UNIT –3

CRASH WORTHINESS

Definition

The degree to which a vehicle will protect its occupants from the effects of an accident.

Crashworthiness is the ability of a structure to protect its occupants during an impact. This is commonly tested when investigating the safety of aircraft and vehicles. Depending on the nature of the impact and the vehicle involved, different criteria are used to determine the crashworthiness of the structure.

Crashworthiness may be assessed either prospectively, using computer models (e.g., LS-DYNA, PAM-CRASH, MSC Dytran, MADYMO) or experiments, or retrospectively by analyzing crash outcomes.

Several criteria are used to assess crashworthiness prospectively, including the deformation patterns of the vehicle structure, the acceleration experienced by the vehicle during an impact, and the probability of injury predicted by human body models.

Injury probability is defined using criteria, which are mechanical parameters (e.g., force, acceleration, or deformation) that correlate with injury risk. A common injury criterion is the Head impact criterion (HIC).

Crashworthiness is assessed retrospectively by analyzing injury risk in real-world crashes, often using regression or other statistical techniques to control for the myriad of confounders that are present in crashes.

Requirements

The vehicle structure should be sufficiently stiff in bending and torsion for proper ride and handling. It should minimize high frequency fore-aft vibrations that give rise to harshness. In addition, the structure should yield a deceleration pulse that satisfies the following requirements for a range of occupant sizes, ages, and crash speeds for both genders:

· Deformable, yet stiff, front structure with crumple zones to absorb the crash kinetic energy resulting from frontal collisions by plastic deformation and prevent intrusion into the occupant compartment, especially in case of offset crashes and collisions with narrow objects such as trees. Short vehicle front ends, driven by styling considerations, present a challenging task to the crash worthiness engineer.

· Deformable rear structure to maintain integrity of the rear passenger compartment and protect the fuel tank.

· Properly designed side structures and doors to minimize intrusion in side impact and prevent doors from opening due to crash loads.

· Strong roof structure for rollover protection.

· Properly designed restraint systems that work in harmony with the vehicle structure to provide the occupant with optimal ride down and protection in different interior spaces and trims.

· Accommodate various chassis designs for different power train locations and drive configurations.

Types of Tests

In spite of the tremendous progress achieved in crashworthiness simulations of vehicle structures from components to full-scale vehicles, using the latest techniques in computational mechanics and super computers, final crashworthiness assessment still relies on laboratory tests. This is especially true in vehicle certification.

There are three categories of tests:

- ➢ **Component Tests,**
- ➢ **Sled Tests, And**
- ➢ **Full-Scale Barrier Impacts.**

The complexity of the test and associated variables increase from component to full-scale tests. This may cause a decline in test repeatability – a reality that may not be realized from the mathematical models.

The component test determines the dynamic and/or quasi-static response to loading of an isolated component. These component tests are crucial in identifying the crush mode and energy absorption capacity. Understanding their performance is also essential to the development of prototype substructures and mathematical models.

In a sled test, engineers use a vehicle buck representing the passenger compartment with all or some of its interior components such as the seat, instrument panel, steering system, seat belts, and air bags. Mechanical surrogates of humans (anthropomorphic test devices - "dummies") or cadaver subjects are seated in the buck to simulate a driver and/or passenger and subjected to dynamic loads, similar to a vehicle deceleration-time pulse, to evaluate the occupant response in a frontal impact or side impact. The primary objective of a sled test is evaluation of the restraints. This is accomplished by high-speed photography of the dummy kinematics.

In addition, various sensors located in the dummy and on the restraints monitor the forces and moments to help determine the impact severity and the effectiveness of the restraint system in reducing loads transferred to the occupant.

The typical full-scale barrier test involves collision of a guided vehicle, propelled into a barrier at a predetermined initial velocity and angle. Typically, a barrier test uses a complete vehicle.

To evaluate individual substructures, a sled test can be equally effective, especially in evaluation of the restraint systems.

Safety engineers run this barrier test to ensure vehicle structural integrity and compliance with government-mandated regulations, for example, United States Federal Motors Vehicle Safety Standard (FMVSS) 208. A fully instrumented vehicle with numerous load cells, accelerometers and instrumented dummy (or dummies) in the driver (and passenger) seat(s) impacts a rigid barrier at zero degrees, plus 30 degrees, and minus 30 degrees, respectively, from an initial velocity of 13.4 m/s (30 mph). The barrier face is instrumented with several load cells to monitor the impact force-time history. For compliance with FMVSS 208, the unrestrained dummies in the driver and right front passenger must score injury assessment values below those established for human injury thresholds for the head, chest, and legs.

In addition, the dummy performance is assessed at a higher impact speed of 35 miles per hour (mph).in what is known as the NCAP (New Car Assessment Program) test. Typically in the NCAP test, the dummy is restrained by three-point lap/ shoulder belt system, in addition to the supplemental restraint air bag. Vehicle impact into a rigid barrier provides a method to assess the effectiveness of the restraint system, as it typically subjects the structure to high deceleration loads.

Another type of testing has emerged over the past few years to evaluate the structural integrity of the vehicle when subjected to frontal offset impact with 40 to 50 percent overlap. The impact target may be rigid or deformable. In this type of test the vehicle front structure is subject to more deformations and potential intrusion and relatively less severe deceleration.

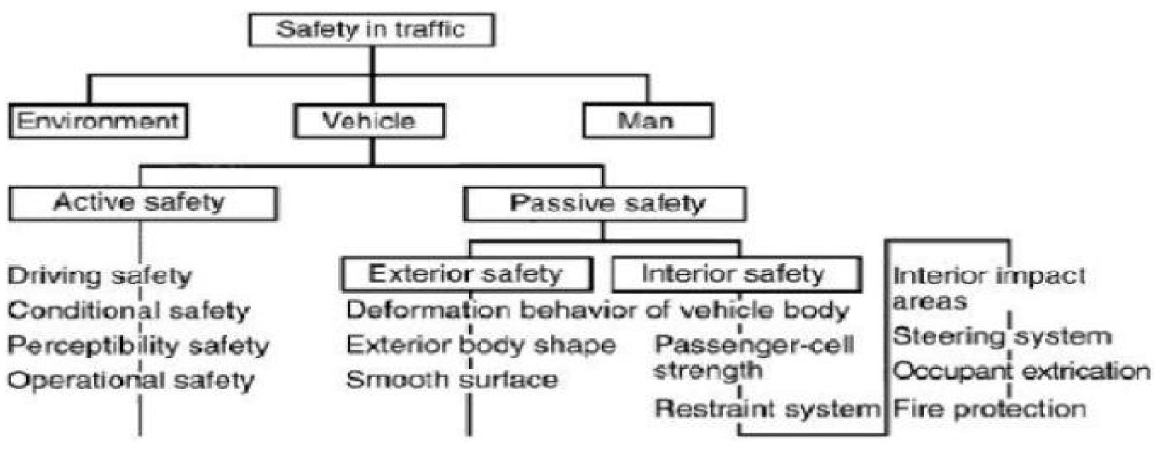
Safety experts conduct similar full-scale tests for side impact, launching a deformable barrier of a particular mass and stiffness into the left or right side of the vehicle from some initial speed and crabbed at a certain angle (FMVSS 214). In this test, side impact dummies (“SID” For the US and “EURO SID1” for Europe) are used in the driver and outboard rear seat locations.

In addition, full-scale tests are conducted on the vehicle rear structure, either by a deformable barrier or by a bullet car to assess the integrity of the fuel tank. To evaluate roof strength according to FMVSS 216, engineers apply a quasi-static load on the “greenhouse,” and ensuring that the roof deformation falls below a certain level for the applied load.

Testing is both time consuming and expensive, particularly at the early stages in vehicle development, where only prototypes are available. To ensure the crashworthiness and compliance with U.S. and international regulations of a vehicle platform, the manufacturer may test more than 100 prototype vehicles, with each early prototype costing between $400,000 - $750,000.

For decades, design engineers have expressed the need to simulate the crash event using mathematical models. Accurate and robust analytical tools using state-of-the-art in computational mechanics and computer hardware are indispensable for crash simulations. To meet ever-increasing safety demands, especially those associated with air bags, vehicle design has evolved into a complementary mix of testing and mathematical modeling. The expected performance and the design stage determine the type of test and level of test complexity. Whether assessing crashworthiness by a test, by a computer simulation, or by a combination of both, the ultimate objective is to determine the potential for human injury due to exposure to real world crash conditions. Unfortunately, each real world crash is a unique event, and therefore attempting to duplicate all real world crash conditions is a formidable task that is both time-consuming and expensive. Accordingly, engineers use selective laboratory crash modes that appear to be most relevant to reducing injuries and saving human lives.

Overall safety can be classified a s given below: In this unit we are going to study about vehicle safety.



Active safety:

Prevention of accidents

Driving safety

It is the result of a harmonious chassis and suspension design with regard to wheel suspension, springing, steering and braking, and is reflected in optimum dynamic vehicle behavior.

Conditional safety

It results from keeping the physiological stress that the vehicle occupants are subjected to byvibration, noise, and climatic conditions down to as low a level as possible. It is a significant factor in reducing the possibility of mis actions in traffic. Vibrations within a frequency range of 1 to 25 Hz (stuttering, shaking, etc.) induced by wheels and drive components reach the occupants of the vehicle via the body, seats and steering wheel. The effect of these vibrations is more or less pronounced, depending upon their direction, amplitude and duration. Noises as acoustical disturbances in and around the vehicle can come from internal sources (engine, transmission, prop shafts, axles) or external sources (tire/road noises, wind noises), and are transmitted through the air or the vehicle body. The sound pressure level is measured in dB(A) (see Motor-vehicle noise measurements and limits).Noise reduction measures are concerned on the one hand with the development of quiet-running components and the insulation of noise sources (e.g., engine encapsulation), and on the other hand with noise damping by means of insulating or anti-noise materials. Climatic conditions inside the vehicle are primarily influenced by air temperature, air humidity, rate of airflow through the passenger compartment and air pressure (see Environmental stresses for additional information).

Perceptibility safety

- Measures which increase perceptibility safety are concentrated
- Lighting equipment (see Lighting),
- Acoustic warning devices (see Acoustic signaling devices),
- Direct and indirect view (see Main dimensions) (Driver's view: The angle of obscuration caused by the A-pillars for both of the driver's eyes binocular must not be more than 6 degrees).

Operating safety

Low driver stress, and thus a high degree of driving safety, requires optimum design of the driver surroundings with regard to ease of operation of the vehicle controls.

Passive safety:

Reduction of accident consequences.

Exterior safety

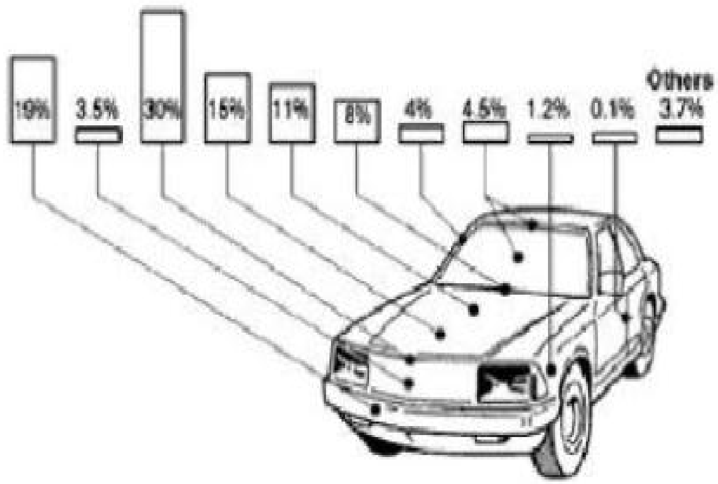
The term "exterior safety" covers all vehicle-related measures which are designed to minimize the severity of injury to pedestrians and bicycle and motorcycle riders struck by the vehicle in an accident. Those factors which determine exterior safety are:

- Vehicle-body deformation behavior,
- Exterior vehicle body shape.

The primary objective is to design the vehicle such that its exterior design minimizes the consequences of a primary collision (a collision involving persons outside the vehicle and the vehicle itself).The most severe injuries are sustained by passengers who are hit by the front of the vehicle, whereby the course of the accident greatly depends upon body size. The consequences of collisions involving two-wheeled vehicles and passenger cars can only be slightly ameliorated by passenger-car design due to the two-wheeled vehicle's often considerable inherent energy component, its high seat position and the wide dispersion of contact points. Those design features which can be incorporated into the passenger car are, for example:

- Movable front lamps
- Recessed windshields wipers,
- Recessed drip rails,
- Recessed door handles.

See also ECE-R26, RREG 74/483.Fig 2



Risk to pedestrians in event of collisions with passenger cars as a function of impact frequency and seriousness of injury (based on 246 collisions)

Comparison between Active and Passive Safety Features on a Vehicle:

	Active Safety Features	**Passive Safety Features**
Definition	Active safety systems are systems that are always active. They use an understanding of the state of the vehicle to both avoid and minimize the effects of a crash.	Passive safety systems are those systems which remain passive until they become active. They become active only when a collision happen
Alternate Name	Primary Safety, Driver Assistance Systems	Secondary Safety, Crashworthy Systems
Purpose	To assist in the prevention of a crash	To protect occupants during a crash
Active	active prior to an accident	active during an accident

Examples	Good visibility from driver's seat, Low noise level in interior, Legibility of instrumentation and warning symbols, Early warning of severe braking ahead, Head up displays, Good chassis balance and handling, Good grip, Anti-lock braking system, Electronic Stability Control, Chassis assist, Intelligent speed adaptation, Brake assist, Traction control, Collision warning/avoidance, Adaptive or autonomous cruise control system.	Passenger safety cell, Deformation zones, Seat belts, Loadspace barrier-nets, Air-bags, Laminated glass, Correctly positioned fuel tanks, Fuel pump kill switches.

Interior safety

The term "interior safety" covers vehicle measures whose purpose is to minimize the accelerations and forces acting on the vehicle occupants in the event of an accident, to provide sufficient survival space, and to ensure the operability of those vehicle components critical to the removal of passengers from the vehicle after the accident has occurred. The determining factors for passenger safety are:

- Deformation behavior (vehicle body),
- Passenger-compartment strength, size of the survival space during and after impact,
- Restraint systems,
- Impact areas (vehicle interior),
- Steering system,
- Occupant extrication,
- Fire protection.

Laws which regulate interior safety (frontal impact) are:

- Protection of vehicle occupants in the event of an accident, in particular restraint systems
- Windshield mounting
- Penetration of the windshield by vehicle body components
- Parcel-shelf and compartment lids

Rating-Tests:

- New-Car Assessment Program (NCAP, USA, Europe, Japan, Australia),
- IIHS (USA, insurance test),
- ADAC, ams, AUTO-BILD.