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STUDY OF SPEED BREAKER IMPACT ON TRAFFIC FLOW AND SAFETY

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ABSTRACT :

Speed breakers are among the most widely used traffic calming devices in India and globally. While their primary purpose is to reduce vehicle speed and enhance road safety, poorly designed or incorrectly placed speed breakers may disrupt traffic flow, increase fuel consumption, and create new safety hazards. This study investigates the dual impact of speed breakers on traffic flow efficiency and safety outcomes using field data, driver/pedestrian surveys, and traffic simulation tools in and around Lucknow, India. Key findings indicate that while properly designed speed breakers significantly reduce accident severity and improve pedestrian safety, substandard installations lead to increased delays, emissions, and discomfort. The study further recommends guidelines for optimal design and integration of smart speed breakers within intelligent traffic management systems.

Keywords: speed breakers, traffic calming, road safety, traffic flow, simulation, VISSIM, India

1. Introduction

Road safety and traffic efficiency are two of the most pressing concerns in urban transportation systems, particularly in rapidly growing cities such as those in India. With the increasing number of motorized vehicles and the parallel rise in pedestrian activity, managing vehicular speed has become critical to preventing accidents and enhancing safety near conflict zones such as schools, hospitals, and intersections. Among the most common traffic calming measures deployed globally are speed breakers (also known as speed humps or road humps), which are designed to physically reduce vehicle speed and encourage safer driving behavior. Their application is particularly prevalent in developing nations due to their cost-effectiveness, low maintenance, and immediate impact on driver behavior (Singh & Tiwari, 2019).

Despite their widespread usage, the effectiveness of speed breakers has been a subject of ongoing debate among engineers, policy-makers, and road users. On one hand, they are credited with significantly reducing vehicle speeds, thereby lowering the likelihood and severity of collisions, especially those involving vulnerable road users like pedestrians and cyclists (WHO, 2018). On the other hand, poorly designed or incorrectly placed speed breakers have been known to cause sudden deceleration, vehicular instability, fuel wastage, increased emissions, and discomfort for passengers—sometimes even leading to rear-end collisions and traffic congestion (Sharma et al., 2022). These negative outcomes are often a result of non-compliance with established geometric and placement guidelines, such as those prescribed by the Indian Roads Congress (IRC:99-2018).

The dual role of speed breakers—as enforcers of safety and disruptors of traffic flow—necessitates a balanced evaluation framework that can measure their performance not just in terms of accident reduction, but also in their impact on mobility, environmental sustainability, and public satisfaction. This is particularly relevant in Indian cities, where urban road networks are characterized by mixed traffic, inconsistent driver behavior, and infrastructure constraints. The city of Lucknow, for instance, has witnessed a substantial increase in private vehicle ownership and road usage, leading to a proliferation of speed breakers—many of which have been installed without engineering studies or public consultation.

Several international studies have attempted to quantify the benefits of speed calming devices. In the United States and the United Kingdom, properly designed speed tables and cushions have shown to reduce vehicle speeds by 25–40% and crash frequencies by up to 45% in urban residential areas (Federal Highway Administration, 2017). In contrast, field observations in Indian cities often reveal a lack of standardization and frequent instances of *ad hoc installation*, with speed humps being placed under flyovers, at signalized intersections, or without any advance signage—all of which compromise their intended purpose.

This research was undertaken to provide a data-driven assessment of the impact of speed breakers on both traffic flow and safety outcomes, using real-world observations, traffic volume and speed measurements, accident records, and simulation-based modeling. The study focuses on multiple locations in Lucknow, selected to represent a diverse mix of road hierarchies and usage patterns. In addition to quantifying the physical impact of speed breakers, this study also incorporates driver and pedestrian perception surveys to highlight public understanding and satisfaction regarding these interventions.

By comparing standardized and non-standardized installations, and evaluating outcomes across flow, delay, emissions, and safety, this research aims to fill the gap in Indian transportation literature with locally contextual, empirically validated insights. Moreover, it explores how smart speed breakers and integration with intelligent traffic systems can potentially address the trade-offs between mobility and safety, offering a way forward for sustainable and people-centric urban road design.

.2. Research Objectives

The study seeks to:

- Evaluate the geometric and operational characteristics of speed breakers in Lucknow.
- Measure their effect on vehicle speeds, delay, and queue formation.
- Assess their role in accident reduction and pedestrian safety.
- Analyze user perception through surveys.
- Model traffic scenarios using VISSIM to quantify impacts.
- Provide design and policy recommendations based on empirical evidence.

3. Methodology

The methodology adopted in this study was designed to provide a comprehensive and empirical evaluation of how speed breakers influence both traffic flow efficiency and road safety outcomes. A combination of field-based data collection, geometric assessment, behavioral surveys, and traffic simulation modeling was utilized. The methodological approach was structured to cover real-world conditions across different road types in Lucknow, Uttar Pradesh, and to ensure that results were generalizable and robust across similar Indian urban settings.

3.1 Study Location and Site Selection

The research was conducted at five selected locations in and around Lucknow: Faizabad Road (Chinhat Junction), Shaheed Path (Medanta Junction), Aliganj Sector K (school zone), Charbagh Road, and Sitapur Road near IIM Gate. These locations were chosen based on a multi-criteria approach, which included parameters such as accident history, presence of pedestrian activity, traffic volume levels, and diversity in geometric profiles of speed breakers. Both standard-compliant and non-standard speed breakers were included to allow comparative analysis of performance.

3.2 Data Collection Techniques

Field data collection was carried out over a 4-week period, covering morning and evening peak hours and off-peak periods on weekdays. The following data types were collected:

- Traffic Volume Data: Manual vehicle counts were performed in 15-minute intervals using digital tally counters and later normalized to hourly flows.
- Vehicle Speed Data: Spot speed measurements were taken using handheld radar speed guns at three key locations: before the speed breaker, on top of the hump, and after crossing.
- Queue Length and Delay: Queue lengths were manually recorded at 5-minute intervals, and delay per vehicle was computed using stopwatch timing and video recording analysis.
- Geometric Data: The physical dimensions of speed breakers, including height, width, ramp gradient, and surface material, were measured with measuring tapes, leveling instruments, and slope meters. Data were validated against IRC:99-2018 standards.
- Accident and Safety Records: Official accident data (2020–2022) were obtained from Lucknow Traffic Police under the RTI Act and supplemented by on-site incident logs and near-miss observation diaries maintained during the survey period.

3.3 Behavioral and Perception Surveys

To capture public perception and behavioral responses, two structured surveys were conducted:

- A driver survey (n = 210) covering vehicle operators from diverse categories such as cars, motorcycles, autos, and buses. Questions focused on comfort, compliance, awareness of speed breaker signage, and safety perceptions.
- A pedestrian survey (n = 150), targeting people who frequently cross near speed breaker locations. Respondents were asked about their sense of safety, driver behavior, and suggestions for improvement.

These surveys were pre-tested, translated into local language (Hindi), and conducted via in-person interviews.

3.4 Traffic Flow Simulation Modeling

To complement field data, microsimulation modeling was conducted using PTV VISSIM. The simulation framework recreated real-life traffic conditions at two representative sites—one with a standard speed table (Shaheed Path) and one with a poorly designed hump (Faizabad Road). The input parameters included:

- Traffic volume by vehicle class

- Geometric data of road segment and speed breaker
- Vehicle acceleration/deceleration profiles
- Lane configurations and saturation flow

Three scenarios were modeled:

1. Baseline Scenario – No speed breaker
2. Standard Hump Scenario – As per IRC:99-2018
3. Non-Standard Hump Scenario – As found in Faizabad Road

Simulation was run for 120-minute periods with 3 replications each, and results were analyzed for average speed, queue length, delay per vehicle, and vehicular emissions.

3.5 Data Analysis Techniques

- Descriptive statistics were used to evaluate average speed, delay, queue length, and accident trends.
- Comparative bar charts and tables were used to visualize differences between standard and non-standard breakers.
- Regression analysis was conducted to estimate the relationship between vehicle speed reduction and delay per vehicle.
- Emissions (CO_2, NO_x) and fuel consumption estimates were calculated using default emission factors from MoRTH and IPCC guidelines.

4. Results and Analysis

To assess how speed breakers affect vehicle performance and traffic fluidity, spot speed measurements were conducted at three points: before, on, and after each speed breaker. In parallel, vehicle delay and queue lengths were estimated using time-lapse analysis and manual logs.

Table 4.1 – Average Vehicle Speeds and Delay at Selected Sites

Location	Type of Breaker	Speed Before (km/h)	Speed on Breaker (km/h)	Speed After (km/h)	Avg Delay per Vehicle (sec)	Avg Queue Length (m)
Faizabad Road (Chinhat)	Non-standard hump	43.5	16.2	29.4	23.8	72
Shaheed Path (Medanta)	Standard table	46.1	24.6	35.3	11.4	28
Aliganj Sector K (School)	Irregular hump	39.2	13.7	25.0	26.5	83
Charbagh Road	Steep patch	40.5	15.3	27.8	21.7	60
Sitapur Road (IIM Gate)	Standard table	44.9	22.3	33.6	12.1	31

Interpretation:

- **Speed Reduction Pattern:**
  Across all sites, vehicle speeds decreased sharply on the speed breaker, with reductions ranging from 45% to 65% depending on the geometry. Standard tables (e.g., Shaheed Path) allowed smoother transitions and faster recovery of speed post-hump, maintaining better flow.
- **Delay Analysis:**
  The average delay per vehicle at non-standard or irregular humps (e.g., Aliganj, Faizabad Road) was nearly double that of standard sites. This suggests that improper slope gradients and abrupt transitions force harsher deceleration and longer dwell time.
- **Queue Length Observation:**
  The queue lengths formed during morning peak hours were highest at Aliganj (83 meters) and Faizabad Road (72 meters), pointing to significant congestion. In contrast, Sitapur Road and Shaheed Path showed much shorter queues, owing to better design and signage.
- **Design Matters:**
  Breakers built as per IRC:99-2018 standards showed a 30–45% improvement in both speed recovery and delay minimization over non-standard humps.
- **Traffic Flow Efficiency:**
  Smooth traffic flow was observed only where speed breakers were well-marked, gently ramped, and integrated with pedestrian crossings—validating international findings (FHWA, 2017; IRC, 2018).

4.2 Safety and Accident Trends

The primary objective of speed breakers is to enhance road safety by reducing vehicular speeds, particularly in pedestrian-dense and accident-prone zones. This section analyzes the safety outcomes of different speed breaker types using accident data from 2020 to 2022, along with near-miss observations collected during field visits.

Table 4.2 – Accident and Near-Miss Data (2020–2022) by Location

Location	Type of Speed Breaker	Minor Accidents	Major Accidents	Fatalities	Near-Miss Incidents (Observed)
Faizabad Road (Chinhat)	Non-standard hump	22	8	2	17
Shaheed Path (Medanta)	Standard table	5	1	0	4
Aliganj Sector K (School)	Irregular hump	18	6	1	19
Charbagh Road	Steep patch	15	5	2	13
Sitapur Road (IIM Gate)	Standard table	4	0	0	3

Source: Lucknow Traffic Police (RTI response); On-site observation journals.

Interpretation and Analysis

- **Fatality and Injury Trends:**
  Fatal accidents were reported in three of the five locations, all of which featured either non-standard or steeply designed speed breakers. In contrast, locations with standard tables (Shaheed Path and Sitapur Road) recorded no fatalities during the 3-year period.
- **Effectiveness of Standard Speed Breakers:**
  Sites like Shaheed Path and Sitapur Road exhibited significantly fewer minor and major crashes. The better outcomes are attributed to compliant designs that maintain visibility, smoother vehicle transitions, and effective warning signage. These findings align with previous research indicating that compliant speed breakers reduce crash rates by up to 40–60% (Singh & Tiwari, 2019).
- **Near-Miss Incidents:**
  Field observers noted frequent near-miss events at Aliganj Sector K and Faizabad Road, often involving two-wheelers and pedestrians. Most of these events occurred due to sudden braking or unpredictable driver maneuvers to avoid discomfort.

5. Discussion

The findings from this study reinforce the notion that speed breakers serve as effective traffic calming devices when designed and deployed appropriately. The empirical data collected from diverse urban sites in Lucknow clearly illustrate a dual impact: improved road safety, especially for vulnerable road users, and measurable trade-offs in traffic flow performance. Standard-compliant speed breakers—characterized by appropriate height, width, slope gradients, and signage—demonstrated significant benefits in terms of reducing vehicle speeds without inducing excessive delay or discomfort. These installations also correlated with lower accident rates and fewer near-miss incidents, validating their intended purpose as per IRC:99-2018 and global best practices (Singh & Tiwari, 2019; FHWA, 2017).

In contrast, non-standard or improperly installed speed breakers not only failed to ensure safety but also introduced new operational challenges. Sites like Faizabad Road and Aliganj Sector K experienced longer queue lengths, higher vehicle delays, and increased emissions due to abrupt deceleration and acceleration patterns. Furthermore, field observations and survey responses highlighted that drivers often reacted unpredictably to these irregular humps—either by swerving or braking sharply—potentially endangering trailing vehicles or nearby pedestrians. These unintended outcomes underscore the critical importance of geometric standardization and contextual placement based on traffic composition and land use.

Another vital insight from the study is the public perception gap. While most drivers and pedestrians acknowledged the need for speed breakers near schools and hospitals, there was strong disapproval of unmarked or excessive installations on arterial roads. This mismatch between policy intentions and user experience suggests a need for more inclusive planning involving road users, urban planners, and traffic enforcement authorities. The simulation results using VISSIM also provided a controlled validation of real-world effects, confirming that compliant speed tables yielded 30–45% less delay compared to irregular humps, and reduced emissions by up to 18%.

6. Conclusion

This study has provided a comprehensive assessment of the impact of speed breakers on traffic flow and road safety using a mixed-methods approach comprising field data, simulation modeling, and public perception analysis. The results clearly demonstrate that properly designed and strategically placed speed breakers significantly improve safety outcomes, particularly in high-risk zones such as school areas and hospital vicinities. Sites equipped with IRC-compliant speed tables showed markedly lower accident rates, reduced near-miss incidents, and smoother vehicular flow when compared to locations with irregular or non-standard humps. These findings confirm the critical role that geometric accuracy, advance signage, and contextual relevance play in ensuring the effectiveness of speed calming infrastructure.

However, the study also reveals important trade-offs. Poorly implemented speed breakers not only fail to enhance safety but also cause operational inefficiencies such as increased vehicle delays, longer queue lengths, higher fuel consumption, and elevated emissions. These adverse effects were particularly evident at sites like Faizabad Road and Aliganj Sector K, where non-standard humps were found to disrupt the traffic stream and frustrate drivers. Survey data further indicate a substantial public dissatisfaction with the visibility, placement, and frequency of speed breakers on arterial roads—emphasizing the disconnect between policy enforcement and user experience.

The simulation results validate the real-world observations, confirming that compliant speed breakers reduce delay by 30–45% and emissions by up to 18% when compared to non-compliant installations. These findings highlight that traffic safety and operational efficiency are not mutually exclusive, but must be balanced through proper engineering, planning, and feedback integration. The study also underscores the need for intelligent, context-sensitive solutions such as smart speed breakers and sensor-based enforcement systems that adapt to real-time traffic behavior, rather than relying on static devices that may become counterproductive over time.

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