Free Vibration Analysis of Sandwich plate using Finite Element Method

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Abstract — The purpose of this paper is to develop a five-layer sandwich plate and calculate the frequency of free vibration using ANSYS 18.0 software. The method which is used for mathematical formulation is the First order shear deformation theory. The sandwich structure is frequently use in daily life because there much advantages. In this paper find out the frequency of plate with change the aspect ratio (a/b) and also change the thickness ratio (a/h) continuously. And also finding the frequency with change the boundary condition such as CFFF, CFCF, CCCC. Find out these all results and plot various graphs in between frequency and modes. All our study and graph we conclude the results in which condition is safe for design.

Nomenclature:

x,y,z = Axis of Cartesian co-ordinate.
Φx, Φy = Rotational normal component.
ZZT = Zigzag theory.
CPT = Classical plate theory.
LWT = Layer wise theory.
CUF = Carrea's unified formulation.
ESLT = Equivalent single layer theory.
HSDT = Higher order shear deformation theory.
FSDT = First order shear deformation theory.
CFFF = One side clamped and three side free.
CFCF = Two side clamped and two side free.
CCCC = All side clamped.
a and b = Length and breadth of sandwich plate.
h = Total thickness of the plate.

Keywords: Vibration Analysis, Sandwich Plate, First Order Shear Deformation, Plate

I. Introduction

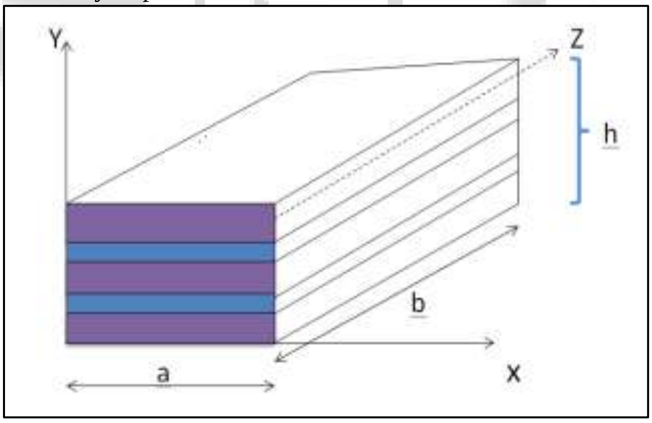
The sandwich plate structure has been studied and used for centuries and it plays a vital role in engineering applications i.e automobiles structures, aircraft, mechanical structures and other manufacturing industries. Sandwich structures are broadly used because of their higher specific modulus and higher specific strength. A sandwich structure is formed by high strength material on faces and low density material in care. In shear deformation the low density material or softer care is deformed fixedly.

Because of its future applications, various researches have been conducted there works with various methods such as Zigzag theory (ZZT), Classical plate theory (CPT), Layer wise theory (LWT), Carrea's unified formulation (CUF) and Equivalent single layer theory (ESLT), Higher order shear deformation theory (HSDT), First order shear deformation theory (FSDT). Sandwich structures have been applied in different sectors for example, A heat-insulating core is used in rocket or missiles or is used in the walls of buildings to maintain the temperature of the body and A sandwich panel with honeycomb core is obtain a high stiffness to mass ratio which is very important in airplanes, also sandwich plates used to isolate sound. In these applications many of the material base/core lies in industries.

On the basis of theories a large number of researcher's work on the different types of plates such as composite sandwich plate, laminated plates, sandwich plate with honeycomb structure etc. Tongan wang and Vladimir sokolinsky work on higher order free vibration of composition sandwich plates. In this work studies both the structure first sandwich plate with composite fore sheets and a soft core and another is symmetric sandwich plate with isotropic face sheets and a honeycomb core. Meiping sheng and Zhiwei Guo studies vibration characteristics of infinite sandwich plate with viscoelastic cores.Thai and kin represents the free vibration on the laminated composite plates. Also, Thai and choi presented first order shear deformation theory on the laminated composite plates, and Wu and Chen analysis of on bending and transverse shear on the laminated sandwich plates and calculate frequencies and study the free vibration.

Based on this available knowledge of the review papers, present the work. This work is based on free vibration analysis of sandwich plate with two-layer ceramics materials. The methodology used is first order shear deformation and calculating frequencies with the use of ANSYS software.

Geometry of plate:



II. Methodology-

The whole study is based in First order shear deformation theory also called the Mindlin-Reissner theory, is the basis theory to take into account. In this theory Kirchhoff hypothesis, third part is neglected. The theory is based on following displacement field:

$$a(x,y,z) = m\varphi x\ (x,y)$$
$$b(x,y,z) = m\varphi y\ (x,y)$$

Model analysis of sandwich plate-

The sandwich plate is made on ANSYS software. The dimension of plate is a = 304 mm and b = 152 mm. The figure 1 represents the structure of the sandwich plate and Figure 2 represents mesh generation on ANSYS software.

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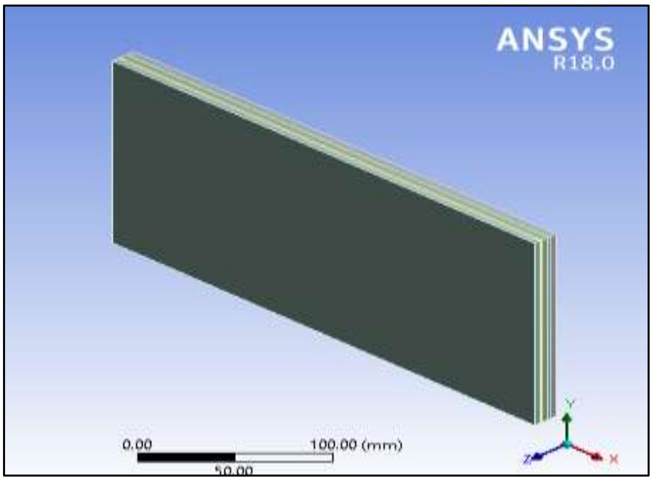

Fig. 1: Geometry of sandwich plate

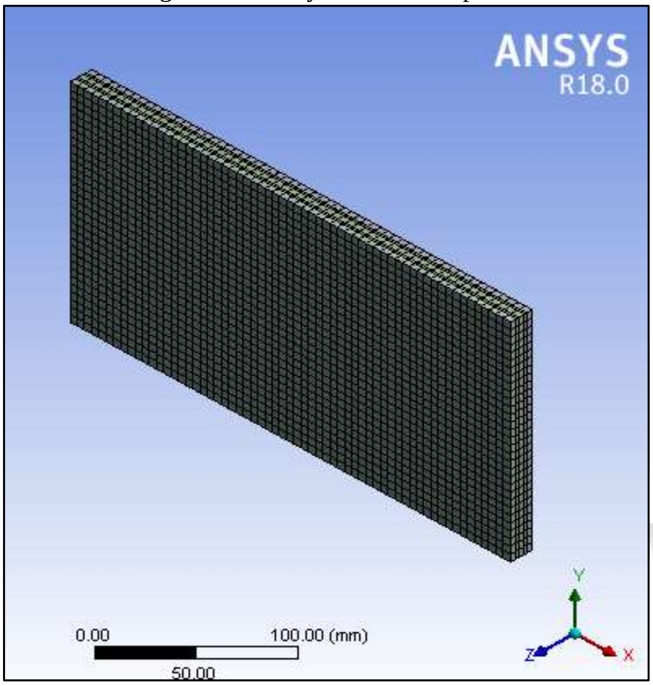

Fig. 2: Mesh generation on sandwich plate

III. Results and Discussion-

In this paper the vibration behavior on viscoelastic sandwich plate is discussed. In this article different frequencies are calculated with change in Aspect ratio (a/b) and also, we change thickness ratio (a/h) with the help of ANSYS 18.0. The material properties of different layer of the sandwich plate is:

	properties	Data
Face layer (1^{st},3^{rd},5^{th})	Young's modulus Poisson's ratio Density	71 Gpa 0.33 2770 kg/m3
Core layer (2^{nd},3^{rd})	Shear modulus Poisson's ratio Density	0.869 Mpa 0.49 999 kg/m3

Table 1: Mechanical properties of plate material.

According to material properties first calculate the frequency with different aspect ratios with CFFF boundary condition.

Aspect ratio	FREQUENCIES (Hz)			
	a/h = 20	a/h =40	a/h = 60	a/h = 80
0.5	64.578	87.026	58.25	43.955
	324.18	467.93	312.63	235.07
	451.58	658.03	439.7	330.59
	697.13	1022.2	683.64	513.97
	785.72	1150.6	769.81	578.75
1.0	64.428	87.039	58.25	49.951
	152.19	212.34	141.99	117.45
	323.55	468.02	312.68	244.6
	411.31	598.37	399.87	310.99
	450.04	658.04	439.69	342.12
1.5	31.651	38.854	30.664	24.115
	128.6	176.31	126.6	97.257
	149.33	208.54	146.69	112.02
	241.17	343.94	238.2	181.04
	355.61	513.51	351.09	265.75
2.0	43.513	21.981	18.189	19.644
	233.96	117.56	84.167	75.273
	329.02	165.31	117.29	103.07
	511.12	257.02	178.31	149.11
	575.3	289.42	199.41	164

Table 2: Frequencies of free vibration analysis with aspect ratio (a/h) is 20 and change in thickness ratio (a/h).

Corresponding graph of the table:

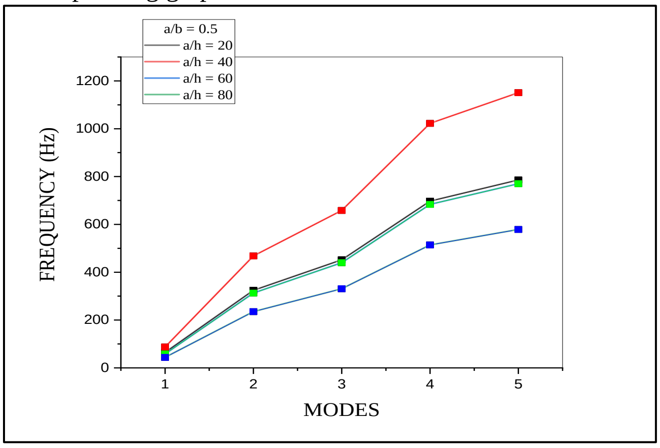

Fig. 3: Variation of frequency w.r.t. change in thickness ratio with CFFF boundary condition and the aspect ratio is 0.5.

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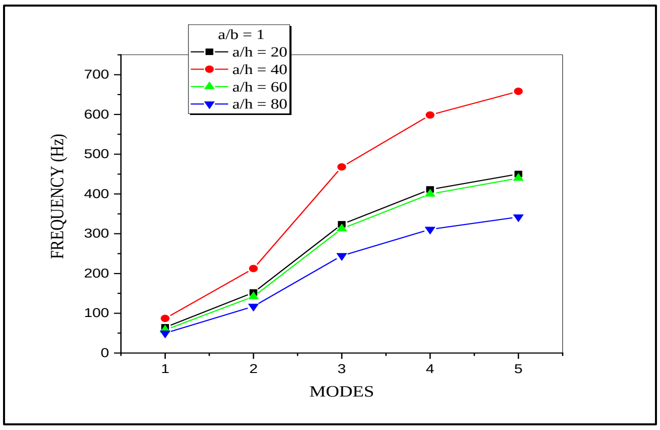

Fig. 4: Variation of frequency w.r.t. change in thickness ratio with CFFF boundary condition and the aspect ratio is 1.

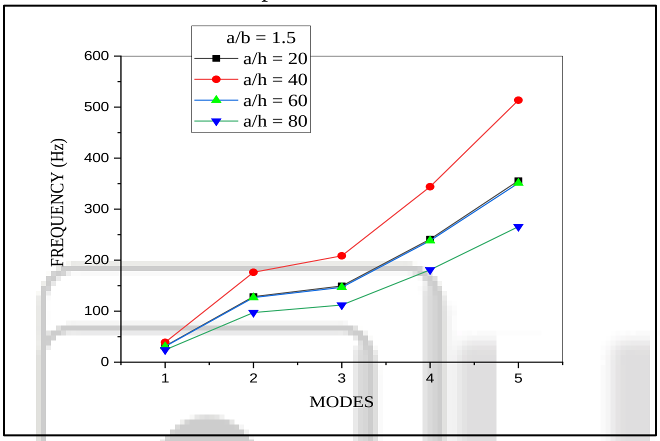

Fig. 5: Variation of frequency w.r.t. change in thickness ratio with CFFF boundary condition and the aspect ratio is 1.5.

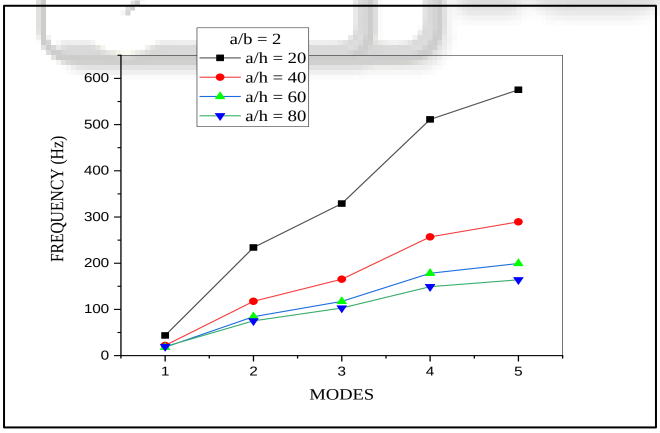

Fig. 6: Variation of frequency w.r.t. change in thickness ratio with CFFF boundary condition and the aspect ratio is 2.

Thickness Ratio	Frequency (Hz)		
	CFFF	CFCF	CCCC
20	43.513	170	756.23
	233.96	271.92	975.67
	329.02	466.86	1366
	511.12	623.06	1921.3
	575.3	833.58	1941.9
40	21.981	85.442	381.61
	117.56	137.72	493.59
	165.31	235.03	693.46
	257.02	315.09	979.87
	289.42	421.28	991.3
60	18.189	61	164.76
	84.167	103.55	212.27
	117.29	162.39	295.34
	178.31	218.69	413.69
	199.41	294.99	417.02
80	19.644	54.153	204.84
	75.273	100.05	263.82
	103.07	134.29	366.48
	149.11	182.29	512.4
	164	249.67	515.58

Table 3: Calculating the frequency with different boundary condition with thickness ratio is 20, 40, 60, 80.

The graph of the table given below:

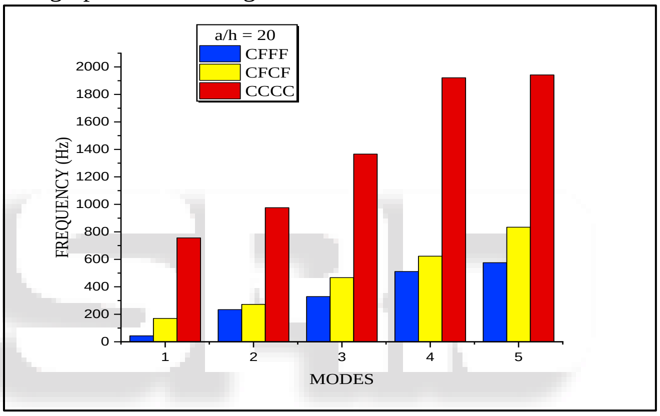

Fig. 7: Variation of frequency w.r.t. change in boundary condition and the thickness ratio is 20.

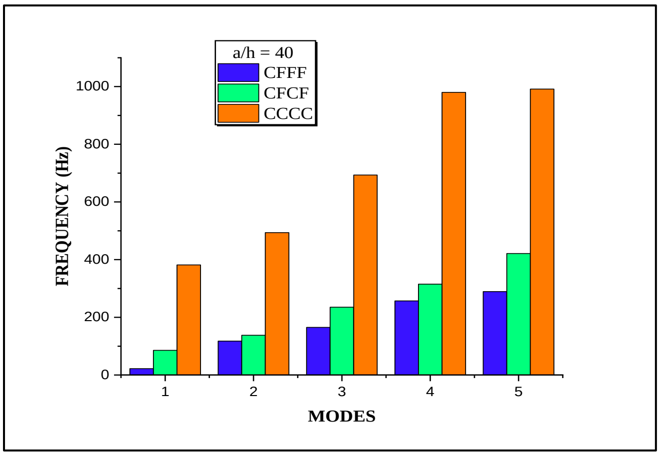

Fig. 8: Variation of frequency w.r.t. change in boundary condition and the thickness ratio is 40.

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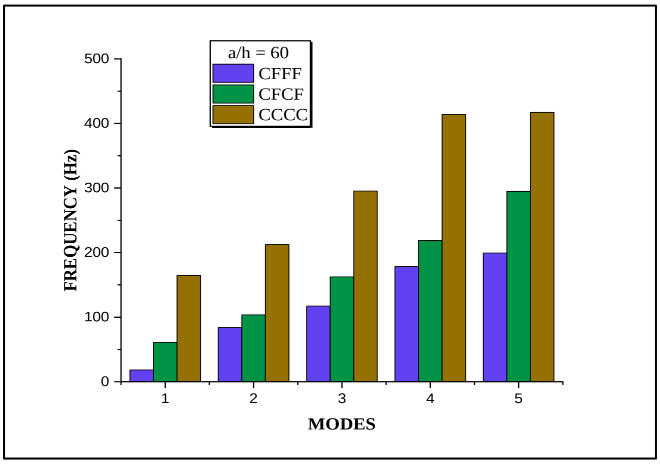

Fig. 9: Variation of frequency w.r.t. change in boundary condition and the thickness ratio is 60.

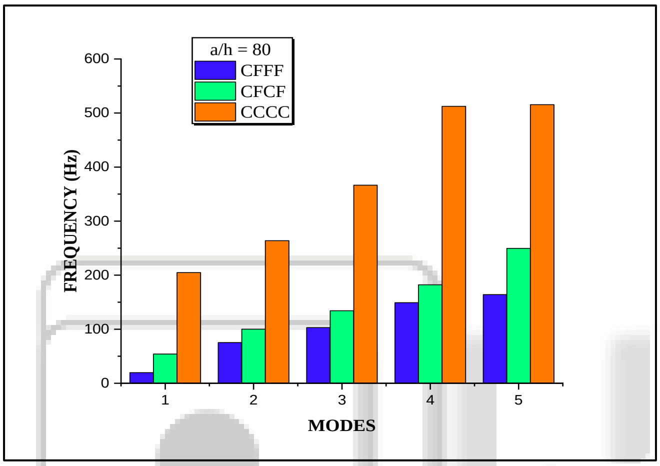

Fig. 10: Variation of frequency w.r.t. change in boundary condition and the thickness ratio is 80.

IV. Conclusion

For sandwich plate free vibration properties were analyzed using first order shear deformation theory and finite element method using ANSYS software. Vibration characteristics such as frequencies were calculated with different boundary condition and change in aspect ratio and thickness ratio. From previous literature the results is compared and validated for the much accuracy. Natural frequencies for the given aspect ratio (a/b) and change in thickness ratio (a/h) were observe that first aspect ratio increases the frequency of vibration also increases but when thickness ratio is above 40 the frequency is decrease. And one observation is also taken when aspect ratio is 2 or more the frequency is decrease throw out when change in thickness ratio.

And other observation is also taken when change in boundary conditions. The frequencies of the CCCC boundary condition is higher as compare to CFFF and CFCF. For all results higher thickness ratio, the design of sandwich plate is safe.

References

[1] Mantari J.L., Oktem A.S., Soares C.G.: "Generalized layerwise HSDT and finite element formulation for symmetric laminated and sandwich composite plates". Comput Struct. 105, 319-331 (2013).

[2] K. Akoussan, H. Boudaoud, E.M.E. Carrera.: "Vibration modeling of multilayer compos structure with viscoelastic layers". Mech Adv Mater Struc. 22, 136-149 (2015).

[3] S. Kapuria, P.C.Dumir, N.K. Jain.: "Assessment of zigzag theory for static loading, buckling, free and forced response of composite and sandwich beams". Compos Struct. 64, 317-327 (2004).

[4] Fazzolari F. A., Carrera E.: "Free vibration analysis of sandwich plates with anisotropic face sheets in thermal environment by using the hierarchical trigonometric Ritz formulation". Compos Part B-Eng, 50, 67-81(2013).

[5] Fazzolari F.A.: "Natural frequencies and critical temperatures of functionally graded sandwich plates subjected to uniform and non-uniform temperature distributions". Compos Struct, 121, 197-210 (2015).

[6] Ferreira A.J.M., Araújo A.L., Neves A.M.A., et al.: "A finite element model using a unified formulation for the analysis of viscoelastic sandwich laminates". Compos Part B-Eng, 45, 1258-1264 (2013).

[7] R.K. Kapania, S. Raciti.: "Recent advances in analysis of laminated beams and plates". Part I. Shear effects and buckling, AIAA J. 27, 923–34 (1989).

[8] Whitney J.M.: "The effect of transverse shear deformation on the bending of laminated plates". J Compos Mater. 3, 534-47 (1969).

[9] H. Matsunaga.: "Vibration and buckling of multilayered composite beams according to higher order deformation theories". J Sound Vib. 246, 47–62 (2001).

[10] Hu H, Belouettar S, Potier-Ferry M, et al.: "Review and assessment of various theories for modeling sandwich composites". Compos Struct. 84, 282-292 (2008).

[11] A. S. Sayyad, Y. M. Ghugal.: "Bending, buckling and free vibration of laminated composite and sandwich beams": A critical review of literature. Compos Struct. 171, 486-504 (2017).

[12] Thai H.T., Choi D.H.: "A simple first-order shear deformation theory for laminated composite plates". Compos Struct. 106, 754–63 (2013).

[13] Sheng, M., Guo, Z., Qin, Q., He, Y.:"Vibration characteristics of a sandwich plate with viscoelastic periodic cores", compstruct.2018.07.110.

[14] A.S. Herrmann, P.C. Zahlen, I. Zuardy: "Sandwich structures technology in commercial aviation, in: Proceedings of the 7th International Conference on Sandwich Structures", Aalborg, Denmark, August 2005, pp.13–26.

[15] H. Ning, G.M. Janowski, U.K. Vaidya, G. Husman: "Thermoplastic sandwich structure design and manufacturing for the body panel of mass transit vehicle", Compos. Struct. 80 (2007) 82–91.

[16] A. Mouritz, E. Gellert, P. Burchill, K. Challis: "Review of advanced composite structures for naval ships and submarines", Compos. Struct. 53 (2001) 21–42.

[17] J. Hegger, M. Horstmann: "Light-weight TRC sandwich building envelopes, in: Proceedings of the Excellence in Concrete Construction through Innovation Conference", London, September 2008, pp.187–194.

[18] Pankaj V. Katariya, Subrata Kumar Panda, Trupti Ranjan Mahapatra, (2018): "Bending and vibration analysis of skew sandwich plate", Aircraft Engineering and

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Aerospace Technology, https://doi.org/10.1108/AEAT-05-2016-0087.
[19] Ashour, A.S. (2009): "The free vibration of symmetrically angle-ply laminated fully clamped skew plates", Journal of Sound and Vibration, Vol. 323 Nos 1/2, pp. 444-450.
[20] Chakrabarti, A. and Bera, R.K. (2006):"Large amplitude vibration of orthotropic sandwich elliptic plates", Mathematical and Computer Modelling, Vol. 44 Nos 1/2, pp. 151-162.

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