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A Review Of Different Experiments Conducted Over Design Of A Crash Box

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ABSTRACT

It has become a very common thing to hear about an accident in our daily life. But, is it fair in all these struggles for our life to leave it in minutes? As food, as shelter, as clothes, transportation and automobiles have also become a very common part in our daily lives. Who wants to be part of an automobile accident? But it is a fact of our environment; accidents occur. Some are small fender benders – usually nothing more than a little paint, metal, and somebody's pride are hurt in a minor skirmish but for a variety of reasons some driver's may get involved in life threatening accidents. To protect the occupants of a car, there are many new tangible safety features such as airbags, crash box, seat belts, ABS brakes. Surviving a crash is all about kinetic energy.

General Terms

Your general terms must be any term which can be used for general classification of the submitted material such as Pattern Recognition, Security, Algorithms et. al.

Keywords

Aluminium sandwich panel, LS-DYNA, dynamic simulation, plastic collapse, hexagonal honeycomb, FEA.

1. INTRODUCTION

In the design of an automobile, the most important task is to minimize the occurrence and consequences of automobile accidents. Automotive safety can be improved by "active" as well as "passive" measures. Active safety refers to technology which assists in the prevention of a crash. Passive safety includes all components of the vehicle that help to reduce the aggressiveness of the crash event. Crash protection priorities vary with the speed of the car when crash occurs:

1. at speeds up to 15 km/h, the main goal is to minimize repair costs;
2. at speeds between 15 and 40 km/h, the first aim is to protect pedestrians;
3. at speeds over 40 km/h, the most important concern is to guarantee occupant protection

2. Need of Crash Box

Crash box, with which a car is equipped at the front end of its front side frame, is one of the most important automotive parts for crash energy absorption. In case of frontal crash accident, for example, crash box is expected to be collapsed with absorbing crash energy prior to the other body parts so that the damage of the main cabin frame is minimized and passengers are saved their lives. Conventionally, a crash box is equipped with several ditches called "crash beads", so that those crash beads may initiate buckling deformation and make the crash box easily collapse. In this research, a multiple ways have been studied and reviewed to not only determine the crash energy absorption capacity but also how to enhance it for a crash box.

3. Establishing Fundamental theory

1. Understanding buckling concept

First of all, axial collapse analysis of a hat channel, which was chosen as a representative shape of an automotive part, was carried out in order to clarify fundamental phenomena caused throughout crash deformation. First, crash deformation is initiated at a certain area of the ridge lines where compressive strain is locally accumulated, as the ridge lines have higher rigidity than the other portions. Then, plastic buckling arises at the above area and thus bending is caused at the plane between the ridge lines, that is a wrinkle. Finally, after the wrinkle is folded, a new plastic buckling is caused at another area of each ridge line just below the above wrinkle. From the start, the load increases until the initial plastic buckling is caused and reaches the maximum value point. Then after the buckling, the load decreases to the minimum value point when the wrinkle is completely folded. The same applies to the following deformation and thus, the load fluctuates throughout the collapse. In summary, the main points to improve the impact energy absorption can be concluded in three points:

- ensuring high buckling load at the ridge lines,
- minimization of buckling cycle time, and
- Minimization of load fluctuation

2. What is FEA?

Stands for Finite Element Analysis. Some say it's a mathematical theory for computer specialists; some regard it as an indispensible tool for all day industrial production development; some may also call it a myth to solve most technical and unsolved problems by a human but in fact none of them is right. Originally Finite Elements were developed to approximate continuous structures by discrete equations which can be solved by any numerical or computer aided technique. With growing computer capacities, human skills.

3. Brief about LS-DYNA

LS-DYNA is an advanced general-purpose multi physics simulation software package developed by the Livermore Software Technology Corporation (LSTC). While the package continues to contain more and more possibilities for the calculation of many complex, real world problems, its origins and core-competency lie in highly nonlinear transient dynamic finite element analysis (FEA) using explicit time integration. LS-DYNA is being used by the automobile, aerospace, construction, military, manufacturing, and bioengineering industries. Some general applications it is used in are:

1. Automotive crash (deformation of chassis, airbag inflation, seatbelt tensioning)
2. Explosions (underwater mines, shaped charges)
3. Manufacturing (sheet metal stamping)

4. Reviewing Several Studies Conducted

Study 1: In order to clarify the influences of cross sectional shape on the load and the mode of crash deformation, fundamental analysis was carried out with various polygons with different diameters and following charts were the output

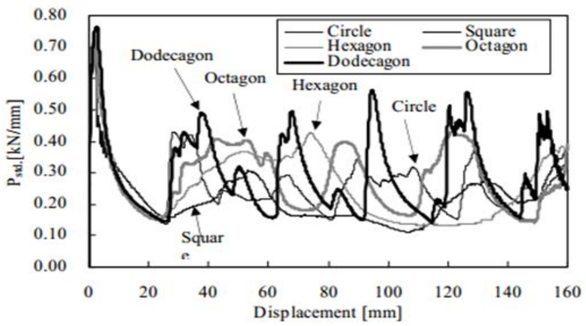

Fig 1 Analytical Results

as a result, it can be concluded that in optimising cross sectional shape for ensuring crash capability for energy absorption, the width of plane is much more important design parameter than the number of ridge lines. Using the results was designed a new structure for a crash box. A new design of the cross sectional shape was established by which four grooves were adopted to its cross section for ensuring optimum width of plane.

And the simulation results of this new design were just what one researcher expects. A wide change in the graphs of displacement and energy absorption capacity was enhanced.

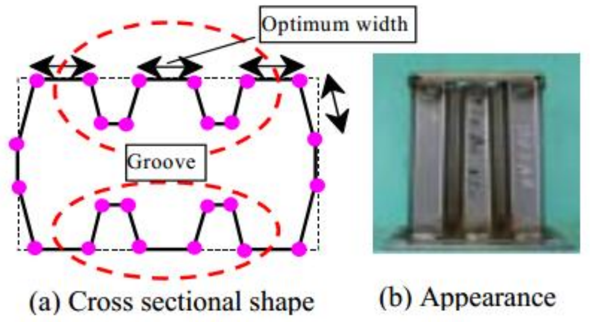

Fig 2 Design for new crash box

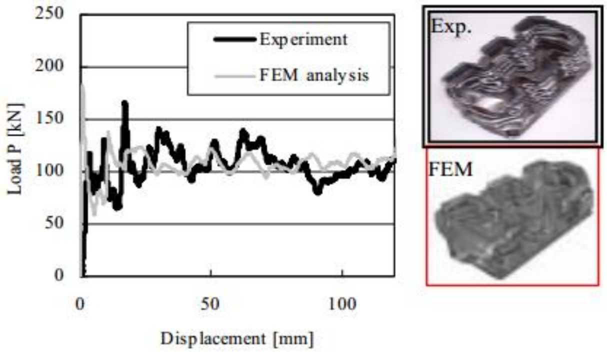

Fig 3 Performance of new crash box

Study 2: Quite similar study was conducted by a different group of people who focused on the strength and durability of a predefined aluminium hexagonal honeycomb core for a crash box. In order to analyse its energy absorbing capabilities numerical simulations, with the explicit finite element code LS-DYNA, was used by tem in addition to dynamic testing.

Table 1: Mechanical properties of aluminum honeycomb core material A5052-H111

Core density (kg/m^3)	68.8
Yield stress (MPa)	193
Elongation (%)	12
Compressive modulus (MPa)	965
Compressive strength (MPa)	2.5
Shear strength, L (MPa)	2
Shear strength, W (MPa)	1.2
Shear modulus, L (MPa)	455
Shear modulus, W (MPa)	205

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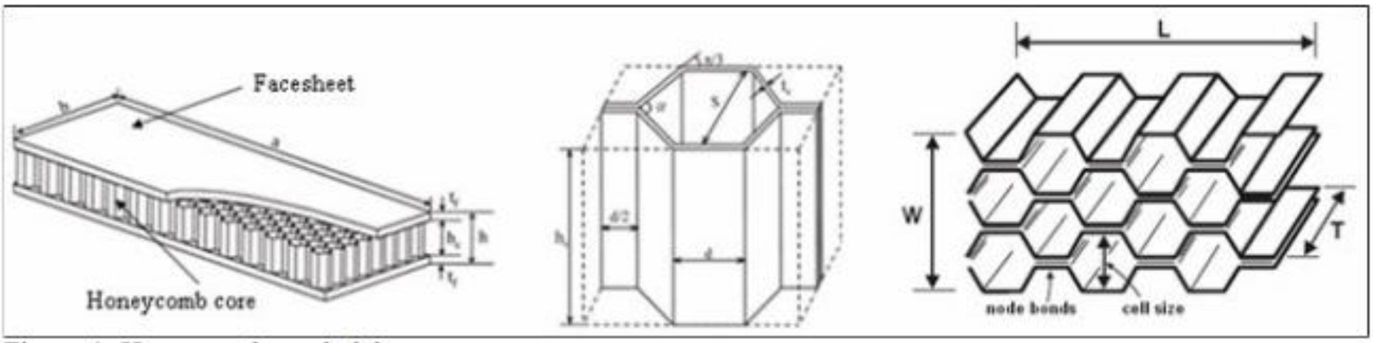

Fig 4 Honeycomb sandwich structure

Beside is the data considered for an aluminium hexagonal honeycomb core using LS-DYNA. What they did was several honeycomb specimens cut from the sheets analysed were crushed between two rigid platens under displacement control in a standard testing machine. A computer operated data acquisition system was used to monitor the load and displacement during the crushing test. After the experiment, the results were verified by a dynamic crash simulation carried in 1980 on a CN2 prototype (sports car) and were found justifying their experiment. The LS-DYNA simulations results showed good agreement with the experimental data recorded during some preliminary crash-tests, in terms of displacement, velocity and deceleration.

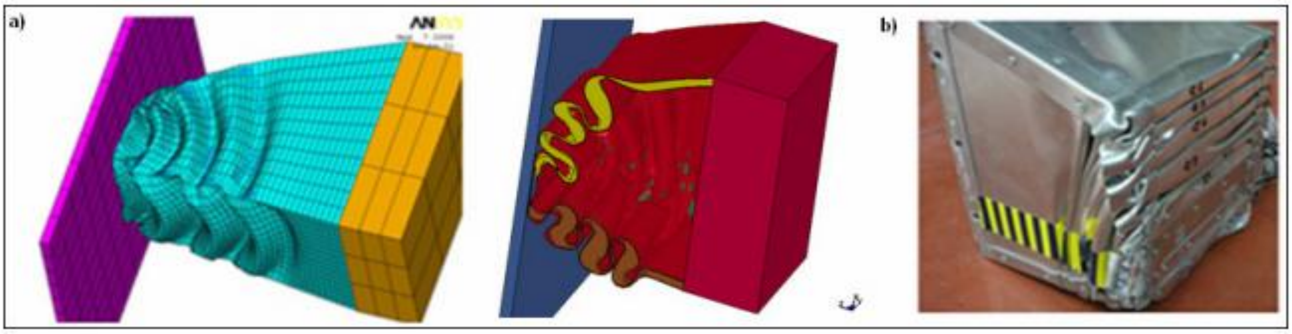

Fig 5 (a)partial numerical deformation (b) real deformation

Study 3: It's actually a super strong lightweight material called stabilized aluminum foam, and one day it might save your life. The foam's high strength-to-weight ratio and its ability to withstand powerful impacts make it an ideal material for an automobile's crash box--the part of a car's front end that absorbs the blow during a collision. Tests by MIT's Impact and Crashworthiness Lab have shown that the foam boosts the impact-absorbing ability of automotive parts as much as 600%. Aluminum foams have been of interest to automotive designers for some time due to their extreme light weight (0.3 to 0.5 g/cm_3) and their potential to absorb energy during impact. The use of stabilized aluminum foams produced by the melt method from Metal Matrix Composites (MMC) in automotive front-end crash box applications.

Study 4: From constructional view, aluminium sandwich construction has been recognized as a promising concept for structural through experiment as well as numerical approaches, the energy absorbing capabilities of a thin-walled crash-box, made of sandwich material, for a racing car. The basic considered structures are panels composed of two aluminium alloy sheets and an aluminium hexagonal cells honeycomb core. Several crash tests were performed, in the conditions related to a frontal impact at the velocity of 12 m/s, in order to acquire information on the dynamic behaviour of the mentioned structure; during these tests the load-deformation diagram, the deceleration and the energy absorbed by the structure were measured. A finite element model is then developed using the non-linear, explicit dynamic code LS-DYNA. In order to characterize the material and to set up the numerical model, a series of strength tests were carried out on aluminium honeycomb-cored sandwich panel specimens. By means of these preliminary tests some necessary material parameters were determined. The simulation results accurately predicted the average deceleration, the specific absorbed energy and the total deformation of the specimen, but appeared to slightly overestimate the initial peak load obtained in the crash tests. Therefore the performed investigation can help to build confidence in the future possibility of using non-linear dynamic finite element code LS-DYNA for the design of sandwich primary structures subjected to crash loading, especially after a further tuning up of the models and material characteristics.

<u>Study 5:</u> This was the experiment done a resident of Karnataka who did no big changes to crash box but still with very little alterations in the scenarios he obtained very considerably effective results using Finite Element Modelling, CATIAV5 and LS-DYNA. He did three changes in the situation of crash simulations.

- <u>Varied cross sectional area</u>

The Energy at loading point can be calculated as follows:

Kinetic energy = ½ m v2 = ½ x 800 x 8.33 2 = 27,775 N-m

Where m is the mass of rigid ball

V is velocity of rigid ball v = 30 km/hr = 8.33 m/s

Table 2: Calculations

Wall thickness in mm	Energy absorbed in N-m	Energy at loading point in N-m
2	9000	27.775
4	25000	27.775

From the above tabulated values we can see that by increasing the wall of the rectangular cross-section crash box to 4mm energy absorbed can be increased to 25000 N-m which is very close to energy at loading point i.e. at the start of the impact 27775N-m.

- <u>Changed the velocity of the crash</u>

At various velocities the behaviour of the crash box was understood, higher the velocity higher the energy absorption and the energy is transferred at a faster rate to other parts of the car.

- <u>Varied the crash box's wall thickness</u>

Increased wall thickness was able to absorb more energy i.e. 4mm was able to absorb more of crash energy than 2mm but practically we also have to consider manufacturing aspect that is design of the car and mass of crash box.

Conclusively, all three proved to be influential over the performance of a crash box.

5. Final review derived from several studies

From all the experiments conducted by several people the very first thing we note is the necessity and importance of a crash box during an accident, which in country like India are likely to happen at every 5th crossing. All the data, information, experiments together suggest a few methods to enhance performance of a crash box and its effectiveness. Majorly we may jot down the following:

• Making it of aluminium foam

• Selection of a hexagonal honeycomb core structure

• That varying cross sectional area and thickness greatly affects its performance

• The potential of a crash box also depends upon car weight and the factor of laden and unladen.

One may suggest any number of methods, the wholesome purpose remains one and that's saving lives and reducing property damage.

6. Conclusion

The final study will now be conclusively used further for our study and will be practically laid in real time scenarios. All the parameters derived will be incorporated in designing a new crash box and its resistance and crash energy absorption capability will be tested. Possibly may get much better results than the existing crash box in today's automobiles.

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