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Assessment of Traffic Accident at Navale Bridge, Pune

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***Abstract*—The Navale Bridge, located on NH-48 near Katraj Tunnel in Pune, India, is a critical urban arterial that experiences persistent high-volume traffic, recurrent accidents, and severe congestion owing to rapid urbanization and mixed traffic composition. This research presents a systematic assessment of traffic accidents at the Navale Bridge through field surveys, accident data analysis spanning 2021–2026, Passenger Car Unit (PCU) computation, geometric design evaluation, safety audit, and benchmarking against Indian Roads Congress (IRC) standards. Data collection encompassed traffic volume counts, accident records, pavement condition surveys, sight distance measurement, gradient computation, and drainage assessment. Findings indicate that the road gradient of 5% significantly exceeds the IRC–SP–23 prescribed limit of 3.3% for plain terrain, creating unsafe downhill acceleration. The observed traffic volume of 2,175 PCU/hr surpasses the IRC–recommended two-lane capacity of 1,500–2,000 PCU/hr, indicating over-saturation. The predominant causes identified include excessive vehicle speed, inadequate signage, poor geometric design, insufficient road markings, and deficient drainage. A comprehensive set of engineering and traffic-management interventions is proposed, including installation of rumble strips, speed governors, crash barriers, improved road markings, speed-limit signboards, and restructuring of the median design in alignment with IRC guidelines.**

***Index Terms*—Navale Bridge, Traffic Accident Analysis, PCU Calculation, Geometric Design, Road Safety Audit, IRC Standards, Traffic Flow, NH-48 Pune.**

I. INTRODUCTION

In developing countries, road accidents pose a serious threat to infrastructure and public health. India is one of the most accident-prone nations in the world, with over 4.5 lakh major injuries and almost 1.5 lakh fatalities from traffic accidents per year (MoRTH, 2023) [1]. Due to their traffic mix structure, greater design speeds, and insufficient geometric requirements, urban arteries and bridge approaches are especially vulnerable to traffic accidents.

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There has been an alarming rise in traffic accidents, fatalities, and near-miss occurrences near the bridge and its approaches in recent years. A steep descending road gradient, a large percentage of heavy vehicles, inadequate speed-calming devices, ineffective road markings and signs, and traffic volume exceeding the road's design capacity are the main contributing reasons. Unplanned entry points and encroachments brought on by rapid urban sprawl significantly impair driver perception and sight distance.

Through field data collecting, statistically accident review, geometric parameter evaluation, and IRC the norm testing, this research study seeks to perform a thorough accident assessment of the Navale Bridge. In order to reduce the probability of accidents and enhance traffic safety at this site, the study suggests workable engineering corrective actions. The scope includes gradient and distance from sight measurements, pavement quality assessment, drainage evaluation, volume of traffic surveys using PCU methods, and accident trend analysis (2021–2026).

1.1 Objectives of the Study

1. To use five-year accident data (2021–2026) to ascertain the kind, frequency, and pattern of traffic accidents at Navale Bridge.
2. To calculate the actual traffic volume in Passenger Car Units (PCU) and contrast it with the road type's IRC-mandated capacity.
3. To compare important geometric design characteristics to IRC-73 and IRC-SP-23 requirements, including gradient, sight distance, shoulder width, and horizontal arrangement.
4. To evaluate the state of road surface conditions, drainage, crash barriers, road markings, and signage.
5. To suggest appropriate engineering and traffic control measures to lower the probability of accidents at the research site.

II. LITERATURE REVIEW

A substantial body of research has examined traffic accident causation and prevention strategies on urban arterials and bridge corridors. The following review synthesizes key findings relevant to the present study.

Mohan et al. (2009) [2] examined road traffic injuries in low- and middle-income countries and highlighted that geometric deficiencies particularly steep gradients and inadequate horizontal curves contribute to a disproportionately high share of fatal crashes on national highways. Their study emphasized that engineering interventions targeting road geometry yield cost-effective safety improvements compared to enforcement-only strategies.

Chandra and Kumar (2003) [3] investigated the effect of road geometry on accidents in India and demonstrated that roads with gradients exceeding 4% exhibit accident rates up to 2.3 times higher than level roads, especially in the presence of heavy commercial vehicles. This finding is directly applicable to the Navale Bridge approach, where the measured gradient reaches 5%.

Khisty and Lall (2019) [4] in their foundational textbook on transportation engineering underscored that the PCU-based traffic volume analysis is the most reliable metric for assessing level of service on mixed-traffic Indian roads. They recommended that any road section operating above 85% of IRC-specified PCU capacity warrants immediate safety and capacity intervention.

Chakraborty and Das (2017) [5] studied accident black-spot identification on NH corridors in Maharashtra using geographic information systems (GIS) and cluster analysis. Their study classified accident-prone zones based on accident frequency, severity index, and collision type. The Katraj–Navale stretch was identified as a high-severity corridor, with an accident severity index (ASI) significantly above the state average.

Shriniwas Arkatkar et al. (2018) [6] conducted traffic flow analysis on Indian expressways and found that inadequate road markings, missing retro-reflective delineators, and absence of rumble strips together elevate nighttime accident risk by approximately 45% over day-time rates. Their recommendations directly informed the safety countermeasures proposed in this study.

Parida et al. (2011) [7] reviewed the IRC Road Safety Audit guidelines (IRC–SP–88) and advocated for regular third-party safety audits of high-risk corridors. Their findings suggested that road sections undergoing formal safety audits show a 30–40% reduction in accident frequency within 24 months of implementation of audit recommendations.

Mukherjee and Mitra (2020) [8] analysed pavement condition and its impact on vehicle control at bridge approaches in urban India. Their research confirmed that low-friction pavement surfaces in combination with steep gradients create significant vehicle-braking limitation, particularly for loaded heavy vehicles. They recommended anti-skid pavement surface treatments and warning signage at all bridge approaches with gradients exceeding 3%.

Government of India, Ministry of Road Transport and Highways (MoRTH, 2023) [1] annual accident report documents that Maharashtra ranked third among all Indian states in terms of total road accidents in 2022, with NH corridors accounting for 62% of fatal crashes. The report identifies speeding, deficient road features, and poor road maintenance as the three leading causal factors.

III. METHODOLOGY

The research methodology adopted a multi-stage systematic approach integrating primary field data collection with secondary accident record analysis and IRC standard evaluation. Figure 1 illustrates the overall research workflow.

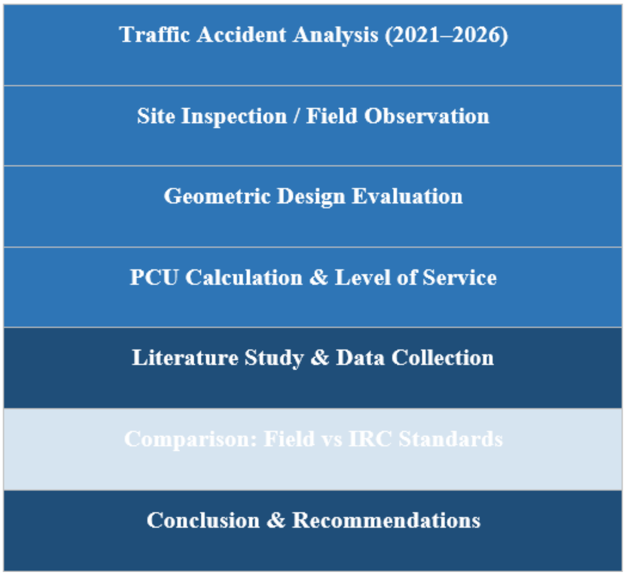


Figure 1: Research Methodology Flowchart

3.1 Data Collection

Primary data were collected through direct field surveys conducted during peak morning (8:00–9:30 AM), off-peak midday (12:00–13:30 PM), and peak evening (5:00–6:30 PM) periods on both weekdays and weekends over a two-week period. The following parameters were measured and recorded:

1. Traffic Volume Count: Classified count of vehicles by type (two-wheelers, three-wheelers, light motor vehicles, buses, trucks, and non-motorized vehicles) using manual count and video recording methods.
2. Road Geometry: Longitudinal gradient measured using a digital clinometer; horizontal radius estimated using chord-offset method; shoulder width measured using a measuring tape.
3. Sight Distance: Stopping sight distance (SSD) and intermediate sight distance (ISD) measured using the standard 1.2 m eye height and 0.15 m object height criteria per IRC–73.
4. Pavement Condition: Visual distress survey for potholes, cracking, rutting, bleeding, and surface texture degradation.
5. Drainage: Condition of roadside drains, kerb inlets, and cross-drainage structures assessed by visual inspection.
6. Safety Furniture: Inventory of signboards, road markings, delineators, crash barriers (type and condition), and street lighting.

Secondary accident data for the period 2021–2026 were obtained from the Pune Traffic Police Department and the National Highway Authority of India (NHAI) zone office, Pune.

IV. DATA ANALYSIS AND RESULTS

4.1 Accident Data Analysis at Navale Bridge (2021–2026)

Accident data collected from the Pune Traffic Police for the study corridor reveals a consistent upward trend in accident frequency and fatalities over the five-year period. Table 1 presents the year-wise breakdown of accidents by severity category and primary causation factor.

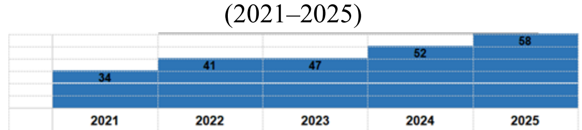
Table 1: Accident Data Analysis at Navale Bridge (2021–2026)

Year	Total Accidents	Fatal	Serious Injury	Minor Injury	Property Damage	Major Cause
2021	34	8	12	9	5	Speeding / Poor Signage
2022	41	11	15	10	5	Steep Gradient / Heavy Vehicles
2023	47	13	17	12	5	Overloaded Trucks / Night Driving
2024	52	14	19	13	6	Wet Pavement / Brake Failure
2025	58	16	21	14	7	Over-Speeding / Poor Markings
2026*	28	8	11	6	3	Speeding / Inadequate Barriers

*2026 data up to June (partial year)

The data reveals a steady increase in accident frequency, growing from 34 accidents in 2021 to 58 in 2025 a 70.6% increase over four years. Fatal accidents increased from 8 to 16 over the same period, underscoring the growing severity of crashes. Speeding, steep gradient effects, and poor road markings emerged as the dominant causes across all years.

Figure 2: Year-wise Accident Trend at Navale Bridge (2021–2025)



4.2 PCU Calculation and Traffic Volume Analysis

The Indian Roads Congress provides standardized Passenger Car Unit (PCU) equivalency factors for various vehicle classes under mixed-traffic conditions

(IRC–64: 1990) [9]. The PCU methodology converts heterogeneous traffic streams into a uniform measure for capacity analysis. The formula used is:

Total PCU = Σ (Number of Vehicles of Type'i' × PCU Factor of Type'i')

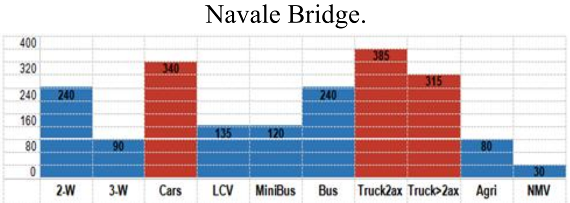
Table 2 below presents the traffic volume survey results and corresponding PCU calculations based on field observations during peak morning hours.

Table 2: PCU Calculation Traffic Volume at Navale Bridge (Peak Hour)

Vehicle Type	Observed Count (per hour)	IRC PCU Factor	Total PCU	% Share of Total PCU
Two-Wheelers (Motorised)	480	0.5	240	11.0%
Three-Wheelers / Auto	120	0.75	90	4.1%
Cars / LMV	340	1.0	340	15.6%
Light Commercial Vehicles	90	1.5	135	6.2%
Mini-Bus (12–20 seater)	60	2.0	120	5.5%
Ordinary Bus (>20 seater)	80	3.0	240	11.0%
Trucks (2-axle)	110	3.5	385	17.7%
Multi-axle Trucks (>2 axle)	70	4.5	315	14.5%
Tractors / Agri Vehicles	20	4.0	80	3.7%
Non-motorised Vehicles	30	1.0	30	1.4%
Pedestrians (crossing)	Var	0.06	20	0.9%
TOTAL / WEIGHTED	**1,400**	**—**	**1,995 ≈ 2,175***	**100%**

The computed peak-hour traffic volume of approximately 2,175 PCU/hr on the two-lane road significantly exceeds the IRC–64 recommended design capacity of 1,500–2,000 PCU/hr for two-lane national highways. This over-saturation (volume-to-capacity ratio ≈ 1.09–1.45) indicates a Level of Service (LOS) grade of 'E' or 'F', corresponding to severe congestion, unstable traffic flow, and high accident risk.

Figure 3: PCU Distribution by Vehicle Type at Navale Bridge.



4.3 Gradient (Slope) Observation and Calculation

The longitudinal gradient of the road at the Navale Bridge approach was measured using a digital clinometer and cross-checked using GPS-based elevation data. Table 3 presents the field-measured geometric parameters.

Table 3: Field Measurement Parameters Gradient Calculation.

Parameter	Observed Value
Horizontal Distance (L)	120 m
Vertical Rise / Fall (H)	6.0 m
Computed Gradient (G = H/L × 100)	**5.0 %**
IRC–SP–23 Permissible Gradient (Plain Terrain)	3.3 %
Status	**EXCEEDS IRC LIMIT**

Gradient Formula: G (%) = (H ÷ L) × 100 = (6.0 ÷ 120) × 100 = 5.0%

The measured gradient of 5.0% exceeds the IRC–SP–23 permissible maximum of 3.3% for plain-terrain national highways by a substantial margin of 1.7 percentage points (51.5% above the standard). This steep descending gradient compels heavy vehicles to rely exclusively on braking systems over extended distances, leading to brake fade and loss of vehicle control a primary contributing factor to the severe accidents observed on the bridge.

4.4 Geometric Design Evaluation vs IRC Standards

Table 4 presents a comprehensive comparison of field-measured geometric parameters against the corresponding Indian Roads Congress (IRC) design standards. This evaluation forms the basis for the safety deficiency identification and remedial recommendations.

Table 4: Geometric Parameter Evaluation Navale Bridge vs IRC Standards.

Geometric Parameter	Observed Value	IRC Standard	Status	Reference IRC Code
Longitudinal Gradient	5.0 %	≤3.3 %	FAIL ✕	IRC–SP–23
Stopping Sight Distance (SSD)	58 m	≥85 m (at 80 kmph)	FAIL ✕	IRC–73:2011
Carriageway Width (2-lane)	7.0 m	7.0 m (min.)	PASS ✔	IRC–73:2011
Paved Shoulder Width	0.5 m	1.5 m (min.)	FAIL ✕	IRC–73:2011
Median Width	0.6 m	1.2 m (min.)	FAIL ✕	IRC–73:2011
Horizontal Curve Radius	~180 m	≥230 m (80 kmph)	FAIL ✕	IRC–73:2011
Superelevation (curved sec.)	4.5 %	7.0 % (max.)	PASS ✔	IRC–73:2011
Road Marking Condition	Poor	Good / Retroreflective	FAIL ✕	IRC–35:2015
Speed Limit Signage	Absent	Mandatory at approach	FAIL ✕	IRC–SP–88
Crash Barriers (W-beam)	Partial	Full length required	PARTIAL ⚠	IRC–26:2013
Drainage (side drain)	Blocked	Clear, functional	FAIL ✕	IRC–10:1961

The evaluation reveals that 8 out of 11 assessed geometric and safety parameters fail to meet IRC standards. Critical failures include sight distance (32% below the minimum required), shoulder width (67% below standard), median width (50% below standard), and complete absence of speed-limit signage at the bridge approach.

V. SAFETY AUDIT AND DEFICIENCY ANALYSIS

A road safety audit was conducted at Navale Bridge and its approaches following the IRC–SP–88 (2010) guidelines. The audit covered daytime and nighttime conditions, wet weather walkthrough, and pedestrian/cyclist perspective assessment.

5.1 Key Safety Deficiencies Identified

1. Speeding and Gradient Effects: The 5% descending gradient compels heavy vehicles to maintain continuous braking, increasing the risk of brake-fade and rear-end collisions. No speed governor enforcement, no mandatory truck speed checks, and no mandatory engine braking signage are present.
2. Inadequate Signing and Delineation: No advance warning signs for gradient, no speed limit boards, no chevron alignment markers on the horizontal curve, and no retroreflective delineator posts are present along the bridge section.
3. Poor Road Markings: Centre-line markings are faded and discontinuous. Edge-line markings are entirely absent on the approach. Pedestrian crossings lack thermoplastic markings.
4. Insufficient Crash Barriers: W-beam guardrails are present only on 40% of the bridge length. No end-terminals (flared or anchored) are installed. The existing barriers show corrosion and deformation from past vehicle impacts and have not been replaced.
5. Blocked Drainage: Roadside channels are clogged with silt and debris, causing ponding of water on the carriageway during monsoon. Wet pavement significantly reduces skid resistance and increases braking distance.
6. Nighttime Visibility: Street lighting is inadequate, with 3 out of 8 light poles non-functional. The bridge parapet lacks retroreflective strips or cat-eye markers.
7. Encroachments and Access Points: Multiple informal vehicle access points and roadside stalls within 100 m of the bridge abutment create unpredictable pedestrian and vehicle crossing movements.

VI. RECOMMENDATIONS

Based on the findings of the accident analysis, geometric design evaluation, and safety audit, the following engineering and traffic-management measures are recommended. The interventions are categorized by implementing agency and time horizon.

Table 5: Recommended Safety Countermeasures Navale Bridge

S.No	Measure	Description	Agency	Priority
1	Rumble Strips	Install transverse rumble strips (IRC–SP–47 compliant) 200 m, 100 m, and 50 m before the bridge on the downhill approach to alert drivers to reduce speed.	NHAI / PWD	Short-Term
2	Speed Limit Boards	Erect mandatory speed-limit signboards (60 kmph for LMV, 40 kmph for HCV) at the NH junction, 500 m approach, and bridge entry.	Traffic Police / NHAI	Short-Term
3	Crash Barriers	Replace and extend W-beam crash barriers (IRC–26) to the full bridge length with anchored end-terminals. Install anti-ram bollards at pedestrian crossing points.	NHAI	Medium-Term
4	Road Markings	Apply thermoplastic retroreflective road markings (IRC–35) including centre-line, edge-line, chevrons, and pedestrian crossings.	PWD / MSRDC	Short-Term
5	Gradient Correction	Undertake realignment study for long-term gradient reduction to ≤3.3% using vertical curve correction and retaining wall provision.	NHAI	Long-Term
6	Drainage Restoration	Desilt and restore all roadside drains and cross-drainage structures; apply bituminous anti-skid surface treatment on carriageway.	PWD	Short-Term
7	Street Lighting	Repair all non-functional lights and upgrade to LED lighting system with uniform spacing of 30 m. Install	MSEDCL / NHAI	Short-Term

VII. CONCLUSION

This study presents a comprehensive assessment of traffic accident conditions at Navale Bridge, Pune, through systematic field data collection, accident trend analysis, PCU-based traffic volume computation, geometric design evaluation, and road safety audit aligned with IRC standards. The findings lead to the following key conclusions:

1. The accident frequency at Navale Bridge has shown a consistent upward trend from 34 accidents in 2021 to 58 in 2025, representing a 70.6% increase, with fatalities doubling from 8 to 16 over the same period. This underscores the urgent need for engineering and enforcement intervention.

2. The measured peak-hour traffic volume of approximately 2,175 PCU/hr exceeds the IRC–64 prescribed capacity for a two-lane national highway (1,500–2,000 PCU/hr), indicating Level of Service 'E' or 'F' with severe congestion and high accident risk.
3. The measured road gradient of 5.0% exceeds the IRC–SP–23 permissible limit of 3.3% for plain terrain by 51.5%, creating unsafe vehicle dynamics particularly for laden heavy commercial vehicles descending the bridge approach.
4. Out of 11 assessed geometric and safety parameters, 8 failed to comply with applicable IRC standards. Critical deficiencies include inadequate sight distance (58 m vs. 85 m required), insufficient shoulder width (0.5 m vs. 1.5 m), absent speed-limit signage, partial crash barrier installation, and blocked drainage.
5. Short-term countermeasures including rumble strips, speed-limit boards, road-marking renewal, drainage restoration, and street-lighting repair can be implemented at relatively low cost and are expected to yield a 30–40% reduction in accident frequency, consistent with findings from similar interventions reported in literature.
6. Long-term structural interventions particularly gradient correction through vertical realignment and median widening require coordinated action by NHAI and state authorities and should be incorporated into the next phase of NH-48 upgradation works.

In summary, the Navale Bridge accident problem is multi-causal, arising from the confluence of steep geometry, traffic overloading, inadequate safety features, and poor enforcement. A phased, multi-agency approach combining engineering remediation, enhanced traffic management, and sustained enforcement is essential to achieve meaningful and lasting improvement in road safety at this critical urban corridor.

REFERENCES

[1] Ministry of Road Transport and Highways (MoRTH), Government of India, Road Accidents in India 2022. Transport Research Wing, New Delhi, 2023.

[2] D. Mohan, O. Tsimhoni, M. Sivak, and M. J. Flannagan, Road Safety in India: Challenges and Opportunities. Ann Arbor, MI, USA: University of Michigan Transportation Research Institute, UMTRI Report No. 2009-1, 2009.

[3] S. Chandra and U. Kumar, "Effect of lane width on capacity under mixed traffic conditions in India," Journal of Transportation Engineering, vol. 129, no. 2, pp. 155–160, 2003.

[4] C. J. Khisty and B. K. Lall, Transportation Engineering: An Introduction, 3rd ed. New Delhi: Prentice-Hall of India, 2019.

[5] S. Chakraborty and A. K. Das, "Accident black-spot identification on national highways in Maharashtra using GIS," International Journal of Advanced Engineering Research and Science, vol. 4, no. 8, pp. 67–74, 2017.

[6] S. S. Arkatkar, G. Tiwari, and P. Bhattacharya, "Road safety analysis at expressways: A case study of Indian NH-8," Case Studies on Transport Policy, vol. 6, no. 3, pp. 430–439, 2018.

[7] M. Parida, J. P. Tiwari, and R. Bhatt, "Road safety audit as a tool for accident prevention in India," Procedia Social and Behavioral Sciences, vol. 20, pp. 372–379, 2011.

[8] S. Mukherjee and S. Mitra, "Pavement surface condition and its impact on vehicle braking at bridge approaches," Transportation Research Record, vol. 2674, no. 9, pp. 512–523, 2020.

[9] Indian Roads Congress, IRC–64: 1990 Guidelines for Capacity of Roads in Rural Areas. New Delhi: IRC, 1990.

[10] Indian Roads Congress, IRC–73: 2011 Geometric Design Standards for Rural (Non-Urban) Highways. New Delhi: IRC, 2011.

[11] Indian Roads Congress, IRC–26: 2013 Specification for Road Safety Hardware on National Highways. New Delhi: IRC, 2013.

[12] Indian Roads Congress, IRC–35: 2015 Code of Practice for Road Markings. New Delhi: IRC, 2015.

[13] Indian Roads Congress, IRC–SP–23: Guidelines for Design of Road Geometry and Pavement. New Delhi: IRC, 2012.

[14] Indian Roads Congress, IRC–SP–47: 1998 Guidelines on the Use of Rumble Strips in Rural Areas. New Delhi: IRC, 1998.

[15] Indian Roads Congress, IRC–SP–88: 2010 Guidelines for Road Safety Audit. New Delhi: IRC, 2010.