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Modal Analysis of Aluminium alloy 6065 Plate with Uncertainty under Various Boundary Conditions

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Abstract: ***The dynamic analysis was performed for aluminium alloy 6065 bare plate (BP), mass plate (MP), spring plate (SP) and bare mass spring plate(SMBP) under different boundary condition. This project work is study the vibration response of various boundary conditions of the plates with uncertain parameters at various frequencies. In the design of practical machine components the uncertain parameters plays a leading role, so the vibrational study very important due the effect of mechanical systems on uncertain parameters. A good number of research is developing to predict the dynamic response of uncertainty structures in different frequency domain. In the present project work aluminium alloy 6065 structural element plate is taken on which mass and stiffness uncertainty are taking in an account***

All edge free condition, significance information is observed that only spring plate (SP) and bare mass spring plate (SMBP) the five mode frequency are same. All edge fixed condition the dynamic behaviour of bare plate, mass plate, and spring plate was same. And all edge simply supported condition in x-direction BP, SP, MP and SMBP plates frequencies are increased with increasing of mode number. All edge fixed free fixed free condition only Bare Plate and Mass Plate frequencies and displacement values are also most equal with mode number.

All Edge Simply Supported in x-direction condition is good for bare, spring and mass and SMBP plates compare to other three boundary conditions. Compare to other three plates mass plate having low frequency (at the first mode) for all edge simply supported condition. Compare to other three plates bare plates having low displacement value (at the first mode) for all edge simply supported condition.

The plate dynamic behaviour in vibrations were found using FEM technique. A good agreement is shown between analytical method and finite element Method for the bare plate under various boundary conditions.

Keyword: Modal Analysis, Uncertainty, Mode shapes, Natural Frequency, Fem

I. ANALYSIS OF RECTANGULAR PLATE UNDER ALL EDGE FREE -FREE-FREE-FREE CONDITION

The dynamic analysis was performed on rectangular plate of aluminium 6065 alloy of bare plate ,spring plat, mass plate and mass spring rectangular plat under all edge free condition. The Natural frequency of rectangle plate calculated using the theoretical equation for all the edge free condition is given by $\lambda_I = b/a * m\pi \sqrt{1+k}$ and $\omega = k(m^2\pi^2/a^2)\sqrt{D/\rho h}$, Compare to fea result and theoretical result was approximately equal as shown in below Table. The goal of modal analysis in structural mechanics is to determine the natural frequencies and mode shapes of an object or structures during free vibration. A square plate of dimension 304.8×304.8×2 mm of al 6065 alloy material, the material properties of square plate are $\rho = 2720\times10^{-12}$ tonnes/mm^3, $\mu = 0.3$, $E = 68.9\times10^3$ MPa. All material properties are applied to various boundary conditions of the bare plate. The element type selected is 'brick 20 node element is suitable for analyzing thin to moderately-thick structures. It is a 20 node element with six degrees of freedom at each node translation in the x, y, and z directions, and rotations about the x, y, and z axes. For Bare plate natural frequency in analytical 907.75Hz where as in Fea 881.7Hz almost equal.

Table-1 -All Edge Free Condition Frequencies in Hz

Bare Plate	Mass Plate	Spring plate	Bare Mass Spring Plate
881.7	1123.2	1112.2	1112.2
1042.8	1123.2	1112.2	1112.2
1042.8	1126.1	1279.6	1279.6
1067.6	1271.6	1317.8	1317.8
1123.1	1271.6	1348.7	1348.7

The Bare plate frequencies are increased and displacements are decreased with respect to the mode shapes. The frequencies are increased and displacements are all most in some particular modes of mass &spring plate. A significance notices observed that spring plate and spring mass bare plate (SMBP) frequencies are equal and seen that the lowest displaced carried by SMBP. The complication table-1 was shown below for B.P, S.P, M.P and SMBP. The fea Results are shown in below representing the first five modes of frequencies of BP, SP, MP, and SMBP.

II. ANALYSIS OF RECTANGULAR PLATE UNDER ALL EDGE FIXED -FIXED-FIXED-FIXED CONDITION

The natural frequencies of al 6065 alloy bare plate (B.P), Spring plate (S.P), Mass plate (M.P) and spring mass bare plate (SMBP) under all edge fixed condition was performed. In this research work for bare plate all edge fixed condition the natural frequency was given by $f_n=\lambda/2\pi a^2*\sqrt{d/\rho}$.

a/b	0.4	0.67	1	1.5	2.5
$f_{n(Hz)}$	176.45	201.49	268.48	453.34	1102.588

The first five modes frequency are increased for bare plate and the displacements are decreased as shown in the Table 2.An excellent behaviour of bare plate,spring plate &mass plate was observed that the five modes of frequency are equal, that show that the dynamic behaviour was same for these cases where as the displacement are same for mass and spring plate. The displacement value of first mode of bare plate &spring mass bare plate was same ,these observations gives the dynamic behaviour of the different plates.

Table-2 -All Edge Fixed Condition Frequencies in Hz

Bare Plate	Mass Plate	Spring plate	Bare Mass Spring Plate
10567.6	10566	10566	1034
10611.3	10612	10612	10858
10612.5	10612	10612	10892
10756.7	10757	10757	10913
10752.2	10758	10758	10950

III.ANALYSIS OF RECTANGULAR PLATE UNDER ALL EDGE SIMPLY SUPPORTED(SS-SS-SS-SS) –CONDITION

Al 6065 material was used to analyze the dynamic behaviour of rectangular plate (BP),(SP),(MP),and (SMBP) under a edge simply supported condition in x- direction. The Bare Plate (BP) frequency values are analyzed using the analytical equation is given by $\omega_{mn}=\sqrt{D/\rho h}\,[(m*\pi/Lx)^2+(n\pi/Ly)^2]$. Results show that a good agreement between analytical and fea for bare plate. The frequencies are increased with increasing in frequency of mode number and the displacement values are decreased and again increased vice-versa.

Mode No	Frequencies in Hz (FEA)	Frequencies in Hz (Analytical)
1	108.10	104.04
2	414.13	916016
3	950.68	936.36
4	1669.7	1664.64
5	2617.5	2601

For all the cases bare plate ,spring plate &mass plate and SMBP plate frequencies are increased and displacements are decreased and again increased with mode number ,these leads the dynamic behaviour of the plates. The SMBP plate given low frequencies values compare to other plates shown in TABLE-3 and also show the first five modes of all the plates.

Table-3 -All Edge SS-SS-SS-SS Condition Frequencies in Hz:

Bare Plate	Mass Plate	Spring plate	Bare Mass Spring Plate
108.10	87.27	91.747	91.96
414.13	115.11	459.96	131.20
550.68	168.65	1122.1	2000.12
16669.7	213.80	1888.5	216.40
2617.5	269.84	2984.9	319.07

IV. ANALYSIS OF RECTANGULAR PLATE UNDER ALL EDGE FIXED-FREE-FIXED-FREE CONDITION

A bare plate (BP) with al 6065 alloy plate was used for analysing the dynamic behaviour under fixed-free-fixed-free conditions as shown in below . The Natural frequency of bare plate (BP) under this condition is given by $F_n=3.55/b^2\sqrt{D/\rho}$. The natural frequency value in analytical method 166.34 Hz and fea in 181.04 hz. A small percentage of error in fea &analytical method, The spring element was used in the spring plate, the spring are attached along the boundary of the bare plate with stiffness $2452.5e^{-3}$. The natural frequency values of BP,MP,SP,and SMBP extracted at different mode condition using ANSYS software observed that bp,mp,frequencies values and a displacement values are almost same if indicates the similar dynamic characteristics behaviour of BP and MP plate under fixed-free-fixed-free condition. The spring plate and mass spring bare plate frequencies are almost same and it indicates the similar dynamic behaviour under this condition as shown in TABLE-4 and the first mode shapes are swon in figures for all the plates.

Table-4 -All Edge Fixed-Free-Fixed-Free Condition Frequencies in Hz:

Bare Plate	Mass Plate	Spring Plate	Bare Mass Spring Plate
181.04	186.48	210.12	203.76
186.48	322.43	213.26	216.81
348.17	348.17	370.37	288.43
384.28	384.28	408.15	376.00
348.28	385.43	427.44	437.96

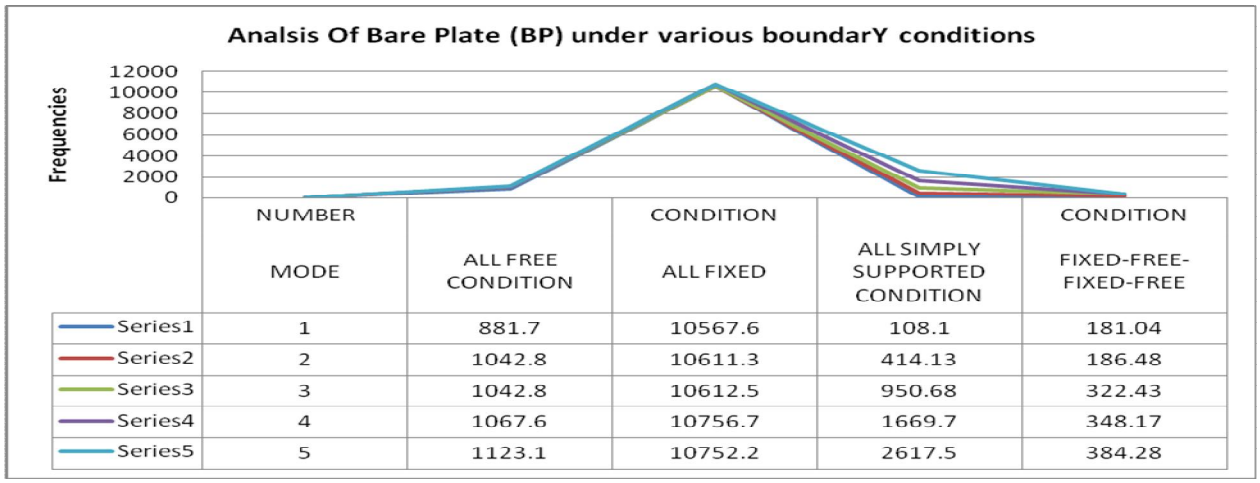
V. RESULTS AND DISCUSSIONS

A. Bare Plate (BP)

All Edge simply supported (ss-ss-ss-ss) condition is good for bare plate because it show low neutral frequency and having less displacement in the first natural frequency Mode. The first five mode frequencies are increased with mode number for all the four boundary conditions of the plate. Table-5 shows the frequencies of all edge free condition, all edge fixed condition, all edge simply supported condition and All Edge fixed free fixed free condition. It was also shown in the form of Graphs for bare plate with four boundary conditions.

Table-5.1 Bare plate Frequencies in Hz:

MODE NUMBER	ALL FREE CONDITION	ALL FIXED CONDITION	ALL SIMPLY SUPPORTED CONDITION	FIXED-FREE-FIXED-FREE CONDITION
1	881.7	10567.6	108.10	181.04
2	1042.8	10611.3	414.13	186.48
3	1042.8	10612.5	950.68	322.43
4	1067.6	10756.7	1669.7	348.17
5	1123.1	10752.2	2617.5	384.28



Graph-5.1 shows Bare plate Frequencies in Hz:

B. Mass Plate (MP)

All edge ss-ss-ss condition is good for mass plate it show low natural frequency, but displacement value is high compared to fixed-free-fixed-free condition at first natural frequency mode.

C. Spring Plate (SP)

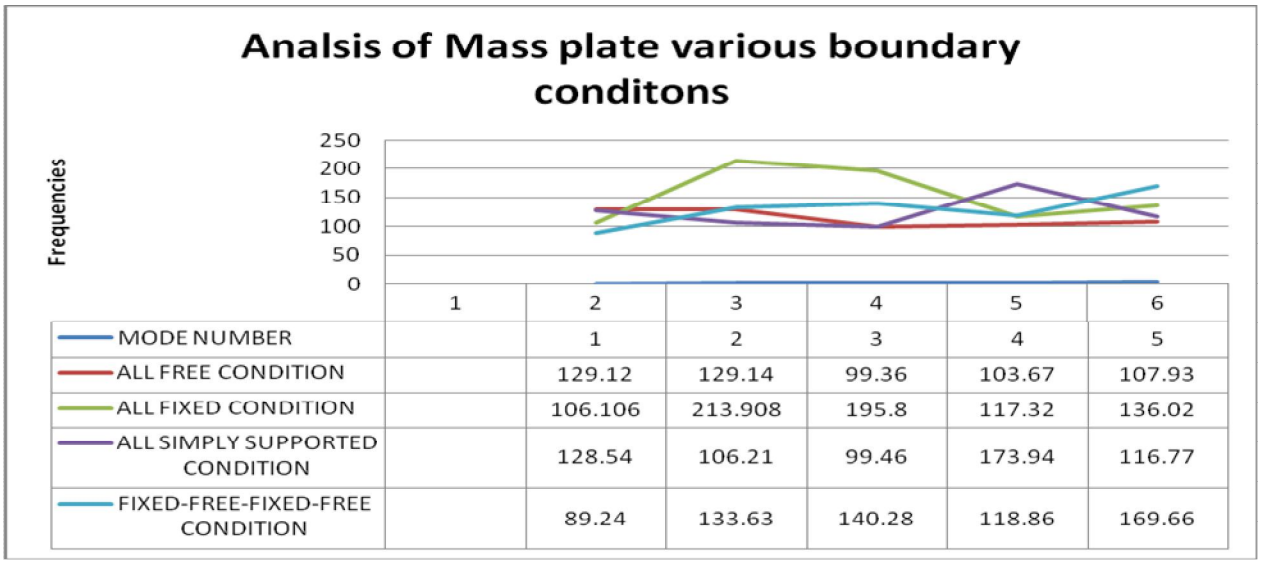
All edge simply supported and all edge free condition is good for spring plate, having low natural frequencies at the first mode .But while considering deflection of a plate all edge free condition is good compare to all edge simply supported condition in the first natural frequency mode.

D. Bare Mass Spring Plate (SMBP)

All edge simply supported in x-direction is good for Bare Mass Spring plate having low natural frequency at the first mode. A table shows the First five modes frequencies and displacements of Bare Mass Spring Plate under four Boundary conditions.

Table-5.2 Mass plate Frequencies in Hz:

MODE NUMBER	ALL FREE CONDITION	ALL FIXED CONDITION	ALL SIMPLY SUPPORTED CONDITION	FIXED-FREE-FIXED-FREE CONDITION
1	1123.2	10566	87.27	186.4
2	1123.2	10612	115.11	322.43
3	1126.1	10612	168.65	348.19
4	1271.6	10757	213.80	384.28
5	1271.6	10758	269.84	385.4



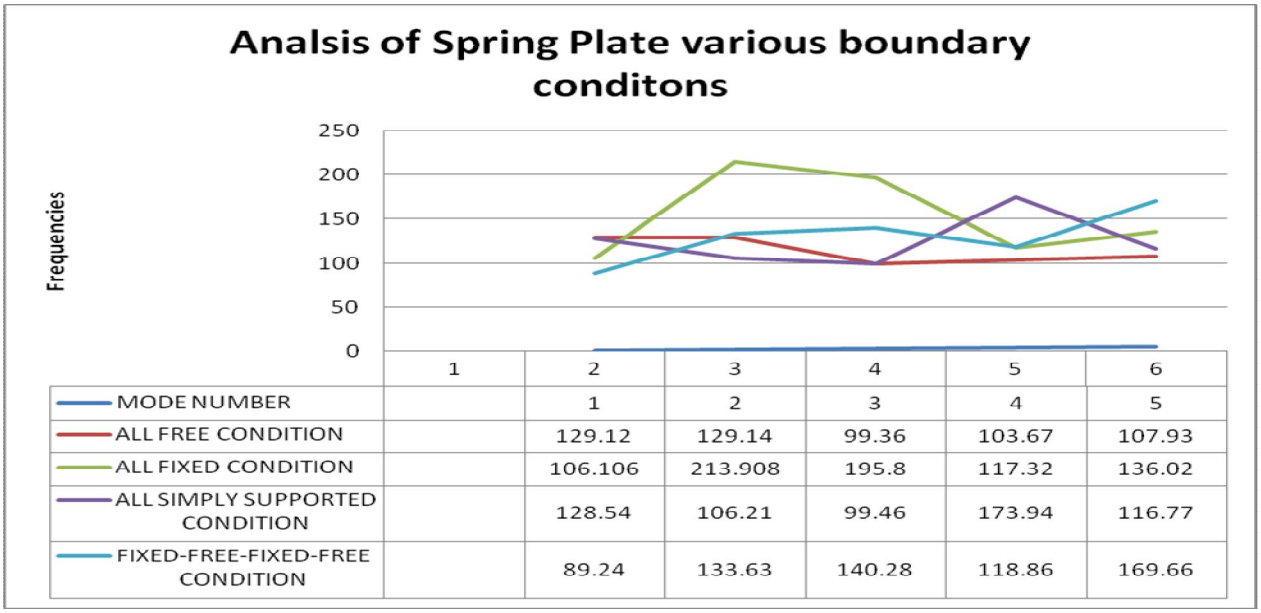
Graph-5.2 shows Mass plate Frequencies in Hz

Table-5.3 Spring plate Frequencies in Hz

MODE NUMBER	ALL FREE CONDITION	ALL FIXED CONDITION	ALL SIMPLY SUPPORTED CONDITION	FIXED-FREE-FIXED-FREE CONDITION
1	1112.2	10566	91.747	210.12
2	1112.2	10612	459.9	213.21
3	1279.6	10612	1122.1	370.37
4	1317.8	10751	1888.5	408.15
5	1348.7	10758	2984.9	427.44

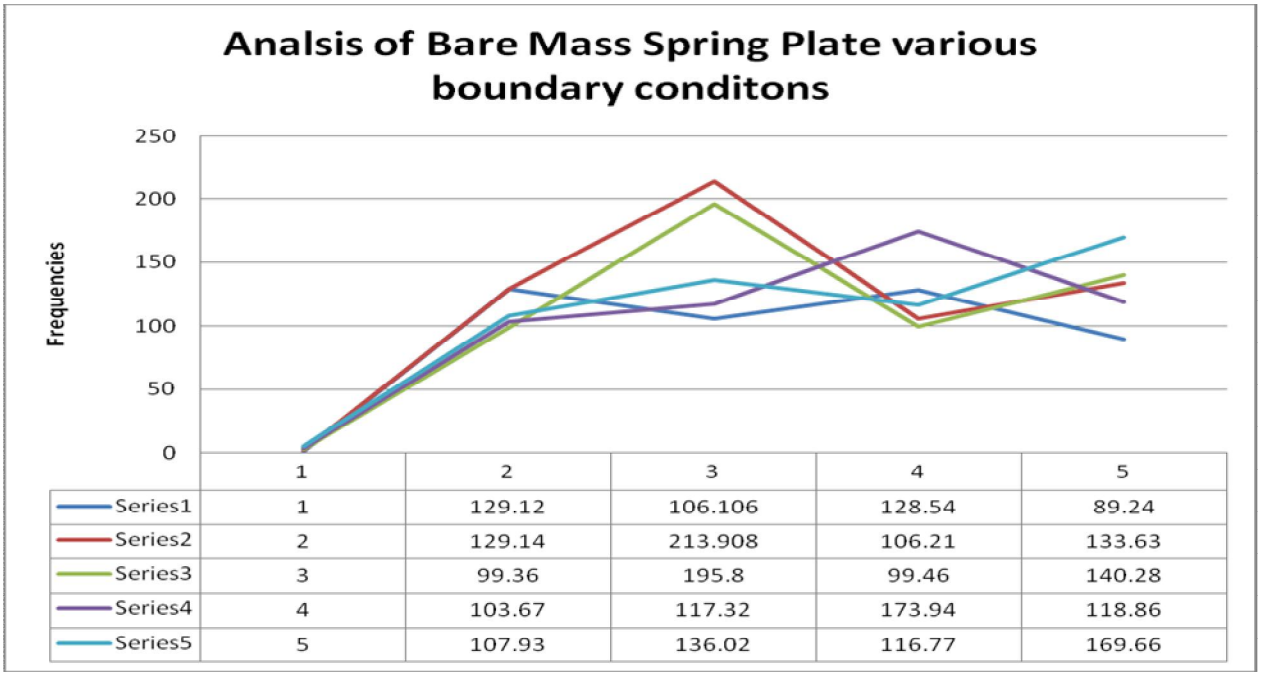
Table-5.4 Bare Mass Spring plate Frequencies in Hz

MODE NUMBER	ALL FREE CONDITION	ALL FIXED CONDITION	ALL SIMPLY SUPPORTED CONDITION	FIXED-FREE-FIXED-FREE CONDITION
1	1112.2	1034	91.96	203.76
2	1112.2	10858	131.20	216.81
3	1279.6	10892	200.12	288.43
4	1317.8	10913	216.40	376.00
5	1348.7	10950	319.7	437.96



Graph-5.3 shows Spring plate Frequencies in Hz

Graph-5.4 shows Bare Mass Spring plate Frequencies in Hz



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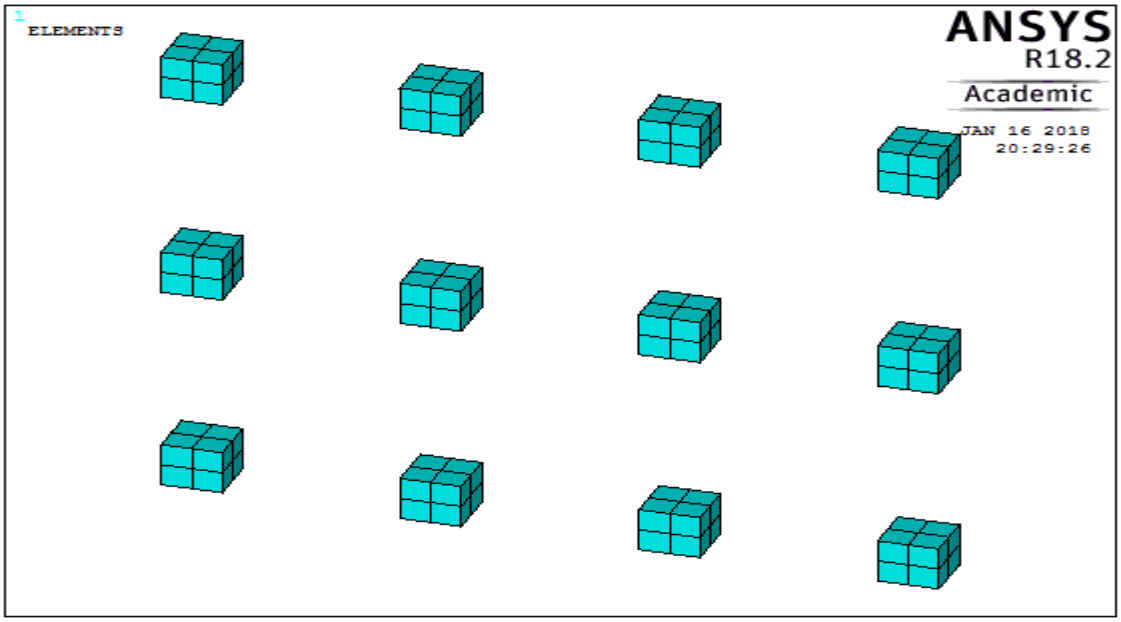
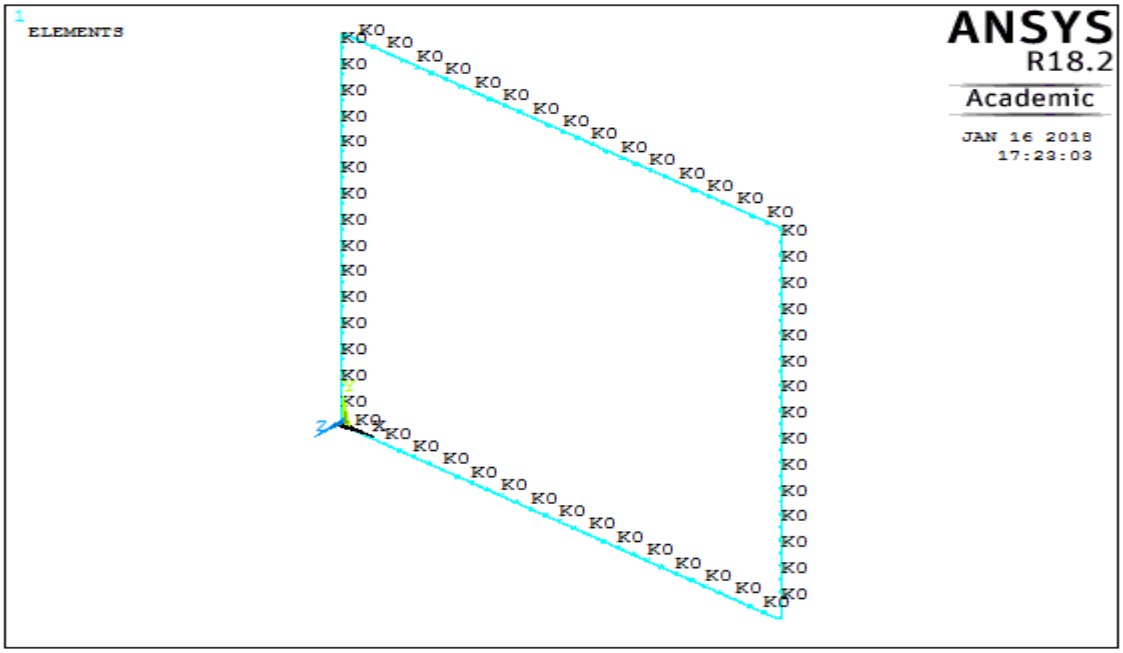
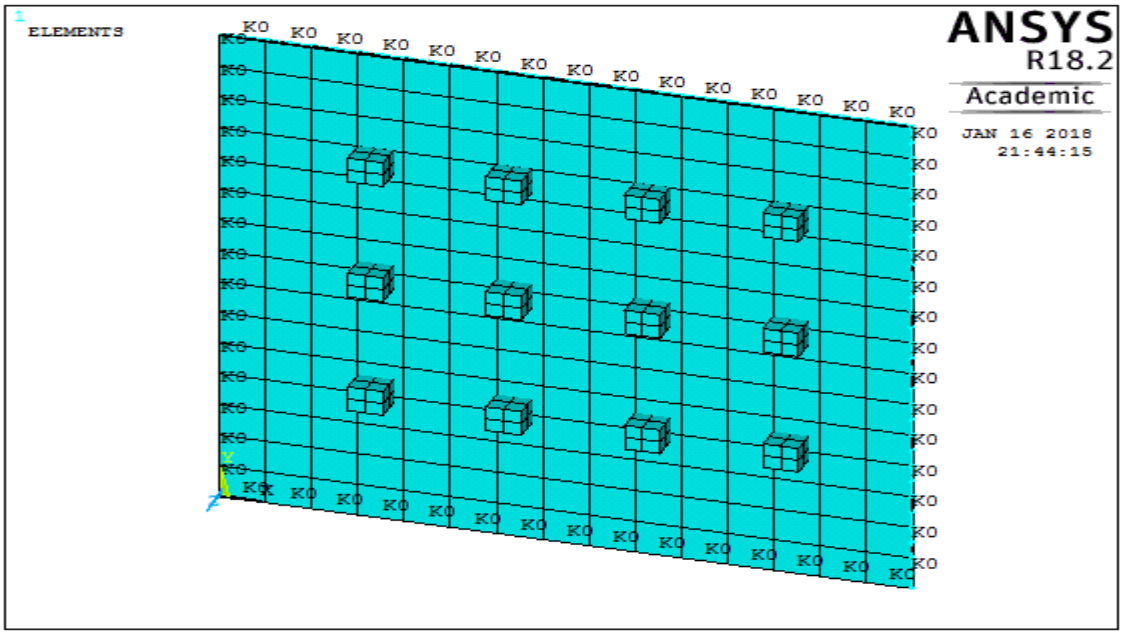
VI. CONCLUSIONS

From the above tables the mass plate having low frequency compare to other plate for all edge simply supported condition, where as an displacement point of view of bare plate is good compare to other three plates. The design and analysis of all the plates shown in figures

Type of plate	SS-SS-SS-SS Condition(Frequencies In Hz)	SS-SS-SS-SS Condition(Displacements In mm)
Bare plate	108.10	104.11
Spring plate	91.747	128.49
Mass plate	87.27	133.7
Spring mass bare plate	91.96	128.54







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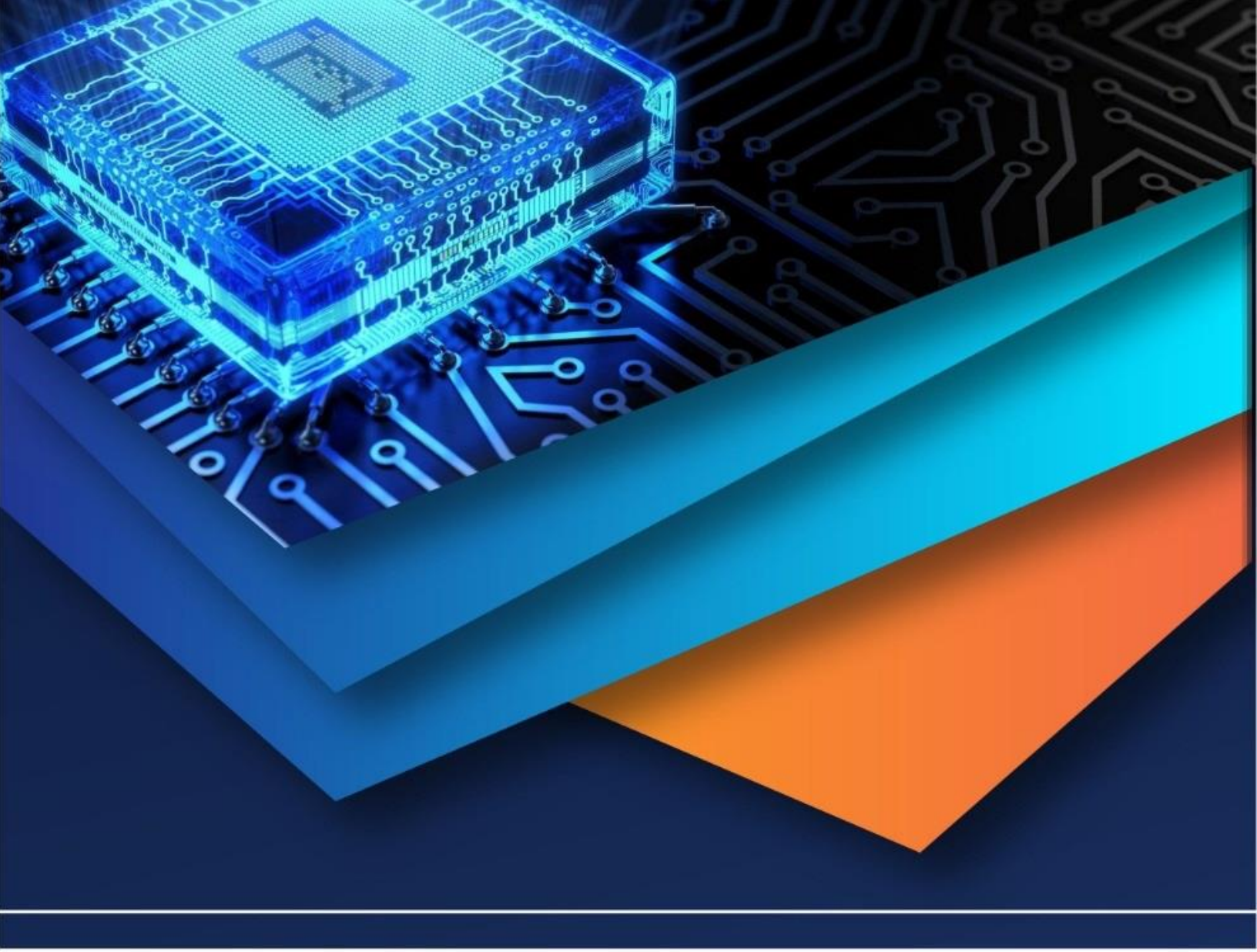

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