



IIT faculty members associated with TRIPP supervise research projects at undergraduate and postgraduate levels. The current and recently completed projects are listed below:

Ph.D. Scholars

Current

Highway design and traffic safety

Scholar: Afzal Hingora

Supervisors: Geetam Tiwari and Dinesh Mohan

Optimal pricing of urban transport - a case of Delhi

Scholar: Akshay Sen

Supervisors: Geetam Tiwari and V. Upadhyay

Study of the effect of thigh and leg muscle activation on the response of human knee to impact loading

Scholar: Anurag Soni

Supervisors: Anoop Chawla and Sudipto Mukherjee

Transportation projects and their effects on the poor: integrating a social impact assessment methodology

Scholar: Anvita Anand

Supervisor: Geetam Tiwari

Constitutive models of soft tissue for human body-vehicle impact analysis

Scholar: B. Karthikeyan

Supervisors: Sudipto Mukherjee and Anoop Chawla

Tool for positioning human body FE model

Scholar: Dhaval Jani

Supervisors: Anoop Chawla and Sudipto Mukherjee

In-vivo measurement of constitutive properties

Scholar: Hemant N Warhatkar

Supervisor: Anoop Chawla and Sudipto Mukherjee

Non-motorized traffic (bicycle): demand estimation and integral planning

Scholar: Himani Jain

Supervisor: Geetam Tiwari

Urban bus route optimization

Scholar: Mukti Advani

Supervisor: Geetam Tiwari

Institutional and regulatory structure for providing urban public transport

Scholar: O.P. Agarwal

Supervisors: Geetam Tiwari and V. Upadhyay

To study the suitability of airbags for motorcyclists

Scholar: Prashant Vidhyadhar Bhosle

Supervisors: Anoop Chawla and Sudipto Mukherjee

Biomechanics of helmet impact

Scholar: Praveen Kumar Pinnaji

Supervisor: Puneet Mahajan

Impact of land use on public transport

Scholar: S S L N Sarma

Supervisor: Geetam Tiwari

B.Tech. Projects

Completed

Assessment of urban road cross section at selective locations with respect to flow and safety

Students: Mandeep Singh Pannu and Shitij Dua

Supervisors: *Dinesh Mohan and Geetam Tiwari*

Estimation of air pollution and traffic trends in selected locations in Delhi

Students: Abhishek Mudgal

Supervisors: *Sanjeev Sanghi and Geetam Tiwari*

Design of optimal signal cycle for three selected intersections

Student: Atul Magoon

Supervisors: *Geetam Tiwari and A.K. Gosain*

Analysis of pedestrian risk on selected locations in Delhi

Student: Udit Gupta

Supervisor: *Geetam Tiwari and N. Chatterjee*

Identification of high capacity bus system network in Delhi

Students: Vikram Joshi

Supervisor: *Geetam Tiwari and R.R. Kalaga*

M.Tech. Projects

Completed

Demand assessment for urban public transportation systems

Student: Dinesh Kumar

Supervisor: *Geetam Tiwari*

Planning criteria for urban public transportation systems

Student: Anantha Lakshmi P.

Supervisor: *Geetam Tiwari*

Material characterization of live body organ using inverse FEM analysis

Student: K.L. Mishra

Supervisor: *Anoop Chawla and Sudipto Mukherjee*

Developing methodology for damage based accident investigation involving two wheeler

Student: T.S. Baviskar

Supervisor: *Anoop Chawla and Sudipto Mukherjee*

Course Announcement

The Transportation Research and Injury Prevention Programme (TRIPP) at the Indian Institute of Technology, Delhi, Volvo Education and Research Foundations and the French National Institute for Transport and Safety Research (INRETS) France, are organizing a seven day "International Course on Transportation Planning and Safety". The course will be held in New Delhi, India, from 10-16 December 2007, and TRIPP will be the host institution. The course will have a common component for the first three days, followed by two parallel modules on Traffic Safety and Biomechanics and Crashworthiness.

Details of the course can be accessed from - www.iitd.ac.in/tripp

Visiting Faculty

Prof. Joseph Fazio, Illinois Institute of Technology, Chicago University, spent 6 weeks (May 26, 2007 to July 16, 2007) at TRIPP, IIT Delhi.

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.





Urban Transport Planning

Geetam Tiwari, is TRIPP Chair Associate Professor at Civil Engineering Department, Indian Institute of Technology, Delhi.

Can you tell us something about transport policy planning in our cities today?

Transport planning, it must be understood, is a complex subject that is inextricably related to urban development; at the policy level, town and country planning organizations and development authorities were expected to prepare city master plans and city development plans. Urban Planning was a state subject; as such it confined itself to issues of infrastructure and never addressed itself to questions of resource and finance. It was thus reduced to a nonparticipatory and exclusive process. Since 1960, such plans have been prepared for several metropolitan cities. However these plans have not been very effective in managing urban growth. Almost all cities have a slum population occupying land which is not earmarked for them.

The growth in any city is almost always accompanied with the expanding size of the urban 'informal economy'. Larger cities have more slums and squatter settlements. In the million plus and mega cities in India, 40-50 per cent of the population live in informal housing. The rising cost of transport within the city and long working hours force the workers to live in proximity to their workplaces. The growth rate of squatter households, as compared to that of the non-squatters is nearly four times higher in Delhi.

A large section of the urban population living in informal settlements is a captive user of low cost travel modes (walking and bicycling) because many of these residents cannot afford to pay even the subsidised fares for

buses. For the poorest 28 per cent of the households with monthly incomes of less than Rs. 2000, a single worker spends 25 per cent or more of the entire monthly income on daily round trip bus fares. For those with incomes much less than Rs. 2000, the already low bus fare is prohibitively expensive.

The impact of recent eviction and resettlement policies in Delhi has adversely affected a large number of poor households in the city. People who were relocated had reduced access to jobs because the new residential locations are 10-15 km away from their previous residences. Hence all walking trips had to be replaced with motorized trips. Often increased distance from the workplace has also meant increased travel time and expenses. Under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) the government of India has identified 63 cities for providing assistance for upgrading the road infrastructure. Detailed guidelines have been provided to ensure that public transport gets priority in these cities. For getting approval for transport projects, the guidelines recommend that the transport infrastructure improvement schemes have to be in compliance with the National Urban Transport Policy (NUTP). Since the NUTP focus is on public transport pedestrians and bicycles, cities are modifying the earlier road expansion projects to Bus Rapid Transit System (BRTs) and bicycle inclusive plans.

Can you walk us through the transportation issues of the informal sector in Indian cities today?

Urban travel in Indian cities is dominated by walking, cycling and public transport trips including intermediate public transport (IPT). The variations in modal shares among these three seem to have a relationship between city size and per capita income. Cities with populations of 0.5 - 1.0 million are characterized by short trip lengths, medium density (-400-800 person/ha) and mixed landuse patterns. Nearly 50% of the trips are by walking and bicycles and another 30% are by para transit. The two wheeler share of trips ranges from 15% to 40% in some cities while the share of car trips remains below 5%. Organised public transport services under the public sector exists in a few cities; however, several state run corporations have been found to be financially unviable in the past and have been closed down. In some cities, private buses have been introduced recently, but predominantly the bus transport operation is under the public sector. IPT modes like tempos, autos and cycle rickshaws assume importance as they are necessary to meet the travel demands in medium size cities in India like Hubli, Varanasi, Kanpur and

Vijayawada. However, there is no policy or project in place which can improve the operation of para-transit modes. Often the fare policy stipulated by the government is not honoured by the operators, the road infrastructure also does not include facilities for these modes. As a result the operators have to violate legal policies to survive in the city

Public transport is the predominant mode of motorized travel in mega cities. Buses carry 20 – 65 per cent of the total trips excluding walk trips. The travel patterns of people living in informal housing or slums are very different from residents in formal housing. Bicycles and walking account for 65 per cent of the commuting trips for those in the informal sector. The formal sector is dependent on buses, cars and two wheelers. This implies that despite high risks and a hostile infrastructure, low cost modes exist because users of these modes do not have any choice, as they are captive users of these modes.



In a word, would it be correct to say that there can be no city or transport planning without addressing the needs of the informal sector?

You cannot have the one without the other; even to emphasize one at the expense of the other will only lead to a lop - sided development. Landuse patterns, population density and socio - economic characteristics influence the choice of the transport system; at the same time the presence of certain transport systems changes the land accessibility and therefore the land value triggering a change in landuse pattern and city form. Therefore city and transport plans and policies prepared by the policy makers, experts and decision makers are expected to play an important role in influencing the future health of our cities. However, a large proportion of the urban population in Asian and other low income cities remains outside the formal planning process. Survival compulsions force the people in the formal sector to evolve as self organized systems. These systems rest on the innovative skills of people struggling to survive in a hostile environment and meet their mobility and accessibility needs. The housing, employment

and transport strategies adopted by this section of society are often termed as "informal housing, informal employment and informal transport". Squatter settlements all over the world are called informal settlements because they are not part of the official plan. The conventional definition of informal – unofficial, illegal or unplanned – denies people jobs in their home areas and denies them homes in the areas where they have gone to get jobs. Transport solutions evolved by this section of society do not become part of the official policy. Their existence is mostly viewed as creating problems for the "normal traffic". Therefore most cities face a complex situation where the investments are for formal plans, whereas the needs of a significant section of the society are met by informal transport. Is this desirable or sustainable? That is the question we should be asking ourselves.

Cities are spending vast sums of money on transport infrastructure. How will this impact on the city citizens?

Different Indian cities are either implementing or looking at new transport systems, be it a metro, high capacity buses or the sky bus. The argument put forward for introducing new technologies is that it serves the high density demands expected on a few corridors in the city. In the last fifteen years comprehensive traffic and transport plans have been made for at least fifteen cities. Travel forecasts for the next thirty to forty years have been used to justify the proposal for light rail or metro systems. Except Delhi no other city has been able to implement these recommendations. Travel demand depends upon city size, trip length, location and density of jobs and residences and other socio-economic conditions. This requires a very high density development within the catchment areas of the rail system. In Hong Kong and Singapore high rise buildings along the metro corridor provide a high density of residences as well as jobs. Therefore the capacity provided by the metro can be well utilized. Indian cities have high density developments in the form of urban slums. Even a subsidized metro system is too expensive for slum dwellers. Therefore the demand for metro systems in Indian cities is low. This is the reason that the Kolkata, Chennai and Delhi metro systems are carrying less than 20 per cent of the available capacity. The metro and Light Rail Transit (LRT) have low social costs in terms of energy consumption and pollution only when the system runs to its capacity. Since the supply exceeds the demand, the system runs at a loss. System demand is dependent on the ease of access, low fares and dependability. The metro is a capital intensive system (Rs. 200-300 crore/km). For the same price a 30-50 km stretches of bus network can be developed including the use of modern buses. This would benefit 30-50 times more people than a metro system. The cost of a single metro trip is at least Rs. 45 compared to Rs. 15 for a bus trip. Since car and personal two wheelers provide a flexible door-to-door service, it is not easy to attract these users to a metro, even if they can afford the cost. Tickets on the metro have to be subsidized at least 10-15 times more than a bus ticket for the same journey.

Several Indian cities have constructed and made plans for new flyovers. The justification for flyover construction is to reduce long delays at intersections and provide uninterrupted movement to long distance traffic. Flyover construction cannot provide long-term solutions because it improves journey time for a small section of the road for cars which form only 20-25 per cent of the total commuter trips in a city like Delhi. In other cities car trips are less than 20 per cent. Flyovers do not have any benefits

for bus commuters because bus stop locations are shifted away from the intersections increasing the walking distance for changing buses going in different directions. With an increase in the speed of road vehicles, bus commuters as well as other pedestrians find it difficult to cross the road. Thus flyovers result in short-term benefits for car users at the cost of increasing traffic hazards and inconveniencing the other road users. They also encourage people to use cars and motorized two wheelers; and move away from public transport, walking and bicycling. This results in more vehicles, congestion and pollution on the roads. A careful look at the road widening and junction improvement schemes shows that widening has been done by reducing the space for pedestrians. Not a single city in India has implemented facilities for bicycles or public transport buses or for intermediate public transport vehicles like three wheelers and rickshaws. Junction improvement schemes have included creating free left turns putting more pedestrians at risk. In other words investments in road infrastructure improvement has meant facilities for vehicles which carry a much smaller share of total trips compared to the trips by pedestrians and non motorized vehicles.

Since the catchment area of a road system depends on the extent of the road network, road based systems are capable of reaching almost 80 percent of the city population. Access to this system includes improved and safe pedestrian paths. If this is done this system will be able to match the convenience and flexibility provided by private modes. Consequently, we can expect a high demand and therefore better capacity utilization of this system.

BRTs and bicycle inclusive plans for five cities have been approved by the central government and another five cities are at different stages of preparation. However, pedestrian and bicycle facilities are not the focus of these projects. This is reflected in the priority for space allocation for various modes in a restricted right of way. In order to accommodate two lanes for cars and an exclusive lane for buses, pedestrians and bicyclists have been given less than desirable space. Implementation of BRTS has commenced in Delhi; The company which has been instituted to implement the project is the Delhi Integrated Multimodal Transport System (DIMTS); it is this company which is busy preparing plans for light rail transit and monorail. BRTS road designs have been modified to "improve" car flow so that after the construction of the BRTs lanes, car users are not inconvenienced, even if it means reducing the level of service to pedestrians and bicyclists.



How do we compare with cities in other countries?

Bogata and Curitiba, both considered to be cities with model public transport systems, have decided to expand their Bus Rapid Transit systems in order to cover the whole city by public transport which does not require subsidy, restricts car usage and has major impacts on safety, pollution and energy consumption. The growing cities, mostly in Africa and Latin America are characterized by diversities and heterogeneity in socio-economic conditions. These mega cities are agglomerations of several small cities having multiple economies, in close proximity to each other. One economy serves the needs of the affluent and features modern technologies, formal markets, and the outward appearance of developed countries. The other services disadvantaged groups and is marked by traditional technologies, informal markets, and moderate to severe levels of economic and political deprivation. The rapidly expanding cities (Say, Shanghai, Mexico city and, Johannesburg) are characterized by a significant proportion of the city population being dependent on the informal sector. A majority of the population is dependent on walking, bicycling and public transport. Automobile mobility is still the preserve of the minority. Historically the three expanding cities – Shanghai, Mexico city and Johannesburg – have been different in many aspects. Shanghai until the mid 80s had a controlled economy and invested in public housing and bicycle infrastructure. A large number of people employed in the informal sector were counted in the floating population. However, since the opening of the economy major changes were brought about in the government policy and the car industry was declared a pillar industry in China; in the last decade, elevated highways, satellite towns and mono-functional districts have put human scale transport infrastructure on the back burner. Shanghai's official policy is to reduce cycling which already led to a drop from almost 40% to 25% of all trips between 1995 and 2004. The city

is successful in attracting more car use which doubled during the same period leading to an increased average in commuting distances of up to 70%.

Around 50,000 mini buses and minibuses are handling a majority of the trips in Mexico city; however, 40% of the city's transport budget between 2000 and 2006 was spent on its Segundo Piso, an elevated highway used by not even 1% of its residents.

Johannesburg's public space is taken over by traffic, shockingly illustrated by its accident statistics of 56 fatalities per 100,000 inhabitants compared to 3 in London and 7 in Mexico City. The percentage of stranded people who walk to work (often in dangerous circumstances) for more than 30 minutes, because they cannot afford any form of public transport has increased. Mini bus taxis the major public transport mode receives no operating subsidy. But the provincial government is planning to invest US \$ 2.7 billion on a rapid rail project.

It is clear that in the name of development and progress auto-based mobility solutions have dominated the public transport policy agenda and investments in the rapidly expanding cities. Sustainable transport concepts are used more to promote capital intensive systems like heavy rail which may not have an extensive catchment area but requires huge capital. Modes which are used by a majority of the people, walking, cycling and minibuses do not become the focus of a sustainable transport policy agenda. At the same time the mature cities which developed around rail based public transport networks, ended up by becoming dependent on automobile based mobility.

What then must we do?

There is a degree of horizontal interdisciplinarity in our academic institutions; however they do not provide platforms that encourage the vertical interdisciplinarity that is required in subjects like Urban Development and Transportation Planning. This would imply that the different disciplines in research settings not only talk to each other but address the needs of all strata of society equitably. This would be crucial in sensitizing the academic community to the conflicting needs of various groups in the city. The thrust areas to be focused upon would be aspects of non-homogeneous traffic with respect to capacity and safety requirements; segregation of bicycle lanes to improve throughput of both bicycles and motorized traffic and design of bus commuter friendly infrastructure.

The current norms for bus lanes and bus stops do not cater to the high capacity systems. Norms based on empirical and theoretical models have to be developed to improve the throughput of buses, intersection designs which can optimize the movement of buses, vehicles and pedestrians. The impact of information technology (GPS/GPRS/) needs to be investigated to improve the safety and efficiency of bus systems. The areas of research on these aspects would cover the study of the capacity of bus lanes with respect to its location (central vs curbside bus lanes); the impact of bus stop location on intersection capacity, bus performance and pedestrian safety; and the impact of platooning on demand and capacity of the system.

Current traffic engineering measures have created a very hostile environment

for pedestrians and bicycles. For example, pedestrian overhead bridges require either staircases or ramps going upto 6-7 m. This increases the walking distance by at least 100 m at a ramp slope of 1:25 at each end of the crossing. Similarly pedestrian subways also require additional walking and climbing down. Detailed research is required to understand pedestrian behaviour on the road, while crossing the road, the capacity of pedestrian paths in the presence of street vendors to facilitate design of signalized intersections and, safe crossings. Microscopic simulation models are required to simulate the interaction of pedestrians with vehicles, and the traffic environment to evaluate the safety and efficiency performance of different traffic engineering solutions and strategies. The special focus would be on issues such as determining what risks pedestrians are willing to take under different traffic engineering strategies? And also, what traffic engineering measures are required to improve the safety and convenience of pedestrians?

All these research areas require development of empirical and theoretical models. This requires inputs from multidisciplinary teams. The long term aim is to develop simulation models to evaluate the performance of different strategies before implementation. If we are to put this new knowledge in planning into practice we have to make sure that we create spaces, fora and platforms that would give participatory voice to the voiceless of the informal sector; it is only when this vast, silent majority is included in the planning and implementation process that our urban development and transportation would become both, meaningful and possible in terms of best practices.

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