Publications

Repositioning the human body lower extremity FE model

Response of tonic lower limb FE model in various real life car-pedestrian impact configurations – a parametric study for standing posture

Response of lower limb in full scale car-pedestrian low speed lateral impact - Influence of muscle contraction

Characterization of human passive muscles for impact loads using genetic algorithm and inverse finite element methods
Chawla A, Mukherjee S and Karthikeyan B (2009)
Biomechanics and modelling in mechanobiology, Vol. 9, Issue 1, pp 67-76.

Dynamic characterization of bovine medial collateral ligaments
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Dhaval Jani, Anoop Chawla, Sudipto Mukherjee, Rahul Goyal, V Nataraju (2009)

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Road safety in India: challenges and opportunities
Dinesh Mohan, Omer Tsimhoni, Michael Sivak and Michael J. Flannagan, (2009)
University of Michigan, Transportation Research Institute, Ann Arbor, MI.

Aerodynamics of a bus with open windows

Developing and validating a simulation model for heterogeneous traffic
TRB Annual Meeting, Washington.

Characteristics of intercity air travel in India
14th HKSTS Conference, Hong Kong.

Cellular automata model for heterogeneous traffic

Application of GPS for traffic studies

Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport
The Lancet, DOI:10.1016/S0140-6736(09)61714-1

Portnoy PK and Mahajan P. (2009)
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Case study of pedestrian risk behavior and survival analysis

Research & Consultancy Projects

Sustainable Urban Transport in Less Motorised Countries: Research and Training
Sponsor Volvo Research & Educational Foundations
Estimation of Emissions and Fuel Consumption of in-use Vehicles in Different Driving Conditions.
Sponsor Petroleum Conservation Research Association
Team G Tiwari, S.R. Kale, R.R. Kalaga and D. Mohan

Sponsor National Highway Authority of India
Team K.N. Jha, G. Tiwari, R.R. Kalaga, D. Mohan and S. Mukherjee
Bicycle Partnership Programme(BPP)
Sponsor Interface for Cycling Expertise (Ice), The Netherlands
Team G Tiwari, and D. Mohan

Scholarships

Volvo Foundation Research Scholarship awarded to Ms. Himani Jain, Ms Mariya Khatoon, Mr. Mike W.J. Arun and Mr. Amit Agarwal
Sumant Moolgaokar Research Scholarship awarded to Mr. Jani Dhaval Ashvinkumar

The Transportation Research and Injury Prevention Programme (TRIPP) at the Indian Institute of Technology Delhi, is an interdisciplinary programme focussing on the reduction of adverse health effects of road transport. TRIPP attempts to integrate all issues concerned with transportation in order to promote safety, cleaner air, and energy conservation. Faculty members are involved in planning safer urban and inter-city transportation systems, and developing designs for vehicles, safety equipment and infrastructure for the future. Activities include applied research projects, special courses and workshops, and supervision of student projects at postgraduate and undergraduate levels. Projects are done in collaboration with associated departments and centres at IIT Delhi, government departments, industry and international agencies.
These environmental concerns coupled with the growing recognition that the current levels of deaths and injuries in traffic accidents, the attendant social and economic costs, and the annual foreseeable increases in those costs if a laissez faire attitude continues, means that environmental and safety issues must be studied as two parts of the same problem.

Injury is a consequence of an intolerable amount of mechanical (kinetic) energy being transferred into the human frame. Kinetic energy increases according to the square of the velocity. Thus the role of speed, particularly in the mixed road user environment of big cities, is a dominant factor in injury risk. Speed also of course influences energy consumption, pollution, noise, stress on road users and vehicle and highway maintenance. Thus speeding is endemic in almost all motorised countries. The enforcement of speed limits is now done in many western countries with the use of speed cameras and fines, but that requires an effective enforcement agency coupled with a transparent legal system. Having excessive power therefore leads to excessive speeds, excessive braking, increased injury risks for all road users, especially VRUs, increased energy use, increased greenhouse gases and air pollution with further health risks, increased noise, increased road and tyre wear, and a pervasive level of fear in many road users.

Indian cities have already reached levels of congestion equal to or worse than that of European and American cities. The heterogeneous nature of Indian traffic, with large numbers of motorcycles, cyclists, three-wheeler taxis, as well as cars, trucks and buses, in fact results in higher flows of equivalent passenger car units than classical traffic flow theory predicts, based on western traffic mix. The history of attempts to reduce congestion all over the world by providing more and more roads is one of failure. Traffic volumes merely grow to fill up the additional capacity.

Therefore alternatives must be developed to meet the demands of less congestion, greater safety and less pollution. The most obvious and immediate priority for city governments is to develop appropriate public transport. Dedicated bus lanes with cheap, comfortable and frequent services are needed, coupled with parking policies and road pricing regimes to discourage private car and motorcycle use. Provision of separate bicycle and pedestrian lanes with preferential treatment at junctions are needed. Speed control and traffic calming are central to reducing traffic injury risk. Roundabouts, chicanes, speed humps, pedestrian refuges, improved street lighting, distinct facilities for pedestrians and cyclists are all well established countermeasures for the urban environment.

Tax, parking and fuel pricing policies can actively discourage large, polluting vehicles and are now used in many countries very aggressively. Electric bicycles and scooters are an attractive option which should be encouraged for urban Indian traffic. Given the traffic mix in urban India and a specified upper limit to its speed of say 65 km/hr then the standard crash performance requirements for conventional cars are not necessarily appropriate for a city car. The prime safety concern must be pedestrian (and VRU) protection. Careful control of the front exterior geometry and compliance of the structures which will be struck by pedestrians can provide major benefits. European standards exist for exterior design to reduce pedestrian injuries, but they are not as effective as they could be.

This is one area of vehicle design where the Indian vehicle industry could be a world leader.

There is great enthusiasm and much technical development over crash avoidance and injury mitigation systems within the car industry at present. Short range radar and automatic proximity braking, pedestrian detection systems, enhanced night vision, adaptive lighting systems, lane departure warning, brake assist, intelligent speed adaptation all offer some potential safety benefits. Predicting what these benefits might be is difficult because many of them alter the relationships between the driver, the vehicle and the road. Risk compensation is a well established phenomenon in man/machine relationships so many of the claims currently made for these new technologies may well be optimistic.

Current costs of these technologies rule them out for the majority of the new car fleet in India, but the application of some of these technologies in buses and trucks used in the urban environment would be appropriate at the present time. In particular, automatic proximity braking and pedestrian sensing systems would likely yield significant benefits.

Night-time collisions rates in both urban and rural conditions are roughly double daytime rates. For highways, vehicle lighting can be much improved with automatic lights and adaptive lights, where the headlights automatically adjust to the light output of approaching vehicles, the headlights turn when a bend is being negotiated and move vertically for hills and declines. LED lighting provides better performance and offers significant energy saving benefits, and will become widespread over the next decade.

The poor conspicuity of all vehicles and pedestrians, under both day and night conditions, is a frequent contributing factor noted in detailed crash investigation studies. White and reflecting materials provide tangible benefits and are legal requirements in many countries for trucks and buses.

Similarly speed governors are specified through regulations in many places for trucks and buses. Again this is an area where government must lead because the perception of the operators is that it puts them at a cost disadvantage.

So far I have concentrated on technological countermeasures relating to road design, traffic management and vehicle design. I have done so in the belief that, for India in particular, with the rapid growth in vehicle ownership, with very rapid urbanization, the low but increasing level of national income per head and the absence of many institutional arrangements taken for granted in high income countries, technological changes will be more effective than countermeasures aimed at changing road user behaviour. The history of traffic safety shows that behavioural changes to be effective require an underlying community structure for enforcement, a level of knowledge of what is good practice in terms of road user behaviour and an acceptance by the general public that individual freedoms have to be restricted for the common good.

Too often western consultants have been applying western countermeasures to the traffic injury problems of LICs. Too often they make implicit assumptions about large and efficient enforcement agencies and lots of expensive technology which in fact are absent in many low income countries. But there are some behaviour issues highlighted in a number of studies in LICs where rapid motorisation is occurring and behavioural change can be effective. Mandatory Seat Belt Use – When enforced, seat belt usage levels in LICs can reach levels of 70% for drivers, although lower for passengers. Helmet Use by MTWs – Again when enforced, helmet use levels can reach over 90% (Umar et al. 2000).

Driving and Alcohol – Although not adequately researched in India, it appears likely that alcohol is a factor in a significant and increasing number of traffic accidents, especially at night and also with pedestrians at night. Random breath testing does take place and when enforcement occurs there is a deterrent effect (ETSC 2003). But to be truly effective in changing attitudes to drinking and driving, random breath testing requires a level of testing and hence police resources which can only be done in HICs. For example in some states in Australia where random breath testing is practiced, on average one driver in three can expect to be tested once a year. In Britain the equivalent number is one driver in six. With such levels of testing real behavioural changes occur. By contrast in the United States where levels of testing are about one driver in a thousand, alcohol remains a factor in some 40% of fatalities.

The technology for detecting alcohol by sampling breath remotely from a sensor in the steering wheel is becoming available. This represents a new way of controlling drinking and driving which has obvious benefits, particularly for fleet operators and commercial drivers. Alcohol interlocks are now used as part of the sentencing procedures for drivers convicted of drinking and driving, but to be effective that requires robust and expensive policing procedures.

Fatigue – Although under researched it is highly likely that fatigue is a major factor, especially in night time accidents on the highways, and especially involving trucks and buses. Driving distances are long and the economic incentives to drive those long distances are attractive. In developing appropriate countermeasures for India’s road system, there is a clear need for better knowledge about the characteristics and extent of traffic crashes, injuries and their consequences. Crash investigation is a specialized skill which needs to be recognized and nurtured within the police service and within highway departments. Establishing robust data collection systems means linking local, regional, state and national organizations together. Traffic crashes and their consequences cover both transport and health sectors. Hence data bases should also be linked. Only by knowing the nature and characteristics of Indian traffic accidents will it be possible to develop the most appropriate countermeasures. Only by having such data will it be possible to measure the effectiveness of changes which are made. Guesswork is no substitute for data.

Economic growth in India has lead to an enormous increase in the demand for energy. At the same time urban air pollution and climate change issues lead to the need to reduce energy consumption and in particular reduce the use of fossil fuels. Along with those conflicts, urban traffic congestion, noise and the real fear of traffic injury dominate life in cities and on the highways. In moving towards a sustainable transport system all of these needs must be addressed. Sustainable transport will not become a reality unless traffic injury risk is reduced.

In this superficial review I have concentrated on the technological countermeasures possibly appropriate for Indian traffic, in the areas of highway design and traffic management, and vehicle design. I have done this because the history of traffic safety shows that engineering countermeasures work more quickly and more effectively than programmes aimed at altering behaviour. However, many of the measures which work in high income countries are not appropriate for Indian traffic because the vehicle fleet is so different. Thus there is a real need to develop new solutions recognizing the vulnerable road users in particular. Where motorcycles and pedestrians dominate, new traffic management solutions are required.

The use of safety and environmental audits for governments is an important mechanism in evaluating new road developments, traffic management schemes and vehicle technologies. Building that capacity to create a forgiving road system is the immediate challenge for government. Thus energy use, climate change, congestion and traffic safety are intimately linked. Sustainable energy and sustainable transport will only be addressed successfully if traffic safety is also addressed.
News

Killer crashes: Fatal road traffic accidents in the UK.

Road traffic accidents are responsible for over 3000 deaths per year in the UK, according to Department for Transport figures. Although progress is being made in a number of areas, vehicle occupant fatalities have not been falling in line with casualty reduction targets for the year 2010. A sample of 1185 fatal vehicle occupant cases was considered, from ten UK police forces, from the years 1994-2005 inclusive. The main findings were: (1) over 65% of the accidents examined involved driving at excessive speed, a driver in excess of the legal alcohol limit, or the failure to wear a seat belt by a fatality, or some combination of these. (2) Young drivers have the great majority of their accidents by losing control on bends or curves, typically at night in rural areas and/or while driving for 'leisure' purposes. These accidents show high levels of speeding, alcohol involvement and recklessness. (3) Older drivers had fewer accidents, but those fatalities they were involved in tended to involve misjudgement and perceptual errors in 'right of way' collisions, typically in the daytime on rural rather than urban roads. Blameworthy right of way errors were notably high for drivers aged over 65 years, as a proportion of total fatal accidents in that age group.


Why we fail to reduce urban road traffic volumes: Does it matter how planners frame the problem?

In a situation with competing objectives, and where knowledge is contested, the actors may choose what they consider as valid knowledge based on ideology, interests or position. Flyvbjerg (1998) found that in situations like this "power defines what counts as rationality and knowledge and thereby what counts as reality" (italics in original). The people who have the power define what count as valid objectives and knowledge. If the actors who promote objectives and knowledge within the new framing are not the most powerful actors in the game, this may be one explanation why plans resulting in increased road traffic volumes are made...We have seen that the planning game is quite complex and involves a number of different actors. Planners are the actors who possess the professional knowledge in this field. How planners frame the problem influences what they see as important objectives, possible alternatives, valid methods for evaluation, etc. This affects the planning, the plans and the ultimate outcome in the form of traffic volumes. In order to reduce urban road traffic volumes, planning and development of urban land use and transport systems need to change. This requires planners to reframe the transport problem from 'predict and provide' towards 'coordinated land use and transport planning for reduced urban road traffic volumes'. This involves a change of objectives as well as applied knowledge. The empirical evidence presented in this article shows that some planners have reframed the problem while others have not. Here, there is a frame conflict situation. This frame conflict reduces the ability of the planning system to focus on both reducing traffic demand and applying strategies and means that would help to achieve the objective. It also opens the way for power to define what constitutes important objectives and valid knowledge. How planners frame the problem, including the frame conflict discussed here, thus appears to be one explanation why urban land use and transport systems are still planned and developed in ways that cause and allow growth in urban road traffic volumes.

Tennyson, A. (2010). Why we fail to reduce urban road traffic volumes: Does it matter how planners frame the problem? Transport Policy, 17, 216-223.

It's a safety marketplace, and consumers are buying

Car safety ratings often grab the media spotlight. Sometimes they're published by the Institute, while other ratings are from the government or Consumer Reports. Bigger news than these periodic media splashes is the growth of the safety marketplace around the world, spurred by the availability of vehicle ratings from multiple sources. "These crashworthiness ratings aren't in competition. One isn't better than another," says Institute president Adrian Lund. "The key is to look at every available source of safety information and choose a car, pickup, or SUV with top ratings across the board. These vehicles are on the market, and buyers are finding them." A new poll confirms the attention that consumers are paying to safety, factoring it into their vehicle choices. In turn, this demand puts pressure on auto manufacturers to compete in the safety marketplace.

Abstract: The present report was designed to analyze the traffic safety situation in India, and to identify countermeasures for areas in which the total harm caused by crashes can be substantially and readily reduced. The report focuses on two aspects of traffic safety in India: challenges and opportunities. The first part of the report provides a comprehensive analysis of the current traffic safety situation in India. It is pointed out in this analysis that fatality rates have increased both on highways and in urban areas during the past few years. Theoretical models suggest that the number of fatalities in India is not likely to start to decline for many years to come unless new policies are implemented. Based on the present analysis, the following six areas are identified as having potential for substantially reducing fatalities in India: (1) pedestrians and other non-motorists in urban areas, (2) pedestrians, other non-motorists, and slow vehicles on highways, (3) motorcycles and small cars in urban areas, (4) over-involvement of trucks and buses, (5) night-time driving, and (6) wrong-way drivers on divided highways. The second part of the report outlines several promising countermeasures for each of these six areas. The third part of the report presents a brief comparison of major traffic safety challenges in India and China.

Keywords: India, road safety, transportation safety, traffic crashes, road fatalities, motorization, driving, countermeasures


Abstract: This paper investigates the effect of muscle contraction on lower extremity injuries in car-pedestrian lateral impact. A full-body pedestrian model with active muscles has been developed. Finite element simulations have then been performed using the full-body model and front structure of a car. Two pre-impact conditions, that of a symmetrically standing pedestrian, representing a cadaver and an unaware pedestrian, have been simulated. Stretch-based reflexive action was included in the simulations for an unaware pedestrian. The results show that due to muscle contraction (1) peak strain in all the knee ligaments reduces, (2) von Mises stresses in tibia and fibula increase and may fail and (3) knee joint effective stiffness increases by 58% in lateral bending.

Keywords: A-LEMS; lower extremity model; dynamic simulation; muscle contraction; standing posture; car-pedestrian impact; knee injury


Abstract: To reduce the weight of the motorcycle helmet, metal foam for outer shell in place of conventional thermoplastics was tested. The dynamic behaviour of this new helmet was studied through experiments and numerical modeling. Open-face motorcycle helmets were designed with metal foam shell and impact experiments were performed with these helmets fitted on a headform. A finite element model was developed and the predicted acceleration of headform from this model was validated against the experiments. The mechanical behaviour of full-face helmets with metal foam shell was investigated next. The FE analysis was performed separately with rigid and deformable heads. Head injury criterion (with rigid head) and stresses in brain (with deformable head) were evaluated separately for metal foam shell and impact experiments were performed with these helmets fitted on a headform. A finite element model was developed and the predicted acceleration of headform from this model was validated against the experiments. The mechanical behaviour of full-face helmets with metal foam shell was investigated next. The FE analysis was performed separately with rigid and deformable heads. Head injury criterion (with rigid head) and stresses in brain (with deformable head) were evaluated separately for metal foam shell and ABS shell helmets. The helmet impact performance is examined with two separate densities of metal foam. The shell with low-density metal foam (150 kg/m3) gives a better performance compared to ABS shell. The metal foam shell showed significant visible plastic deformation in the impact region.

Keywords: Helmets, metal foam, impact, finite elements.
Continued from overleaf:


Abstract: We used Comparative Risk Assessment methods to estimate the health effects of alternative urban land transport scenarios for two settings—London, UK and Delhi, India. For each setting, we compared a business-as-usual 2030 projection (without policies for reduction of greenhouse gases) with alternative scenarios—lower-carbon-emission motor vehicles, increased active travel, and a combination of the two. We developed separate models that linked transport scenarios with physical activity, air pollution, and risk of road traffic injury. In both cities, we noted that reduction in carbon dioxide emissions could not reproduce all the observed traffic characteristics, it was however able to reproduce the trends observed in real traffic. The model has undergone many changes since then and its evaluation with time. Later, some modifications are proposed and

Keywords: Green house gas, DALY, climate change, public health.


Abstract: There exists a need for traffic flow modelling in developing countries on account of the growth in personalized traffic. For many developing cities, traffic management schemes are gaining importance. The core of any traffic management scheme is a better understanding of traffic behaviour. Since the traffic is heterogeneous in nature and vehicle characteristics vary widely, it is not known whether any conventional microscopic (car following) or macroscopic models are applicable to developing countries. In most of the simulation models, either space or time or both are considered as continuous variables, and since these models involve numerous elements (various vehicle types, different road conditions etc.), they require immense computational time. The objective of this study is to achieve a better computational efficiency in modelling complex traffic systems for different scenarios. The model developed in the present study is based on the Nagel and Schreckenberg’s (NS) approach (1992). In the NS model, interactions between different elements (vehicles, road and driver) were considered implicitly and even though this basic model could not reproduce all the observed traffic characteristics, it was however able to reproduce the trends observed in real traffic. The model has undergone many changes since then and its applicability is now extended to model network traffic flows (Simon and Nagel, 1998). A detailed literature review is presented in the next section which is followed by discussion on the basic structure of the CA model and its evaluation with time. Later, some modifications are proposed and

Keywords: Pedestrian behavior, traffic flow, intersections.