# Pedestrian Safety :A Head Impact Analysis And Design Automation

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## ABSTRACT

Car-pedestrian accidents account for a considerable number of automobile accidents in industrialized countries. Head injury continues to be more concerned in Automobile impacts. Because the head is the most seriously injured part in many collisions including in pedestrian/ automobile collisions. Head injuries are the most common cause of pedestrian deaths in car to pedestrian collisions. To reduce the severity of such injuries international safety committee have proposed subsystem tests in which headform impactors are impacted upon the car hood. Pedestrian protection has become an increasingly important consideration in vehicle crash safety. Pedestrian-vehicle crashes cause a significant number of pedestrian fatalities and injuries globally. Computer models are powerful tools for understanding how to reduce the severity of injuries in such crashes. Headform impactors are used to test the behaviour of vehicle structures such as the hood. The two head form impactors used in this project is adult head impactors & child head impactors. Automation of the analysis allows users to reduce the time of analysis. An addition to test parameter sensitivity evaluation; some reconstruction of PCDS (Pedestrian crash data study) cases with laboratory impact tests is selected.

## Keywords

Bonnet, Headforms (child and adults), Headforms to Bonnet Impact, HIC (Head Injury Criteria), Impact angles, EEVC WG10 (European Enhanced Vehicle Safety Committee)

## 1. INTRODUCTION

Vehicle safety has become the most important issue in automobile design. Hence, Manufacturers now incorporate numerous safety devices and features in vehicles, including airbags, energy-absorbing steering columns, side-door beams, etc. However, all efforts to improve safety devices focus on enhancing safety features for occupants. Notably, pedestrians are the third largest category of traffic fatalities. Thus, vehicle safety should not just focus on vehicle occupant safety: protecting pedestrians is an important field in traffic safety. Many countries and automotive manufacturers have recently been concerned with ways to reduce pedestrian fatalities and head injuries. Developing pedestrian-friendly vehicles is one solution for reducing the pedestrian fatality rate. To assess the degree of pedestrian protection of a Vehicle, it is necessary to develop an efficient evaluation and analysis methodology to examine vehicles for pedestrian protection. The EEVC, IHRA and NHTSA have developed pedestrian subsystem test methods that assess vehicle capabilities to protect pedestrian during accidents.



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In the late 1980's and early 1990's, including those at NHTSA, showed that relatively minor changes to the front ends of vehicles could significantly reduce the potential for death and injury to pedestrians. Much of this research focused on head impacts to the hood and fenders; however, vehicle geometry and designs have changed substantially in the past years. This has resulted in smaller, more aerodynamic cars with shorter, lower, and more sloped hoods than those that were tested. Light trucks and vans (LTVs) also make up a larger proportion of vehicles on the road today. It is not known how the geometry these vehicles will affect their interaction with pedestrians.

## 2. LITERATURE STUDY

In this section there is the description of the most important results presented in several paper and conference, coming from international committee for vehicle safety, FEM software supplier, automotive industries, and research centre.

Below we report the research results organized by topics divided in impactors' modeling, and testing method.

### 2.1 Impactors' modeling

On this argument it has been dealt with the simulation advantages in the vehicle front part design within pedestrian safety environment, and with possibility to use simulation to know the human body dynamic during the pedestrian collision, with the aim to evaluate the influence of several parameters on the tests, in order to obtain a starting-point for future discussions on the vehicle design.

LS-DYNA has been used to study the degree of design change needed to pass the pedestrian impactor tests. The studies were confined to locations where there was scope for beneficial change. Even in these locations, significant compromises had to be made and limitations placed on styling possibilities.

About the pedestrian behavior in the accident, several described ellipsoidal simulation dummy are used to evaluate dynamics of human body parts, and are correlated to several experimental results. Also, the FEM analysis method which is the basis for analytical evaluation of the vehicle body configuration and structure was established.

A preliminary FE model for a child pedestrian has been described, using the MRI scans from a 6-years-old child. In the study, this model has been used for injury mechanism analysis and injury criteria development for child pedestrians.

It has been showed that LS-DYNA finite element models of adult head, child head, upper leg, and leg pedestrian impactors were developed. Therefore, it was necessary, for the pedestrian impactor finite element models, a deepening of development in order to meet certification requirements, also another approach to validate a human head FE model has been introduced.

The relationship between skull fracture and the predicted physical parameters can be determined. Thereby, we can finally obtain reasonable advices to improve safety design of car frontal structure for minimizing the risk of pedestrian head injuries.

## 3. TESTING METHODOLOGY

For this methodology we can find several papers that validated testing procedure or compared results obtained by simulation with experimental one to evaluate how testing procedure are good.

The effect of the vehicle front design on pedestrian head impact responses and injury related parameters based on accident reconstructions and simulation analyses of car-pedestrian impacts has been determined. The results indicated that the head impact conditions in vehicle pedestrian collisions are dependent on the vehicle travel speed, the front shape, the size of pedestrians, the initial posture of pedestrian at the moment of impact.

It has been described results from tests, and demonstrates the current level of pedestrian protection. Test locations that offer relatively high levels of protection indicate that solutions to the problem of achieving better pedestrian safety are often readily available, low cost, and could be applied over a higher proportion of the car surface.

Reconstruction of PCDS (Pedestrian Crash Data Study) cases with laboratory impact tests and computer simulations has been conducted and demonstrates that it's able to replicate an actual case by using a computer model simulation and laboratory impact with an adult headform.

Head injury risk in pedestrian impact with vehicles was examined, based on headform impact tests, moreover there are legislation proposals before the European Commission, but no introduction timetable has been set. International regulations for pedestrian testing are recommended as the Australian vehicle fleet use vehicles sourced from Europe, Japan, Korea and the United States.

A suitable numerical model has been created. A project to review and develop the JARI pedestrian model has been detailed, as chosen by the IHRA to develop their pedestrian head impact test procedure.

The object of this study is to clarify the differences by comparing the results of sub-system tests and full scale dummy tests on the same impact condition in a compact car, considering the differences between EEVC subsystem tests and full-scale dummy tests.

## 4. METHODOLOGY

The first step is to choose the vehicle and create 3D model of the bonnet and headforms (child and adult) has been created for the purpose of this study. These headforms were based on EEVC WG10. The same models are imported in Hypermesh for preprocessing. In preprocessing certain materials should be assigned to bonnet as well as the headforms. After assigning the material and material properties proper thickness is given to models.

Boundary conditions such as constraints to the bonnet are specified. FE model of headform is used in simulation of impact to bonnet. Impact conditions were in accordance to them that were prescribed by EEVC WG10. Set of seven mathematical simulations of child headform impacts were done to verify results of the theoretical study. Models of engine and all relating structures in motor bay were removed out of the basic model to eliminate an influence of reinforcement due to contact of bonnet with those structures. The results of the headform to vehicle bonnet impact were compared to check the HIC values.

The points on the bonnet are selected depending upon the impact angle as specified and the value of HIC is compared.

To obtain a frame of reference for pedestrian head impact test conditions, it is necessary to know the impact points, impact speeds and impact angles for the pedestrian heads. To this end, all the above data are taken wherever possible from different literatures.

## 5. HEAD IMPACTS

Two headforms are used to simulate this type of head impact: a child headform with a mass of 2.5 kg and an adult head form with a mass of 4.8 kg. The child headform strikes are to the front of the bonnet (wrap-around distance 1 to 1.5m) while the adult headform strikes are to the rear of the bonnet or beyond (wrap around distance 1.5 to 2.1 m).

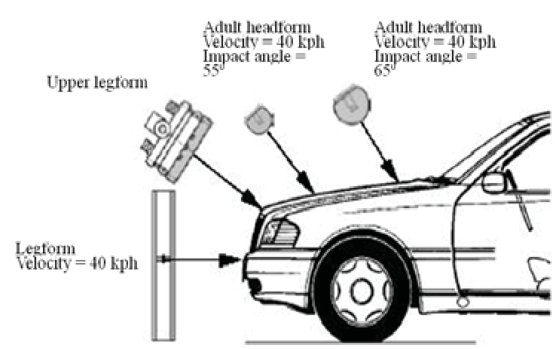


**Fig.1 Pedestrian protection concept of WG10**

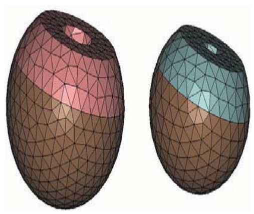

Fig.2

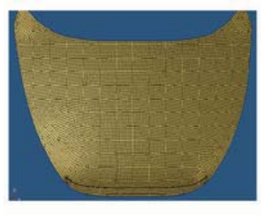

Fig.3

**Fig.2 Finite element models of adult and child headform**

**Fig.3 Finite element model of Bonnet**

**(Tata Indica DLS)**

Six tests are conducted with each headform, based on three equal transverse zones and two impacts within each zone. One impact location is chosen for highest injury potential, such as above engine parts, suspension mounting points or bonnet hinges. The other is chosen to be the least injurious. Where the left and right zones have similar structures judged to be the most injurious the next worst location is chosen for one of the zones.

If between one third and two thirds of a test zone for the adult headform test is found to be within the windscreen area then three default scores are assigned for the windscreen/a-pillar: one poor (a-pillar) and two good (glass away from dash) giving a score of 4. This is added to the three scores for impact tests to the bonnet. The impact locations in two of the bonnet zones are chosen for highest injury potential. The least harmful location is chosen for the third zone.

If more than two-thirds of the adult headform test zone is within the windscreen then only one impact test is usually conducted. Five default scores are assigned: two poor (a-pillars) and three good (glass, away from dash) giving an adult headform score of 6. This is added to the score for the single test that is chosen for the highest injury potential in the centre zone. This is generally located at the lower centre of the windscreen where the headform is likely to contact the dash through the glass.

Accelerometers in the headform are used to determine Head Injury Criterion (HIC). Euro-NCAP assigns a red (poor) rating if the test results in a HIC of 1,500 or more (HIC) is assumed but the deceleration curve is typically a spike of less than 8mins duration.

## 6. AUTOMATION OF THE ANALYSIS

The automation of the pedestrian head impact analysis is also possible and useful. For customization of the hyper mesh TCL (Tool Command Language) and TK (Tool Kit) language are used. TCL (Tool Command Language) a scripting language that has a simple and programmable syntax. We can use it as a stand-alone application or embedded in application programs.

TK (Tool Kit) is included with each copy of TCL and allows us to create powerful GUIs quickly.

In HyperWorks 4.0 and above, TCL/TK v8.2.3 is embedded in HyperMesh, allowing us to develop custom scripted applications, including user-defined panels, and to add logic to HyperMesh command files. Virtually all of the functionality of the HyperMesh command file replay system is available through Tcl, along with additional commands that allow us to extract information from the HyperMesh database, such as:

- IDs on a mark
- List of assemblies
- Components
- Elements per component
- Nodes per element
- Node values

There is also a command to allow us to access HyperMesh using the template system. For example, the following lines of code ask us to select a node, and if any were selected, print out each nodes ID and XYZ values.

LS-PREPOST is a general purpose pre-and post-processor that provides multiple functions for LS-DYNA users to prepare and manipulate their models. SCRIPTO is a customization tool for all users to expand their experience with LS-PREPOST. It gives users a means to better manipulate and organize their models and invite the users of LS-PREPOST to give it a new look. SCRIPTO is the tool designed to have the script writers participate in the customizing process. Through SCRIPTO, users may

–Redesign and re-implement the user interfaces

–Regroup and reorganize the existing functions

–Easily plug in a new function implemented by a third party or themselves to manipulate the model

-Regroup the needed functions so that users do not need to navigate through multiple steps to get things done

–Allow users to put the focus back on their problem domains, and eventually improve the productivity,

SCRIPTO (SCRIPT-ing, O-objects) Builds on an in-house script parser, C-Parser, that incorporates most of the C language syntax. It is native after interpreted/compiled by C-Parser. Once parsed, the interfaces generated and functions added become part of LS-PREPOST. SCRIPTO has application programming interfaces (APIs) that are open to all script writers. There are now over 270 functions provided by SCRIPTO. APIs can be categorized into 3 different areas based on the functions they provide

1. User Interface

2. Model Data

3. Utility

## 7. SUMMARY

This work takes a look at pedestrian head impact mechanics and discusses possibilities in pedestrian protection, when impacting with compact passenger car. Headform impact response is observed when risk to head injury was assessed. Impact points were changed on the bonnet and by changing the impact angles the HIC values are studied and the resultant displacement is calculated. Automation of the analysis allows users to reduce the time of analysis.

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