An Overview of Mobility and Safety Issues Related to Highway Transportation in India

DURING THE PAST TWO DECADES, DRAMATIC CHANGES HAVE TAKEN PLACE IN THE LIFESTYLE OF THE MIDDLE CLASS POPULATION OF INDIA. THE EXPANSION OF THE HIGHWAY INFRASTRUCTURE, ESPECIALLY IN MAJOR METROPOLITAN AREAS, HAS NOT KEPT PACE WITH THE INCREASING TRAFFIC DEMAND. SUCH IMBALANCE IN SUPPLY AND DEMAND IS CAUSING AN UNPRECEDENTED LEVEL OF MOBILITY AND SAFETY CHALLENGES.

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INTRODUCTION

The movement of people and goods is essential to achieving economic growth in a country and improving the lifestyle of its citizens. Moreover, the mobility and safety of any transportation system must be well balanced to realize the maximum benefits from the investments made on building and maintaining a highway infrastructure.

The movement of commodities, especially produce, between various regions in a large country is essential to the efficient use of such commodities and profitability of the growers and manufacturers. Efficient commodity movement often reduces consumer costs; thus, such a savings finds its way into the economy, satisfying the other essential needs and desires of the consumer.

Over the past two decades, the lifestyle of the people of India, in terms of mobility of people and goods, has dramatically changed. The reasons behind such changes include globalization and the low cost of services, which in turn promote the phenomena of outsourcing. This has also led to a substantial increase in the average income level in India. However, due to the rising price of gasoline worldwide and its high demand and limited supply, there is major concern with regard to the future mobility of people and goods, not only in developing countries but also in Western countries such as the United States.

Automobile manufacturers are predicting that India and China will realize a significantly high increase in the ownership of personal automobiles in the next decade. In reaction, a country such as India will face a variety of detrimental issues associated with the increased demand of travel. Some of these issues are very challenging, such as highway fatalities and injuries, congestion, air pollution and the increased cost of transportation.

This article provides an overview of highway-related mobility and safety issues in India, recent recommendations made by a committee on road safety and traffic management, the authors' recommendations based on their study and observations, and future transportation-related research needs.

HIGHWAYS IN INDIA COMPARED TO OTHER COUNTRIES

Interstate routes in the United States, motorways in Europe and freeways and expressways in developed countries are the vital links for commodity flow, whereas local, collector and arterial roads provide the most passenger movement. If we compare roadway length and mobility data for various countries, the relative mobility becomes transparent. A sample of such data is presented in Table 1. It is virtually impossible to obtain uniform data relevant to the transportation of goods and people across the nations. However, Table 1 presents our best effort at obtaining some basic data through numerous published and Web-based sources.

A sample of nine countries has been selected for the purpose of comparing relative mobility indices. The mobility index used in this study consists of the following definitions:

- length of roadway per 1,000 square kilometers (sq. km) (386 square miles [sq. mi.]) of land area. This measure, when viewed with the overall population density, provides a measure of mobility opportunities for people and commodities;
- length of motorway/freeway/national highway per 1,000 sq. km (386 sq. mi) of land area;
- length of roadway per 10,000 population; and
- length of freeway/motorway per 10,000 population.

The sample data of nine countries shows that Bangladesh has the highest density of population. Passenger mobility

Table 1. Roadway length and mobility index of different countries.

Country	Total length of all roads (km)	Total length of motorway/ freeway/ national highway (km)	Population in thousands	Land area (sq. km)	Population density (population in thousands/ 1,000 sq. km)	Mobility index (based on all roads)		Mobility index (based on motorway/ freeway/national highway)	
						km/1,000 sq. km of land	km/10,000 population	km/1,000 sq. km of land	km/10,000 population
India	3,315,231 [2]	58,112 [1-1]	1,045,547 [3]	2,973,190 [4]	352	1115.0	31.71	19.5	0.56
Pakistan	255,856 [5]	8,885 [1-2]	148,720 [5]	778,720 [4]	191	328.6	17.20	11.4	0.60
Bangladesh	239,226 [1-2]	3,485 [6]	141,340 [7]	133,911 [4]	1,055	1786.5	16.93	26.0	0.25
USA	6,358,571 [8]	90,205 [8]	282,909 [9]	9,161,923 [4]	31	694.0	224.76	9.8	3.19
Germany	231,400 [10]	12,000 [10]	82,501 [10]	357,045 [10]	231	648.1	28.05	33.6	1.45
U.K.	387,674 [11]	3,100 [11]	59,834 [12]	241,590 [4]	248	1604.7	64.79	12.8	0.52
France	863,100 [13]	10,390 [4]	62,324 [14]	545,630 [4]	114	1581.8	138.49	19.0	1.67
Japan	1,183,000 [15]	7,200 [15]	127,619 [15]	324,200 [15]	394	3649.0	92.70	22.2	0.56
China	1,624,952 [16]	34,300 [16]	1,299,880 [16]	9,326,411 [4]	139	174.2	12.50	3.7	0.26

Sources of Data

[1-1] World Bank, 2002
[1-2] World Bank Local Staff, 2004
[2] Department of Road Transport and Highways, GOI, 2002
[3] 2002 Projection from Census of India (http://www.censusindia.net)
[4] www.infoplease.com
[5] Federal Bureau of Statistics, Pakistan, 2004
[6] Roads and Highways Department of Bangladesh, 2004
[7] Bangladesh Bureau of Statistics (BBS), 2004
[8] United States Bureau of Transportation Statistics, 2003
[9] U.S. Census Bureau, 2003
[10] Federal Statistical Office, Germany, 2004
[11] Road Traffic Statistics-2004, Department of Transport, U.K.
[12] Official U.K. Statistics, 2004 (www.statistics.gov.uk)
[13] OECD, 2004 (http://www.oecd.org/statsportal)
[14] National Institute for Statistics and Economic Studies France, INSEE, 2004
[15] Japan Statistical Yearbook, 2006
[16] National Bureau of Statistics of China, 2004

is probably the highest in the United States and the lowest in China. India comes in in the middle of the pack, considering the category of roadway length per 10,000 population. If we consider the issue of commodity flow, then the United States also ranks the highest and China ranks the lowest based on motorway/freeway length per 10,000 population. This data demonstrates where India ranks in terms of providing mobility for people and goods as compared to other countries.

An increase in motorized transportation has a detrimental effect on society, namely congestion, traffic accidents, fatalities and injuries. Table 2 provides some sample data relevant to this issue. The quality of data on road accidents, injury and fatality remains quite unreliable in various countries. In general, most Western countries maintain reliable databases and have created efficient reporting systems; however, in most Asian countries the related data are, at best, approximate. If a comparison of fatalities per 1,000 registered vehicles is made among the sample nine countries, the United Kingdom shows the lowest rate of fatality and Bangladesh shows the highest. India has the third-highest fatality rate among the group of nine countries in this comparison.

Moreover, due to recent developments in the Indian highway corridor system, such as the north-south and east-west corridors, the mobility and the speed of vehicles on highways have increased substantially. Traffic control systems, vehicle safety features and driver education are going to take the most important roles in dealing with the improved systems, and having a good and reliable information system emerges as an important goal for India.

The authors of this paper feel that a safer driving environment is expected in India for the following two reasons: A significant percentage of vehicles are still operated by professional drivers, and the overall travel speed is much lower in India compared to Western countries.

The recent largest public infrastructure project in India's history is the ongoing "Golden Quadrilateral," which is a highway network consisting of a 5,846-km (3,633-mi.) expressway linking India's four major metropolitan cities: Delhi, Mumbai, Chennai and Kolkata. According to *National Geographic*, "Much as the U.S. Interstate highway system mobilized American society and grooved the postwar economy, India hopes the Golden Quadrilateral will push the country's economic engine into overdrive—bringing the benefits of growth in its booming metropolis out to its impoverished villages, where more than half the population lives."[1]

SAFETY SCENARIOS IN INDIA

As India progresses through economic growth, the traffic demand may also reach a breaking point, unless some high-priority strategic actions are adopted, especially in large metropolitan areas. It has been reported that the greatest number of accidental deaths in India are due to road accidents (34 percent) followed by railroad and other railway-related accidents (8 percent).[2] Tables 2 and 3 indicate that India faces more than double the current roadway

Table 2. Population, land area and road transportation characteristics comparison.

Country	Total length of all roads (km)	Total length of motorway/freeway/ national highway (km)	Population in thousands	Land area (sq. km)	Total number of motorized vehicles	Fatality by road accidents	Fatality/ 1,000 registered vehicles
India	3,315,231[2]	58,112 [1-1]	1,045,547 [3]	2,973,190 [4]	58,863,000 [2]	84,700 [2]	1.44
Pakistan	255,856 [5]	8,885 [1-2]	148,720 [5]	778,720 [4]	5,132,037 [5]	5,119 [5]	1.00
Bangladesh	239,226 [1-2]	3,485 [6]	141,340 [7]	133,911 [4]	786,598 [17-1]	3,053 [17-2]	3.88
USA	6,358,571 [8]	90,205 [8]	282,909 [9]	9,161,923 [4]	161,490,000 [9]	42,884 [18]	0.27
Germany	231,400 [10]	12,000 [10]	82,501 [10]	357,045 [10]	54,082,200 [10]	5,842 [10]	0.11
U.K.	387,674 [11]	3,100 [11]	59,834 [12]	241,590 [4]	32,259,000 [12]	3,321 [19]	0.10
France	863,100 [13]	10,390 [4]	62,324 [14]	545,630 [4]	37,269,752 [13]	5,530 [19]	0.15
Japan	1,183,000 [15]	7,200 [15]	127,619 [15]	324,200 [15]	78,279,000 [15]	10,913 [15]	0.14
China	1,624,952 [16]	34,300 [16]	1,299,880 [16]	9,326,411 [4]	41,753,700 [16]	107,077 [16]	2.56

Sources of Data

[1-1] World Bank, 2002
[1-2] World Bank Local Staff, 2004
[2] Department of Road Transport and Highways, GOI, 2002
[3] 2002 Projection from Census of India http://www.censusindia.net
[4] www.infoplease.com
[5] Federal Bureau of Statistics, Pakistan, 2004
[6] Roads and Highways Department of Bangladesh, 2004
[7] Bangladesh Bureau of Statistics BBS, 2004
[8] United States Bureau of Transportation Statistics, 2003
[9] U.S. Census Bureau, 2003
[10] Federal Statistical Office, Germany, 2004
[11] Road Traffic Statistics-2004, Department of Transport, UK
[12] Offcial U.K. Statistics, 2004 www.statistics.gov.uk
[13] OECD, 2004 http://www.oecd.org/statsportal
[14] National Institute for Statistics and Economic Studies France, INSEE, 2004
[15] Japan Statistical Yearbook, 2006
[16] National Bureau of Statistics of China, 2004
[17-1] Bangladesh Road Transport Authority, 2004
[17-2] Bangladesh Road Transport Authority, National Road Traffic Accident Report, 2002
[18] National Center for Statistics and Analysis, NCSA, 2003
[19] European Commission, 2004 www.ec.europa.eu

accidents when compared to the United States, whereas the roadway length in India is about half of that in the United States.

In 2005, the government of India established a national committee on road safety and traffic management. Table 4, adopted from the above-mentioned committee's report, provides the fatalities and injuries on Indian roadways. The report indicates that the fatality numbers reported might be close to the actual numbers; however, the actual *injuries* could be 15 to 20 times the number of fatalities.[3]

From Table 4, it appears that the number of people killed and injured on national highways is less than on all roadways, whereas the proportion of deaths on national highways is much higher than that of the latter. Based on the lengths of road network reported by the National Highways Authority of India (NHAI) and accident data reported for 2004, the fatality rate on national highways is 0.52 fatalities per km, or more than one fatality occurring every 2 km on average.[4] For all other roadways, the fatality rate is much lower (0.02 fatality per km, or an average of one fatality occurring every 50 km). The major contributing factors resulting in higher fatality rates on national highways include higher speed, a higher proportion of truck traffic, infrastructure inadequacies, a lack of driver education and a lack of law enforcement. With an average vehicle growth of 10.16 percent annually over a period of five years, as reported by NHAI, the potential safety issues within the next decade will be very challenging.[5]

The breakdown of 105,725 persons killed in road accidents in 2006 alone, as shown in Table 5, indicates that there is a high ratio of male to female occupants

Table 3. Road accident deaths vs. total accidental deaths in India (2002–2006).

Sl. No.	Year	Number of accidental deaths		% share in unnatural total deaths
		Road accidents	Total unnatural	
(1)	(2)	(3)	(4)	(5)
1	2002	84,059	243,399	34.5
2	2003	84,430	244,671	34.5
3	2004	91,376	258,326	35.2
4	2005	98,254	271,760	36.2
5	2006	105,725	293,202	36.1

SOURCE: 2007 Accidental Deaths and Suicides in India

killed (5.4 to 1). This does not compare the driving skills between males and females, since most of the professional drivers (chauffeurs) in India are male, and male vehicle occupants are usually much higher in number than female. The statistics also show that the maximum number of fatalities involved commercial trucks (22.6 percent), followed by two-wheelers (17.8 percent) and buses (11.9 percent). The combined percentage of pedestrians and bicyclists killed in road accidents is also significant (11.1 percent). The trend of fast-increasing ownership of personal automobiles, such as cars or vans, will create higher potential threats to the occupants in these types of vehicles. The highest proportion of commercial-truck-related fatalities could be due to contributing factors such as disobeying traffic laws and roadway inadequacies. Regarding the second-highest fatalities, involving two-wheelers, there are driver behavioral issues, such as improper lane changing, weaving and speeding, that pose high risks to these smaller vehicles.

A study by the Planning Commission of India estimated the societal costs of road accidents in India at 550 billion rupees annually. (Considering year 2000 costs and the currency-conversion factor, this is equivalent to $12 billion USD.) The cost of road accidents in developed countries constitutes about 1 to 2 percent of gross domestic product; the corresponding figure for India is about 3 percent.[6]

From the literature review, the authors found that the *Report of the Committee on Road Safety and Traffic Management* is quite comprehensive and covers several important recommendations and guidelines. A review of the current institutional setup by the committee resulted in the following conclusions:

- Existing institutions are not fully equipped to deal with the increasing traffic or to adopt advanced technologies to promote road safety.
- Responsibility for road safety is diffused, and there is no single agency to deal with a range of problems.
- The role of key ministries and public sector agencies are peripheral—safety is not a priority on their agenda.
- The National Road Safety Council does not have adequate statutory backing, budget, or the mandate to be an effective organization to execute road safety plans.[7]

The committee also reviewed and reported on the best practices in road safety in advanced countries, namely the United States, Australia, Sweden and the United Kingdom. After detailed investigations and studies, the committee recommended the formation of a board with a multidisciplinary background in areas such as roadway and traffic engineering, automobile engineering, traffic law enforcement,

Table 4. Road accidents on national highways and all roadways (1999–2004).

Year	All roads			National highways		
	Accidents	Persons killed	Persons injured	Accidents	Persons killed	Persons injured
1999	386,456	81,966	375,051	103,839	28,713	98,427 P
2000	391,449	78,911	399,265	110,508	30,216	124,600
2001	405,637	80,888	405,216	115,824	32,108	119,592 P
2002	407,497	84,674	408,711	131,738	33,621	132,307
2003	406,726	85,998	435,122	127,834	33,153	131,102
2004 P	429,910	92,618	464,521	130,265	34,723	143,140

P = Provisional

SOURCE: Report of the Committee on Road Safety and Traffic Management

Table 5. Road accident deaths by gender and type of vehicle (2006).

Sl. no.	Type of vehicle	Number of road accidental deaths			
		Male	Female	Total	% share of total vehicles
(1)	(2)	(3)	(4)	(5)	(6)
	Truck/lorry	20,958	2,910	23,868	22.6
1	Government	440	78	518	0.5
	Private	20,518	2,832	23,350	22.1
	Bus	10,170	2,455	12,625	11.9
2	Government	3,556	800	4,356	4.1
	Private	6,614	1,655	8,269	7.8
	Tempo/vans	4,592	1,047	5,639	5.3
3	Government	124	27	151	0.1
	Private	4,468	1,020	5,488	5.2
	Jeep	7,480	1,636	9,116	8.6
4	Government	209	56	265	0.3
	Private	7,271	1,580	8,851	8.4
	Car	7,507	2,027	9,534	9.0
5	Government	144	36	180	0.2
	Private	7,363	1,991	9,354	8.8
6	Three-wheeler	4,757	1,128	5,885	5.6
7	**Two-wheeler**	16,491	2,342	18,833	17.8
8	Bicycle	2,672	235	2,907	2.7
9	**Pedestrian**	7,403	1,503	8,906	8.4
10	Others	7,147	1,265	8,412	8.0
	Total	**89,177**	**16,548**	**105,725**	**100.0**

SOURCE: 2007 Accidental Deaths and Suicides in India

capacity building and education, data collection, reporting and analysis, emergency care and trauma management. The committee also recommended that the primary functions of the board should be as listed below:

- road-related measures—designing, setting standards and conducting audits;
- vehicle-related measures—prescribing safety features;
- road-safety research—institutional linkages and training;
- traffic laws, operations and management;
- capacity building;
- road-user behavior strategies, public awareness and education;
- medical care and rehabilitation; and
- other functions, such as advising central government on road safety and providing technical assistance to the state boards.[8]

The committee also recommended a budget-approval process and funding mechanism at the national and state levels. The authors have found that increased safety education and awareness programs are recently being undertaken by major municipal agencies, as well as by nongovernmental organizations (NGOs) such as ArriveSAFE.[9] This particular NGO is also assisting police departments in improving their enforcement activities. With funding from the World Bank, a Web-based integrated data evaluation system for accidents has been developed, with training support provided by ArriveSAFE. While NGOs, heavily relying on donations and volunteers, play a vital role in promoting safety, the roadway agencies should give safety as high of a priority as mobility. A shift in "the way public agencies work," along with positive changes in the policy makers' and decision makers' mindsets, leading to a rational and scientific "safety culture" at all levels, is critical to the success of the highway transportation system in India.

RECOMMENDATIONS

The authors of this paper recommend the following key strategies to manage the growing traffic demand in urban areas, as well as to keep the system safe:

- the use of traffic-demand management techniques, including efficient traffic flow through signal retiming/optimization, alternate hours of travel, flexible work schedules, telecommuting, alternative modes of travel, reversible lanes, real-time traffic information and intelligent transportation system (ITS) technology;
- transportation infrastructure improvements that include roadway expansions, the building of elevated highways and flyovers, pavement maintenance and rehabilitation and effective travel lane designations;
- effective planning and decision making, including managing land use; integrating land use and transportation planning, decision making and implementation; and encouraging joint developments to minimize traffic impacts;
- utilization of smart growth principles that include mixed land uses; taking advantage of compact building design; creating a range of housing opportunities and choices; creating walkable communities; fostering distinctive and attractive communities with a strong sense of place; preserving open space, farmland, natural beauty and critical environmental areas; strengthening and directing development toward existing communities; providing a variety of transportation choices; making development decisions predictable, fair and cost-effective; and encouraging community and stakeholder collaboration in development decisions;[10]
- implementing safety strategies that include developing a traffic accident records system to identify safety problems at high-accident locations and corridors, implementing effective countermeasures, incorporating safety into the planning process, performing road safety audits, access management along arterials (e.g. installing medians, reducing number of accesses at the corners of intersections, consolidating driveways), ensuring reasonable pavement quality and condition, adopting proper roadside safety features (e.g. shoulders, barriers, crash cushions, clear recovery zones), performing reviews to ensure traffic control devices comply with standards and evaluating implemented safety measures.

FUTURE RESEARCH

Developing countries tend to seek assistance from consultants from Western countries, but it is important to recognize that the traffic engineering and safety solutions that may work in one country may not function well in another country with totally different transportation system characteristics. Both traffic operations and safety often include the influence of three basic components of transportation (the vehicle, the driver and the highway infrastructure). Driver education and training play an important role in the transportation infrastructure of a community and a country. Therefore, university education and research must be focused on the development of critical operational and safety parameters that exist in India under Indian driving conditions. The use of concepts from Western countries or from Australia may not produce a viable alternative for transportation professionals in India. For example, the level of service analysis concept itself is applicable anywhere in the world. However, use of level of service categories must be based on real data from India.

With the increased use of properly designed traffic signals, countdown signals and actuated and semi-actuated signals in urban at-grade intersections, there is a tremendous opportunity for researchers and professional engineers in India to develop large-scale traffic operational and performance databases. Such data can assist in the development of realistic measures of capacity and level of service. The planned office, commercial and residential developments in India present an opportunity to make predictions for future trip generation and trip making characteristics. Such future predictions must be done objectively to evaluate the future effects of such planned developments. The top two safety issues involving commercial trucks and two-wheelers need to be reviewed and researched to identify the potential issues and develop the most appropriate countermeasures. It is equally important to evaluate the effectiveness of any accident mitigation measures undertaken by the road agency. While increasing mobility is one of the priorities for a country like India, better safety analyses by using more accurate and timely

traffic accident data, followed by identification of issues and development of suitable countermeasures, are needed to maintain a balance between mobility and safety.

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DISCLAIMER

Any statements expressed in this article are those of the individual authors and do not necessarily represent the views of the agencies they are affiliated with. ■

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