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Fundamental natural frequency and flexural rigidity analysis of isotropic plate with analysis of normal stresses with compressive stresses for two stress function approach

Abstract

In present paper the effects of variations of material properties, geometric properties on fundamental natural frequency and flexural rigidity of clamped supported rectangular thin isotropic plate and the analysis of variations of normal stresses and compressive stresses for finding buckling and flexural vibration by varying aspect ratios for two stress function approach using MATLAB codes is investigated. Coefficients of fundamental natural frequency (f), coefficients of fundamental natural frequency (f1), fundamental natural frequency (ω) and flexural rigidity (D) data are generated on varying plate aspect ratio and plate thickness ratio. In the results thus obtained, it is seen that the in-plane solutions are quite similar in terms of x direction normal stresses. The y direction normal stresses show the wide variations among the various methods. It is noticed that fundamental natural frequency and flexural rigidity both decrease on increase of plate thickness ratio whereas fundamental natural frequency decrease for increase of plate aspect ratio and flexural rigidity increase on increase of plate aspect ratio. This investigation gives the parameters to be considered for design of plate for various applications. Scope of this study is in design of such plates applicable for aerospace engineering as well as ground engineering applications.

Keywords: fundamental frequency, aspect ratio, geometric properties, flexural rigidity, normal stress, compressive stress

Volume 10 Issue 1 - 2026

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Received: November 26, 2025 | **Published:** January 05, 2026

Introduction

Some literature is available for the investigation of fundamental natural frequency and flexural rigidity of plate. Sakata et al.,[1] studied natural frequencies of orthotropic rectangular plates obtained by iterative reduction of partial differential equation. Thin plates and shells: theory, analysis and applications studied by Ventsel and Krauthame.[2] Lee.,[3] investigated free vibration analysis of plates by using a four-node finite element formulation with assumed natural transverse shear strain free vibration analysis of rectangular plates using Galerkin's-based infinite element method studied by Werfalli and Karaid.[4] Chakraverty.,[5] studied vibration of plates. Static and dynamic analysis of rectangular isotropic plates using multi quadric radial basis function studied by Misra.,[6] applied numerical methods with matlab for engineers and scientists studied by Chapra.[7] Ibearugbulem et al.,[8] investigated vibration analysis of CSSF and SSFC panel. free vibration analysis of thin rectangular isotropic CCCC plate using Taylor series formulated shape function in Galerkin's method studied by Njoku et al..,[9] Ebirim et al.,[10] investigated free vibration analysis of isotropic rectangular plate with one edge free of support (CSCF and SCFC plate). Vibration analysis of plate with one free edge using energy method (CCCF plate) studied by Ezeh et al.,[11] Ibearugbulem et al.,[12] investigated the energy methods in theory of rectangular plates. Development of computer programs for analysis of single panel and continuous rectangular plates studied by Adah.[13] Limited literature is available on the subject. Based on the mechanics of solids the (FSDT) and (HSDT) subjected to uniform or non-uniform temperature distribution with temperature independent material properties studied.[14–16] However, Chen and Chen,[17] Shen,[18] Srikanth and Kumar,[19] Shariyat,[20] and Pandey et al.[21] investigated the thermo elastic stability analysis of 666 laminated composite plates: an analytical approach. Nonlinear flexural response of laminated composite plate under hygro-thermo-mechanical loading studied by Upadhyay et al.[22] Rajesh et al.[23] Rajesh et al.[24]

Effects of Variations of Material Properties and Geometric Properties on Fundamental Natural Frequency and Flexural Rigidity of Isotropic Plate and analysis of variations of normal stresses and compressive stresses for finding buckling and flexural vibration by varying aspect ratios for two stress function approach using MATLAB simulation is not studied to the best of author's knowledge.

In present study the effects of variations of material properties, geometric properties on fundamental natural frequency and flexural rigidity of clamped supported rectangular thin isotropic plate using Matlab codes is investigated.

Materials and methods

Material properties used for present study

The following material properties are studied in Matlab code for finding coefficients of Natural Frequency (ω) and FlexuralMaterial Properties (Graphite Epoxy)

Young Modulus E = 1.3937e + 11

Poisson Ratio v = 0.3

Plate dimension along x - axis – length - (a) = 0.05 (m)

Plate dimension along y-axis – width - (b) = 0.05 (m)

Plate Thickness Ratio (t = a/h) = (10-100)

Plate Aspect Ratio (a/b) = 1 - 2

Plate Thickness (h) = a/t

Specific Density (p) = 1530

Material Properties (Si_3N_4)

Young Modulus E = 348.43e + 9

Poisson Ratio v = 0.24

Specific Density (p) = 2370

Material Properties (SUS304)

Young Modulus E = 201.04e+9

Poisson Ratio v = 0.3262

Specific Density (p) = 8166

Material Properties (ZrO_2)

Young Modulus E = 244.27e + 9

Poisson Ratio v = 0.24

Specific Density (p) = 2370

Material Properties (Ti - 6Al - 4V)

Young Modulus E = 122.56e + 9

Poisson Ratio v = 0.24

Specific Density (p) = 8166

Method for analysis

The complete procedure for analysis normal stresses and compressive stresses is given in.[22–24] MATLAB program is made to investigate the normal and shear stresses in x, y and xy direction to further investigate the buckling, vibration and flexural analysis.

Results and discussion

The effects of variations of material properties, geometric properties on fundamental natural frequency and flexural rigidity of clamped supported rectangular thin isotropic plate and the analysis of variations of normal stresses and compressive stresses for finding buckling and flexural vibration by varying aspect ratios for two stress function approach using MATLAB codes is investigated. Coefficients of fundamental natural frequency (f), coefficients of fundamental natural frequency (f1), fundamental natural frequency (ω) and flexural rigidity (D) data are generated on varying plate aspect ratio and plate thickness ratio.

Validation study for fundamental natural frequency (ω) response

Table 1 shows the comparative study of coefficients of fundamental natural frequency and fundamental natural frequency (ω) for rectangular plate a = 0.05, b = 0.05, plate thickness ratio a/h =10, plate aspect ratio a/b=1-2.It is noticed that present results are in good agreement with published results of Njoku et al.[9] and Ibearugbulem et al.[10]

Table 1 Comparative study of coefficients of fundamental natural frequency and fundamental natural frequency(ω) for rectangular plate

Aspect ratio (a/b)	(f) [Present result]	(f) Njoku et al.,[9]	Difference %	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^2$ [Present Result]
1	36	35.9709	0.081	1039.75
1.2	30.774	30.7508	0.075	888.823
1.5	27.047	27.0305	0.061	781.18
1.6	26.333	26.3175	0.059	760.537
2	24.648	24.6377	0.041	711.87
%diff.			0.063	
Aspect ratio (a/b)	**f1= (f/π^2) [Present result]**	**f1= (f/π^2) Ibearugbulem et al.,[10]**	**Difference %**	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^2$ **[Present result]**
1	3.648	3.644	0.11	1039.75
1.2	3.118	3.115	0.096	888.823
1.5	2.74	2.738	0.073	781.18
1.6	2.668	2.666	0.075	760.537
2	2.497	2.496	0.04	711.87
Aver. %diff.			0.079	

Parametric study for fundamental natural frequency (ω) and flexural rigidity of plate (D) response

Table 2 shows the effects of variations of plate thickness ratio on the fundamental natural frequency (ω) and flexural rigidity (D). It can be noticed that fundamental natural frequency and flexural rigidity is significantly influenced for thick and thin plate. Fundamental natural frequency decreases from 4159.011 to 10.39753, flexural rigidity decreases from 12763.00 to 1.5954. For thin plate the values drastically decrease i.e. the plate vibrates at lower fundamental frequency.

Table 2 Effects of variations of plate thickness ratio on the fundamental natural frequency (ω) and flexural rigidity (D)

(a/h)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^{2}$	$D=\frac{Eh3}{12(1-v2)}$
5	4159.011	12763
10	1039.753	1595.4
20	259.9382	199.4191
30	115.5281	59.0871
40	64.98455	24.9274
50	41.59011	12.7628
100	10.39753	1.5954

Table 3 shows the variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/h=5-100) for (Si3N4) material properties. It can be noticed that fundamental natural frequency and flexural rigidity is significantly influenced for thick and thin plate. Fundamental natural frequency decreases from 5192.038 to 12.98009, flexural rigidity decreases from 30811.00 to 3. 8513. For thin plate the values drastically decrease i.e. the plate vibrates at lower fundamental frequency.

Table 3 Variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/h=5-100) for (Si3N4) material properties

(a/h)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^{2}$	$D=\frac{Eh3}{12(1-v2)}$
5	5192.038	30811
10	1298.009	3851.3
20	324.5023	481.4144
30	144.2233	142.6413
40	81.12559	60.1768
50	51.92038	30.8105
100	12.98009	3.8513

Table 4 shows the variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/h=5-100) for (SUS304) material properties. It can be noticed that fundamental natural frequency and flexural rigidity is significantly influenced for thick and thin plate. Fundamental natural frequency decreases from 2181.918 to 5.454795, flexural rigidity decreases from 18748.00 to 2. 3435. For thin plate the values drastically decrease i.e. the plate vibrates at lower fundamental frequency.

Table 4 Variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/h=5-100) for (SUS304) material properties

(a/h)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^{2}$	$D=\frac{Eh3}{12(1-v2)}$
5	2181.918	18748
10	545.4795	2343.5
20	136.3699	292.9417
30	60.60883	86.7975
40	34.09247	36.6177
50	21.81918	18.7483
100	5.454795	2.3435

Table 5 shows the variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/h=5-100) for (ZrO2) material properties. Fundamental natural frequency is4347.255 and flexural rigidity is 21600 for thick plate. For thin plate fundamental natural frequency decreases to 10.86814 and flexural rigidity decreases to.2.7000. For thin plate the values drastically decrease i.e. the plate vibrates at lower fundamental frequency.

Table 5 Variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/h=5-100) for (ZrO2) material properties

(a/h)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^{2}$	$D=\frac{Eh3}{12(1-v2)}$
5	4347.255	21600
10	1086.814	2700
20	271.7034	337.4999
30	120.7571	100
40	67.92586	42.1875
50	43.47255	21.6
100	10.86814	2.7

Table 6 shows the variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/ h=5-100) for (Ti-6Al-4V) material properties. Fundamental natural frequency is 1658.914 and flexural rigidity is 10838 for thick plate. For thin plate fundamental natural frequency decreases to 4.147285 and flexural rigidity decreases to 1.3547. For thin plate the values drastically decrease i.e. the plate vibrates at lower fundamental frequency.

Table 6 Variations of fundamental natural frequency (ω) and flexural rigidity of plate (D) on varying plate thickness ratio (a/h=5-100) for (Ti-6Al-4V) material properties

(a/h)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^{2}$	$D=\frac{Eh3}{12(1-v2)}$
5	1658.914	10838
10	414.7285	1354.7
20	103.6821	169.3372
30	46.08095	50.174
40	25.92053	21.1671
50	16.58914	10.8376
100	4.147285	1.3547

Table 7 shows the effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (Graphite Epoxy) on coefficient of fundamental frequency (f) decreasing from 36 to 24.648, coefficient of fundamental frequency f1=(f/pi^2) decreasing from 3.648 to 2.497, fundamental natural frequency(ω) decreasing from 1039.753 to 711.8701 and flexural rigidity increases from 1595.4 to 12763.

Table 8 shows the effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (Si3N4) on coefficient of fundamental frequency (f) decreasing from 36 to 24.648, coefficient of fundamental frequency f1= (f/pi^2) decreasing from3.648 to2.497, fundamental natural frequency (ω) decreasing from 1298.009 to 888.6863 and flexural rigidity increases from 3851.3to 30811.

Table 7 Effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (Graphite Epoxy)

(a/b)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^2$	$D=\frac{Eh3}{12(1-v2)}$
1	1039.753	1595.4
1.2	888.8231	2756.8
1.5	781.1803	5384.3
1.6	760.5379	6534.6
2	711.8701	12763

Table 8 Effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (Si3N4)

(a/b)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^2$	$D=\frac{Eh3}{12(1-v2)}$
1	1298.009	3851.3
1.2	1109.591	6655.1
1.5	975.2119	12998
1.6	949.4424	15775
2	888.6863	30811

Table 9 shows the effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (SUS304) on coefficient of fundamental frequency (f) decreasing from 36 to 24.648, coefficient of fundamental frequency f1= (f/pi^2) decreasing from 3.648 to 2.497, fundamental natural frequency (ω) decreasing from 545.4795 to 373.4643 and flexural rigidity increases from 2343.5 to 18748.

Table 9 Effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (SUS304)

(a/b)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^2$	$D=\frac{Eh3}{12(1-v2)}$
1	545.4795	2343.5
1.2	466.2981	4049.6
1.5	409.8261	7909.4
1.6	398.9966	9599.1
2	373.4643	18748

Table 10 shows the effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (ZrO2) on fundamental natural frequency (ω) decreasing from 1086.814 to 744.0905 and flexural rigidity increases from 2700.3 to 21600.

Table 10 Effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (ZrO2)

(a/b)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^2$	$D=\frac{Eh3}{12(1-v2)}$
1	1086.814	2700
1.2	929.0527	4665.6
1.5	816.5378	9112.5
1.6	794.9611	11059
2	744.0905	21600

Table 11 shows the effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (Ti-6Al-4V) on fundamental natural frequency (ω) decreasing from 414.7285` to 283.9452 and flexural rigidity increases from 1354.7 to 10838.

Table 11 Effects of variations of plate aspect ratio (a/b) varying from1-2 for material properties (Ti-6Al-4V)

(a/b)	$(\omega)=\frac{f}{a2}\left[\frac{D}{ph}\right]^2$	$D=\frac{Eh3}{12(1-v2)}$
1	414.7285`	1354.7
1.2	354.5269	2340.9
1.5	311.5911	4572.1
1.6	303.3575	5548.8
2	283.9452	10838

Geometry of the Isotropic plate is presented in Figure 1.

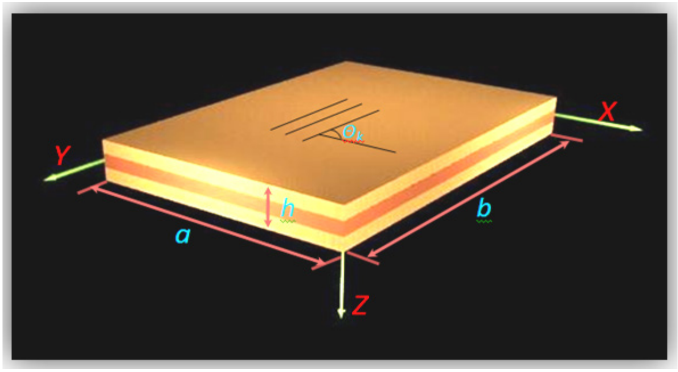

Figure 1 Geometry of the Isotropic plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for Graphite Epoxy Material plate is presented in Figure 2. Fundamental Frequency for (a/h=20) is 259.9382 and for (a/h=100) is 10.39753. Flexural Rigidity (a/h=20) is 199.4191 and for (a/h=100) is 1.5954. It is noticed that for thick plate fundamental frequency and flexural rigidity is higher compared to thin plate.

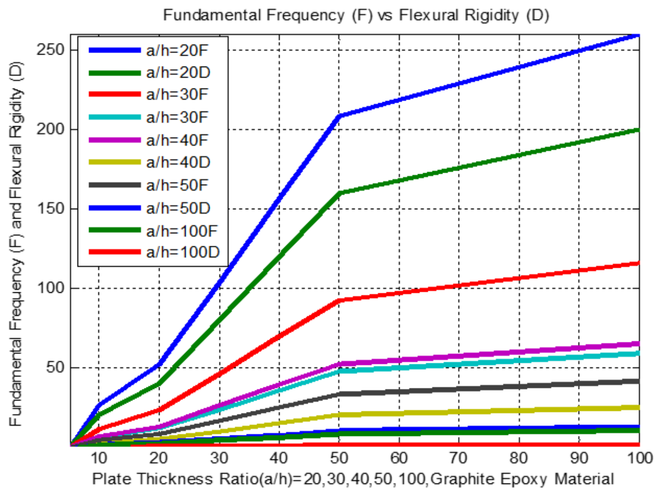

Figure 2 Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for Graphite Epoxy Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for Si3N4 Material plate is presented in Figure 3. Fundamental Frequency for (a/h=20) is 324.5023 and for (a/h=100) is 12.98009. Flexural Rigidity (a/h=20) is 481.4144 and for (a/h=100) is 3.8513. It is noticed that for thick plate fundamental frequency and flexural rigidity is higher compared to thin plate.

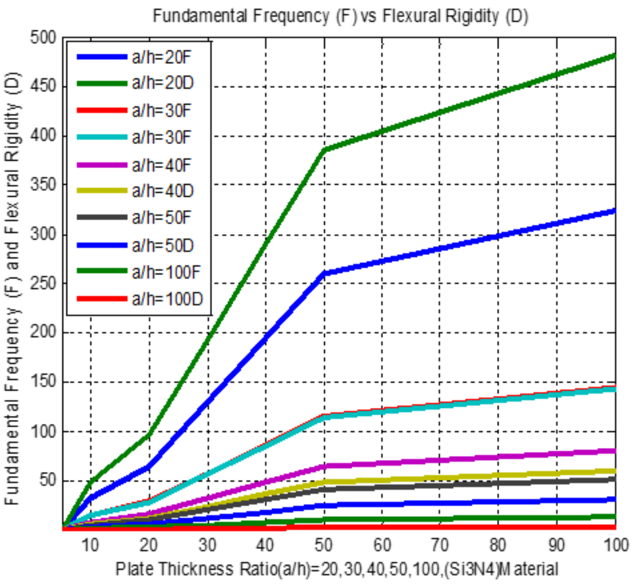

Figure 3 Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for Si3N4 Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for SUS304 Material plate is presented in Figure 4. Fundamental Frequency for (a/h=20) is 136.3699 and for (a/h=100) is 5.454795. Flexural Rigidity (a/h=20) is 292.9417 1and for (a/h=100) is 2.3435. It is noticed that for thick plate fundamental frequency and flexural rigidity is higher compared to thin plate.

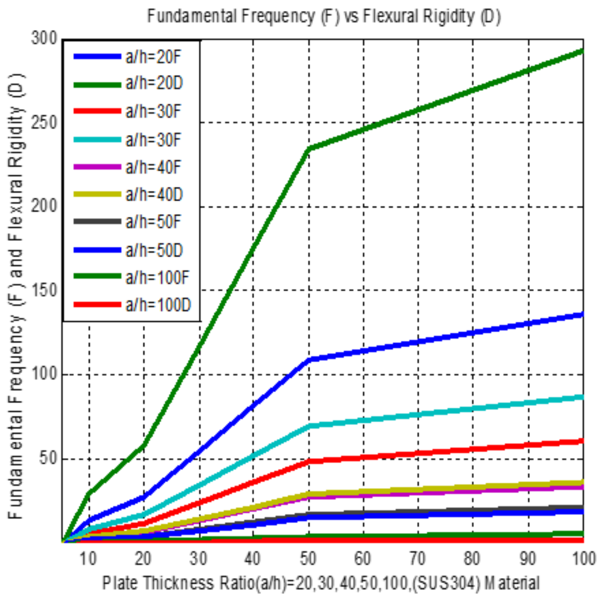

Figure 4 Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for SUS304 Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for ZrO2 Material plate is presented in Figure 5. Fundamental Frequency for (a/h=20) is 271.7034 and for (a/h=100) is 10.86814. Flexural Rigidity (a/h=20) is 337.4999 and for (a/h=100) is 2.7000. It is noticed that for thick plate fundamental frequency and flexural rigidity is higher compared to thin plate.

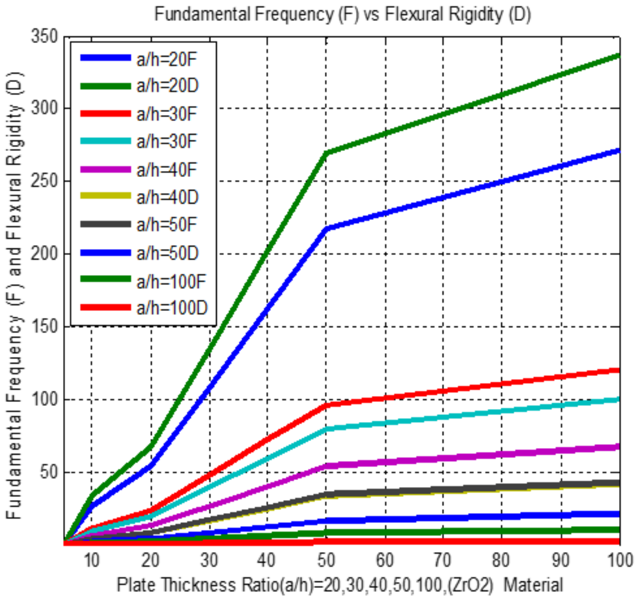

Figure 5 Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for ZrO2 Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h = 20-100) for Ti-6Al-4V Material plate is presented in Figure 6. Fundamental Frequency for (a/h=20) is 103.6821 and for (a/h = 100) is 4.147285. Flexural Rigidity (a/h=20) is 169.3372 and for (a/h=100) is 1.3547. It is noticed that for thick plate fundamental frequency and flexural rigidity is higher compared to thin plate.

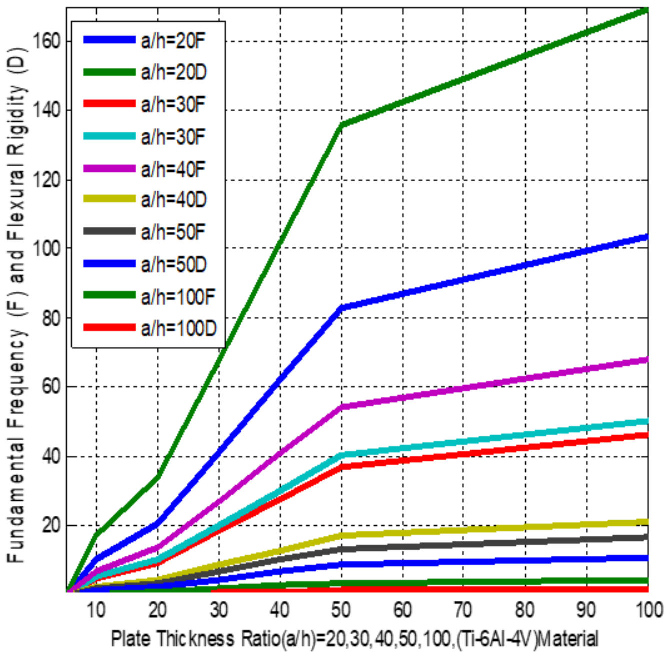

Figure 6 Fundamental Frequency (F) and Flexural Rigidity (D) for plate thickness ratio (a/h= 20-100) for Ti-6Al-4V Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b=1-2) for Graphite Epoxy Material plate is presented in Figure 7. Fundamental Frequency for (a/b=1) is 1039.753 and for (a/b=2) is 711.8701. Flexural Rigidity (a/b=1) is 1595.4 and for (a/b=2) is 12763. It is noticed that for square plate fundamental frequency

Citation: Kumar R. Fundamental natural frequency and flexural rigidity analysis of isotropic plate with analysis of normal stresses with compressive stresses for two stress function approach. *Aeron Aero Open Access J.* 2026;10(1):1‒10. DOI: 10.15406/aaoaj.2026.10.00242

is higher compared to rectangular plate and flexural rigidity is lower compared to rectangular plate.

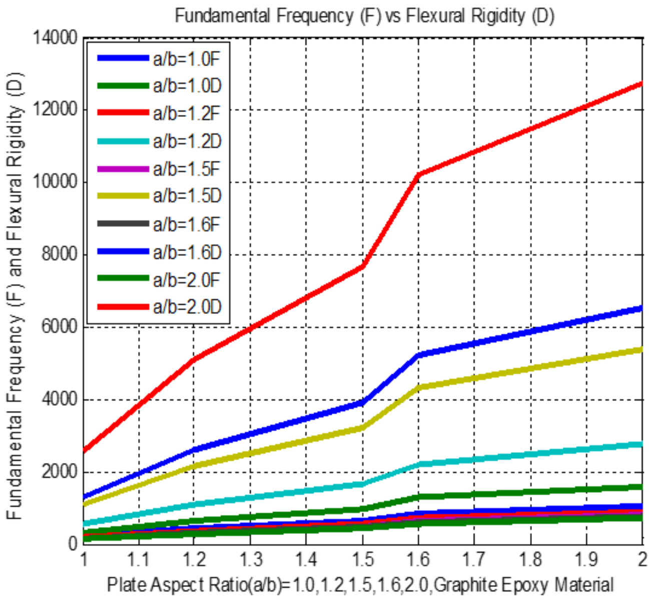

Figure 7 Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b=1-2) for Graphite Epoxy Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b= 1-2) for Si3N4 Material plate is presented in Figure 8. Fundamental Frequency for (a/b=1) is 1298.009 and for (a/b=2) is 888.6863. Flexural Rigidity (a/b=1) is 3851.3 and for (a/b=2) is 30811. It is noticed that for square plate fundamental frequency is higher compared to rectangular plate and flexural rigidity is lower compared to rectangular plate.

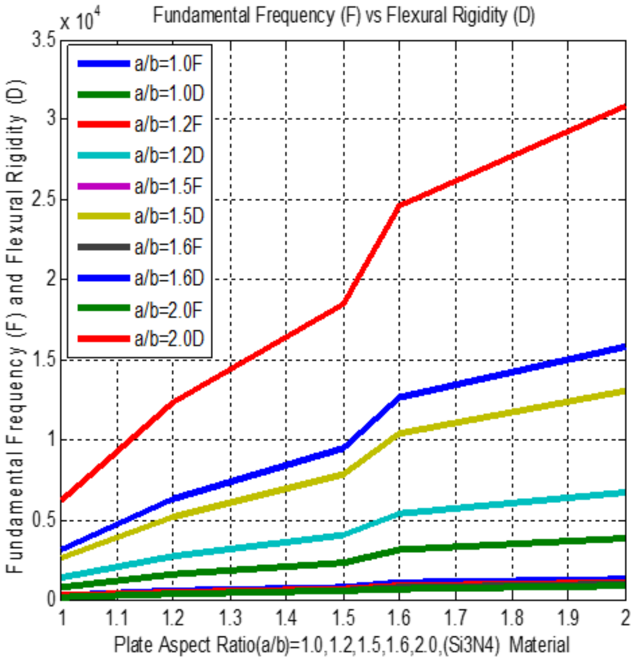

Figure 8 Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b= 1-2) for Si3N4 Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b= 1-2) for SUS304 Material plate is presented in Figure 9. Fundamental Frequency (a/b=1) is 545.4795 and for (a/b=2) is 373.4643. Flexural Rigidity (a/b=1) is 2343.5 and for (a/b=2) is 18748. It is noticed that for square plate fundamental frequency is higher compared to rectangular plate and flexural rigidity is lower compared to rectangular plate.

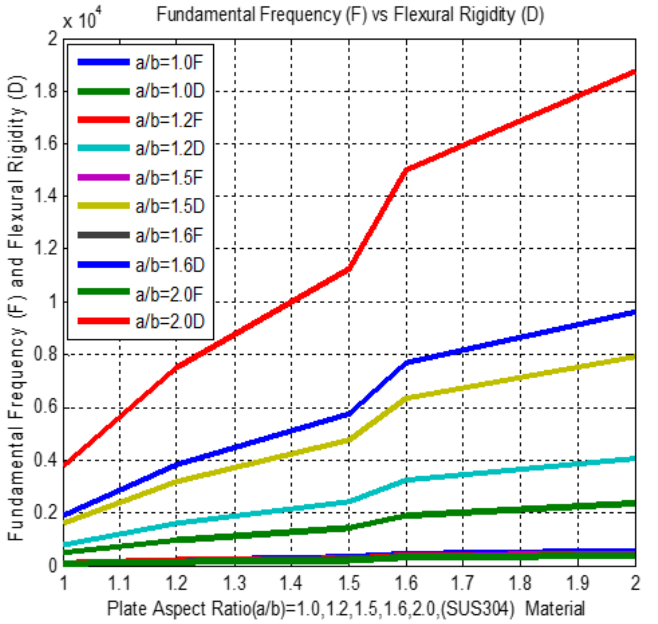

Figure 9 Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b= 1-2) for SUS304 Material plate.

Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b= 1-2) for ZrO2 Material plate is presented in Figure 10. Fundamental Frequency for (a/b=1) is 1086.814 and for (a/b=2) is 744.0905. Flexural Rigidity (a/b=1) is 2700 and for (a/b=2) is 21600. It is noticed that for square plate fundamental frequency is higher compared to rectangular plate and flexural rigidity is lower compared to rectangular plate.

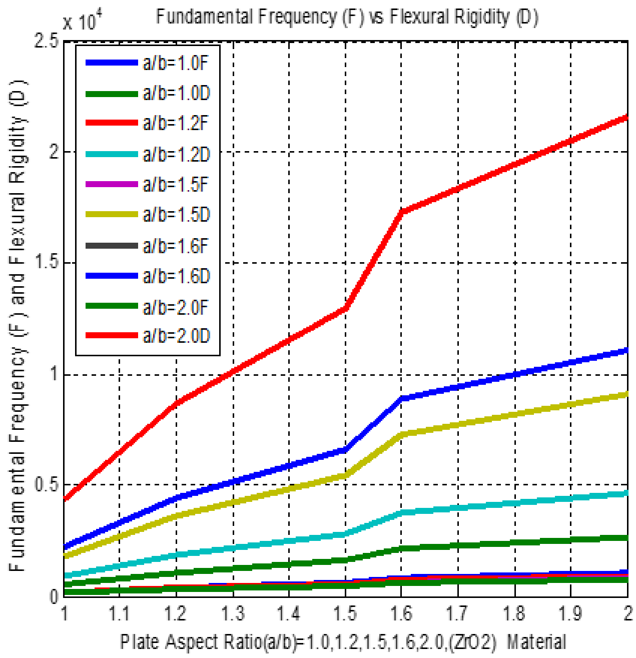

Figure 10 Fundamental Frequency (F) and Flexural Rigidity (D) for plate aspect ratio (a/b= 1-2) for ZrO2 Material plate.

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Fundamental frequency (F) and flexural figidity (D) for plate aspect ratio (a/b=1-2) for Ti-6Al-4V material plate is presented in Figure 11. Fundamental frequency for (a/b=1) is 414.7285`and for (a/b=2) is 283.9452. Flexural Rigidity (a/b=1) is 1354.7 and for (a/b=2) is 10838. It is noticed that fundamental frequency for (a/b=1) is higher and for (a/b=2) is lower for different combinations of aspect ratios. On the other hand flexural rigidity is lower for (a/b=1) and higher for (a/b=2) for same combinations of aspect ratios.

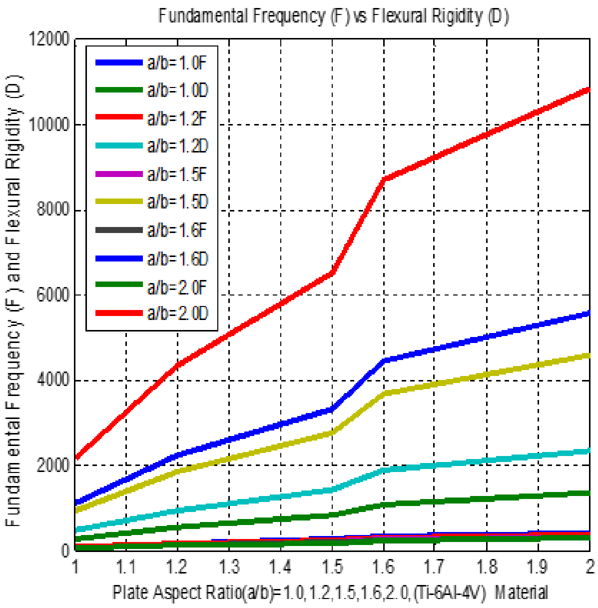

Figure 11 Fundamental frequency (F) and flexural figidity (D) for plate aspect ratio (a/b=1-2) for Ti-6Al-4V material plate.

Figure 12 presents the dimensionless natural frequencies for Graphite Epoxy, Si3N4, SUS304, ZrO2 and Ti-6Al-4V materials plate, (a/h=5-100). It is seen that for same plate thickness ratio the dimensionless natural frequencies of Si3N4 material plate has higher values with thickness ratio (a/h) = 5 is 5192 and for (a/h) =100 is 12.98 and dimensionless natural frequencies of Ti-6Al-4V material plate has lower values with thickness ratio (a/h) = 5 is 1658 and for (a/h) =100 is 4.14.

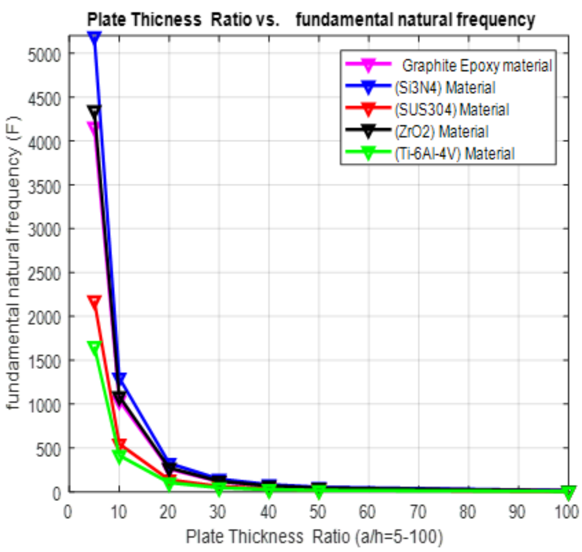

Figure 12 Dimensionless natural frequencies for Graphite Epoxy, Si3N4, SUS304, ZrO2 and Ti-6Al-4V materials plate, (a/h=5-100).

Dimensionless flexural rigidity for Graphite Epoxy, Si3N4, SUS304, ZrO2, Ti-6Al-4V materials plate, (a/h=5-100) is presented in Figure 13. It is seen that for same plate thickness ratio the dimensionless flexural rigidity of Si3N4 material plate has higher values with thickness ratio (a/h=5) is 30811 and for (a/h=100) is 3.85 and dimensionless flexural rigidity of Ti-6Al-4V material plate has lower values with thickness ratio (a/h= 5) is 10838 and for (a/h =100) is 1.35.

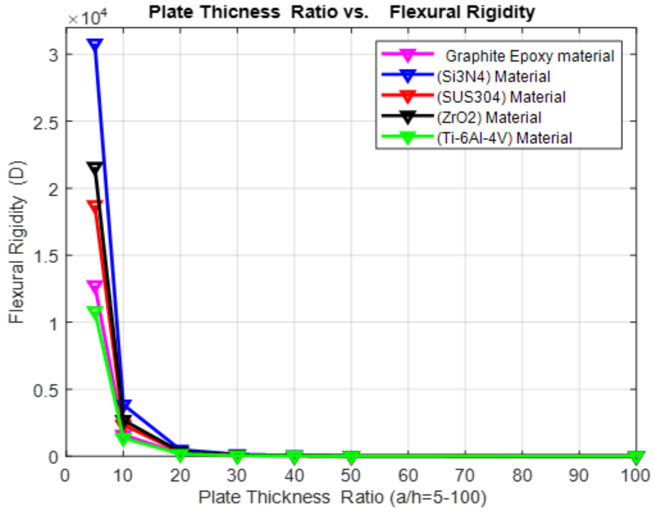

Figure 13 Dimensionless flexural rigidity for Graphite Epoxy, Si3N4, SUS304, ZrO2, Ti-6Al-4V materials plate, (a/h=5-100).

Figure 14 presents the dimensionless natural frequencies for Graphite Epoxy, Si3N4, SUS304, ZrO2, Ti-6Al-4V materials plate, (a/b=1-2). It is seen that for same plate aspect ratio the dimensionless natural frequencies of Si3N4 material plate has higher values with aspect ratio (a/b=1) is 1298 and for (a/b) =2 is 888 and dimensionless natural frequencies of Ti-6Al-4V material plate has lower values with aspect ratio (a/b= 1) is 414 and for (a/b =2) is 283.

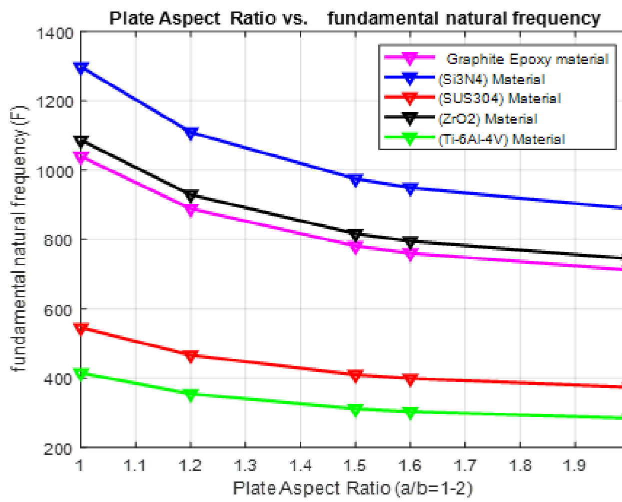

Figure 14 Dimensionless natural frequencies for Graphite Epoxy, Si3N4, SUS304, ZrO2, Ti-6Al-4V materials plate, (a/b=1-2).

Dimensionless flexural rigidity for Graphite Epoxy, Si3N4, SUS304, ZrO2, Ti-6Al-4V materials plate, (a/b=1-2) is presented in Figure 15. It is seen that for same plate aspect ratio the dimensionless flexural rigidity of Si3N4 material plate has higher values with aspect ratio (a/b=1) is 3851 and for (a/b) =2 is 30811 and dimensionless flexural rigidity of Ti-6Al-4V material plate has lower values with aspect ratio (a/b= 1) is 1354 and for (a/b =2) is 10838.

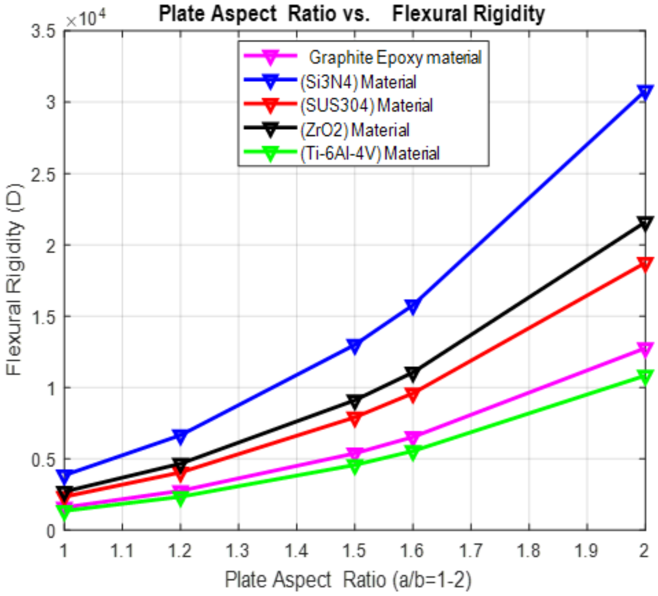

Figure 15 Dimensionless flexural rigidity for Graphite Epoxy, Si3N4, SUS304, ZrO2, Ti-6Al-4V materials plate, (a/b=1-2).

Figure 16A presents the Real part of Frequency Response Function, Figure 16B presents the Imaginary part of FRF, Figure 16C presents the Magnitude of the FRF, Figure 16D presents the Phase of the FRF and Time vs Frequency Response Function is reflected in Figure 16E.

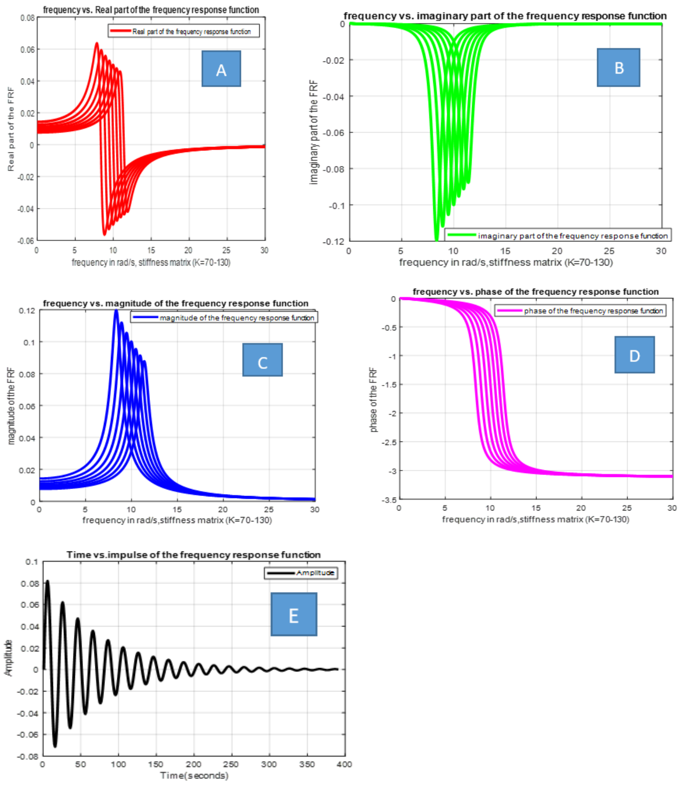

Figure 16 A-E Real part of Frequency Response Function, Imaginary part of FRF, Magnitude of the FRF, Phase of the FRF and Time vs Frequency Response Function is reflected.

Figure 17 shows the Geometry of the plate for normal stresses and compressive stresses for two stress function approach.

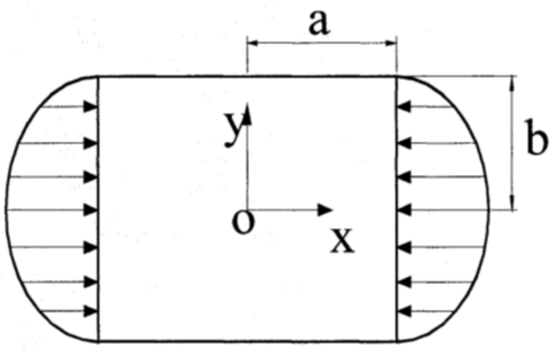

Figure 17 Geometry of the plate for normal stresses and compressive stresses for two stress function approach.

Figure 18 shows the compressive stress sigma x coefficients for aspect ratio=1.2. It is noticed that compressive stress is 0.5 and falls to negative value-0.3 for point 2 and further increases to positive value and further remains constant up to point 8 and finally increases to 0.33.

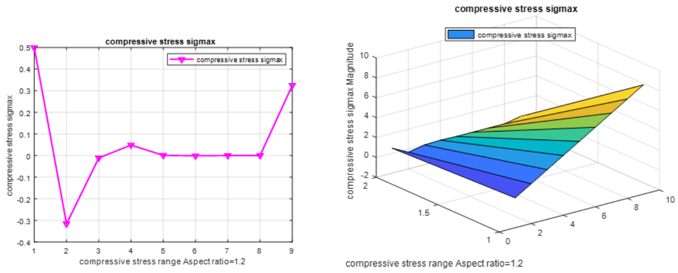

Figure 18 Compressive stress sigma x coefficients for aspect ratio=1.2.

Figure 19 shows the compressive stress sigma y coefficients for aspect ratio=1.2. It is noticed that compressive stress is -0.18initially and increases to positive value 0.33 for point 2 and further decreases to negative value and further remains constant up to point 9 and finally increases to 0.

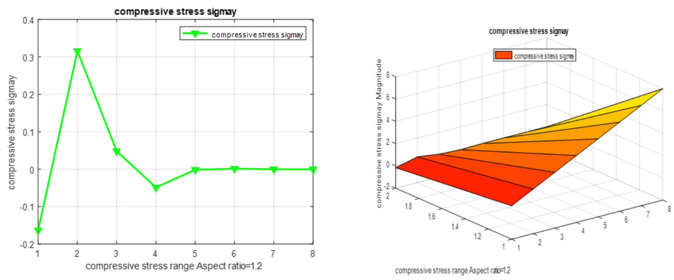

Figure 19 Compressive stress sigma y coefficients for aspect ratio=1.2.

Figure 20 shows the compressive stress sigmaxy coefficients for aspect ratio=1.2. It is noticed that compressive stress is -0.32 initially and increases to positive value 0.33 for point 2 and further decreases to negative value and further remains constant up to point 9 and finally increases to 0.

Figure 21 shows the normal stress resultant in x direction for aspect ratio=1.0 to 3. It is noticed that normal stress resultant in x direction is 0.4 initially and decreases to lower value up to point 1 and further increases to higher value on increasing aspect ratio. It is highest 10.5041 for initial value at aspect ratio=3 and decreases to zero value.

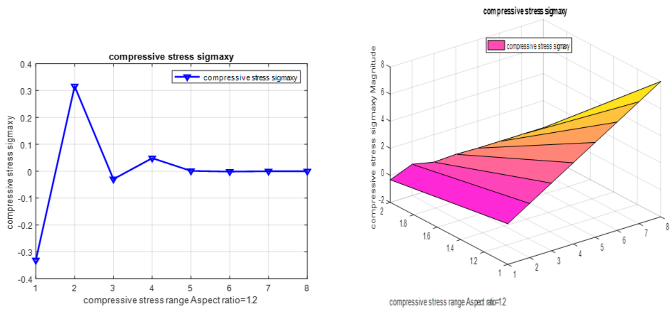

Figure 20 Compressive stress sigmaxy coefficients for aspect ratio=1.2.

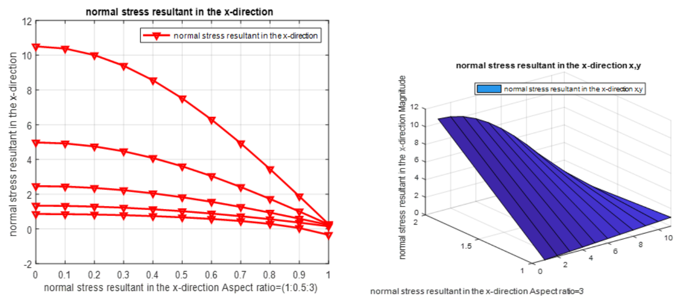

Figure 21 Normal stress resultant in x direction for aspect ratio=1.0 to 3.

Figure 22 shows the normal stress resultant in y direction for aspect ratio=1.0 to 3. It is noticed that normal stress resultant in y direction is 0.1 initially and decreases to lower value up to point 1 and further increases to higher value on increasing aspect ratio. It is highest 8.3 for initial value at aspect ratio=3 and decreases to zero value.

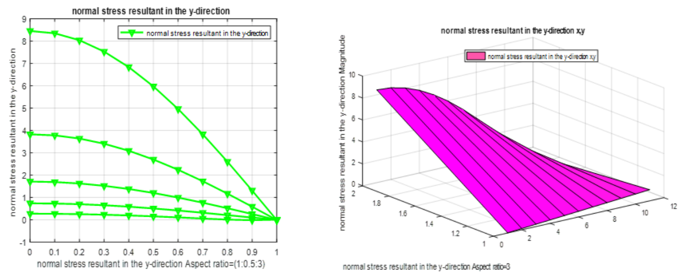

Figure 22 Normal stress resultant in y direction for aspect ratio=1.0 to 3.

Figure 23 shows the Compressive stress x1 and y1, Aspect ratio=1-2. It is noticed that Compressive stress x1 and y1 increases on increasing aspect ratio 1-2. However, the increment is noticed higher on higher aspect ratios.

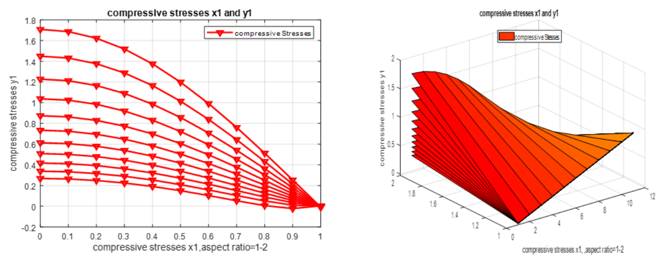

Figure 23 Compressive stress x1 and y1, Aspect ratio=1-2.

Figure 24 shows the Compressive stress x2 and y2, Aspect ratio=1-2. It is noticed that compressive stresses do not vary uniformly on increasing aspect ratios. It is negative in starting and becomes positive finally as presented in graphs.

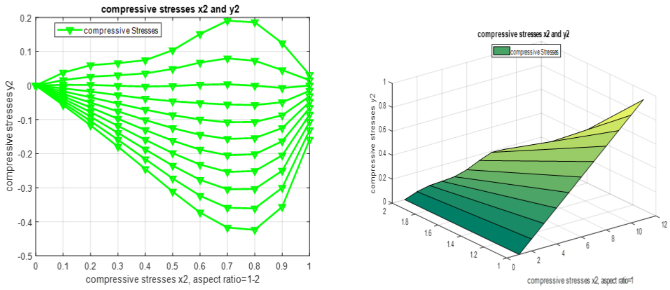

Figure 24 Compressive stress x2 and y2, Aspect ratio=1-2.

Figure 25 shows the Shear stress resultant, Aspect ratio= (1:.5:3). It is noticed that shear stress resultant is 0 initially and decreases to lower value up to point -1.7 and further increases to higher value. On increasing aspect ratio, it increases as shown in figure.

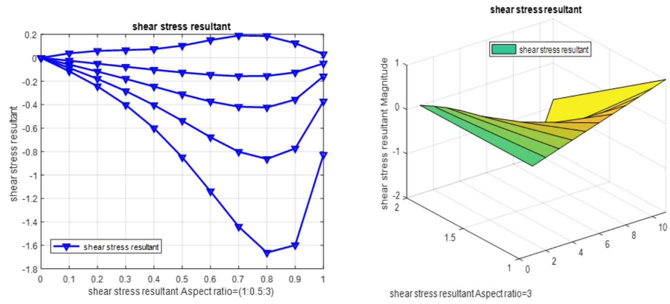

Figure 25 Shear stress resultant, Aspect ratio= (1:5:3).

Results and recommendations

The effects of variations of material properties, geometric properties on fundamental natural frequency and flexural rigidity of clamped supported rectangular thin isotropic plate and the analysis of variations of normal stresses and compressive stresses for finding buckling and flexural vibration by varying aspect ratios for two stress function approach using MATLAB codes is investigated. Coefficients of fundamental natural frequency (f), coefficients of fundamental natural. In present study the effects of variations of material properties, geometric properties on fundamental natural frequency and flexural rigidity of clamped supported rectangular thin isotropic plate using Matlab codes is investigated.

It is noticed that fundamental natural frequency and flexural rigidity both decrease on increase of plate thickness ratio whereas; fundamental natural frequency decrease for increase of plate aspect ratio and flexural rigidity increase on increase of plate aspect ratio.

In the results thus obtained, it is seen that the in-plane solutions are quite similar in terms of x direction normal stresses. The y direction normal stresses show the wide variations among the various methods.

It is further noticed that dimensionless natural frequencies for aspect ratio (a/b=1-2) and plate thickness ratio (a/h) = 5, the dimensionless natural frequencies of Si3N4 material plate has higher values and Ti-6Al-4V material plate has lower values among Graphite Epoxy, Si3N4, SUS304, ZrO2**,** materials plate. Similarly dimensionless flexural rigidity for aspect ratio (a/b=1-2) and plate thickness ratio (a/h) = 5, the dimensionless flexural rigidity of Si3N4 material plate has higher values and Ti-6Al-4V material plate has lower values among Graphite Epoxy, Si3N4, SUS304, ZrO2**,** materials plate. This is useful for selection of material for the plate. Normal stress, compressive stress resultants values in x, y directions and shear stress

Citation: Kumar R. Fundamental natural frequency and flexural rigidity analysis of isotropic plate with analysis of normal stresses with compressive stresses for two stress function approach. *Aeron Aero Open Access J.* 2026;10(1):1–10. DOI: 10.15406/aaoaj.2026.10.00242

resultants values also change on varying aspect ratios. Scope of this study is in design of such plates applicable for aerospace engineering as well as ground engineering applications.

Conclusion

The effects of variations of material properties, geometric properties on fundamental natural frequency and flexural rigidity of clamped supported rectangular thin isotropic plate using Matlab codes are investigated. It is noticed that fundamental natural frequency and flexural rigidity is significantly influenced by material properties, and geometric properties plate thickness ratio (a/h) and plate aspect ratio (a/b) of plate used in study.

It is noticed that fundamental natural frequency and flexural rigidity both decrease on increase of plate thickness ratio whereas fundamental natural frequency decrease for increase of plate aspect ratio and flexural rigidity increase on increase of plate aspect ratio. This investigation gives the parameters to be considered for design of plate for various applications. It is investigated in present work that for thick plate fundamental frequency and flexural rigidity is higher compared to thin plate and for square plate fundamental frequency is higher compared to rectangular plate and flexural rigidity is lower compared to rectangular plate.

A MATLAB code generated normal stress and compressive stress and shear stress resultants components in X and Y direction is presented. Aspect ratio is varied for each type of stress and it is seen that variation in aspect ratio there is different pattern of variations of stress components. It is seen that the in-plane solutions are quite similar in terms of x direction normal stresses. The y direction normal stresses show the wide variations among the various methods. These stresses are significant to decide whether component is suitable for compressive stress or shear stress prone while in use.

Acknowledgement

The author would like to express his sincere appreciation to the anonymous reviewers for their careful analysis, helpful criticism, and insightful ideas that significantly improved this paper. Reviewer's exhaustive review wise comments and attention to detail have greatly enhanced the manuscript's quality and clarity

Data availability: All models or codes generated or used during the study are available from the corresponding author by request. However, the database is proprietary/confidential in nature and may only be provided with restrictions

Conflict of interest

Author has no conflicts of interest.

Funding

No funding is provided by anybody.

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