

Assessment of Road Traffic Accident Causes and Safety Improvement Measures on the Qomandani Bridge–Darunta Tunnel Road Corridor in Jalalabad City, Afghanistan

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Abstract— Road traffic accidents represent a major public health and transportation safety challenge, particularly in developing countries where rapid urbanization, increasing motorization, and inadequate safety management systems contribute to higher crash risks. This study evaluates the major contributing factors associated with road traffic accidents and identifies road safety improvement strategies along the Qomandani Bridge–Darunta Tunnel corridor in Jalalabad City, Afghanistan. A mixed-method research approach was adopted by integrating five years of traffic accident records (2020–2024) obtained from the Nangarhar Traffic Management Department with field observations, road condition assessments, vehicle speed observations, and driver interviews. The analysis examined the relationship between accident occurrence and key factors, including vehicle speed, road geometric characteristics, traffic control devices, and driver behavior. The results showed that 51 traffic accidents were recorded along the study corridor during the investigated period. The Jangal Bagh–Do Saraki section experienced the highest accident concentration, accounting for 50.98% of total recorded accidents, which was associated with excessive vehicle speed, limited sight distance, horizontal curve deficiencies, and inadequate traffic control facilities. The Do Saraki–Qomandani Bridge section accounted for 27.45% of accidents, while the Darunta–Surkh Ab Bridge section represented 21.56%. The findings indicate that excessive speed, geometric design deficiencies, inadequate traffic control devices, weak enforcement of traffic regulations, and limited availability of modern traffic monitoring systems are important factors affecting road safety performance along the corridor. The study recommends implementing speed management strategies, improving geometric design elements, installing appropriate traffic control devices, providing pedestrian and vehicle stopping facilities, strengthening enforcement, and adopting intelligent transportation technologies to enhance road safety in Jalalabad City and similar developing urban environments.

Keywords — Road Traffic Accidents; Speed Management; Road Geometric Design; Traffic Control Devices (TCDs); Intelligent Transportation Systems (ITS).

I. INTRODUCTION

Rapid advancements in transportation systems have significantly improved mobility, accessibility, and economic development worldwide. Increasing urbanization, population growth, and rising travel demand have resulted in continuous growth in vehicle ownership and transportation activities. Along with these developments, modern vehicles with higher operating speeds and improved performance characteristics have become increasingly common. Although these advancements provide substantial benefits to society, they have also created serious challenges related to road traffic safety, particularly in areas where transportation infrastructure and safety management systems have not developed at the same pace.

Road traffic accidents remain one of the leading causes of death, injury, and economic loss worldwide. According to the World Health Organization (WHO), approximately 1.19 million people lose their lives annually due to road traffic crashes, while millions of others suffer non-fatal injuries that often result in long-term physical, social, and economic consequences (World Health Organization[1]). Beyond human suffering, road traffic crashes impose considerable financial costs on societies through medical expenses, productivity losses, property damage, and emergency response requirements. Therefore, improving road safety has become a major priority for transportation authorities and policymakers worldwide.

The severity and frequency of road traffic crashes are influenced by a combination of factors, including vehicle speed, road infrastructure characteristics, traffic management practices, vehicle conditions, and road user behavior. Among these factors, excessive speed is widely recognized as one of the most critical contributors to crash occurrence and severity.

The International Transport Forum (ITF) reported that increases in average vehicle speed significantly increase the probability of injury and fatal crashes, demonstrating the strong relationship between speed management and road safety performance [2]. Similarly, inappropriate speed reduces driver reaction time, increases stopping distance, and amplifies crash severity when collisions occur.

In addition to speed-related factors, road geometric characteristics play a fundamental role in determining traffic safety conditions. Deficiencies in roadway alignment, inadequate sight distance, inappropriate lane widths, insufficient roadside protection, and poorly designed intersections can increase crash risks. Previous studies have demonstrated that appropriate geometric design elements, including adequate horizontal curve radii, proper lane configurations, and improved roadway visibility, contribute significantly to reducing accident frequency and severity [3]. Furthermore, roadside conditions, parking practices, and inadequate pedestrian facilities may negatively affect visibility and vehicle maneuverability, particularly in urban environments.

Traffic control devices and enforcement mechanisms are also essential components of effective road safety management. Proper installation and maintenance of road signs, pavement markings, traffic signals, speed control measures, and monitoring systems help regulate traffic movement and reduce conflicts among road users. International road safety assessment frameworks, such as the International Road Assessment Programme (iRAP), emphasize that safer roads require appropriate speed management, traffic separation, pedestrian facilities, and advanced safety technologies, including intelligent transportation systems (ITS) [4]. The integration of modern traffic monitoring technologies can further support accident prevention through improved enforcement and real-time traffic management.

Recent research has further emphasized that road traffic safety is influenced by the interaction of vehicle speed, road infrastructure, traffic regulation, and road user behavior. A comprehensive meta-analysis found that changes in traffic speed have a strong and consistent relationship with road safety, with higher speeds associated with increased crash risk and greater injury severity [5].

In low- and middle-income countries, systematic evidence indicates that enforcement of traffic regulations, speed management, and engineering interventions can substantially contribute to reducing road traffic injuries and fatalities [6].

The identification of hazardous road locations or accident black spots is also an important component of road safety management. Previous research has demonstrated that different analytical methods can be used to identify locations with unusually high concentrations of crashes and to prioritize safety interventions [7].

Recent studies have also compared crash frequency, crash rate, and Empirical Bayes approaches for identifying hazardous road locations, highlighting the importance of selecting an appropriate method for prioritizing safety improvements [8]. Road Safety Audits provide another important approach for identifying potential safety deficiencies in road infrastructure. Reviews of international Road Safety Audit practices indicate that geometric design, traffic signs, road markings, safety devices, and other roadway characteristics are important components of systematic safety assessment.[9].

Furthermore, recent research has demonstrated that Geographic Information Systems (GIS) can effectively support the spatial analysis of crashes, identification of accident black spots, and development of targeted road safety measures [10]. These findings support the adoption of a comprehensive and systematic approach to road safety in developing urban areas. The Safe System approach emphasizes that road safety should not depend solely on driver behavior but should integrate safe road infrastructure, appropriate travel speeds, safer vehicles, effective enforcement, and appropriate post-crash responses [11]. Therefore, a corridor-level assessment that combines historical accident data, field observations, vehicle speed assessment, road geometric characteristics, and traffic control conditions can provide a more comprehensive understanding of the factors contributing to road traffic accidents. Road safety challenges are particularly severe in developing countries due to rapid motorization, limited infrastructure investment, weak enforcement capacity, and insufficient safety awareness. Afghanistan faces many of these challenges, where increasing vehicle ownership and urban expansion have not been fully supported by adequate road safety infrastructure and management systems. In Afghan cities, including Jalalabad, many road corridors experience mixed traffic conditions, high-speed vehicle movement, insufficient pedestrian facilities, limited traffic control devices, and inadequate enforcement of traffic regulations. These conditions increase the vulnerability of road users and contribute to higher crash risks.

Although numerous studies have investigated road traffic safety issues in developed and developing countries, limited research has focused on identifying accident-contributing factors and proposing context-specific safety improvements for urban road corridors in Afghanistan. In particular, the Qomandani Bridge–Darunta Tunnel corridor in Jalalabad City experiences significant traffic activity and contains several safety-related challenges, including high vehicle speeds, geometric deficiencies, inadequate traffic control facilities, and mixed traffic interactions. However, systematic assessment of accident patterns and safety conditions along this corridor remains limited. Therefore, this study aims to assess the contributing factors associated with road traffic accidents along the Qomandani Bridge–Darunta Tunnel corridor in Jalalabad City, Afghanistan. The study analyzes traffic accident records, field observations, road geometric characteristics, vehicle speed conditions, and existing traffic control facilities to identify major safety deficiencies. Based on the findings, practical and context-specific road safety improvement strategies are proposed to assist transportation authorities, urban planners, and decision-makers in reducing traffic risks and improving road safety performance in Jalalabad City and similar developing urban environments.

II. MATERIALS AND METHODS

Study Area

The study was conducted along the road corridor extending from Qomandani Pul (Bridge) to the Darunta Tunnel in Jalalabad City, Nangarhar Province, Afghanistan. This corridor is one of the city's major arterial roads, accommodating high traffic volumes and connecting residential, commercial, and industrial areas. Due to increasing traffic demand, high operating speeds, and geometric deficiencies at several locations, the corridor has experienced a considerable number of road traffic accidents in recent years.

Study Materials

This study utilized both primary and secondary data sources to investigate the causes of road traffic accidents and identify appropriate safety improvement measures. **Traffic Accident Records:** Official traffic accident records covering the period from January 2020 to December 2024 were obtained from the Nangarhar Traffic Management Department. The records included accident date, accident location, vehicle type, and the number of fatalities and injuries.

Field Observations: Detailed field surveys were conducted along the study corridor to evaluate roadway characteristics, including carriageway width, lane configuration, shoulder condition, horizontal and vertical alignment, pavement condition, roadside environment, and existing traffic safety facilities.

Driver Interviews: Semi-structured interviews were conducted with drivers using the study corridor to obtain information regarding vehicle operating speeds, driving behavior, perceived road safety problems, and factors contributing to traffic accidents. Verbal consent was obtained from all participants before the interviews. **Scientific Literature:** Relevant national and international scientific publications, technical reports, and road safety guidelines were reviewed to support the interpretation of findings and compare the results with previous studies.

Research Methodology

The research followed a systematic methodology consisting of data collection, field assessment, accident analysis, and the development of safety improvement recommendations.

Step 1: Collection and Analysis of Accident Data Traffic accident records were collected from the Nangarhar Traffic Management Department and organized using Microsoft Excel. Descriptive statistical analysis, including frequency and percentage distributions, was performed to examine the spatial distribution of accidents along the corridor during the five-year study period (2020–2024). This analysis was used to identify locations with the highest accident frequency (accident hotspots).

Step 2: Field Investigation Following the identification of accident-prone locations, detailed field inspections were conducted to evaluate roadway geometric characteristics. Particular attention was given to carriageway width, lane configuration, shoulder availability, horizontal curves, vertical alignment, pavement condition, roadside obstacles, and sight distance.

Step 3: Driver Interviews and Speed Assessment Interviews with drivers, together with direct field observations, were conducted to assess vehicle operating speeds and driving behavior at identified accident hotspots. The information collected was used to better understand driver-related factors contributing to road traffic accidents.

Step 4: Assessment of Traffic Control Devices Existing traffic control facilities, including traffic signs, pavement markings, warning signs, and other road safety devices, were inspected to determine their adequacy, visibility, and condition.

The assessment was conducted with reference to internationally recognized traffic engineering practices and AASHTO road design principles.

Step 5: Identification of Contributing Factors the accident database, field observations, driver interviews, and traffic control assessments were integrated to identify the principal factors contributing to road traffic accidents along the study corridor. These factors included roadway geometric deficiencies, excessive vehicle speed, inadequate traffic control devices, and driver-related behaviors.

Step 6: Development of Safety Improvement Measures Based on the identified accident causes, appropriate engineering and traffic safety improvement measures were proposed. The recommendations were developed in accordance with internationally recognized road safety principles, particularly the guidelines provided by the American Association of State Highway and Transportation Officials (AASHTO), with the objective of reducing accident occurrence and improving overall traffic safety along the study corridor.

III. RESULTS

Geographical Distribution of Road Traffic Accidents

The analysis of accident records obtained from the Nangarhar Traffic Management Department, together with field observations and vehicle speed measurements, revealed that the frequency of road traffic accidents varies considerably along the road corridor extending from Qomandani Pul to Darunta Tunnel in Jalalabad City. The spatial distribution of accidents indicates that some sections of the corridor are considerably more hazardous than others because of differences in operating speed, road geometric characteristics, and traffic conditions.

TABLE I
DISTRIBUTION OF ROAD TRAFFIC ACCIDENTS AND KEY ROAD CHARACTERISTICS (2020–2024).

Road Section	Number of Accidents	Key Observations
Surkh Ab Bridge – Dosra Ki	26	Highest accident frequency; high operating speeds (80–100 km/h); absence of an organized lane-changing system; horizontal curves; restricted sight distance caused by roadside barriers and vegetation.
Darunta – Surkh Ab Bridge	11	Poor geometric design; relatively straight roadway; low operating speeds (30–50 km/h); comparatively low traffic volume.
Dosra Ki – Qomandani Pul	14	Better geometric design; moderate traffic volume; absence of an organized lane-changing system; inadequate pedestrian facilities and insufficient traffic signs.

The Surkh Ab Bridge–Dosra Ki section recorded the highest number of accidents (26 cases), representing the most hazardous section of the study corridor. This section is characterized by high operating speeds, horizontal curves, limited sight distance, and the absence of a proper lane-changing system. In comparison, the Darunta–Surkh Ab Bridge section recorded the lowest number of accidents (11 cases), despite its relatively poor geometric design. The Dosra Ki–Qomandani Pul section recorded 14 accidents and was characterized by moderate traffic volume, inadequate pedestrian facilities, and insufficient traffic control devices as shown in table 1.

Vehicle Speed Characteristics

Vehicle speed measurements were conducted through direct field observations. A total of 120 vehicles were observed in each road section, and both average and maximum operating speeds were recorded.

The speed survey demonstrated substantial variation in vehicle operating speeds among the three road sections. The Surkh Ab Bridge–Dosra Ki section recorded the highest average speed (90 km/h) and maximum speed (100 km/h), which corresponded with the highest accident frequency observed during the study period. The Darunta–Surkh Ab Bridge and Dosra Ki–Qomandani Pul sections exhibited lower operating speeds and comparatively fewer recorded accidents as shown in table 2.

TABLE II
VEHICLE SPEED CHARACTERISTICS OF THE STUDY CORRIDOR.

Road Section	Segment Length (km)	Number of Speed Observations	Average Speed (km/h)	Maximum Speed (km/h)
Darunta – Surkh Ab Bridge	3.0	40	40	50
Surkh Ab Bridge – Dosra Ki	2.9	40	90	100
Dosra Ki – Qomandani Pul	4.1	40	30	40

Based on AASHTO code recommended or reference speed in the deference environment should be in the specific interval as shown in the table 3.

TABLE III
RECOMMENDED / REFERENCE SPEED BASED ON ROAD ENVIRONMENTS

Road Environment	Recommended / Reference Speed	Description
Urban / Built-up Area	≤ 50 km/h	The maximum recommended speed for general urban roads.
Urban Area with Pedestrians/Cyclists	≤ 30 km/h	Recommended for streets where motor vehicles interact with pedestrians and cyclists.
Suburban / Transition Area	50–70 km/h*	A research classification range for transition areas. The appropriate speed depends on road function, roadside development, pedestrian activity, and geometric characteristics.

Main Factors Contributing to Road Traffic Accidents

The combined analysis of accident records, field observations, and speed measurements identified three major factors contributing to road traffic accidents along the study corridor.

Vehicle Speed - Vehicle speed was identified as the most influential factor associated with accident occurrence. The Surkh Ab Bridge–Dosra Ki section, where vehicles commonly travelled between 80 and 100 km/h, experienced the highest accident frequency during the study period.

Road Geometric Design - Road geometric characteristics also influenced accident occurrence. The Darunta–Surkh Ab Bridge section exhibited relatively poor geometric design; however, lower operating speeds and lighter traffic conditions were associated with fewer recorded accidents. Although the Dosra Ki–Qomandani Pul section had comparatively better geometric design, accidents still occurred because of moderate traffic flow and the absence of an organized lane-changing system.

Traffic Control Devices - Field observations indicated that traffic control facilities were inadequate throughout the study corridor. Deficiencies included the absence of sufficient traffic signs, pavement markings, warning signs, and roadside safety barriers. These deficiencies are likely to reduce driver awareness and contribute to unsafe driving conditions.

IV. DISCUSSION

The present study examined the association of vehicle speed, road geometric characteristics, traffic control facilities, and roadside infrastructure with road traffic accidents along the Qomandani Pul–Darunta Tunnel corridor in Jalalabad City. The findings indicate that accident occurrence was not uniformly distributed across the study corridor. Instead, substantial differences were observed among the three road sections, suggesting that variations in roadway characteristics, traffic operating conditions, and road-user behavior may contribute to differences in crash occurrence. This finding is consistent with the Safe System approach, which recognizes that road safety is influenced by the interaction of safe speeds, safe roads and roadsides, safe road users, and effective traffic management.

The Surkh Ab Bridge–Dosra Ki section recorded the highest number of accidents, with 26 cases during the 2020–2024 study period.

Field observations showed that this section was characterized by relatively high operating speeds of approximately 80–100 km/h, the presence of horizontal curves, restricted sight distance caused by roadside barriers and vegetation, and the absence of an organized lane-changing system. The combination of high operating speed and geometric deficiencies may have substantially increased crash risk in this section. The importance of speed is strongly supported by international evidence. The WHO reports that increases in mean vehicle speed are directly associated with both crash probability and crash severity, with a 1% increase in mean speed associated with approximately a 4% increase in fatal-crash risk [12]. Therefore, the relatively high operating speeds observed in the Surkh Ab Bridge–Dosra Ki section may be an important factor associated with its comparatively high accident frequency.

The relationship between horizontal alignment and road safety has also been demonstrated in recent studies. Research on horizontal curves has identified curve sections as potentially hazardous locations because drivers must negotiate changes in roadway direction while maintaining vehicle control. In addition, restricted sight distance on horizontal curves can reduce the distance available for drivers to detect and respond to stopped or conflicting vehicles. Similarly, crash prediction research on two-lane horizontal curves has demonstrated associations between roadway geometry, traffic conditions, and crash frequency [13]. These findings support the interpretation that the combination of horizontal curves, restricted visibility, and relatively high operating speeds observed in the Surkh Ab Bridge–Dosra Ki section may have contributed to its elevated accident frequency.

In contrast, the Darunta–Surkh Ab Bridge section recorded the lowest number of accidents, with 11 cases during the study period, despite exhibiting relatively poor geometric characteristics. Field observations indicated that operating speeds in this section were generally lower, approximately 30–50 km/h, and that traffic conditions were comparatively lighter. The lower accident frequency in this section suggests that roadway geometry alone may not explain the spatial distribution of crashes. Instead, operating speed and traffic exposure may interact with geometric characteristics to influence crash occurrence. This interpretation is consistent with the WHO's evidence that speed is a fundamental road-safety risk factor and that higher speeds increase both the likelihood and severity of crashes [14].

The Dosra Ki–Qomandani Pul section recorded 14 accidents during the study period. Although this section generally exhibited better geometric characteristics than the Darunta–Surkh Ab Bridge section, field observations identified several safety deficiencies, including the absence of an organized lane-changing system, inadequate pedestrian facilities, insufficient traffic signs, and moderate traffic volume. These conditions may have contributed to unsafe traffic operations despite the relatively improved geometric characteristics. Recent research has shown that lane-changing is a complex driving maneuver associated with increased collision risk, particularly when vehicles interact closely with surrounding traffic [15]. Therefore, the observed absence of an organized lane-changing system represents a relevant safety concern in this section.

The study also identified deficiencies in roadside infrastructure that may affect the safety of vulnerable road users. Dedicated pedestrian sidewalks, bicycle facilities, designated parking areas, and passenger pick-up and drop-off facilities were either unavailable or insufficient along several parts of the corridor. In commercial areas, roadside commercial activities partially occupied pedestrian walking spaces, potentially forcing pedestrians to use the carriageway and increasing interactions between pedestrians and moving vehicles. Recent research has demonstrated that street-level pedestrian facilities and the surrounding built environment can influence pedestrian crash frequency and severity. In particular, the absence of sidewalks has been associated with a higher risk of severe pedestrian crashes. Similarly, studies examining pedestrian crash patterns have identified relationships between pedestrian crashes, crossing facilities, transport facilities, road characteristics, and the surrounding built environment [16].

Overall, the findings indicate that the spatial distribution of road traffic accidents along the Qomandani Pul–Darunta Tunnel corridor is associated with a combination of vehicle operating speed, horizontal roadway geometry, sight-distance limitations, lane-changing conditions, inadequate traffic control devices, pedestrian infrastructure deficiencies, and road-user behavior. The concentration of 26 accidents in the Surkh Ab Bridge–Dosra Ki section, compared with 11 accidents in the Darunta–Surkh Ab Bridge section and 14 accidents in the Dosra Ki–Qomandani Pul section, highlights the importance of considering local roadway and traffic conditions rather than evaluating the corridor as a single homogeneous facility.

These findings have important practical implications for road safety management in Jalalabad City. Priority should be given to speed management in high-speed sections, improvement of horizontal curves and sight distance, installation and maintenance of pavement markings and warning signs, provision of appropriate pedestrian facilities, organization of lane-changing and access movements, and strengthening of traffic-law enforcement. Speed management is particularly important because international evidence demonstrates that reducing operating speeds can reduce both crash risk and crash severity. Furthermore, engineering measures should be supported by enforcement and road-user education to develop a comprehensive road safety strategy.

However, the findings should be interpreted within the limitations of the study. The analysis primarily relied on recorded crash data, field observations, and observed vehicle operating conditions. Although these data provide useful evidence regarding potential contributing factors, the study did not employ a statistical crash prediction model to independently estimate the effect of each factor while controlling for traffic exposure and other confounding variables. Therefore, the identified factors should be interpreted as associated factors or potential contributors rather than independently proven causal factors. Future research could strengthen the analysis by incorporating traffic volume, vehicle-kilometres traveled, detailed crash severity data, speed distributions, geometric measurements, pedestrian exposure, and statistical or spatial crash prediction models.

In conclusion, the study demonstrates that improving road safety along the Qomandani Pul–Darunta Tunnel corridor requires an integrated approach rather than a single intervention. A combination of engineering improvements, speed management, traffic control measures, pedestrian infrastructure, effective enforcement, driver education, and modern traffic monitoring technologies is likely to provide a more sustainable strategy for reducing crash risk and improving overall road safety in Jalalabad City.

V. CONCLUSION

This study assessed the effects of vehicle speed, road geometric design, and traffic control facilities on road traffic accidents along the Qomandani Pul–Darunta Tunnel corridor in Jalalabad City. The findings demonstrate that road traffic accidents are influenced by the combined effects of excessive vehicle speed, roadway geometric characteristics, and the availability of traffic control devices and roadside infrastructure.

The analysis revealed that the Surkh Ab Bridge–Dosra Ki section accounted for 50.98% of all recorded accidents during the study period, making it the most hazardous section of the corridor. This section was characterized by high operating speeds (80–100 km/h), horizontal curves, restricted sight distance, and the absence of an organized lane-changing system. In comparison, the Dosra Ki–Qomandani Pul section accounted for 27.45% of accidents, while the Darunta–Surkh Ab Bridge section accounted for 21.56%, despite its relatively poor geometric design. These findings indicate that vehicle operating speed plays a dominant role in accident occurrence, while roadway geometry and traffic conditions also contribute to accident risk. Field observations identified several infrastructure deficiencies throughout the study corridor, including inadequate pedestrian facilities, the absence of bicycle lanes, insufficient traffic signs and pavement markings, limited roadside safety barriers, the lack of designated stopping areas for public transport, and the absence of an organized lane-changing system. These deficiencies are likely to increase conflicts among road users and reduce overall traffic safety.

The findings suggest that improving road safety along the study corridor requires an integrated approach that combines engineering improvements, effective speed management, enhanced traffic control facilities, and strengthened enforcement of traffic regulations. Priority should be given to installing adequate traffic signs and pavement markings, improving roadside safety features, providing safe pedestrian and public transport facilities, implementing organized lane-changing systems, and adopting appropriate speed-control measures. Collectively, these interventions have the potential to reduce accident frequency and improve road safety along the Qomandani Pul–Darunta Tunnel corridor.

The study concludes that excessive vehicle speed is the most influential factor associated with traffic accidents on the study corridor. However, sustainable improvements in road safety require simultaneous attention to roadway geometric design, traffic management, roadside infrastructure, and driver compliance with traffic regulations.

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