Analysis and Optimization of Traffic Flow at Dandekar Bridge Junction: Simulation Base Case Study

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Abstract: **Urban mobility is greatly hampered by traffic jams at the intersections of major roads, which causes longer traveling-times, delays and operating inefficiency. This study is aimed at modelling and optimizing the traffic circulation at one of the critical locations the Dandekar bridge junction in Pune city by simulating its traffic management, to ease up the traffic flow at the location using Vissim, a microscopic traffic simulation tool. Comprehensive traffic survey and inventory data were collected and applied to the trailing modelling, representing the current situation. The model was calibrated based on field data and vehicle behaviors observed. Average delay, queue length and average vehicle travel time were selected as the primary measures for studying the current situation. Based on the results of the traffic survey and important indicators, an improvement proposal was proposed with the aim of improving traffic operation and reducing the number of conflict points. Simulation of such design produced a large enhancement in junction efficiency performance. This intersection is a signalized junction, and the focus of this study is on optimizing such signalized intersections in Indian urban area. This study offers insights into traffic congestion diagnosis and location-based traffic management solutions for urban transportation planning through data-driven simulation.**

Index Terms. **Junction Improvement, Simulation, Traffic Flow Optimization, Urban Road**

I. INTRODUCTION

Today's cities are critically dependent on urban mobility, which in turn affects environmental sustainability, economic productivity, and quality of life. Among the most acute problems of the contemporary urban environment is the issue of traffic congestion, particularly at the critical points where several flows of traffic meet. Not only does traffic at these intersections cause delays, but it also leads to more waste of fuel, enhanced pollution, and overall poor performance of the transportation system.

Traffic congestion is a critical concern in cities such as Pune, which are growing urban populations and vehicles numbers. An important intersection in Pune is a good example of the challenges that urban planners face in attempting to find the best way of handling the traffic flow. Like so many intersections in fast-growing cities, this one often gets jam-packed during rush hours, leading to frustrating gridlock and delays. The selected intersection, Dandekar bridge, was identified based on its consistent congestion levels and strategic role in connecting key residential and commercial areas.

Understanding the nature of traffic and the prediction of the changes brought about by different interventions would be important in the management of such vital junctions. Traditional traffic control schemes do have little effect to cope with the sophisticated city traffic. Such a situation calls for Vissim and other sophisticated traffic simulation tools. Vissim can help planners to analyses the impacts of various potential situations and assess the possible effectiveness of different traffic management measures by enabling the generation of dynamic and comprehensive traffic flow models.

To assess and improve the traffic flow at the intersection, the analysis is carried out using Vissim. The purpose of this study is to analyze the existing traffic flow, to discover the issues, and suggest possible solutions to traffic congestion by developing a detailed simulation model based on a large amount of traffic data. Such metrics as average vehicle time, delays and queue lengths are considered in the analysis that provides a quantitative basis for the proposed measures.

II. METHODOLOGY

This work focuses methodologically on systematically analyzing traffic flow issues at a critical intersection in Pune using simulation tools. Fig.1. illustrates the comprehensive steps taken in the study to evaluate and improve the traffic conditions at the selected road network.

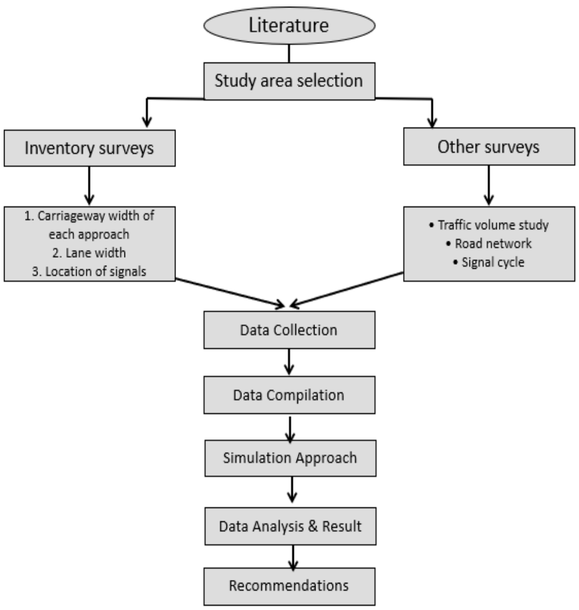

Fig. 1. Methodology flow chart

STUDY AREA SELECTION: -

The Dandekar bridge (Dr. Ambedkar Chowk) is a busy intersection on the south-western side of the city of Pune and consists of a T-intersection. The east-west roadway is the Sinhagad Road (Narveer Tanaji Malusare Road) while the north-south roadway is Lal Bahadur Shastri Road (along Dandekar bridge). (See Fig. 2) image of the intersection.

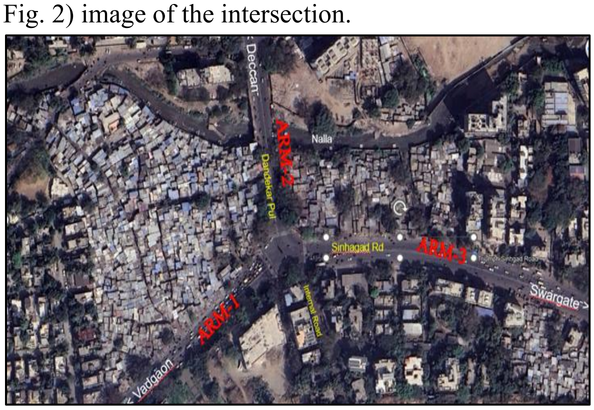

Fig. 2. Study location

The study location is the confluence of a major east-west arterial road – Sinhagad road and the north south major collector road of Lal Bahadur Shastri Road that ends at Sinhagad Road in a T-Junction. Shastri Road goes over a major nalla at the Dandekar bridge. With the roadways meeting at the intersection being major, the amount of traffic using this intersection every day is very high as well. The location was selected due to consistently high traffic volumes, documented delays, and its importance as a connecting node between residential and commercial zones in Pune. Recent trends have shown a major upturn in traffic congestion at this intersection and a solution to this problem has become important for every local and road user using these roadways.

DATA COLLECTION: -

Data collection is the foundation of any traffic simulation study because the model must equal real world conditions. The data collection process is divided into two major phases for this study traffic surveys and inventory surveys. The traffic survey captures the total number of PCU at junction, while the inventory survey captures the physical and operational characteristics of the junction. Therefore, it is possible to create a calibrated VISSIM model of current traffic behavior from these datasets to offer a solid foundation for examining the proper solution.

Inventory survey: The inventory survey documents the junction's physical and operational attributes, which directly influence traffic flow dynamics.

1. Geometric Design: The number of lanes by approach, and lane widths (for example, 3.5 m for standard lanes). Aids and information provision can be reduced if lanes are narrow, and this may require changes in the simulation. Using a measuring tape, we found that all three legs of the junction have six-lane, two-way traffic, three lanes on each side, separated by a central divider.
2. Traffic control device: The junction is currently signalized, and the signal cycle diagram is provided below. There is a total of six turning movements. ARM2R means Arm 2 right turning movement. Likewise, L for left turning and 'T' for through movement of that Arm. Signal coordination inefficiencies are a major cause of delays and queues.

Fig. 3. Existing signal cycle

Traffic survey: The survey was done as per IRC SP-090 (2010) to maintain the highest accuracy and reliability. A traffic survey was conducted using video cameras. Multiple cameras were positioned at the intersection viewing each movement within the intersection. The data is manually extracted from video recording, classifying vehicle types (e.g., cars, buses, trucks) and documenting turning movements in the three directions: left, straight, and right. With recording data over 24 hours and 7 days a large volume of data was collected and organized into excel spreadsheets detailed traffic report for further analysis. Photos of the traffic survey in progress are shown in (See Fig.4).

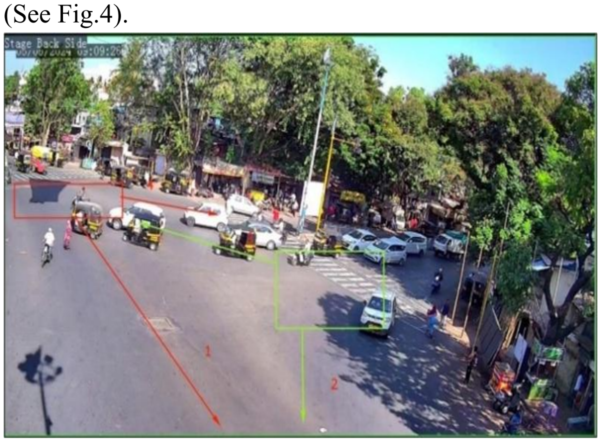

Fig. 4. Data collection at intersection

MODELLING OF EXISTING TRAFFIC CONDITIONS IN VISSIM: -

For depicting the real time traffic scenario at the study intersection (Dandekar bridge) in Pune, an in depth model on Vissim was created. This is the base model for the analysis of congestion detection and improvement strategies. Traffic counting, geometric and signal timing data were obtained using traffic and inventory surveys at the outset of the development process. They were carefully employed as input to model traffic features behaviors at the simulation environment. Driver behavior parameters were adjusted using the Wiedemann 99 car-following model with customized settings to reflect the mixed and lane-indiscipline Indian traffic. Vehicle input was entered as raw vehicle count (Veh/hr), not PCU/hr, as required by VISSIM. PCU values were only used for policy threshold comparison. The baseline model is designed to capture current traffic conditions, such as vehicle flows, signal timings, and performance metrics. The simulation properly models the operation of the current intersection under peak hour conditions obtaining critical performance metrics such as delay, queue lengths and average vehicle travel time to cross for the various approaches and turning movements. These performance metrics allow the detection of severe bottlenecks and bring insight into the validation of a proposed infrastructure.

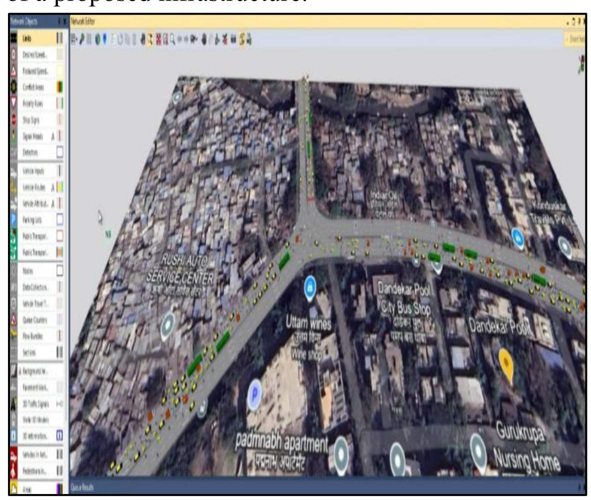

Fig. 5. Simulation model of existing traffic conditions

III. RESULTS AND RECOMMENDATION

TRAFFIC DATA ANALYSIS: -

Recording data from primary and secondary sources has been recorded in Excel sheets, composed, checked and corrected and then processed for analysis. Traffic flow analysis has been conducted to investigate traffic behavior and travel patterns within the study location.

The analysis covers peak hour patterns, direction trends and types of vehicles, on the road.

Passenger car unit: Given the heterogeneous nature of Indian traffic, it is standard practice to convert traffic volumes into Passenger Car Units (PCUs). This conversion allows for a consistent assessment of traffic flow. The collected vehicle data was converted to PCUs based on IRC-106 (1990) guidelines to determine the Average Daily
Traffic (ADT) and their equivalent PCUs. In the Below Table lists the adopted PCU equivalent for different vehicle types.

Vehicle type	Equivalent PCU factor	
	Percentage composition of vehicle type in traffic stream	
	5%	10% and above
Two Wheelers	0.5	0.75
Passenger Car, Pick-up van	1	1
Auto-Rickshaw	1.2	2
Light Commercial Vehicle	1.4	2
Truck or Bus	2.2	3.7
Agricultural Tractor Trailer	4	5
Cycle	0.4	0.5
Cycle Rikshaw	1.5	2
Tonga (Horse drawn vehicle)	1.5	2
Tractor	1.5	N/A
Tractor with Trailor	4.5	N/A

TRAFFIC SURVEY RESULT: -

Based on the conducted traffic survey, it was found that the base-year traffic (2024) total Passenger Car Units (PCU) at the intersection is 11,061 PCU/hr, surpassing the threshold of 10,000 PCU/hr. As per IRC-SP-90 (2010), signalized intersections exceeding 10,000 PCU/hr warrant grade separation. The intersection exceeds this threshold in all three peak periods, justifying the need for grade separation based on established national guidelines. This shows the urgent need for grade separation in the current scenario itself, not even accounting for growth.

Peak hour time	PCU/hr
Morning Peak (9.00 am -10.00 am)	11304
Afternoon Peak (12.00pm -1.00 pm)	10616
Evening Peak (6.00 pm -7.00 pm)	11267

It should be noted that the current pedestrian movement within the study location is also high with over 1000 pedestrians using the junction during peak hour pedestrian movement (6 pm to 7 pm). A high pedestrian movement with a high traffic movement is indicative of delays caused to both traffic and pedestrians due to conflicting movements and speed in addition to safety concerns. A grade separation is expected to reduce traffic load at-grade thereby giving respite to pedestrians as well.

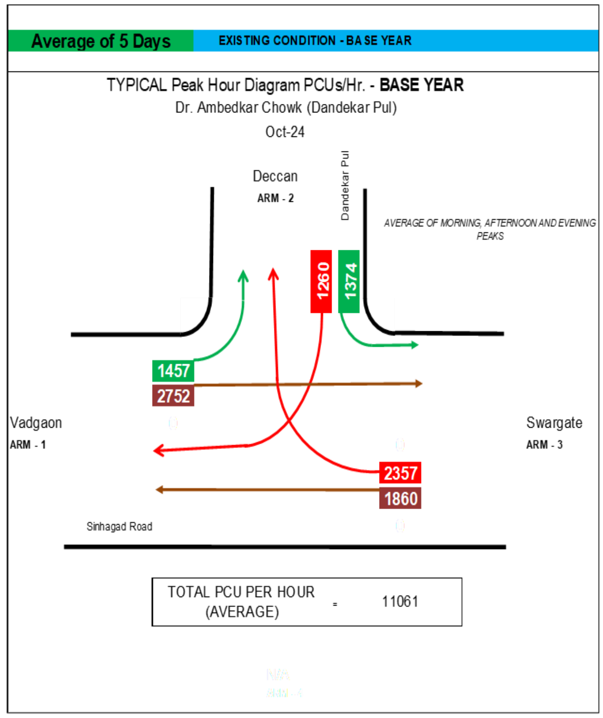

Fig. 6. Existing traffic volume average of all peak hour

Future traffic Projection**:** Estimating a growth rate for an area or city is generally a very involved process and is affected by a multitude of factors from urbanization trends to GDP growth to population growth. IRC SP-090 (2010) recommends the use of 7.5% as the growth rate in the absence of a separate detail study. Based on the general trends of urbanization in and around Pune, the staggering GDP growth, and the recorded population growth a growth rate of 7.5% appears to match these factors. A 20-year design period was used to project the traffic flow in 2044. The projected total PCU at the intersection is 46,982 PCU/hr as shown in (Fig. 7) below.

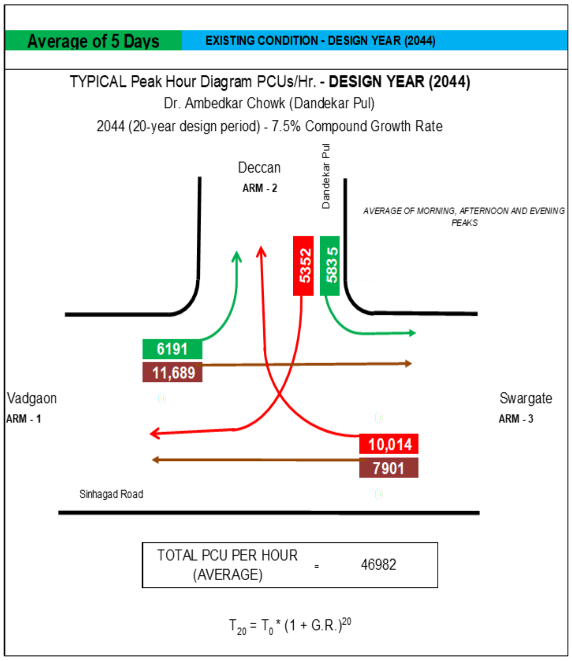

Fig. 7. Future traffic projection

SIMULATION RESULTS: -

Queue length: The simulation results indicated significant queuing at the junction, particularly during peak hours.

Sr.no.	Simulation Time (Sec)	Queue Counter	Queue length (m)	Max. queue length (m)
1	0-3600	ARM 1	127.39	140.48
2	0-3600	ARM 2	71.75	78.36
3	0-3600	ARM 3	167.89	183.00

Average vehicle travel time: Travel time through the junction was recorded using travel time measurement sections.

Sr.no.	Simulation time (Sec)	Turning movement	Avg. vehicle travel time (sec)	Avg. vehicle travel time (Min)
1	0-3600	Arm 1T3	285.23	4.75
2	0-3600	Arm 1L3	245.84	4.10
3	0-3600	Arm 2R1	221.99	3.70
4	0-3600	Arm 2L3	258.53	4.31
5	0-3600	Arm 3T1	318.89	5.31
6	0-3600	Arm 3R2	297.98	4.97

Average vehicle delay time: Average delay per vehicle was recorded on each approach. Higher delays indicate inefficient traffic flow.

Sr. no.	Simulation time (Sec)	Turning movement	Stop delay (Sec)	Vehicle delay (Sec)
1	0-3600	ARM 1T3	119.61	202.19
2	0-3600	ARM 1L3	117.69	197.18
3	0-3600	ARM 2R1	132.51	172.74
4	0-3600	ARM 2L3	141.77	196.71
5	0-3600	ARM 3T1	129.00	241.33
6	0-3600	ARM 3R2	124.75	233.04

RECOMMENDATION

Double-Level Grade Separation with Two-way Flyover and a One-way Underpass Description of Proposal: Proposes construction of a two-way two-lane flyover along Sinhagad Road. This flyover will cater to both eastbound and westbound through traffic along Sinhagad Road and eliminate the need for this traffic to conflict with the rest of the movements thus reducing traffic congestion at the intersection. Additionally, an underpass from Swargate to Deccan along Sinhagad and Shastri Roads. This will be a single-lane, one-way underpass carrying all right turning traffic from Swargate to Deccan. The underpass will start along Sinhagad road and curve towards Deccan on Shastri Road before ending before the Mangir Baba Temple Chowk (Bar. Nath Pai Chowk). After construction 19,590 through PCU/hr from Vadgaon to Swargate and Swargate to Vadgaon will use the new four-lane flyover. The underground ramp from Swargate to Deccan will eliminate 10,014 PCU/hr turning right from Swargate to Deccan. This is the second highest movement at the intersection denoting the huge benefit of grade-separating this movement. All figures are for 2044 and for the peak hour.

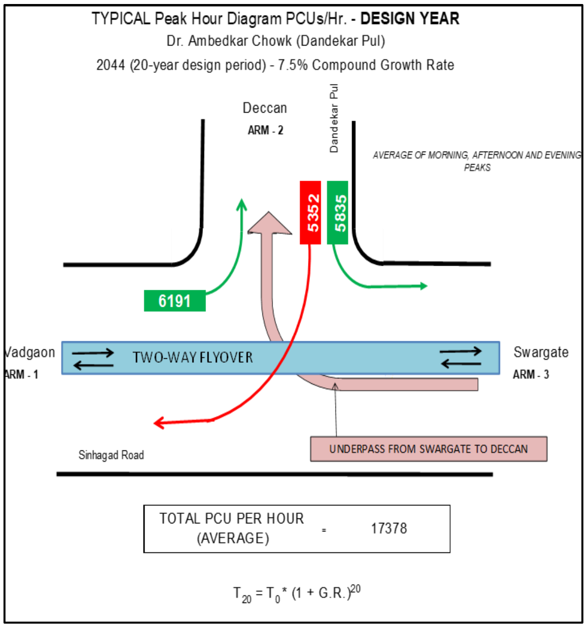

Fig. 8. Intersection traffic improvement proposal

IV. CONCLUSION

- Based on traffic survey the highest turning movement is the Vadgaon to Swargate and the second most is Swargate to Deccan.
- The current condition of intersection was found that the base-year traffic (2024) total Passenger Car Units (PCU) at the intersection is 11,061 PCU/hr, surpassing the threshold of 10,000 PCU/hr which necessitates grade separation. This shows the urgent need for grade separation.
- Average delay per vehicle was recorded on each approach. Higher delays indicate inefficient traffic flow.
- The simulation results indicated significant queuing at the junction, particularly during peak hours is up to 183 meters on ARM 3
- Encroachment is observed on site which leads to traffic congestion.

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