# Crash Analysis of Front Bumper

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*Abstract: Proper design of front bumper is essential in safeguarding engine bay during low impact collisions. The energy absorption characteristics of bumpers should be good enough to absorb impact energy without much injury to pedestrian. The current research investigates the effect of bumper height on pedestrian injury. The CAD model of bumper is developed in Creo design software and FEA analysis is conducted in ANSYS software. The analysis is conducted for 200mm bumper height, 250mm bumper height and 300mm bumper height. For all the cases, the impact analysis is conducted at 40Km/hr. The equivalent elastic stress, equivalent elastic strain and internal energy absorption values are determined from analysis.*

*Key Words: Front bumper, Impact Strength, Energy absorption*

## 1. INTRODUCTION

Most pedestrian-vehicle crashes involve frontal impacts, and the vehicle front structures are responsible for most pedestrian injuries (fig 1). In a frontal impact, the chronology of the crash scenario is well documented: the vehicle bumper contacts the lower limbs, the leading edge of the bonnet strikes the proximal lower limb or pelvis, and, finally, the head and upper torso hit the top surface of the bonnet or windscreen as shown in figure 1 below

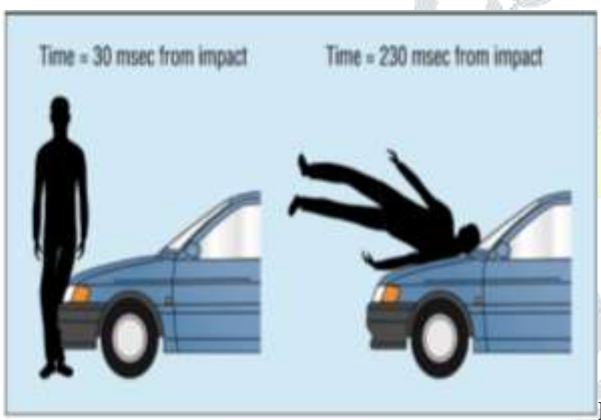


Fig 1: Sequence of events in a pedestrian-vehicle crash [1]

## 2. LITERATURE REVIEW

R. Ranjithkumar et al., [2], were used Pro/E and SOLID WORKS for conceptual design and impact analysis of bumper, in which the structural parameters such as displacement, strain energy, equivalent strain were considered for comparative study. Glass fiber based composite and ABS Plastic were the materials used for numerical simulation.

Nitin S. Motgi et al [3]., this paper provided the procedures involved in the bumper problems in the perspective of numerical methodology, in which CAD/CAE tools played the predominant role.

V. Kleisnera [4] et al., deals the analyze of composite bumper using the PAM-Crash software. Shell and Ladeveze elements were used in this paper for the purpose of representation of composite original behavior in software.

Lande P. R [5]., implemented the Honeycomb sandwich panel in the crash investigation of car and thereby the results were estimated successfully.

A. R. Mortazavi Moghaddam et al., [6] implemented the Glass Materials in bumper to enhance its properties. CATIA and LS-DYNA tools were used here for conceptual design and structural analysis respectively. From all the previous studies, the following details are obtained which are standard details about bumper are learned, element type, methodology used, boundary conditions, mechanical properties of materials.

## 3. OBJECTIVE

The bumpers are designed to protect vehicle at low velocity and also to reduce pedestrian injuries. In this regard, the placement of bumper at optimum height from ground can be a significant criterion to minimize pedestrian injuries. The current research deals with the investigation of injuries caused by car front bumper to pedestrians and determining the optimum height for minimum injury. The CAD model of bumper and legform is developed in creo design software and FEA analysis is conducted using ANSYS software.

## 4. METHODOLOGY

The CAD model of car body is done using Creo design software. The software is sketch based, feature based, parametric 3d modelling software developed by PTC and has the properties of bi-directional associativity and parent child relationship. The car body is modelled using extrude tool, revolve, pattern and other tools. The detailed description is provided in further sections.

Figure 2: Assembly model of bumper and legform at 250mm from ground

The CAD model of bumper and legform assembly is converted in .iges format and imported in ANSYS Design Modeler. It is checked for geometric errors like hard edges, inflation and surface patches.

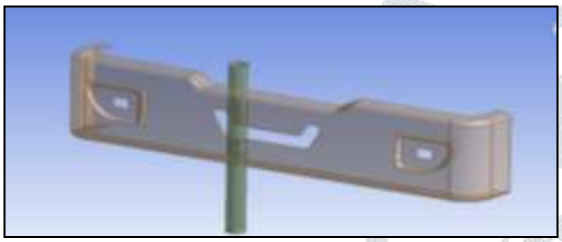

Figure 3: Imported CAD model of bumper and legform in ANSYS design modeler

The CAD model of bumper and legform assembly is meshed using ANSYS mesher. The model is meshed using tetrahedral elements. The element sizing is set to fine and inflation set to normal, smoothing set to high. transition ratio .272.

Figure 4: Meshing of front bumper assembly in ANSYS mesher

Number of elements generated is 10030 and number of nodes generated is 4920. The loads and boundary conditions involve applying initial velocity to bumper on bumper. The legform is applied with displacement support on bottom. The loads and boundary conditions involve applying initial velocity to bumper on bumper. The legform is applied with displacement support on bottom.

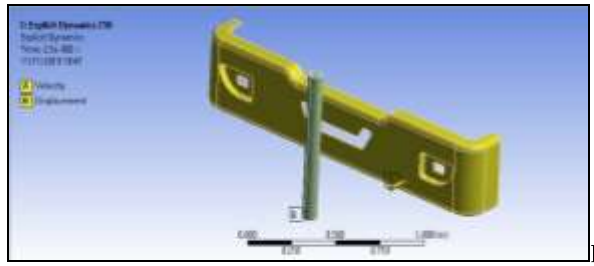

Figure 5: Loads and Boundary conditions

The analysis is performed for .025 secs. The initial velocity considered for impact analysis is 11.1 m/s which is 40Km/hr.

## 5. RESULTS AND DISCUSSION

The current section describes the stress and strain developed on bumper at low velocity impact of bumper on pedestrian. The explicit dynamic analysis is conducted on ANSYS Explicit Dynamics.

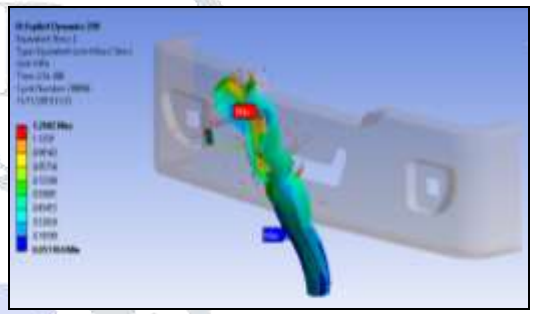

Figure 6: Equivalent stress developed on leg form at 200mm bumper height

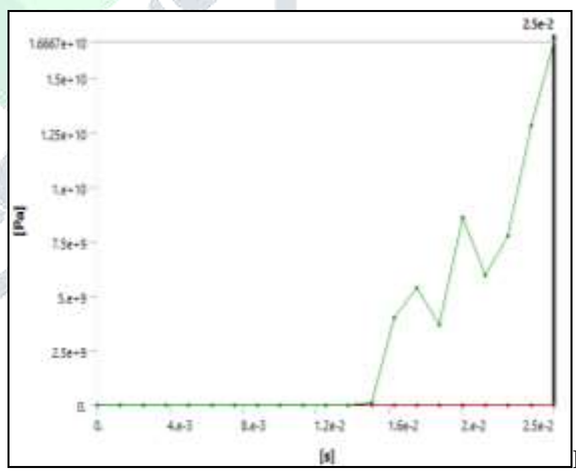


Figure 7: Equivalent stress vs time at 200mm bumper height

The equivalent stress plot generated as shown in figure 7 above shows the maximum stress in the region of femur section with magnitude of 1.26MPa at .025s after impact and minimum stress is generated on outer flesh region with magnitude of .185Mpa. Figure 8 shows zero stress till vehicle comes in contact with legform and gradual increase after .014s (at the time of impact) and increases upto $1.66*10^{10}$ Pa. The equivalent elastic strain plot shown in figure 5.3 below shows maximum strain of .919 for topmost portion of leg form and minimum magnitude of .0848 at bottommost portion of leg form at last time of impact i.e. .025secs.

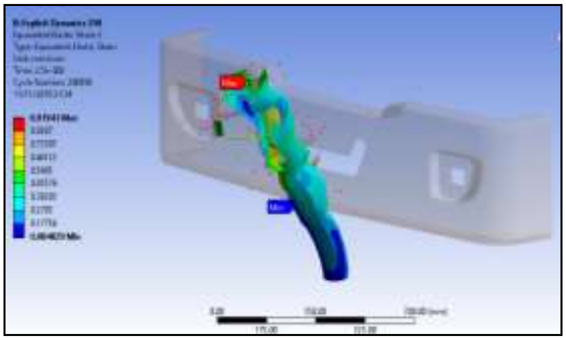

Figure 8: Equivalent elastic strain developed on leg form at 200mm bumper height

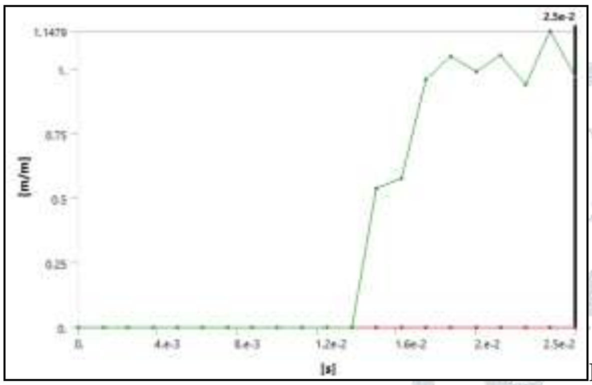


Figure 9: Equivalent elastic strain vs time at 200mm bumper height

The equivalent strain is zero till the time of initial impact i.e. .014secs and then increases to maximum at 1.147 at .023s and then decreases to .919.

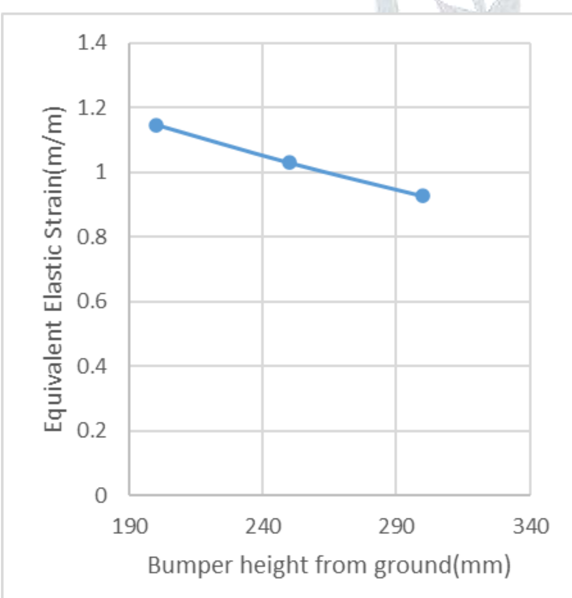


Figure 10: Equivalent elastic strain vs bumper height

Bumper height has significant effect on equivalent strain developed in legform as its evident from figure 10 above. With increase in bumper height, the amount of eq. strain developed in legform reduces and minimum strain is observed for bumper height of 300mm.

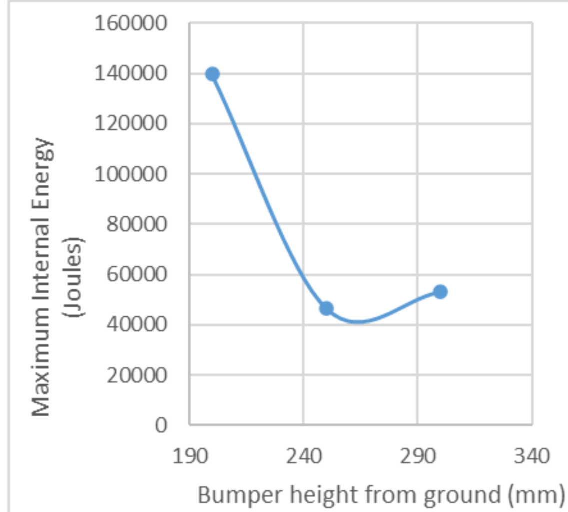


Figure 11: Maximum internal energy vs bumper height

The bumper height also influences the amount of internal energy in legform as shown in figure 11. The internal energy developed is highest for bumper height of 200mm and decreases for 250mm bumper height and again increases for bumper height of 300mm.

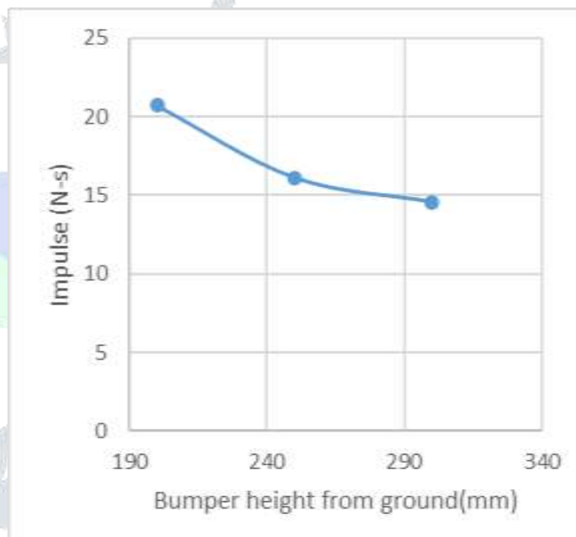


Figure 12: Impulse vs bumper height

The bumper height also influences the impulse on legform as shown in figure 12. The maximum amount of impulse is developed for bumper height of 200mm which consecutively decreases for increase in bumper height to 250mm and 300mm.

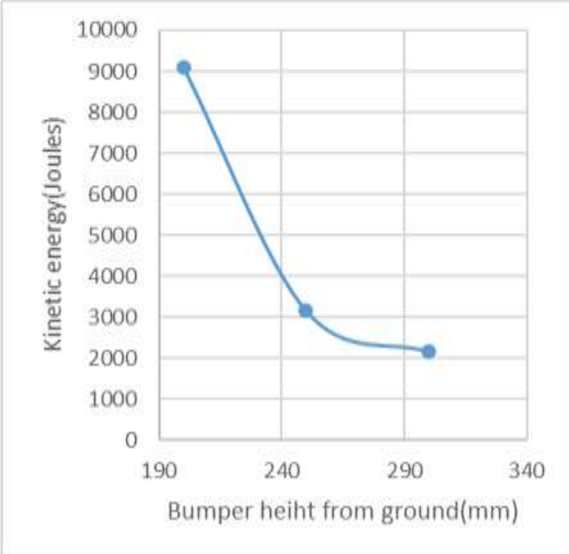


Figure 13: Kinetic energy vs bumper height

The kinetic energy of legform decreases with increase in bumper height as shown in figure 13 above. The highest kinetic energy is observed for 200mm height and reduces with increase in bumper height consecutively for 250mm and 300mm.

## 5. CONCLUSION

The current research investigated the effect of bumper height on pedestrian safety using ANSYS Explicit Dynamics platform. Three different heights were considered for analysis are 200mm, 250mm and 300mm. Bumper height has significant effect on equivalent strain developed in leg form. With increase in bumper height, the amount of equivalent strain developed in legform reduces and minimum strain is observed for bumper height of 300mm. The bumper height also influences the amount of internal energy in legform. The internal energy developed is highest for bumper height of 200mm and decreases for 250mm bumper height and again increases for bumper height of 300mm.

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