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Dimension Enhancement Design of Bracket for Strength Improvement of the Bus Bare Chassis in which Shape is Fixed

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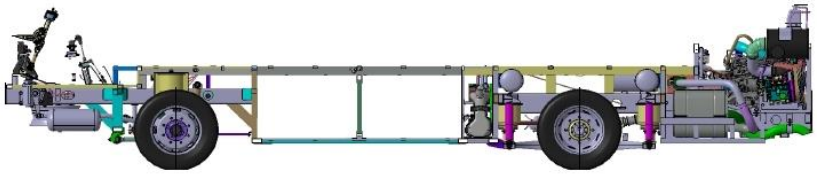
Abstract

One of the basic tasks in the automobile manufacturing process is to design a bare chassis, which is the basic frame of a vehicle, and a bracket is a member connecting various devices to the frame. Bracket, which is a member connecting the engine, transmission, and suspension, which are the core devices of driving and operating the vehicle, to the frame, must maintain safety during vehicle operation. If the bracket connecting the various devices constituting the vehicle to the frame does not have durability, serious accidents may occur during operation of the vehicle. In this study, we performed stress analysis on the brackets installed in the bare chassis of the 25-passenger bus in the development stage. Based on the stress analysis performed, an improved bracket dimension was proposed.

Keywords: *Dimension Improvement, Bracket, Bare Chassis, Stress Concentration, Stress Analysis*

1. Introduction

The most basic step in the construction of a vehicle is to construct a bare chassis. In the early stages of developing a commercial vehicle such as a bus, a bare chassis is designed. In the bare chassis, the bracket interlinking the mounting serving to keep the weight of the vehicle body with frame to frame is installed. Moreover, when the vehicle weight transfers in the acceleration and deceleration to frame, brackets interlinking attenuator are installed. Figure 1. represents the bare chassis of a 25-passenger bus in development.



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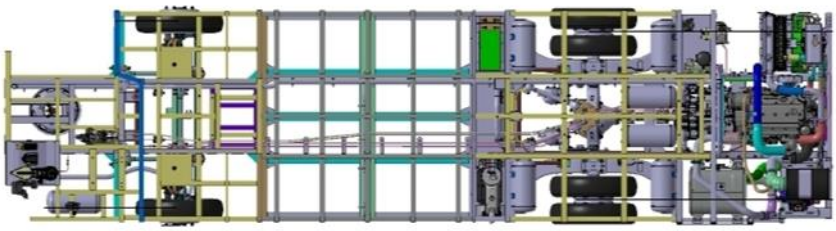


Figure 1. Bare chassis of developing bus

The content of the bare chassis of Figure 1. is shown in Figure 2. more specifically. In Figure 2, the upper part of bracket 1 is connected to a mounting that buffers the weight of the vehicle body, and is connected to the frame in two places on the side. It is also connected to an absorber that buffers the vehicle during deceleration and acceleration on the side, and is connected to bracket 3 at the end of the absorber. The bracket 2 is connected to a mounting that buffers the weight of the vehicle body, and the side surface is connected to the frame [1, 2]. Due to the shape limitation of the external manufacturer's design due to the bare chassis structure, the bracket was designed under these conditions.

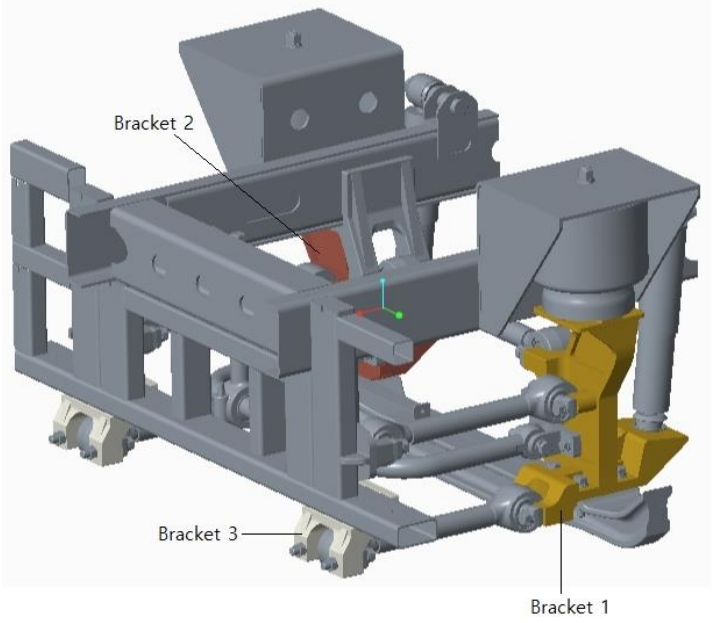


Figure 2. Brackets connected to the bare chassis

The shapes of the brackets in the bare chassis of the bus to improve the dimension design are shown in Figure 3. These brackets are connected to the bare chassis. The shapes of Figure 3. were used for modeling for stress analysis [3, 4]. The contents of the improvement of the dimension design focused on the existing bracket dimension rather than the change of the shape of the bracket [8, 9, 10].

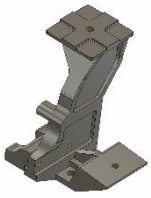
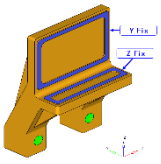
No.	Bracket 1	Bracket 2	Bracket 3
Figure			

Figure 3. Shape of brackets

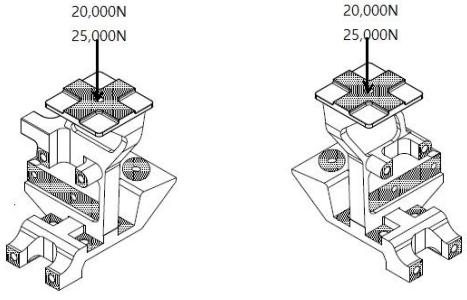
2. Stress analysis

In order to perform stress analysis on the bracket, the material should be selected first. The material of the bracket is composed of SC450, and the physical properties according to it are shown in the following table [11].

Table 1. Mechanical property of SC450(=SC46)

classification	SC450(=SC46)
elastic modulus [GPa]	200
poisson's ratio	0.29
limit of fatigue [MPa]	275
limit of yield [MPa]	350 ~ 550
limit of intensity [MPa]	650 ~ 880
elongation[%]	8 ~ 25

The finite element model for the stress analysis of the three brackets was used by Altair's Hyper-mesh 2017, and the solver used was Altair's Optistruct. In order to perform the stress analysis, the boundary conditions acting on the bracket should be analyzed. The boundary conditions classify the driving condition of the vehicle, calculate the load accordingly, and classify them into six categories as shown in the following figures [5, 6, 7]. Figure 4. is the load action of the vehicle body, Figure 5. is the load and braking of the vehicle body, Figure 6. is the unevenness passage, Figure 7. is the unevenness and braking, Figure 8. is the load, unevenness and acceleration of the vehicle body, Figure 9. shows the vehicle body load, unevenness, and the boundary condition at the acceleration and cornering state.



bracket 1 bracket 2

Figure 4. Boundary condition for vehicle body weight

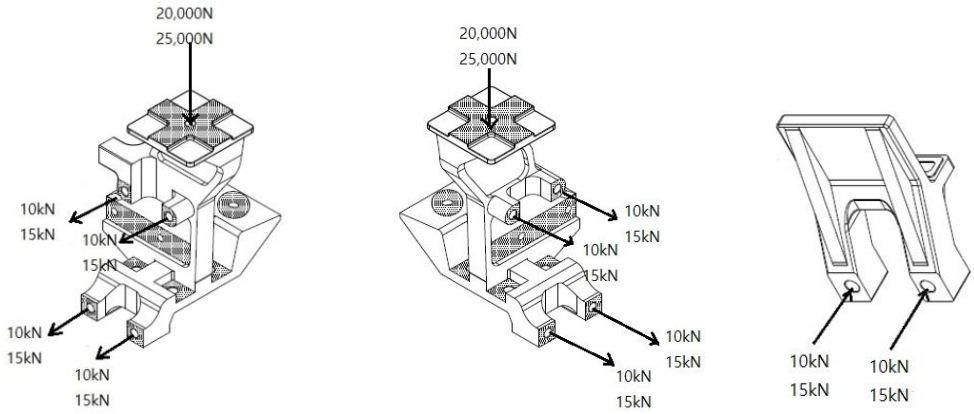


Figure 5. Boundary condition for vehicle body weight & brake

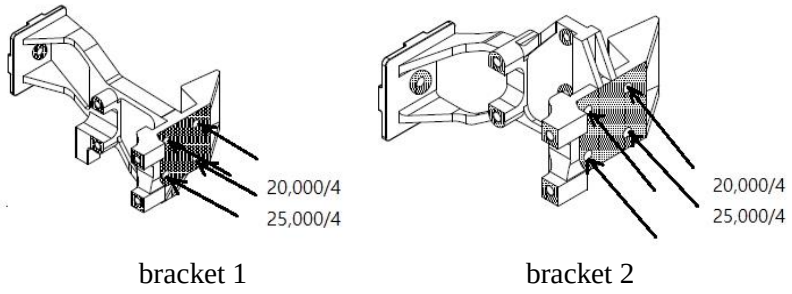


Figure 6. Boundary condition for unevenness

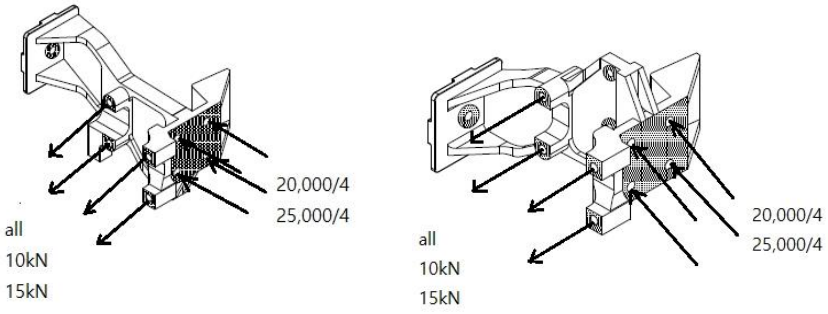
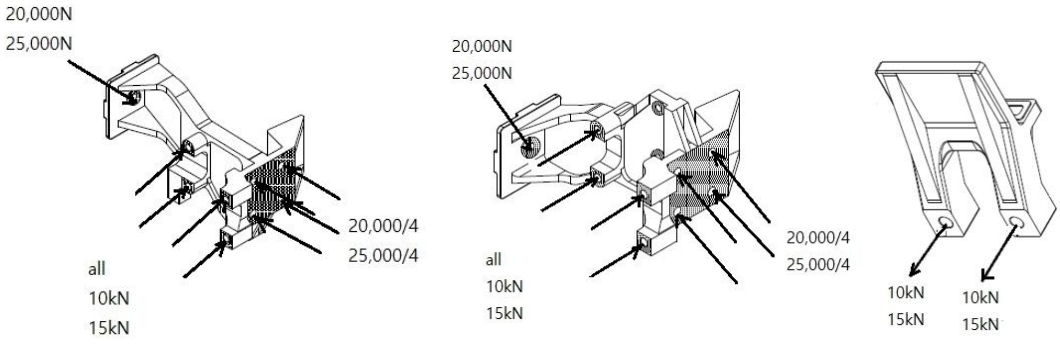
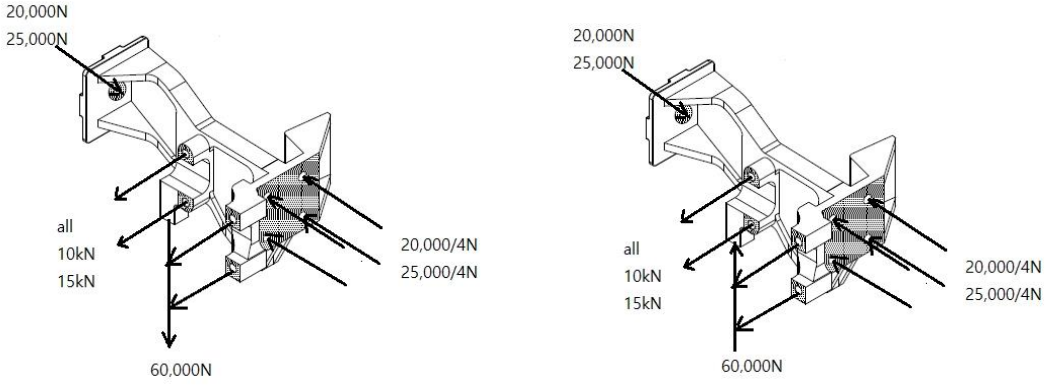


Figure 7. Boundary condition for unevenness & brake

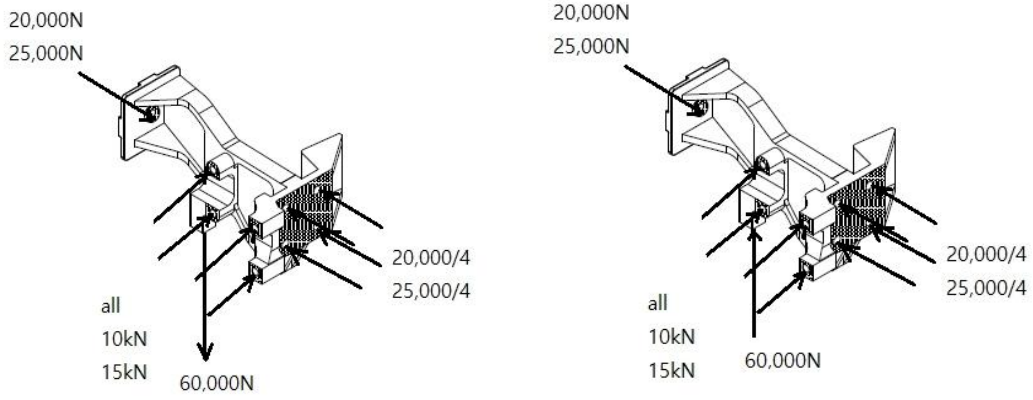


bracket 1 bracket 2 bracket 3

Figure 8. Boundary condition for vehicle weight & unevenness & acceleration



bracket 1 (Case #1) bracket 1 (Case #2)



bracket 1 (Case #3) bracket 1 (Case #4)

Figure 9. Boundary condition for vehicle weight & unevenness & acceleration & cornering

3. Dimensional design improvement

From the results of stress analysis, the maximum stress according to the driving condition of the vehicle is shown in Table 2. The yield strength of SC450 used as a bracket material is 350~550MPa, the tensile strength is 650~880MPa, and the fatigue limit is 275MPa. A bare chassis of a bus in which brackets are used is provided

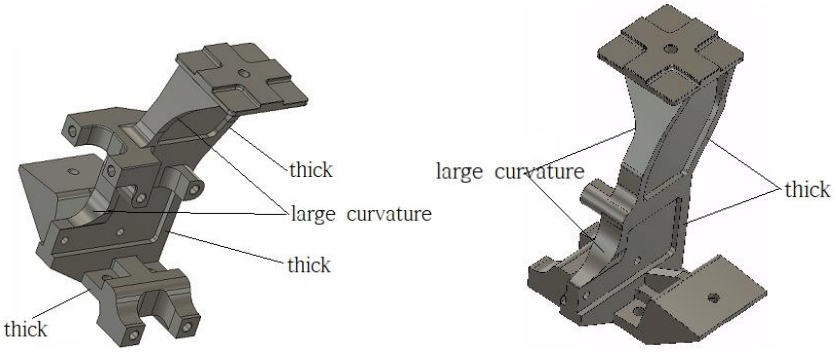
to receive fatigue load since load is repetitively applied while a vehicle travels. The maximum stress is 260.9MPa in the condition of ⑥ body load action & unevenness passage & acceleration/deceleration & cornering vehicle, which is a severe condition acting on the bracket, Therefore, an improved design is needed to reinforce the strength by changing the shape of the bracket. Bracket 3 is operated only during acceleration and deceleration, and it is judged to be safe because it is sufficiently smaller than the fatigue limit. However, in bracket 1 and bracket 2, the maximum stress is approaching the fatigue limit in N0. ② and No. ⑥. The places where the stress is concentrated on Bracket 1 and Bracket 2 are the curved part, the lower support and the bottom part.

Table 2. Maximum stress

No.	vehicle situation	applied load	applied bracket	max. stress (MPa)
①	vehicle body weight	20kN	1	97.6
		25kN	1	122.0
		20kN	2	97.8
		25kN	2	122.6
②	vehicle body weight & brake	20kN, all 10kN	1	148.7
		25kN, all 15kN	1	207.5
		20kN, all 10kN	2	150.5
		25kN, all 15kN	2	210.7
		10kN×2	3	71.1
		15kN×2	3	106.7
③	unevenness	20kN	1	65.8
		25kN	1	82.3
		20kN	2	64.7
		25kN	2	80.8
④	unevenness & brake	20kN, all 10kN	1	84.5
		25kN, all 15kN	1	96.6
		20kN, all 10kN	2	86.2
		25kN, all 15kN	2	127.6
⑤	vehicle weight & unevenness & acceleration	20kN, all 10kN	1	78.0
		25kN, all 15kN	1	120.3
		20kN, all 10kN	2	76.4
		25kN, all 15kN	2	115.1
		20kN	3	71.9
		30kN	3	107.9
	vehicle weight	20kN, all 10kN, Right, brake	1	190.9

⑥	& unevenness & acceleration & cornering	25kN, all 15kN, Right, brake	1	233.4
		20kN, all 10kN, Left, brake	1	238.5
		25kN, all 15kN, Left, brake	1	260.9
		20kN, all 10kN, Right, acceleration	1	200.5
		25kN, all 15kN, Right, acceleration	1	198.5
		20kN, all 10kN, Left, acceleration	1	228.9
		25kN, all 15kN, Left, acceleration	1	239.3

Figure 10. shows the direction of improvement of dimensional design that can grasp where stress is concentrated in stress analysis results and reinforce it.



(a) Bracket 1 (b) Bracket 2

Figure 10. Improved design direction for brackets

4. Conclusion

In this study, stress analysis was performed on three types of brackets installed in the bare chassis of a 25-passenger bus in the development stage. The purpose of stress analysis on the brackets is to evaluate whether the brackets are safe against the loads applied while the bus is running. In order to perform the stress analysis, the physical properties of the SC450, which is the material constituting the bracket, were confirmed, and the driving conditions of the vehicle were classified into six types and the boundary conditions were given. As a result of the stress analysis by applying the classified boundary conditions, an improved dimensional design method was proposed considering the maximum stress acting on the bracket. A series of processes performed in this paper may perform dimensional design improvements for brackets of other vehicles. The results of this study are summarized as follows.

1) The bracket used in the vehicle's bare chassis can improve the design in the order of design content analysis - stress analysis - stress concentration position confirmation - dimension variation.

2) The magnitude of stress on bracket 3 under the given boundary condition is considered to be safe because it is sufficiently smaller than the fatigue limit, yield strength, and tensile strength of SC450, which is a bracket material.

3) In bracket 1, the stress concentration generates in the top 2 place, and the curved portion of the lower

part 1 place and down support stand and bottom portion. Therefore, the radius of curvature of the curved portion and size of the thickness of the down support stand and floor are adjusted and the maximum stress can be reduced.

4) In bracket 2, the stress concentration generates in the curved portion of the top 2 place, and the lower part 1 place and down support stand and bottom portion. Therefore, the radius of curvature of the curved portion and size of the thickness of the down support stand and floor are adjusted and the maximum stress can be reduced.

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