Effect of Buckling Initiator on Energy Absorption in Oblique loading of Bumper System

B. S. Mashalkar[1]
P.G. Student Mechanical department,
Walchand Institute of technology, Solapur
Solapur, Maharashtra.

S. B. Tuljapure[2]
Assistant Professor Mechanical department,
Walchand Institute of technology, Solapur
Solapur, Maharashtra.

Abstract— **In this work the influence of triggers on the energy absorption properties of Bumper System under oblique loading is investigated. The bumper system in this study consists of c-channel with rectangular crush tubes and triggers are the cuts at the corner of the crush tubes. The material used for Bumper System is mild steel. The loading is in different angle of 0°, 10°, 20° and 30°.The influence of changing the load angle and influence of initiator on absorption properties has been investigated. Results show that collapse initiator change deformation mode from general buckling to progressive buckling and decrease considerably the peak load and energy absorption of bumper system.**

Keywords—Bumper System, Energy Absorption, Peak Load, LS-DYNA.

INTRODUCTION

The accidents are considered as one of the most threatening dangers in daily life. It is an unexpected event that can change people's life radically. Frontal accidents on country roads against other cars have a high fatality rate, frontal collisions not always axially. The C - Channel with two main longitudinal members (Bumper System) under oblique loading is investigate by the FEM simulation to find the effect of buckling initiator on energy absorption capacity. Studies in this area are limited.

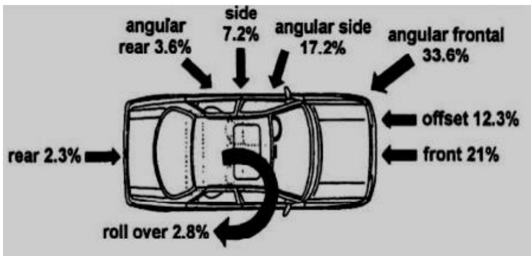


Fig.1.Distribution of real-world car accidents by type of collision

Je-Seung Park [1], the passengers' injuries decrease as much as the absorbed energy by vehicle structures, Instead of reinforcing the column end, the same result can be obtained by weakening the front of column. Initiators are used for this purpose. A. Alavi Nia [2], Energy absorbers are designed in order to prevent or reduce the impact induced damages of main structures. In order to reduce the peak load it is recommended the initiators are located at near top of the tube and the highest initiator set at the first contact side of the tube. Javad Marzbanrad [3], In his research, difference between energy absorption of three different geometries studied i.e. Square, circle, and ellipse with the same area and thickness (1.5 mm) and the same height (150 mm) used here for comparison of load-displacement diagram. The amount of energy absorption per weight of steel tube is 4.5 times greater than for the aluminum tube for all 3 sections. A. Reyes [4] the deformation mode seems to depend on both load angle and thickness. Satyanarayana Kokkula [5], In general most research is based on only an axial load, while more realistic load cases are with an angle of incidence. W.J. Witteman [6], for improved frontal car safety it is necessary to design a structure that absorbs enough energy in each realistic crash situation. To protect the occupants, the passenger compartment should not be deformed and intrusion must be avoided too. Gregory Nagel [7], Bumper beams are one of the main structures of passenger cars that protect them from front and rear collisions. The effects of load angle on the mean load and energy absorption of the bumper system were investigated. The ability of the system to maintain its energy absorption capacity under increasing load angles was of interest from a practical point of view.

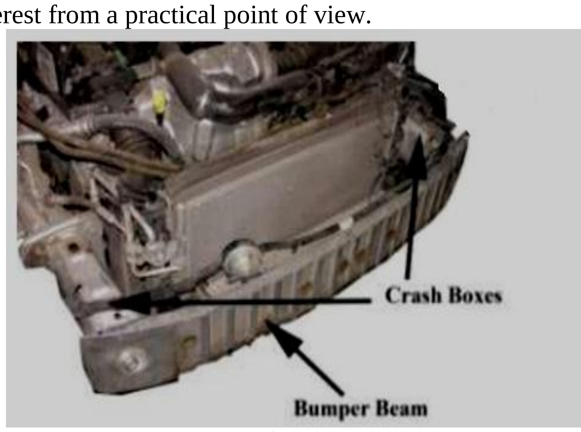


Fig.2 Positions of Bumper and cashbox.

In this paper the influences of triggers on the energy absorption properties of Bumper System under oblique loading were investigated. The bumper system in this study is c-channel with rectangular crush tubes and triggers are the cuts at the corner of the tubes. Investigations were done by the FEM simulation. The loading was done in different angle of 0°, 10°, 20° and 30°. The influence of changing the load angle and influence of initiator on absorption properties has been investigated.

A. Peak load:

Peak load, P_{max} refers to initial maximum load during loading after which the first folding of the tube occurs. This is an important parameter in optimum design of energy absorbers and attempts are made to reduce its value with respect to residual energy absorption capacity.

B.Energy Absorption:

The area under the curve in Load vs. Displacement shows the amount of energy absorbed during impact in KJ.

I. QUASI-STATIC ANALYSIS OF RECTANGULAR TUBE

***A.** Analytical value of Mean Load:*

The quasi-static mean load for rectangular tube is obtained using the expression proposed by W. Abramowicz and N. Jones [8].

These equations used for the validation of analysis of rectangular tube are strictly speaking only applicable to square tubes, however it has been found to produce reasonable results for rectangular tubes [9].

The mean crushing load (P_m) is given by,

$P_m/M_o=52.22(c/h)^{1/3}$ …………………………….. (1)

Here c = side length of tube = (110 + 60) / 2 = 85 mm and

h is thickness of tube = 2.5 mm

Here M_o = fully plastic bending moment per unit length for sheet metal

$M_o = \sigma 0\, h^2/4$ …………. Here σ_0 is flow stress (yield stress) of the material.

Thus,

$\sigma_0 = (\sigma_{0yield}) = 293.8$ MPa

Hence,

$M_o = 293.8 \times (2.5)^2/ 4 = 459$ MPa

Thus,

$P_m/ M_o = 52.22\ (c / h)^{1/3}$

$P_m = M_o \times 52.22\ (c / h)^{1/3}$

$P_m = 459 \times 52.22\ (85 / 2.5)^{1/3}$

$\mathbf{P_m = 77.6}$ **KN**

B. Finite Element Model & Meshing

Finite element analysis is carried out to determine the performance of the rectangular tubes. Software HYPERWORKS & LS DYNA is used. Finite element analysis is carried out to determine the performance of the rectangular tubes. Software HYPERWORKS is used for pre-processing & post processing LS DYNA is used. Model of the rectangular tube is as shown in the Fig.3 Meshing is done using Belytschko Tsay shell element. Total No. of Elements was 3760 & No. of Nodes was 3873.

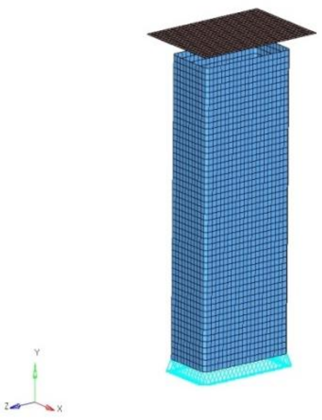


Fig.3 Meshed model of rectangular tube

A fillet of 3 mm is used at the corners of the model. Element size used was 5 mm x 5 mm as is used by Nagel [7] for a similar geometry. On the top side a rigid plate is modelled. The length of the tube 250mm, width is 60X110mm and thickness is 2.5 mm.

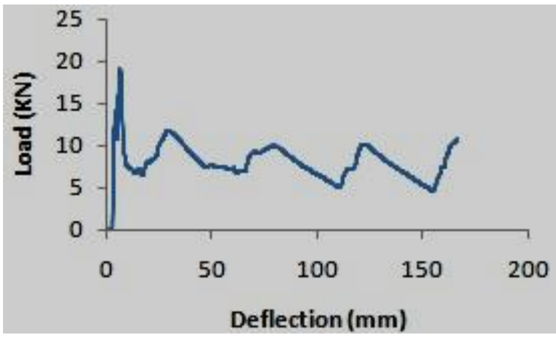


Fig. 4 load-deflection curve for quasi-static analysis

Fig. 4 shows load-deflection curve for quasi-static analysis of rectangular steel tube, the deformation length of the is 2/3 of total tube length.

C. Comparison of Result:

TABLE 1
COMPARISON OF MEAN LOAD VALUES

Type of analysis	Mean crushing load		
	Analytical(for square tube)(KN)	F.E.A.(for rectangular tube)(KN)	Diff. %
Quasi-static	77.6	80.5	3.60

II.DYNAMIC ANALYSIS OF TUBE WITH INITIATOR

The rectangular tube and the rigid plate are modeled with 2D shell elements. The element size used is 5mm. The tube is constrained at the bottom in all translational and rotational directions. For both the components, no. of integration points is used as 5 and element type used is Belytschko Tsay shell. Mass of the plate is 125kgs. Initial velocity of 15m/s is given to the plate. The No. of Elements is 3715&No. of Nodes is 3864. The buckling initiator is used for the tube is similar as initiator used by Je-Seung Park [1].

A. Dimensions of tube and Initiator

Three different position of buckling initiator are tried, among that top initiator 35mm is performed best.

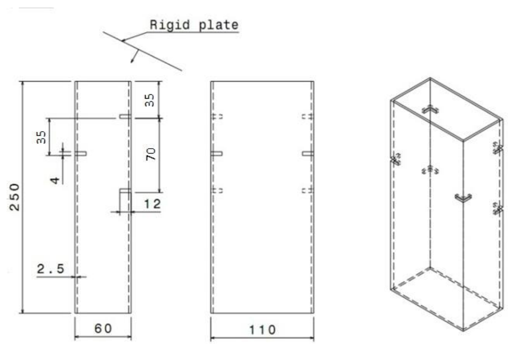


Fig.5 Dimension of the tube and position of initiator

B. Finite Element Model & Meshing

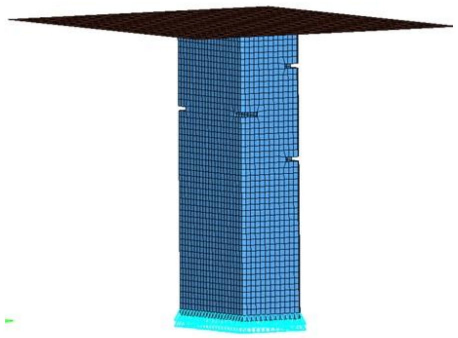


Fig.6 Model of the tube with initiator

TABLE 1
COMPARISON OF ENERGY ABSORPTION VALUES FOR TUBE

Angles	Energy Absorption(J)	
	F. E. A.(Without Buckling Initiator)	**F. E. A. (With Buckling Initiator)**
0^0	13940.97	13990.2
10^0	13822.35	14170.29
20^0	9129.20	11731.99
30^0	5984.36	8819.625

Table1. Show that Energy Absorption of steel tube is increases for every angle by using this Initiator.

III.DYNAMIC ANALYSIS OF BUMPER SYSTEM WITH INITIATOR

A. Dimensions of Bumper System

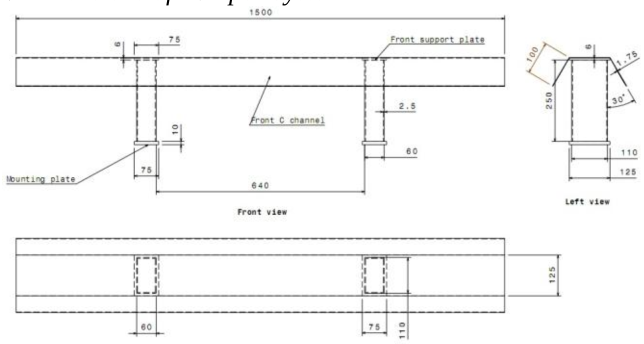


Fig.7Dimensions of the Bumper System

A Fig.7 show Dimensions of the Bumper System, the dimensions of bumper system is in mm and it is selected from the survey of group of vehicles which has seating capacity is 8-9 passengers.

B. Finite Element Model & Meshing

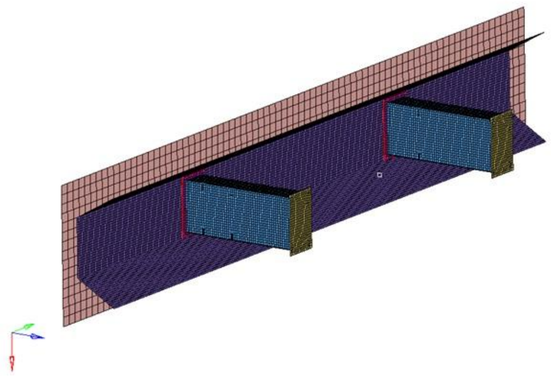
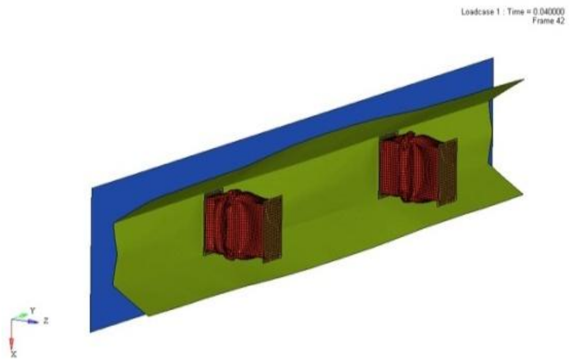


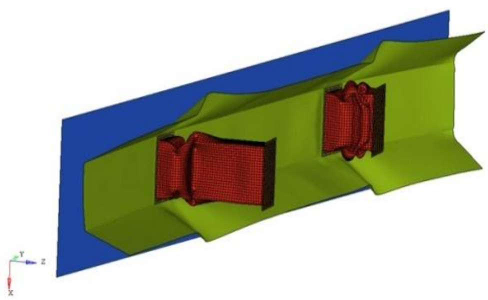
Fig. 8 Model of Bumper System

The tube with initiator is attached to c-channel in opposite manner, because in every cases accident will not happens obliquely from left or right side. In some cases it will happen from left side or in some cases from right side.

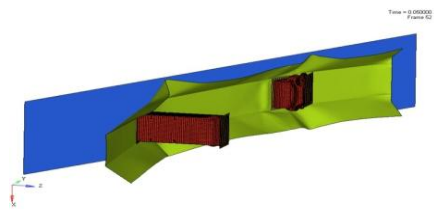
III. RESULT AND DISCUSSION



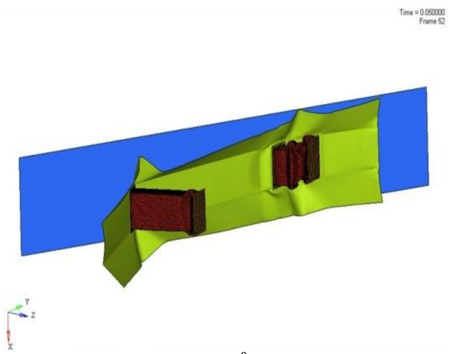
a. For 0^0



b.For10^0

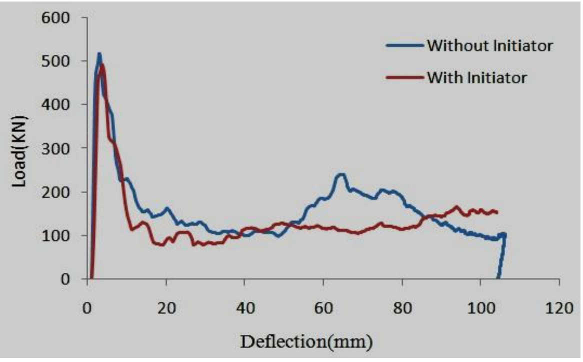


c. For 20^0

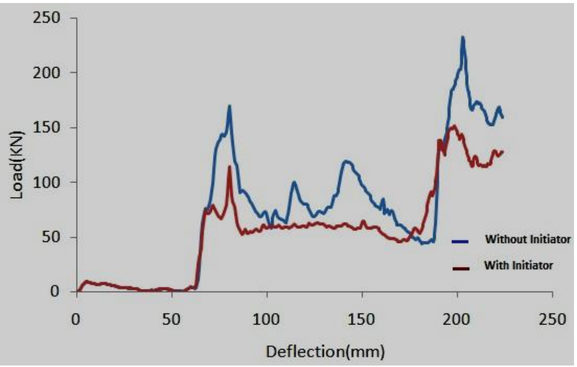


d. For 30^0

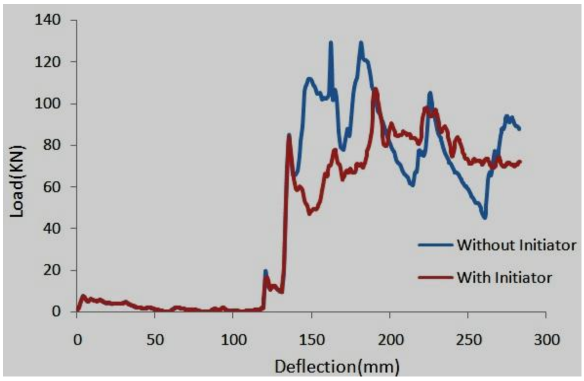
Fig.9 crushing analysis of bumper system for various angles



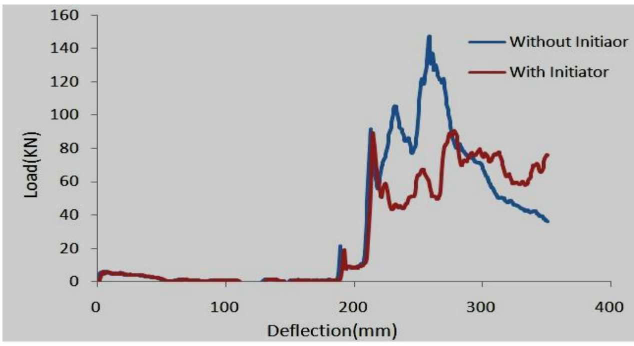
a. For 0^0



b .For 10^0



c. For 20^0



d. For 30^0

c. For 30^0

Fig.10 Comparison of Load vs. Deflection graph for with and without initiator.

Fig.10 shows Comparison of Load vs. Deflection cure for with and without initiator, the peak load is decreases when using initiator for every angle.

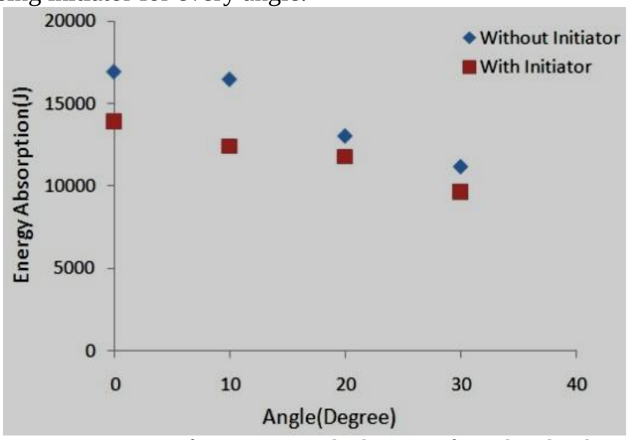


Fig.11 Comparison of Energy vs. Angle absorption for with and without initiator.

Fig.11 shows Angle vs. Energy absorption, the initiator is used for only tubes then energy absorption is increased but the same initiator is used for whole bumper system then energy absorption is decreases for every.

TABLE 2
COMPARISON OF ENERGY ABSORPTION VALUES FOR BUMPER SYSTEM

Angles	Energy Absorption(J)	
	F. E. A.(Without Buckling Initiator)	F. E. A. (With Buckling Initiator)
0^0	16915	13925.23
10^0	16457.12	12400.4
20^0	13051	11769.15
30^0	11215	9615.7

IV .CONCLUSION

Due to buckling initiators, there is decrease in Peak Load for all cases; also the energy absorption is decreased for all cases with buckling initiators, but the tube individually absorbed more energy &are not contributing to the energy absorption by bumper system.

V. ACKNOWLEDGMENT

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