International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 06 | June -2017 www.irjet.net p-ISSN: 2395-0072

Finite Element Analysis, Harmonic Analysis and Modal Analysis of the Car Floor by Using With and Without Stiffener

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Abstract - *This project is concerned with the finite element modal analysis and experimental modal analysis of an automotive car floor. To improve ride quality and comfort zone for the passengers and to extend fatigue life of car floor component under study condition. The main objective is to determine and compare the vibration characteristics like frequencies, mode shapes and damping factors of an automotive car floor using both FEM and FFT analyzer techniques. The development of an automotive car floor structure under the constraint of vibration behavior is explored by using FEM and FFT analyzer method.*
First, car floor geometry is modeled in CATIA and meshed in HYPERMESH software. Then, a free-free modal analysis is done by using Optistruct as a solver. To get results of frequencies and mode shapes.
Second, modal analysis is done experimentally through FFT analyzer to obtain the results of frequencies, mode shapes and damping factor.
Third, to control the vibration one of the methods used to changing frequency of the system by adding stiffener to automotive floor structure, again free-free modal analysis is done in both FEM and FFT analyzer method with stiffener condition. And compare the results obtained.

Key Words: FEM, FFT Analyzer, Hyper-mesh, car floor, free -free modal analysis

1. INTRODUCTION

Now a day's vibration concept was involved in human activities in one form or other. In recent technology and development we have seen many engineering applications regarding with vibration like design of machines and machine components, foundations, structures, engines, turbines and control systems.
Most of the machines have vibration difficulties due to unbalance faulty designs and poor manufacturing. Due to this reason the machine component subjected to vibration can fail because of material fatigue resulting from the cyclic variation of the induced stress.

Vibration causes more wear and tear of machine parts such as bearings and gears and also creates an excessive noise. Although the frequency of vibration of a machine or machine structure coincides with the frequency of the external excitation it occur a resonance which results to excessive deflections and failure of a structure.

2. METHODOLOGY

The methodology of experimentation of flow chart is shown in figure.1.

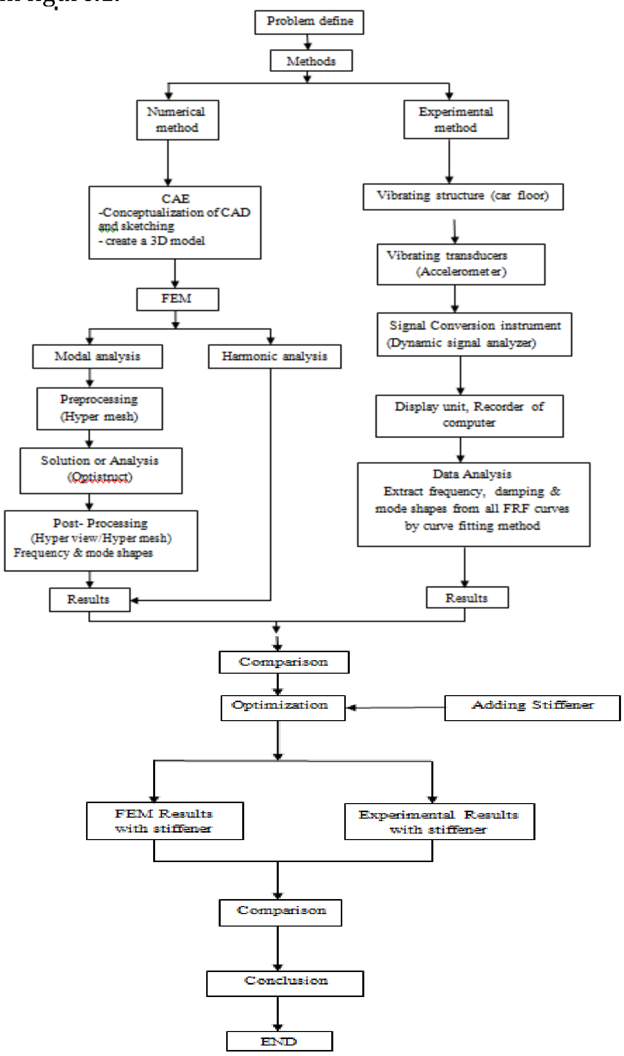

Figure.1. Methodology flow chart

GEOMETRIC MODEL

Catia V5 software is used to create the geometric model of floor of a car as shown in Figure.2

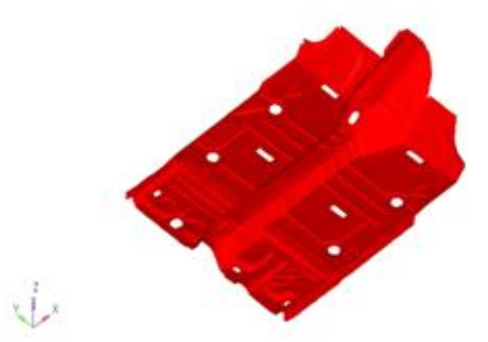

Figure.2. 3D view of geometric model of the floor of a car

FINITE ELEMENT MODEL

Meshing is carried out in Hyper- mesh software. The meshed or FE model is as shown in Figure.3

Figure.3. Meshed or FE model of the floor of a car

Table.1. General Statistics of meshed car floor

Sl. No.	Type of element	No of element
1	CQUAD4	18989
2	CTRIA3	893
	Total	19882

Nodes(Grids)	19862
Elements	19882
Mesh Type	P-SHELL
Analysis Type	Free un-damped vibration Analysis

LOADS AND BOUNDARY CONDITIONS

In the free - free analysis there are no loads and boundary conditions.

EXISTING MODEL

The modal analysis is done for floor component in terms of without stiffener and with stiffener to study the maximum displacement, minimum displacement and frequency occurs. The Figure.4 shows the floor component having free free condition and without stiffener.

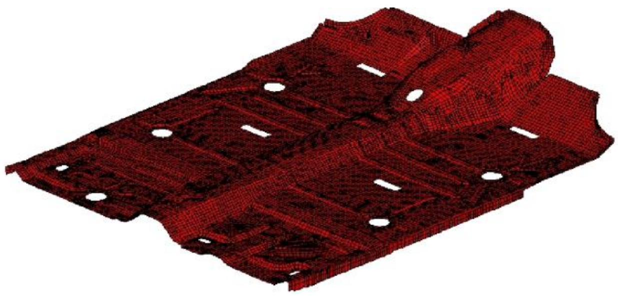

Figure.4. meshed floor component in free - free condition and without stiffener

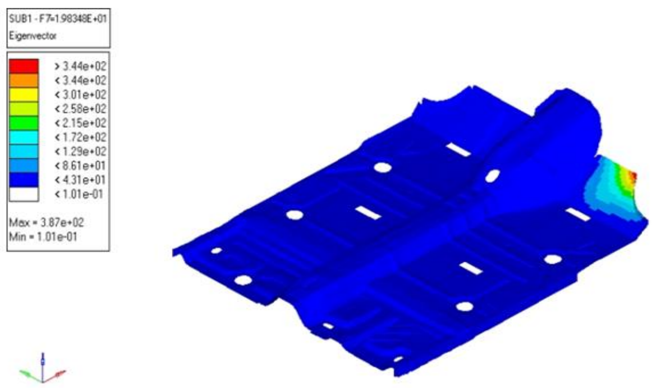

Figure.5. Mode 7th for free -free boundary condition without stiffener

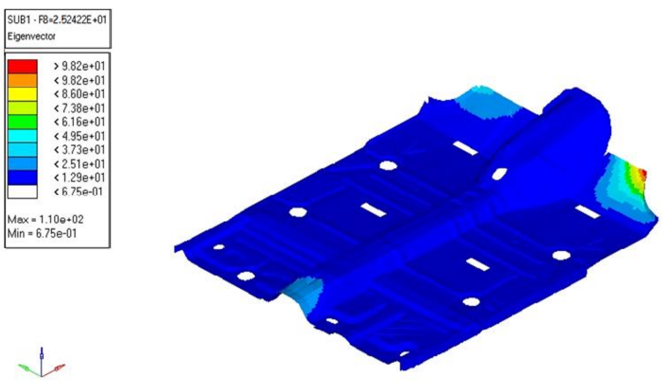

Figure.6. Mode 8th for free - free boundary condition without stiffener

Table.2. The frequencies and displacement of without stiffener condition

Mode No	FE Method Without stiffener	
	Frequency in Hz	Maximum displacement in mm
7	19.83	387
8	25.24	110
9	31.58	236
10	33.14	349
11	50.74	52.8

Table.3. The frequencies and displacement of with stiffener condition

Mode No	FE Method With stiffener	
	Frequency in Hz	Maximum displacement in mm
7	25.69	39.4
8	43.89	22.2
9	50.73	317
10	56.82	206
11	79.38	131

The floor component having free- free condition and with stiffener material used in the component is steel and having thickness of 10mm with welded at all four ends of the component.

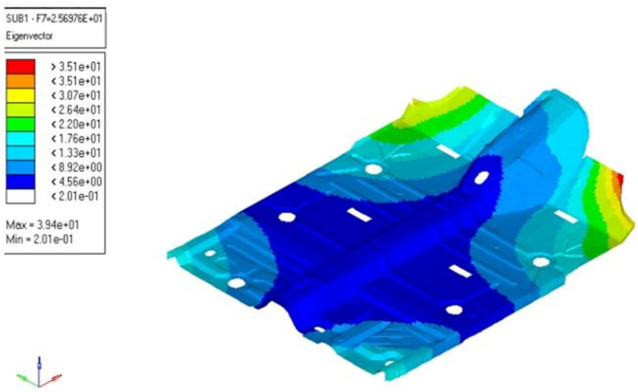

Figure.7. Mode 7th for free - free boundary condition with stiffener

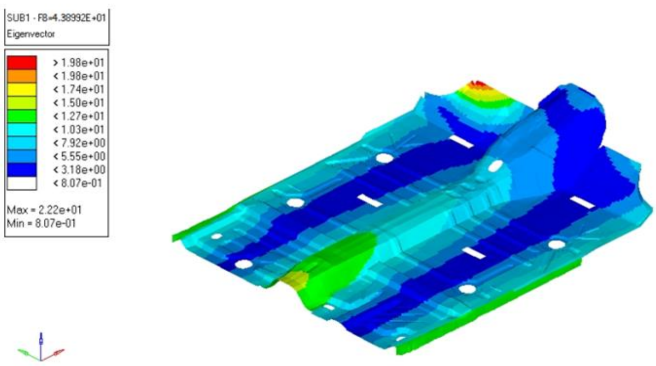

Figure.8. Mode 8th for free - free boundary condition with stiffener

3. EXPERIMENTAL MODAL ANAYSIS

Figure.9. The floor component of a car hanged freely

i. To prepare the test specimen of automotive car floor first to measure the length and breadth of floor structure and divided into 50mm x 50mm grids with a total number of node points from 1 to 155. The floor is hanged or suspended by 7 elastic ropes for free- free analysis condition. The accelerometer is located into the right location point for the set of FRFs dimension. The accelerometer is attached to the second channel of the signal analyzer in order to trace the response of the floor structure. The accelerometer is fixed to floor at node 7.

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ii. Care should be taken to make connections of the signal analyzer, laptop, accelerometer and impact hammer.

iii. Switch on the power supply, open the ME' Scope software give the required inputs and required settings in the software. Ensure that there is proper supply and interactions between the devices are connected.

iv. We have given impacts by the impact hammer on the nodes marked on the floor structure one by one. Accelerometer is connected at node 7. Hits all the points from 1 to 155. Signals from the impact hammer and accelerometer is transferred to the dynamic signal analyzer for each impact given one by one and will be compared and analyzed by the ME' Scope software. The software generates the frequency response function to find the frequencies of the floor structure. Observe the graph marking frequencies corresponding to the peaks. The peaks correspond to the frequencies.

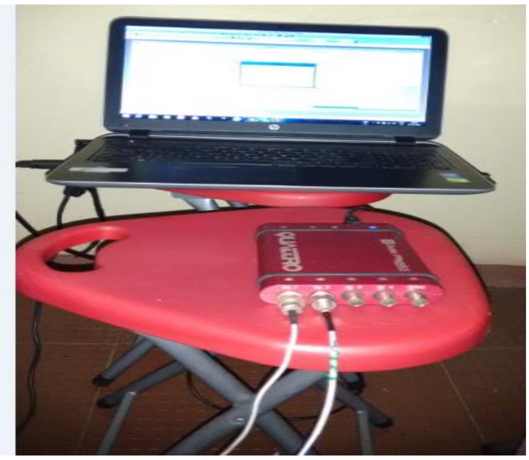

Figure.10. The arrangement of experimental analysis

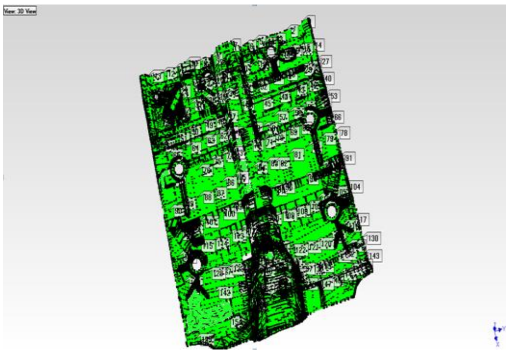

Figure.11. The nodes applied or marked on the surface of floor component

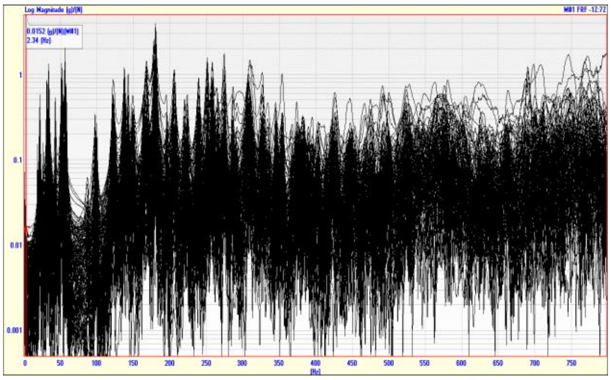

Figure.12. The combination of all frequencies occurred at different points

Figure.13. The floor component hanged freely using hangers without stiffener

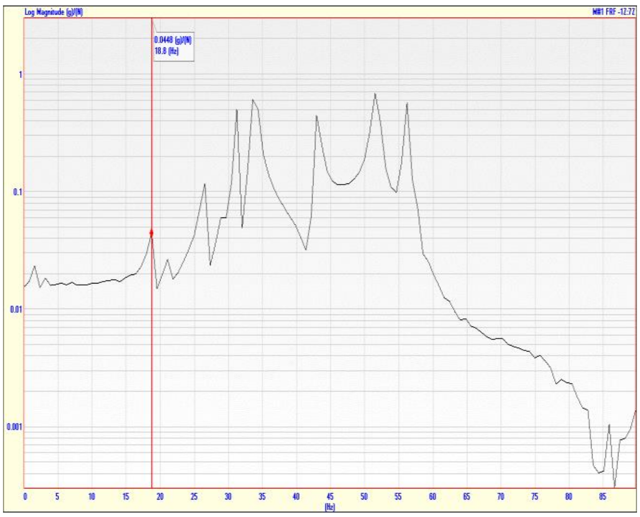

Figure.14. Mode 7th on free - free condition without stiffener

Table.4. The frequencies of without stiffener condition

Mode No	Experimental analysis without stiffener
	Frequency in Hz
7	18.6
8	21.7
9	26.4
10	31.3
11	33.9

Figure.15. The floor component with stiffener

Figure.16. Mode 7th on free - free condition with stiffener

Table.5. The frequencies of with stiffener condition

Mode No	Experimental analysis With stiffener
	Frequency in Hz
7	22.82
8	42.7
9	47.3
10	54.7
11	78.2

4. RESULT AND DISCUSSION

Table.6. The comparison of FE Method and experimental modal analysis with stiffener

Mode No	FEM	Experimental
	Frequency in Hz	Frequency in Hz
7	25.69	22.82
8	43.89	42.7
9	50.73	47.3
10	56.82	54.7
11	79.38	78.2

Table.7. The comparison of FE Method and experimental modal analysis of without stiffener

Mode No	FEM	Experimental
	Frequency in Hz	Frequency in Hz
7	19.83	18.6
8	25.24	21.7
9	31.58	26.4
10	33.14	31.3
11	50.74	33.9

Table.8. The comparison of with and without stiffener of FE Method

Mode No	FE Method	
	Without stiffener	With stiffener
7	19.83	25.69
8	25.24	43.89
9	31.58	50.73
10	33.14	56.82
11	50.74	79.38

Table.9. The comparison of with and without stiffener of experimental modal analysis

Mode No	Experimental analysis	
	Without stiffener	With stiffener
7	18.6	22.82
8	21.7	42.7
9	26.4	47.3
10	31.3	54.7
11	33.9	78.2

Fixed –fixed mode without stiffener

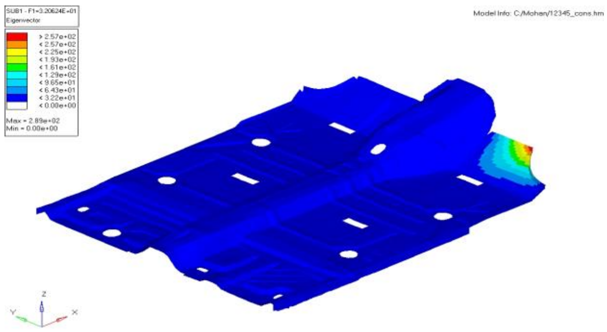

Figure.17. Mode 1st for fixed boundary condition without stiffener

Table.10. The frequency values of fixed - fixed mode without stiffener

Mode No	Fixed - fixed mode without stiffener	
	Frequency in Hz	Displacement in mm
1	32.06	289
2	43.81	196
3	55.47	106
4	72.63	26
5	79.04	26.3
6	81.60	62.9

Fixed - fixed mode with stiffener

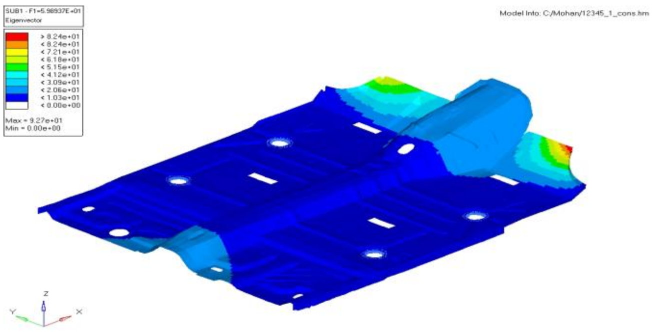

Figure.18. Mode 1st for fixed boundary condition with stiffener

Table.11. The frequency values of fixed - fixed mode with stiffener

Mode No	Fixed - fixed mode With stiffener	
	Frequency in Hz	Displacement in mm
1	59.89	92.7
2	71.37	191
3	82.39	120
4	102.05	32.5
5	106.75	65.6
6	113.27	66

Harmonic Analysis

Harmonic response analysis gives the ability to predict the sustained dynamic behavior of structures, thus it enabling to verify whether or not designs will successfully overcome resonance, fatigue and other harmful effects of forced vibrations.

Simple harmonic motion is the movement of a simple harmonic oscillator; the action is intermittent, as it repeats itself at regular intervals in a definite manner-described as being sinusoidal, with regular amplitude. The harmonic analysis is carried out by means of MSC Nastran which is described by its amplitude, its period which is the time for a single fluctuation, its frequency which is the number of cycles per unit time, and its phase, which decided the initial position on the sine wave. In words simple harmonic motion is “movement where the acceleration of a body is relative to, and reverses in direction to the displacement from its equilibrium position”. Simple harmonic motion can provide as a numerical form of a variety of motions and provides the foundation of the description of more difficult motions through the techniques of Fourier analysis.

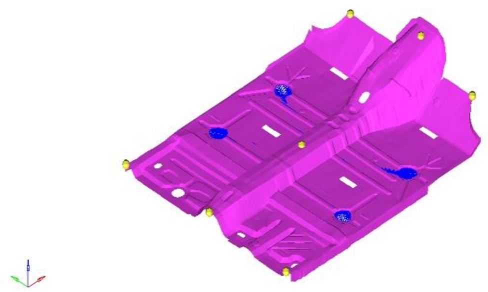

Figure.19. Image of Harmonic analysis for with stiffener condition

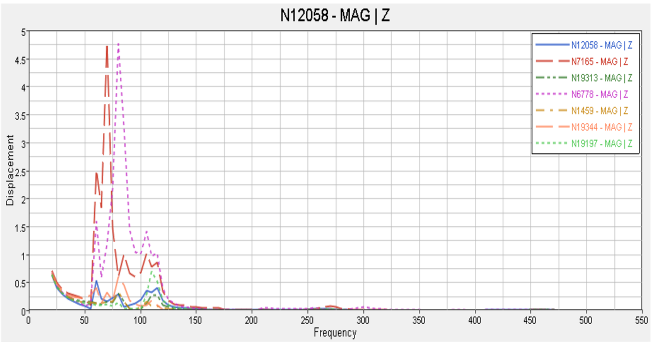

Figure.20. Simple harmonic analysis is performed in fixed- fixed modes with stiffener
Displacement Vs Frequency

Table.12. Displacement and Frequency

	With stiffener
Frequency (Hz)	59.89
Displacement (mm)	92.7

The simple harmonic analysis chart evaluates the fixed-fixed mode shape frequency values. The key material properties that are relevant to safeguarding cost and structural performances are density, young’s modulus and poison’s ratio.

5. CONCLUSIONS

The structural vibration excitations of automotive vehicle are caused by many different sources. In our project we have consider one of the key element of automotive vehicle that is automotive floor model vibration excitation under free condition. Firstly the modeling is accomplished for the automotive floor model in CATIA and meshed in HYPERMESH then the FEM modal analysis were carried out using optistruct as a solver. And experimental modal analysis was conducted using FFT analyzer. To obtained the results of modal parameters by FEM and FFT analysis of without stiffener condition. To validate the FEM results with FFT analysis results. To improve the modal parameters by adding stiffener in the form T-section are welded on the deterministic supplementary vibration floor area. Again both FEM and FFT analysis was conducted of with stiffener condition. Finally obtained the results and it’s validated. In addition to this fixed or clamped modal analysis is done by Optistruct and harmonic analysis is done by MSC NASTRAN.

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