International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 08 | August - 2022 Impact Factor: 7.185 ISSN: 2582-3930

FEA Correlation of Automotive Bumper Beam Design with Experimental Test

Mr. Aniruddha Srinath Parab[1], Prof. Dr. M.S. Deshmukh[2]
1. *P.G. Student, AISSM's, College of Engineering, Pune, India.*
2. *Professor, AISSM's, College of Engineering, Pune, India.*

Abstract- Whenever we design automotive bumper beam, it is necessary to consider its bending strength as well as crushing strength to ensure safety of passengers & vehicle as well as its surrounding important components such as headlights, cooling panel. Bumper beam cross section should be design in a such a way that it can absorb maximum impact energy in case of low-intensity impact. Also, bumper beam must have good bending strength as well as good section stiffness. It is very important that bumper beam should give optimum performance with optimize mass. Optimize mass further helps in reduction in cost as well as lightweight of vehicle.

Keywords: 3 Point bend test, Section crush Test, FEA Analysis, Correlation, Experimental test.

Introduction:

Important function of Bumper system is to protect occupants & its component in case of low-speed impact, components like cooling pack, lighting system, exhaust muffler which are costly for repair as well as replace. These days bumpers are designed to absorb as much as energy. Bumper design must ensure good engagement with other vehicle in case of collision despite of over-riding or under-riding situation. Lot of research has been done to improve bumper beam bending strength & crushing stiffness. We can determine bending strength & section stiffness experimentally by performing 3-point bend test & section crush test.

Literature Review:

Talnak, Sonmez, and Senaultun [1] explained that optimizing the bumper beam section to meet strength and durability requirements at low and high speeds. **Khedkar, Kumar, Sonawane [2]** has discussed that it is important to study 3-Point bend test experimentally & numerically. Passenger vehicle at low speed if meets the impact then it undergoes similar behavior like 3-point bend test. From 3-point bend test we can estimate about bending strength of bumper beam & also necessary to design bumper beam section to absorb more energy at low-speed impact**. Mahesh Kumar, Butkar, and Raykar [3]** stated that design the front bumper beam with two major factors in mind: the internal absorbed energy by the bumper beams must be kept high by using material with excellent yield strength, as well as good stiffness and minimal deformation. Highest bumper beam deflection was kept within allowable levels. The bumper's stress value should be less than the material's yield stress. **Javad, Masoud, and Mahdi [4]** mentioned that how the deformation of the bumper beam must be minimized as much as possible so that in the occasion of a low-speed impact, the powertrain as well as other neighboring components are not damaged. **Kankariya, Niketa, Sayyad [5]** used a rib pattern to modify the section profile of the beam, which reduces deformation of the bumper beam and improves energy absorption. The addition of a ribbing pattern will increase the rigidity of the bumper beam. **Roopesh and Rao [6]** used FEM to characterize low and high-speed impact and beam structure to absorb energy in the case of low and high-speed impact. By enhancing the bumper thickness and rigidity, the impact force and rigidity of the bumper could be enhanced. the addition of ribs, which leads to the direct increase in impact force and reduce in bumper deformation

Bumper System of Passenger Vehicle:

Image 1: Bumper System.

Image above showing typical bumper system of a passenger vehicle. Bumper system consists of Bumper beam, crush box & rail plate. These 3 parts are welded together. In case of low-speed impact, bumper system serves as energy absorber, it absorbs load acting in axial direction. In case of low-speed impact bumper beam absorb initial load & then it smoothly transfers the load on crush box which further absorbs most of the energy, purpose of the rail plate is to keep bumper & crush box attached with remaining structure of vehicle behind it.

Bumper Beam selection for experimental testing:

We found following important points while studying literature review & following conclusions were made.
a) It is necessary to study bending strength & cross section stiffness of bumper beam, no research was found on the same.
b) Bumper beam with close cross section design is good in performance in case of low speed & high-speed impact.
c) Most of the bumper beam has close section profile with either rectangular or square shape.

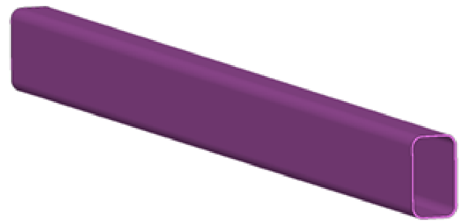

Image 2: Bumper Beam design in CATIA for FEA analysis.

Image 2 shows, available bumper beam cross section in the market. Bumper beam has 95mm height & 50mm depth & 3mm thickness. We perform ASTM tensile test to determine material, we found that material has UTS of 400 Mpa.

FEA Analysis :

Using Hypermesh, we build FEA model of bumper beam which we brought from market. Meshing is carried on mid surface & 3mm thickness was assigned. Input conditions were applied on FEA model for 3-point bend test as well as Section Crush Test. 3 Point bend test setup consist of bumper beam placed on fixed support & displacement were applied to moving impactor in specified direction so that bumper can bend similarly for section crush test, we placed piece of bumper beam on fixed rigid support & crushed bumper beam by moving impactor. Image-3 & Image-4 are showing setup conditions used for 3-point bend test & section crush test respectively. after applying boundary conditions to FEA model, it simulated in LS-Dyna solver for impact analysis. After finishing FEA analysis, we post process the data & plot Force Vs Displacement curve for FEA model. We got peak load of 29.3 KN & for Section Crush Test, we got peak load of 122.9 KN.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 08 | August - 2022 Impact Factor: 7.185 ISSN: 2582-3930

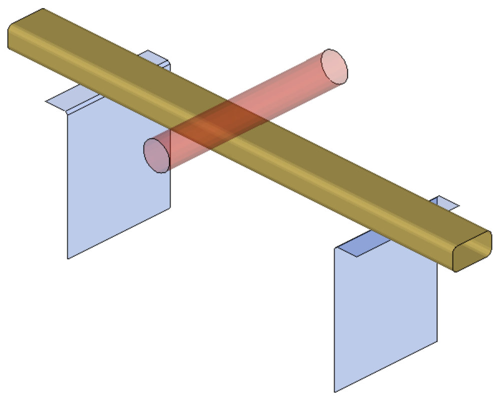

Image 3: 3 Point Bend Test FEA Setup

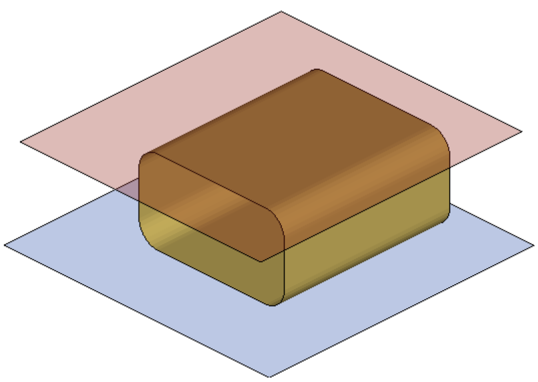

Image 4: Section Crush Test FEA Setup

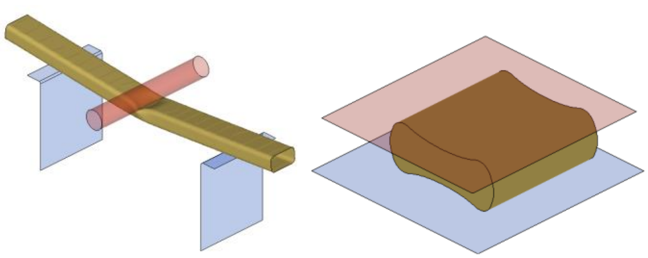

Image 5: Deformed stage of 3 Point Bend Test & Section Crush Test in FEA.

Experimental testing for 3 Point Bend Test.

Mechanical properties of Bumper beam material were determined through ASTM E8 Tensile test. We determined Yield strength, % elongation & Ultimate strength of bumper beam material. We got TS of bumper beam material around 400 Mpa.

To perform 3-point bend test on UTM machine, we kept bumper beam length to 800 mm as total length. We kept distance between two fixed supports as 400 mm. image-6 shows experimental setup for 3-point bend test. Fixed supports are rigid supports on which we have placed bumper beam on equal distance from both supports. Moving impactor is attached to UTM machine in such a way that it impacts the bumper beam exactly center of entire span & deform at center. We have applied constant displacement to rigid impactor so that it can deform the bumper beam to determine the bending strength of bumper beam section. UTM machine is connected to computer which was measuring Force-Vs Displacement characteristic. We perform total 2 test & peak load we observed was 27.7 KN & 27.6 KN respectively. Image-6 & Image-7 are showing before & after test picture of 3-point bend test.

Image 6: Bumper Beam testing for 3 Point Bend Test

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 08 | August - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Image 7: Bumper Beam testing for 3 Point Bend Test

Experimental Testing: Section Crush Test

We cut Bumper beam section pieces each by 260mm so that we can perform section crush test to determine section stiffness of bumper beam section. Section crush test experimental setup consist of bumper beam placed on flat rigid plate & flat rigid impactor was mounted on UTM machine so that it can crush entire piece of bumper beam uniformly throw-out its length. We applied constant displacement to moving impactor. Images 8 & 9 are showing experimental setup for section crush test for before & after scenario of testing. We perform total 2 experimental test & we determined section crush strength as 117.8 & 117.5 KN respectively.

Image 8: Experimental setup for Section Crush Test

Image 9: Experimental setup for Section Crush Test

FEA and experimental testing correlation:

We perform tested 2 samples for each test in order to see repeatability in the performance of experimental testing. Using Hyperview, we overlay Force vs Displacement curve for FEA test & experimental test together to see correlation between FEA & experimental testing.

It is very important to perform correlation of experimental Vs FEA analysis performance curves, it gives us the accuracy of FEA simulation results.

Test	Experimental Peak Load	FEA Peak Load	
		Test Sample-1	Test Sample-2
3 Point Bend Test	29.4 KN	27.8 KN	27.7 KN
Section Crush Test	122.9 KN	117.9 KN	117.5 KN

Table 1: Peak Load comparison

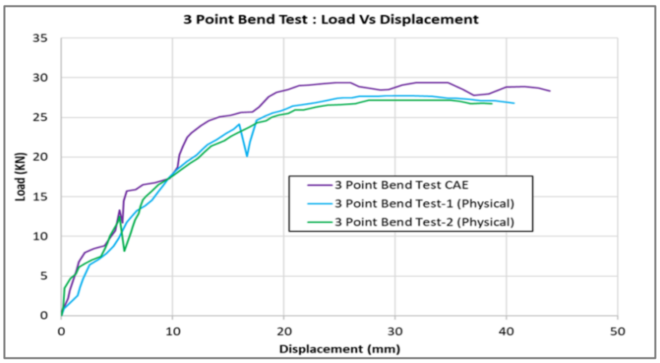

Image10 : 3 Point Bend Test Load Vs Displacement curve overlay for FEA & Experimental test

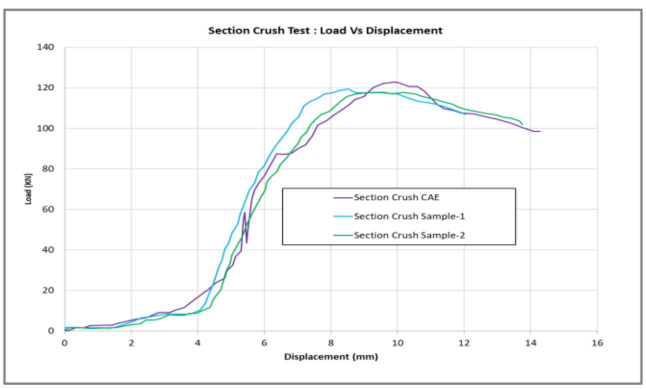

Image11 : Section Crush Test Load Vs Displacement curve overlay for FEA & Experimental test

Image-10 & Image-11 are showing FEA Vs Experimental test correlation for 3-point bend test as well as section crush test. Also, Table-1 is showing peak load comparison for 3-point bend test & section crush test from which we can understand the level of correlation or accuracy between FEA & experimental test results.

Conclusion:

For the current study, we use FEA & experimental testing approach to confirm correlation between FEA simulation & experimental testing. We characterized the mechanical properties using ASTM E8 Tensile test. Also, we perform FEA simulation & experimental test for 3-point bend test & section crush test. After reviewing curve overlay & pre-post images of experimental testing we draw following conclusions:

a) We observed similar peak load in 3-point bend test & section crush test for FEA & experimental testing.
b) Images of Pre & posttest are showing similar kind of deformation mode for both 3-point bend test & section crush test.
c) Initial stiffness as well as peak load characteristic are looking similar for both testing.

We can conclude that there is a good correlation between FEA simulation & experimental test in terms of peak load, initial stiffness & overall load level.

References:

[1] Davoodi, M. M., S. M. Sapuan, Ali Aidy, NA Abu Osman, Azim Ataollahi Oshkour, and WAB Wan Abas. "Development process of new bumper beam for passenger car: A review." Materials & Design 40 (2012): 304-313.

[2] Khedkar, Nitin K., C. R. Sonawane, and Satish Kumar. "Experimental and static numerical analysis on bumper beam to be proposed for Indian passenger car." Materials Today: Proceedings 42 (2021): 383-387.

[3] Dange, Maheshkumar V., Rajesh B. Buktar, and Nilesh R. Raykar. "Design and analysis of an automotive front bumper beam for low-speed impact." IOSR J. Mech. Civil Eng. 12 (2015): 17-27..

[4] Marzbanrad, Javad, Masoud Alijanpour, and Mahdi Saeid Kiasat. "Design and analysis of an automotive bumper beam in low-speed frontal crashes." Thin-walled structures 47.8-9 (2009): 902-911.

[5] Kankariya, Niketa, and F. B. Sayyad. "Numerical simulation of bumper impact analysis and to improve design for crash worthiness." Int. J. Engrg. Sci 4.5 (2015): 58.

[6] Roopesh, E. S., and L. Bhaskara Rao. "Design and Analysis of an Automotive Frontal Bumper Beam for Low-Speed Crashes." Journal of Multidisciplinary Engineering Science and Technology (JMEST) 2 (2015): 994-998.

.