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Design and Development of Urban roads in Developing Countries

Jitendra Wadhwani
Intercontinental Consultant and Technocrats Pvt Ltd., Delhi, India

1. ABSTRACT

Roads are one of the most important components for socio-economic development of any part of the world. Construction of New roads and improvement of the existing road is the key to expand development of small town and bring them to their full potential. Development of major towns and capitals was emphasised which indirectly creates chaos, encouraged human migration, scarcity of basic utilities. Lack of focus and low investments has suppressed small towns and failed in bringing out the full potential of available infrastructure assets and human resources. In this paper, development of small towns in Indian subcontinent and associated challenges are highlighted.

In recent years, India-a developing country has realized need of small-town development and initiated “Smart City Mission” to bring the additional investment in urban areas in different states of the country. Road development and mobility are the key component of this mission.

The main challenge with road design in small town are unorganized existing infrastructure, competency of technical staff with municipal corporation, construction quality of local contractors, lack of standards, specifications and guidelines, trust deficit of public in government works, Policies, SOPs, Law, order and enforcement issues etc. To overcome above challenges, it is important to bring the sound policies, deal with competency issues of engineers and win the trust of public or end users.

For a good road development, a good and flawless design is utmost important. Improvement of existing roads and utilities such as storm, sewer and electric lines play important role in road design and needs to be considered as an integral system instead of designing these components separately.

This paper provides the brief of the planning and design elements of urban roads development in small towns, issues & challenges faced by stakeholders and way forward. It has been observed that existing infrastructure of small town is unorganized, unplanned and mismanaged. To overcome these issues and bringing new development, keeping the town operational, detailed planning and good design is required before start of any ground activities. Paper brings the steps to review existing infrastructure, investigations required, stakeholder engagement, design parameters and components, quantity measurements and technical input to tender documents.

Keywords: Urban Road design, transport planning, drainage infrastructure, smart cities, transaction advisory

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2. HISTORY OF ROADS DEVELOPMENT IN INDIA

2.1 Initiatives before Independence (Before August, 1947)

The first evidence of road development in the Indian subcontinent can be traced back to approximately 2800 BC in the Indus Valley Civilization. Monarchs of ancient and medieval India, ruling emperors of Mauryan Empire, Sur Empire, Mughal Empire continued to construct roads to connect the cities.

In the 1830s, the British East India Company started programme of metalled road construction. Public Works Department and the Indian Institute of Technology Roorkee were founded, to train and employ professionals. In December 1934, the Indian Road Congress (IRC) was formed which was key towards first systematic development of roads. Nagpur Plan was brought to set the vision of road planning and construction across India. Road development was categorised into four parts

- National Highways, traversing provinces or states and be of national importance for strategic, administrative purposes etc.
- Provincial and State Highways which are other main roads of a Province or State
- District Roads, to distribute traffic from the main roads to the interior of the districts which are further classified as Major District Roads (MDR) and Other District Roads (ODR).
- Village Roads to link the villages to the road system

2.2 Initiatives by Independent India (Post August, 1947)

After independence, the Central Government had taken over the complete financial responsibility for the development and maintenance of the National Highways. In 1959, a twenty years plan (1961-81) was drafted in the meeting of Chief Engineers known as Bombay Plan or Chief Engineer’s plan. Targets of every category of roads were set based on some rational formula, which was 10,57,000 km. in total involving Rs.5.2bn (700Mn USD).

Third plan, Lucknow Road Plan was approved in the year 1984. This twenty-year plan aims at increasing the total road length 1.5 million kms in 1981 to 2.7 million Km in 2001.

National Highways Authority of India (NHAI) was established 15 June 1989 by an Act of Parliament. The Act empowered NHAI to develop, maintain and manage India's road network through National Highways. Since 1995, NHAI has increasingly privatized road network development in India.

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Pradhan Mantri Gram Sadak Yojana (PMGSY) begun from in December, 2000. The target for this project to connectivity for villages with population more than 500 by the year 2010.

In year 2015, Ministry of Road Transport started Bharatmala Pariyojana. Bharatmala is a centrally-sponsored and funded road and highways project of the Government of India, Bharatmala Pariyojana is a new umbrella program for the highways sector that focuses on optimizing efficiency of freight and passenger movement across the country by bridging critical infrastructure gaps through effective interventions like development of Economic Corridors, Inter Corridors and Feeder Routes, National Corridor Efficiency Improvement, Border and International connectivity roads, Coastal and Port connectivity roads and Green-field expressways.

By looking at all such initiatives by Indian governments, it reveals that national highway and village road had been given more priority over urban roads and development of urban road left on States and Urban Local Bodies.

2.3 Statistics of Roads

India has one of the largest road networks in the world of over 5.4 million km as of Financial Year 2015. Over the years, there has been consistent improvement in accessibility and mobility through the construction of new roads and the up-gradation of the existing roads. Road length has been growing by **CAGR** 4.18% and at the same period, the registered motor vehicles grew at a CAGR of 9.9%.

National Highways	**103,933**
State Highways	161,487
OPWD	1,101,178
Rural Roads	**3,337,255**
Urban Roads	467,106
Project Roads	301,505

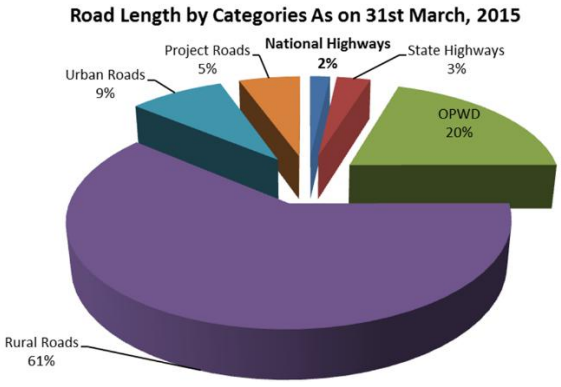

Figure1: Road Length by Road Categories as on 31st Dec, 2015 (in Kms)

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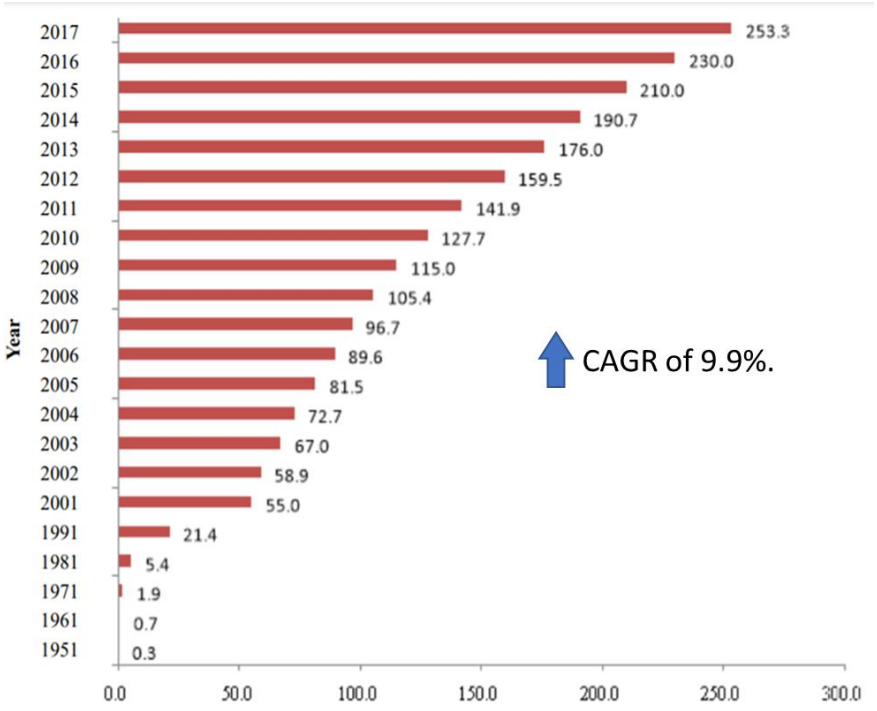

Figure 2: Total Number of Registered Motor Vehicles (in million) 1951 – 2017 (Road Transport Year Book, MoRTH, India)

Statistics of the road development in India also reveals that urban roads have 9% of share in comparison with 20% and 61% of the district roads and village road respectively. Whereas in developed country like USA, urban road share is 30%. There is more traffic growth in Urban areas in comparison with rural areas but still road development growth is way less which increase gap in demand/supply and leads to deterioration of quality of life.

3. Urban India and Roads

The total urban population living in India's towns and cities has increased consistently over the last century. About two thirds of India's economic output is located in its cities and the trend will continue as 70 per cent of net new jobs upto 2030 are also expected to be generated in these cities. The rate of urbanization increased from 17.6 per cent in 1961 to 31 per cent in 2011. India had 450m urban population in 2020 and estimates suggest that the urban population could grow to 600 million people by 2030.

Today, India has about 8,000 individual towns/cities. This growing development of urban sector needs better infrastructure which is lacking in Country and posing significant hurdle to the growth of nation's infrastructure. The fast-growing population, exceptional rate of motorization coupled with the ever-growing urbanization has made people vulnerable to frequent road accidents resulting in fatalities, injuries/disabilities. Recorded annual death toll in road accidents in India is over 140K and out of this approximately 50k fatality is from Urban areas

only. Most of the road accident takes place due to over speeding and other violations which can be overcome by safe and forgiving road designs.

Urban roads are key component of urban infrastructure. Urban roads are required for both intra-city and intercity movement and render much higher level of service compared to Regional Roads, State Highways and National Highways.

There are various challenges and issues being faced in development of urban road. Most of the small town developed gradually in unplanned manner along the river banks and around the railway, bus stations etc. Over the time due to significant increase in urban population; these areas have become densely populated and congested. Due to space limitations; right of way is not uniform and varies quite frequently which poses challenge on safe geometry design. In urban areas; Quality of life depends on efficient urban Road system with the support of other infrastructural services such as water supply, sewerage, drainage, electricity, telephones etc. Hence, focus on integrated road network with network of utilities services is required which is generally absent in planning of urban areas.

Most Indian cities are struggling to address the urban transportation problem mainly because they are not equipped with the appropriate institutional capacity and required financial resources. Functional responsibilities for urban transport are fragmented among central, state and local level governments with primary responsibility of implementation with states to get it implemented through local bodies. Urban Local Bodies (ULBs) in India have been empowered by the Constitution (74th Amendment) Act, 1992 to assume responsibilities for development of urban transport, but most of them do not have adequate power to raise financial resources. Their revenues mainly depend on property tax collection and inter-governmental transfer from the state.

The staff and management at these agencies are more comfortable with traditional solutions, government grants and loans. With limited fund and competencies, especially in small towns, the ULB management gives priority to water supply, sewerage, temporary road works and management of parking & bottlenecks of the road rather than integrated road development.

Lack of trust of local residents, market associations, religious institutions and NGO in government initiatives also a big hindrance in road development projects.

Although central and state government comes with number of schemes, time to time, for development of urban infrastructure to improve the quality of life and raise the local economy. However, those initiatives lacked an integral development approach and smooth flow of funds. Recently, Indian government announced the “Smart city mission” which

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gave confidence to ULBs, especially in small towns, to break away from traditional solutions to Smart solutions.

3.1 Smart City Mission

“Smart Cities Mission” was launched in India on 25 June, 2015 with an objective to promote cities that provide core infrastructure, clean and sustainable environment and give a decent quality of life to their citizens through the application of ‘smart solutions’. The Mission aims to drive economic growth and improve quality of life through comprehensive work on social, economic, physical and institutional pillars of the city. The focus is on sustainable and inclusive development by creation of replicable models which act as lighthouses to other aspiring cities. 100 cities have been selected to be developed as Smart Cities through a two-stage competition.

Following are the Smart city mission strategies to meet its development objective:

i) City improvement (Retrofitting)
ii) City renewal (Redevelopment)
iii) City extension (Greenfield development)
iv) Pan-city development

To overall check the proposals and its implementation, monitoring committees at National Level, State Level, City Level were constituted.

The Smart Cities Mission (SCM) is a centrally-sponsored scheme, where state governments and urban local bodies (ULBs) will have to contribute funds for implementation of projects specified in the Smart City Proposal, on a matching basis with the funds provided by the central government. The entire budget for the Mission over five years is estimated to be Rs 480 billion (6 billion euro). The Government of India allocated around Rs 2 lakh crore (25 billion euro) to develop 100 cities under the Smart Cities Mission.

Smart city mission now attracted many countries such as Spain, United States, Germany, Japan, France, Singapore, Sweden, Israel, the Netherlands, United Kingdom and Hong Kong. These countries are ready to help in terms of knowledge & technology share as well as funding.

The core infrastructure elements in a Smart City includes:

i. Water supply,
ii. Electricity supply,
iii. Sanitation, including solid waste management,
iv. Urban mobility and public transport,
v. Affordable housing, especially for the poor,

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vi. IT connectivity and digitalization,
vii. e-Governance and citizen participation,
viii. Sustainable environment,
ix. Health and education.

It has been seen that road development proposals accounts 40% of total allocated funds which clearly hints the requirement of the hour. In urban areas, all the utilities including water supply, storm, sanitary sewer, electric supply, communication lines and gas lines run along the major road and streets, hence it becomes important to consider this as a single entity while designing rather than designing these components separately.

4. Urban Road Design

Road infrastructure is one of the most important components of Urban mobility. A safe road design plays an important role in Road User's Safety (motorised and no-motorised both). Road development in urban areas require a wholistic approach with objective to break away from the short-term fixes applied to the perennially chaotic city roads and take a lifecycle cost approach to spend efficiently on the Road system, of course, with the support of other infrastructural services such as water supply, sewerage, drainage, electricity, telephones etc. for long term value for money and a highly increased quality of life for the users.

4.1 Major Issues and Challenges of road development in small towns

Road development project in urban areas brings bunch of issues & challenges and key challenges are listed below:

- Major Variations in ROW resulting to bottlenecks.
- Significant Movement of NMT vehicles along the entire corridor.
- Pedestrian Facilities are insufficient and poorly maintained.
- Haphazard on-street parking by private vehicles resulting in reduced carriageway width.
- Traffic congestion due to indiscriminate stopping / parking of Autos, E-Rickshaws and cycle rickshaws at junctions.
- Encroachment by commercial establishments is severe and will be difficult to control post development.
- Overhead powerlines
- Lack of data and mapping of underground utilities
- Poor Co-ordination between agencies
- No Implementation Plans

4.2 Urban Road Design Framework

Integral design approach is the key for successful execution of urban road projects; specially to make roads accessible to all road user for all season

and to enhance the local cultural appeal of the cities. The methodology to be adopted for development of urban roads & the crucial aspects of any urban road project are as illustrated in flowchart depicted in Figure 3. These crucial aspects are discussed subsequently.

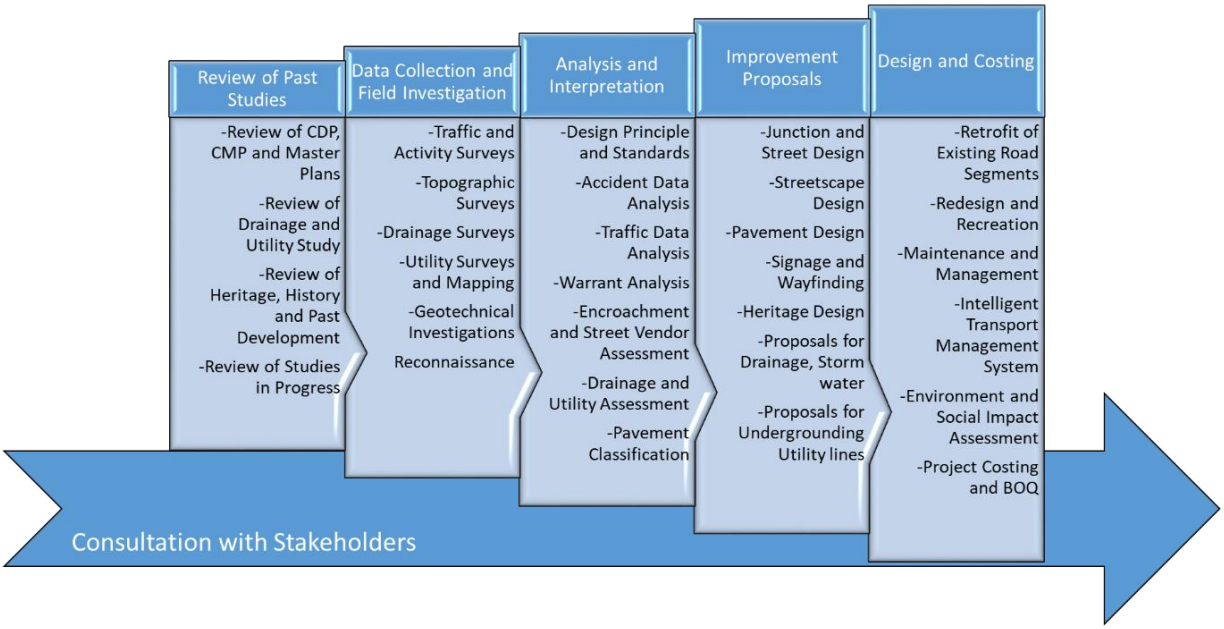

Figure 3: Wholistic approach & aspects of urban road design networks

4.3 Road Design Element and Various Disciplines

Road development is multi-disciplinary, a brief description of each discipline is presented below:

- **Traffic Engineering**

  Demand and supply gap, circulations of motorised and non-motorised road users, traffic and parking management issues, junction capacity and other constraints.

- **Geometry Design (Straight, curve sections and junctions)**

  The alignment of any road comprises of various elements that together will create a safe and smooth facility for the intended function. These include the factors such as design speed, minimum and maximum limits of various parameters, sigh distances, gradients, entry/exits at junctions, checks on bottlenecks, space for of pedestrians and NMTs.

  A typical cross section comprises of space for pedestrians, non-motorised, motorised traffic and transit services. Following are the common design parameters compiled from various guidelines and may be picked for design of the urban distributor/ collector roads:

Table 1: Urban Road design parameters (Code of practice, Institute of Urban Transport India)

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<table>
<tr><th>Criteria</th><th>Motorised Carriageway</th><th>NMV Lane</th><th>Walkways</th></tr>
<tr><td>Design Speed</td><td>>30 km/h & < 50 km/h</td><td></td><td></td></tr>
<tr><td>ROW</td><td>12m – 30m</td><td></td><td></td></tr>
<tr><td>Horizontal curve</td><td>10m or more</td><td></td><td></td></tr>
<tr><td>Gradient</td><td>1.75 to 2%</td><td>1:12 – 1:20</td><td>1:20</td></tr>
<tr><td>Number of lanes and Location</td><td>Maximum 4 lanes of 3.0m width each
Or
2 lanes of 3.0 to 3.3m width with or without an intermittent median</td><td>On the edge of the carriageway, adjacent to the footpath or parking. 1.5 to 2.5m</td><td>1.5 to 3.0m (including curbs) each Effective capacity as per LOS C:<table><tr><th>persons per/min counted over 15 min</th><th>Effective width of footpath(m)</th></tr><tr><td>23-50</td><td>1.5</td></tr><tr><td>58-83</td><td>2.5</td></tr><tr><td>81-116</td><td>3.5</td></tr><tr><td>115-165</td><td>5.0</td></tr></table></td></tr>
<tr><td>Minimum Width for</td><td>2 lanes of 3.0 to 3.5m</td><td>1.5m</td><td>1.5m</td></tr>
<tr><td>Minimum Width for bus lane</td><td>Mixed traffic</td><td>-</td><td>-</td></tr>
</table>

- **Geotech-** Geotechnical studies are one of the key design parameters, it depends upon the geographical and geologic condition of project area. Bearing capacity of soil, slope protection works and foundations type are the crucial elements derived from Geotechnical studies. Most of the countries have their geological maps and design manual which helps in develop improvement proposals. Site-specific geotechnical investigations are generally performed as well.
- **Pavement Design-** Pavement design of any project depends upon the loading pattern and soil conditions. Pavement design decides the overlays, reconstruction for motorised and non-motorised paving along with cost/benefit analysis.
- **Hydrology-** Adequate drainage is a primary requirement for maintaining the structural soundness and functional efficiency of a road. Pavement structure including subgrade must be protected from any ingress of water; Urban drainage classified as surface and subsurface drainage, cross drainage and longitudinal drainage.

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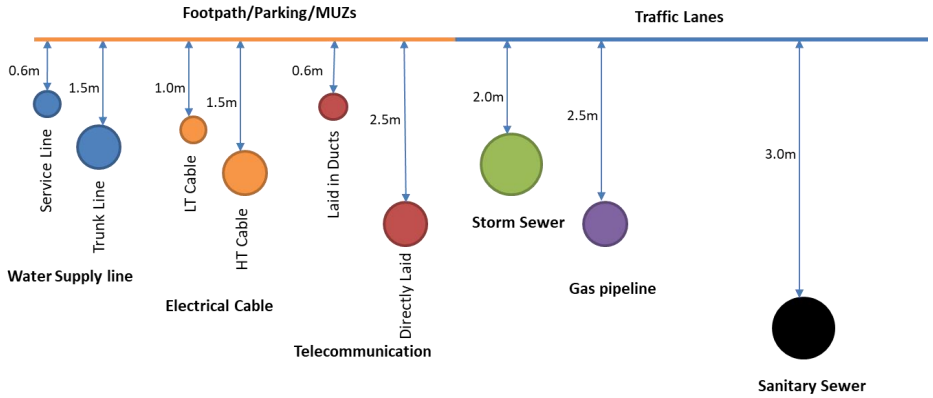
- **Underground Utilities-**Water supply, sanitary and storm sewers, electricity, communication cables and gas lines. Vertical & horizontal separation between utilities to be examined critically while design the urban roads networks. Broad recommendations about depth of laying (denoting the bottom of trench) of services is provided in Table-2 below.

Table-2: Generic recommendations about depth of laying of various utilities

S.No.	Type of utility	Depth (in meters)
1	Trunk Sewer Line	2 to 6m
2	Water Supply line	1 – 1.5
	i)Service Line	0.6 - 1
	ii)Trunk Line	1 – 1.5
3	Electric Cable	1 – 1.5
	i)LT Cable	0.6 - 1
	ii)HT Cable	1.5 - 2
4	Telecommunication cable	2-3
	i)Directly laid	0.6 - 1
	ii)Laid in ducts	2-3
5	Gas Mains and lines carrying combustible materials	2-3



- **Junction Design-** Junctions are designed so that all users understand that they must share space with and be aware of others. While designing the junction following points have to be considered:

  - Accommodate the needs and accessibility of all modes of transport.
  - Ensured the hierarchy with vulnerable users (pedestrians) first and motorised traffic last
  - Provide good visibility, particularly between pedestrians and motorists. Trees, signs and other street furniture should not obstruct visibility.
  - Avoid extreme angles and complex junctions.

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- Minimise pedestrian exposure to moving vehicles by reducing crossing distance.

➢ **Architectural Features**

Plantation along the road-Tree belt, if provided, should have a minimum clear width of 0.7m and a desirable width of 1.5m or more on. In general, green areas are intended to strengthen the Greens and verges.

Hawker Spaces- All Indian cities experience street vendors operating on major roads and they are found occupying the footpath or the left most lane of the carriageway, which affects those who use this facility. In such cases, the pedestrians or cyclists are pushed toward the median creating conflict between the fast-moving traffic and other road users. Integrating the road infrastructure with designed hawker spaces reflects a safer and ordered design.

Street Furniture- Furniture in the external environment consists of a diversity of elements such as light standards, seats, picnic tables, bins, information panels, traffic signs, parking meters and post boxes etc, often placed independently over time and without co-ordination. Good placing and coordination of furniture will result in a tidy, legible pathway or street that is easy to move along. It is important to design furniture to retain local culture and heritage values of cities.

Lighting- Lighting is required for visibility of a roadway and it adds to the safety of all features of a road design. Required illumination levels for different types of roads are provided in Table-3 below.

Table-3: Recommended illumination levels for urban roads (BIS, 1981)

Particulars	**Illumination Level**
Important traffic routes carrying fast traffic	30 lux
Main roads carrying mixed traffic like city main roads/streets, arterial roads, throughways	15 lux
Secondary roads with considerable traffic like local traffic routes, shopping streets	8 lux
Secondary roads with light traffic	4 lux

➢ **Social and Environment assessment-** Social and environmental impact assessments are an important part of project design while initiating and implementing developmental interventions Any change in the living environment, how-so-ever miniscule it might seem, brings about considerable change in the way of life of the affected population. A detailed social impact assessment (SIA)

needs to carried out to make project design responsive to social development concerns. The EIA or environmental impact assessment to be undertaken to create the benchmarks for air, water, soil and noise quality for project monitoring and to assess the adverse impacts, if any, of the project on the local environment.

- **Estimation**- Cost estimation of various options to ease the decision-making process.

5. Implementation Plan

A sound and strong implementation plan is required to finish any development project in complex urban environment, especially in small towns. Four-point implementation plan has been summarised hereunder.

5.1 Regulatory Framework

Regulatory ground work which involves administrators, engineers, discipline expert and local representatives need to be done on continuously throughout the life span of the project i.e. during design, development and execution of projects. Following key tasks needs to carried out conception to execution of the project,

- Meeting with Stakeholders (Market Associations, NGOs, and various Govt Authorities etc)
- Creation of Encroachment removal Committee involving the members of Market Associations, NGOs, RWAs and various Govt Authorities
- Formulation and Implementation of Policy which mainly includes awareness, enforcement, maintenance and safety of VRUs
- Licensing with various Govt Officials

Aim of this exercise to take all the concerned stakeholders in confidence and to bring them in the larger plan at an early stage. This will also help in identify the potential risk or challenges in execution and same can be mitigate at an early stage. This exercise will be carried out along with design/tendering/award of the project.

5.2 Tendering, contracts and defect liability

Key points to be taken care during tendering works are listed as below:

- Consolidated tenders of all the services along the roads rather than having individual tenders
- No overlapping of tasks
- Eligibility rules to be framed to attract more contractors at national level rather than focussing on local contractors
- Joint venture bids to be allowed considering the multi discipline project
- Balanced change of scope conditions with optimum defect liability period

5.3 Construction Management and Planning

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Tips for efficient construction management & planning are as follows:

- Pre construction activities -Material placement, testing labs, dumping yards, accommodations, approvals
- Awareness among the local people
- Compensation to affected people
- Traffic management plans and its implementations
- Frequent Stakeholders engagements
- Proper Benchmarking permanent as well as temporary (Coordinates and levels)

5.4 Special Enforcement Zone

Special enforcement zones which may be considered during urban road frameworks:

- Traffic Enforcement - to ensure the safety of non-motorised vehicles and pedestrians. Action on traffic violators, no entry for heavy vehicles between 8AM to 10PM.
- Encroachment free area- to ensure the clear space for road users and maintain the aesthetics of Right of Way
- Organised Parking- Parking, pickup, drop-offs in designated area only
- No-Honking Zone- No vehicular horn allowed except emergency vehicles
- The maintenance of the archaeological cultural heritage refers to the landscape maintenance of a stationary relic or other archaeological entity and its surroundings
- Security Marshals to be hired on contract basis and shall be trained by traffic police, there must be mechanism for them to liaison with local police and municipal corporation for quick check and report of any traffic violation and encroachment. These marshals must be equipped with head camera, safety jacket, uniform, speed radar and beacon etc.

6. Case Studies

Two Case studies on urban road projects which are examples of good execution are being discussed, in brief

6.1 Tender S.U.R.E. (Specifications for Urban Roads Execution), Bengaluru, India

Tender S.U.R.E is the kind of project implemented in Bengaluru in the state of Karnataka, India to fix urban roads in terms of underground utilities as well as at grade mobility for all modes of transport whilst promoting non-motorized transport (NMT), creating safe intersections, improving last mile connectivity to public transit and educational institutions. The detailed project report and contracts are being referred by most the PMC and SPVs to develop smart roads in their respective areas.

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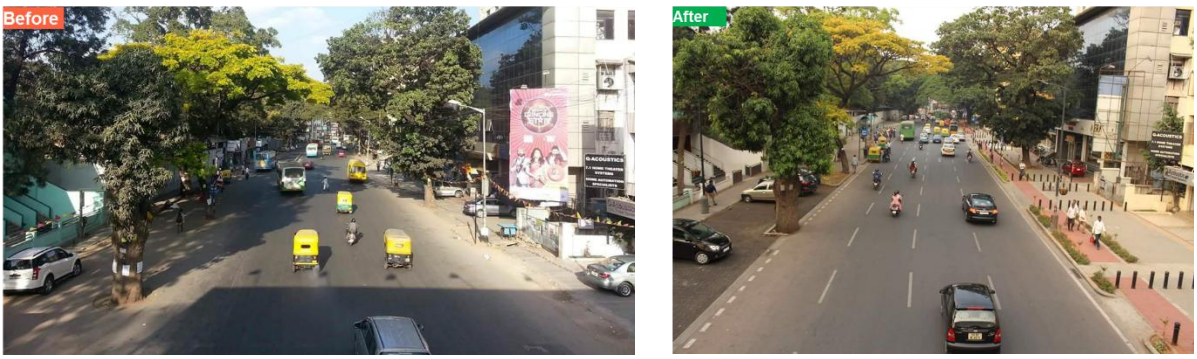

Residency Road – Bengaluru, Karnataka, India

6.2 Smart Pedestrian Street, Pune, India

Pune is currently a leading example in India in the field of sustainable transportation, especially the creation of streets as vibrant public spaces. From adopting the progressive policies such as the Pedestrian Policy and Parking Policy, and implementing high quality pilots - like the JM Road under Pune Streets Program, DP Road under Smart City Complete Streets Project - which prioritise walking and cycling; to creating city-wide plans for cycling, and setting up an Urban Design Cell to build the institutional capacity, Pune is transforming from a car-centric city to a people-friendly urban setup. To further ensure the sustainability of the projects, the city is focusing on community participation and public private collaboration.

DP Road – Pune, Maharashtra, India

7. Conclusions and Way Forward

Road development in urban area requires a wholistic approach with objective to break away from the short-term fixes applied to the perennially chaotic city roads and take a lifecycle cost approach to spend efficiently on the road system.

Also, an attempt has been made to summarise various design components (adopted from existing guidelines) of urban road to bring it at one place in concise form. Following approach needs to be adopted as way forward for successful urban transport projects:

- In urban areas, all the utilities including water supply, storm, sanitary sewer, electric supply, communication lines and gas lines run along the major road and streets, hence it becomes important to consider this as a single entity while designing rather than designing these components separately.
- It is required to develop an urban road manual (Revision of PWD Manual, IUT Codes and Street design guidelines) which expedite the design processes by including quick design parameters, survey methods, calculation sheets and technical specifications to cater urban road design and implementation need for small town. Manual should also cater the social/environmental assessments and mitigation measures.
- Contracts to be designed to perform quality work in time bound manners giving equal preference to bidders at national level.
- Maintenance works to be prioritised to make project sustainable for long term.
- Pocket books for construction management, traffic management and awareness for quick implementation should be prepared.
- Revision of SORs Schedule of rates documents) and Manual on normative cost to expedite the estimation process.
- Guidelines for various approval processes and accountability of department needs to be fixed
- A smooth funding mechanism to transfer funds direct to urban local bodies on performance basis should be ensured.

Bibliography

Taylor (1995). A Star Shall Fall. Collins. ISBN 978-81-7223-066-1.

St. John, Ian (2011). The Making of the Raj: India under the East India Company. ABC-CLIO. pp. 83–84. ISBN 9780313097362. Retrieved 5 May 2021.

Gupta, Das (2011). Science and Modern India: An Institutional History, c.1784-1947: Project of History of Science, Philosophy and Culture in Indian Civilization, Volume XV, Part 4. Pearson Education India. pp. 454–456. ISBN 9788131753750.

Jagarlamudi, Vishnu. "History of Road Development in India". Retrieved 5 May 2021 – via Scribd.

"Ministry proposes construction of 20,000 km of roads under Bharat Mala project", The Economic Times, New Delhi, 9 January 2016

"Bharatmala Pariyojana - A Stepping Stone towards New India | National Portal of India". www.india.gov.in. Retrieved 9 May 2021.

Chattaraj, Rajib (2010) "History of road development in India" Retrieved 3 June 2021 – via https://www.academia.edu*.*

Basic Road Statistics of India 2014 (Report). Ministry of Road Transport & Highways. 23 May 2014. Retrieved 9 May 2021.

https://www.fhwa.dot.gov/policyinformation/statistics/abstracts/2015/

Urban Roads Manual, (Second Edition) Published by Public Works Department Government of Delhi, December 2014.

Indian Institute for Human Settlements (2015) Urban transport in India challenges and recommendations IIHS RF paper on urban transport. http://iihs.co.in/knowledge-gateway/wp-content/uploads/2015/07/RF-Working-Paper-Transport_edited_09062015_Final_reduced-size.pdf. Accessed 1 June 2021

Ahluwalia, I.J., 2011. Report on Indian Urban Infrastructure and Services The High P.,

Report on Smart City Mission-India by Seconded European Standardization expert in India

https://smartcities.gov.in/, Accessed 1 June 2021

https://smartnet.niua.org/sites/default/files/resources/Tender%20SURE%20Project%20Report.pdf, Accessed 1 June 2021

https://go.itdp.org/display/public/J+M+Road-+Photographs, Accessed 1 June 2021

Design of Urban Roads: Code of Practice Part-1 – Cross sections. (Ministry of Urban Development, Government of India)