

Quantification of Capacity Loss Due to Roadside Encroachment and Design of Traffic Mitigation Strategies: A Case Study of Rewa City

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Abstract: Roadside encroachment is a major urban transportation problem in Indian cities, leading to traffic congestion, reduced roadway capacity, parking conflicts, environmental pollution, and unsafe pedestrian movement. Rapid urbanization, increasing vehicle ownership, and unplanned roadside activities such as hawking, illegal parking, and temporary structures have significantly affected the operational efficiency of urban roads in Rewa. These encroachments reduce the effective carriageway width and obstruct smooth traffic flow on arterial, sub-arterial, collector, and local roads. The present study, titled "Quantification of Capacity Loss Due to Roadside Encroachment and Design of Traffic Mitigation Strategies: A Case Study of Rewa City", evaluates the impact of roadside encroachment on traffic performance and roadway capacity. Field surveys, traffic volume studies, speed and delay analysis, parking assessment, and encroachment mapping were conducted at selected corridors and intersections in Rewa City. The study investigates the influence of road width, pedestrian activity, roadside friction, and encroachment intensity on vehicular speed and traffic flow characteristics. The results indicate that roadside encroachment and high pedestrian density have a significant negative effect on traffic speed and road capacity, whereas wider carriageways improve traffic performance. The study identifies major causes of encroachment, including inadequate parking facilities, lack of traffic management, poor roadside infrastructure, and uncontrolled roadside vending activities. Based on the findings, several traffic mitigation measures are proposed, such as organized parking management, pedestrian facility improvement, relocation of roadside vendors, roadway redesign, enforcement strategies, and development of proper roadside infrastructure. The study aims to provide practical and sustainable solutions for improving urban mobility, traffic safety, and transportation efficiency in Rewa City.

Keywords: Roadside Encroachment, Traffic Congestion, Capacity Loss, Urban Transportation, Traffic Mitigation Strategies, Rewa City.

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I. INTRODUCTION

Traffic problems are the one of the major issues in the cities (especially in Metropolitan cities) of India. Many are the root causes of these issues such as faulty design of the different road patterns, irregular

alimentation of the roads, ignorance of traffic rules, traffic loads, and illegal encroachments on the roads etc. The encroachment is the main root cause of traffic problems, which is basically describe as holding of land illegally and without any authorization for self-

motive or self-interest. The holding or occupying any of the footpath, two-wheeler moving path, any open space/ public space and government land is coming under the category of encroachment because in that case the illegal land holder not have any satisfactory authorization to use that particular piece of land for their self-interest and self-motive.

The illegally growth of slums or mushrooming development along the different pattern of roads and hawker activities along the pedestrian path, footpaths, main carriage way and roadside area are the most common types of urban encroachments in the cities. With the fastest increase of urbanization and population in India (especially in the Indian cities because of rural to urban migration), the new urban problems are taking birth like as illegally construction of ramps in front of houses (mainly on the street space), creation of structures along the drains, illegal mining and sand excavation from the rivers, illegal parking along the roads and on the main carriage way (especially in the commercial areas and streets).

As per the urban pattern of the roads and allocation of the spaces for hawkers, all Arterial & Sub Arterial roads are taken as under the category of no vending roads where the vehicular traffic is very fast, so these roads are not taken as for vending zone roads because there had being not any parking provision on these roads. The Express roads also kept under the category of No vending roads. Turning points on Arterial roads, Sub Arterial roads and Collector roads are also strictly use as No vending Zone.

Urban road networks in Indian cities are increasingly experiencing severe operational inefficiencies due to rapid urbanization, population growth, and unplanned roadside activities. One of the most critical factors affecting urban traffic performance is roadside encroachment, which includes unauthorized parking, street vending, temporary structures, loading–unloading activities, and pedestrian spillover onto carriageways. These encroachments effectively reduce the available roadway width, disrupt traffic flow, and lead to significant capacity loss, increased congestion, travel delays, and safety hazards.

Despite the widespread presence of roadside encroachments, their quantitative impact on roadway capacity is often inadequately addressed in traffic planning and design. Most conventional capacity estimation methods assume ideal roadway conditions and fail to incorporate real-world constraints such as

effective carriageway reduction and friction caused by roadside activities. Therefore, a systematic study to quantify capacity loss due to roadside encroachments and to develop context-specific traffic mitigation strategies is essential.

This study focuses on Rewa City, Madhya Pradesh, as a case study to analyze the extent of roadside encroachment, assess its impact on roadway capacity, and propose practical traffic management and mitigation measures suited to local conditions.

II. OBJECTIVES

- To identify and classify different types of roadside encroachments present on selected urban roads in Rewa City.
- To analyze traffic characteristics such as traffic volume, composition, speed, and roadway geometry under mixed traffic conditions.
- To quantify the reduction in effective roadway width caused by roadside encroachments.
- To estimate and compare roadway capacity under encroached and non-encroached conditions.
- To evaluate the extent of capacity loss and level of service degradation due to roadside encroachments.
- To develop suitable traffic mitigation strategies, including traffic management, parking control, and geometric or operational improvements.
- To propose practical recommendations for improving traffic flow and roadway performance in Rewa City.

III. LITERATURE REVIEW

Prem Prakash in the year 2025. This research discusses how roadside encroachments by informal vendors significantly reduce effective road width, disrupting traffic flow and causing congestion in city cores. The study highlights the need for inclusive urban planning and enforcement to maintain road capacity.

National Academies of Sciences in the year 2025. The roadside encroachment database highlights how roadside interactions and encroachments contribute to crash rates, reduced capacity, and increased congestion, stressing improved roadside design and management for mitigation.

Bibliometric Road Encroachment Study in the year 2025. Research mapping indicated growing interest in

road encroachment impacts on traffic, but noted a scarcity of high-impact congestion mitigation studies globally.

Umesh C. Kulshrestha in the year 2024. This paper examined traffic congestion causes in Indian cities, noting that roadside encroachment, illegal parking, and wrong-side driving significantly contribute to traffic delays and loss of road capacity.

Systematic Review (IJRISS) in the year 2024. A review of encroachment dilemmas showed how informal roadside activities reduce available carriageway, slow down vehicles, and create conflicts with pedestrians, worsening congestion and travel time.

A. O. Tijjani et al. in the year 2023. This narrative review highlighted the socio-economic drivers of roadside encroachment in urban Nigeria and its implications on traffic flow, safety, and environment, emphasizing the need for regulatory interventions.

IV. METHODOLOGY

The present study adopts a systematic methodology to evaluate the impact of roadside encroachments on roadway capacity in Rewa City and to develop suitable traffic mitigation measures. Initially, the problem of traffic congestion and reduction in effective road width due to roadside encroachments is identified. Based on this, the objectives of the study are formulated to quantify capacity loss and suggest improvement strategies.

Selected highway corridors and urban roads with high traffic volume, significant encroachments, and congestion are chosen as study areas. Primary data such as traffic volume, traffic composition, speed, delay, roadway geometry, and encroachment characteristics are collected through field surveys during peak and off-peak hours.

The collected data are analyzed to identify the effects of encroachments on traffic flow, including reduction in carriageway width, bottlenecks, and side friction. Suitable remedial measures such as parking management, traffic channelization, relocation of vendors, and pedestrian facility improvements are then proposed.

Further, detailed surveys are conducted to prepare encroachment maps and proposed improvement models. Finally, the results are interpreted to assess roadway capacity loss and improvement in traffic performance after mitigation measures. Conclusions and recommendations are drawn for effective urban traffic management in Rewa City.

V. SELECTION OF STUDY AREA

Rewa is a city in the north-eastern part of Madhya Pradesh state in India with latitude of 24.5362° N and longitude of 81.3037° E. The maximum length of Rewa district is 125 km from east to west and the length of Rewa from north to south is 96 km. This area is surrounded by Kaimur hills to the south Vindhyachal ranges pass through the middle of the district. Two stretches of Rewa City were selected for the study which are: -

- New bus stand to Janta College Road.
- PTS Chowk to Ghur Chowk
- Ghur Chowk to D-mart road
- Sirmour to New Bus Stand
- New bus stand to PTS Chowk

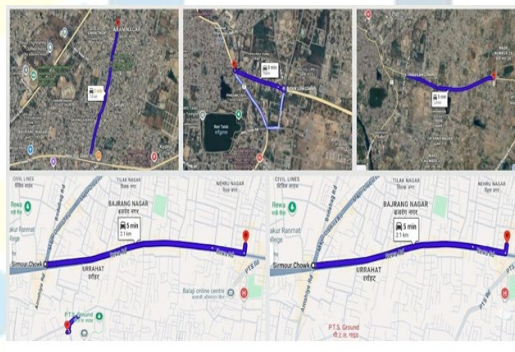


Fig. 1 Selection of Study area Images

VI. ANALYSIS OF STUDY

Descriptive Statistics

Average vehicle speed across corridors ranged from 17 km/h to 48 km/h. Roads with proper lane demarcation and minimal roadside encroachments exhibited higher mean speeds.

Table 1 Descriptive Statistics

Corridor	Avg Speed	Encroachment (%)	Road Width	Pedestrian Density

	(km /h)		dth (m)	y (/min)
PTS Chowk	42.1	25	6.0	5
Janta College Road	19.3	38	4.0	26
Gurh Chowk	31.8	10	5.0	14
Samdareeya hotel Road	26.7	30	4.5	19
Sirmour Chowk	18.5	35	10.0	23
D-Mart Road	48.9	9	6.5	10

The scatter plot shows a clear negative relationship—as encroachment increases, average vehicular speed decreases. Roads like Janta College Road and Sirmour Chowk, with high encroachment, show much lower speeds.

Coefficients Table

Using the calculated coefficients for your data, we get the following values:

Model	Unstandardized B	Std. Error	Beta (Standardized)	t-value	Sig. (p)
(Constant)	54.12	19.34		2.798	0.107
Encroachment	-0.362	0.541	-0.370	-0.669	0.573
Road Width	0.675	1.765	0.126	0.382	0.739
Ped. Density	-0.493	0.680	-0.448	-0.725	0.544

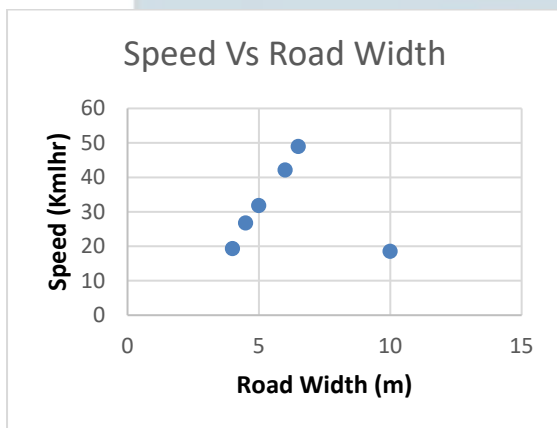


Fig. 2 Graph of Speed Vs Road Width

This plot reveals a positive correlation—wider roads like PTS Chowk and D-mart Road enable higher vehicle speeds due to better movement space and lane discipline.

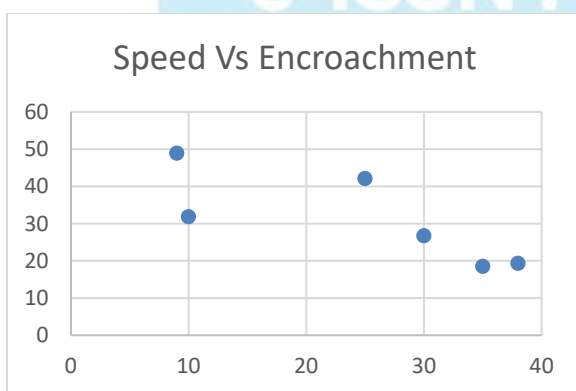


Fig. 3 Graph of Speed Vs Encroachment

The Final Model Equation

Based on the Unstandardized B coefficients from your SPSS output, the mathematical model for the corridors is:

$$\text{Avg. Speed (km/h)} = 54.12 - 0.362 \{\text{Encroachment}\} + 0.675 \{\text{Road Width}\} - 0.493 \{\text{Ped. Density}\}$$

VII. ENCROACHMENT STUDY & RECOMMENDATIONS



Janta College Road

Current State	Recommended Target State
Pedestrians forced onto the main road.	Obstruction-free, raised footpaths.
Auto-rickshaws idling in the middle of lanes.	Dedicated, bollard-segregated pick-up bays.
Vendors blocking turns and intersections.	Organized, designated vending zones off the main road.
Chaos and unpredictable driving patterns.	Clear lane markings, one-way hours, and active camera enforcement.

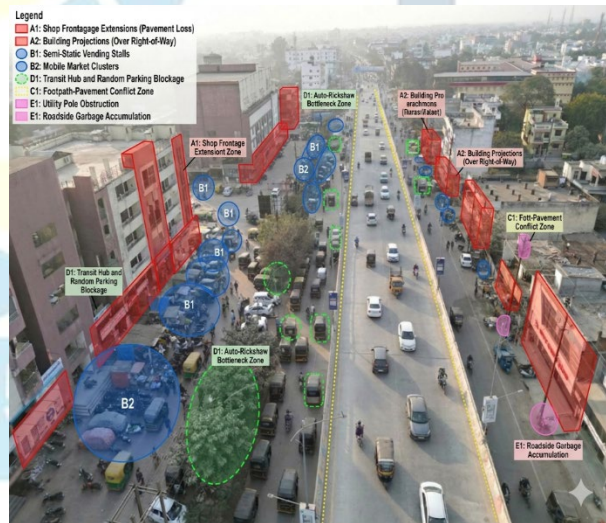


PTS Chowk

Problem Area	Current Chaotic State	Recommended Engineered State
Intersection Corners (B1)	Heavy stalls blocking sightlines;	Clear Sight Triangle; smooth left-slip lanes.

Problem Area	Current Chaotic State	Recommended Engineered State
	forced wide turns.	
Transit Management (D1)	Rickshaws blocking lanes right at the intersection.	Bollard-segregated passenger boarding bays 50m back.
Pedestrian Movement	Pedestrians walking in active vehicle lanes.	Raised, continuous footpaths and marked zebra crossings.
On-Street Vending (B2)	Unregulated market sprawl narrowing the road.	Off-street, organized Vending Zones with unified kiosk spaces.

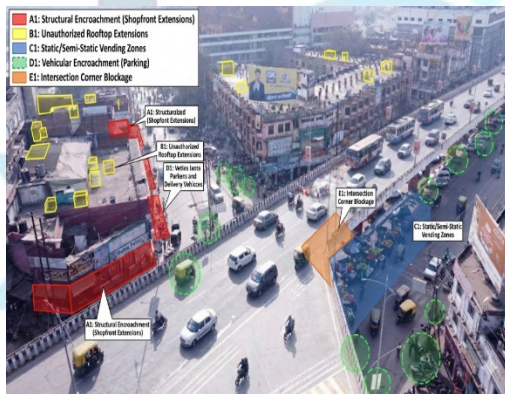
New Bus Stand / Sirmour Road corridor



Target Issue	Current Bottleneck	Proposed Engineering Solution
Transit Chaos (D1)	Rickshaws parking 2-3 units deep, blocking service lanes.	Bollard-segregated lanes dedicated exclusively to transit vehicles.

Target Issue	Current Bottleneck	Proposed Engineering Solution
Market Spillover (B2)	Mobile vendors taking over active asphalt.	Relocation to a designated, off-street municipal vending zone.
Pedestrian Safety (C1)	Pedestrians walking in traffic due to missing pavement.	Construction of continuous, raised footpaths and a pedestrian bridge over Sirmour Road.
Private Encroachment (A1)	Ramps and steps extending onto the road.	Clear setback rules with strict enforcement of the yellow line.

Sirmour Chowk



Target Issue	Current Bottleneck	Proposed Engineering Solution
Vending Obstructions (C1)	Markets taking over valuable service lane width.	Relocate vendors to a structured, off-street municipal market space.
Transit Friction (D1)	Rickshaws idling in active merging lanes.	Construct curbed passenger bays set back from the intersection.
Parking Encroachment	Service lanes reduced to single lanes by parked vehicles.	Enforce a strict on-street parking ban supported by a nearby parking plaza.

Gour Chowk



Target Issue	Current Bottleneck	Proposed Engineering Solution
Corner Blockages (E1)	Sharp, blind turns due to structures near the flyover nose.	Clear sight triangles and establish dedicated free-left slip lanes.

Target Issue	Current Bottleneck	Proposed Engineering Solution
Main Roadway Capacity Reduction	Area A (Street Vendors): Dense line of static street vendors occupying the active	* Relocation: Transition informal vendors from the active asphalt road to a designated,

Target Issue	Current Bottleneck	Proposed Engineering Solution	Target Issue	Current Bottleneck	Proposed Engineering Solution
	carriageway, narrowing the driving lanes and creating a severe physical bottleneck.	organized municipal vending zone. * Buffer Zones: Enforce a strict, marked "No-Vending Zone" within 50 meters of the junction.		entry/exit capacity of the leg.	Transport (IPT) bay. * Off-Road Queuing: Set up a designated pickup/drop-off point shifted at least 30 meters away from the intersection conflict zone.
High-Risk Pedestrian Conflict	Area B (Pedestrian Path Encroachment): Stalls and parking immediately adjacent to the roundabout perimeter, forcing pedestrians directly into the path of moving vehicles.	* Refuge Protection: Install physical railings or high-visibility bollards around the central island and junction corners to secure pedestrian paths. * Clear Zone: Establish a 15 meter zero-occupancy buffer around the roundabout.	Inefficient Intersection Weaving	Poor Junction Geometry: Mixed traffic merging without physical lane discipline; lack of entry flares and channelization.	* Geometric Redesign: Construct raised splitter islands on approaches to guide vehicles systematically. * Slip Lanes: Introduce dedicated, physically segregated free-left-turn slip lanes to bypass the roundabout weave entirely.
Junction Mouth & Approach Throttling	Area C (Unorganized Auto-Rickshaw Parking): Multi-lane queuing of shared transit vehicles blocking active lanes, restricting	* IPT Channelization: Install plastic water-filled barriers or curbs to construct a dedicated, single-lane Intermediate Public			

VIII. CONCLUSION

Based on the observed problems, several practical traffic mitigation strategies were proposed, including:

- Removal and regulation of roadside encroachments,
- Strict parking management and no-parking enforcement,

- Relocation and organized management of street vendors,
- Improvement of pedestrian facilities and footpaths,
- Traffic channelization and roadway marking improvements,
- Development of dedicated parking zones,
- Public awareness and coordinated enforcement by municipal and traffic authorities.

The study concludes that effective management of roadside encroachments can substantially improve roadway capacity, reduce travel delays, enhance safety, and improve the overall efficiency of urban transportation systems in Rewa City. The proposed mitigation measures provide a practical framework for urban traffic management authorities to address congestion problems in rapidly growing medium-sized Indian cities operating under heterogeneous traffic conditions.

Finally, this research emphasizes the importance of integrating encroachment control measures with urban transport planning and roadway management policies to achieve sustainable and efficient urban mobility in the future.

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