Project Report

On

"PNEUMATIC BUMPER"

for partial fulfillment of the requirements

for the award of the degree

B. Tech (Automotive Design Engineering)

By

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Under The Guidance Of

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Asst. Prof.

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Dehradun

May, 10

CERTIFICATE

This is to certify that, Mr. Ankur Singhal (R140206010) & Mr. Lalit Saini (R140206029), students of B.Tech (Automotive Design Engineering), University of Petroleum and Energy Studies Dehradun have worked on 'Pneumatic Bumper'. They have successfully completed the project for fourth year .Their contribution in the project is significant and useful.

Mr. R.K TRIPATHI

Assistant Professor

COES, UPES

ACKNOWLEDGEMENT

We are indebted to our project guide Mr.R.K.Tripathi for his continuous encouragement throughout the course of the project. It was a pleasure and a true learning experience working under his guidance and support.

We would like to express our gratitude to him for his keen interest in our project and valuable guidance despite his busy schedule. We are thankful to him for trusting our capabilities to handle the project and for giving his valuable inputs to improve it even further.

His guidance has been vital and instrumental for us in adopting a holistic view during the project.

We also like to thank all the faculties and students for providing their kind support in completion of this project.

Ankur Singhal- R140206010 Lalit Saini- R140206029

DECLARATION

We, Mr. Ankur Singhal(R140206010), Mr. Lalit Saini(R140206029), students of B.Tech (Automotive Design Engineering) University of Petroleum and Energy Studies, Dehradun hereby declare that the dissertation entitled "Pneumatic Bumper" embodies the report of project work carried out at 'University of Petroleum and Energy Studies, for fourth year under guidance of Mr. R. K. Tripathi, this work has been submitted for the partial fulfillment of thc requirement for the award of the degree of 'Bachelor of Technology in Automotive Design Engineering'.

Date: MAY 14,2010

Contents

ABSTRACT

In this project we have studied the construction and working of pneumatic bumper having two air chambers, one is forward and one is rearward. The construction of the forward chamber is such that when pressure is applied to periphery of the front chamber than air in the front chamber passes to the rear chamber gradually in order to release stress caused by the shock.

In this project we are going to illustrate one specific type of bumper known as "Pneumatic Bumper" and its types. Simultaneously we are going to analyze and explain the effect of several parameters i.e. bumper mounting, bumper height & its material type to the pedestrian and occupant safety during collision.

We are also going to simulate the effect of impact on a bumper system. To measure the effect of collision during crash of a vehicle we have used Solid Works as a modeling and analysis tool.

In Solid Works we have performed several analysis on a virtual bumper model at variable load and angles to get the most suitable and optimum solution. By varying load and angles in each analysis we have tried to cover up maximum types of impact conditions.

Chapter 1: Introduction

1.1 Introduction to pneumatic bumper

This project deals with the type of bumper that reduces the impact on the vehicle during the collision and thus providing safety to the passenger as well as prevent vehicle from larger damage. This type of bumper uses pneumatic equipments integrated within it to lower the effect of collision and to minimize the effect of shockwave generated during collision hence it is known as pneumatic bumper.

An apparatus mounted on a vehicle front and rear end, comprising of valves and having air storage chambers acts as an energy absorbing equipment to reduce the effect of sudden impact or collision is known as pneumatic bumper. The air chambers and the valves are designed in such a way such that when an inline or axial load applied to the apparatus then the valves gets close to seal the air chambers and restrict air to pass down after that during the collision when the equipment gets compressed up to maximum possible limit then valves starts open sequentially to release the air slowly, this process of releasing air slowly is called ventilation. In this way apparatus prevents rebound during collision.

This type of inflammable energy absorbing system comprises an elongated frame attached with one upper and one lower projecting lip, two air chambers forward and rearward and also an "H" shaped tube which is inflatable in nature. To hold the tube in place there are two lips mounted on the frame opposite to each other. Lateral Folds in accordion like shape can be used as an alternative which is mounted across the upper and lower surfaces of the front air chambers in order to provide necessary resilient compression under impact.

The energy absorbing capacities of these types of bumpers are limited in nature but there are researches conducted continuously to increase the energy absorbing capacity of these bumpers. A typical bumper available today is able to neutralize the effect of shock at maximum up to 15 miles/hour of vehicle speed without any severe damage to the vehicle.

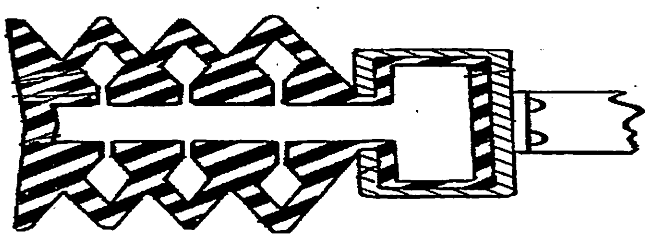


Fig a. Collapsible type pneumatic bumper

1.2 Construction details

The below description is going to illustrate the construction of pneumatic bumper in brief

- FIG.1 is showing the top view of the bumper when it is mounted at front end of the vehicle.
- FIG.2 is showing cross sectional view of FIG.1 about the reference line 2-2.
- FIG.3 is showing a front elevation of FIG.1 and FIG.2.
- FIG.4 is showing the cross-sectional view of an alternative design of this bumper.

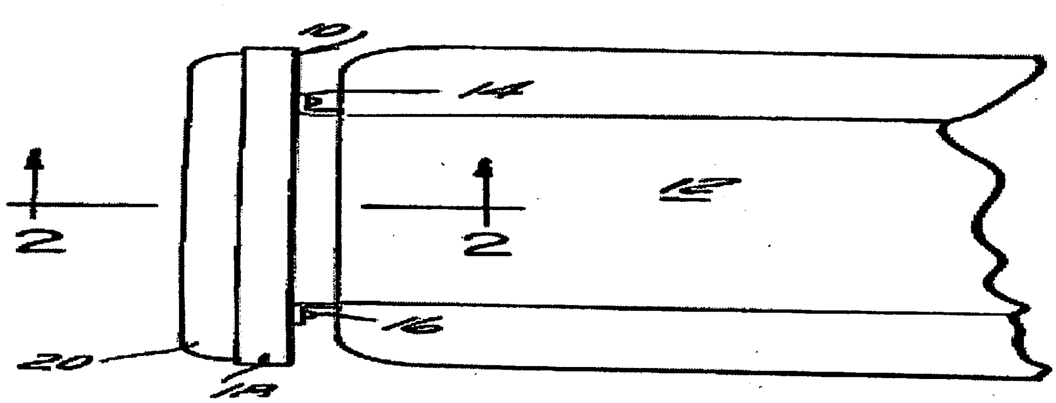


Fig.1 Top view of bumper

- In FIG.1 number 10 represents the bumper and number 12 represents the vehicle's front end. It shows the mounting of bumper on the vehicle. A pair of spaced brackets 14 and 16 is implied to mount bumper safely on the motor vehicle. A total metal frame 18 is used to support the bumper tube 20 and hold it in place. A pneumatic tube 20 is implied which is forwardly extended. The tube is used to store air at high pressure which can be introduced through suitable valve members.

- The detailed construction of the bumper is shown in FIG.2. It mainly deals with the construction of the pneumatic tube 20 and the frame 18 which is used to hold the tube. The perfect materials for construction of the pneumatic tube 20 are generally the cord and rubber material. The tube is attached with the forward air storing chamber 22 which is going to face the collision and a rearward air storing chamber 24. Generally the cross-section of the forward chamber is made larger than the rearward chamber.

- One set of lips 26 and 28 are attached with the frame 18. The upper lip 26 extends downwardly opposite to lower lip 28. By this arrangement of lips the mounting of the other parts of the bumper 10 is done. To hold the ruptured tube 20 in the frame an another threaded tube 10 is settled cross wise between the lips 26 and 28 in non inflated condition, once the tube get mounted on the frame it gets inflated. The bending of the lips is necessary with the movement of the tube and thus they are manufactured by spring steel to permit maximum bending during collision. The lips 26 and 28 bends during the impact and after the impact they get restored at their original position

- Thus the two lips 26 and 28 prevents frame 18 from any severe damage or permanent deformation by compensating the impact energy. The rearward air chamber 24 is used to stop excessive rearward bending of the lips 26 and 28 so that the effect of the shock can be compensated and dampened properly transferred by the front end of the bumper 10.

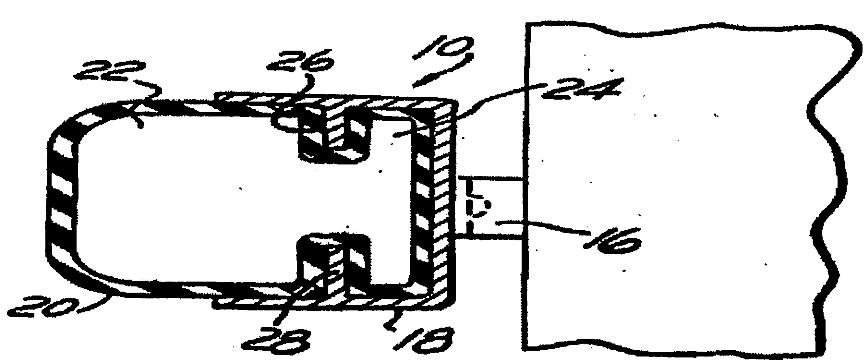


Fig.2 Cross sectional view of bumper

- FIG.3 is the front view of the bumper 10. The two protruding edges above and below of the tube 20 are the edges of the frame 18. When the tube 20 is fully inflated then the forward chamber 22 is appeared at the front of the frame 18 after in bumper assembly.

When inflated fully the tube 20 extend throughout the length of the frame 18 and fill it internally.

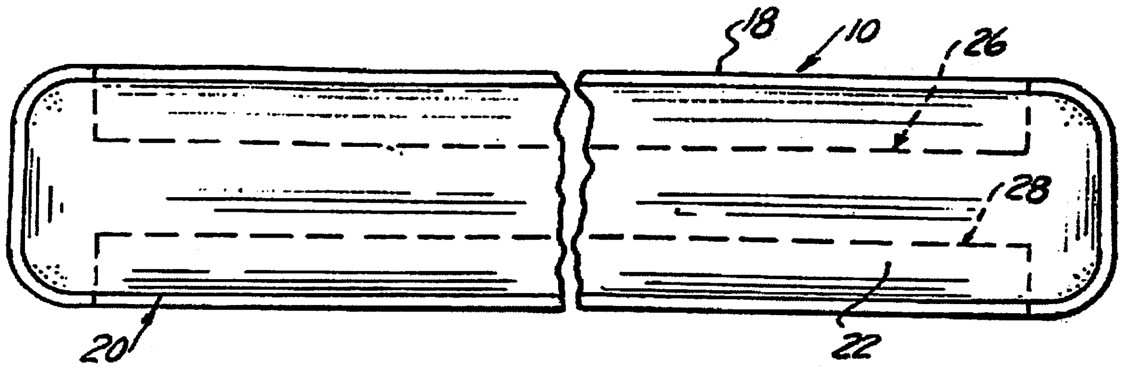


Fig.3 Front view of bumper

- An alternate design of the above bumper is shown in the FIG.4. This design is different from the design shown in FIG.1 - FIG.3. The design of the front chamber of tube 20 and the mode of construction is different in this alternative design. In this frame 19 is different from the frame 18 in the previous construction. Instead of only using forward chamber 20 it uses another air storing chamber 22a comparably smaller in size with respect to the chamber 22 shown in FIG.2 in previous design. An accordion like fold shape is implied shown by the forward chamber 20 in the FIG.4.

- Numeral 30 shows the upper folds having transverse central air sac 32. Each of the transverse sacs is connected with the forward chamber 22a by means of the passage 34. When the impact occurs at the front end of the chamber 20 then air passes through the passage 34 into the sacs 32 in order to release the stress from the tube 20. The design is modified by using a recessed portion 36 at the end of the front chamber 22a in order to get proper folding when compressed at the front end.

- The function of the upper and lower lip i.e. 26 and 28 remains the same as it was in the previous construction as to hold the pneumatic tube 20 at place. When the height of the forward chamber 20 is measured between upper fold 30 and the lower fold 31, then it comes quite greater than the height of the frame 19. This design allows the collapsible chamber 20 to be folded and readily deflected over or around the lower and upper edges of the frame 19 without cracking or breaking any tube fold and the frame. The effect of shock is compensated by using two flexible lips 26 and 28.

- This is the more improved design for the vehicle bumper hen the previous one in context of energy absorbing capability and the low cost of fabrication of the bumper components. The accomplishment or replacement of any part get damaged due to collision can be done readily in this design.

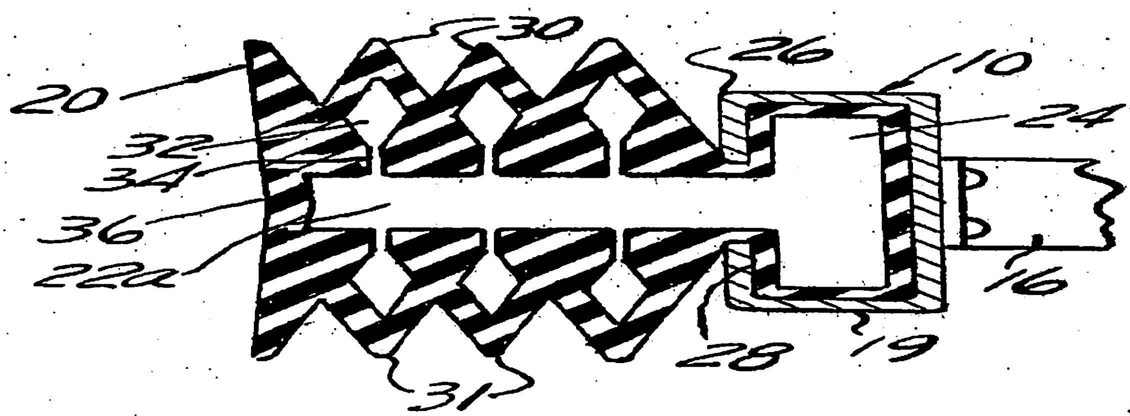


Fig.4 Collapsible type pneumatic bumper

Chapter 2: Literature Review

An automobile's **bumper** is the front-most or rear-most part, ostensibly designed to allow the car to sustain an impact without damage to the vehicle's safety systems. They are not capable of reducing injury to vehicle occupants in high speed impacts, but are increasingly being designed to mitigate injury to pedestrians struck by cars.

2.1 Background

This invention belongs to the field of automotive safety. In brief it is a bumper which is made by such materials which are inflatable in nature and having capability to absorb the impact energy before it transfers to the main vehicle body hence to minimize the effect of shock. Pneumatic bumper can be mounted at both rear and front end of the vehicle. These bumpers can be classified on the basis of the incorporation of the tire type air chamber or single tube type. Generally the two are mounted on the bumper frame transversely and supported by a bead like structure.

2.2 Current scenario

In most jurisdictions, bumpers are legally required on all vehicles. The height and placement of bumpers may be legally specified as well, to ensure that when vehicles of different heights are in an accident, the smaller vehicle will not slide under the larger vehicle.

In 1971, the U.S. National Highway Traffic Safety Administration (NHTSA) issued the country's first regulation applicable to passenger car bumpers. Federal Motor Vehicle Safety Standard No. 215 (FMVSS 215), "Exterior Protection," took effect on 1 September 1972 — when most automakers would begin producing their model year 1973 vehicles. The standard prohibited functional damage to specified safety-related components such as headlamps and fuel system components when the vehicle is subjected to barrier crash tests at 5 miles per hour (8 km/h) for front and 2.5 miles per hour (4 km/h) for rear bumper systems. In October 1972, the U.S. Congress enacted the Motor Vehicle Information and Cost Saving Act (MVICS), which required NHTSA to issue a bumper standard that yields the "maximum feasible reduction of cost to the public and to the consumer". Factors considered included the costs and benefits of implementation, the standard's effect on insurance costs and legal fees, savings in consumer time and inconvenience, and health and safety considerations.

2.3 Standards

2.3.1 Strengthening standards

The requirements promulgated under MVICS were consolidated with the requirements of Federal Motor Vehicle Safety Standard Number 215 (FMVSS 215, "Exterior Protection of Vehicles") and promulgated in March 1976. This new bumper standard was placed in the United States Code of Federal Regulations at 49CFR581, separate from the Federal Motor Vehicle Safety Standards at 49CFR571. The new requirements, applicable to 1979-model passenger cars, were called the Phase I standard. At the same time, a zero-damage requirement, Phase II, was enacted for bumper systems on 1980 and newer cars. The most rigorous requirements applied to 1980 through 1982 model vehicles; 5 miles per hour (8 km/h) front and rear barrier and pendulum crash tests were required, and no damage was allowed to the bumper beyond a ⅜ in (10 mm) dent and ¾ in (19 mm) displacement from the bumper's original position.

2.3.2 Weakening standards

Facing pressure from automakers, and operating under the Reagan administration's pledge to reduce regulatory burdens on industry, NHTSA most recently amended the bumper standard in May 1982, halving the front and rear crash test speeds for 1983 and newer car bumpers from 5 miles per hour (8 km/h) to 2.5 miles per hour (4 km/h), and the corner crash test speeds from 3 miles per hour (5 km/h) to 1.5 miles per hour (2 km/h). In addition, the zero-damage Phase II requirement was rolled back to the damage allowances of Phase I. At the same time, a passenger car bumper height requirement of 16 to 20 inches (41–51 cm) was established for passenger cars. At that time, NHTSA promised to conduct research and testing to provide consumers with accurate information on the quality of new car bumpers, but no such information has been provided.

Consumer and insurance groups have decried the weakened bumper standard, saying it has increased consumer costs without any attendant benefits except to automakers.

In 1986, Consumers Union petitioned NHTSA to return to the Phase II standard and disclose bumper strength information to consumers. In 1990, NHTSA rejected that petition.

The weakened regulations permitted automakers to design bumpers with emphasis on style and low cost; protection dropped substantially and repair costs rose. In 1990, IIHS conducted four crash tests on three different-year examples of the Plymouth Horizon. The results illustrated the effect of the changes to the U.S. bumper regulations (repair costs quoted in 1990 dollars):

Canada's bumper standard, first enacted at the same time as that of the United States, was generally similar to the U.S. regulation. However, the Canadian standard was not weakened from 8 km/h (5 mph) to 4 km/h (2.5 mph) in accord with the weakened U.S. standard of 1983. Some automakers chose to provide stronger Canadian-specification bumpers throughout the North American market, while others chose to provide weaker bumpers in the U.S. market, which hampered private importation of vehicles from the U.S. to Canada.

In early 2009, Canada's regulation shifted to harmonize with U.S. Federal standards and international ECE regulations. Consumer groups are upset with the change, but Canadian regulators assert that the 4 km/h (2.5 mph) test speed is used worldwide and is more compatible with improved pedestrian protection in vehicle-pedestrian crashes.

2.5 Effect on design

Cars were equipped with bulky, massive, heavy, protruding bumpers to comply with the bumper standards of the 1970s and early 1980s. By the late 1980s most bumpers were concealed by a painted thermoplastic fascia.

Chapter 3: Bumper versus pedestrian safety

The function of a conventional bumper is to absorb energy during collision without any damage to the bumper itself and no damage to the vehicles front or rear end. In an automobile the purpose to imply a bumper is mainly concerned to permit the vehicle to sustain a shockwave after impact without any severe damage to the vehicle, its safety system and its occupants.

The aim is just not only the safety of the occupants but also to mitigate the danger to the pedestrian when struck by a vehicle.

- An average of 1.2 million peoples killed in the road accidents every year, two third of them are pedestrian. In the recent years engineers have succeeded to invent such types of bumper which have proven safe to protect the pedestrian while any road accident. This includes bumper redesign and makes the current bumper softer so that it can absorb energy without compromising the vehicle safety promises.

- Bumper acts as a front line protector for the pedestrian in case of the front end collision. The primary motive of an automobile bumper is to compensate the damping energy and distribute the energy during the impact. A bumper absorbs force and momentum to decrease the effect of collision. Many other parameters i.e. bumper type, its mounting height, material type used in the fabrication of the bumper component affects the safety of the pedestrians on road as well. There are many materials which are being used to fabricate a bumper i.e. spring steel, composite steel foam and crush can absorb energy.

- Our study sought to assess the effect of several bumper parameters on the pedestrian safety especially in case of leg impact and leg impact severity. Leg kinematics was extracted and the leg impact severity estimated. There are bumpers available which can either move or change its stiffness to minimize the collision effect. Pedestrian safety is a subject of concern which has accepted globally.

- According to standard data during the pedestrian impact the knee bending angle should be always less than 15 degree, knee shear should be less than 6 mm, tibia acceleration should be less than 150 g, force should be less than 5000N and bending moment should be less than 300Nm for minimum damage to the pedestrian legs. This standard data's we are going to use in our analysis.

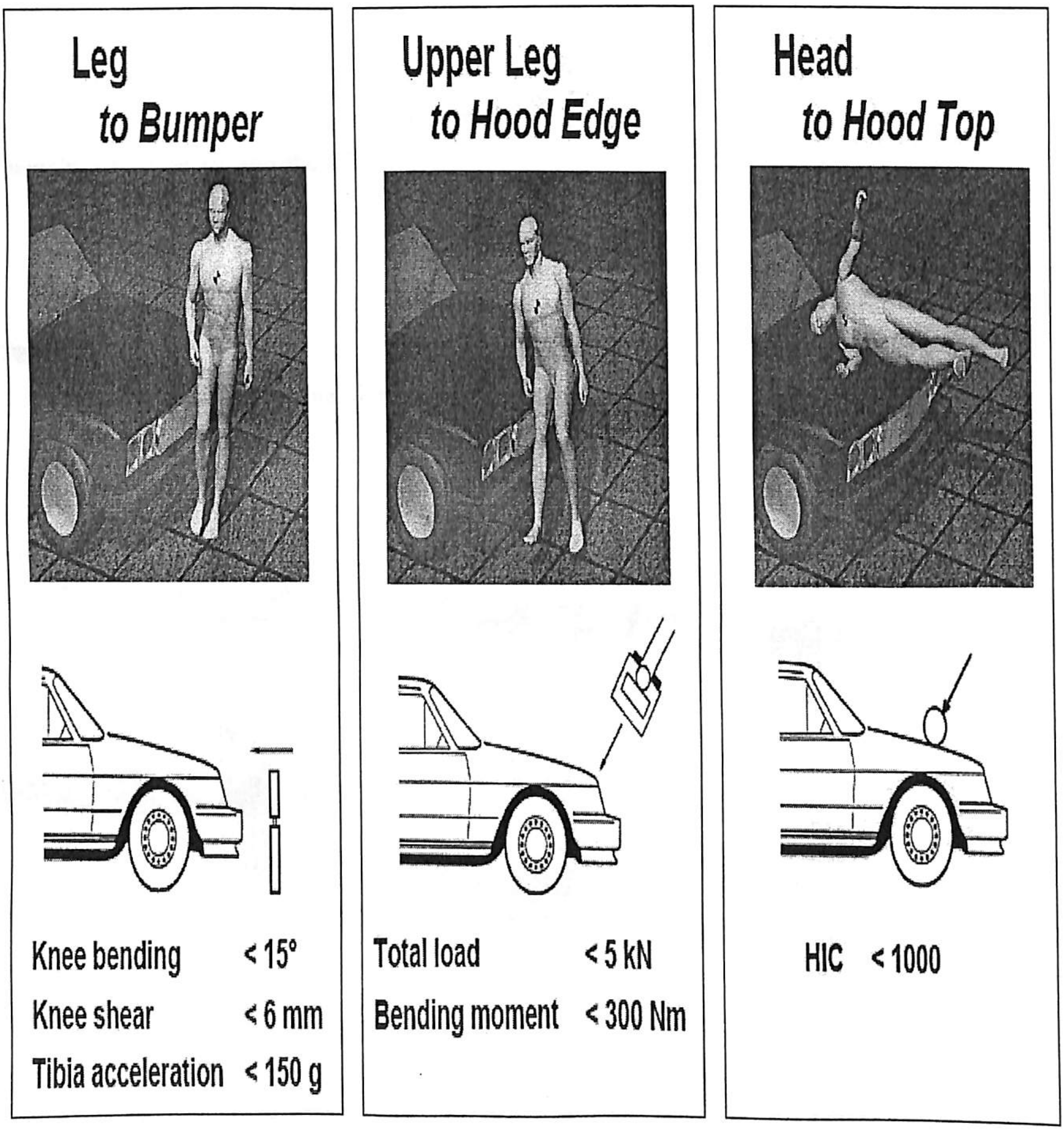


Figure 1: Pedestrian Impact Test Procedures

3.1 Pedestrian leg impact test

- The main objective to perform the leg impact test is to reduce severe injuries to lower limb of the pedestrian during accidents hence to reduce fatalities. Ligament fracture, intra-articular bone fracture and comminuted fracture are the most common injuries to the pedestrians while struck by any vehicle. In this test a typical "leg-form" model is developed using solid works then it is thrown towards a stationary bumper model at a velocity of 40 km/hr and the effect has been analyzed. This experiment can be done at any point across the bumper between the 30 degree of bumper corner.

- The criteria for deciding performance has been shown in FIG.2 and proposed leg model has been shown in FIG.3. In FIG.2 the maximum acceleration value is intended to reduce normal fractures of the tibia during bumper contact hence to prevent comminuted fractures. Shear deformation and maximum knee bending angle are the standard parameters to eliminate intra-articular bone fractures and ligament rupture.

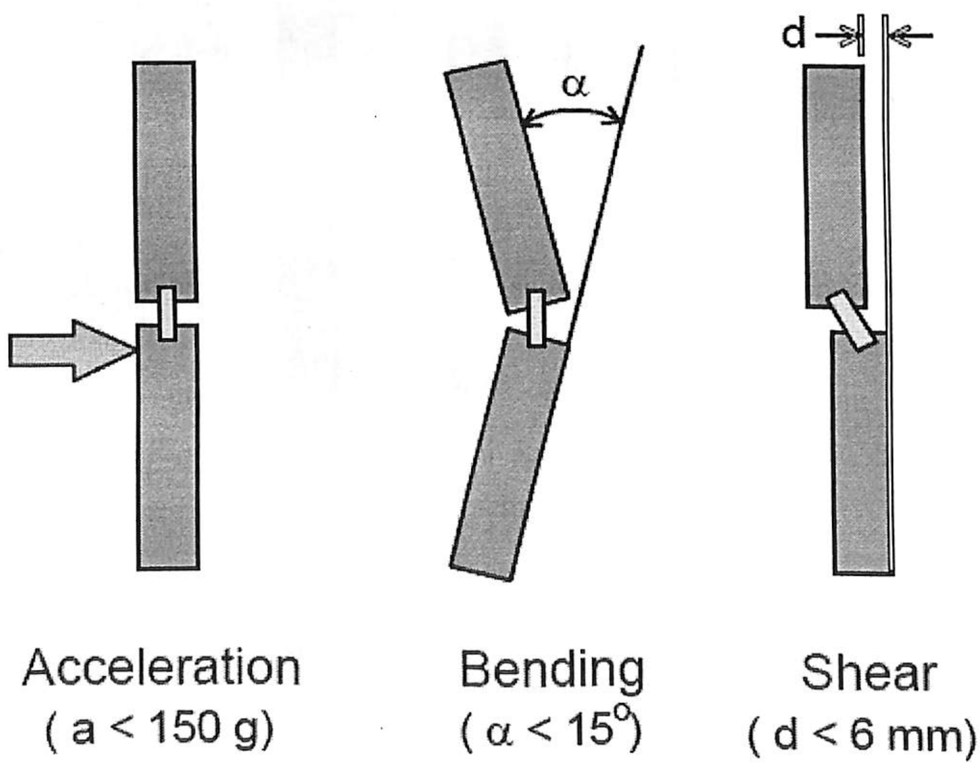


Fig 2 Modeling of lower limbs

- The proposed leg model has two core cylinders having diameter of 100mm connected with a deformable knee joint.

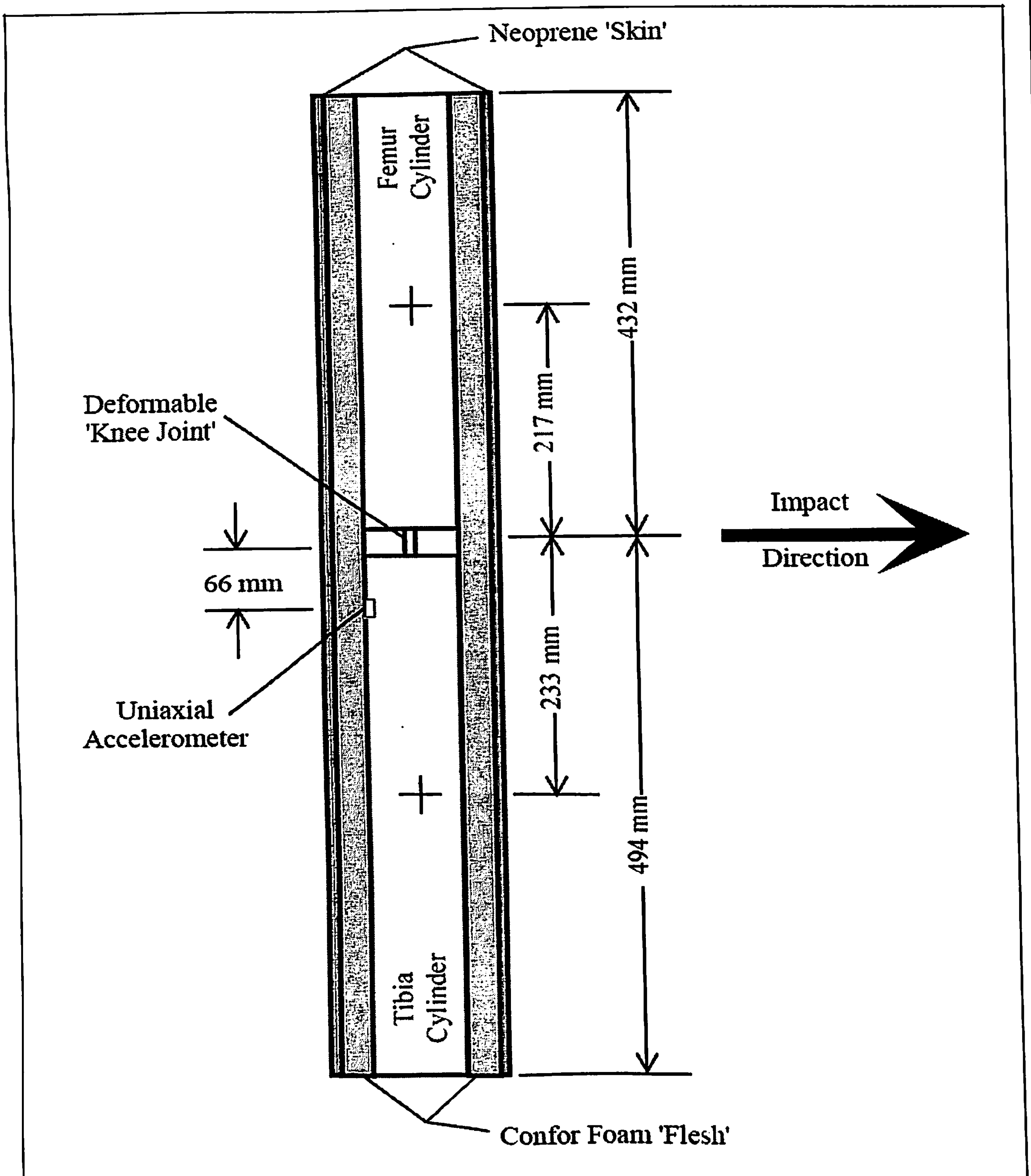


Figure 3: Proposed pedestrian 'leg-form' impactor

Chapter 4: Analysis

4.1 Overview

- Design of a bumper virtual model using Solid Works 3D modeling and analysis tool to Design all components of the vehicle front bumper to give sufficient damping or cushion the impact while at the same time supporting all limb components to secure minimum damage and to prevent stress concentration.

4.2 Cushioning (Impact energy absorption)

- The phenomenon of cushioning (impact energy absorption) is directly deals with the effect of the acceleration in a road accident. It is related to reduce the severity of bone fracture after collision between bumper and the pedestrian. The function of any cushioning apparatus is mostly similar to the conventional bumper used to absorb impact energy having only two differences:

1. **Acceptance Criteria:** - To secure maximum safety to the pedestrian legs the acceleration of the lower limbs should not greater than 150 g, this is also important from the view point to prevent bumper and vehicle components from damage. Hence the main key objective is to limit the acceleration, to cushion the pedestrian and bumper collision and to secure minimum damage to the vehicle components.

2. **Impact Energy:**-According to this criteria the bumper energy absorption system requires at least capable to absorb double impact energy that caused by a pedestrian impact.

For example if a pedestrian leg model have nominal diameter of 100mm than by assuming typical bumper energy absorbing system having approximately 150mm tall, than area of contact between the bumper and the leg model will be-

100 x (150) = 15000 mm^2. Than the total impact energy can be calculated by the formulae $1/2MV^2$ = (11.4kg) x $(11.1 m/sec)^2$ = 825 joules. Than energy absorption capacity of a bumper is (825/15000) = 0.055 J/mm^2.

4.3 Load distribution

- This function of bumper directly deals with the knee bend angle. The purpose of introducing these criteria is to eliminate the danger of the serious knee joint injuries i.e. intra-articular fractures and ligament ruptures. The aim is to provide maximum support below and above the bumper to minimize the bending moment at the knee joints at the time of collision. Here the importance of the bumper mounting height comes into contrast. There are two primary design requirements which should satisfied before adjusting the height of the bumper:-

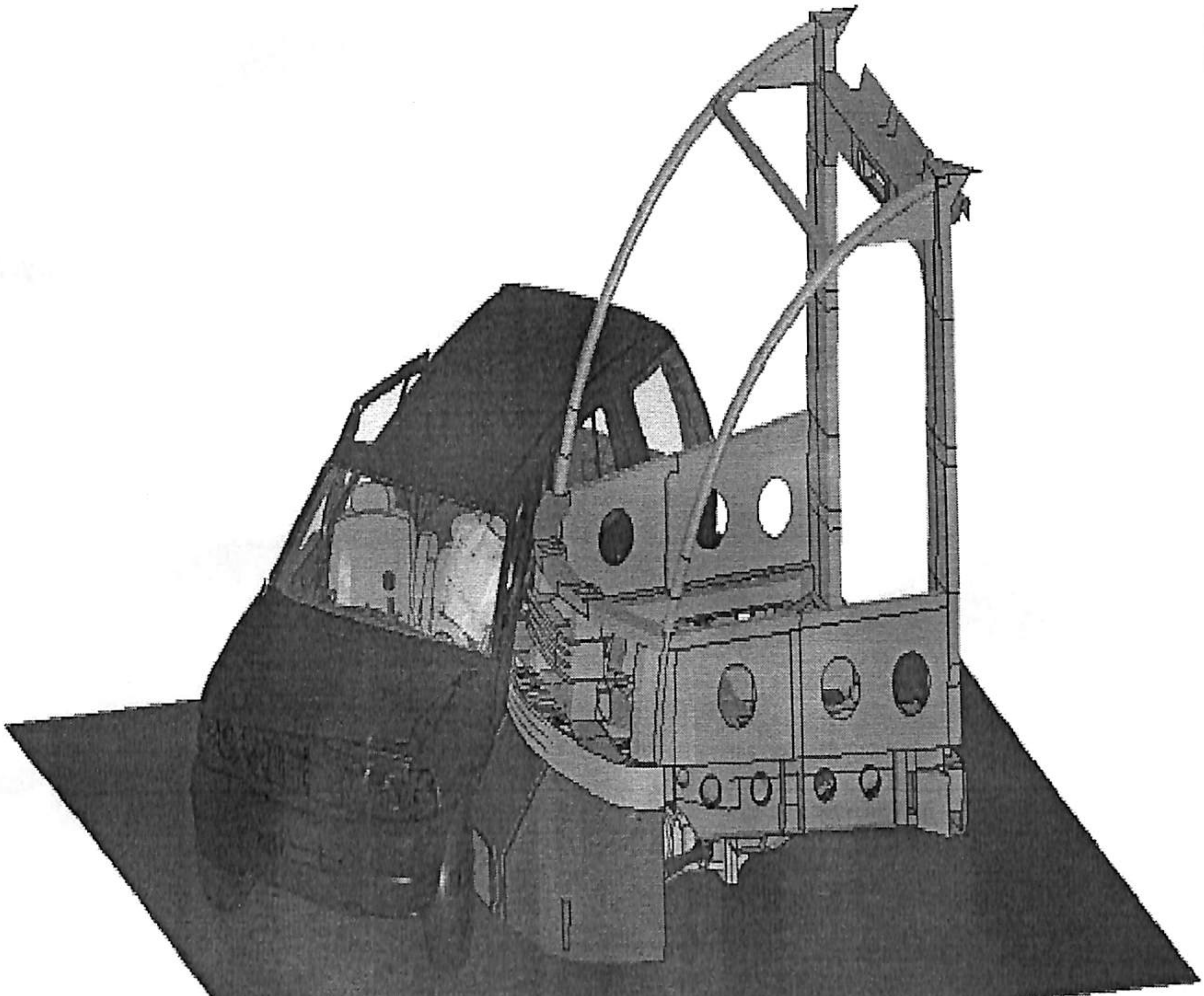
  a) According to the general standards of the bumper mounting the front bumper should be mounted at the height of the pedestrian knee. So that the maximum bending moment can occur there because the knee joint is able to rotate so that it can isolate maximum effect of the collision rather than any other part of the leg. This is also necessary from the view point to secure minimum vehicle component damage.

  b) When driving up slopes to prevent the front end of the vehicle the front-end approach angle is the key factor which decides how low to the ground the location of any component can be adjusted.

- So the motive is to design the vehicle component such that the bending of the knee joint can be reduced and maximum support could be offered to the limb without compromising performance and styling.

Chapter 5: Case Study

Impact safety and reduction improvements for light rail vehicle (LRV)



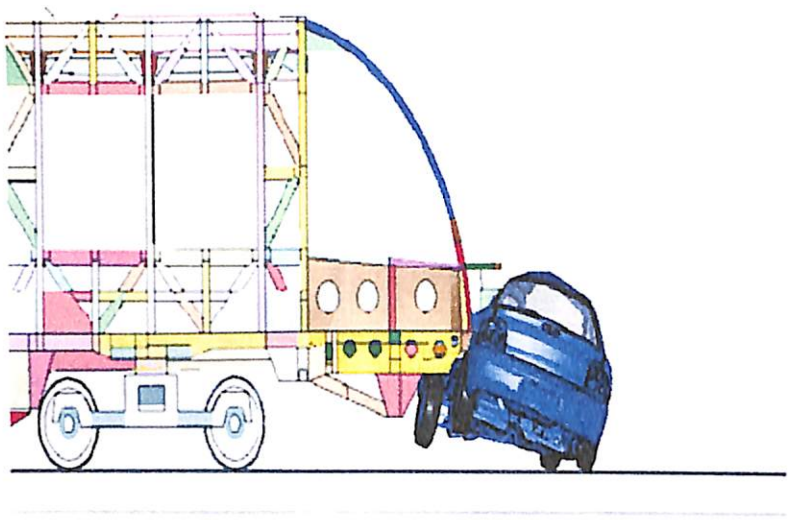
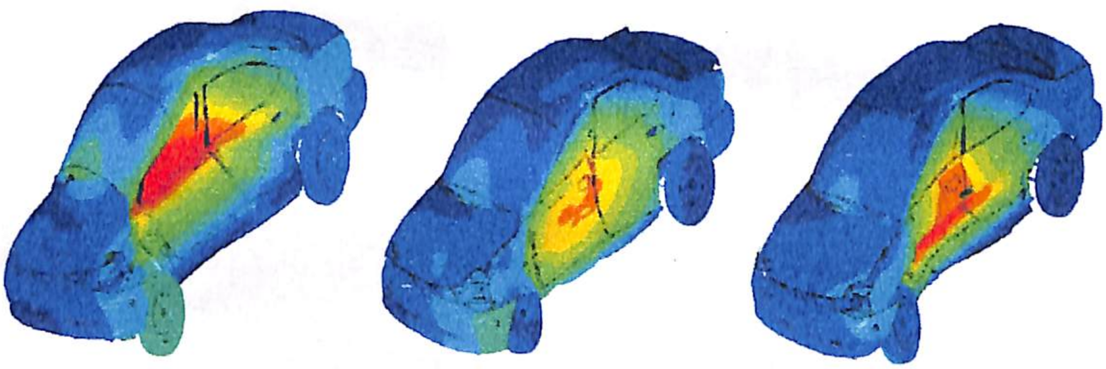


Figure 1. Simulation of a 20 mph Collision of a Siemens S70 LRV and Dodge Neon [3].



(a) Without bumper (94%) (b) With bumper (69%) (c) With pilot beam (75%)

Figure 2. Calculated crush for 90 degree, 20 mph collision between an S70 LRV and a Dodge Neon.

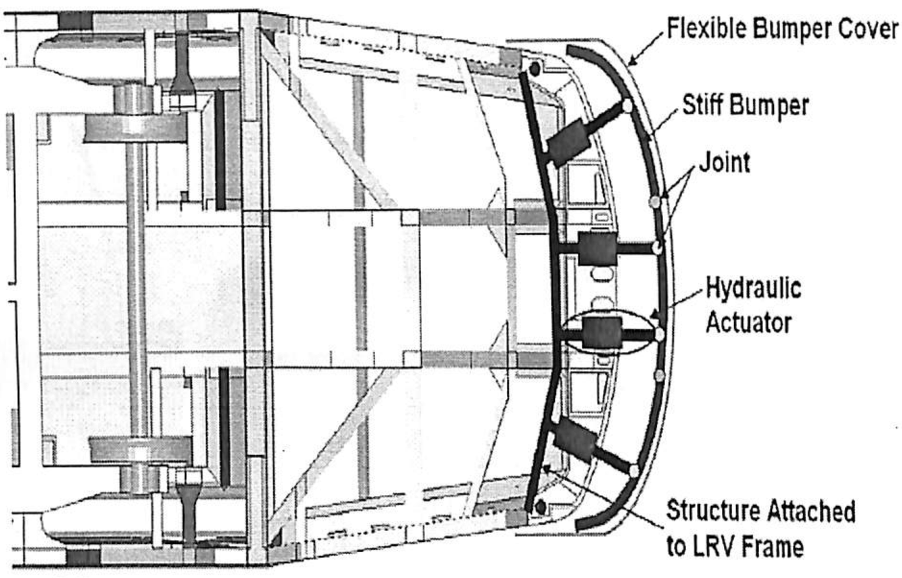
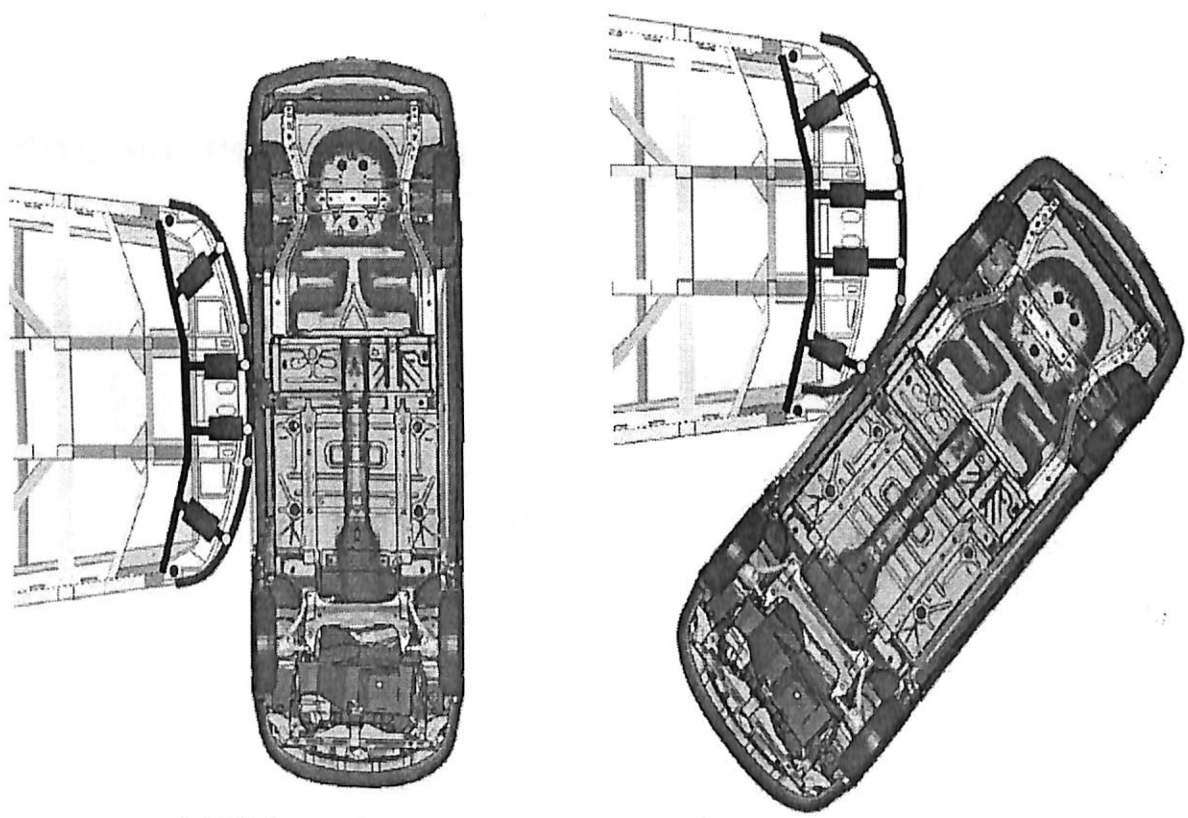
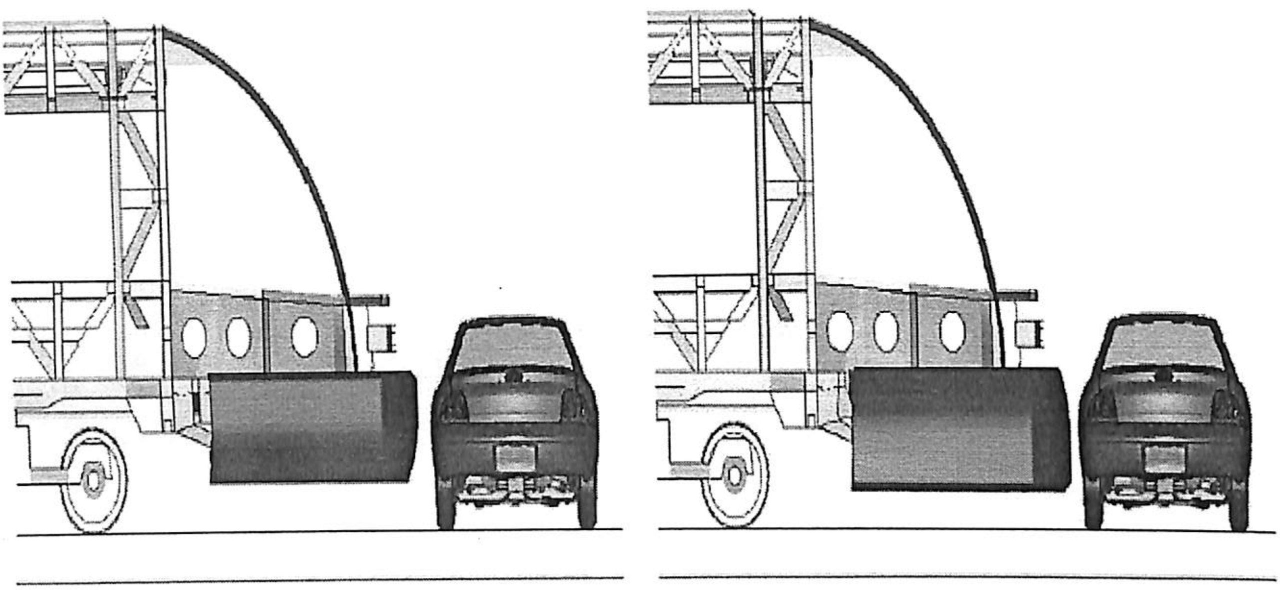


Figure 3. Proposed segmented bumper retrofit on the front-end of a Siemens S70 LRV.



(a) 90 degree impact (b) 45 degree impact

Figure 4. Proposed bumper retrofit functionality during normal and 45 degree impacts with a Dodge Neon.



(a) Existing bumper profile (b) Less aggressive lowered profile

Figure 5. Proposed bumper retrofit geometries.

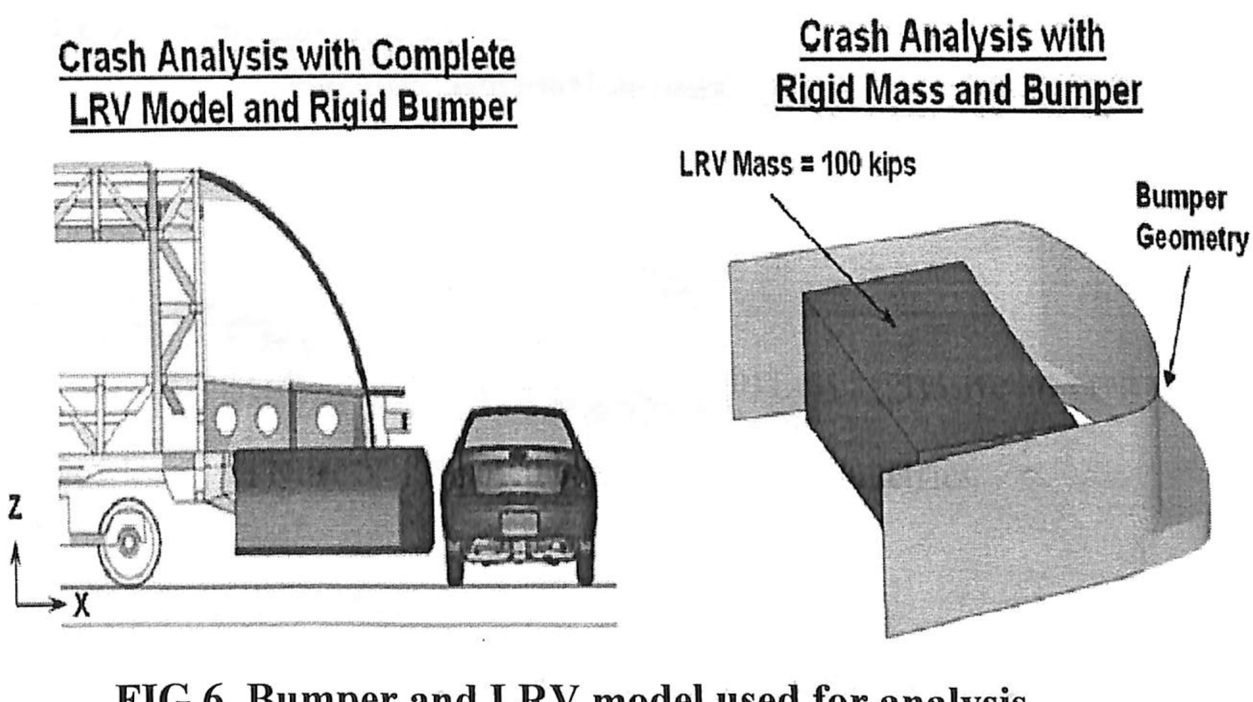


FIG.6 Bumper and LRV model used for analysis

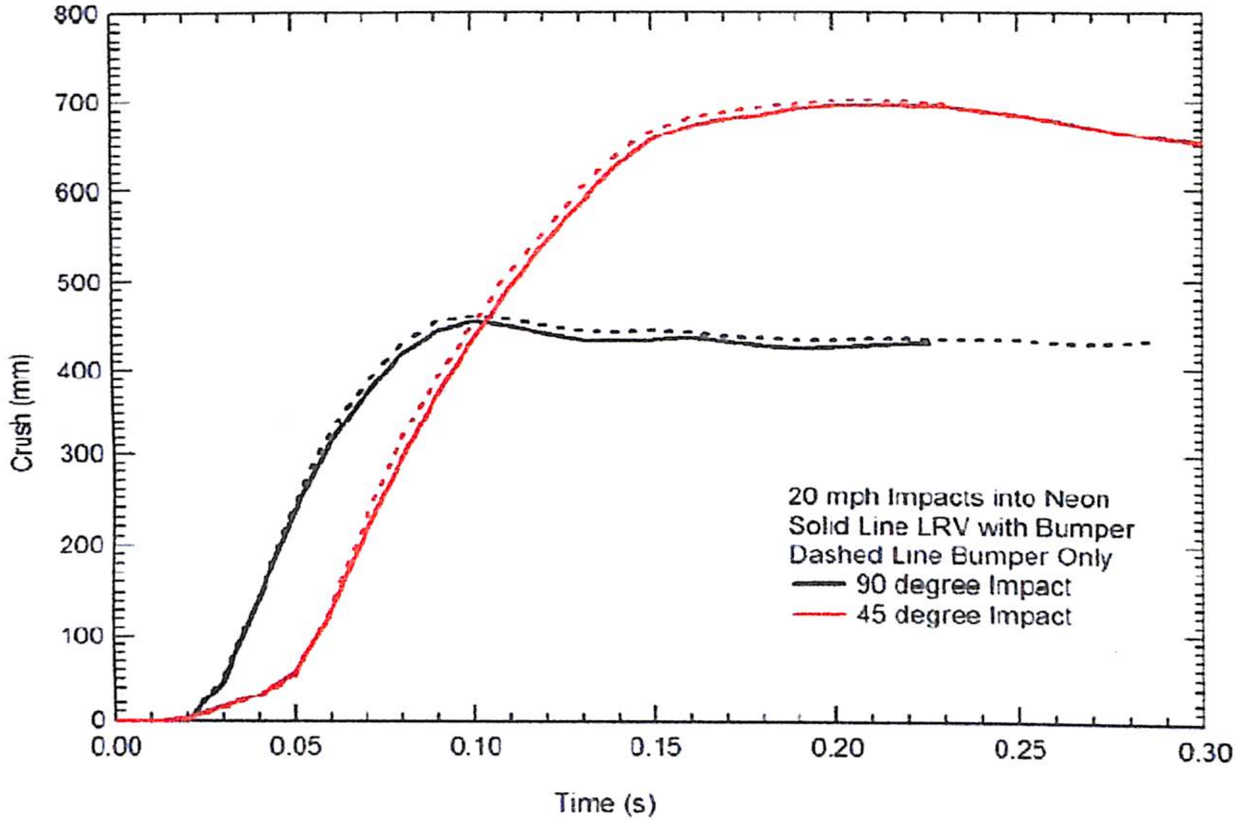


FIG.7 Comparison of LRV and bumper simulation VS Bumper simulation only

	Min -1	Base 0	Max +1
HAG	23.5 cm	35.5 cm	47.5 cm
BH	14.6 cm	27.9 cm	73.4 cm
DEPTH	15 cm	22.5 cm	30 cm
ANGLE	30°	0°	60°

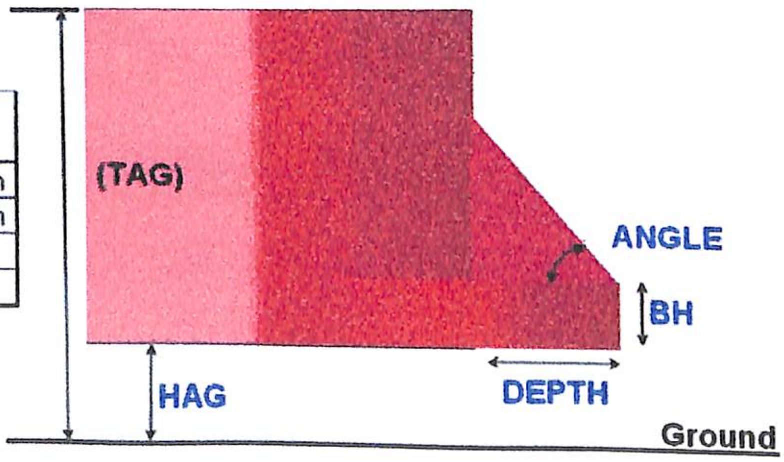


FIG.8 Bumper front end design Parameters

HAG- Height above ground, TAG- Total height above ground, BH- Bumper height

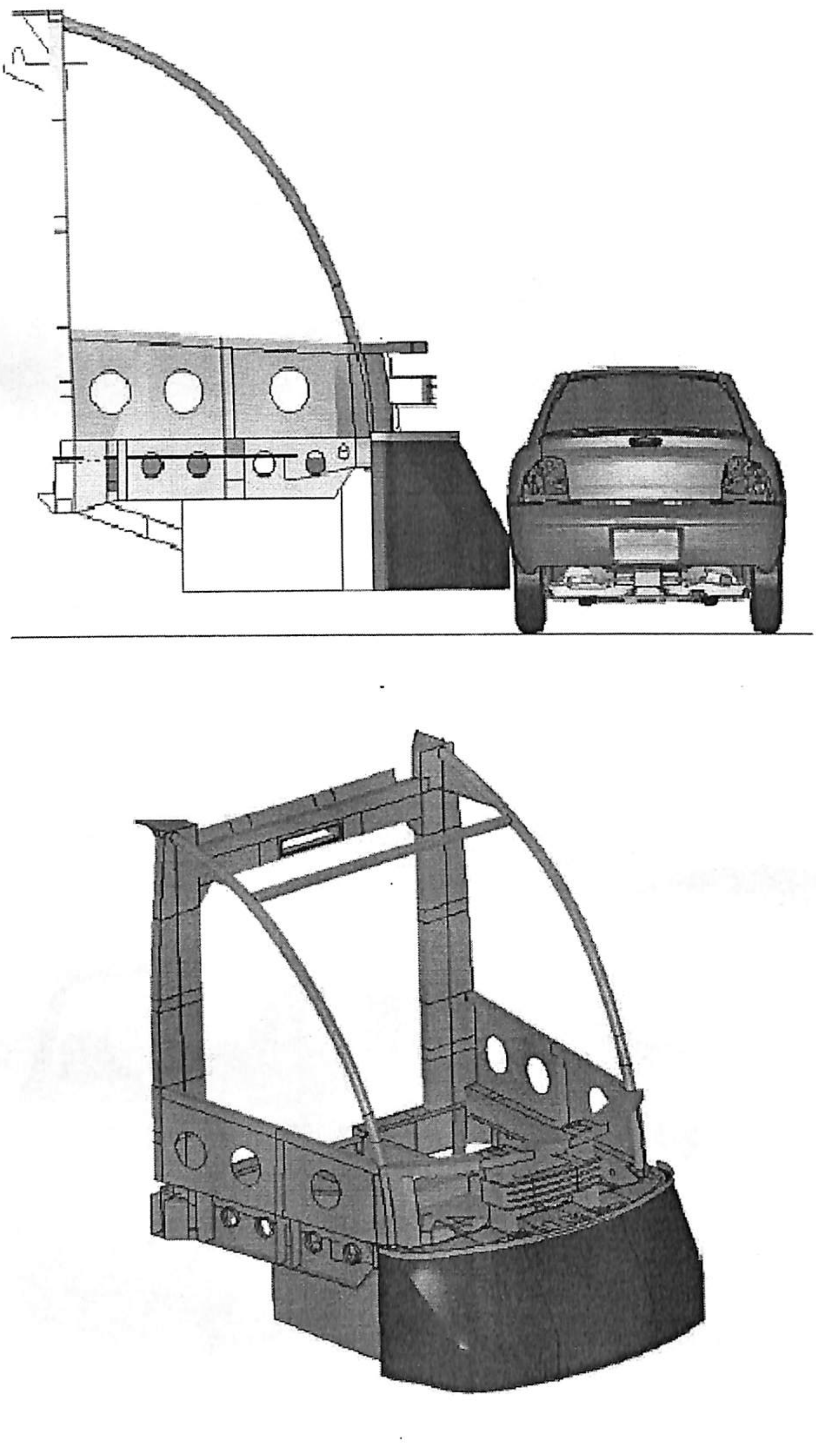
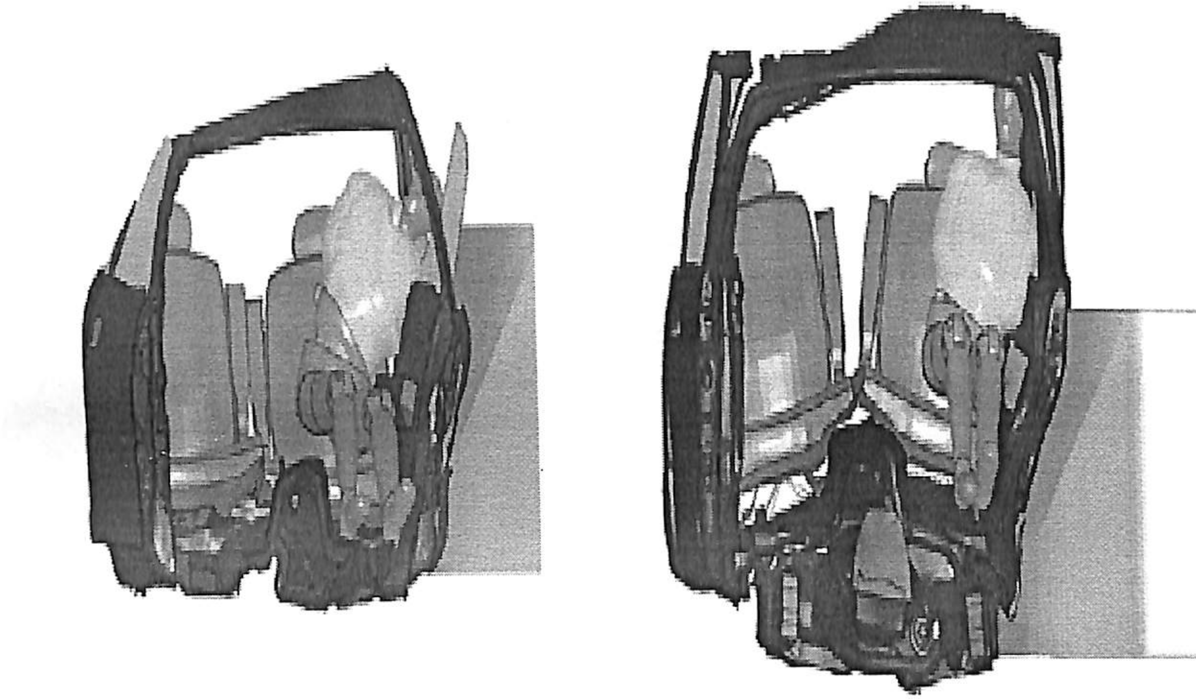
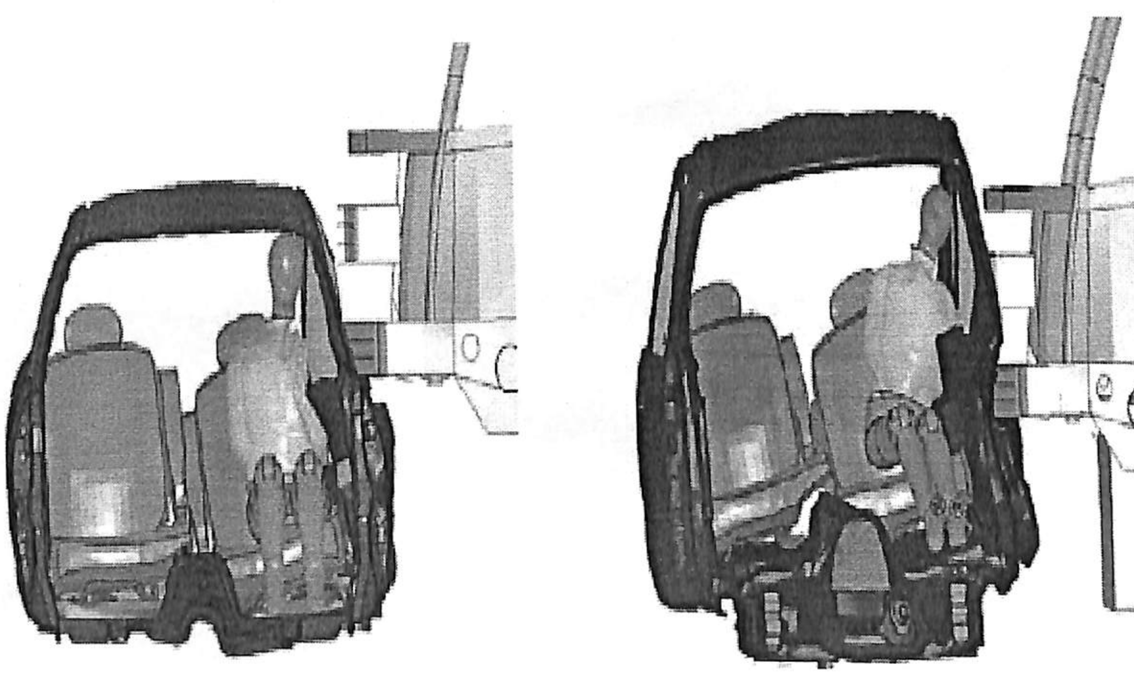


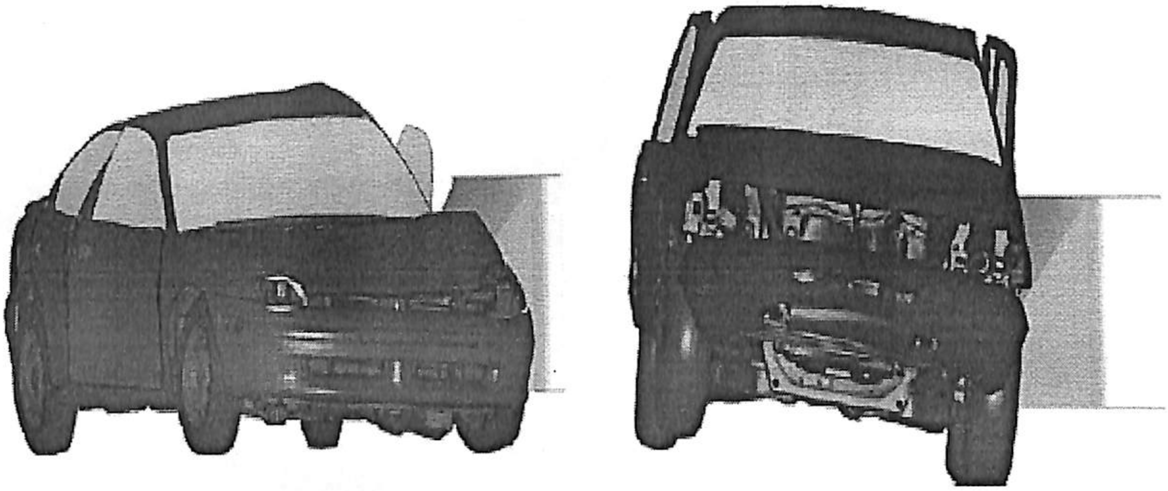
FIG.9 Bumper on the front of S70 LRV



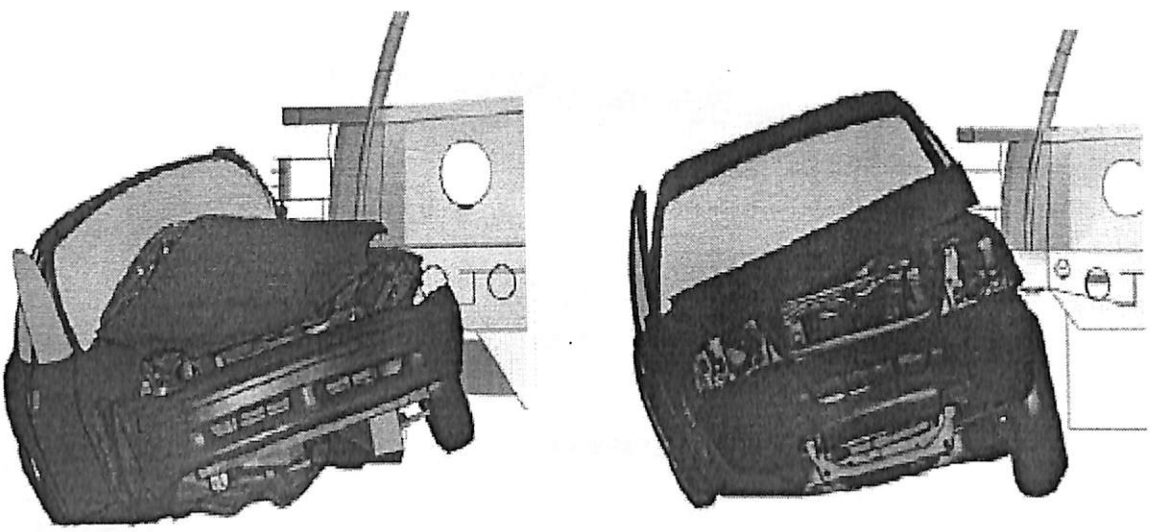
With Bumper



Without bumper



With Bumper



Without bumper

FIG.10 Bumper effect

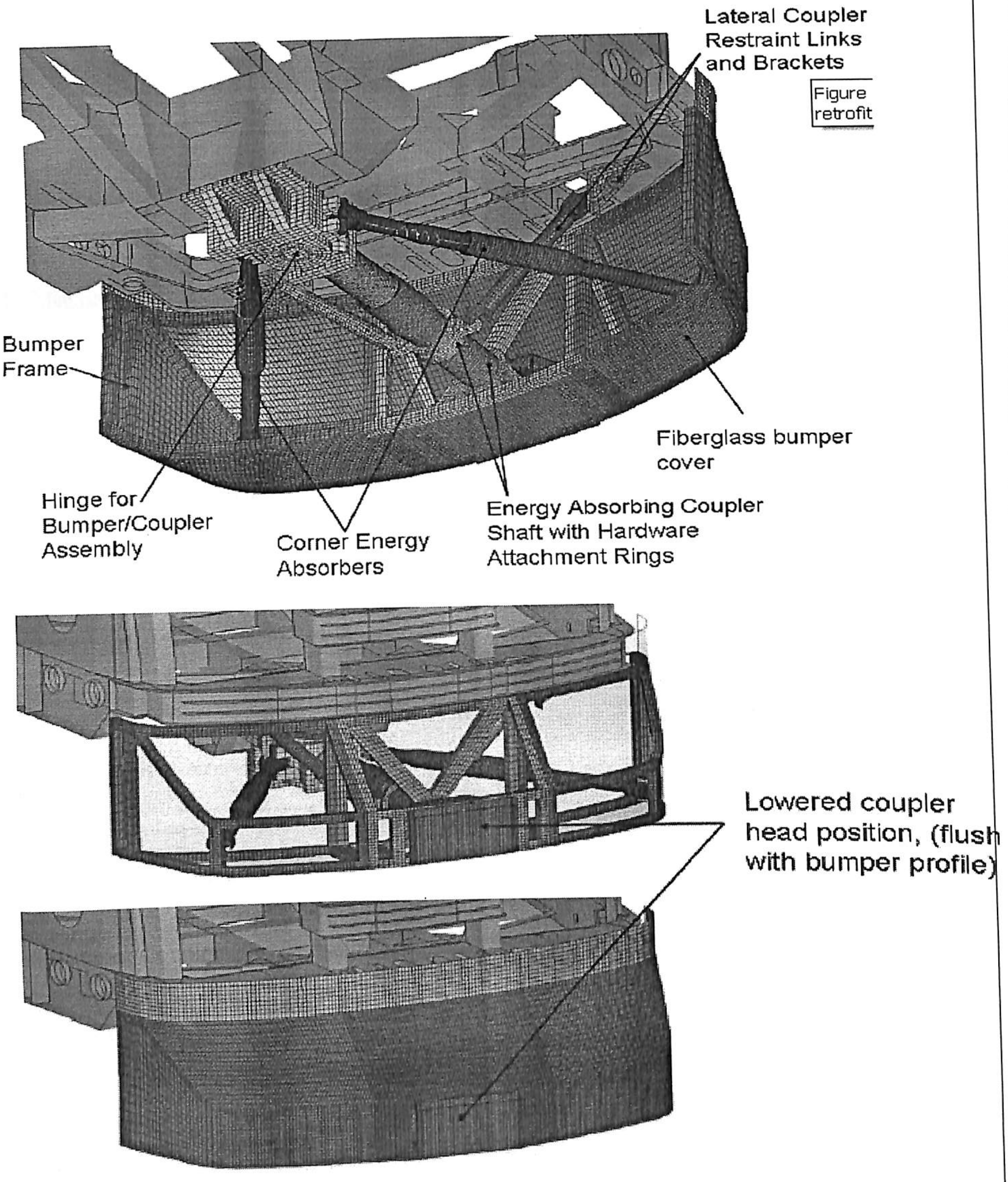


FIG.11 Detailed Bumper Design for LRV S70

Chapter 6: Bumper analysis using Solid Works

6.1 Analysis No.1Bumper front collision

Steps Taken:

1. Introduction
2. File Information
3. Materials
4. Load & Restraint Information
5. Study Property
6. Results
    a. Stress
    b. Displacement
    c. Deformation
    d. Design Check
7. Appendix

1. Introduction

The FEM analysis on bumper.

2. File Information

Model name: Bumper

Study name: Cosmos express Bumper collision Study

3. Material Used

No.	Body Name	Material	Mass	Volume
1	bumper 1	[SW]Alloy Steel	92.6453 kg	0.0120319 m^3

4. Load & Restraint Information

Restraint		
Restraint1 bumper	On **3 Faces** immovable (no translation).	

Load	
Load1 **bumper**	on **1 Faces** apply normal force **6000 N** using uniform distribution

5. Study Property

Mesh Information	
Mesh Type:	Solid Mesh
Meshed Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobean Check:	4 Points
Element Size:	2.2918 cm
Tolerance:	0.11459 cm
Quality:	High
Number of elements:	11734
Number of nodes:	23289

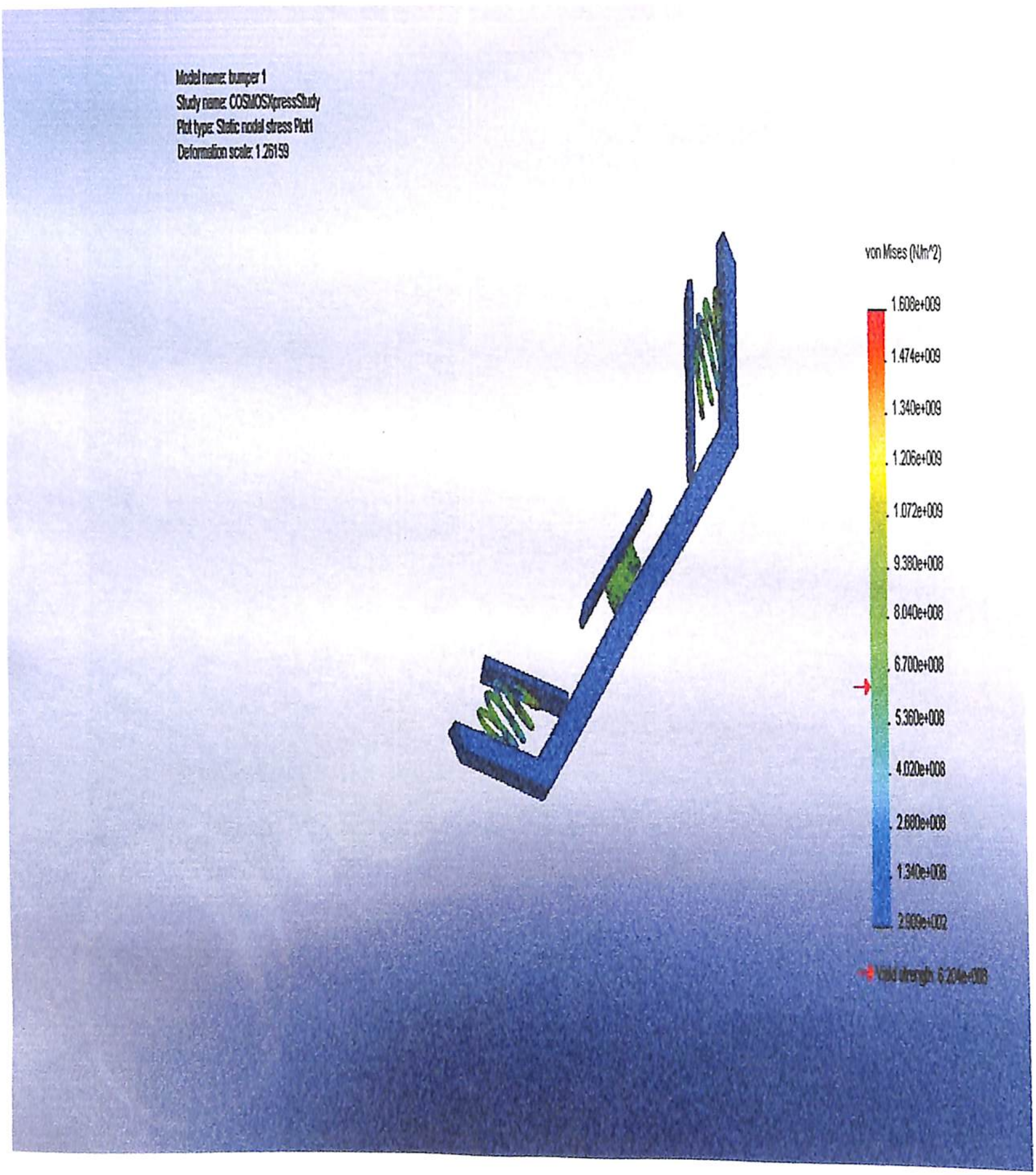
6. Results

6a. Stress

Name	Type	Min	Location	Max	Location
	Stress	290.921 N/m^2	(81.2898 cm, 16.4816 cm, -19.8523 cm)	1.60794e+009 N/m^2	(18.3311 cm, 5.92254 cm, -14.9983 cm)

bumper 1-COSMOSXpressStudy-Stress-Plot1

JPEG

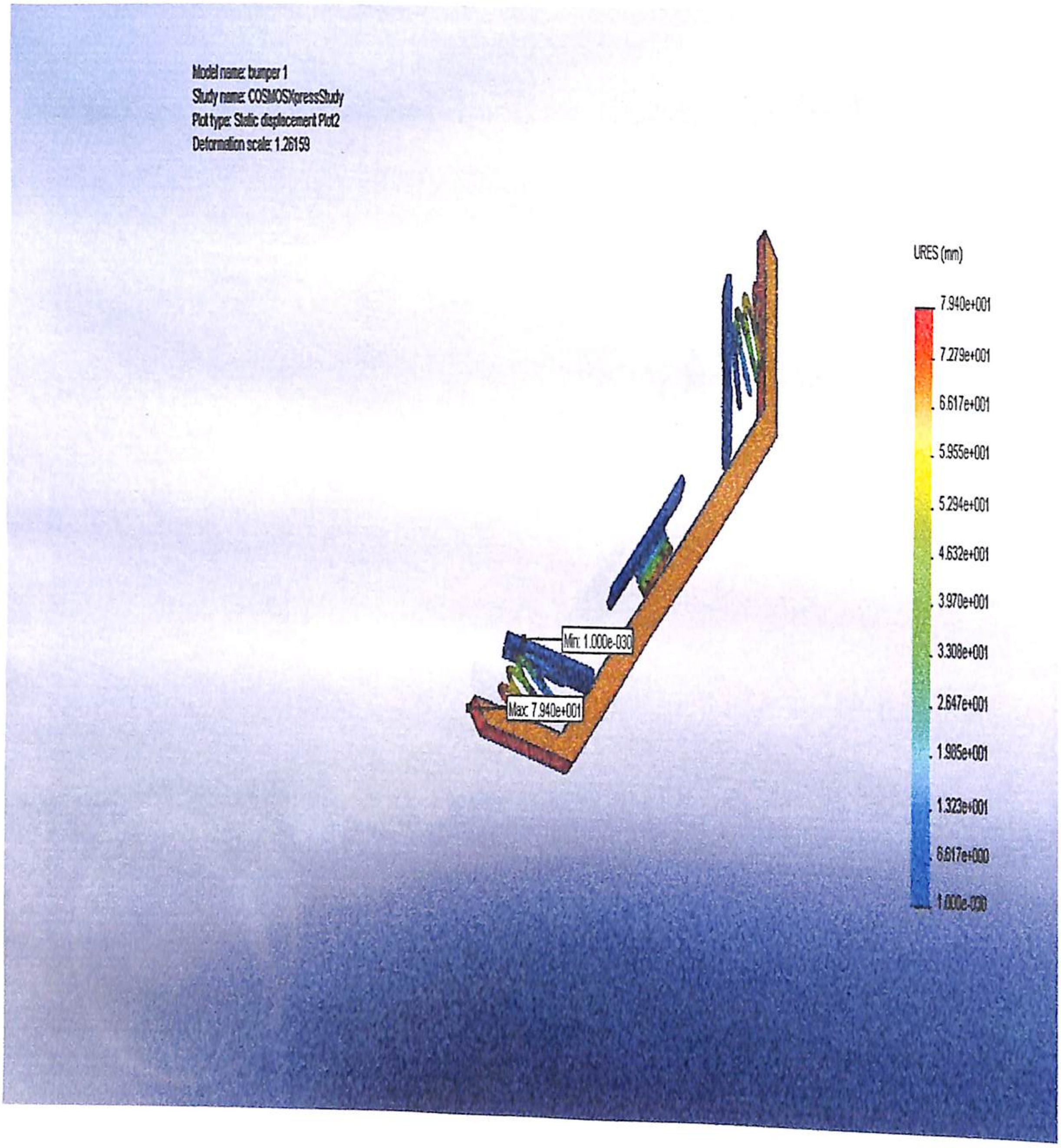


6b. Displacement

Name	Type	Min	Location	Max	Location
Plot2	Resultant Displacement	0 mm	(11.1749 cm, 20.1388 cm, -26.9349 cm)	79.403 mm	(-0.842418 cm, 0 cm, -17.1453 cm)

bumper 1-COSMOSXpressStudy-Displacement-Plot2

JPEG



6c. Deformation

bumper 1-COSMOSXpressStudy-Deformation-Plot3
JPEG

6d. Design Check

bumper 1-COSMOSXpressStudy-Design Check-Plot4
JPEG

7. Appendix

Material name:	[SW]Alloy Steel
Description:	
Material Source:	Used SolidWorks material
Material Library Name:	
Material Model Type:	Linear Elastic Isotropic

Property Name	Value	Units
Elastic modulus	2.1e+011	N/m^2
Poisson's ratio	0.28	NA
Mass density	7700	kg/m^3
Yield strength	6.2042e+008	N/m^2

6.2 Analysis No.2: Bumper Side collision

Steps Taken:

1. Introduction
2. File Information
3. Materials
4. Load & Restraint Information
5. Study Property
6. Results
    a. Stress
    b. Displacement
    c. Deformation
    d. Design Check
7. Appendix

1. Introduction

The FEM analysis of bumper.

2. File Information

Model name: Bumper

Study name: Cosmos express Bumper collision Study

3. Material Used

No.	Body Name	Material	Mass	Volume
1	bumper 1	[SW]Alloy Steel	92.6453 kg	0.0120319 m^3

4. Load & Restraint Information

Restraint		
Restraint1 bumper	On **3 Faces** immovable (no translation).	

Load	
Load1 **bumper**	on **1 Faces** apply normal force **6000 N** using uniform distribution

5. Study Property

Mesh Information	
Mesh Type:	Solid Mesh
Meshed Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobean Check:	4 Points
Element Size:	2.2918 cm
Tolerance:	0.11459 cm
Quality:	High
Number of elements:	11734
Number of nodes:	23289

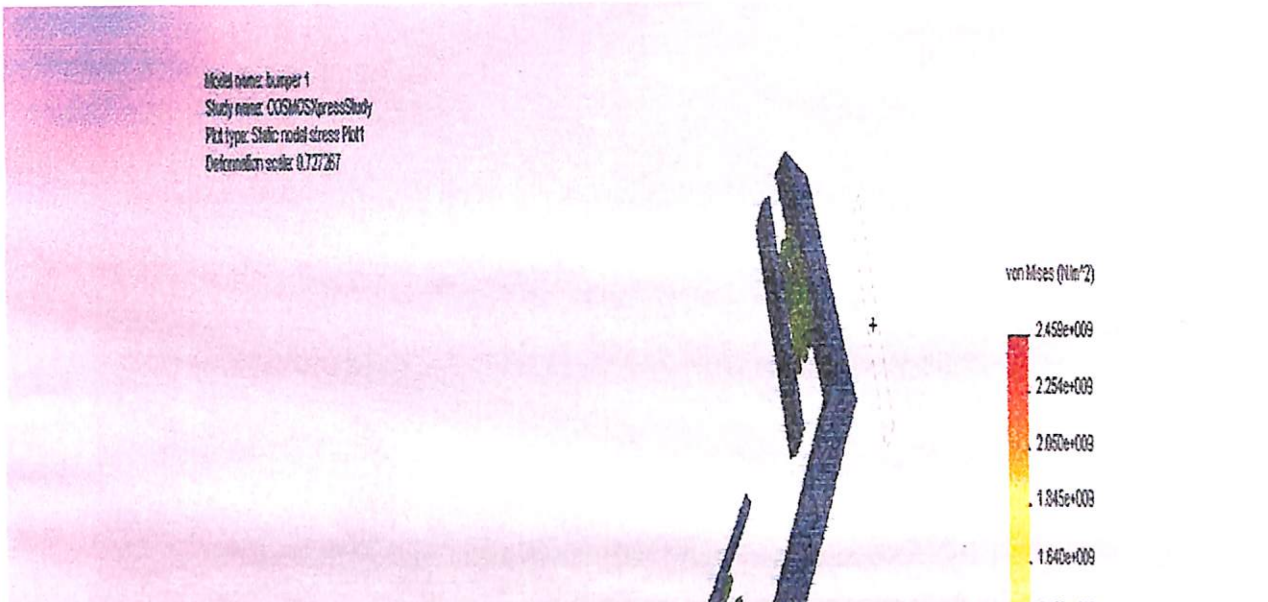
6. Results

6a. Stress

Name	Type	Min	Location	Max	Location
Plot1	Stress	280.683 N/m^2	(22.0507 cm, 16.7824 cm, -13.4728 cm)	2.45941e+009 N/m^2	(79.9051 cm, 9.09766 cm, -12.2378 cm)

bumper 1-COSMOSXpressStudy-Stress-Plot1

JPEG

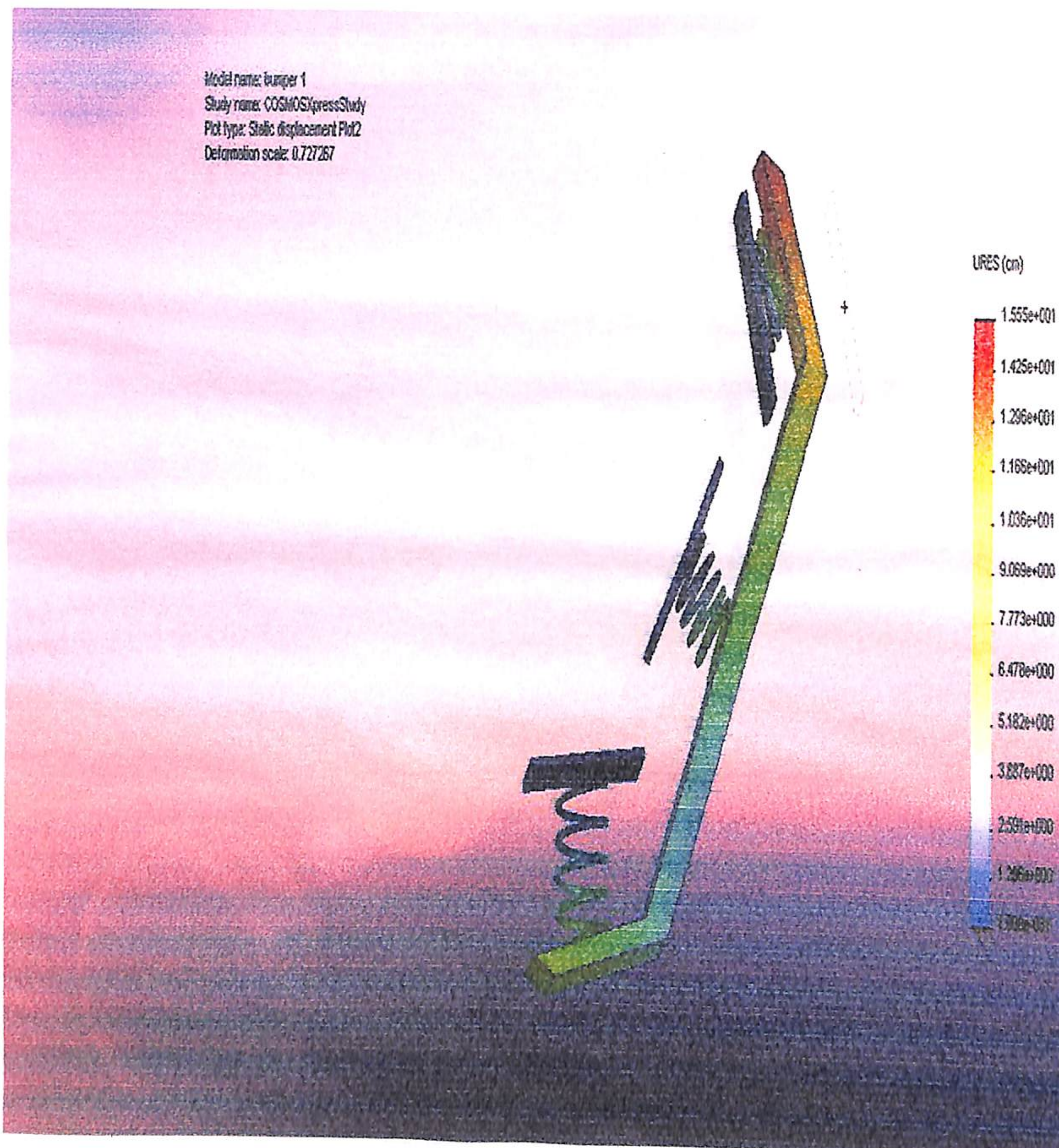


6b. Displacement

Name	Type	Min	Location	Max	Location
Plot2	Resultant Displacement	0 cm	(11.1749 cm, 20.1388 cm, -26.9349 cm)	15.5469 cm	(99.1576 cm, 0 cm, -17.1453 cm)

bumper 1-COSMOSXpressStudy-Displacement-Plot2

JPEG



6c. Deformation

bumper 1-COSMOSXpressStudy-Deformation-Plot3

JPEG

6d. Design Check

bumper 1-COSMOSXpressStudy-Design Check-Plot4

JPEG

7. Appendix

Material name:	[SW]Alloy Steel
Description:	
Material Source:	Used SolidWorks material
Material Library Name:	
Material Model Type:	Linear Elastic Isotropic

Property Name	Value	Units
Elastic modulus	2.1e+011	N/m^2
Poisson's ratio	0.28	NA
Mass density	7700	kg/m^3
Yield strength	6.2042e+008	N/m^2

Conclusion

The following outcomes are observed after carrying out this project.

1. The side collision analysis of a vehicle that we carried out in our project shows that bumper reduces damage during collision. As shown by simulation the vehicle without bumper suffers 94% damage, with pilot beam it is 75% and with bumper it is minimum that is 69%. So bumper reduces the collision impact.
2. As pedestrian safety is major concern now a day's by this project we have calculated the critical parameters in context of pedestrian safety.
   2.1 Knee bending angle should be less than 15 degree.
   2.2 Knee shear should be less than 6 mm.
   2.3 Force during impact should be less than 5KN.
3. From this study we have also concluded the mounting parameters for bumper.
   3.1 Bumper height should be 14.6-73.4 cm.
   3.2 Bumper depth should be 15-30 cm.
4. From the Solid works analysis it is cleared that pneumatic bumper absorbs more impact energy than conventional bumper.