 18cm. For small delamination length, natural frequencies are less effected. This behavior was also concluded by [46, 67]

Lee et al [68] conducted vibration analysis and investigated the effect of delamination length on Multi-delaminated composite beam Figure 6. Experimental work was performed by semi-autoclave and analytical results were generated using classical laminated beam theory. On the increase of Delamination length, natural frequencies proportionally decreased. Minimum value of natural frequency was observed as the delamination level reaches to 0.5 subjected to all cross-ply and angle-ply laminations. The value of natural frequency decreased with an increase in the number of delamination. This behavior was also reported by Zhu and Ju [69-70] analytically.

Luo et al [71] used Through-width delamination in composite beam. Experimental tests were conducted to find the effect of delamination length and location. Results were compared with Shen [23]. Predicted frequencies by experimental method showed great agreement to numerical results. When the delamination is close to the mid plane and its length is small then both free and constrained modes show similar frequencies.

Hammai et al [72] found the relation of nonlinearity with delamination. Delaminated glass fiber reinforced composite was used. Handy layup method was used for laminates and central delamination was intruded for experimental setup. It was concluded that Nonlinearity of composite structure increases as the delamination increases.

Kumar et al [73] used Thick square composite plate with rectangular cutout. Finite element governing equations were obtained from first order shear deformation theory and higher order shear deformation theory using Hamilton's principle and the values of natural frequencies obtained from Higher order shear deformation (HSDT) are higher than those obtained from first order shear deformation theory. Similar behavior was reported by Reddy et al [74]. Also deviation between two results increased on an increase in the cutout size. It was concluded that the natural frequencies of the plate were largely affected by large and medium sized delamination. Large cutouts had not significant impact on delamination size although thickness wise location of the delamination had significant impact on results.

2.3. Finite Element Method

Shu et al [75] conducted vibration analysis of composite beams. Structure was incorporated with two delamination (non-overlapping). The structure is composed of seven interconnected Euler–Bernoulli beams with delamination.

It was observed that the primary frequency values and the corresponding mode shapes were greatly influenced by the size and location of delamination.

In this case of two non-equal lengths delamination, the shorter delamination has little impact than the larger delamination however for mid-plane delamination, there was no significant impact. Delamination opening is more noticeable at the mid-plane or nearer to the free-end of the composite laminated beam.

Rout et al [76] conducted finite element analysis to find the impact of delamination, fiber orientation and twist angle on the vibration characteristics of pre-twisted laminated cylindrical shells. They used Lagrange's equation of motion. It was concluded that fundamental frequencies increased significantly by addition of stiffeners. NDFF significantly increased from 0 to 90 degree but rapidly decreased between 30 to 60 degrees irrespective of the delamination shown in Figure 3.

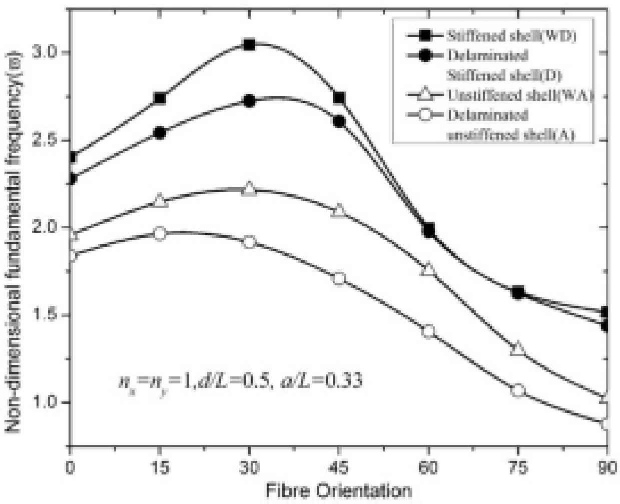

Figure 3. NDFF for Delaminated stiffened and unstiffened shells [76]

Thornburgh et al [77-78] analyzed vibration characteristics of delaminated composite laminates using finite elements. They used third order shear deformation theory. Ply thickness was reduced while incorporating matrix cracking.

It was concluded that fundamental frequency further decreased in the presence of matrix. However, this decrease in fundamental frequency was not significant for small delamination.

Sahoo et al [79] conducted finite element method analysis using MATLAB code to find the delamination influence on the non-linear characteristics of composite laminated plate. They used higher order shear deformation theory as governing equations. It was concluded that structural stiffness decreases with an increase in the size of delamination.

Ramazan et al [80] did an investigation to find the effect of delamination size and location on the free vibration characteristics of delaminated curved beams. The governing equations were produced using Hamilton's principle. Three interfaces were developed to consider corresponding effects. It was concluded that delamination reduced the natural frequencies as already investigated by Ahmed [81]. Also straight beams are more sensitive to delamination as compared to curved beams. Natural frequency has a reverse influence on the delamination arc length.

Ganesh et al [82] conducted vibration analysis using first order shear deformation theory and computational methods to analyze vibration characteristics of delaminated composite plate. The delamination location is shown in Figure 4.

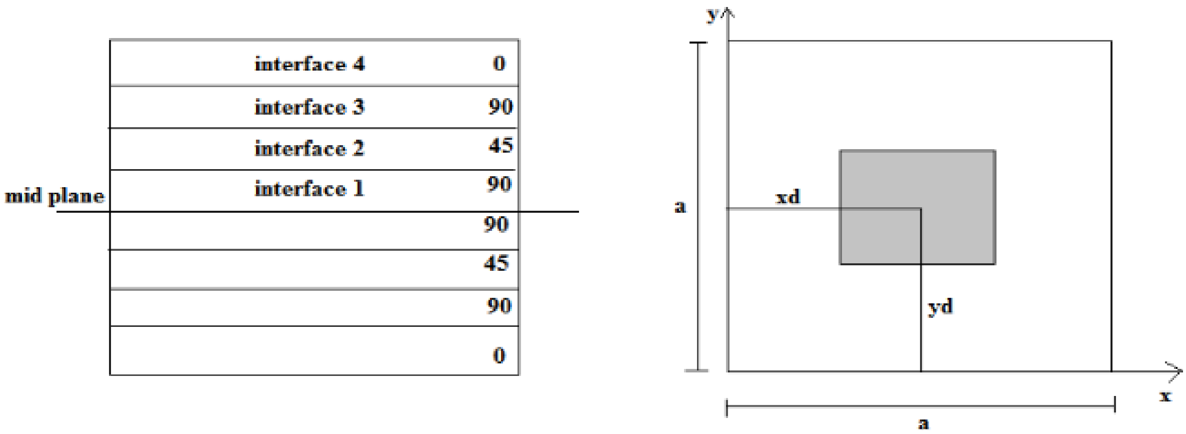

Figure 4. Delamination location and ply configuration [82]

It was concluded that simple supported constrained mode (S-S-S-S) showed greater natural frequencies than cantilever-free boundary conditions (C-F-F-F). Also natural frequency with delamination at mid-plane is higher than the natural frequency values obtained at other interfaces.

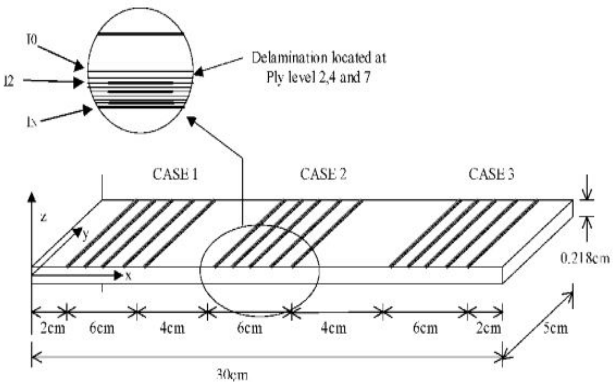

Figure 5. Delamination Location [45]

Nagesh et al [83] did finite element analysis to find the effect of delamination on the natural frequencies. Shankar et al [84] developed MATLAB code to find the vibration properties of delaminated composite plate. First order shear deformation theory was used for analytical results. 6.25%, 25% and 56.25% of the total plate area was considered as delamination area. The results were compared with [85] that were in great agreement for the S-S-S-S boundary condition , C-F-F-F boundary condition and C-C-C-C boundary condition. It was concluded that the value of natural frequency decreased with an increase in delamination size.

Della et al [86] concluded that If the slenderness ratio is increased, the frequency decreased using Finite element method on Delaminated multilayered beam.

Amit et al [87] conducted vibration analysis to find the effect of crack length on natural frequencies of Graphite Epoxy Composite pre twisted shells using Finite element method. For Crack length 0.5, Long Cylindrical shells provide higher frequencies than short cantilever shells. For Crack length 0.25, Symmetric (0/90/0) composite shells provide higher values of frequency than unsymmetric (0/90) composite shells.

Hu et al [88] used Delaminated composite plate to find the effect of delamination using FEM based higher order shear deformation theory. It was concluded that the Natural frequency for clamped square plate subjected to delamination decreased significantly with increase in delamination size. This behavior was also concluded by [89]

Park et al [90] concluded that an increase in size fod delamination caused to decrease the natural frequencies in Mode II-IV. Change in frequency value is small for small cutouts. For delamination size of 0% and 30%, there is slight difference for first mode. They used composite skew plates with delamination by quadrilateral cutouts using Finite Element based higher order shear deformation theory (HSDT) and ABAQUS tool.

Saravanos and Hopkins [91] investigated the delaminated laminates and beams using Generalized laminate theory. Analytical and experimental results show that natural frequencies decrease on an increase in delamination length.

Ju et al [70] did an investigation on the delaminated composite plate using Finite Element method with 8-node, 40 degree of freedom isoparametric plate element and mindlin theory was used for analytical solution. They configure that more the constrained, greater the effect of delamination size observed. Higher mode shapes were badly affected by delamination size. This behavior was also observed by [23, 70, 91-94].

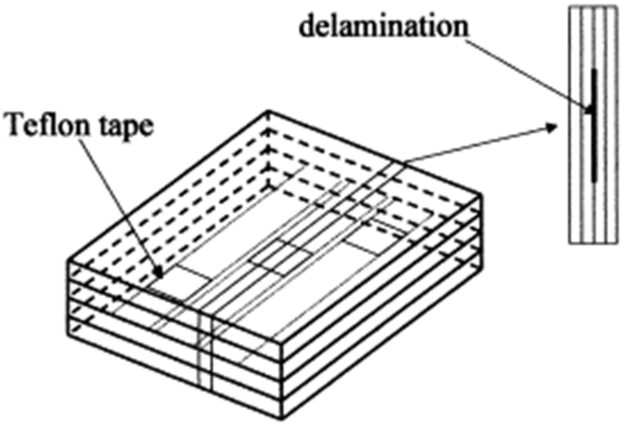

Figure 6. Schematic View of Delamination with Teflon tape [68]

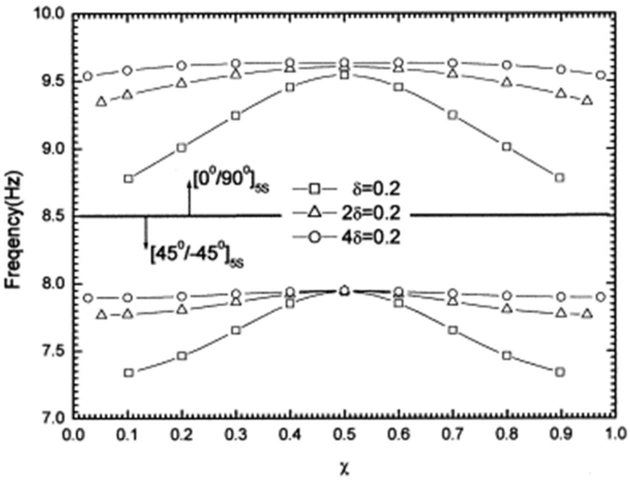

Figure 7. Comparison of Delamination size and fundamental natural frequencies [50]

3. DISCUSSIONS

Fundamental frequency decreases upon increase of depth of crack. Also for a fixed crack depth, the value of fundamental frequency also decreases if the location of the crack gets nearer to the center of the beam. Primary and secondary frequencies decreases as the length of the delamination increased however reduction of primary frequency is not significant. It was also observed that natural frequency and mode shapes are largely dependent of the assumed constraints. It was concluded that double delamination further reduced the value of natural frequency and mode shape of the beam. When the delamination size is small, insignificant changes in natural frequency are observed. It was shown that effect of multi delamination are more significant than those for single delamination.

Declining frequency trend was observed for constrained mode shape model. When a delamination is incorporated at the mid plane, minimum value of non-dimensional fundamental frequencies are obtained. For small amplitude, larger value of frequency would be observed with greater length of delamination. The natural frequency of laminated circular plate decreased with decrease in the delamination depth. For plates without delamination, natural frequency increases with increase in mode number.

Delamination with shorter length with 0.25 times of the total length of structures, had insignificant impact on the fundamental and higher frequency modes subjected to all boundary conditions.

Increase in Non-linearity in composite was observed on delamination length. Fundamental frequencies decreases as the delamination diameter tends to increase. Also increase in the bending stiffness caused an increase in the frequency. Natural frequency decreased as the thickness ratio increased and natural frequencies increased with an increase in constrained modes.

It was shown that the fundamental frequencies and mode shapes are greatly impacted by the sizes and locations of the delamination.

4. CONCLUDING REMARKS

Vibration behavior in composite plate structures are of utmost interest to the scientific and engineering societies for many years. Composite plate structures are widely being used in almost every industrial application from simple mechanisms to broad range of aviation and energy products. Delamination presence in the composite structure reduces the properties like stiffness and strength of the composite material and consequently reduces the life of the structure. While reviewing the literature, it is evident that delamination reduces the frequencies of the structures. The current research work is to review the vibration properties of composite structures with delamination as delamination is present in every component. The present research focuses the work already done in the field of vibration of composite structures with delamination.

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