Resonance Prevention in Truck Body through Structure Design Modification - Result Discussion

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Abstract

The major amount of worldwide transportation is done by using automobiles. In automotive industries truck chassis are designed as per the design standards but the bodies manufactured by various manufacturers are designed without standard design considerations. In India there is huge market of these manufacturers. These bodies are manufactured as per their loading capacity, there is no standardization of design considering engine vibrations and dynamic performance. Truck bodies manufactured without design standards are unsafe for dynamic performance. The body is excited by dynamic force induced by the engine. Under such dynamic excitations, the body tends to vibrate at some frequency, as truck engine operating rpm range is between 900rpm to 3000rpm. Because of engine, truck body undergoes vibration range between 15Hz to 50Hz. Whenever the natural frequency of vibration of a truck body structure coincides with the frequency of the external excitation induced by engine, there occurs a phenomenon known as resonance, at resonance drastic increase in deflection occurs which leads to excessive deflections and failure of the truck body structure. Hence there exists a need for the industry sector to modify the design of dump truck body structure which allows dump truck body to withstand safe between engine excitation frequencies and simultaneously improvising the strength, reducing weight, and prolonged operational life.

Keywords: Truck Body, Modal Analysis, Frequency Response Analysis, FEA

I. Introduction

The vehicle vibration is an unwanted effect. It causes many difficulties i.e. increases in fuel consumption, damages to elements of vehicles and causes vibration of roadside buildings. It is also one of the sources of noise disturbance for people. For driving safety and comfort it is very important what kind and values of vibration transfers from road to car body.

A. *Objective*

The main objectives of the work is

- To perform FEA analysis(natural frequency) of the Truck body
- To identify the areas on the body where the resonance is occurring.
- To alter the design of these areas so as to avoid resonance.

B. *Methodology*

Various steps involved in study of nonstandard design of truck body are:

- Data accumulation: TATA TRUCK2515 body selected for the analysis. From a local manufacturer all design data related to dimensions of existing nonstandard design truck body obtained. With the help of vernier caliper measured the thickness of all components and connection between components studied.
- CAD model generation: As per design data obtained, a cad model generated by using CAD software Solid works. Proper connections created in CAD model as per the data collected from manufacturer.
- Finite Element Model generation: A finite element model of truck body has generated using CAD model in hyper mesh. As per geometry dimensions suitable element configurations used for meshing. Mesh was generated according to the set criteria. Material and elemental properties was assigned to the mesh and proper constraints and forces applied to the mesh model for analysis purpose.
- Modal analysis of the truck body using FEA: We perform modal analysis, for finding the mode shapes and the different vibrating frequencies. For this purpose we formed two load collectors: spc & eigrl .lay the constraint to the model and process it for solver.
- Static analysis of the truck body using FEA: we perform static analysis, for finding displacement for applied load. For this purpose we form 2 load collectors: 1 spc & force. Lay the constraint to the model and process it for solver.
- Identifying the areas of resonance: By carrying out frequency response analysis we obtained maximum resonance location, amplitude and displacements at frequency range of truck engine excitation.

– Altering the design of these areas. Since there was a scope for optimization in the model, we took iterative steps and changed the thickness of various components where resonance was maximum. Again modal, static and frequency response analyses were done

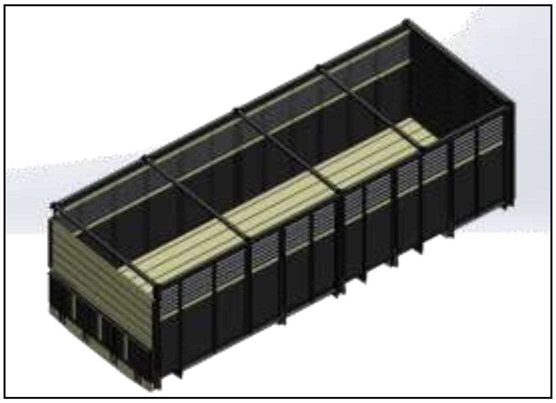


Fig. 1: Components

II. Analysis

A. Loading

The truck body is loaded with static forces from the material it carry. The load carrying capacity of the truck is 18 tons. Thus forces exerted = weight*9.81. Assuming that:

- 100 % of the forces acts at the bottom
- 10% on the sides
- 15% on the front

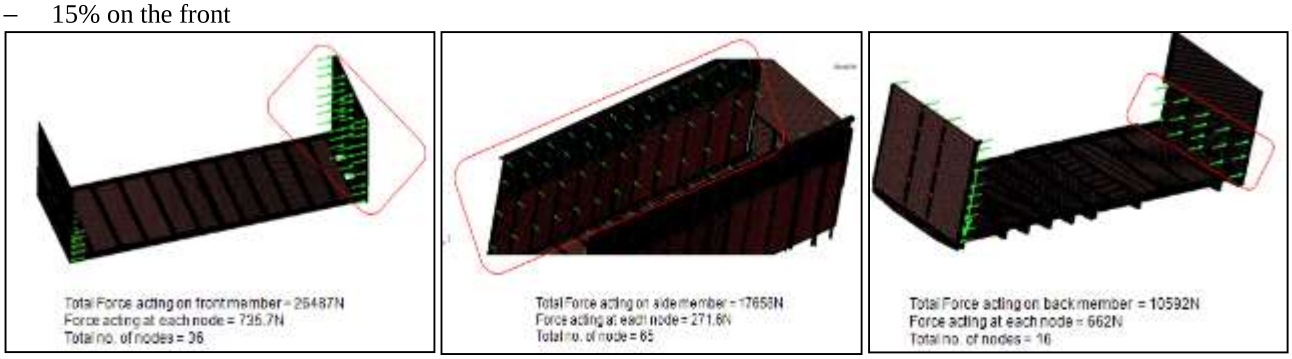


Fig. 2: Truck Body Components

B. Solution

1) F.E Results (Modal)

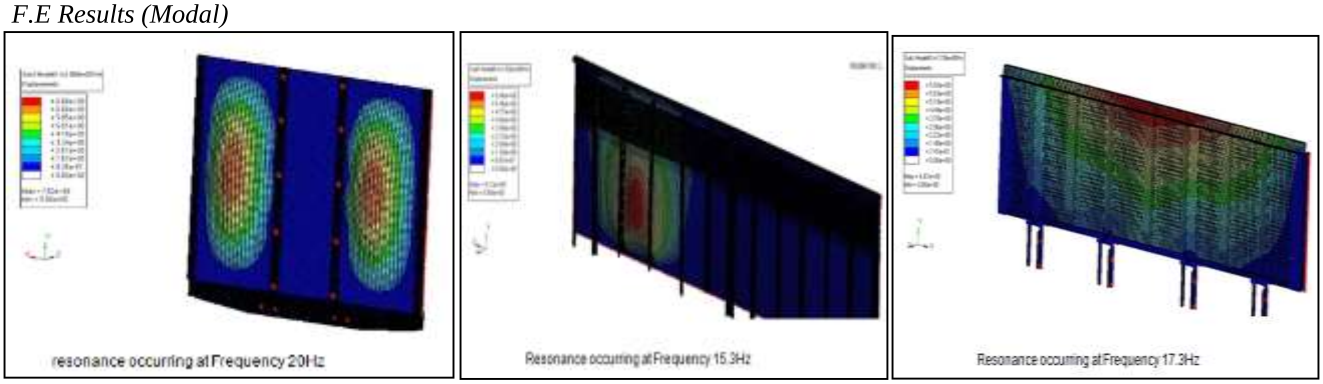


Fig. 3: F.E Results (Modal)

2) *F.E Results (Static)*

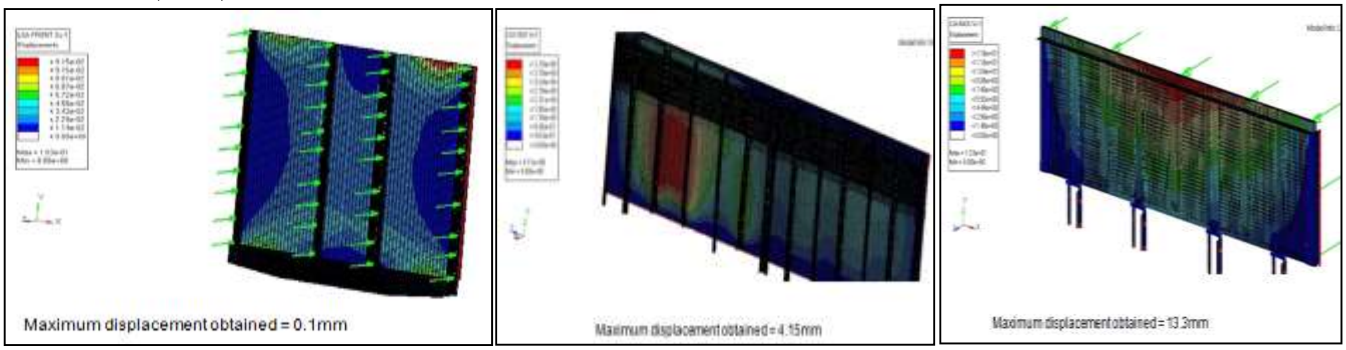
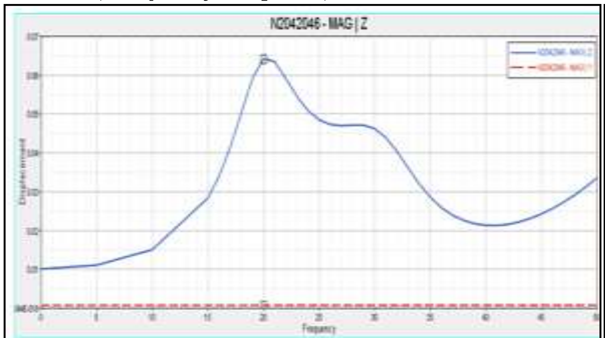


Fig. 4: F.E Results (Static)

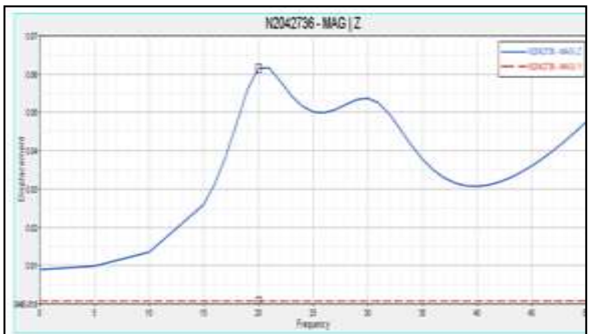
3) *F.E Results (Frequency Response)*



Maximum original displacement at resonance location at node id:2042046 is 0.065mm

NODE 2042046

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	0.01	31	0.044
5	0.011	32	0.04
10	0.016	33	0.036
15	0.028	34	0.032
16	0.034	35	0.028
17	0.041	36	0.026
18	0.05	37	0.024
19	0.06	38	0.023
20	0.0645	39	0.022
21	0.064	40	0.021
22	0.06	41	0.021
23	0.055	42	0.021
24	0.05	43	0.022
25	0.048	44	0.027
26	0.047	45	0.024
27	0.047	46	0.0255
28	0.0475	47	0.027
29	0.0475	48	0.029
30	0.046	49	0.032
		50	0.034

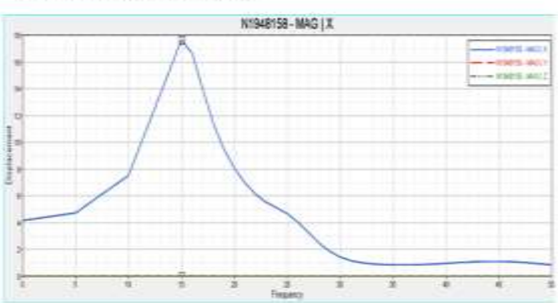


Maximum original displacement at resonance location at node id:2042736 is 0.061mm

NODE 2042736

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	0.01	31	0.052
5	0.011	32	0.05
10	0.013	33	0.045
15	0.026	34	0.042
16	0.031	35	0.037
17	0.038	36	0.035
18	0.047	37	0.033
19	0.055	38	0.032
20	0.061	39	0.031
21	0.061	40	0.031
22	0.058	41	0.031
23	0.054	42	0.032
24	0.052	43	0.033
25	0.05	44	0.035
26	0.05	45	0.036
27	0.051	46	0.038
28	0.052	47	0.04
29	0.053	48	0.041
30	0.054	49	0.045
		50	0.047

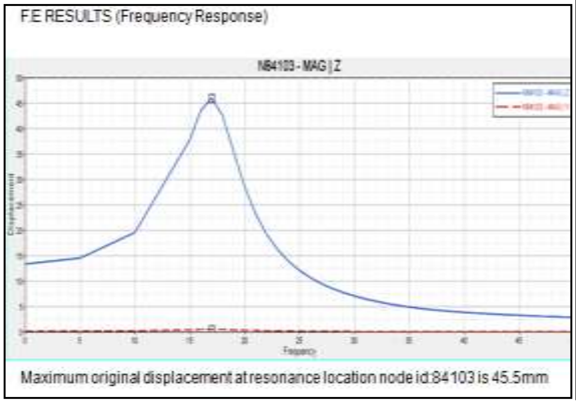
F.E RESULTS (Frequency Response)



Maximum original displacement at resonance location node id: 1948158 is 17.8mm

NODE 1948158

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	4.15	31	1
5	4.7	32	1
10	7.7	33	1
15	17.8	34	1
16	16.8	35	1
17	14	36	1
18	11.5	37	1
19	9.5	38	1
20	8.1	39	1
21	7	40	1
22	6	41	1
23	5.5	42	1
24	5	43	1
25	4.5	44	1
26	4	45	1
27	3.2	46	1
28	2.5	47	1
29	1.9	48	1
30	1.4	49	1
		50	0.9



NODE 84103

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	13.5	31	6.5
5	15	32	6
10	20	33	05.5
15	37	34	5
16	43	35	5
17	45.5	36	4.8
18	42.5	37	4.7
19	35	38	4.6
20	27	39	4.6
21	23	40	4
22	20	41	4
23	16	42	4
24	14	43	3.1
25	12.5	44	3
26	10.5	45	3
27	9.5	46	3
28	8	47	3
29	7.5	48	3
30	07	49	3
		50	2.5

Fig. 5: F.E Results (Frequency Response)

C. *Modification (1) of Front Member*

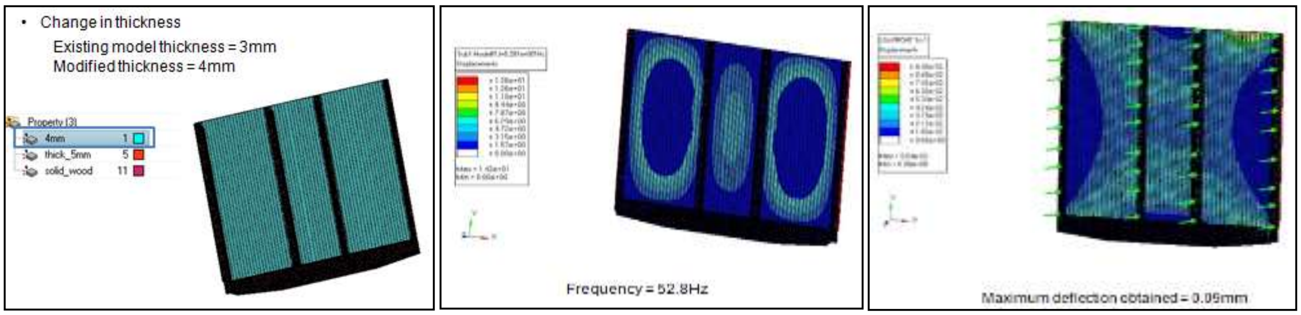
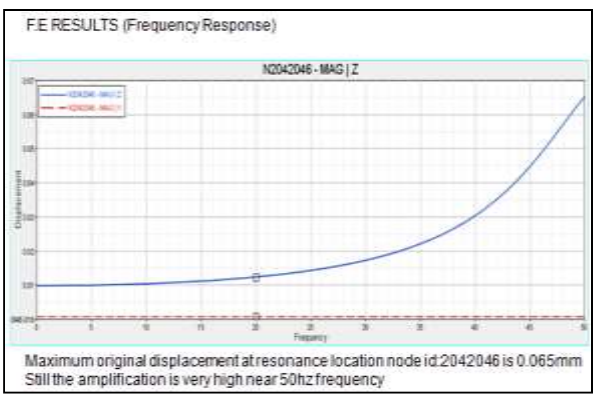
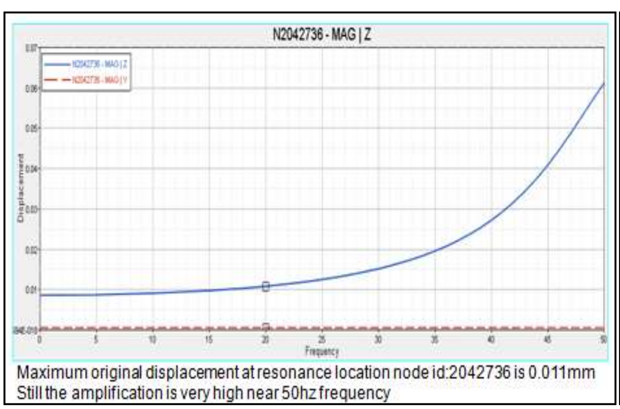


Fig. 6: Modification (1) of Front Member



NODE 2042046

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	0.01	31	0.0175
5	0.01	32	0.018
10	0.01	33	0.02
15	0.011	34	0.021
16	0.0112	35	0.022
17	0.0114	36	0.023
18	0.0116	37	0.025
19	0.0118	38	0.027
20	0.012	39	0.029
21	0.0123	40	0.03
22	0.0127	41	0.032
23	0.013	42	0.035
24	0.0135	43	0.037
25	0.014	44	0.042
26	0.0143	45	0.045
27	0.015	46	0.048
28	0.016	47	0.053
29	0.0165	48	0.057
30	0.017	49	0.061
		50	0.065

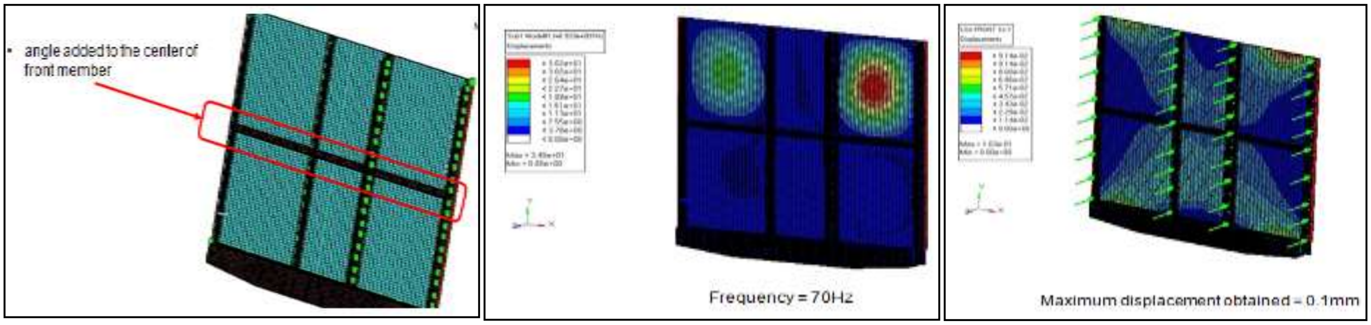


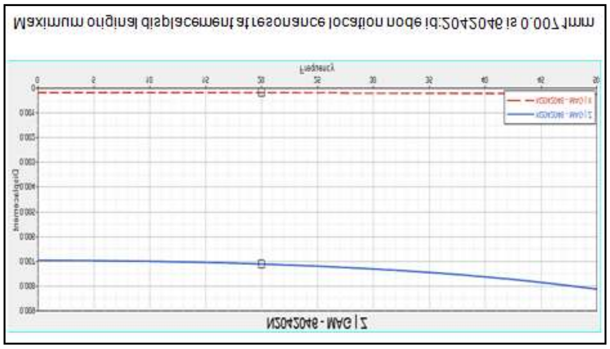
NODE 2042736

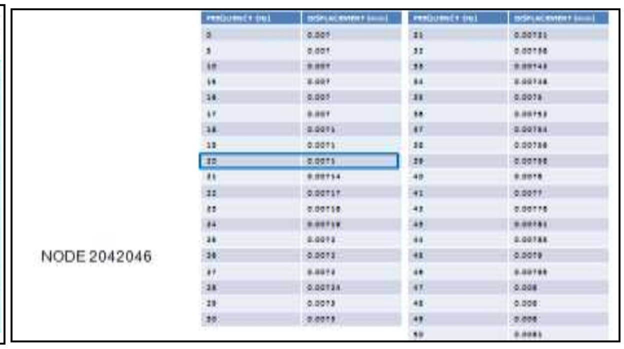
FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	0.008	31	0.0158
5	0.008	32	0.016
10	0.009	33	0.018
15	0.01	34	0.019
16	0.01	35	0.02
17	0.01	36	0.021
18	0.01	37	0.022
19	0.0105	38	0.023
20	0.011	39	0.025
21	0.0115	40	0.027
22	0.012	41	0.03
23	0.0123	42	0.033
24	0.0128	43	0.035
25	0.013	44	0.037
26	0.0134	45	0.041
27	0.135	46	0.045
28	0.014	47	0.049
29	0.0147	48	0.052
30	0.015	49	0.056
		50	0.062

Fig. 7: Modification (1) of Front Member

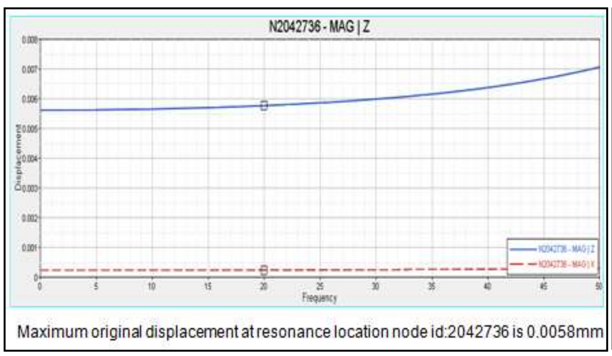
D. Modification (2) of Front Member

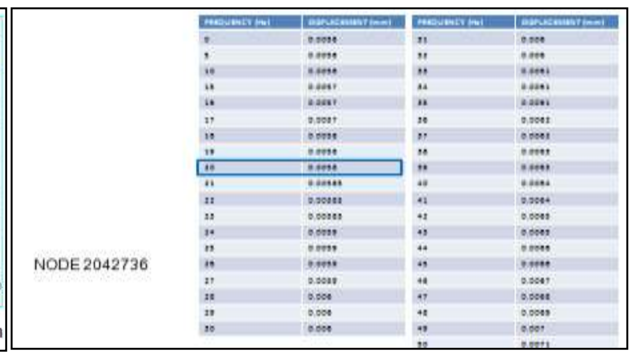





NODE 2042046

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	0.007	31	0.00731
5	0.007	32	0.00736
10	0.007	33	0.00743
15	0.007	34	0.00748
16	0.007	35	0.0075
17	0.007	36	0.00752
18	0.0071	37	0.00754
19	0.0071	38	0.00756
20	0.0071	39	0.00758
21	0.00714	40	0.0076
22	0.00717	41	0.0077
23	0.00718	42	0.00776
24	0.00719	43	0.00781
25	0.0072	44	0.00788
26	0.0072	45	0.0079
27	0.0072	46	0.00798
28	0.00724	47	0.008
29	0.0073	48	0.008
30	0.0073	49	0.008
		50	0.0081

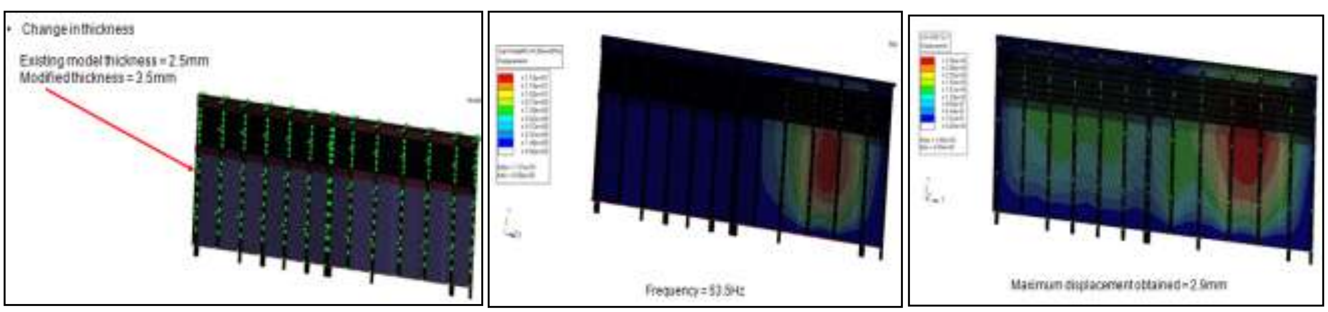


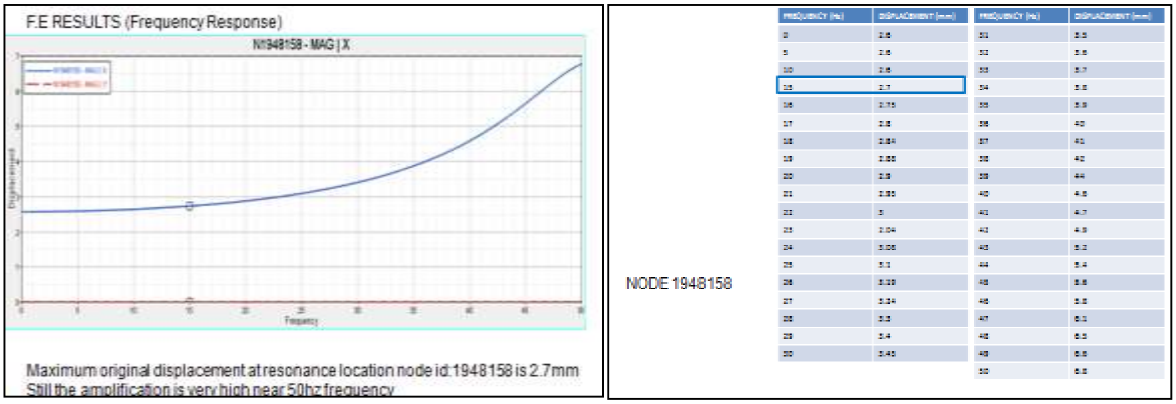

NODE 2042736

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	0.0056	31	0.006
5	0.0056	32	0.006
10	0.0056	33	0.0061
15	0.0057	34	0.0061
16	0.0057	35	0.0061
17	0.0057	36	0.0062
18	0.0058	37	0.0062
19	0.0058	38	0.0062
20	0.0058	39	0.0063
21	0.00585	40	0.0064
22	0.00582	41	0.0064
23	0.00583	42	0.0065
24	0.0059	43	0.0065
25	0.0059	44	0.0066
26	0.0059	45	0.0066
27	0.0059	46	0.0067
28	0.006	47	0.0068
29	0.006	48	0.0069
30	0.006	49	0.007
		50	0.0071

Fig. 8: Modification (2) of Front Member

E. Modification (1) of Side Member

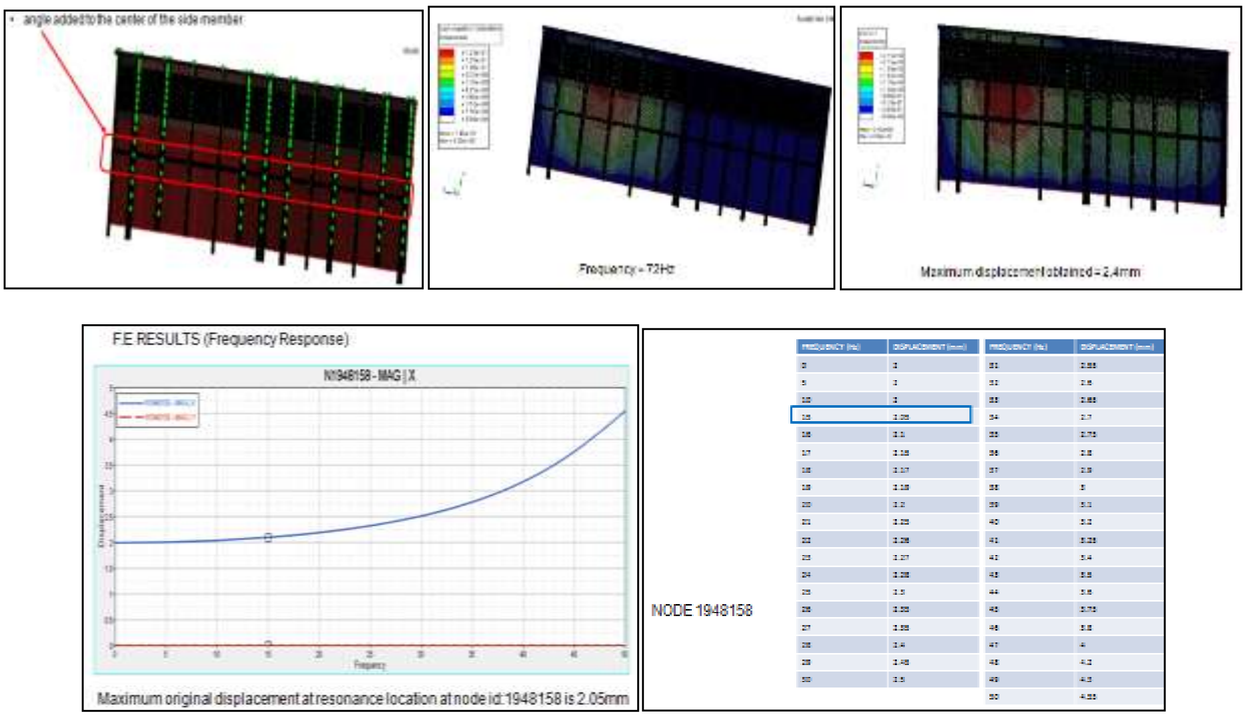




FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	2.6	31	3.5
5	2.6	32	3.6
10	2.6	33	3.7
15	2.7	34	3.8
16	2.75	35	3.9
17	2.8	36	4.0
18	2.84	37	4.1
19	2.88	38	4.2
20	2.9	39	4.4
21	2.95	40	4.6
22	3	41	4.7
23	3.04	42	4.9
24	3.08	43	5.2
25	3.1	44	5.4
26	3.19	45	5.6
27	3.24	46	5.8
28	3.3	47	6.1
29	3.4	48	6.5
30	3.45	49	6.8
		50	6.8

Fig. 9: Modification (1) of Side Member

F. *Modification (2) of Side Member*

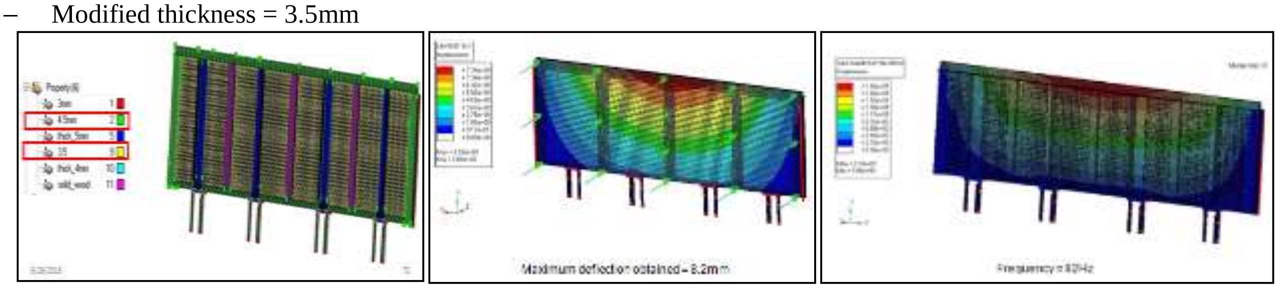


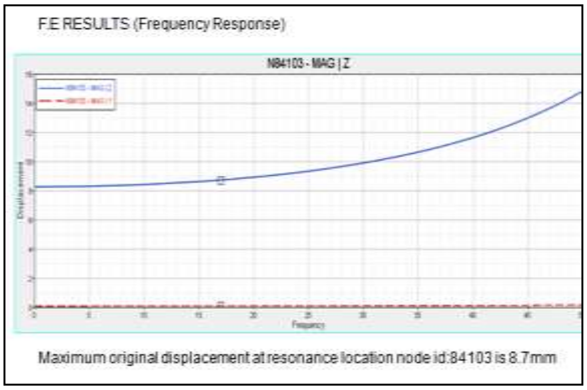
FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	2	31	2.55
5	2	32	2.6
10	2	33	2.65
15	2.05	34	2.7
16	2.1	35	2.75
17	2.15	36	2.8
18	2.17	37	2.9
19	2.19	38	3
20	2.2	39	3.1
21	2.25	40	3.2
22	2.26	41	3.25
23	2.27	42	3.4
24	2.28	43	3.5
25	2.3	44	3.6
26	2.35	45	3.75
27	2.38	46	3.8
28	2.4	47	4
29	2.45	48	4.2
30	2.5	49	4.3
		50	4.35

Fig. 10: Modification (2) Of Front Member

G. *Modification of Back Member*

1) Change in thickness of metal bar shown
   – Existing model thickenss = 3mm
   – Modified thickness = 4.5mm
2) Change in thickness of metal plate shown
   – Existing thickness = 2.5mm
   – Modified thickness = 3.5mm





NODE 84103

FREQUENCY (Hz)	DISPLACEMENT (mm)	FREQUENCY (Hz)	DISPLACEMENT (mm)
0	8.2	31	10
5	8.2	32	10.2
10	8.2	33	10.4
15	8.5	34	10.6
16	8.6	35	10.8
17	8.7	36	10.9
18	8.8	37	11
19	8.9	38	11.2
20	9	39	11.5
21	9	40	11.8
22	9	41	12
23	9.1	42	12.1
24	9.1	43	12.4
25	9.2	44	12.8
26	9.2	45	13
27	9.3	46	13.2
28	9.6	47	13.6
29	9.8	48	14
30	9.9	49	14.4
		50	14.9

Fig. 11: Modification of Back Member

III. RESULTS & DISCUSSION

At first, a careful study of the truck body carried out so as to get a better understanding of the problem. After that, suitable designs that could serve the purpose were selected from existing nonstandard designs. To find the natural frequencies and vibrating mode shapes, a modal analysis was carried out. Static analysis was carried out to obtain the displacements at zero frequencies. To identify the resonance area in truck body, a modal frequency response analysis was carried out. We obtained 3 natural frequencies in between engine excitation range are 15.3Hz, 17.3Hz and 20Hz at different locations. And natural frequencies of the body components, maximum resonating areas studied for design modification.

After this step design of the resonating area was improved by making slight alteration in thickness of resonance area to enhance its workability. Again modal, static and frequency response analyses were carried out to check the modified design for presence of resonance in truck body between truck engine operating frequencies. Truck body was improved further by making slight modifications in design to enhance its workability. Finally, analyses were carried out and the results were noted. We found resonance of the components shifted beyond the frequency range of our area of interest. Which means our truck body is now safe and standardize for dynamic performance through FEA.

IV. CONCLUSION

Thus through the Modal analysis we have found out the Four frequency which falls under the engine excitation frequency range of 15Hz to 50Hz, They are 19Hz, 21Hz, 23Hz and 34Hz, and we prevented resonance phenomenon and unusual body vibration and placed the natural frequencies beyond the excitation frequency range by reinforcing the parts that are participating in resonance through design changes.

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