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Research Article

Identification and Improvement of Traffic Problems at the Canal Junction, Karad, Using Traffic Volume Surveys and Accident Data

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Abstract

The explosive population rise in student and commuter traffic in small townships in India has reached levels that can be compared to major urban centers. However, despite the widespread problem, cities are not thoroughly researched yet. The current study is discussing a study conducted on Canal Junction (Karad, Maharashtra), defined as an uncontrolled three-way junction. The paper describes the analysis for the intersection of College Road (D1) and the National Highway 166E, the two directions of which are indicated as D2 and D3 respectively. A traffic volume count survey was conducted over seven days (October 13-19, 2025). As a result of the analysis, several metrics were assessed: Passenger Car Units, Average Annual Daily Traffic (AADT), Peak Hour Factor and Volume-to-Capacity Based Level of Service for the junction as a whole. The research showed that D2 moves the most traffic (AADT = 49,834 vehicles per day) and has the highest congestion level (Level of Service F for four hours). At the same time, the overall junction volume reached 11,942 veh/hr (around 11,264 PCU/hr) with Level of Service F recorded during six out of twelve hours. In its design three legs converge at one point without any of the legs being collinear. Thus every vehicle entering the junction must turn on the roundabout and no traffic management aids such as signalling or channelising the lines of approach can help. The recommendations for short, medium and long-term measures regarding signalisation of the junction, creating channelised turning lanes and widening of the D2 entrance with approximate cost estimates have been developed which allow quantitative justification not only for Karad Traffic Police but also for Karad Municipal Council.

Keywords: *Traffic Congestion; Classified Traffic Volume Survey; Level of Service; Passenger Car Unit; Three-Leg Junction; Karad; Road Safety Audit*

1. Introduction

1.1 General Introduction – Road transport carries more than 60% of cargo and approximately 90% of the population movement in India using a network which is over 62 lakh kilometers long (1). But motorization is growing faster than road capacity, thus leading to congestion in not only big cities but increasingly in small and medium towns where many institutions and business entities are located [1]. In these towns peak hour traffic jams during the hours when colleges and offices are starting work rival those in the cities even though no traffic management is applied there.

1.2 Context of Karad and Canal Intersection – Karad is situated at the merging point of Krishna and Koyna rivers in Satara district, Maharashtra. It acts as a center for administration and education. Around one lakh people use the roads of this town on a daily basis out of which around fifty thousand are students. In the area of canals, College Road (Masur Road) meets National Highway 166E at an uncontrolled junction which acts as a three-legged junction known as Canal Junction for the purpose of this study. It is a true "Y" or trident junction because none of the three legs are aligned. All incoming vehicles must take executed turning movements to get onto any of the other two legs thus making the geometry of the junction unlike normal intersection which are simple in design as seen in Indian context in other studies. The corridor is a narrow college road (D1) dominated by two-wheelers, four-lane national highway (D2/three) that experiences a mixed volume of traffic as well as unregulated parking at Krishna Naka and uncontrolled movement on the toll road.

1.3 Importance of the Present Study – Traffic congestion causes both direct and indirect economic losses. In India, urban traffic congestion is estimated to have cost around USD 22.29 billion in 2018 [4]. However, these estimates are based on studies, which are mostly limited to metropolitan corridors and do not include intermediate cities like Karad. In this context, the present study seeks to fill this research gap through a scientifically sound IRC:SP:41-1994 compliant field survey of Canal Junction and its three arms to arrive at

traffic parameters including volume, PCU, AADT, Peak Hour Factor and LOS for the junction as well as its individual arms and finally make recommendations and suggestions for the phased implementation of expenditure approval pertaining to improvement measures.

2. Research Gap

Earlier studies on Karad have been useful but offered only incomplete insights: Karande et al. [2] developed a Performance Index to evaluate the performance of roads; Malwadkar et al. [5] analysed the Intelligent Transport Systems at one location – the Krishna Naka junction; and Kumbhar et al. [6] employed the PTV VISSIM simulation software to study a single-day direction movement of vehicular traffic on the Karad–Masur highway. Outside Karad, Marve and Bhorkar [7] studied the relationship among inefficient traffic signal timings and road geometry and traffic congestion and accidents in Nagpur and Savithramma et al. [8] showed that for controlled intersections one of the tier-2 cities (Tumakuru), a volume to capacity ratio above a threshold of 0.73, combined with significant time wasted during the green time, leads to traffic congestion even when everything looks alright from the operational perspective. Nonetheless, these studies did not study the continuous directional associated traffic in an uncontrolled three-legged junction and investigate whether the overall traffic on the junction was in any manner different from individual entrances to it, nor quantify variations in weekday against weekend traffic trends at such a junction. Therefore, this dissertation-based study has been carried out to fill this gap regarding the Canal Junction.

3. Problem Statement

The Canal Junction area of Karad is known for chronic traffic congestion during peak hours and continues to experience serious problems in terms of its roadway geometry consisting of three legs where vehicles are expected to turn within a completely unregulated environment. There are also problems caused by on-street parking and by pedestrian-vehicle conflicts with a lot of accidents occurring in the area as well, with no complete traffic engineering analysis of the junction conducted before. So, this paper seeks to establish and quantify the problems related to traffic and safety at Canal Junction and at its approaches and come up with a practical, prioritized measure set to overcome these problems.

4. Study Area and Survey Framework

4.1 Study Area – Canal Junction is located just before the Krishna River/canal junction where College Road (D1), which is used by Sadguru Gadage Maharaj College, Ligarde Patil Jr. College of Science and other educational institutions intersects with NH 166E, a four-lane national highway that connects Ratnagiri and Solapur. On the NH 166E highway, the road is divided into two lanes, D2 (in the direction of Karad) and D3 (in the direction of Vita). College Road (D1) has a length of around 1 km and has 2 lanes for traffic (2-way) and a width of about 6.5-7.5 m with limited pedestrian pathways, while NH 166E has a 14 m width (consisting of two lanes of 3.5 m width each) along with both paved and unpaved areas on the sides of the highway, having a centre median of 4-5 m before leading to the junction ahead, thus having a total formation width of about 23 m. For this purpose, three counting stations have been set up on the three lanes, D1a/D1b, D2a/D2b, and D3a/D3b, thus ensuring that counting can take place without interruption and no counting of each route takes place again.Table 1: Practical Capacity Assumed for Each Approach [9]

Approach	Description	Practical Capacity (PCU/hr)
D1	College Road (Masur Road)	3,400
D2	NH 166E, Karad-ward leg	4,600
D3	NH 166E, Vita-ward leg	3,000
Junction	Canal Junction (D1+D2+D3 combined)	8,000

The lower unified junction capacity, compared to the total of the three leg capacities (≈ 11,000 PCU/hr as per IRC:SP:41-1994) reflects the added conflict created when three legs that are not in line join at an uncontrolled location.

5. Methodology

5.1Secondary Data -- Road inventory and geometric information was acquired from local authority databases, history of accidents from Karad Traffic Police, local statistics were provided by the Directorate of Economics and Statistics, Government of Maharashtra[11], and national accident records were accessed from Ministry of Road Transport and highways [12 ; last two options provided the information regarding how local records compare with the records available in state and national level.

5.2 Primary Field Survey-- A classified survey of traffic volume was conducted in compliance with IRC Proforma-1 in line with IRC:SP:41-1994, for a full week (from Monday, October 13th, to Sunday, October 19th, 2025) between the hours of 7 AM and 7 PM. Around the three corners of the junction, the traffic was filtered manually every 15 minutes into eight vehicle categories, namely two-wheelers, three-wheelers, cars, light commercial vehicles, buses, trucks, agriculture tractors, and the rest. Other traffic-related activities carried out during the week included turning counts, speed measurements, travel time measurements, curb parking survey, and pedestrian conflict observations.

5.3 Data Reduction – To convert the raw vehicle counts into Passenger Car Units (PCU), IRC:106-1990 equivalence ratios [9] were appropriately used (the value stands to be 0.5 for two-wheeler vehicles and bicycles, 0.75 for three-wheelers, 1.0 for cars, 1.5 for LCVs and 3.0 for heavy duty trucks and fleets). AADT was quantified using the following equation: AADT= (Weekly Average 12 hr Volume)/f, where f is 0.90 [13]. Peak Hour Factor was calculated using the formula PHF= Peak Hour Volume/(4* highest value of 15-minute volume in that hour). The level of service was calculated based on Volume-to-Capacity ratio (V/C= Hourly PCU Volume/ Practical Capacity) [14], [9] according to the Highway Capacity Manual Level of Service categories from A-F while applying data from Table 1.

6. Results

6.1 Daily and Weekly Traffic Volume by Leg – Table 2 gives the 12-hour daily volumes recorded on each leg over the seven survey days.

Table 2: Daily Traffic Volume by Leg — Canal Junction (13–19 October 2025)

Day	D1 (veh)	D2 (veh)	D3 (veh)	Junction Total (veh)
Mon 13-Oct-25	37,827	47,786	25,415	111,028
Tue 14-Oct-25	36,362	46,388	24,595	107,345
Wed 15-Oct-25	37,554	47,911	25,113	110,578
Thu 16-Oct-25	36,864	46,895	24,791	108,550
Fri 17-Oct-25	38,983	49,938	26,050	114,971
Sat 18-Oct-25	32,309	42,049	22,197	96,555
Sun 19-Oct-25	24,964	32,987	17,584	75,535

Leg D2, which has the highest traffic volume, averages 44,851 vehicles per week (AADT ≈ 49,834 vehicles daily); Leg D1 averages 34,980 vehicles per week (AADT ≈ 38,867); Leg D3 is the least busy section with 23,678 vehicles per week (AADT ≈ 26,309). Daily traffic volumes are higher than weekend volumes by 15-35%, with a notable bimodality in hourly traffic on weekdays (due to overlaps in college and office peak hours), in contrast to the flatter hourly distribution of weekend traffic.

6.2 Traffic Composition by Leg – College Road (D1) is dominated by two-wheelers; the two NH 166E legs carry proportionally more cars, LCVs, trucks and buses, with D3 additionally carrying agricultural tractors.

Table 3: Weekly Average Traffic Composition by Leg (% share)

Vehicle Class	D1 (%)	D2 (%)	D3 (%)
Two-wheeler	57.13	43.54	49.26
Three-wheeler/Auto	9.69	6.97	8.47
Car/Jeep/Van	9.81	15.36	10.88
LCV	2.78	6.27	4.47
Bus (mini + full)	2.77	4.51	2.54
Truck (2-axle + multi-axle)	3.97	7.76	5.48

Vehicle Class	D1 (%)	D2 (%)	D3 (%)
Agricultural tractor	1.05	2.29	3.17
Cycle/rickshaw/others	12.82	13.31	15.72

6.3 Level of Service by Leg – Table 4 summarises the peak-hour condition and the number of hours (of the 12 surveyed) at which each leg fell to LOS E or F on the representative weekday (Monday, 13 October 2025).

Table 4: Level of Service Summary by Leg, Monday 13 October 2025

Leg	Peak PCU/hr	Peak V/C	Peak LOS	Hours at LOS E/F	Best LOS Observed
D1 (College Road)	3,476	1.02	F	3 (2E + 1F)	A
D2 (Karad-ward)	5,507	1.20	F	6 (2E + 4F)	C
D3 (Vita-ward)	2,299	0.77	C	0	A

In isolation, Leg D2 is the most congested leg, registering LOS F in four different hours of the day (09:00-10:00, 15:00-16:00, 16:00-17:00, and 17:00-18:00) without any improvement to LOS C. In comparison, D1 only reaches LOS F during the evening peak (17:00-18:00) but suffers a lower LOS E between 09:00 and 11:00 and between 16:00 and 17:00 due to its link to the college. D3 maintains its LOS with a value of at least C throughout.

6.4 Traffic at the Junctions – Each vehicle entering the junction must turn into one of the other two legs since Legs A, B, and C are not collinear. The share of turns in the peak hour was established from field observations conducted on-site (see Table 6).

Table 5: Approximate Turning-Movement Shares at the Canal Junction (Peak Hour)

Incoming Direction	Share to Leg 1	Share to Leg 2
From College Road (D1)	47% → D2 (Karad)	53% → D3 (Vita)
From Karad (D2)	42% → D1 (College)	58% → D3 (Vita)
From Vita (D3)	46% → D1 (College)	54% → D2 (Karad)

6.5 Combined Junction Analysis – Summing the three legs' PCU flows for each hour (without double-counting any vehicle) gives the junction-level loading against the assumed 8,000 PCU/hr practical capacity of Table 1.

Table 6: Combined Junction Peak Condition, Monday 13 October 2025

Parameter	Value
Peak-hour junction volume (17:00–18:00)	11,942 veh/hr (11,264 PCU/hr)
Peak V/C ratio	1.41
Peak LOS	F
Hours (of 12) at LOS F	6 (09:00–11:00, 15:00–18:00)
Secondary peak (09:00–11:00)	≈ 10,100 veh/hr

Accordingly, Canal Junction is said to function at LOS F level throughout the period when it was measured where the bulk of cases occur between 0900 and 1100 hours due to the convergence of traffic from educational institutions and from offices and from 1500 to 1800 hours due to the overlap of evening peak hour traffic of D1 and D2 without any one leg being in deficit throughout this period emphasizing the fact that it is three-way convergence which is a limiting factor and not one of the legs.

6.6 Accident Benchmarking – Historical data of accidents pertaining to Karad Traffic Police were compared against the data of the state [11] and that of MoRTH [12].

Table 7: Canal Junction Accident Pattern Benchmarked Against State/National Statistics

Parameter	Canal Junction	Maharashtra Avg.	National Avg.
Share of accidents involving two-wheelers	≈64%	≈42%	≈44%
Share of accidents at uncontrolled junctions	≈58%	≈35%	≈31%

Parameter	Canal Junction	Maharashtra Avg.	National Avg.
Share of accidents involving pedestrians	≈21%	≈15%	≈17%

A supplementary case-wise record of seven additional accidents (from January to May 2026) issued later by the Karad Traffic Police confirms this pattern. In five of the seven accidents (including four two-wheeler vs two-wheeler accidents), two-wheelers were involved. Furthermore, five out of the seven accidents were caused by overspeeding or the failure to maintain safe speed limits, while six of the seven accidents took place on the NH 166E route (legs D2/D3).

7. Discussion: Problem Identification and Proposed Improvement Measures

By summarizing the conclusions of Section 6, various factors such as the LOS F situation of the overall junction, the isolated congestion of the D2 entrance, the lack of any channelization in a junction where all vehicles must turn, unmanaged street parking by Krishna Naka, unmanaged pedestrian crossings close to the college entrance, and the high proportion of two-wheeler and uncontrolled-junction accidents from Table 7 are identified as the main problems which need interference. A phased solution involving three stages is suggested.

Table 8: Order-of-Priority Summary of Proposed Improvement Measures

Measure	Horizon	Relative Cost	Primary Problem Addressed
Signage, road marking, parking-bay demarcation (all legs)	Short-term (0–6 mo.)	Low	Parking encroachment, lane discipline
Traffic warden deployment at peak hours	Short-term	Low	Pedestrian–vehicle & turning conflict
Speed-warning signage, all approaches	Short-term	Low	Approach-speed related accidents
Three-phase signal at Canal Junction (highest priority)	Medium-term (6–18 mo.)	Medium–High	Junction LOS F, delay
Channelised turning lanes, D2 approach priority	Medium-term	Medium	100% turning conflict on all legs
Footpath continuity & formal pedestrian crossings	Medium-term	Medium	Pedestrian–vehicle conflict
Carriageway widening, D2 (Karad-ward) approach	Long-term (1.5–3 yr)	High	D2 bottleneck capacity
Physical median on D2/D3 (NH 166E)	Long-term	High	Head-on conflict, lane discipline
Low-cost ITS deployment (speed cameras, sensors)	Long-term	Medium–High	Enforcement, monitoring

The urgency of the required interventions is clear, as short-term interventions can be undertaken at little expense (up to INR 18 lakh, in total) using the existing resources of municipalities as well as the traffic police. Though, it is also essential to incorporate the medium-term intervention of Canal Junction signalization and channelization in the present Council's Capital Budgets. This specific measure is regarded to be the sole effective solution for the complex geometry of turning conflicts discussed in Section 6.4. Finally, long-term solutions related to D2 expansion and median installation are likely to be limited due to constraints of the neighboring Krishna canal embankment and may require individual feasibility and land surveys.

8. Conclusion

According to a seven-day all leg classified traffic volume study carried out at the Canal Junction of Karad, this uncontrolled three-legged junction is under significant stress. The Karad leg (D2) at the junction registers an LOS (level of service) "F" for four hours daily, while the overall junction (which can handle 8,000 PCU/hr) experiences LOS "F" for six of the twelve hours recorded. The peak LDV in these hours reaches 12,194, indicating that the turning conflicts at this junction severely limit its overall performance. At this type of

junction, every traffic entering the junction must turn to one of the other two legs of the junction. Moreover, there is no provision for channelisation, traffic signals, or dedicated turning lanes at this junction. Therefore, it is observed that congestion at this junction is largely due to its geometry rather normal increase in the volume of traffic. In addition to this, there is the unsupervised street parking, uncontrolled point of pedestrian movement along the college entry points, and the accident statistics where the two-wheeler accidents and the accidents caused at junctions (about 64% and 58%, respectively) that are much higher than the average numbers of the country and those of the state. The proposed phased set of low-cost solutions for immediate actions, medium-term solutions involving signalization and channeling, and long-term capacity and median schemes together with the already mentioned dataset giving a seven-day picture of the amount of traffic and Level of Service situation that is new to the Karad Municipal Council and Karad Police Department.

8.1 Future Scope:

The future studies should include a study of traffic behavior at the Canal Junction to determine the need for phase signaling or an overpass; micro-simulations (e.g., PTV VISSIM or AnyLogic) to verify safety measures in action; monitoring of changes in the quality of service and accident rates before and after the introduction of short-term measures; using cheaper traffic monitoring devices based on IoT.

Declarations

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Ethics, Consent to Participate, and Consent to Publish declarations
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