JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

BEYOND LOS: A TECHNICAL AUDIT AND ROTARY WEAVING BASED EVALUATION OF ROADWAY PERFORMANCE IN REWA CITY

Authors:

[1]**Swarnim Khare,**

M. Tech Scholar, Department of Civil Engineering, Rewa Engineering College, Rewa (M.P.), India.

swarnimkhare1992@gmail.com

[2]**Rajat Choudhary,**

Assistant Professor, Department of Civil Engineering, Rewa Engineering College, Rewa (M.P.), India.

Abstract

Assessment of roadway performance in Indian cities often relies on traffic volume, roadway capacity and the Level of Service (LOS). While these measures are useful, they do not consistently account for operational constraints that arise from geometry, side friction and traffic behaviour in mixed-use environments. This study examines roadway performance in Rewa City through a combined approach involving a technical audit, LOS-based evaluation and weaving analysis of a key rotary.

Six locations within the city were selected to represent a range of conditions from high-activity centres to peripheral stretches. Peak-hour classified counts were converted to Passenger Car Units (PCU) and compared against IRC-based capacity estimates to determine LOS. In parallel, each site was examined for carriageway configuration, pedestrian activity, encroachment, surface condition and other friction factors. A detailed analysis of the rotary at Sirmour Chouraha was undertaken, using measured dimensions to derive weaving parameters and estimate its capacity under prevailing conditions.

Results show that peripheral road sections, despite favourable LOS grades, lack basic operational width and pedestrian space, indicating capacity reserve but infrastructural limitation. Central intersections operate close to or above their estimated capacities, with the Sirmour Chouraha rotary exhibiting oversaturation primarily because of short weaving length and high weaving proportion. These findings suggest that LOS alone cannot fully diagnose performance issues where congestion is driven by design constraints rather than traffic volume. The study supports the inclusion of geometric and operational audits alongside LOS for a more reliable evaluation of roadway performance in Tier-III mixed traffic settings.

Keywords: Mixed Traffic, Level Of Service(LOS), Passenger Car Unit(PCU), Roadway Capacity, Technical Audit, Weaving Analysis, Rotary Intersection Performance, Urban Transport Evaluation.

Introduction:

Urban mobility systems rely not only on the availability of roads, but on how efficiently those roads continue to perform under growing pressure. In medium-sized Indian cities such as Rewa, transport planning has largely evolved around widening carriageways, adding lanes, or signalising intersections. However, everyday experience shows that congestion persists even where capacity improvements are attempted. This disconnect between design assumptions and on-ground performance forms the central motivation of this work.

Conventional evaluation in Indian road networks relies heavily on Level of Service (LOS). LOS expresses how comfortably traffic is flowing at any location, especially under peak demand. While LOS provides a useful first-stage diagnosis, it responds only to traffic volume. It assumes ideal geometry, uniform driver behaviour and unconstrained weaving areas—assumptions that do not hold in heterogeneous, mixed traffic conditions found in Indian cities.

The situation becomes more challenging at rotary intersections, where vehicles must enter, circulate, weave, and exit within limited space. When capacity is derived theoretically, junctions may appear capable of handling flow; yet in practice, breakdown can occur because of geometry limitations, short weaving lengths, high turning proportions, or pedestrian interference. Such breakdowns are not mere operational issues—they represent design failure.

Rewa City offers a sharp example of this gap. Six critical locations were selected for analysis, including three major linear corridors and the pivotal Sirmour Chouraha rotary, which experiences frequent queuing despite serving traffic volumes that appear moderate for a junction of its type. Field observations suggested that the rotary may be failing not due to excessive traffic alone, but because its geometric proportions are out of balance with the way drivers must manoeuvre through it.This study therefore adopts a data-centric, calculation-intensive approach involving:

- Technical audits of carriageway width, side friction, pedestrian intrusion, and traffic composition,
- Hourly traffic volume conversion into Passenger Car Units (PCU),
- Determination of LOS using observed V/C ratios,
- And, crucially, a full weaving-based rotary performance analysis using IRC-recommended procedures.

By comparing theoretical capacity ranges with capacity derived from actual weaving conditions, the study identifies whether congestion is demand-driven or design-induced. The resulting assessment provides a clearer picture of why certain locations deteriorate faster than others, and why decisions based solely on LOS may lead to misleading conclusions in Indian mixed-traffic environments.

The results ultimately demonstrate that for intersections like Sirmour Chouraha, congestion is not simply a function of traffic volume. It emerges from how vehicles are forced to merge, diverge and negotiate short weaving segments in constrained geometry. Recognising this distinction is essential for improving traffic performance, prioritising junction redesign, and supporting transportation planning decisions in rapidly growing Tier-III cities.

Literature Review:

Traffic performance assessment in India has historically relied upon the principles presented in the Highway Capacity Manual (HCM) and adapted into domestic practice through the Indian Roads Congress (IRC). Early analytical models assumed homogenous traffic streams and disciplined lane behaviour, which broadly reflect Western roadway conditions. However, a growing body of research has questioned the suitability of these models for Indian urban environments, where a mix of two-wheelers, three-wheelers, intermediate public transport and variable driving behaviour dominate.

A significant research contribution in this regard originates from IIT Delhi's Transportation Research and Injury Prevention Programme (TRIPP). Studies led by Geetam Tiwari and Dinesh Mohan emphasise that transport system performance must be grounded in actual operating environments rather than imported planning assumptions. Their work highlights how pedestrian movement, informal transpo rt, and side roadway activities influence flow breakdown in ways not captured by LOS alone. These findings underline the need for location-specific measurement rather than model transfer.

Parallel studies at IIT Bombay, particularly through the NPTEL modules developed by Tom V. Mathew and K.V. Krishna Rao, have expanded analytical tools for evaluating intersections under mixed traffic. Their work identifies rotary junctions as especially vulnerable to operational failure when geometric proportions deviate from recommended standards. Weaving-related delays, lateral conflict and insufficient entry deflection are cited as core causes of congestion even at moderate traffic levels.

Research at IISc Bangalore by Ashish Verma further argues that evaluating junction performance requires attention to spatial constraints and turning behaviour, particularly where public transport and para-transit share space with private vehicles. His studies emphasise that the relationship between flow and delay is highly non-linear in Indian cities, meaning that small geometric or behavioural variations may rapidly escalate into full breakdown.

Complementing these efforts, IIT Roorkee and NIT Warangal have produced capacity estimation models tailored to heterogeneous traffic, demonstrating that empirical weaving capacity commonly falls below classical values when entry width, circulating width, and weaving length do not satisfy required proportions. Several of these works propose that LOS may remain acceptable while operational delay becomes critical—indicating that static V/C ratios conceal dynamic turbulence within the weaving zone.

Across these investigations runs a common thread: Indian traffic conditions cannot be represented adequately by LOS alone, and even conventional capacity assessment may lead to misleading conclusions if geometric constraints are ignored. The literature therefore supports the need for audits that integrate field-measured geometry, traffic movement composition, and weaving dynamics.

The gap emerging from this research is clear. While there is extensive work developing tools and models, few applied studies examine real-world performance by jointly analysing roadway geometry, side friction, and weaving flow for specific junctions in smaller cities. Moreover, limited research addresses the distinction between volume-driven congestion and design-induced congestion, despite field evidence that the latter plays a decisive role at many Indian rotaries.

The present study builds directly upon these insights by applying a comprehensive technical assessment to a working rotary in Rewa City. In doing so, it contributes empirical data to an area where theoretical understanding exists, but real-world verification is sparse, particularly outside major metros.

Methodology:

The methodology adopted in this study combines geometric assessment, field traffic observation, capacity computation and performance evaluation in accordance with established IRC procedures. The sequence of tasks is outlined to ensure that every analytical step directly follows from verified ground measurements.

1. Site Selection

Six locations within Rewa City were identified based on recurring congestion reports and their importance in linking major urban and semi-urban regions:

Sirmour Chouraha (rotary), Bus Stand Road, Ghoda Chouraha, Karahiya , Nipaniya , Itaura

The first three represent high-demand corridors characterised by mixed vehicular composition and roadside commercial activity, whereas the remaining locations represent lower-volume but structurally constrained corridors. This distribution allowed comparison of geometric performance across varying operational loads.

2. Field Geometry Survey

Each site was subjected to a roadway technical audit using direct measurement:

- Carriageway width (W)
- Shoulder width
- Median and pedestrian refuge presence
- Entry width, exit width and weaving length (for rotary)
- Central island dimension and circumference

At Sirmour Chouraha, key weaving parameters including weaving width, weaving length (L), and circulating lane width were recorded, enabling the application of weaving-based capacity estimation.

3. Traffic Volume Observation and Conversion to PCU

Manual classified counts were conducted during the morning peak hour. Vehicle categories included:

Two-wheelers, Three-wheelers (including e-rickshaws) , Cars/LMVs, LCVs/HCVs (if present)

Counts were converted to Passenger Car Units (PCUs) using IRC-recommended equivalency factors for mixed traffic. These PCU flows formed the basis for computing:

Peak hour volume per leg, Turning proportions, Circulating flow at the rotary

4. Side Friction and Pedestrian Interaction

At non-rotary sites, side friction was documented by recording observed events per 15 minutes involving:

- Pedestrian crossings
- On-street parking or unloading
- Auto stoppages
- Random obstructions

The total friction frequency was used as a qualitative indicator of disturbance severity, complementing flow-based LOS calculations.

5. Level of Service Estimation

Roadway performance was assessed using:

V/C= Peak Hour Volume/Practical Capacity

where practical capacity was taken from IRC guidance based on roadway width and prevailing heterogeneous traffic conditions.

LOS was assigned using standard interpretation ranges:

- A–D satisfactory to near unstable
- E–F saturated or failing flow

This enabled direct comparison between linear segments and the rotary.

6. Rotary-Specific Weaving Analysis

The Sirmour Chouraha rotary was evaluated not only on LOS, but using weaving theory from IRC:

- Traffic was decomposed into four weaving sections
- Movement flows were grouped as a, b, c, d (entering, circulating, diverging, exiting)
- Weaving proportion p was computed

  $p = (b+c)/(a+b+c+d)$

- Weaving width and length were used to compute effective geometric ratio (L/W)
- Practical weaving capacity was calculated as:

  $Q_P = [\{280W(1 + e/W)(1 – P/3)\}] / [\{(1 + W/L)\}]$

This produced a real-world capacity estimate that could be directly compared with theoretical capacity ranges.

7. Performance Interpretation

Finally, V/C ratios derived from observed volumes were compared to:

- Theoretical capacity limits
- Calculated weaving capacity
- LOS values
- Side friction severity

Locations were categorised as:

- Satisfactory
- Approaching instability
- Geometry-induced failure

The combination of classical LOS criteria and geometry-based capacity estimation enabled a more comprehensive diagnosis of performance breakdown.

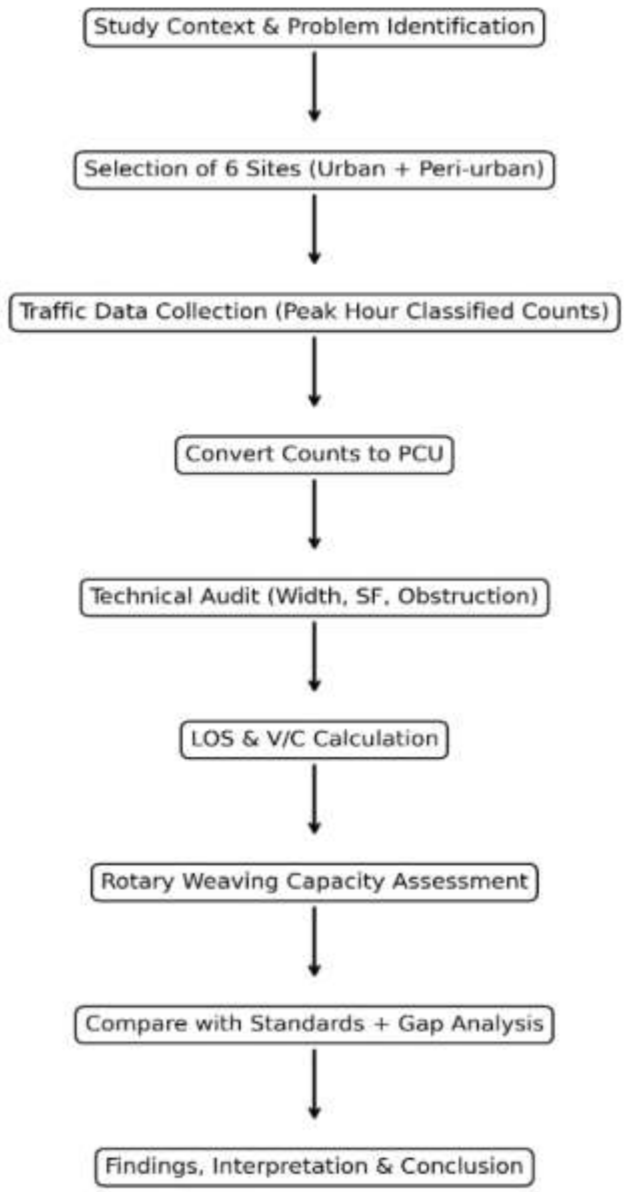

Fig 1: Methodology Flowchart

Results & Discussion

The tabulated results demonstrate a three-tier performance structure within the city.Low-volume links such as Karahiya, Nipaniya and Itaura show V/C ratios $\leqslant$0.35 and LOS grades A–B. These corridors offer stable operations even under mixed traffic conditions, implying that infrastructure provision is adequate for current demand.

Conversely, urban intersections—particularly Ghoda Chowk and the New Bus Stand—operate with higher flow intensities. Although V/C ratios remain below unity, LOS values deteriorate to D and B respectively due to the influence of side friction elements such as pedestrian intrusion and informal stopping maneuvers. This establishes that capacity alone does not predict performance where friction is high.

The Sirmour Chouraha rotary exhibits the system's most critical deficiency. Despite a total inflow (4243 PCU/hr) that appears only moderately excessive relative to theoretical capacity (~3000 PCU/hr), weaving-based supply collapses.

The combination of short weaving length (L/w = 1.25) and very high weaving proportion (P ≈ 0.93) results in practical capacity of only 2884 PCU/hr, yielding LOS F. This confirms that geometry-induced underperformance pre-empts traffic-induced failure.

Location	Peak PCU/hr
Karahiya A	459
Karahiya B	507
Nipaniya A	104.5
Nipaniya B	115.25
Itaura A	348.75
Itaura B	402
Ghoda Chouraha	774.75
New Bus Stand	600(approx)
Sirmour Chouraha	4243(Total in)

Table 1: Peak hour PCU across all locations

The PCU distribution clearly separates the low-demand peripheral corridors (100 – 500 PCU/hr) from the high-demand urban nodes (⩾750 PCU/hr), confirming that congestion in Rewa is concentrated at a limited set of intersections rather than city-wide.

Location	V/C	LOS
Karahiya A	0.31	B
Karahiya B	0.34	B
Nipaniya A	0.07	A
Nipaniya B	0.08	A
Itaura A	0.23	B
Itaura B	0.27	B
Ghoda Chouraha	0.561	D
New Bus Stand	0.21-0.28	B
Sirmour Chouraha	1.47	F

Table 2:LOS Based om V/C Ratios

Peripheral corridors operate within LOS A–B and exhibit reserve capacity.Urban mid-links approach or exceed LOS C–D despite moderate volumes, reflecting side friction influence.Sirmour rotary governs the system's weakest point, operating beyond failure.

Parameter	Sirmour chouraha	New Bus Stand	Ghoda Chouraha	Itaura	Nipaniya	Karahiya
Carriageway width(m)	10.5	11.0	9.8	5.2	4.8	5.0
Footpath Provision	Discontinous	Present(Encroached)	Absent	Absent	Absent	Absent
Shoulder	0.8 m	1.2 m	0.6 m	Absent	Earthen	Damaged
Pavement condition	Good	Very Good	Fair	Poor	Poor	Very poor
Drainage	Partial	Adequate	Poor	None	None	Kutcha
ROW Obstruction	High	Very High	Moderate	Low	Low	Low

Table 3: Technical audit summary of selected corridors in Rewa

The technical audit reveals a stark contrast between central and peripheral road sections in Rewa.

New Bus Stand and Sirmour Chouraha possess relatively wider carriageways (10.5–11m), yet suffer from very high right-of-way obstruction and encroached pedestrian space, leading to operational inefficiency despite adequate geometric width.Ghoda Chouraha, although moderate in obstruction and carriageway width, is constrained by poor pavement and insufficient drainage, contributing to localized delays and surface deterioration.

In contrast, peripheral corridors—Nipaniya, Itaura and Karahiya—offer narrower carriageways (4.8–5.2m) with limited structural support facilities. These corridors lack footpaths, have compromised shoulders and poor or non-existent drainage, reflecting both design inadequacy and absence of maintenance intervention. However, because traffic demand here is lower, the operational impact remains moderate.

The table reinforces that performance limitations arise from both geometry and roadside environment rather than carriageway width alone. At Sirmour and New Bus Stand, high ROW obstruction actively cancels out the benefit of wider roads, while in remote sections inadequate infrastructure has not yet manifested as congestion due to suppressed demand.

Parameter	Observed Value
Weaving Length(L)	22.95 m
Effective width (w)	18.4 m
L/W Ratio	1.25
Required (IRC)	$\geq$2.0
Mix weaving proportion, P	0.9265
Practical capacity	2884 PCU/hr

Observed Inflow	4243 PCU/hr
Overload	47%
Resulting LOS	F

Table 4:Rotary Geometry & weaving capacity parameters

Rotary failure stems from geometry. Not merely traffic load. Insufficient weaving length (L/W<2) with very high P(>0.9) forces vehicles into severe conflict motion & blocks downstream legs.

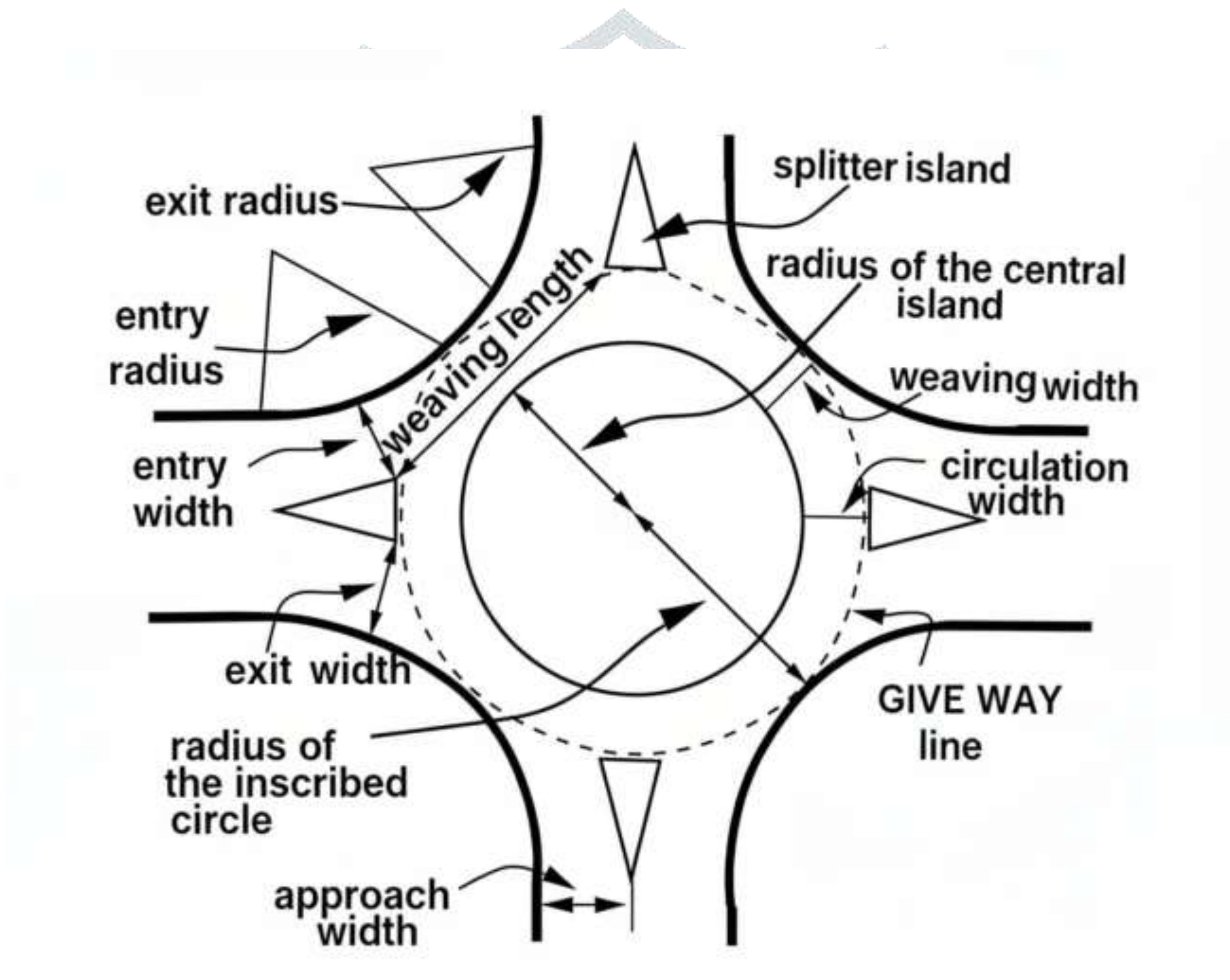

Fig 2: Geometric components of a Rotary

Conclusion:

The analysis undertaken across six selected road links and one critical rotary junction in Rewa city establishes a clear distinction in the operational performance of different elements of the network. The results show that while the peripheral and semi-urban links possess adequate reserve capacity and operate at LOS A–B, the inner urban junctions are functioning near or beyond their operational thresholds.

Among these, Sirmour Chouraha emerges as the dominant point of congestion, not because of traffic volume alone but due to geometric limitations intrinsic to its rotary design. The computed practical rotary capacity of 2884 PCU/hr, against an observed peak flow of 4243 PCU/hr, translates into a 47% overload, causing queuing, delay and unstable flow conditions. Moreover, key geometric indicators—L/W ratio of 1.25 (below the recommended ⩾2.0) and weaving proportions exceeding 0.5, peaking at 0.93—demonstrate that the facility is unable to facilitate smooth merge–diverge operations. These conditions confirm that the rotary operates under structural failure, reflected by a V/C ratio of 1.47 and LOS F.

The broader comparison also underscores the limitations of applying LOS alone as a diagnostic tool in mixed-traffic environments. Multiple sites with moderate V/C ratios nonetheless exhibited delay due to side friction, turning movements, and uncontrolled pedestrian activities—characteristics typical of Indian urban contexts that TRIPP and other transport research groups have consistently highlighted.

In summary, the findings establish that deterioration in traffic performance in Rewa is localized and design-driven, not systemic. The rotary-based intersection at Sirmour is undersized for its functional demand and cannot be expected to provide satisfactory operational conditions without geometric intervention. Targeted modification at a limited number of bottlenecks, rather than network-wide expansion, offers the most effective and economical path to restoring acceptable service levels.

Limitations:

Although the study provides a comprehensive assessment of traffic performance in Rewa, certain constraints limit the generalisation of results.

First, the analysis relies on single peak-hour manual counts, which, while standard practice for field diagnosis, do not capture temporal variations such as off-peak behaviour, seasonal surges, festival fluctuations, or examination periods that can significantly alter demand patterns.

Second, only one rotary junction was analysed in operational detail, due to the absence of comparable rotaries in the selected corridor. While Sirmour exhibits typical failure symptoms common to Indian roundabouts, conclusions regarding rotary performance elsewhere in the city require further verification.

Third, the study is based on observed heterogeneous traffic conditions without lane discipline, but does not incorporate simulation or behavioural modelling. As a result, driver interactions, critical gap acceptance, and queue spillover dynamics are inferred indirectly from measured flows rather than captured explicitly.

Finally, the work does not include pedestrian safety audits, economic loss quantification, or environmental externalities, though these are important components of contemporary planning discourse.

Recommendations:

Based on the observed performance deficit, three categories of interventions are proposed:

1) Rotary-Specific Engineering Measures

- Increase effective weaving length (L) by approach flaring or realigning entry geometry
- Reduce weaving width (W) or channelise traffic using raised islands or delineators

→ improves lane discipline and reduces lateral conflict

- Restrict turning dominance through partial signalisation during peak hours
- Implement turbo-roundabout

2) Friction Reduction Measures for High-Activity Corridors

- Demarcate autorickshaw stopping bays outside the main flow path
- Provide median refuge or zebra crossings for pedestrian movement
- Enforce no-parking zones around Bus Stand and Ghoda Chouraha approach mouths

- Introduce physical separators to maintain usable carriageway width

3) Network-Level Low-Cost Strategies

- Stagger institutional or market timing to distribute demand
- Promote intermediate public transport (IPT) loading areas away from intersections
- Integrate signage, lane markings and rumble strips approaching bottlenecks

These measures allow immediate performance gains without full-scale reconstruction.

Scope for Future Work:

The study identifies several opportunities for deeper inquiry:

Expanded Temporal Coverage

- Repeating measurements across:

Evening peak, Weekend and festival peaks, Longitudinal seasonal surveys will strengthen the confidence interval for capacity estimation.

Dynamic Simulation

Microsimulation through VISSIM / AIMSUN / SUMO can:

- Model driver behavior
- Represent weaving conflicts explicitly
- Test design alternatives virtually before implementation

Comparative Analysis Across Cities

Similar weaving-based audits in other tier-II or tier-III cities can validate:

- Whether Rewa is a representative case
- How geometry interacts with modal composition in differing regions

Integration with Human and Social Dimensions

While excluded from this technical paper, future phases can evaluate:

- User delay perception
- Accessibility to essential services
- Quality-of-life implications of congestion

These aspects align with on going work by TRIPP and IISc researchers.

References

Government & Standards

1)Indian Roads Congress (IRC), IRC:106–1990 – Guidelines for Capacity of Urban Roads.

2)Indian Roads Congress (IRC), IRC:65–1976 – Recommended Practice for Traffic Rotaries.

3)Indian Roads Congress (IRC), IRC SP:41–1994 – Guidelines for the Design of At-Grade Intersections.

4)Indo-HCM, Indian Highway Capacity Manual (2017), CSIR-CRRI, New Delhi.

IIT / IISc / TRIPP Related

5. Tiwari, G. (2011). Urban Transport for Indian Cities: Challenges and Emerging Research. TRIPP, IIT Delhi.

6. Mohan, D. & Tiwari, G. (2000). Road Safety and Urban Traffic Management in India. Transportation Research and Injury Prevention Programme (TRIPP), IIT Delhi.

7. Verma, A. (2014). Sustainable and Equitable Urban Transport in India, IISc Bangalore Working Paper Series.

8. Parida, M., & Bhuyan, P. (2016). Performance Evaluation of Urban Road Corridors, IIT Roorkee Transportation Systems Group.

9. Mathew, T.V. & Rao, K.V.K. (2007). Introduction to Transportation Engineering. IIT Bombay NPTEL Lecture Notes (Module on Intersections & Rotaries).

Foundational / Mixed-Traffic & Design

10. O'Flaherty, C.A. (1997). Transport Planning and Traffic Engineering. Edward Arnold Publishers.