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Role of Crashworthiness in Setting the Safety Standards of a Vehicle

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Abstract: **Modern day scenario makes us give more importance to safety of human beings and this is achieved in crashworthiness. Crashworthiness is the ability of any given structure to protect its occupants from getting severely jeopardized during an impact or collision in the case of a moving structure. This is commonly tested when investigating the safety of vehicles and aircrafts. The nature of the impact on the vehicle involved makes us determine different criteria. Crashworthiness may be tested either prospectively by using computer models such as LS-DYNA, MSC-Dytran or by carrying out real time experiments by analyzing crash outcomes. There are several criteria based on which crashworthiness is assessed such as the acceleration experienced by the vehicle during an impact and the injury probability predicted by using human dummy models. A common injury criterion is the Head Impact Criterion (HIC). Crashworthiness is assessed by discerning the analysis of injury risks involved in real world crashes and the multitudinous of confounders that are present in the crashes. Crash test is a form of detrimental testing generally performed in order to ensure safe design of vehicles that can match the standards of crashworthiness in various modes of transportation.**

Keywords: Crashworthiness, impact, injury probability, head impact criterion, LS-DYNA, crash test, safe design, modes of transportation

1. INTRODUCTION

Crashworthiness is the ability of any given structure to protect its occupants from getting severely jeopardized during an impact or collision in the case of a moving structure. It connotes a measure of the vehicle's structural ability to plastically deform and yet maintain a sufficient survival space for its occupants involving crashes. This is commonly tested when investigating the safety of vehicles and aircrafts. The nature of the impact on the vehicle involved makes us determine different criteria. Crashworthiness may be tested either prospectively by using computer models such as LS-DYNA, MSC-Dytran or by carrying out real time experiments by analyzing crash outcomes.

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In addition, restraint systems and occupant packaging provide additional protection to the occupants.

2. REQUIREMENTS OF CRASHWORTHINESS

The body structure includes various crush zones to absorb part of the kinetic energy. The vehicle should crumple on impact so that it doesn't come to a sudden stop. Vehicles maintain the integrity of the passenger compartment and simultaneously control the impact of the crash. Accident reconstruction and analysis of vehicle crashes provide information regarding the safety performance. Crash test is done on four different modes: frontal, side, rollover and rear crashes. It is conducted under rigorous standards. Each crash test is very expensive so it is of paramount importance to collect maximum data from each test.

3. TESTS ON CRASHWORTHINESS

Frontal impact tests is what most of us think when it comes to crash tests. In this a car is made to collide with a solid concrete wall at a stipulated speed. This is usually done for hatchbacks and sedans. SUV's are not considered for this test because of their high ride height.

Side impacts have a significant detrimental effect not just on the car but also the occupants because of the absence of a crumple zone.

Roll over tests are conducted to test a car's ability to support itself in a dynamic impact. More recently dynamic rollover tests have been proposed over static crush testing.

Rear side crashes are not of significant importance when it comes to crash tests. It is done to analyze the impacts on the passenger when the vehicle is hit from the back.

4. CRASHWORTHY SYSYTEMS

Crashworthy systems are a system of devices that mitigate the severity of injuries when a crash is imminent or actually happening.

- Seatbelts limit the forward motion of the driver or other passengers. It stretches to absorb energy and lengthen the time of occupant's negative acceleration in a crash by reducing the loading on the occupants body. They prevent occupants being ejected from the vehicle and ensure that they are in the correct position for the operation of the airbags.
- Airbags inflate to cushion the impact of a vehicle occupant with various parts of the vehicle's interior. This is activated as soon as the vehicles collides within micro-seconds. The most important being the prevention of direct impact of the driver's head with the steering wheel and door pillar. Loads of research is carried out to improve the timing of air-bag inflation
- Laminated glasses remain in one piece when impacted, preventing penetration of unbelted occupants' heads. It is mainly used on the windshield. It maintains a minimal but adequate transparency for control of the car immediately following a collision. It is also a bonded structural part of the safety cell. Tempered glass side and rear windows break into granules with minimally sharp edges, rather than splintering into jagged fragments as ordinary glass does.
- Crumple zones absorb and dissipate the force of a collision, displacing and diverting it away from the passenger compartment and reducing the negative acceleration impact force on the vehicle occupants. Vehicles will include a front, rear and maybe side crumple zones too. This adds to the cost of the vehicle.
- Safety Cell - the passenger compartment is reinforced with high strength materials, at places subject to high loads in a crash, in order to maintain a survival space for the vehicle occupants.
- Side impact protection beams, also called anti intrusion bars takes the impact at the sides.
- Collapsible steering columns, along with steering wheel airbag. The steering system is mounted behind the front axle - behind and protected by, the front crumple zone. This reduces the risk and severity of driver impact.
- Padding of the instrument panel and other interior parts in order to avoid any injuries to the occupants when vehicle crashes.

Out of Position (OOP)- This is not the normal seating position of a driver. In a normal position, the driver will be seated upright with the seatbelts locked. But there might be situations where a driver might not be in his normal position like he is bending down to pick something from the car floor or when his seatbelts aren't locked. This can prove fatal to the driver when accidents are imminent or occurring.

5. INJURY RISKS

Out of position occupants are at increased risk of injury. Even low speed impacts can cause disc hemiation and lumbar fracture. Even airbags can prove fatal on OOP passengers. Crash tests show increases impact on neck and torso of the dummy models. A different type of folding pattern of airbags is proposed to reduce the injuries of OOP passengers.

According to the Insurance Institute for Highway Safety, head injury risk is evaluated mainly on the basis of head injury criterion. A value of 700 is the maximum allowed under the provisions of the U.S. advanced airbag regulation (NHTSA, 2000) and is the minimum score for an "acceptable" IIHS rating for a particular vehicle.

6. SAFETY OF INDIAN CARS

Based on the crash tests on various best selling Indian small cars, New Car Assessment Programme (NCAP) revealed that most of the Indian cars are not safe on roads. Tests were conducted on five small cars including Tata Nano, Maruti Suzuki Alto 800, Hyundai i10, Volkswagen Polo and Ford Figo. Base level or entry level versions were selected for the crash tests. None of these cars had air bags which is the most basic requirement for any car to pass safety test across the globe. Two tests were conducted at different speeds of 56 kmph and 64 kmph. All cars failed the safety tests.

Based on the tests, only Ford Figo and Volkswagen Polo showed good structural rigidity and hence a safer passenger cabin, while the other cars failed in this test. Euro NCAP test conducted on European version of Hyundai i10 did well on the safety scale, whereas the Indian version failed. This raises serious questions, whether the Indian made cars are compromised over safety reasons. 1, 40, 000 people die every year in India alone out of 5, 00, 000 accidents. This calls for a change in the design of Indian made cars.

7. PRE-CRASH SENSING

Quicker crash sensing times and more robust information are required to upgrade motor vehicle safety involving the deployment of occupant protection systems. The main objective of pre-crash sensing applications is to detect a collision earlier than the current accelerometer-based approaches with anticipatory and more descriptive sensors, communicate this information to the vehicle and its occupant protection systems, and take appropriate actions to prevent or reduce the severity of crash injury. This type of active safety measure is aimed at reducing injuries once the crash is deemed unavoidable, as opposed to crash warning systems that help drivers avoid the crash.

Pre-crash sensing countermeasures fall under two categories. The first category encompasses reversible features that are activated just before a potential crash, but usually with the capability of being reset in case the crash does not occur. Examples include air bag pre-arming, non-pyrotechnic seat belt pre tensioning, bumper extension or lowering, and brake assist. The second category consists of non-reversible features that are initiated just before a crash, but usually with the drawback of not being re-settable, such as pyrotechnic seat belt pre-tensioning. System reliability is paramount for pre-crash sensing countermeasures, as is fast decision-making time, given the short time available to deploy such countermeasures. The potential benefits of pre-crash sensing applications span a number of vehicle-to-vehicle and vehicle-to-obstacle crash types.

A pre-crash sensing system is generally composed of sensors, decision-making units, and actuators. Sensors may include remote sensors (e.g., radar), vehicle sensors, occupant sensors, and/or pedestrian sensors. While remote sensors can detect obstacles on the road, vehicle sensors monitor vehicle kinematics and occupant sensors identify the existence and/or motions of vehicle occupants. Pedestrian sensing and discrimination can be applied to improve pedestrian protection. Computers serve as the decision-making units that process the signals received from the sensors and determine if a crash is unavoidable.

Once a crash is deemed imminent, the decision-making units quickly determine the countermeasure strategies and send signals for the actuators to preemptively deploy the safety systems. Actuators can be activated automatically or upon receiving a signal from a driver interface such as a pressure pulse on the brake pedal. Production systems of pre-crash sensing applications follow the path toward total vehicle safety by sharing forward-looking sensors for crash prevention applications such as rear-end crash warning and adaptive cruise control.

8. GENERAL STATISTICS OF CRASHES IN THE UNITED STATES OF AMERICA

According to the survey conducted by the National Highway Traffic Society Administration belonging to U.S department of transportation, following stats were revealed.

This report addresses research in advanced restraint systems to mitigate disabling injuries and reduce fatalities of front seat occupants.

TABLE I

Breakdown of FSP 13+ Restraint Use in Front-Damage Vehicles by Number of Impacts and Crash Type (1997-2005 CDS)

FSP 13+ - Front seat passengers above the age of 13

CDS- Crashworthiness Data System

	Single-Impact Crash		Multiple-Impact Crash		Total	
	Restrained	Unrestrained	Restrained	Unrestrained	Restrained	Unrestrained
Vehicle-Vehicle Crash	291,000	44,000	171,000	32,000	462,000	76,000
Vehicle-Object Crash	127,000	16,000	74,000	13,000	201,000	29,000
Total	417,000	60,000	246,000	45,000	663,000	105,000

TABLE II

Breakdown of FSP 13+ Restraint Use in Front-Damage Vehicles by Number of Impacts and Crash Type (1997-2005 CDS)

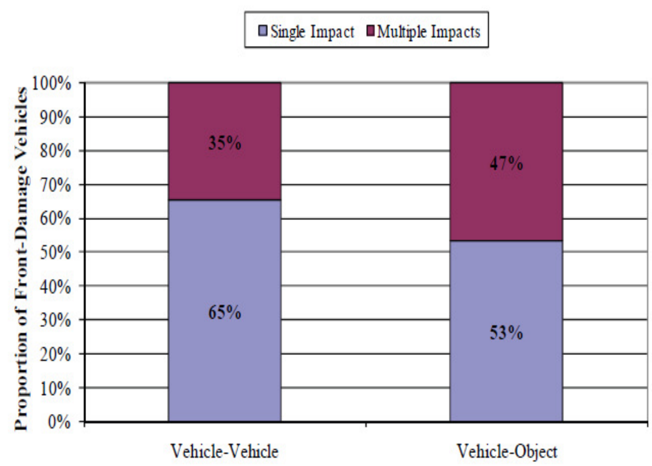

TABLE III

Breakdown of FSP 13+ Restraint Use in Front-Damage Vehicles by Number of Impacts and Crash Type (1997-2005 CDS)

Body Region	MAIS1+			MAIS3+		
	Restrained	Unrestrained	Total	Restrained	Unrestrained	Total
Head	12,000	18,000	30,000	1,000	1,000	2,000
Face	72,000	43,000	115,000	1,000	-	1,000
Neck	20,000	1,000	21,000	-	-	-
Thorax	79,000	6,000	85,000	4,000	1,000	5,000
Abdomen	39,000	2,000	41,000	-	-	-
Spine	64,000	25,000	89,000	-	-	-
Upper Extremity	82,000	30,000	112,000	2,000	-	2,000
Lower Extremity	97,000	46,000	143,000	5,000	3,000	8,000
Total	465,000	171,000	636,000	13,000	5,000	18,000

The table illustrates illustrates the proportions of front-damage vehicles by the number of impacts and crash type. Front-damage vehicles are more likely to get involved in multiple impacts in vehicle-object crashes than in vehicle-vehicle crashes. About 47 percent of FD vehicles in vehicle-object crashes had multiple impacts as opposed to only 35 percent of FD vehicles in vehicle-vehicle crashes

- The head accounted for the highest proportion of these injuries when the driver was unrestrained in multi-impact crashes. The thorax had the highest proportion of these injuries in other crash categories.
- The face was as high as the thorax when the driver was unrestrained in single-impact vehicle-object crashes.

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