International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Flexural Analysis of Functionally Graded Plate by Using ANSYS

Pranoti P. Mahajan[1], Dr. Prashant M. Pawar[2]

[1]P.G. Student, M.E. Structure, Solapur University, SVERI's C.O., Engineering, Pandharpur, Gopalpur, India

[2]Professor, M.Tech, Structure, PhD (IISC) Bangalore, Solapur University, SVERI's C.O. Engineering, Pandharpur, Gopalpur, India

Abstract: ***Main objective of project is to analyze Functionally Graded plate for static and modal analysis. The various material are used in plate. The plate is analyzed for various boundary and loading condition. The ANSYS is advanced technique of FEA. In modal analysis plate is made up of five different materials. Thickness of plate is same while doing static and modal analysis. Only the material properties are changed along thickness. In static analysis uniformly distributed load is applied to the plate, maximum deflection, maximum shear stress equivalent stiffness are calculated for different boundary condition.***

Keywords: (FEA) finite element analysis, (FG) Functionally graded, ANSYS, (SSSS) Simply supported, (CCCC) all edges clamped/fixed.

1. Introduction

Functionally graded material defines that material properties are continuous varies from one material to the another material with 100% smooth transitions. It having ability to sustain extreme temperature condition. It can avoids delamination, matrix cracking because they avoid stress concentration. FG plate are made up of two or more material which changes the material properties along thickness by functionally.

2. Frequency, Mode shapes of five material FG plate for different boundary conditions.

In this title plate is made up of five material such as aluminum, steel, ceramic, zircon, alumina. Thickness of plate is 0.05m. size of plate is 1mx 1m . for finer accuracy 20x20 element division are created for mesh. The plate is analyzed for modal frequency for different boundary condition. The plate is analyzed in the form of increasing and decreasing order of Young's modulus material in the following way.

a) The material is taken increasing order of Young's modulus.
b) The material taken decreasing order of Young's modulus.

Purpose of this arrangement of material for FG plate is to check mode shapes and frequency for different boundary conditions.

2.1 For Simply Supported (SSSS) condition

Table 1: Frequency for (SSSS) condition

Mode no.	Material having Increasing order of Young's modulus. (a)	Material having Decreasing order of Young's modulus (b)
1	219.90	219.90
2	549.97	549.97
3	549.97	549.97
4	874.52	874.52
5	1104.0	1104.0

Five modes are taken for modal analysis. From table no.1 frequency are remain same while doing material arrangement in increasing and decreasing order of Young's modulus for modal analysis of plate.

Mode 1 Mode 2

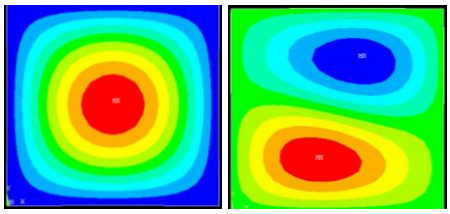


Figure 1: Modes shapes of Material having Increasing order of Young's modulus.

Mode 1 Mode 2

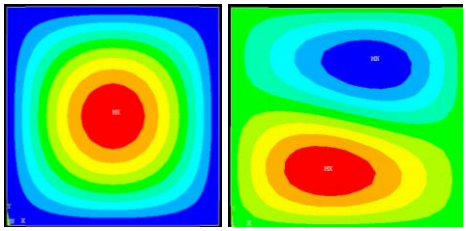


Figure 2: Modes shapes of Material having Decreasing order of Young's modulus.

2.2 For All fixed edges (CCCC) condition

Table 2: For (CCCC) Condition

Mode no.	Material having Increasing order of young's modulus. (a)	Material having Decreasing order of young's modulus (b)
1	398.13	398.13
2	811.11	811.11
3	811.11	811.11
4	1183.5	1183.5
5	1457.7	1457.7

Licensed Under Creative Commons Attribution CC BY

Mode 1 Mode 2

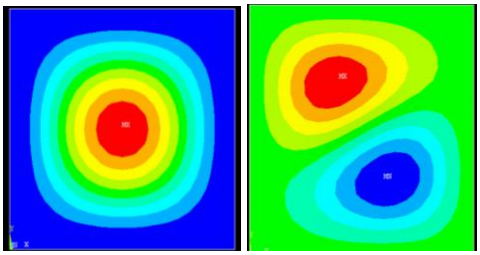


Figure 3: Modes shapes of Material having Increasing order of Young's modulus.

Mode 1 Mode 2

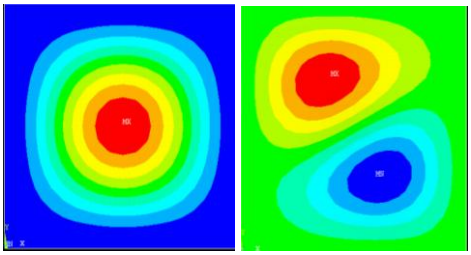


Figure 4: Modes shapes of Material having Decreasing order of Young's modulus.

2.3 For Two edges simply supported and two edges is free (SSFF) condition.

Table 3: For (SSFF) Condition

Mode no.	Material having Increasing order of young's modulus. (a)	Material having Decreasing order of young's modulus (b)
1	107.76	107.76
2	179.89	179.89
3	407.08	407.08
4	436.51	436.51
5	521.43	521.43

Mode 1 Mode 2

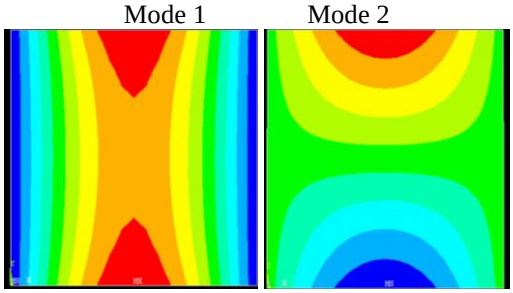


Figure 5: Modes shapes of Material having Increasing order of Young's modulus

Mode 1 Mode 2

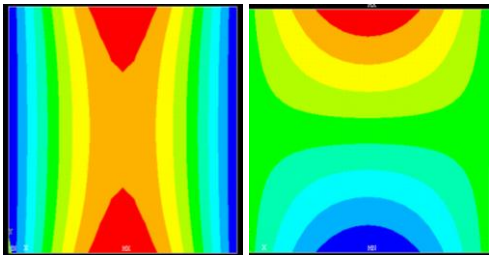


Figure 6: Modes shapes of Material having Decreasing order of Young's modulus.

2.4 For Two edges clamped and two edges is free (CCFF) condition.

Table 4: For (CCFF) Condition

Mode no.	Material having Increasing order of young's modulus. (a)	Material having Decreasing order of young's modulus (b)
1	247.01	247.01
2	292.82	292.82
3	480.02	480.02
4	682.25	682.25
5	745.37	745.37

Mode 1 Mode 2

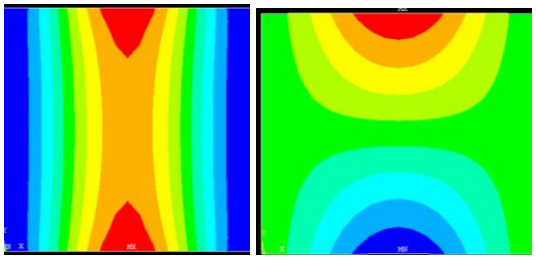


Figure 7: Modes shapes of Material having Increasing order of Young's modulus.

Mode 1 Mode 2

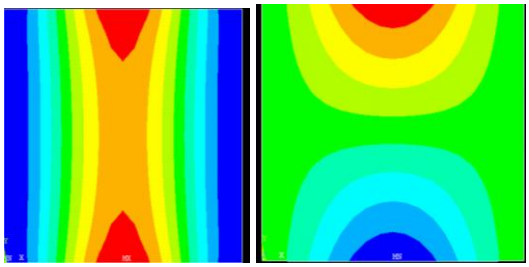


Figure 8: Modes shapes of Material having Decreasing order of Young's modulus.

3. Effect of B/D ratio on Isotropic and Functionally Graded Plate

To check the frequency and maximum deflection we have taken B/D ratio as 1, 1.5, 2, and 2.5,3. In this point we have noted that while length of the plate increasing that time frequency of plate goes on decreasing at that boundary condition.

3.1 For simply supported edges(SSSS)

Table 5: For (SSSS) Condition

B/D Ratio (1)	Steel (2)	Two material high (E) and low (E) (3)	Two material low (E) and high (E)(4)	Five material increasing order of (E) (5)	Five material decreasing order of (E) (6)
1	169.06	526.53	526.53	219.9	219.9
1.5	222.17	350.87	350.87	276.98	276.98
2	152.20	247.94	247.94	237.4	237.4
2.5	108.88	179.43	179.43	170.93	170.93
3	80.642	133.23	133.23	122.41	122.41

Licensed Under Creative Commons Attribution CC BY

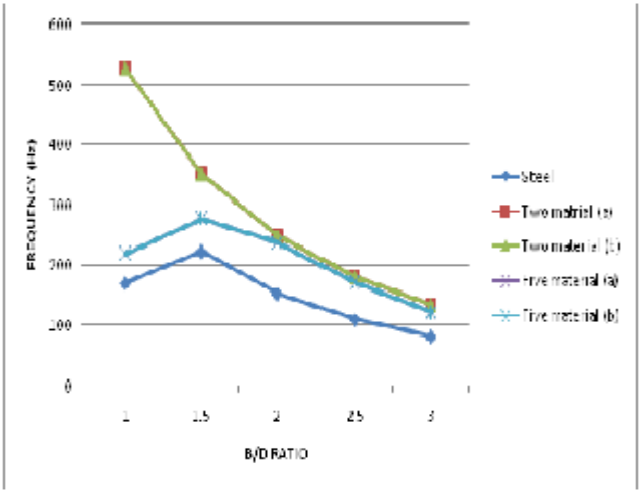


Figure 9: graph for (SSSS) Condition

3.2 For (CCCC) condition

Table 6: For (CCCC) Condition

B/D Ratio (1)	Steel (2)	Two material high (E) and low (E) (3)	Two material low (E) and high (E) (4)	Five material increasing order of (E) (5)	Five material decreasing order of (E) (6)
1	303.3	1550.5	1550.5	398.13	398.13
1.5	621.03	1019.1	1019.1	546.2	546.2
2	400.22	648.65	648.65	624.54	624.54
2.5	270.72	432.91	432.91	418.22	418.22
3	192.52	304.58	304.58	299.05	299.05

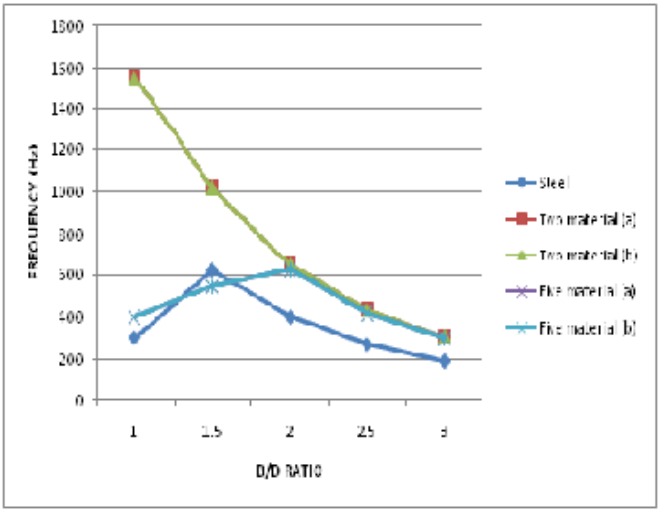


Figure 10: graph for (CCCC) Condition

3.3 For (SSFF) Condition

Table 7: For (SSFF) Condition

B/D Ratio (1)	Steel (2)	Two material high (E) and low (E) (3)	Two material low (E) and high (E) (4)	Five material increasing order of (E) (5)	Five material decreasing order of (E) (6)
1	82.816	225.55	225.55	107.76	107.76
1.5	70.386	97.109	97.109	38.501	38.501
2	39.105	51.418	51.418	56.337	56.337
2.5	24.192	31.115	31.115	34.188	34.188
3	16.124	20.553	20.553	11.809	11.809

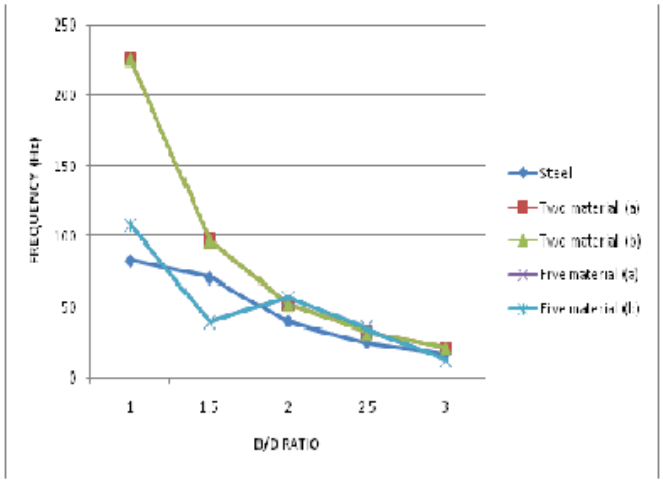


Figure 11: graph for (SSFF) Condition

3.4 For (CCFF) Condition

Table 8: For (CCFF) Condition

B/D Ratio (1)	Steel (2)	Two material high (E) and low (E) (3)	Two material low (E) and high (E) (4)	Five material increasing order of (E)(5)	Five material decreasing order of (E) (6)
1	188.88	379.27	379.27	247.01	247.01
1.5	143.32	168.54	168.54	227.89	227.89
2	77.79	91.202	91.202	102.25	102.25
2.5	47.684	55.845	55.845	62.576	62.576
3	31.742	37.166	37.166	42.005	42.005

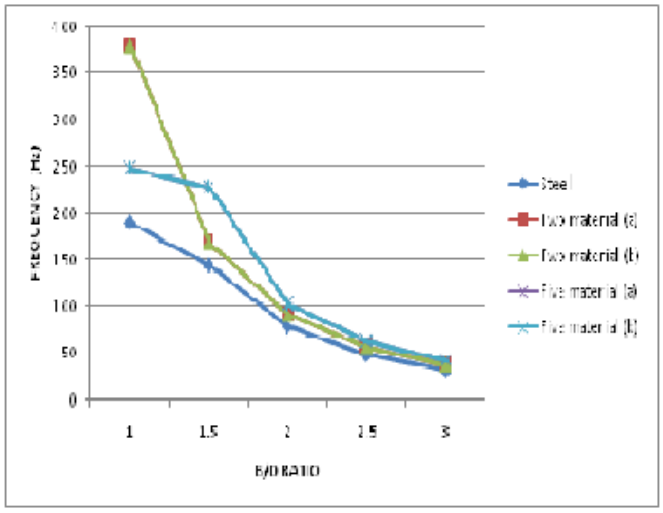


Figure 12: graph for (CCFF) Condition

4. Failure load for FG (5 material) plate in increasing order of young's modulus for different boundary condition

In this section plate of 1mx 1m. The stress and deflection analysis is carried out for various boundary conditions. There plates are analyzed under uniformly distributed load of about 70% of the load failure stress of any material.

Licensed Under Creative Commons Attribution CC BY

4.1 For all edges Simply Supported (SSSS)

Failure load = 650 KN/m^2 .For this failure load maximum Deflection = 0.002329 m, Equivalent Stiffness (K) = 279089.7381 KN/m.

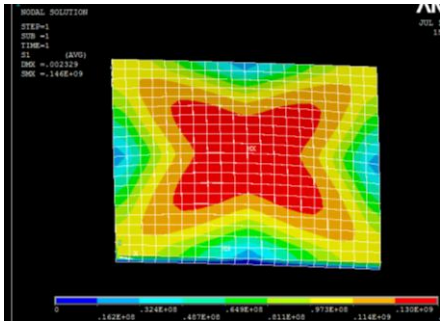


Figure 13: Max.deflection for (SSSS) Condition

By taking approximately 70% of failure load, we can check the deflection.
70% of 650KN/m^2 = 455 KN/m^2
Maximum Deflection = 0.00163 m
Max. Shear stress = 0.725x 10^8 N/m^2
Equivalent Stiffness = 279141.1043 KN/m

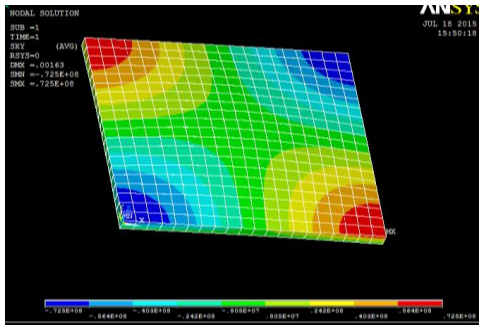


Figure 14: Max. Shear stress for (SSSS) Condition

4.2 for (CCCC) Condition:

Failure load = 1350KN/m2, Maximum Deflection = 0.001534 m ,Equivalent Stiffness = 880052.15 KN/m.

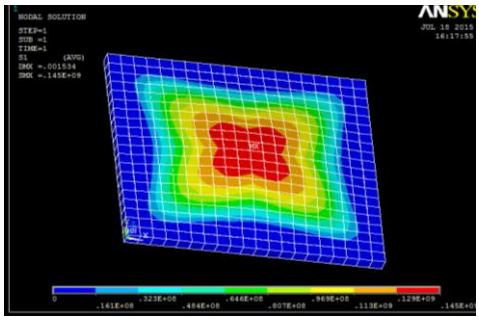


Figure 15: Max. deflection for (CCCC) Condition

By taking approximately 70% of failure load, we can check the deflection.
70% of 1350 KN/m^2 = 945 KN/m^2
Maximum Deflection = 0.001074 m
Max. Shear stress = 0.393x10^8 N/m^2
Equivalent Stiffness = 879888.2682 KN/m.

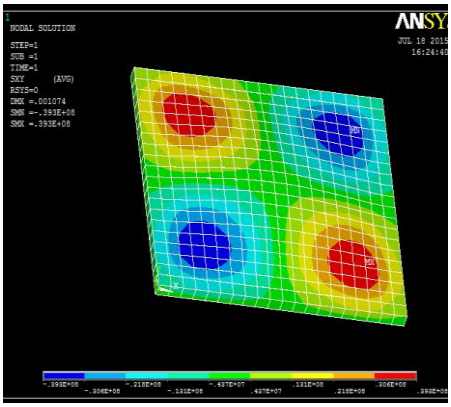


Figure 16: Max. Shear stress for (CCCC) Condition

4.3 For (SSFF) Condition

Failure load = 231 KN/m^2. Max.deflection = 0.003019 m Equivalent Stiffness = 76515.40245 KN/m

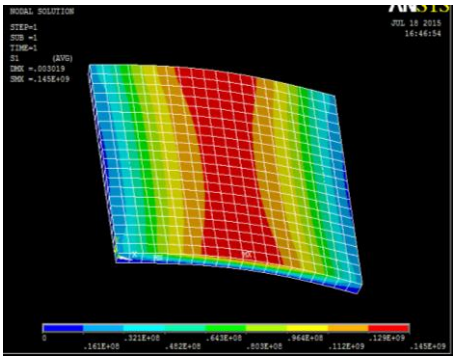


Figure 17: Max.deflection for (SSFF) Condition

By taking approximately 70% of failure load, we can check the deflection
70% of 231 KN/m^2 = 161.7 KN/m^2
Maximum Deflection = 0.002113 m
Max. Shear stress = 0.136 x 10^8 N/m^2
Equivalent Stiffness = 76526.26597 KN/m

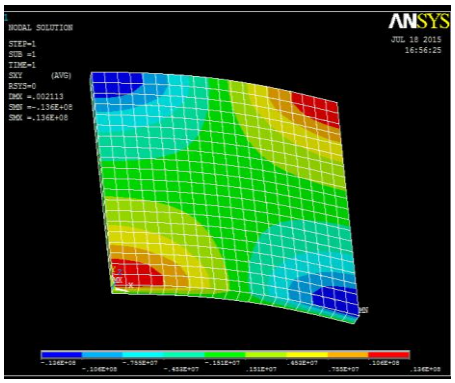


Figure 18: Max. Shear stress for (SSFF) Condition

5. Conclusion

- Advanced software of FEA is ANSYS, is very efficient for modal and static analysis.
- When five material FG plate is analyzed for modal analysis then frequency are same for both increasing and decreasing order of Young's modulus for various boundary condition.

Licensed Under Creative Commons Attribution CC BY

- Effect of B/D ratio shows only length of plate increases that time frequency go on decreasing. But for single material steel plate and five material FG plate certain length frequency increases and suddenly decreases only for (SSSS) ,(CCCC) condition.
- In static analysis equivalent stiffness is increases for (SSSS), (SSFF) condition and decreases for (CCCC) condition.

.

References

[1] Modal Analysis of Simply Supported Functionally Graded Square Plates, by Kevin Pendley, Rensselaer Polytechnic Institute.

[2] Ghannad S.A.M. Pour and Alinia M.M., (2006) "Large deflection behavior of functionally graded Pour plates under pressure loads." Journal of Composite Structures, Vol.75, pp. 67-71.

[3] Singha M.K., Prakash T. and Ganapathi M. (2011) "Finite element analysis of functionally graded plates under transverse load." Journal of Composite Structures,Vol.47, pp. 453-460.

[4] Zenkour A. M. (2006) "Generalized shear deformation theory for bending analysis of functionally graded plates." Journal of Applied Mathematical Modeling, Vol. 30, pp. 67-84.

[5]] Jha D. K., Kant T. and Singh R. K. (2013) b "Free vibration response of functionally graded thick plate with shear and normal deformation effects." Journal of Composite Structures, Vol. 96, pp. 799-823.

Licensed Under Creative Commons Attribution CC BY