Linear Settlements and Safety Issues along Highways in India: A Case for integrated Approach for Highway Development

By

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ABSTRACT

India has a vast network of roads aggregating to around 3.4 million kms which is second largest in the world. Its hierarchal system comprises around 71,000kms of National highways which is about 2% of the total network but carries about 45% of traffic, and accounts for 25% of road traffic accidents, 28% of injuries and 34% of total fatalities. Many of these accidents prone stretches are characterised by linear settlements. The development of National Highways commenced immediately after independence and its length has increased by accretion rather than development of new alignments. As a sequel to this approach many stretches of the alignment either suffer from geometric limitations or capacity shortages. India has embarked upon multipronged programme including expressway development to provide significantly improved accessibility to all its rural settlement and improved mobility on its urban and inter urban roads. Recognising the growing problem of linear development the national government has recently enacted legislation on road side development to minimise the impact of linear development. However, their enforcements on a large network are a serious limitation.

Several financial models of highway development involving international and private developers have formed unique partnerships to create a new mosaic of human settlement and transport network. Recently some infrastructure modification and safety reduction measures including legal enforcement have been experimented to contain the rising fatality rates along highways. Research investigations have revealed that introduction of above interventions; have demonstrated a positive impact in fatality reduction, however their integration at the policy level in India is yet to be done.

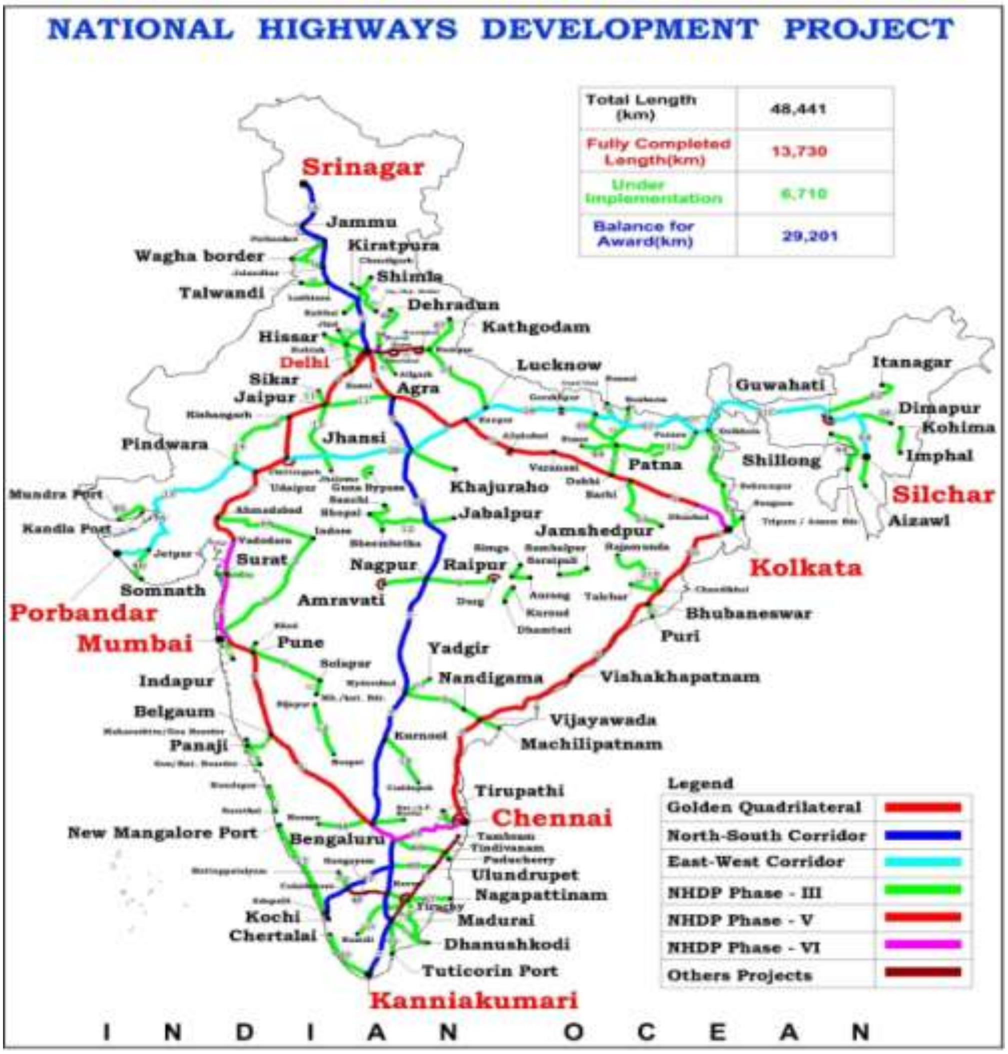
This paper makes an assessment of safety issues and challenges, along improved National Highways. The assessment is done using ‘before and after ‘approach. The improvement in terms of impact on safety is quantified through data collected along experimental stretches and established secondary sources. It examines the impact of legal and infrastructural tools and determines the ineffectiveness of managing the impact of linear settlements**.** Conclusively, the paper argues for developing a preventive approach to linear developments via-a-vis the currently adopted curative the causal factors associated with linear development.

1.0. Background

National Highways are the arterial roads of the country for inter-state movements of passengers and goods. They traverse the length and width of the country connecting the National and State capitals, major ports and rail junctions and link up with border roads and foreign highways.

NHAI was set up under an act of Parliament, “the National Highways Authority of India Act, 1998”. It became operational in February 1995 and is mandated to: (a) develop, maintain and manage National Highways entrusted to it; (b) collect fees on National Highways and; (c) facilitate private sector participation In order to expand and improve road connectivity in the country. The Government of India has launched National Highways Development Project (NHDP). It is the largest highways project ever undertaken in the country. The NHDP is being implemented by NHAI in various phases. (Figure 1.0)

“Figure 1.0 – National Highways Development Project”.



The **NHDP Phase-I** which is nearing completion was approved in December 2000 envisaged four laning of National Highways comprising Golden Quadrilateral (GQ) linking major metros, viz. Delhi, Mumbai, Chennai & Kolkata having an aggregate length of 5846 km; (b) North-South and East-West corridors covering 981 km; (c) port connectivity of 315 km of other national Highways. The total agreed length of National Highways for upgrading under Phase I was placed at 7498 km. The total length completed up to 31st March 2010 was 7328 km. The current status of national highways is given in table 1.0. It can be appreciated that bulk of National highway network(78.4%)is still made up one or two lane highway and only one percent is six lane and above, thus posing differential conditions for movement in a diversified socio-economic environment.

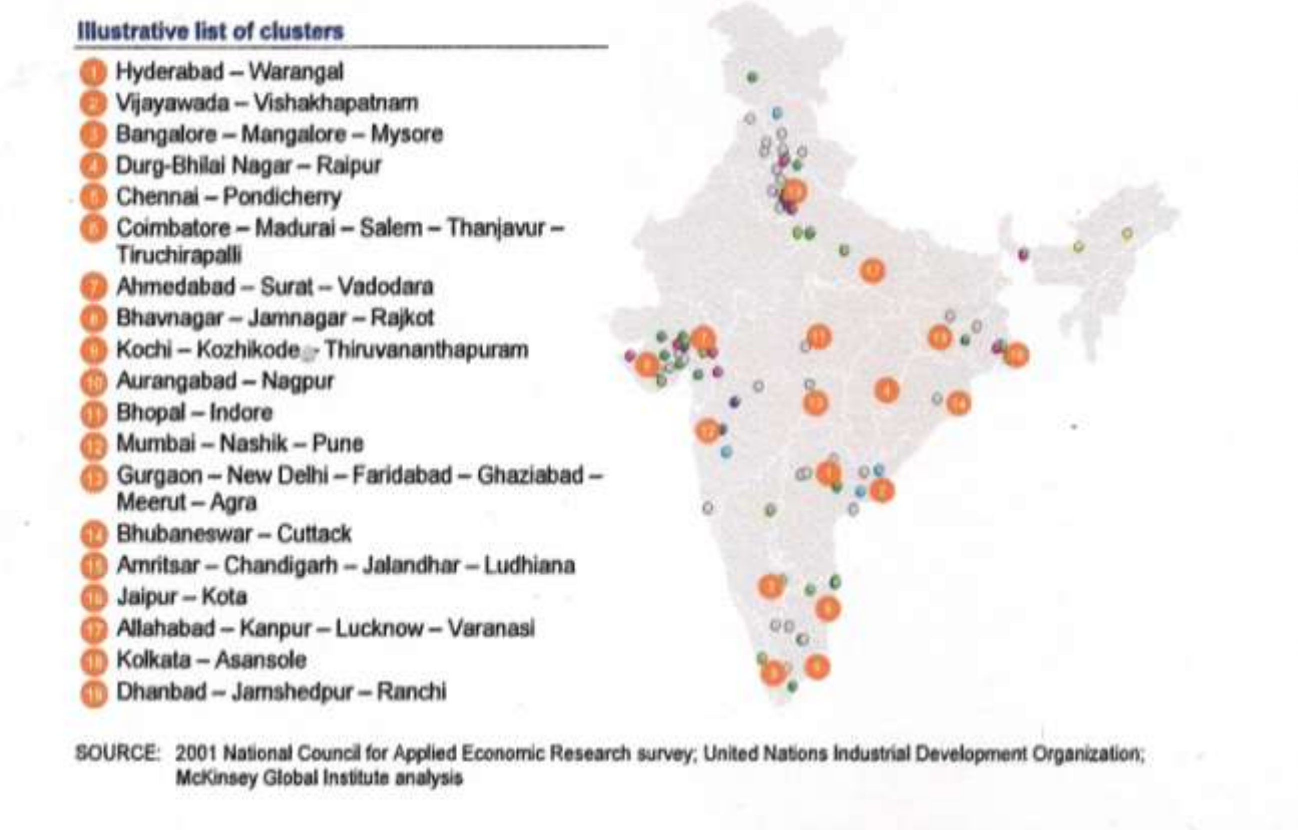
“Table 1.0 – Status of National Highways”.

Lane Status	Length in km
6 lane and above	731 (1%)
4 lane (2 lane dual carriageway)	14,584 (20.6%)
2 lane (7 meters)	37,488 (52.8%)
Single/Intermediate lane	18,131 (25.6%)
Total length of National Highways	70,934

The National Highways which account for only 2 percent of the network carry about 40% of the total traffic. Traffic along these roads is currently growing at about 10-12 percent per annum. In spite of the geometric improvements being undertaking in the programme outlined above there has been appreciable increase in the number of fatalities. The number of road accidents along national highways, increased from 129,994 in 2005 to 140,158 in 2006. The numbers of fatalities have increased from 35,439 to 42,670 during the period 2005 to2008. The total numbers of injuries have also risen from 145,582 to 149,693 during the same period. Whilst the traditional statistical analysis of the accidents are suggestive that large number of accident occur on account of overloading oversized cargo loadings, drunken driving and exceeding speed limits, there is also a reason to believe that highway deficiencies are also causal factors for road fatalities.

India is currently faced with high rates of GDP growth thus fuelling the rates of urbanisation. The country is expected to have 570 million people (55%) of its total population moving into urban areas. The Mickensy report on urbanisation suggests “India’s top-tier cities would be more productive if communication and transport links between them were stronger. We recommend facilitating the emergence of economic clusters of top-tier cities by providing rapid transport systems (such as eight to ten lane expressway) to connect them. We have identified 19 such clusters of two or more big cities together with their surrounding towns that account for 55 percent of the urban population and can seed the next wave of urbanization in India even beyond 2030.Such transportation corridors cost around $ 50 per capita to build, and offer a low–cost seeding mechanism for India‘s ongoing urbanization. If India were to adopt and implement these recommendations, India’s portfolio of cities would develop the shape illustrated in figure 2.0. If this is to be realised the concept linear corridor development will have to totally re-devised to evolve an integrated approach to land use –highway planning, currently not and totally absent in the planning of highways.

"Figure 2.0 - Building selected transportation corridors and creating clusters".



2.0. Highway Improvement Typologies-Traffic Segregation

Highway improvements under the NHDP programme are directed towards augmenting the capacity of highways and removal of geometric deficiencies. In this context there was no major effort undertaken to realign the existing highways, except where highways were to pass the large urban settlements by developing urban bypasses or elevate the highway on existing alignment to minimise land acquisition. The augmentation of highway capacities from two lanes to four lanes along existing alignments initially improved the level of service in the short run, but with the passage of time and due to rapid and uncontrolled developments of adjacent lands, could not maximise the advantages of capacity augmentation. As a result most of improved highways are now saddled with new problems of incident management, VRU movements and output of linear development. The impact of segregating traffic flows (urban and inter urban) along highways by design, i.e. construction of bypass, or change of grade of the main alignment, such as, Chennai bypass, and along NH-1 in Panipat have been examined with respect to accident occurrence, to appreciate their impact of containing fatalities.

Whilst there is abundant literature on the use of interventions related to technology, enforcement, emergency care, communication to save lives along high speeds, inter urban roads, in developed countries, there is little or no. evidence regarding their fatality containment capabilities, consequently, there is very little application and enthusiasm to incorporate the same in design guidelines for highway. In the end, the enabling frameworks required for containing the problems accruing from ribbon development become incidental in the context of developing countries, since communities thrive upon traffic volumes, which are potential customers, to earn their daily lives and where secondary road systems have not been adequately developed to provide alternate routes for meeting the travel needs of the society, the social –political forces often down play the need for high end interventions.

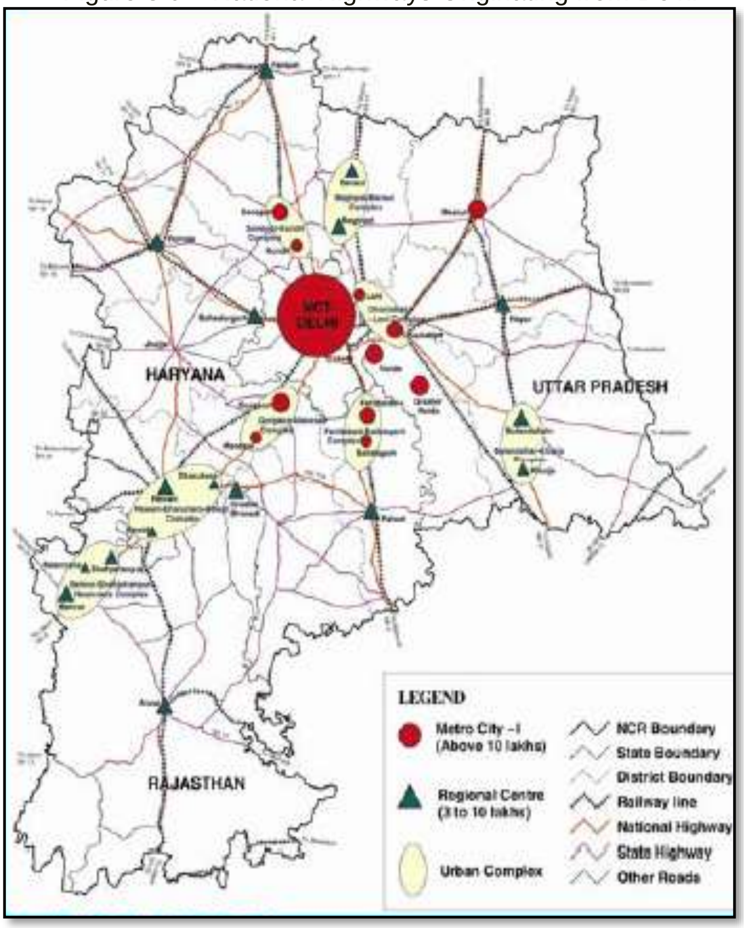
Dr. S. Birth (19) in a recent paper has advocated the use of human factors in the design of roads and Hans Vollpracht (18) on his active involvement in Vietnam, Egypt, Portugal, Romania and Togo has clearly established that inter urban and urban roads need to designed on separate considerations. Access control along improved road needs to be enforced along highways to reduce accident occurrence probabilities. With the help of three case studies, that uses different strategies it is demonstrated that linear development along highways do play significant part in declining safety levels along highways and if tackled with a multi pronged strategy the safety environment can be improved.

2.0 Case Studies

2.1. Linear Development along National Highways around Delhi

Like many other cities **Delhi**, the capital city of the country, is connected with its hinter land by five intercity Highways i.e. **NH-2, NH-8, NH-24, NH-10**, and **NH-1** with the major cities and capitals of the adjoining states of the country. These highways form a part of NHDP-1

"Figure 3.0 – National Highways Originating from Delhi".



“Figure 4.0 – National Highways Originating from Delhi”.

All the above highways radiate from the heart of the capital city of Delhi in cardinal directions. Prior to their improvements these radials were instrumental in providing linear growth as the adjoining states of Punjab, Haryana, and Uttar Pradesh developed new townships along the highways and used these highways as intra urban roads to provide accessibility to the resident population.

“Figure 5.0 – National Highways Originating from Delhi”.

With the passage of time large towns and village which were located along the highways have also grown significantly thus resulting in linear development. Extending along the length, currently, nearly 200 kms of improved roads around Delhi are characterised by development. Table-2.0: exhibits that 5.0 to 6.0 million people were residing in towns located along the highway in 2001.The number would have doubled since then. Apart from this a large number of rural settlements are also located along these alignments.

"Table 2.0 – Population along Improved Radial Highways around Delhi with linear development".

	NH-2 (kms)	**NH-8** (kms)	**NH-10** (kms)	**NH-24** (kms)	**NH-1** (kms)
Nearest Town	**Faridabad** (29)	**Gurgaon** (30)	**Bahadurgarh** (32)	**Ghaziabad** (19)	**Kundli** (31)
Adjacent Towns	**Ballabgarh** (30)	**Manesar** (39)		**Noida** (14.7)	**Rai** ()
	Palwal (60)	**Behror** (128)	**Rohtak** (71)	**Pilakhuwa** (42.6)	**Sonepat** (60)
	Hodal (88)	**Kotputli** (152)	**Hissar** (164)	**Hapur** (60)	**Karnal** (124)
	Kosi (104)	**Maharajpur**		**Babugarh** (113)	**Panipat** (129)
	Vrindaban (135)	**Shahpur** (273)		**Garmukhteshwar** (130)	**Kurukshetra** (167)
Last Major City Within 150-200 Km	**Mathura** (145)			**Moradabad** (158)	**Ambala** (192)
Total Population	**23,79,690**	**2,90,497**	**6,81,918**	**22,33,572**	**12,94,537**

Figures in bracket are distances from Delhi.

A sample analysis of 126 kms if NH-2 four laned stretch from Badarpur to Mathura on NH-2 revealed that the highways passes through Faridabad, Palwal, Hodal, Kosi and many large villages resulting in the creation of 52 junctions and several road side facilities, such as, fuel stations, vehicle repair shops, dhabas, motels and strip shopping in rural settlements with no enabling infrastructure and secondary road to support the linear development. On overage an intersection occurs at 1.5 kms and a presence of a rural habitat.

"Figure 6.0 – Rural Development along National Highways".

Similarly, a presence of a major urban settlement is observed at a distance of 20-25 kms and a village occurs at an average distance of 3.5 kms. It could thus be observed that the linear development virtually covers the entire stretch of the highway and all the developments draw a direct access from the inter city highway. However, this development is only 500 metres deep followed by agricultural uses.

The land use along the project road falls under four categories, viz. Industrial, Agricultural, Mixed and Residential. The stretch of the project road from Badarpur Border to Ballabgarh town is predominantly under industrial use. Similarly the section of the project road near Palwal, Hodal and Mathura are also under industrial use. The major industries include Glassware, Ceramics, Automobiles, Air conditioning and Refrigeration, Container Bays, Sugar Plant, textiles, Rubber and Rubber products, Heavy Engineering etc. the stretch of the project road passing through small towns and villages have both residential and commercial resulting in mixed land use. The balance length fall under agriculture and open land. The breakup of land use along the project road is presented below:

“Table 3.0 – Land use characteristics along highways”.

Land use	Length (km)	% age
Industrial	24	20
Mixed	13	11
Agriculture	81	67
Residential	3	2
Total	**121**	**100**

The appreciation of the linear development and its impact on level of service revealed that more than one incident per km on the highway: this is not only adversely affects the performance, it also enhances the accident occurrence possibilities.

3.0. Safety Interventions

3.1. Change of Grade along NH-1, Panipat Elevated Corridor

The change of grade along NH-1 near linear settlements has reflected an appreciable drop in fatal accidents .However the minor and major accidents the rate remains unchanged. Further, causal analysis and review of site situation indicates that the minor and major accidents have occurred due to the non provision of VRU related facilities along the grade separated stretch of the highway.

“Figure 7.0 – Panipat Bypass”.

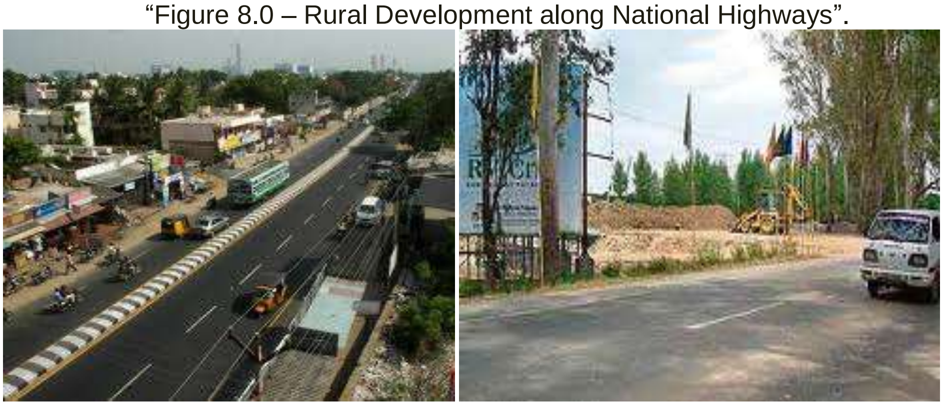
“Table 4.0 –Thirty month average of accidents along Panipat Elevated Corridor along NH-1”.

Accident Trends	Minor	Major	Fatal	Total
Before(2006-08)	37	8	30	75
After(2008-10)	37	8	4	45
% Change	00	00	-89	-35

3.2. Change of alignment - Chennai Bypass

The Chennai bypass connects NH-45 near Tambaram and NH-4 near Maduravoyal .The total length of the road is about 19km and is aligned outside the corporation limits. Chennai bypass was developed to provide an access control link between the two highways,NH-45 and NH-4 and is proposed to be extended to the link it with NH-5.This is anticipated to segregate the local and regional traffic. Recent traffic analysis has clearly established that traffic on Chennai bypass has reduced the burden on inner ring road in Chennai. The traffic diversion on Chennai bypass has largely been on account of the better level of service offered to heavy commercial and fast passenger vehicles of intercity nature.

“Figure 8.0 – Rural Development along National Highways”.



Accident data for past 9 months was collected analysed and compared with NH-4 and NH-7. Data consisted of location, time, vehicles involved type of injury and other site observations. A total of 118 accidents were recorded on the bypass among which 24 were fatal in which 31 persons lost their lives from April 2003 to Jan 2004. Comparison of the accident rate/km/year and fatal accident rate/km/year of Chennai bypass with NH-4 and NH-7 shows that rates are much lower than that of stretches of NH-4 & NH-7.

“Table 5.0–Comparison of the accident rate/km/year and fatal accident rate/km/year of Chennai bypass”.

	Total (acc/km/year)			**Fatal (acc/km/year)**		
	1999	**2001**	**2002**	**1999**	**2001**	**2002**
CBP	N.A.	N.A.	7.4	N.A.	N.A.	1.5
NH-4	30.82	45.23	N.A.	5.38	6.67	N.A.
NH-7	N.A.	16.71	33.54	N.A.	3.6	7.24

The higher safety levels appear to have been achieved due to the higher operational performance of Chennai Bypass. The accident data was analysed in respect of time. The accidents during dusk (table 6.0) came out to be the highest i.e. 8.50 accidents/hour which is more than double the rate of that of dawn, day and night time accidents. A further analysis of the data reveals that the rate of accidents per 1000 vehicles at night (table 9.0) is just double than of the day indicating the need of proper street lighting along the bypass. The above observations are reinforced by the analysis of accidents during day and night.

“Table 6.0 – Periodic variation of accidents on CBP

Duration		**No. of accidents**	**No. of hours**
Dawn	4:30 to 6:30	12	1
Day	6:30 to 17:30	51	11
Dusk	17:30 to 19:30	15	2
Night	19:30 to 4:30	40	9

Table 7.0: Accident Rate per 1000 vehicles during day and night

Time	**Number of accidents**	**Accidents/1000 vehicles**
6:00 – 19:00	63	8.7
19:00 – 6:00	55	17.3
Total	**118**	

SAFETY ISSUES AND REMEDIAL MEASURES

The safety audit of Chennai bypass (Table 8.0) reflected that the developed facility needs multipronged efforts for improving the design to service the wide and varying requirements of traffic and vulnerable road users.

Table 8.0: Safety Issues and Remedial Measures

S.No	Key Issues	Short Term	Long Term
A	**General**		
a)	Heterogeneity of traffic	Provision of service roads as indicated in strip plan	Conversion of two lane highway into 4 lane divided highway
b)	Differential operating speeds of HCV and LMV	Provision of differential speed signage for HCVs & LMVs	Categorize fast and slow lanes
c)	Problem of parking /stopping on shoulders /carriageway	Ban parking /stopping along CBP. Install signage as indicated in strip plan	Widen embankment to provide adequate clear zone to accommodate broken down vehicles.
d)	Cross sectional inadequacies restricting errant vehicles to regain control, lead to collision with street furniture	Lower down speeds from 80kmph to differential speed of 50kmph and 70kmph for HCV and LMV respectively	
e)	Road environment during nights deteriorates for want of illumination	Provide illumination as per IRC standards	
f)	Inadequacy of signage lower the safety levels on the high speed highways	Provide mandatory, warning and informatory signage as suggested in the strip plans and table	Regular maintenance
B	**Road Geometrics**		
a)	Right Turning Traffic not only creating conflicts but also increases the travel length	Modify interchange features as suggested in the drawings	Provide for uninterrupted turning movement flow by organizing and providing additional slip roads
b)	Width deficiencies in merging lanes from dual carriageway to undivided carriageway causing safety hazards	-Trim central median at 0/800 and widen left side carriageway to two lane width and align taper to merge into undivided carriageway. -Provide warning signs at both ends of merging	
c)	Deficiency of geometric design and operational installations at intersection of CBP with nh-4 at Maduravoyl	Redesign the geometric features and install automatic signals with pedestrian phase	Develop interchange before extending CBP to NH-5
C	**Other Issues**		
a)	Land use interaction induces about 20% of 2 wheelers and 3 wheeler traffic on CBP beside pedestrian movement causing accidents and reduction of levels of service	Develop an integrated service road system with the existing roads and underpasses	Provide additional underpasses simultaneously with the construction of four laning.
b)	Illegal crash barrier cuttings shows inadequacy of pedestrian and slow moving vehicular access routes between the communities staying by its side	Provide pedestrian underpasses Provide service roads to quarry mining and other industrial areas and connect it to the existing road network as suggested in strip plans	
c)	Total absence of road user facilities such as filling station, restaurants ,std booths etc cause the vehicles to stay on the limited road space causing safety hazards	Provide truck lay by with facilities ,in each direction, where the road formation height is less	Provide two wayside amenities and facility station as suggested in the strip plan one in each direction

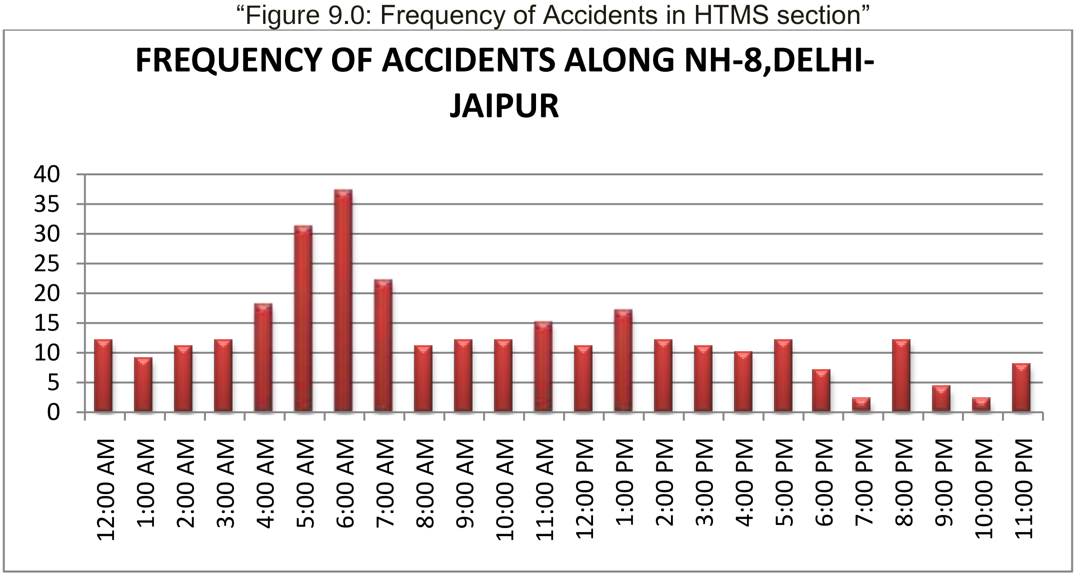
3.3. ITS interventions NH-8 (Delhi-Jaipur Highways)

Recognising the high rate of incidences along improved highways, the NHAI decided to introduce the use of HTMS system to examine the effectiveness of its technologies in improving safety levels. The HTMS services include an emergency telephone system, variable message sign system, CCTV, TC classification system, meteorological system, mobile radio system, a traffic control centre and a power centre for twenty hour power centre operations. The effectiveness of the experimental system was evaluated in respect of safety analysis. The accident data clearly reflected the figure 9.0.

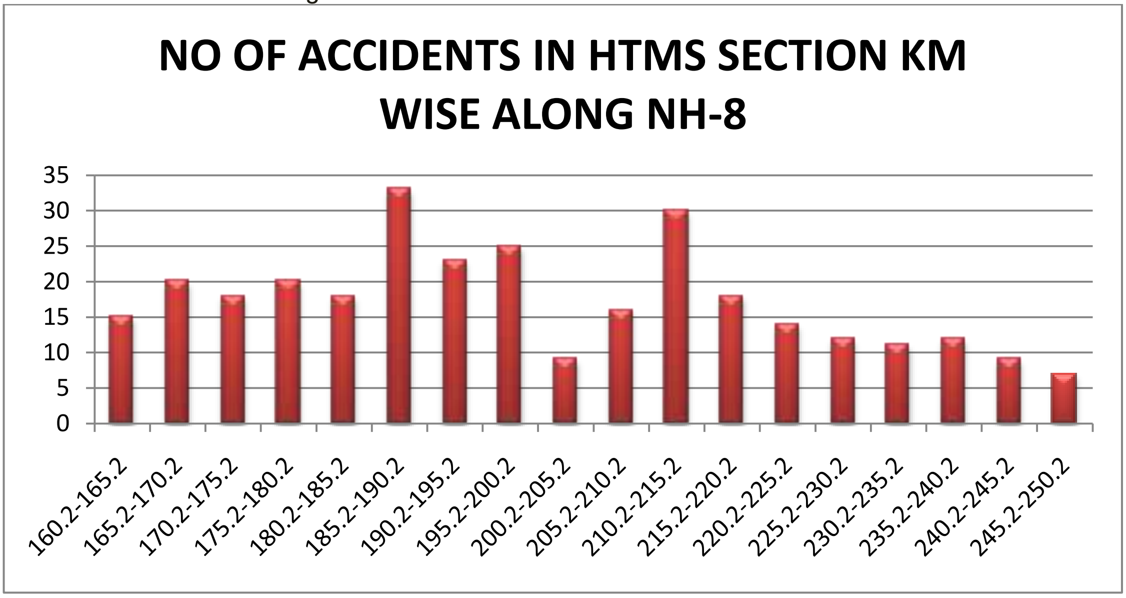
From the statistics of the location of the accidents, it is clear that frequency of accidents is more in the built up stretches rather than in the rural ones. Hence traffic management measures are must in the urban stretches and installation of the surveillance HTMS equipments like CCTV cameras are must in that stretch.further more the following inferences are drawn

- By the help of emergency call boxes, faster communication of the data was possible and thus by reaching of timely help, there is 23.25% reduction of fatality in 1st year & 25.58% in 2nd year when compared with the figures before and after the installation of the HTMS.
- There is 19.84% reduction of serious injury in 1st year & 57.69% in the 2nd year.The numbers of accidents in this stretch have reduced from 554 to 468 in 2001-02 and 428 in 2002-03 for the corresponding period. Some of the possible reasons are advance information to road users on road conditions, diversions, CCTV monitoring etc.
- With advance information and timely action in incident clearing, the numbers of major traffic jams have reduced from 276 in 2000-01 to 88 in 2001-02 in the above period.
- 70%of the accidents from Nov.01 to Sept 02 in this stretch were reported through the control room indicating high level of usage by the road users.

"Figure 9.0: Frequency of Accidents in HTMS section"



"Figure 10.0: Distribution of accidents in HTMS section"



4.0 Conclusion

The introduction of various experimental measures discussed indicates that geometric measures coupled with technology can bring about a significant improvement in the safety standards. However, it must be noted that whilst both the measures i.e., bypasses and change of grade have resulted in reducing fatal accidents, these measures need to be supported by:

a). Development of bypasses needs to be supported by an integrated land use –highway planning approach which clearly outlines the need for enabling facilities to keep the traffic movement areas free from VRU's encroachments incidents and way side facilities to prevent the re-occurrence of linear development.

b).the design efforts to change the grade if highways in linear settlements stretch need to tackle with a more sensitive approach to meet the needs of VRU users. The experience accrued from the above, is indicative that if India is to meet its urbanising needs in the next two decades it has to consider the options of creating an exclusive framework of expressway with adequate provisions of access control, along the identified corridors.

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