Design and Analysis of Crash Box with Different Models

Mohammad Kaleem Pasha[1] |Dr K.Vasantha Kumar[2]

[1]M.Tech Student, Department of Mechanical Engineering, Jawaharlal Nehru Technological University Hyderabad College Of Engineering, Jagtial, Telangana State, India

[2]Assistant Professor and HOD, Department Of Mechanical Engineering Name, Jawaharlal Nehru Technological University Hyderabad College Of Engineering , Jagtial, Telangana State, India

Abstract: Crash box is a separate component in a vehicle that is installed between the main frame and the front bumper. The Crush Box is a deformable thin-walled structure that connects the car bumper to the chassis. The Crush box has a much larger role in absorbing impact energy. In the event of a front-end accident, the crash box is expected to flex and absorb crash energy, which can then be transferred to other cabin elements, minimizing damage to the occupant cabin and occupant.

The passenger is protected and comfortable by the crash box structure in the event of a frontal collision. The energy absorption of a plane crash box with varied thickness is investigated in this project. Analytical, experimental, and numerical work are used in this study. The impact of various characteristics such as width, thickness, and taper on crash box performance is investigated. On the UTM machine, an experimental test is carried out. The results of the analytical, experimental, and numerical methods were found to be in good agreement. Different designs are developed and simulated for maximum energy absorption by altering the parameters and application of beads.

Keyword: Crash Box, Energy Absorption, Front collision, FEA analysis.

DOI of the Article: https://doi.org/10.46501/IJMTST0708037

Available online at: http://www.ijmtst.com/vol7issue08.html

As per UGC guidelines an electronic bar code is provided to seure your paper

To Cite this Article: Mohammad Kaleem Pasha and Dr K.Vasantha Kumar. Design and Analysis of Crash Box with Different Models. *International Journal for Modern Trends in Science and Technology* 2021, *7*, pp. 230-236. https://doi.org/10.46501/IJMTST0708037

Article Info. Received: 12 August 2021; Accepted: 24 August 2021; Published: 27 August 2021

1.INTRODUCTION

In today's world, the automotive sector faces a constant and growing pressure from consumers as well as numerous regulatory and certification bodies who demand that the vehicle meet specific specifications. The two most essential regulatory criteria are car crash safety and pollution. However, under urban driving conditions, the car is frequently susceptible to low-speed accidents, resulting in vehicle damage and repair. These low-speed collisions are becoming more common, resulting in higher repair costs, which affect insurance companies indirectly.

Road travel is India's most popular means of transportation, both in terms of traffic volume and contribution to the national economy. The number of cars and the length of the road network have risen throughout time to accommodate the demand for road transportation. The growth in road accidents and fatalities is a negative externality related with the country's expanding road network, motorization, and urbanization. A Traffic safety and car accidents have become a major focus of automotive research in recent years. The number of people using the roads is growing all the time, making serious injury and death from car accidents a major issue. Every year, as the number of vehicles on the road grows, so does the number of people killed in car accidents.

Road accidents are becoming more common, causing significant damage to both individuals and automobiles. In normal traffic, the most common sort of collision is a frontal collision. In the event of a collision, not only the damage to the vehicle but also the injuries to the occupants are critical. As a result, vehicle safety and protection against severe damage play critical roles in vehicle design. If the car is more severely damaged, the cost of repair will likely increase. As a result, safety measures must be developed in accordance with usage in order to decrease the risk of human life and vehicle damage.

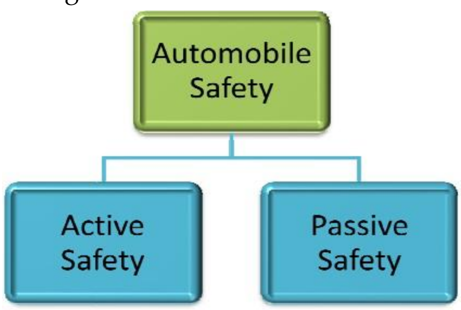

Fig.1.2: Classification of vehicle safety

There are two types of vehicle safety: active safety and passive safety (fig.1.2). Active safety systems assist occupants (mostly the driver) in preventing vehicle collisions through a variety of approaches, such as assisting in vehicle handling and control. Anti-lock braking system (ABS), cornering aid (to preserve stability in abrupt corners), hill hold assist, hill descend assist, remote tyre pressure monitor, and driver sleep/nap warning system are examples of active safety technology. Passive safety systems allow injury control and minimization during a collision by using laser sensors to detect obstacles/animals/pedestrians in advance. Three-point seatbelts, driver and passenger airbags, side airbags, curtain airbags, knee airbags, and seats with head/neck support are all examples. These are critical for an occupant's life following a car accident or collision. The crash box is also a passive safety feature since it reduces the impact of a collision on the passenger by absorbing the energy of the collision. It is also built into the vehicle's structure, unlike other passive parts.

2. LITERATURE REVIEW

Langseth et al. (1998) investigated the crashworthiness of aluminium extrusions subjected to impact loading and validated a numerical model with experimental results using LS-DYNA. An experimental evaluation was performed to study the combined effect of extrusions and aluminium foams for increasing the energy absorption ability of thin walled aluminium structures subjected to axial impacts.

Noma et al. investigated the compressive and bending type loading of a crash box as a walled beam structure representing a part of the vehicle structure using a finite-element process (2002). According to them, the component area can be divided into two distinct areas: effective and ineffective. The effective collapse force was investigated, and the vehicle structure was improved.

Costas et al., (2013) used experiments and numeric analysis to investigate five different types of energy absorbers. When compared to the base specimen, the results showed that the entire steel padding components absorbed more energy. Furthermore, the tube with corrugated CFRP insert and the cork-crammed tube needed to be redesigned in terms of efficiency, therefore the simulations with the new design revealed a significant increase in absorbed energy.

Oshkovr et al., (2013) investigated various types of quasi-static compressive tests using rectangular tubes manufactured from 12, 24, and 30 layers of silk and epoxy laminates. In terms of failure modes and crashworthiness features, the results from the two methodologies, finite element analysis and testing, were found to be in good agreement.

Gedikli et al. (2013) investigated the crashworthiness of tubes made of aluminium (AL6061 T6), high-strength-steel (AIS I1018, HSLA 350, DP 600, DP 800) and tailor welded tube (T.W.T), made of aluminium and high-strength-steel (AL 6061 -T6 & AIS I1018, AL 6061 -T6 & DP 600, A simulation analysis was performed to determine the effectiveness of various materials, thicknesses, and aspect ratios (tube-length/diameter) of tubes.

Waimer et al. (2013) investigated the dynamic failure behavior of generic CFRP specimens when axially stressed, which could be used as crash absorbers in aerospace applications. To investigate the behavioural consequences, several materials and designs were parameterized. On the basis of force displacement characterization and energy absorption, the effectiveness of all parameters was investigated.

The energy absorption of a plane crash box with varied thickness is investigated in this project. Analytical, experimental, and numerical work are used in this study. The impact of various characteristics such as width, thickness, and taper on crash box performance is investigated.

3. OBJECTIVE AND METHODOLOGY

As we all know, automobile safety has been a major focus of interest and research for many years. The hunt for better energy-absorbing structures is still ongoing. Researchers have been experimenting with different parameters on materials and conducting research on them to see how much energy they can absorb.

A. The objective of this project is to determine the impact effect on various types of Energy Absorption tubes.

B. Using finite element analysis and experiments, study the influence of axial crush behaviour of various constructions on energy absorption aluminium tubes.

3.1 Methodology :

The notion of a space frame made of thin walled prismatic columns has been found as a very efficient impact energy absorbing system in the design of metallic energy dissipation structures. Energy is generally absorbed by a combination of gradual folding and bending of the column in this structural type. Low density metal filler, such as aluminium honeycomb or foam, has the ability to increase energy absorption of a thin-walled prismatic column in light-weight designs. The filler's substantial compressive deformation will absorb the increase in energy.

Recent advancements in the fabrication of low density cellular materials, such as aluminum foam, have paved the path for their use in energy absorption devices to support a space frame construction.

There are several approaches for increasing the energy absorption capacity of a crash box. As previously stated, a variety of factors influence the crash box's energy absorption capacity. Other filler materials, such as other low density polyethylene materials, can be used in place of these filler components. The form is another factor that influences energy absorption. On various shapes and cross-sectioned crash boxes, we conducted experiments and stimulation

4. MODELING AND ANALYSIS

We performed some FEA simulations on the ABAQUS CAE software for the crash box designed in catia software for various models to check various parameters such as energy absorption capacity, various stress induced, and whether the scope is available or not for further improvement.

Model No 1:

The model's dimensions are 65 x 39 x 100 (length x width x height). Figure 3 depicts the crush box model based on the designed values used in current applications.

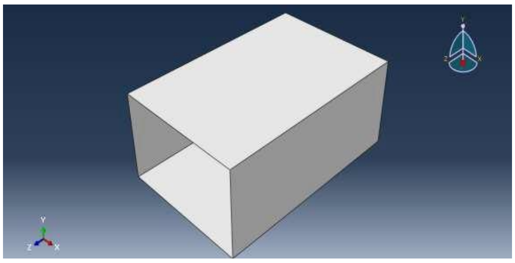

Fig. 4.1 Crash Tube CAD model (Test no. 1)

A.Material Properties:

Table 1 shows the Aluminum Material Specifications used in the analysis.

TABLE I MECHANICAL PROPERTIES OF ALUMINUM

Property	Value
Density (kg /m³)	2.78
Modulus of Elasticity (GPa)	68.3
Poisson's Ratio	0.34

B.FEA Boundary conditions:

For any model to be stimulated in CAE software, specific boundary conditions must be specified, which are likely to exist in the actual model for correct results. This has to do with the model's practical applications. We assembled the crush tube with two undeformable plates at the top and bottom of the tube for this purpose. One end of the tube is fastened to the lower plate in BC, while the other side, i.e.. top side contains velocity conditions.

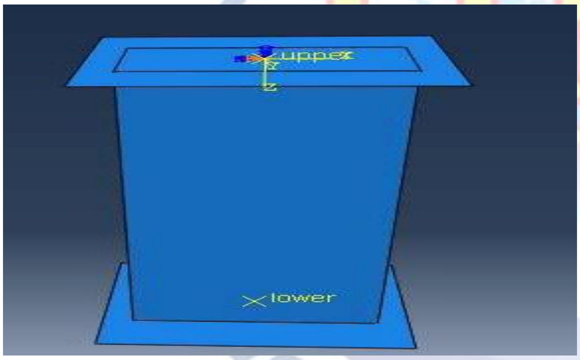

Fig. 4.2 Boundary Conditions

Model No 2:

The model's dimensions are 85x45x100 (length x width x height). Figure 7 depicts the crush box model based on the designed values used in current applications.

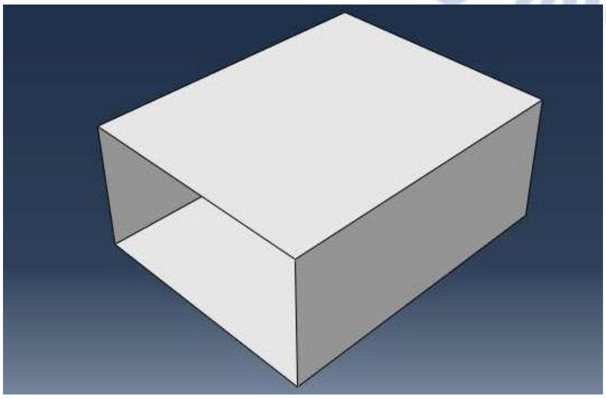

Fig. 4.3 Crash Tube CAD model (Test no. 2)

A.Material Properties:

Following Table shows the Aluminum material specifications used in the analysis.

TABLE II MECHANICAL PROPERTIES OF ALUMINUM

Property	Value
Density (kg /m^3)	2.78
Modulus of Elasticity (GPa)	68.3
Poisson's Ratio	0.34

B.Meshed Crash Box Assembly :

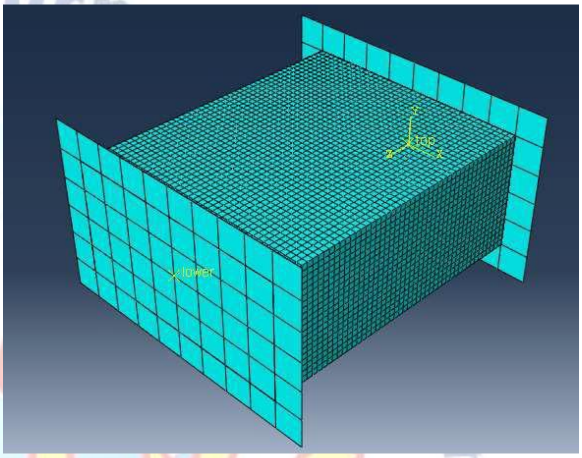

Fig. 4.4 Meshed CAD Assembly (Test no. 2)

Model No 3:

The model's dimensions are 64x100 (diameter x length). Figure 3 depicts the crush box model based on the designed values used in current applications.

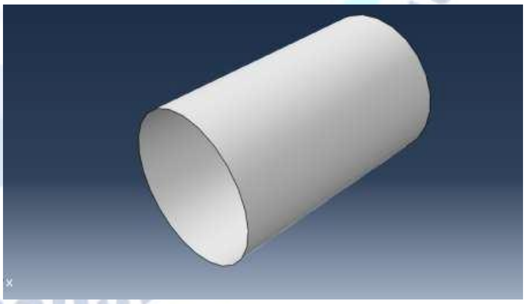

Fig. 4.5 Crash Tube CAD model (Test no. 3)

A.Material Properties:

Following Table shows the Aluminum material specifications used in the analysis.

TABLEIII ALUMINUM MECHANICAL PROPERTIES

Property	Value
Density (kg /m^3)	2.78
Modulus of Elasticity (GPa)	68.3
Poisson's Ratio	0.34

B.Meshed Crash Box Assembly

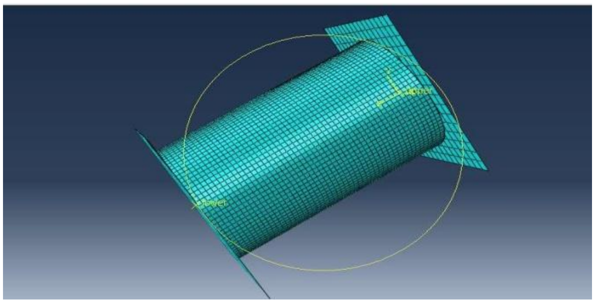

Fig.4.6 Meshed CAD Assembly (Test no.3)

Model No 4:

The model's dimensions are 60x45x100 (length x width x height). Figure 3 depicts the crush box model based on the designed values used in current applications.

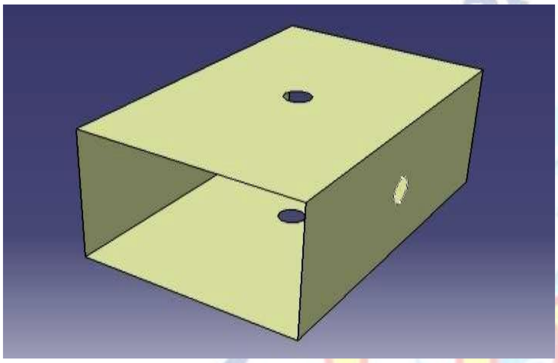

Fig. 4.7 Crash Tube CAD model (Test no. 4)

A.Material Properties:

Following Table shows the Aluminum material specifications used in the analysis.

TABLE IV ALUMINUM MECHANICAL PROPERTIES

Property	Value
Density (kg /m^3)	2.78
Modulus of Elasticity (GPa)	68.3
Poisson's Ratio	0.34

B.Meshed Crash Box Assembly:

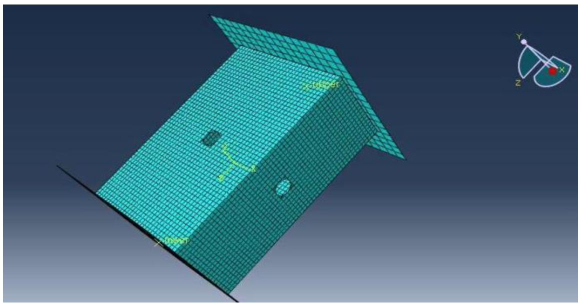

Fig. 4.8 Meshed CAD Assembly (Test no.4)

5. RESULTS AND DISCUSSIONS

Model NO.1 : The model's dimensions are 65x39x100 (length x width x height). ALUMINUM

A.Simulation Result

The various findings produced using the aforesaid inputs and the abaqus CAE software are shown in Figures.

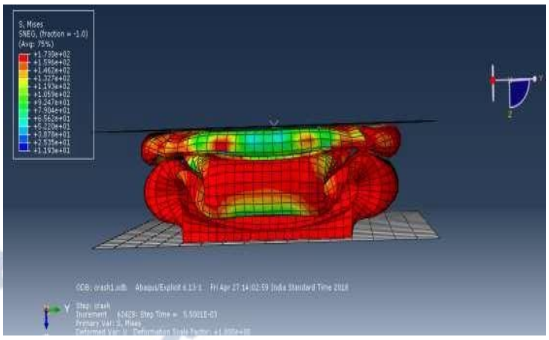

Fig. 5.1 The Crush Tube's Deformed Shape (Test no. 1)

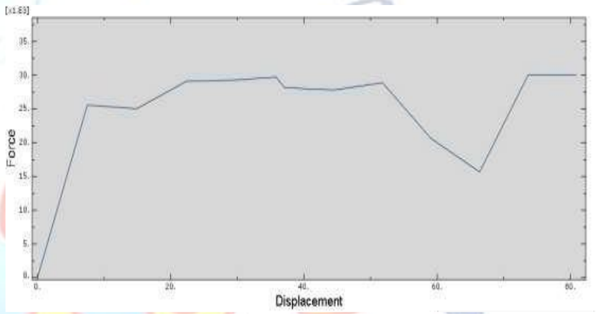

Fig. 5.2 Plot of Deformation vs. Force (Test no. 1)

TEST NO.2:

The model's dimensions are 85x45x100 (length x width x height). ALUMINUM

A.Simulation Result

Using the above inputs and the use of the abaqus CAE software various results obtained are as shown in Figures.

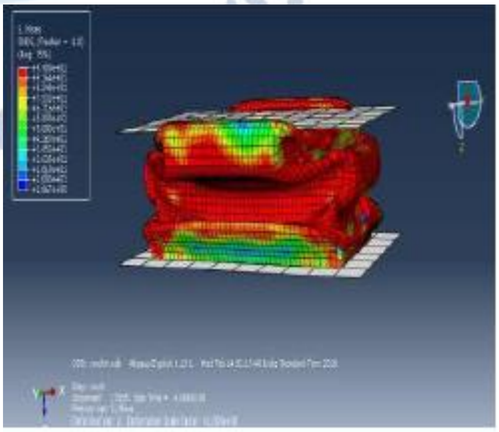

Fig. 5.3 The Crush Tube's Deformed Shape (Test no.2)

Fig. 5.4 Plot of Deformation vs. Force (Test no. 2)

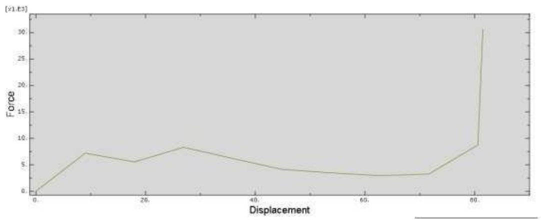

Fig. 5.4 Plot of Deformation vs. Force (Test no. 2)

TEST NO.3:

The model's dimensions are 64x100 (diameter x length).Aluminum

A.Simulation Result

The various findings produced using the aforesaid inputs and the abaqus CAE software are shown in Figures.

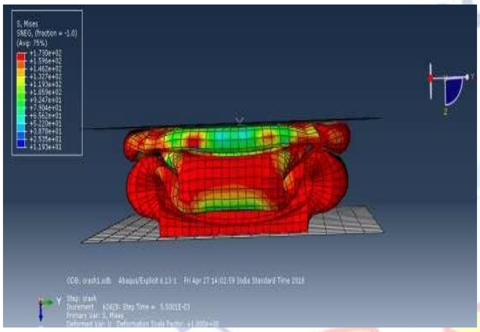

Fig. 5.5 The Crush Tube's Deformed Shape (Test no.3)

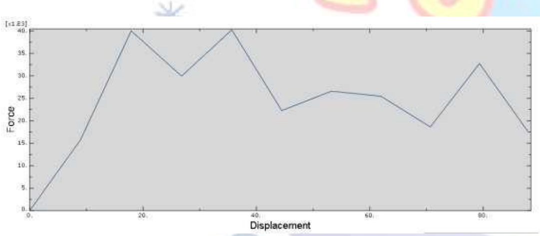

Fig. 5.6 Plot of Deformation vs. Force (Test no. 3)

TEST NO.4:

The model's dimensions are 60x45x100 (length x width x height).Aluminum

Simulation Result:

The various findings produced using the aforesaid inputs and the abaqus CAE software are shown in Figures.

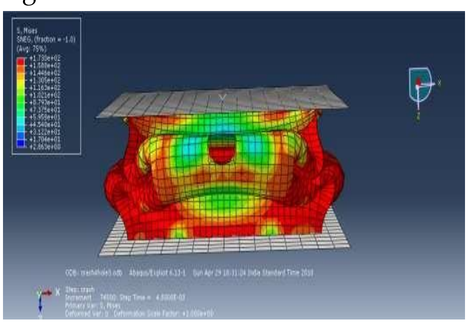

Fig. 5.7 The Crush Tube's Deformed Shape (Test no.4)

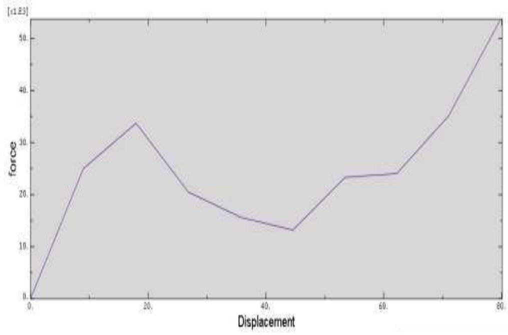

Fig. 5.8 Plot of Deformation vs. Force (Test no. 4)

EXPERIMENTAL ANALYSIS

A.Test No 1

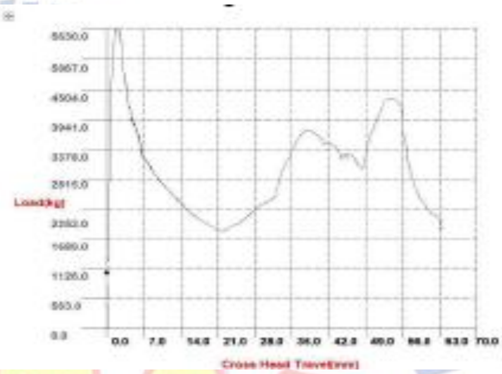

Fig.5.10 Load vs. Displacement Graph (Test no. 1)

B.Test No 2

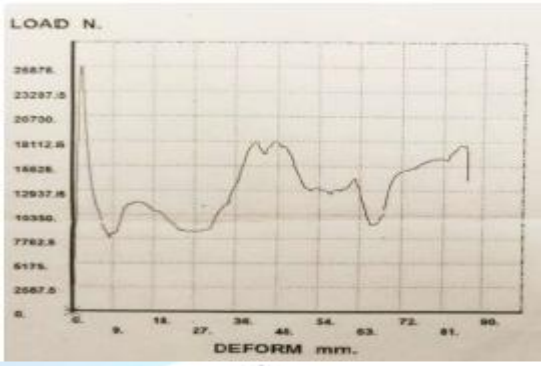

Fig. 5.12 Load vs. Displacement Graph (Test no. 2)

C.Test No 3

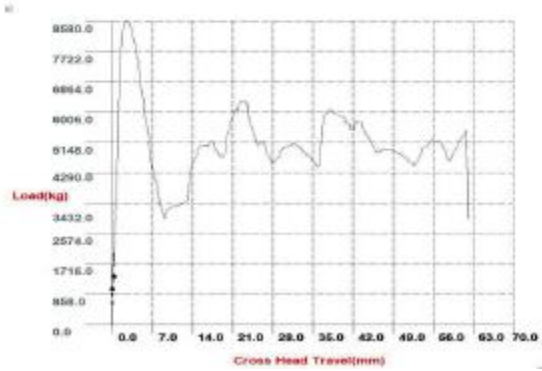

Fig. 5.15 Load vs. Displacement Graph (Test no. 3)

D.Test No 4

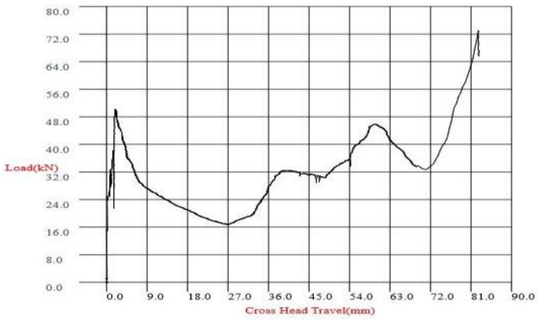

Fig. 5.17 Load vs. Displacement Graph (Test no. 4)

6.RESULT TABLE

Test	Peak Load (N)	Energy Absorbed		Percentage difference
		FEA (J)	Experimental (J)	
Test No 1 Rectangular c/s (65X39X100)	54230.3	2036.493	2247.354	9.78
Test No 2 Rectangular c/s (85X45X100)	24827.0	1015.854	1012.037	8.46
Test No 3 Circular c/s (OD=64 ID=50)	83169.8	2694.719	2801.077	3.64
Test No 4 Rectangular c/s with 4 holes (60X45X100)	51837.1	2752.349	3092.563	7.4

7.CONCLUSION

A.ABAQUS-based experimental and numerical simulation is done .The plane crash box is subjected to explicit dynamic analysis.

B.There was a lot of agreement between the analytical, experimental, and numerical analysis results.

C.When the cross section of the crash box is changed from rectangular to circular, or when irregularities such as holes are added to rectangular cross sectioned tubes, the mean crushing load and absorbed energy increases.

D.The crash box profile has been updated and can now meet the requirements. We also get to the conclusion that as the thickness of the material rises, the amount of energy absorbed increases.

REFERENCES

[1] Liu Yanjie, Ding Lin, Yan Shengyuan, and Yang Yongsheng, "Computer simulations and experimental study on automobile crash box in low speed collision," International Conference on Experimental Mechanics 2015, Vol. 7375, 737562-1..

[2] Dhananjay D. Desai and Prof.M.A.Kadam, "Analysis And Development Of Energy Absorbing Crash Box," IJARIIE-ISSN(O)-2395-4396, Vol-2 Issue-3 2016.

[3] Ashutosh S. Kalshetti and Dr. Sanjaysingh Vijaysingh Patil, "Energy absorption of varying thickness rectangular section crash box for quasi-static axial loading", International Engineering Research Journal, pp. 387-391.

[4] Yanjie LIU and Lin DING, "A Study of Using Different Crash Box Types in Automobile Frontal Collision," DOI: 10.5013/IJSSST.a.17.38.21.

[5] Gangadhar Biradar and Anjan Babu V.A, "Automotive Crash Box Performance Analysis and Simulation During Frontal Rigid Barrier Crash," International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064, Impact Factor (2012): 3.358.

[6] Santosa, S., and T. Wierzbicki, "Crash behaviour of box columns filled with aluminium honeycomb or foam," Computers and Structures 68 (1998) 343-367.

[7] H.R. Zarei and M. Kroger, "Optimization of foam-filled aluminium tubes for crashbox application," Thin-Walled Structures 46 (2008) 214–221.

[8] A.Siva Kumar, G.Himabindu, M.Sankar Raman, and K.Vijaya Kumar Reddy, "Experimental Investigations with Crash Box Simulations for Different Segment Cars Using LS-DYNA," International Journal of Current Engineering and Technology, E-ISSN2277–4106, P-ISSN2347–5161.

[9] Z. Ahmad, D. P. Thambiratnam, and A.C.C. Tan, "Dynamic energy absorption characteristics of foam-filled conical tubes subjected to oblique impact loading," International Journal of Impact Engineering 37 (2010) 475–488.

