ON THE DETERMINATION AND COMPARISON OF THE NATURAL FREQUENCIES BY EXPERIMENTAL AND NUMERICAL (FE MODAL ANALYSIS) METHODS

Anant J. Sheth*

S. S. Pathan**

ABSTRACT

Finite Element Analysis (FEA) is the best analysis package as it gives nearly equal results as found experimentally. For complex structures like car door the natural frequencies are determined both with FE Modal analysis and experimental method. The results of both are compared and they found closely matching.

Keywords: *FE Modal analysis, Experimental modal analysis, Natural frequency, Shaker.*

*L.D.C.E, A'Bad, Gujarat, India.

**Assistant Professor, Mechanical Engineering Department, L.D.C.E, Gujarat, India.

INTRODUCTION

System is having infinite natural frequencies. Whenever any excitation frequency matches any of the natural frequency, resonance occurs. Thus its better to know natural frequencies in advance so by any of the vibration control method, the chances of resonance could be avoided.There are mainly three methods to determine the modal parameters, they are (1) FE modal analysis (2) Experimental modal analysis (3) Operational modal analysis.

(1) FE modal analysis: It is the most effective and simplest way to determine the natural frequency and mode shapes. Model of the product could be made in any of the commercially available CAD package. The model could be imported to the FE environment. With the proper material properties and appropriate element selection the meshed model could be prepared for the modal analysis. By giving proper constraints, motion of the model is restricted. The analysis gives the list of natural frequencies and mode shape.

(2) Experimental modal analysis: The system is externally excited with either Impact hammer or shaker table. The data extracted is post processed to get the FRF i.e. Frequency Response Function. By using proper curve fitting technique the damping is also available.

(3) Operational modal analysis: The system is analyzed in its operating condition without disturbing its performance. Here again the data captured is to be post processed to determine the dynamic properties.

CAD model preparation: With the help of the INVENTOR professional the CAD model of car door have been prepared. Though the ANSYS also provides modeling facility, it's difficult to create complex shapes.

Converting the CAD file to IGES format it could be imported to the ANSYS environment. During preparing the design utmost care is to be taken while giving constraints, as during bringing to ANSYS environment there are chances of data loss. With the help of the modeling facility available with ANSYS the data could be corrected.

With the following Figure 1, the CAD model of car door is shown.

Figure 1: CAD model of car door (left), Actual car door (right)

FE modal analysis: The CAD model is brought to the ANSYS work environment. With the material model tool the material specifications are provided. Element 'Shell 63' is considered for meshing.

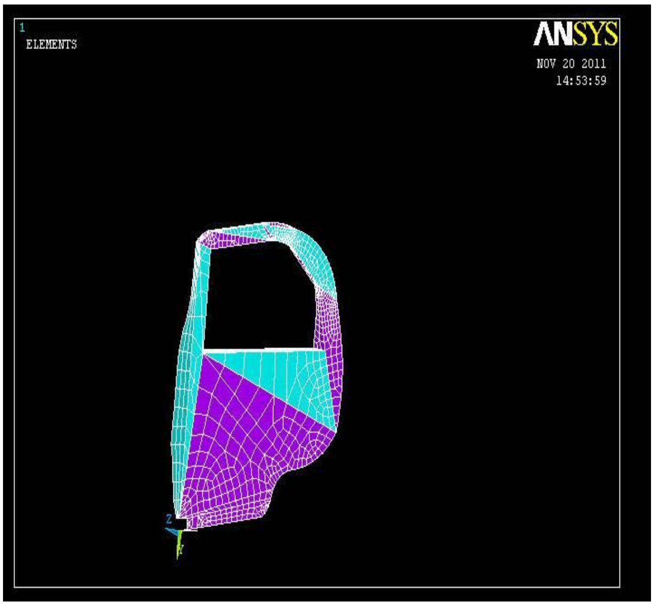
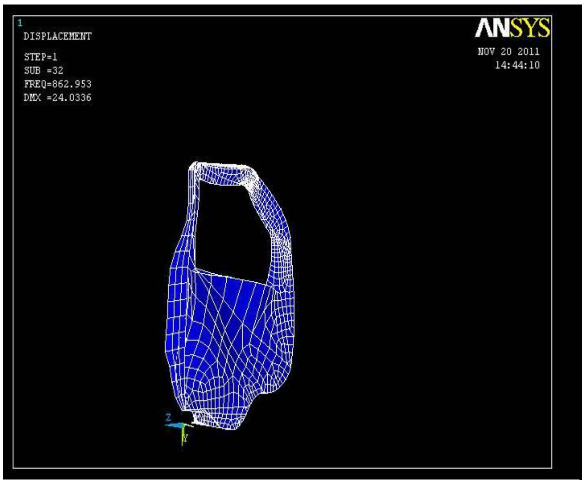


Figure 2: FE Meshed model of car door

With 'loads' tool, the displacement option is used to provide the constraints. By providing constraints at the hinge and the lock position of the door, we have constrained the motion.

With the ‘solution’ tool, going with modal analysis option. Keeping the default frequency range and specifying the modes to be extracted, we are now ready for the modal analysis .
Following are the mode shapes obtained at the specified frequency. The data for the natural frequency is there in Table 1.



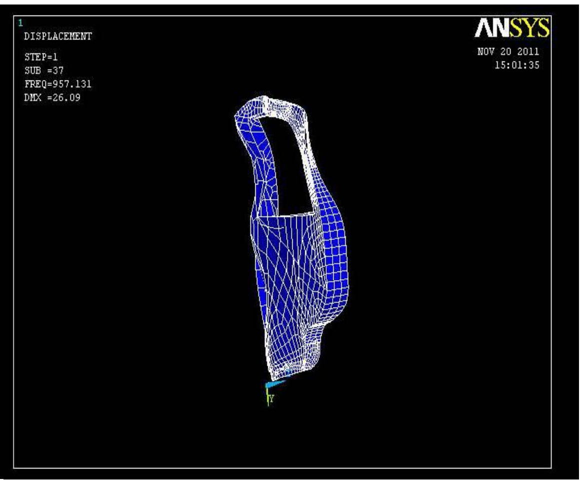
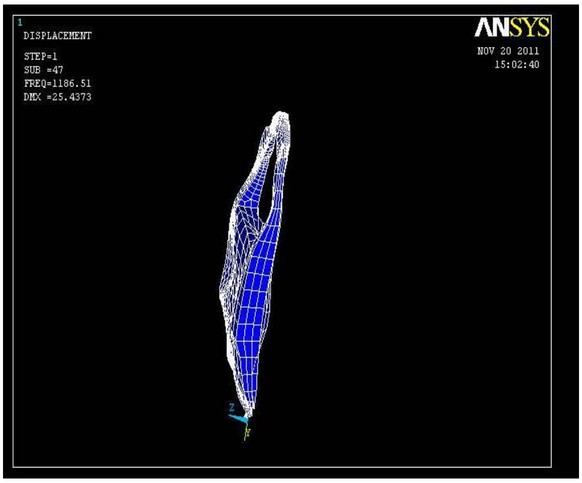


Figure 3:Mode shape at frequency 862 Hz. Figure 4:Mode shape at frequency 957 Hz.



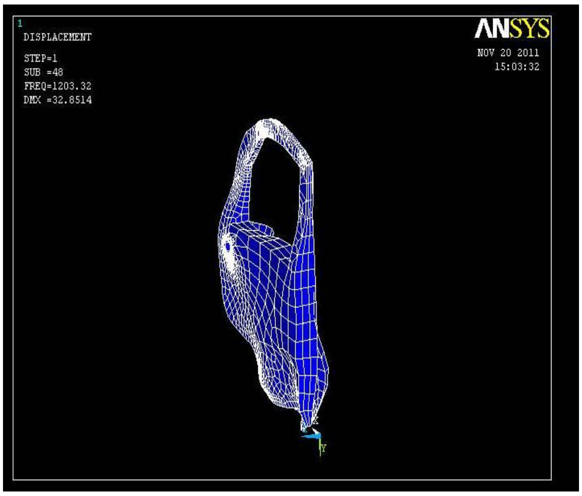


Figure5:Mode shape at frequency 1166Hz. Figure 6:Mode shape at frequency 1203Hz

The mode shape shows the elastic deflection at different nodes at the natural frequency of the system. The vibrations are free vibrations.
With the following section, the experimental setup for the modal analysis and its results are shown.
Experimental setup and results: The shaker table is having capacity for frequency range 0-2000 Hz.

Figure 7: Experimental setup for car door natural frequency determination.

Totally two sensors were used, one is attached at the top of car door and the other is put on the table surface. The following is the vibration spectrum available from the experiment.

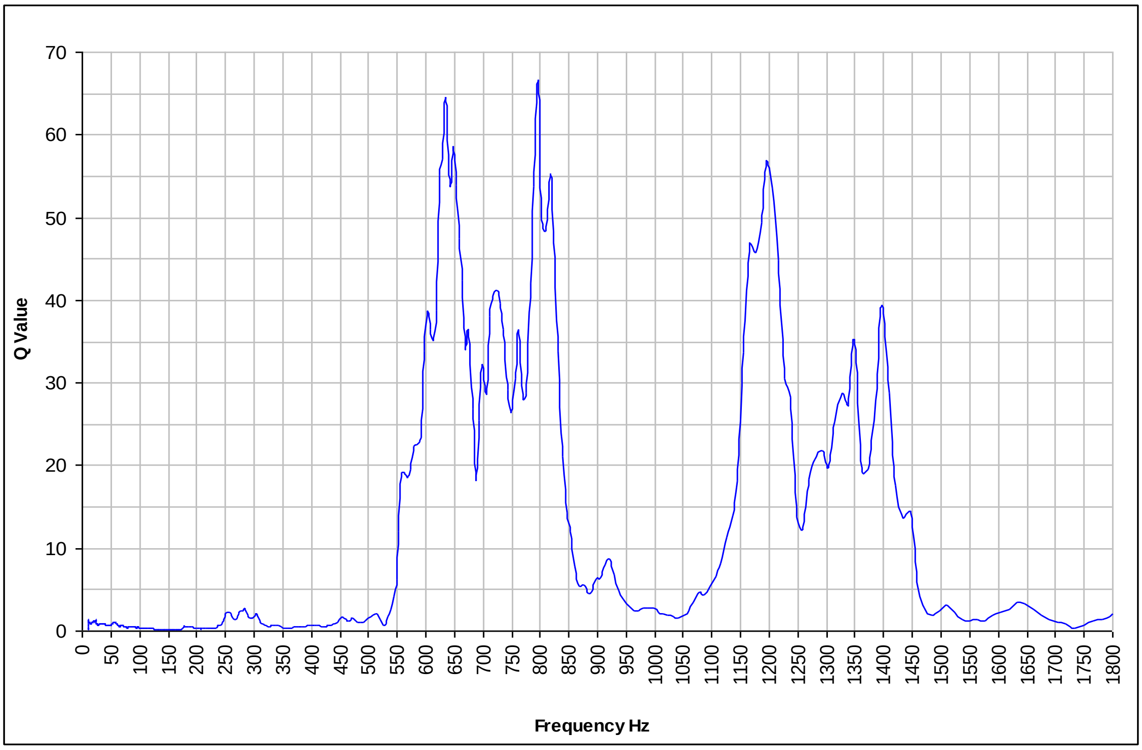


Figure 8: The vibration spectrum of the car door

Natural frequency by Experiment	Natural frequency by FE modal analysis	%Error in FE modal analysis	Natural frequency by Experiment	Natural frequency by FE modal analysis	%Error in FE modal analysis
10	--	--	830.8	830.11	0.083052
12.64	--	--	845.8	843.54	0.267203
24.49	24.616	-0.5145	875.2	872.41	0.318784
55.79	58.556	-4.95788	922.4	924.43	-0.22008
64.7	65.251	-0.85162	1005.1	1000	0.507412
133.8	132.15	1.233184	1077.1	1074	0.28781
184.3	184.82	-0.28215	1097.1	1097.1	0
245.3	233.59	4.773746	1164.5	1170.2	-0.48948
265.5	276.8	-4.25612	1195.2	1186.5	0.727912
289.1	294.91	-2.00969	1206.2	1203.3	0.240424
307.2	329.01	-7.09961	1238	1226.6	0.92084
340.9	346.24	-1.56644	1292.6	1295.4	-0.21662
452.86	452.03	0.18328	1303	1301.1	0.145817
481.7	481.11	0.122483	1349.3	1344	0.392796
520.9	527.51	-1.26896	1397.4	1399.9	-0.1789
548.5	548.7	-0.03646	1446.3	1442.8	0.241997
562.9	564.03	-0.20075	1510.1	1517	-0.45692
583	577.33	0.972556	1632.8	1545.7	5.334395
635.6	634.43	0.184078	1632.8	1633.1	-0.01837
698.8	693.55	0.751288	1646.6	1647.6	-0.06073
762.4	766.14	-0.49056	1705.1	1702.4	0.158348
796.66	798.29	-0.2046	1764.4	1764.9	-0.02834

Table 1: Natural frequency by Experiment, FE modal analysis and the percentage error in the numerical analysis.

Here in Table 1 the natural frequency by both the methods is shown, the percentage error value is important, as we are come to know about the deviation of results of numerical analysis from the experimental values.

The resulting natural frequencies from of both the experimental and FE modal analysis are matching except the FE natural frequencies 329.01 and 1545.7 which are deviating by more than 5% of the experimental values.

The percentage error is graphically presented in Figure 9 as follows,

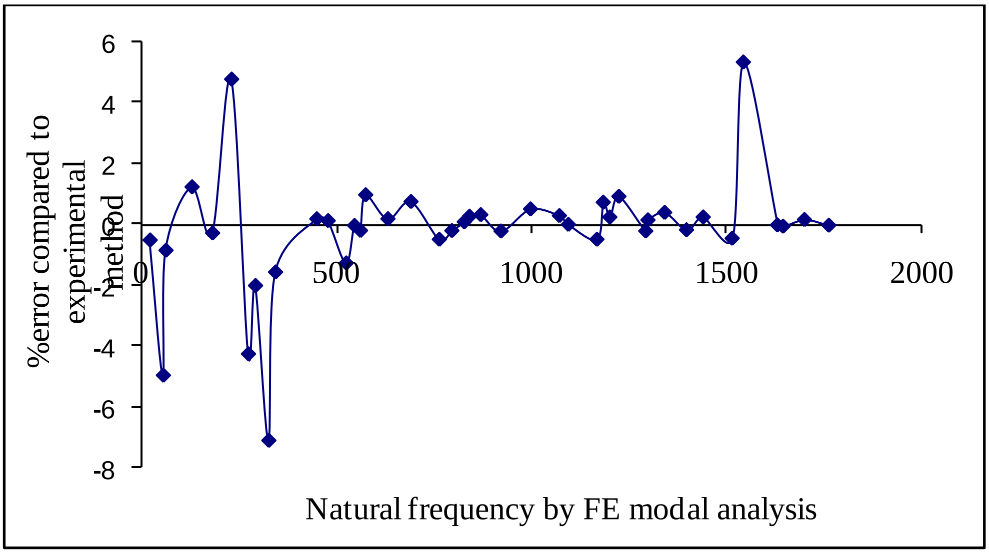


Figure 9: Percentage error in natural frequency obtained by FE modal analysis & experiment.

CONCLUSION

The natural frequencies determined by the FE modal analysis are closely matching the frequencies determined experimentally. Except the FE natural frequencies 329.01 and 1545.7 Hz deviating by more than 5% of the experimental values, all values are in close matching.

REFERENCE

ANSYS modal analysis tutorials.