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Durability Analysis of Automotive Seat Frame by Shape

Kyekwang Choi[*], Jaeung Cho[**,#]

[*]Department of Metal Mold Design Engineering, Kongju National UNIV.,
[**]Division of Mechanical and Automotive Engineering, Kongju National UNIV.

자동차 시트 프레임의 형상별 내구성 해석에 관한 연구

최계광[*], 조재웅[**,#]

[*]공주대학교 금형설계공학과, [**]공주대학교 기계자동차공학부

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ABSTRACT

The automotive seat appropriately absorbs the vibrations or shocks transmitted through a vehicle when it is in operation so as to provide a comfortable ride for passengers. In this study, the structural strength and durability of each model were investigated using structural analysis. The natural and critical frequencies at the seat were analyzed through vibration analysis. Through the results of this study on automotive seat frame models, the durability against the load and vibration is shown to be dependent on the configuration of the model.

Key words : Automotive Seat Frame(자동차 시트 프레임), Structural Strength(구조 강도), Natural Frequency (고유 진동수), Critical Frequency(위험 진동수)

1. Introduction

With the development at designing and ma nufacturing the human-centered vehicle at the automotive industry, the advanced technologies to reduce vibration and noise of vehicles have been developed rapidly. The automotive sheets situated closely with passengers become the important items for consumers who want to be satisfied with their own vehicle. In case of automotive seat, the vibration due to the road condition or the engine vibration is an important element influenced much on the ride comfort as these noises are directly transmitted to the passengers. In a vehicle, the automotive seat appropriately absorbs the vibrations or shocks transmitted when the vehicle is driven, by providing a comfortable ride for the passengers. On the other hand, a automotive seat has the role to protect the passengers against the collision of car. Recently, the automotive company has been striven to develop the eco-friendly car with high-efficiency because of the stricter environmental regulations. The weight of automobile inevitably increases in order to increase the vehicle performance. The automotive seat consists mainly of the head constraint, the back frame, the cushion frame and the seat support. An automotive

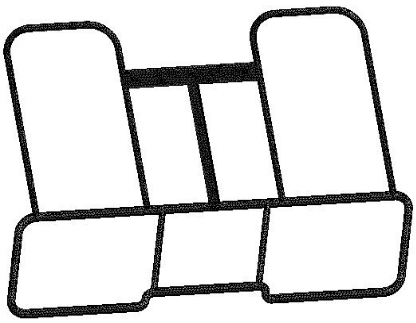
Corresponding Author : jucho@kongju.ac.kr
Tel: +82-41-521-9271, Fax:+82-41-555-9123

seat must be made in order to comply with many safety regulations for the safety of passenger. In this study, three kinds of seat frame models are designed by CATIA modelling. Also, the structural analyses[1-13] are carried out with ANSYS program and the vibration transferred from car seat is also analyzed. The natural frequencies and the critical frequencies at the seat are analyzed through vibration analysis. The strength[3,13] and durability[11] of each model are investigated through the structural analysis and vibration analysis[3,8].

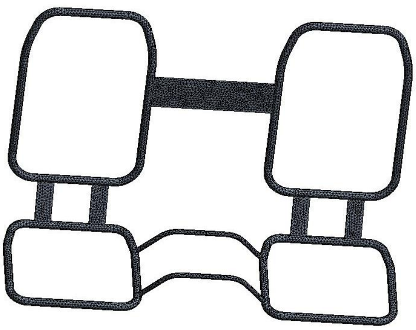
2. Study Model

2.1 Configuration of model

In this study, the models of car seat were designed like the real seat frames. For the analyses, the configurations with meshes on three models are shown by Fig. 1.



(a) Model 1



(b) Model 2

(c) Model 3

Fig. 1 Configurations of models with meshes

Table 1 Material property

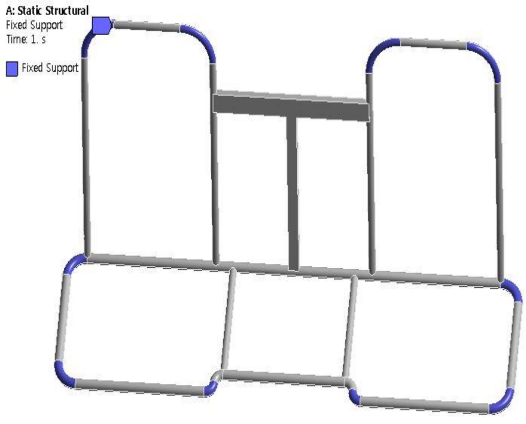
Intents	Values
Young's modulus	71000 MPa
Poisson's ratio	0.33
Density	2770 kg/m³
Tensile yield strength	280 MPa
Compressive yield strength	280 MPa
Tensile ultimate strength	310 MPa

The node numbers of meshes on models 1, 2 and 3 are 31925, 38879 and 36309 respectively. The element numbers of meshes on models 1, 2 and 3 are 31925, 38879 and 36309 respectively. The material property of aluminum alloy on all models is shown by Table 1.

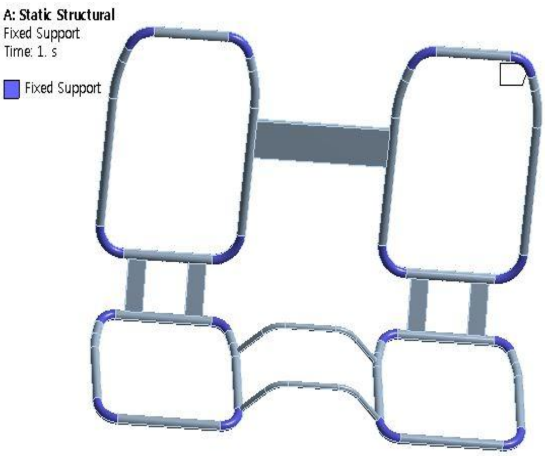
2.2 Boundary condition

Figs. 2 and 3 shows the boundary conditions of fixed and forced applications for the analyses at models 1, 2 and 3 respectively. Fig. 2 shows the fixed condition at each model. At models 1 and 2, the fixed conditions are applied to the floor and the edges of backrest parts. At model 3, the back and bottom are applied as the fixed conditions. Fig. 3 shows the forced condition at each model. The direction of the load is applied on the Z+ direction, assuming the force directed from the ground.

The force of 30000 N was applied on the direction from the underside of the vehicle in order to examine



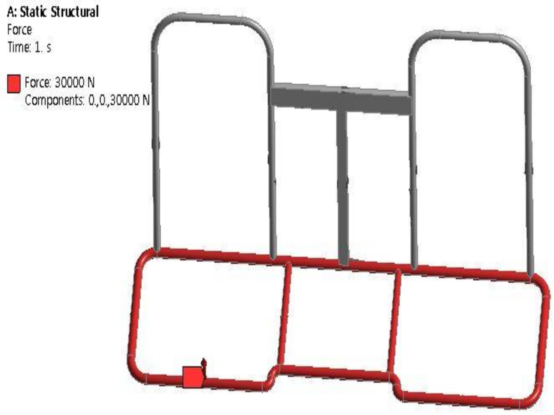
(a) Model 1



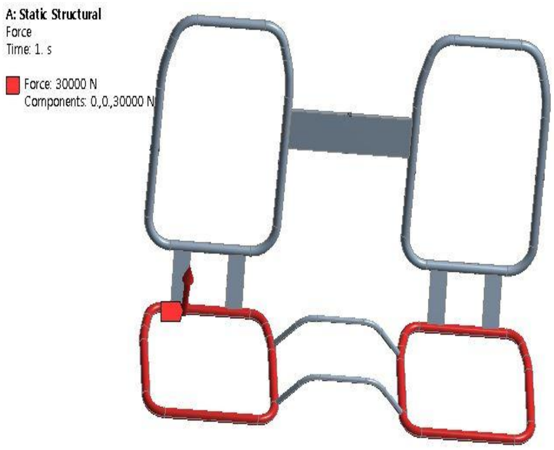
(b) Model 2

(c) Model 3

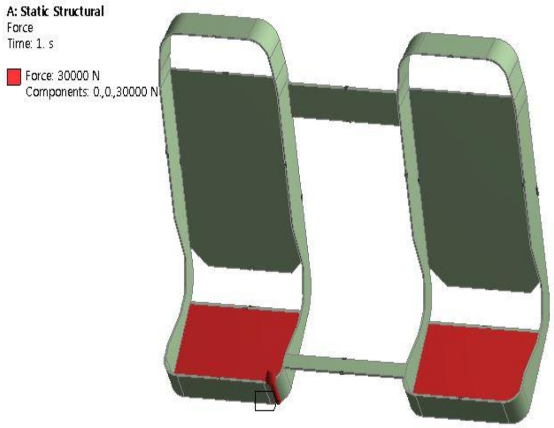
Fig. 2 Fixed condition at each model



(a) Model 1



(b) Model 2

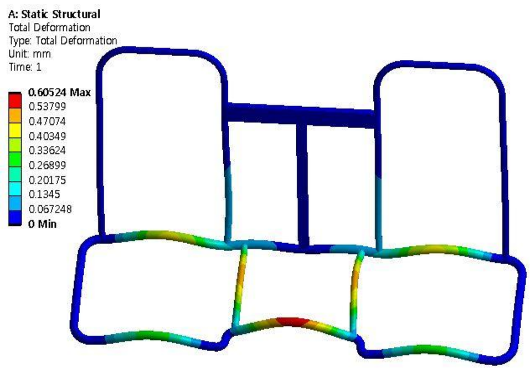


(c) Model 3

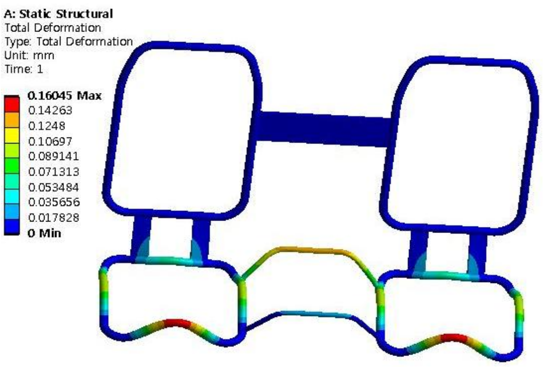
Fig. 3 Forced condition at each model

the maximum strength, since the direction of vibration and shock was usually due to the ground when the car was driven.

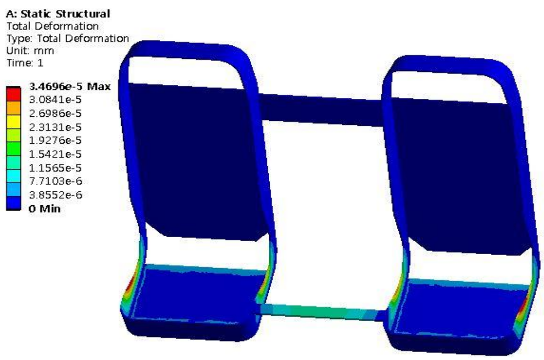
3. Analysis Result



(a) Model 1



(b) Model 2



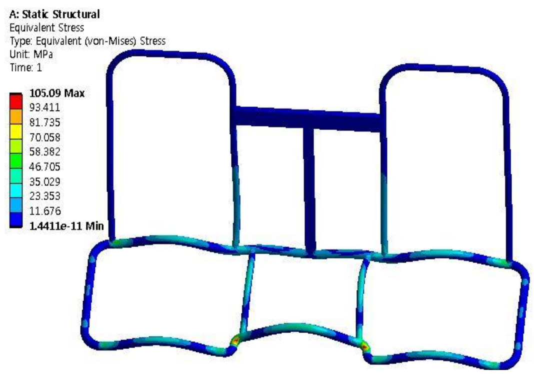
(c) Model 3

Fig. 4 Contours of total deformations by model

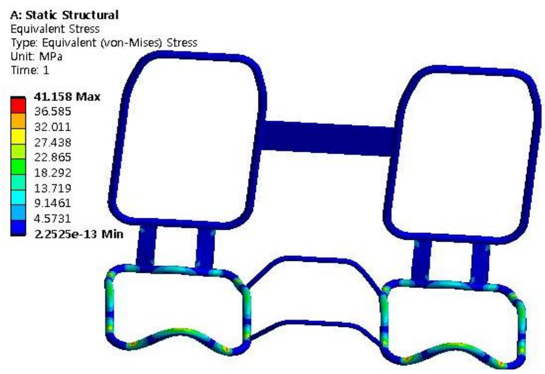
3.1 Structural analysis

As the result of structural analysis, Figs. 4 and 5 show the contours of the total deformations and equivalent stresses at models 1, 2 and 3.

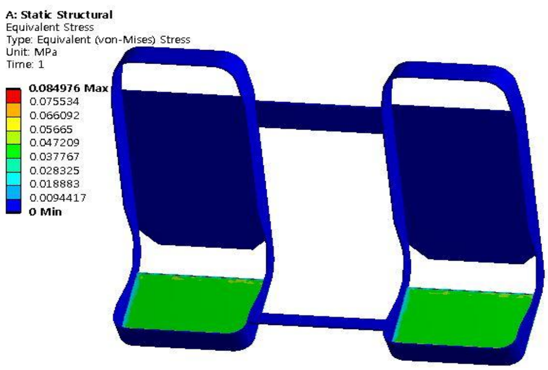
The maximum deformations at models 1, 2 and 3



(a) Model 1



(b) Model 2



(c) Model 3

Fig. 5 Contours of equivalent stresses by model

are 0.60524mm, 0.6045mm and 0.023378mm respectively. Also, the maximum equivalent stresses at models 1, 2 and 3 are 105.09 MPa, 41.158 MPa and 0.084976 MPa respectively. As the maximum stress or deformation is smaller in the order of models 3, 2 and 1, the structural strength is improved in the order of models 3, 2 and 1. So, model 3 is considered to have the best strength among three models.

Table 2 Natural frequencies and maximum total deformations by mode at model 1

Mode	Natural frequency(Hz)	Maximum total deformation(mm)
1'st	277.41	74.795
2'nd	277.53	74.816
3'rd	294.72	74.789
4'th	294.88	74.808
5'th	383.18	58.117
6'th	283.69	58.19

Table 3 Natural frequencies and maximum total deformations by mode at model 2

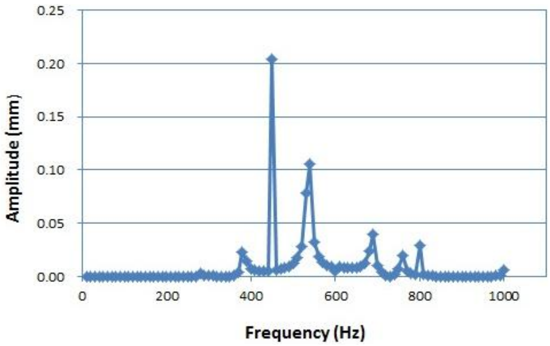
Mode	Natural frequency(Hz)	Maximum total deformation(mm)
1'st	284.19	105.6
2'nd	297.85	106.94
3'rd	477.66	62.467
4'th	477.86	62.472
5'th	546.91	63.452
6'th	547.07	63.455

Table 4 Natural frequencies and maximum total deformations by mode at model 3

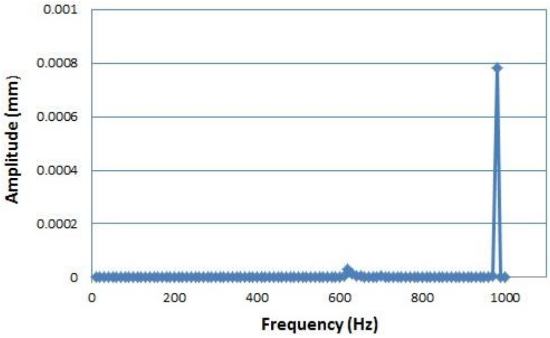
Mode	Natural frequency(Hz)	Maximum total deformation(mm)
1'st	240.09	71.085
2'nd	509.59	105.54
3'rd	509.78	105.56
4'th	512.43	108.46
5'th	513.26	108.58
6'th	565.68	103.91

3.2 Vibration analysis

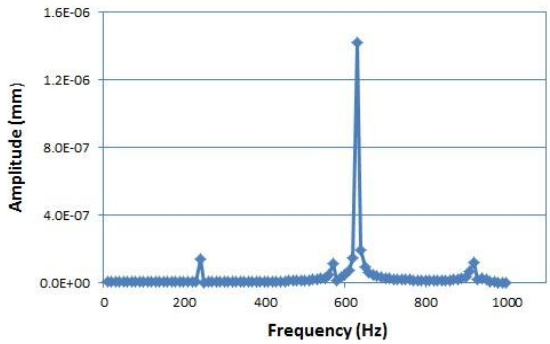
The vibration analyses by model were carried out in order to investigate the natural frequencies from modes 1 to 6 of the seat frame. In cases of models 1, 2 and 3, Tables 2, 3 and 4 show the natural frequency and maximum deformation at each mode.



(a) Model 1



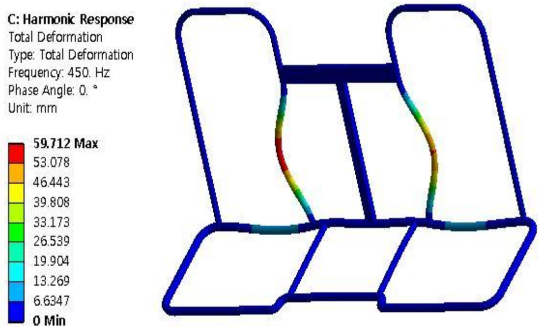
(b) Model 2



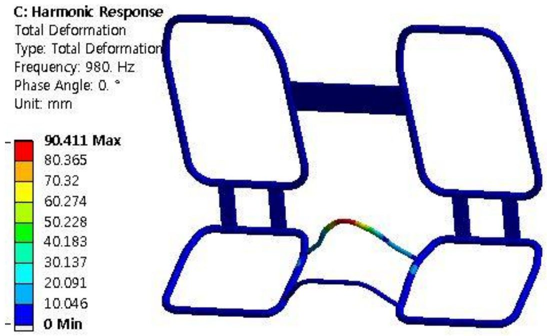
(c) Model 3

Fig. 6 Amplitude displacement due to frequency at harmonic response by model

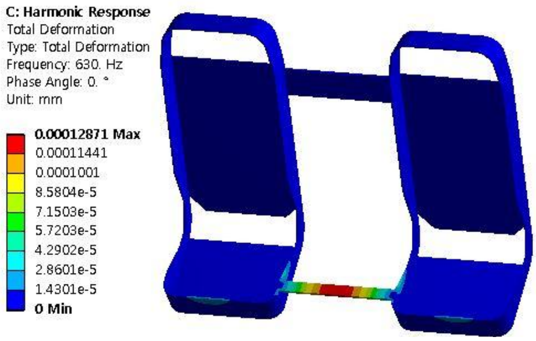
Overall, model 3 is seen to become strongest against resonance among three models in the largest range of natural frequencies. However, model 1 is seen as the weakest against resonance among three models for resonance in the smallest range of natural frequencies. Fig. 6 shows the amplitude displacement due to frequency at harmonic response by model. As the constraint conditions at structural analysis, the load was applied and fixed as shown by Figs 2 and 3. The actual load was supposed to be 300 N and the vibration range was set up until 1000 cycles. By comparing with the amplitude displacements for each



(a) Model 1

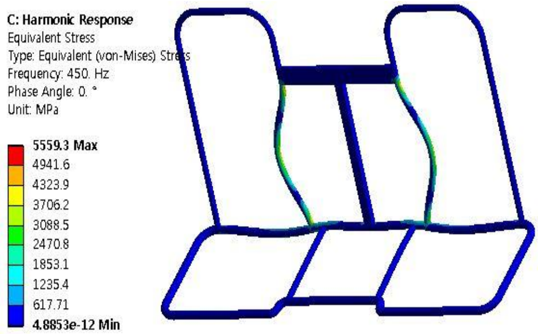


(b) Model 2

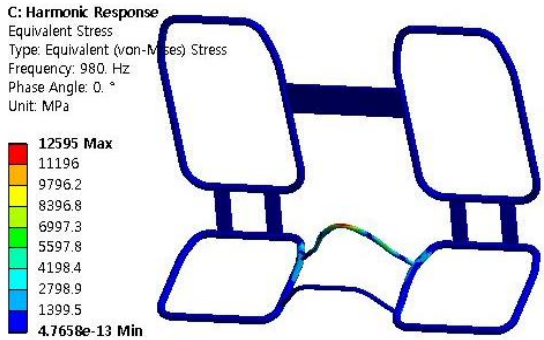


(c) Model 3

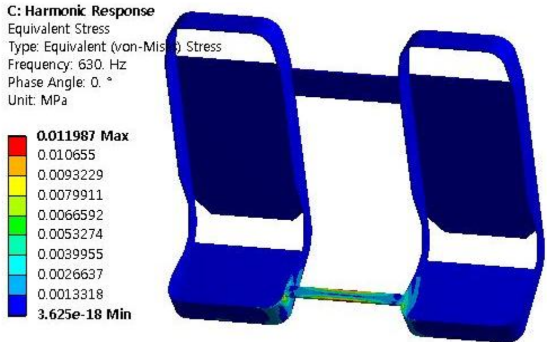
Fig. 7 Total deformations at critical frequencies by model



(a) Model 1



(b) Model 2



(c) Model 3

Fig. 8 Equivalent stresses at critical frequencies by model

model, the critical frequencies at the peak amplitude displacements at models 1, 2 and 3 were seen as 450 Hz, 980 Hz and 630 Hz, respectively. Also, the peak amplitude displacements at critical frequencies became 0.19618 mm, 0.14226 mm and 0.00338 mm, respectively. Among three models, model 3 is thought to have the least amount of displacement by making it the most durable against the actual vibration.

Figs. 7 and 8 show the contours of total deformations and equivalent stresses at the critical frequencies by model. Among three models, model 3 has the least total deformation and equivalent stress. So, model 3 is shown to have the most durability among all three models.

4. Conclusion

In this study, the structural analyses are carried out and the vibrations transferred from car seats are also analyzed. The results are obtained as follows;

1. As the maximum stress or deformation is smaller in the order of models 3, 2 and 1, the structural strength is improved in the order of models 3, 2 and 1. So, model 3 is considered to have the best strength among three models.
2. Model 3 is seen to become strongest against resonance among three models in the largest range of natural frequencies. However, model 1 is seen as the weakest against resonance among three models for resonance in the smallest range of natural frequencies.
3. By comparing with the amplitude displacements for each model, the critical frequencies at the peak amplitude displacements at models 1, 2 and 3 are examined. Among three models, model 3 is thought to have the least amount of displacement and equivalent stress by making it the most durable against the actual vibration.
4. Through the result of this study on the automotive seat frame models, the durability against the load and vibration is shown to become dependant on the configuration of model.

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