

Human Tolerance and Crashworthiness

S. Mukherjee, A. Chawla

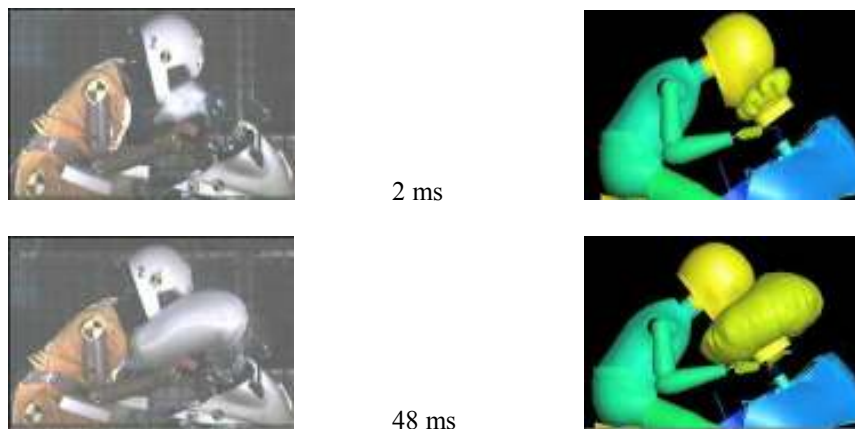
Transportation Research and Injury Protection Programme
IIT Delhi

Occupants of modern day cars are protected by the research undertaken in the last 30 years in the major automobile making countries. Bulk of casualty in India is people outside the car. We have been researching means of addressing India specific problems and propose a roadmap.

Work at IIT Delhi

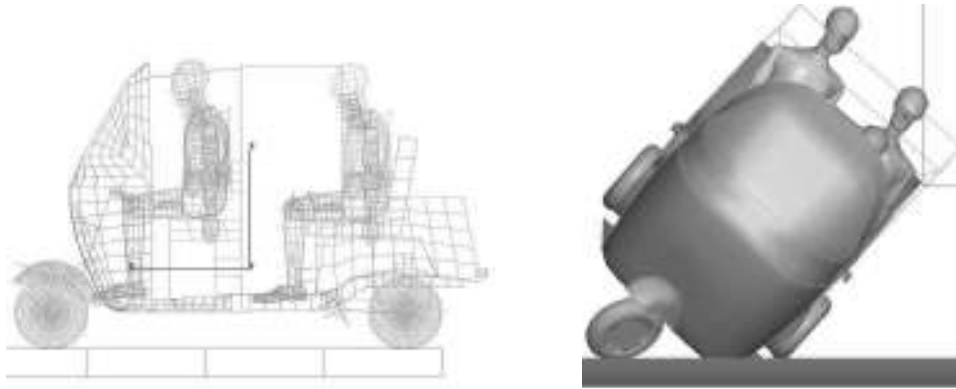
Techniques for developing accurate finite element models for two wheelers have been established. Comparison with tests carried out at the Japan Automobile Research Institute (JARI) and models developed at TRIPP are shown. Techniques for protecting the riders of such two wheeled vehicles are being studied.

Airbags deployment has to meet stringent requirements, as it has to be fully deployed within 5 ms to avoid 'slapping' the rider. The airbag mass is about 200 gm. and moves at a peak speed of around $0.5\text{m}/.005\text{s} = 100\text{m/s}$! Energy content is about 1000 Joules ! The slap can be strong enough to break the riders jaw. Following which it has to deflate as the rider impacts the surface to minimize the injury to the rider.

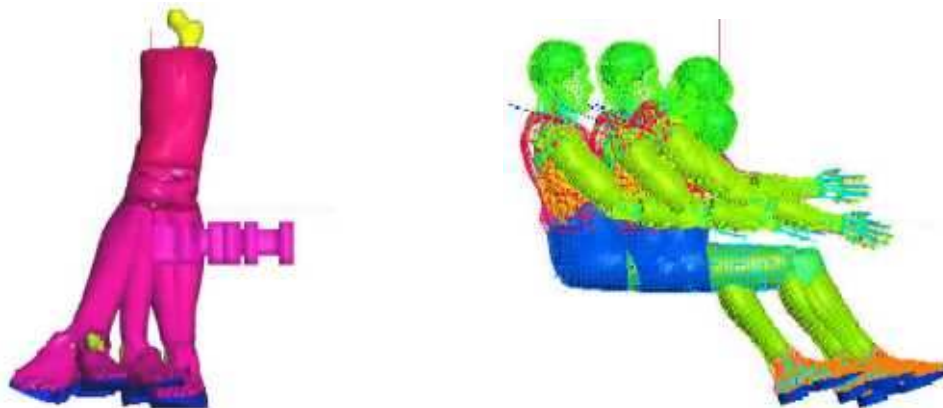


Airbags, Experiment and simulation at 2 ms and 48 ms

The figure above shows simulation of the airbag inflation process that is used to study the inflation and iterate on the design of airbags. Needless to say, the driver side and passenger side airbags are of completely different designs because of the space availability.



Extensive studies on the safety issues in Three Wheeled Vehicles (TWV) have been conducted. Analysis shows that the TWV studied is stable and does not rollover easily as the frame acts as an outrigger. The picture above shows FE models used to study methods to limit injuries on the unlikely event of a rollover.



The automobile seat is very restrictive in terms of the posture which the occupant (obviously assumed belted!) can be in at the time of impact. The pedestrian can be in many more orientations and positions, reducing the effectiveness of using crash dummies. To investigate methods to make the roads safer for pedestrians, it is essential to develop FE human body models. Simulation of impact on a knee is shown (Note the unusual predicted movement of the foot). The neck model has been studied by simulating the Mertz tests in which a sledge is decelerated rapidly.



Accounts of onlookers and passengers often lead to incorrect representation of crash events. Reconstruction of crashes is used to establish a sequence of events in a crash

consistent with basic mechanics. Software packages are used to remove the chore of tedious calculations. A scene of a car-truck crash is shown.

A road ahead ?

The expertise available in India in traffic management and safety research at all levels (central, state, city and departmental) is not adequate for the task at hand. There are no well-funded and functional road safety departments at any level in the country. The funds allocated for road safety work, audits and research are also critically sub-optimal. Very few academic and research institutions in India have dedicated road safety professionals at present. This is because the subject has not been given any importance and no specialised groups have been set up which have the critical mass necessary to produce meaningful work on a sustainable basis.

It is proposed that multidisciplinary accident research teams be set-up across the country. This group would typically consist of the minimum of:

- a) A medical practitioner, to categorise the injuries and have a first hand feel of the trauma management required.
- b) A road/transport planner.
- c) Expert on crash reconstruction.
- d) Expert on vehicle design principles.
- e) A behavioural scientist

The mandate of the group will be to attain expertise in scientific analysis of accidents, and subsequently propagate this methodology to a larger forum. Design of system based to popular perceptions is not recommended.

To improve safety in the long run, safety audits must be undertaken on all the roads.

It is proposed that safety audits should be carried out on typical roads of at least two metros and one rural segment. (My offhand recommendation is Delhi, Pune and MP for the rural sector). This will be vital input in understanding the transport requirement and mix in the Indian scenario. Needless to say, it is the data generated from this exercise that should form the basis for future transport planning and not *gut feeling*.

Vehicle Design Issues

India should also apply additional standards to make the vehicles more suitable for their specific traffic conditions. Some of these issues could include the possibility of making turn indicator lights more conspicuous and more easily visible to pedestrians, motorcyclists and bicyclists, and impact standards for pedestrians, bicycles and motorcycles with cars. Vehicle design issues that might need special consideration in India are summarised below.

Locally Designed Vehicles

There has been a growth of vehicles in India that have been designed locally and do not conform to international safety standards. There is a wide variety of these

vehicles but they can be broadly classified into three groups: (i) three-wheeled vehicles, (ii) four wheeled vehicles, and (iii) trailers pulled by tractors or other similar vehicles. Construction methods, materials used and economic considerations will not allow for the imposition of international car safety standards on these vehicles. It will also not be very easy to design very efficient crash attenuating frontal structures for them. However, design changes can be attempted in the following areas: (i) improvements in rollover characteristics of the vehicles; (ii) body designs which restrict passenger ejection from vehicles; (iii) removal of all pointed and sharp objects from the inside surfaces of the cabin (eg. bolts, rivets, etc.); (iv) provision of impact absorbing padding in areas where passengers are likely to hit the vehicle surfaces during a crash; (v) improvements in conspicuity of the vehicles and lighting arrangements. The types of changes mentioned above will not require heavy investments in research and can be implemented with local initiative. A crash modelling exercise to improve the safety of three-wheeled scooter taxi has been attempted in India, which indicates that this is possible.

Design of less aggressive buses and trucks

During the past decade, the pedestrian safety problem for impacts with private cars in HMCs has been studied using mathematical models, epidemiological studies, and impact tests with mechanical dummies and biological materials. Various recommendations for the front structure design of vehicles (mainly private cars) have been made. However, the fronts of buses and trucks have not been designed to be "forgiving" in impacts with VRUs. Preliminary studies show that it is possible to design fronts of buses such that impact forces in a bus pedestrian impact can be reduced significantly. A similar study has been done for fronts of trucks also. Much more work needs to be done to optimise properties for impacts at different velocities and for different age groups of pedestrians. Once these material properties are determined, then designs will have to be developed for retrofitting old vehicles also. Standards will have also to be developed for crashworthiness of buses and trucks for impacts with motorcyclist and bicyclists.

Summary

Some activity in IIT Delhi has been highlighted. We at TRIPP, have a vision of what is needed to make transportation safer based on state of the art research over the past decade. Based on our experiences, a road ahead has been outlined.