IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 2 Ver. I (Mar. - Apr. 2018), PP 16-23
www.iosrjournals.org

New Airbag Protection Cover Development of Cell Phone Against Free Fall Using Advanced Finite Element Analysis Approach

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Abstract : *Researchers widely used physical testing method toinvestigate the damage of cellular phone during free fall. It is always very costly, time consuming and complex. Finite element analysis is an advanced simulation tools which provide numerical models without spent so much money on physical testing methods. Drop test simulation plays asignificant role in exploring impact performances and finding weak points of a cellular phone at design stage since actual testing is expensive and time consuming.Present research work deals with the new airbag protection covers development of cellphone against free fall using advanced finite element analysis.Drop test simulation technique is one of the important tooluses to analyze the impact behaviour study of cellular phones. It identifies weak design points during the impact behaviour of cellular phone. In order to provide safety to the cell phone against drop new cover with airbag was developed and compared with the baseline model in 1m drop. Based on the results, it was found that significant amount of acceleration values were reduced using newly developed airbag protection cover. LS-Dyna tool was used to simulate the cases.*

***Key Words**: Cellphone, FEA, LS-Dyna, Airbag, Drop Test*

Date of Submission: 22-02-2018 Date of acceptance: 10-03-2018

I. Introduction

The most publicdisaster of cellular phones is possibly the impact due to unintentional drop, sothe companies aim to develop products that are impact proof and can endure the droptest from specific height. Physical test as well asfinite element (FE) simulation isusedin the industry to perform drop tests. At the primary design stage, Finite Element method plays a more imperativerole becausephysicalfree fall test can only be performedafter the completion of the project cycle. The advanced Finite Element simulation canassistdevelopers to understand thecomponents arrangements in the assembly and the failure and mechanism is developedunder the impact loading [1]. Drop impact response of portable electronic products at different impact orientations and drop heights were analyzed by Lim & low in 2002. The impact force, strains and level of shock induced at the PCB were measured and compared. This research work can helpindustrialists not only in designing improved components and electronic packages but also goods which are more strong and consistent, to handle drop loading. Kim and Park in 2004studied the drop simulation for a cellular phone which was carried out using the explicit code LS-DYNA [2] . The research group investigated effect of drop on cellphone and identifies the failuremechanisms. They developed the drop performance criteria for cellular phones because they must survive unexpected drops. Recently Liu and group in 2011published the drop study of a cell phone design with split steel bands [3] . The finite elementmodel of the assembly was developed by using ANSA, and analyzed with LS-DYNA.The cellphone was dropped on a rigid floor from the height of onemeter with different orientations, such as face drop, edgedrop and corner drop. Primary focus was paid on some key components. The integrity of the split band was investigated carefully, the stresses for cover glass and LCD layers were evaluated numerically and the shock absorbing performance of different visco-elastic pads attached on camera was compared in details.

Based on FEM and different designs iterations a new method was discussed in detail to find the effects of all possible parameters by Gu et al. in 2006 [4]. 3D detailed model was used to investigate the drop effects in this study. LS-Dyna explicit solver was used in this study.

The effect of shock loading on electronics andconsumer products during the early stages of productdevelopment were investigated by Deiters et al [5]. Another study was performed by Lee et al. (2010) to find themechanical response of PCBs inside electronic products which were subjected to drop impact [6]. Two portable electronic products were dropped from different heights and orientations. This study helped aided to understandthe product structure, drop orientation andlocation on the PCB. 2-D modeling and 3-D modeling are generally two types of analysis that are used in industry.

This research work discusses the drop test simulation of a cell phone using hyperworks and ls-dyna.LS-DYNA, the non-linear explicit FEA code was selected for the analysis due to its robust capability of handling impact phenomenon. The FE model, was developed by using Hypermesh, the state-of-the-art pre-processor in which different engineers' mesh work was incorporated and managed efficiently; high quality meshes were generated quickly, and the model was assembled and modified conveniently. Airbag protective cover was developed and compared the results with the baseline model.

II. Methodology

In this study detailed FE model of cell phone was used to simulate the drop impact test and propose a protective cover against the same test. In order to simulate drop impact in FEA our understanding about this test must be clear. The setup of drop test is shown in figure 1.

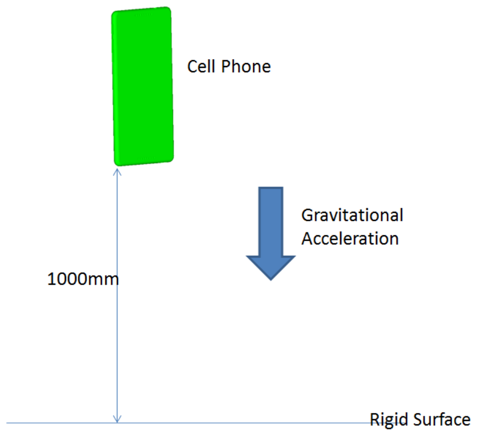


Figure 1: Drop test setup of cell phone in 1m height

The test cell phone is placed so that it can fall with gravitational force. The detailed modelling of cell phone with material properties of glass and plastic were performed. Figure 2 shows the detailed cell phone model Glass display, front camera along with rear camera.

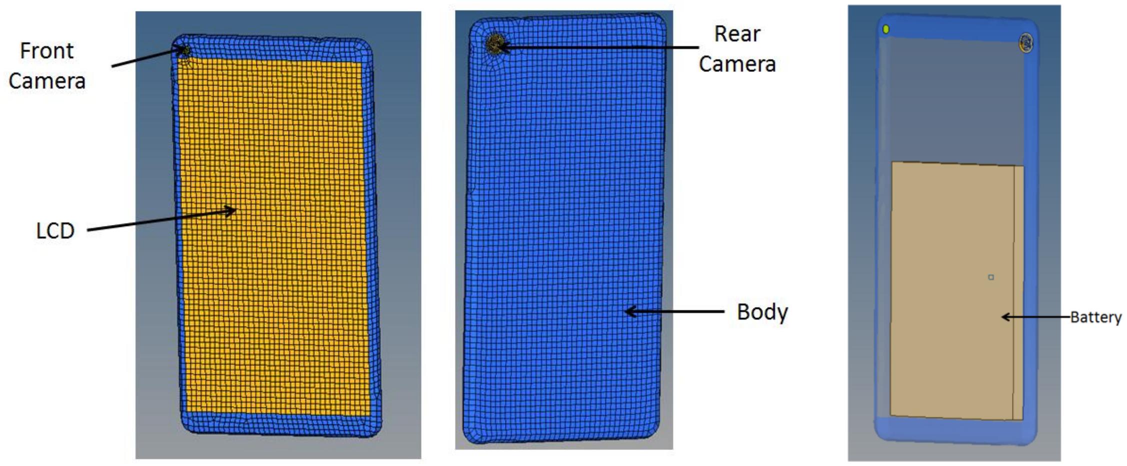
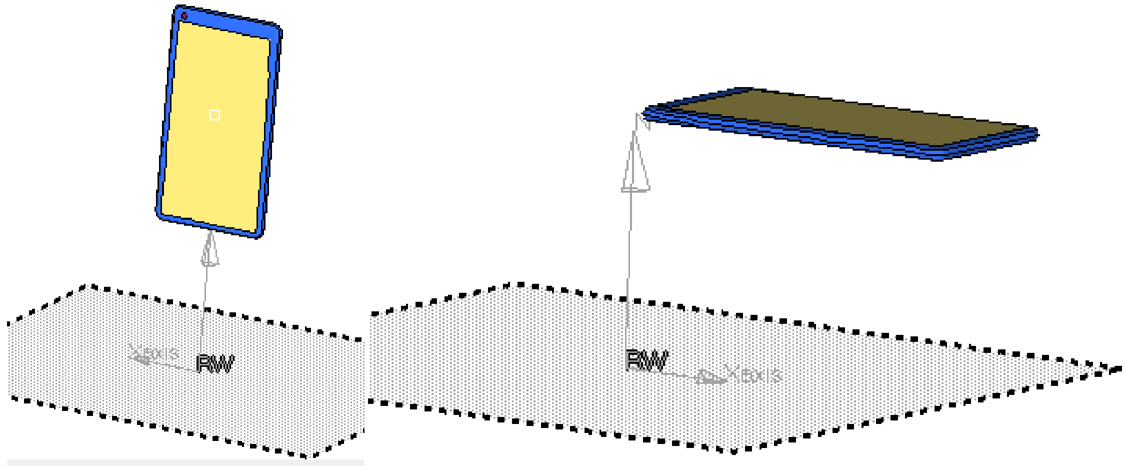


Figure 2: FE Model of Cellphone

Two drop orientation were performed namely:
1. Vertical Drop
2. Horizontal Drop

These cases are shown in figure 3. These two cases again simulated with airbag frame and results were compared.



(a) (b)

Figure 3 a: Vertical drop setup , b: Horizontal drop setup

The airbag frame cover model was developed as shown in figure 4. Airbag fabric material properties were used along with pressure inlet. The peak pressure for airbag deployment was used as 8MPa.

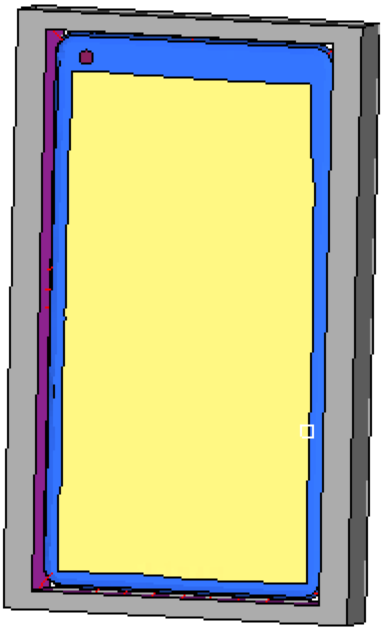


Figure 4: Airbag frame of cell phone

III. Results

Figure 5 shows the cell phone movement step by step without airbag frame. The cellphone contact with ground was observed in 23ms.

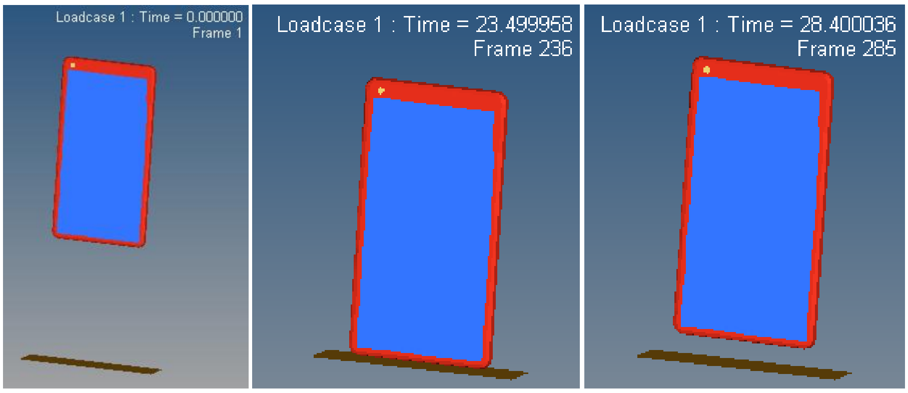


Figure 5: Cell phone movement step by step without airbag frame

Figure 6 shows the cell phone movement step by step with airbag frame. Airbag came into action at 20 ms.

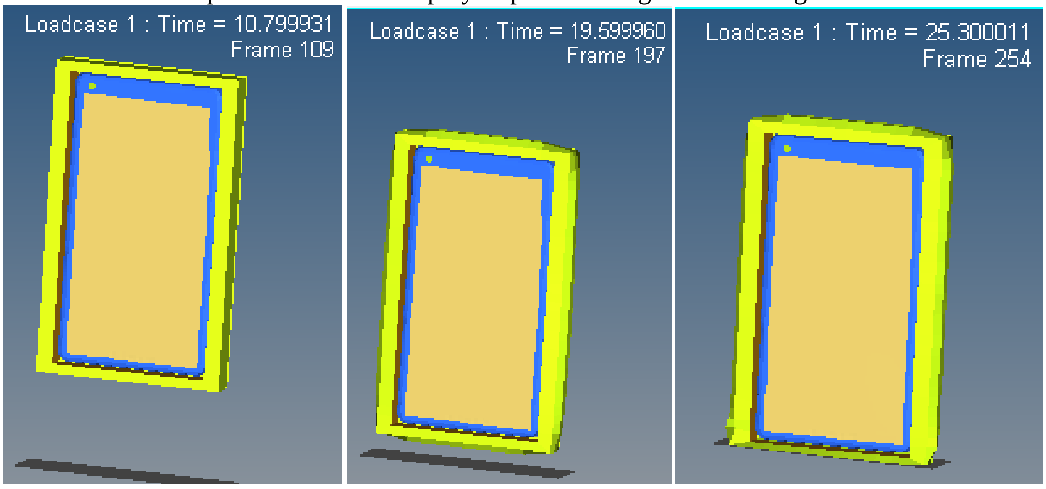


Figure 6: Cell phone movement step by step with airbag frame

Figure 7 shows the cell phone movement step by step without airbag frame in horizontal drop. The cellphone contact with ground was observed in 23ms.

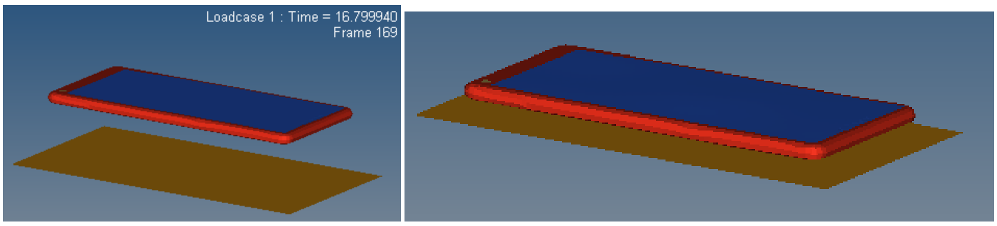


Figure 7: Cell phone movement step by step without airbag frame in Horizontal Drop

Figure 8 shows the cell phone movement step by step with airbag frame in Horizontal drop. Airbag came into action at 20 ms.

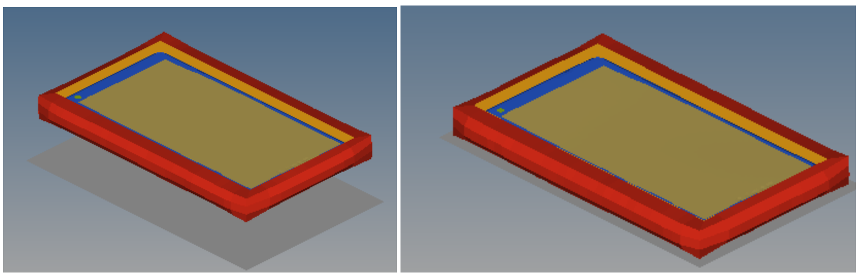


Figure 8: Cell phone movement step by step with airbag frame in horizontal drop

Figure 9 shows the acceleration levels at LCD, front and rear camera locations. Maximum acceleration was found at LCD location. Minimum accelerations level were found in front camera locations.

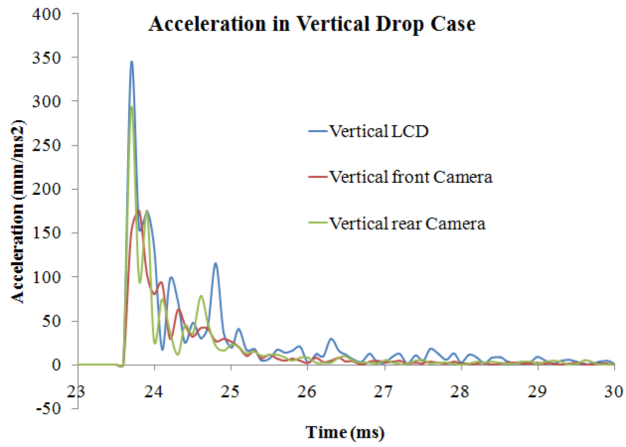


Figure 9: Acceleration level at different locations of Cellphone

Figure 10 shows the acceleration levels at LCD, front and rear camera locations with airbag frame. Maximum acceleration was found at LCD location. Front and rear camera showed similar level of accelerations in case of airbag cover.

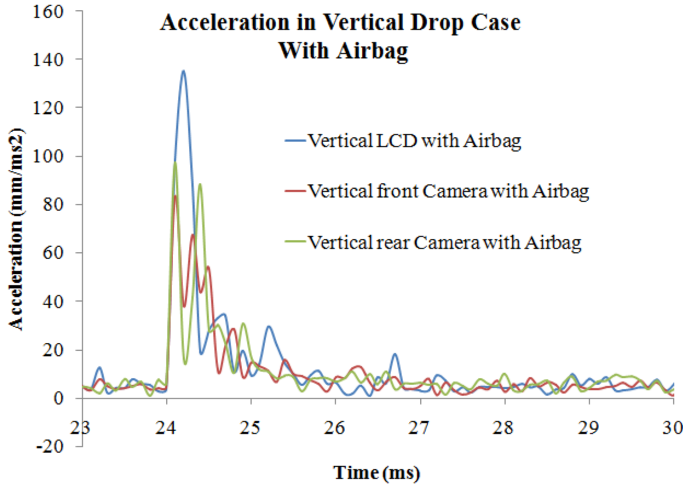


Figure 10: Acceleration level at different locations of Cellphone with Airbag

Figure 11 shows the acceleration levels comparison at LCD with and without airbag frame. It can be seen clearly that airbag frame can reduce the acceleration levels at LCD screen of more than 60%.

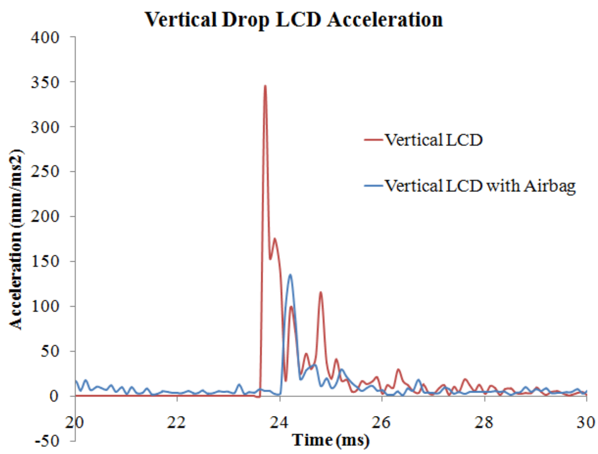


Figure 11: Acceleration level comparison in vertical drop at LCD

Figure 12 shows the acceleration levels comparison at Front Camera with and without airbag frame. It can be seen clearly that airbag frame can reduce the acceleration levels at front camera of more than 60%.

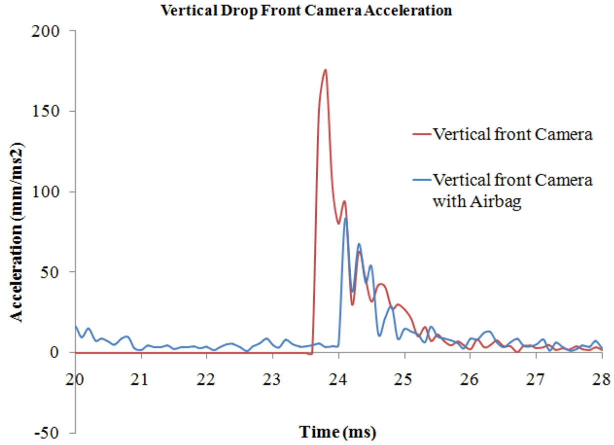


Figure 12: Acceleration level comparison in vertical drop at Front Camera

Figure 13 shows the acceleration levels comparison at Rear Camera with and without airbag frame. It can be seen clearly that airbag frame can reduce the acceleration levels at front camera of more than 70%.

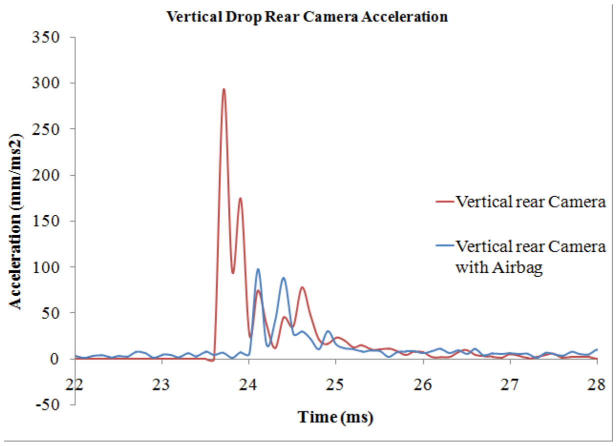


Figure 13: Acceleration level comparison in vertical drop at Rear Camera

Figure 14 shows the acceleration levels at LCD, front and rear camera locations without airbag frame in horizontal drop case. Maximum acceleration was found at LCD location. Rear camera showed lowest acceleration.

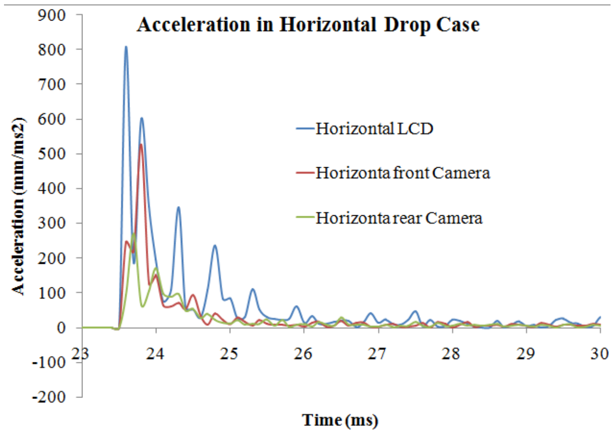


Figure 14: Acceleration level at different locations of Cellphone

Figure 15 shows the acceleration levels at LCD, front and rear camera locations with airbag frame in horizontal drop. Maximum acceleration was found at LCD location. Front and rear camera showed similar level of accelerations in case of airbag cover.

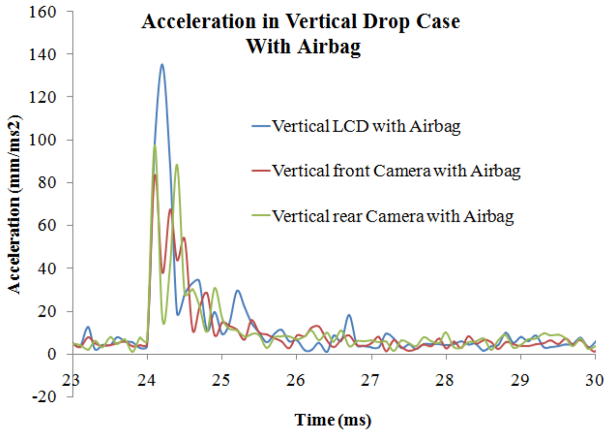


Figure 15: Acceleration level at different locations of Cellphone with Airbag

Figure 16 shows the acceleration levels comparison at LCD with and without airbag frame in Horizontal Drop. It can be seen clearly that airbag frame can reduce the acceleration levels at front camera of more than 40%.

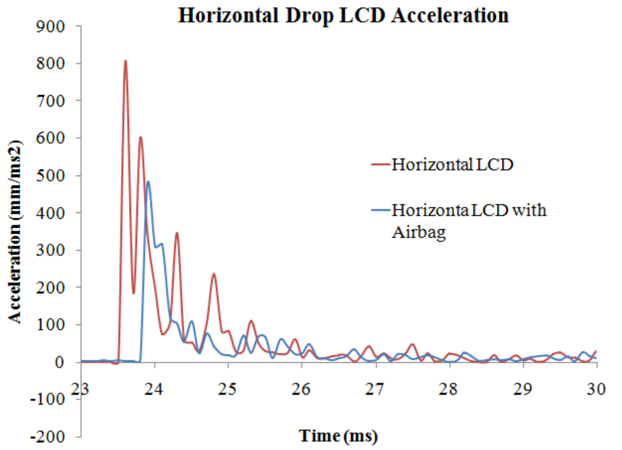


Figure 16: Acceleration level comparison in Horizontal drop at LCD

Figure 17 shows the acceleration levels comparison at front camera with and without airbag frame in Horizontal Drop. It can be seen clearly that airbag frame can reduce the acceleration levels at front camera of more than 60%.

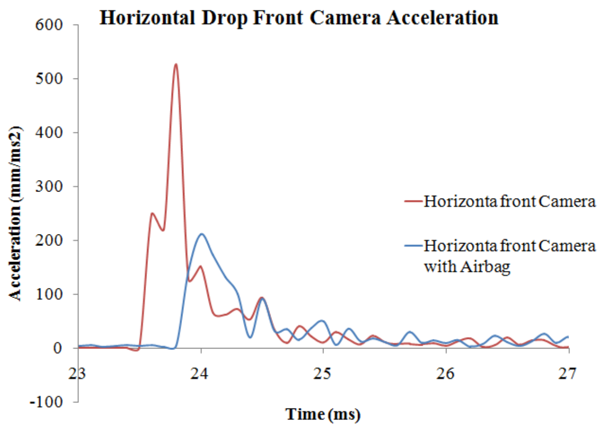


Figure 17: Acceleration level comparison in Horizontal drop at Front Camera

Figure 18 shows the acceleration levels comparison at rear camera with and without airbag frame in Horizontal Drop. It can be seen clearly that airbag frame can reduce the acceleration levels at front camera of more than 10%.

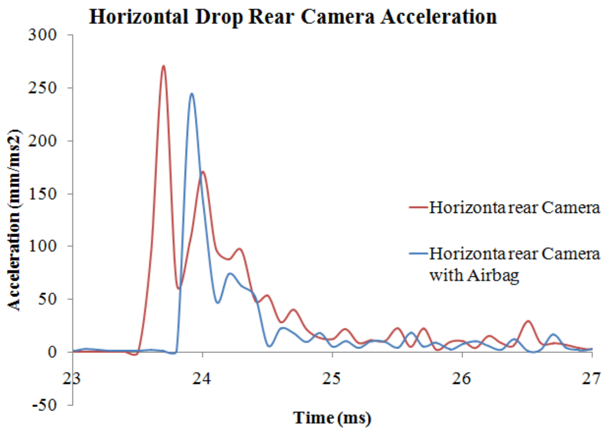


Figure 18: Acceleration level comparison in Horizontal drop at Rear Camera

IV. Conclusions

This research work discussed the drop test simulation of a cell phone using hyperworks and ls-dyna.LS-DYNA, the non-linear explicit FEA code was selected for the analysis due to its robust capability of handling impact phenomenon. The FE model, was developed by using Hypermesh, the state-of-the-art pre-processor in which different engineers' mesh work was incorporated and managed efficiently; high quality meshes were generated quickly, and the model was assembled and modified conveniently. Airbag protective cover was developed and compared the results with the baseline model. Airbag cover showed significant protection to the airbag in both vertical and horizontal drop cases.

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Jivya1, Harshita." New Airbag Protection Cover Development of Cell Phone Against Free Fall Using Advanced Finite Element Analysis Approach." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 15, no. 2, 2018, pp. 16-23