# DESIGN AND SIMULATION OF STRUCTURAL DURABILITY OF PASSENGER CAR FRONT IN COLLISION

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## ABTRACT

*In this paper, design and calculate a damping system with HYPERMESH software. Research using LS-DYNA software to analyze finite element model and structural strength of passenger car front and violate the safe space on impact. Simulation results with a speed of 50 km/h according to ECE R66 standards show a reduction of 27%. Meet the requirements on the condition of the car head structure. The safe space is not violated according to ECE R66 standards in a head-on collision. Additionally, the numerical analysis techniques employed in this study could be used for future research on collisions between maritime structures including fishing boats and aquaculture engineering.*

***Keywords:*** *ECE R66 standard, HYPERMESH software, LS-SYNA software, collision, passenger car, damping system.*

## I. INTRODUCTION

Currently, frontal traffic accidents on passenger cars are mainly deformed at the front of the vehicle and trespassing into a safe space according to ECE R66 standard. However, the research is only interested in the issues of chassis durability, not the absorption of frontal force in the collision. Javad Marzbanrad studied the material analysis and the front bumper system of the car at low speed [1]. L Wågström studies a sudden decrease in average speed causes a higher rate of neck injuries [2]. Dawid Bruski has studied car collisions with barriers on winding roads to protect drivers [3]. Aleksandra Krusper Researched improving the head car structure in a collision [4]. Muhammed Talha AŞKAR conducted to check on the force absorbed by the front bumper and the reaction to the front of the vehicle in the collision with rigid barrier [5]. X.T. Liu analyzes the frontal collision on the bus chassis [6]. Some authors have studied, calculated, and simulated the structural strength of the passenger car's front and energy absorption in the collision [7-24]. In this study, Design a force absorption system at the front of the vehicle to ensure a safe space and the driver is not compromised. The structural strength of the force absorption system is simulated and evaluated by LS-DYNA software. Base on the ECE R66 standard [25]. Evaluation and analysis using HYPERVIEW software. The study's findings can be applied to the design of various structures, including marine vehicles, fishing boats and aquaculture engineering, especially for their protection parts that are subjected to collisions.

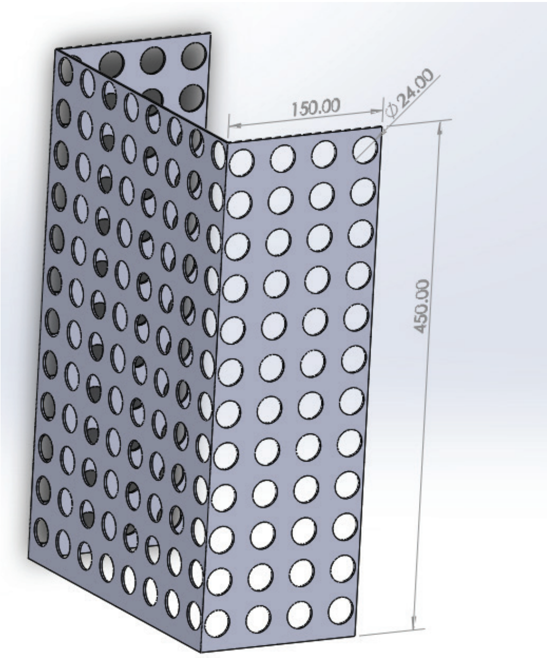
## II. MATERIAL AND METHODS

### 2.1 Model of the energy absorption system

Model of energy absorption system designed using SOLIDWORKS software. The system is designed to be able to absorb the frontal force of the vehicle. The vertical and horizontal dimensions of the system are shown in Figure 1. With the size as shown in Figure 1, it is suitable when welding to the front bumper of passenger cars, The material and structural parameters of steel are shown in Table 1.

**Table 1. Steel specifications and materials**

| Steel name | Specific weight Kg/m$^3$ | Elastic module GPA | Coefficient Poisson | Melt stress, $\sigma_c$/MPA | Allowable stress σ/MPA |
|---|---|---|---|---|---|
| D159 | 7660 | 196 | 0.28 | 382 | 254 |



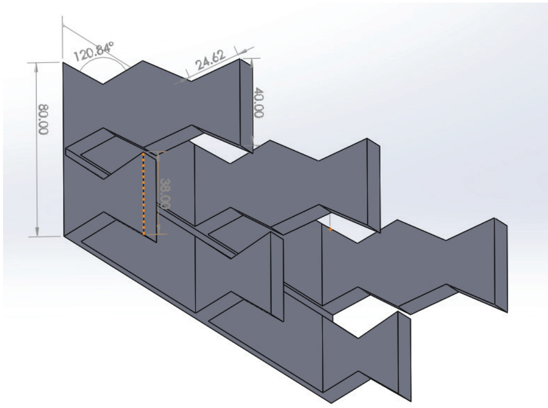




**Figure 1. Building 3D damping models.**

Currently, D159 steel is widely applied to passenger cars. D159 steel has a suitable stress value and is easy to machine. The steel parameters and the boundary conditions of the material are shown in Table 1. Yield strength is 254 MPA. Tensile strength is 382 MPA. These two boundary conditions. It is suitable to apply passenger cars in collision cases.

**2.2 Finite Element Analysis**

Apply ALTAIR HYPERWORKS software to conduct meshing. Building a finite element model based on LS-DYNA and analyze the structural strength of the front force absorption system. In the process of building a finite element analysis model, The mesh size is important because it will affect whether the parameters are close to reality or not. Therefore, the simulation in this paper applies a mesh size of 5mm.

When the car runs on the road until the collision with the bumper 100% of the front area of the car at a speed of 50 km/h according to ECE R66 standard. The time from the start of the collision until the end of the collision, the head of the vehicle will be completely subjected to the forces. Therefore, the energy absorber is welded at the position of the undercarriage of the front of the vehicle shown in Figure 2.

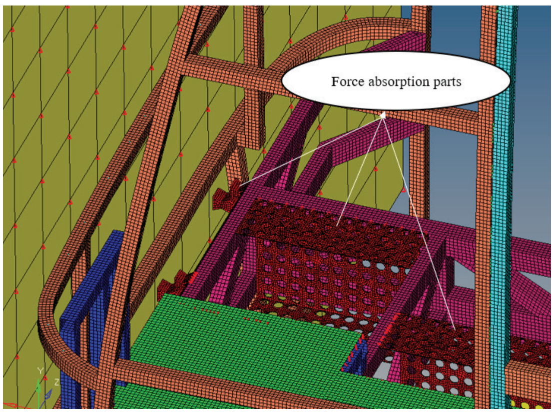



**Figure 2. Meshing.**

**2.3 Dynamic analysis of cars in a frontal collision.**

Apply formula (1) to the frontal collision calculation with the following parameters

v: initial velocity at impact

$v_0$: velocity after impact

$$\varepsilon = \left| \frac{v}{v_0} \right| \quad (1)$$

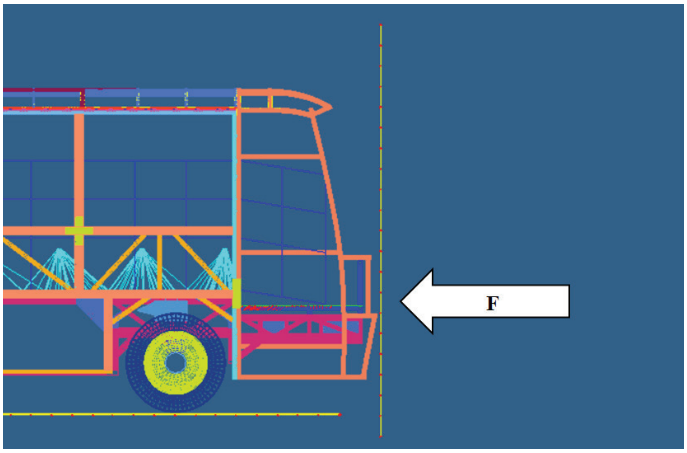



**Figure 3. The head of the vehicle in contact with the barrier.**

## III. ANALYZE SIMULATION RESULTS

**3.1 Results of structural strength analysis**

Collision simulated at 50 km/h using LS-DYNA software. The simulation results show that the force is mainly concentrated on the head of the vehicle. Therefore, the stress at the position of the front chassis at the part with the energy absorption system will have maximum stress shown in Figure 4. But some locations overcome the allowable stress is 245 MPa. Because it must absorb a lot of collision energy so that the passenger car does not violate the safe space. With energy absorption in Figure 4, the safe space is completely protected.

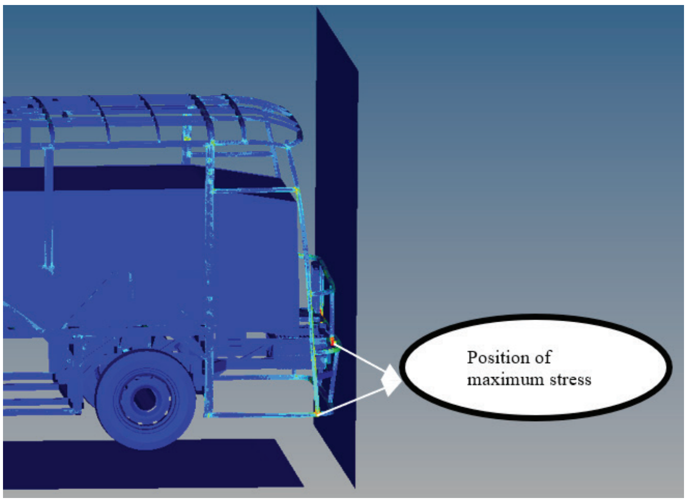



**Figure 4. Maximum stress at process collision.**

To assess the structural strength of the vehicle's head. We have to simulate a car collision with a 100% vehicle head obstacle to check the stress and displacement of the vehicle's head. Figure 4 shows the stress concentrated mainly in the front of the vehicle and at the points of the energy absorption system.

**3.2 Analysis results**

*Case 1: No energy absorption system.*

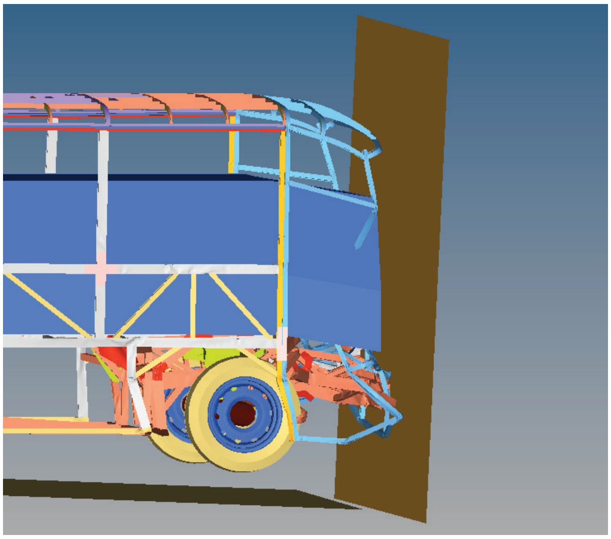


**Figure 5. The collision process hasn't energy absorption systems.**

Simulation results in Figure 5 show that when hasn't force absorption system, during the collision, The safe space accord ECE R66 standards are violated. Inferring that the safe space is violated will affect drivers at the strongest collision.

*Case 2: Has an energy absorption system.*

The simulation results in Figure 7 show that

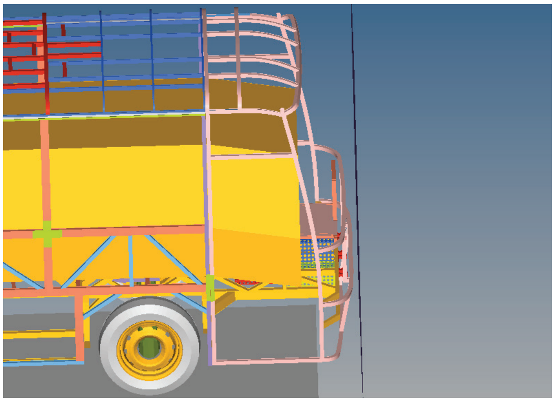


**Figure 6. Before the collision.**

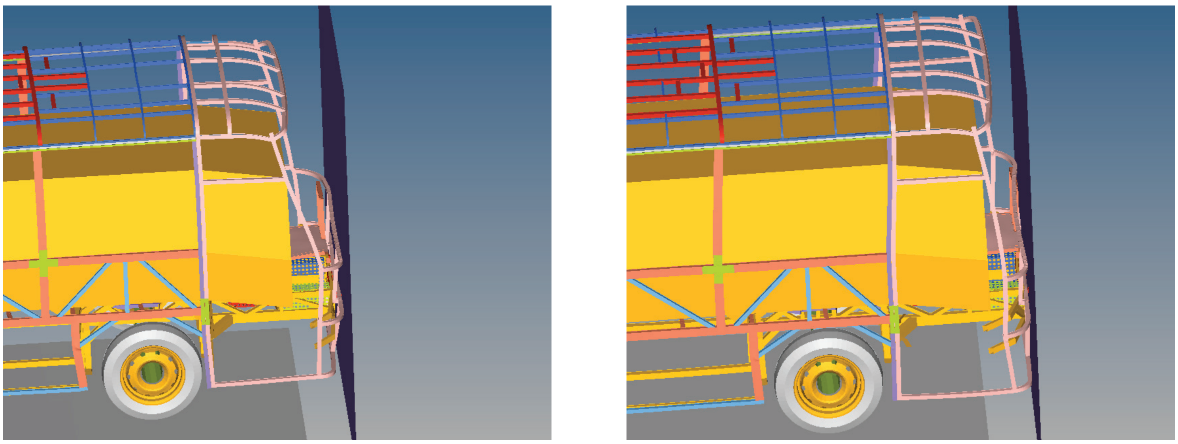


**Figure 7. The collision process has an energy absorption system.**

when improving the head of the passenger car has an energy absorption system. The head of the passenger car is better protected when a head-on collision with an area of 100 % of the head of the vehicle. Figure 7 shows the safe space is not violated and meets the ECE R66 standard. In conclusion, the energy absorption system in this study is efficient and suitable for use with passenger cars.

## IV. CONCLUSION

This study has calculated and designed an energy absorption system for passenger cars 29/34 Samco made in Vietnam in Figure 1. Simulate passenger cars running at 50km/h and frontal collisions with an obstacle. Simulation results show that the durable structure of the system completely meets the structural strength condition when the collision occurs. Compared to the head of passenger cars without an energy absorption system improvement of 27%. Proves that the energy absorption system will protect the safe space and a driver is safe in frontal collision according to ECE R66 standards. The study‘s findings can be applied to the design of various structures, including marine vehicles, fishing boats and aquaculture engineering, especially for their protection parts that are subjected to collisions.

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