Diverging Diamond Interchange: A Comprehensive Review

*[1]MUJAMMEL.Z.SHAIKH, [2]SUJESH GHODMARE, [3]ASIF UL ISLAM, [4]SHRINIVAS URADE
[1,2,3,4] Dept. of Civil Eng., G.H.R.C.E, Nagpur (India)

Abstract: From Last few decades Diverging Diamond Interchange (DDI) is widely implemented in many developed countries. This interchange is suitable when arterial road cross freeway. DDI is recognized due to its prevailing features but if we consider the Heterogeneous Traffic Scenario of India, with increase in urbanization the performance of existing road falls. This increases the traffic impact on other accessible roads. To overcome this problem the interchange is provided. The attempt has been made by modelling of "Diverging Diamond Interchange in PTV VISSIM. Traffic analysis is carried out from PTV Vissim software and different parameters such has Signal synchronizing, Signal optimization, Level of service, Average Delay, Queuing length etc. are analyses. In this paper an attempt has been made to analyses the change in traffic scenario to analyses the change in traffic scenario after implementation of DDI, and results are summarized for the purpose of recommendation.

Index Terms **- Diverging Diamond Interchange (DDI), Traffic Analysis, Modal Simulation on Vissim**

I. INTRODUCTION

In urban area, due to increase in traffic volume the current road facilities are insufficient. This increases the traffic impact on existing roads. Augmentation of lane is required, but this is not solution. Many times we need to think out of box likes implication of interchanges.

Diamond interchange is an important means of controlling the demand for transportation in urban areas. As per Sangsoo lee et al (2004) Diamond Interchange is typical type of interchange use when freeway is crossing arterial road but limit left turning movement Fig1. Diamond interchange is of two types- Diamond interchange with two intersections (DIT) and Diamond Interchange with One intersection (DIO). As per Steven Venglar et.al (1995) major intersection that links arterial street system to freeway is known as diamond interchange. As per Avijit Maji et al (2013) DDI overcomes cons of diamond interchange by On-Ramp and Off-Ramp, and the movement of internal traffic is controlled by a two-phase signal. Short-cycle two-phase signal makes DDI one of the most popular solutions. DDI has attracted attention of nation and international level in recent year because of its innovative feature. As per Yao Cheng et al (2018) compared to a conventional diamond interchange, a DDI can reduce conflict point for turning movement.

The logic behind DDI is to provide efficient and smooth movement for though, left turning traffic and to transfer left turning traffic without using left turning bay. This DDI can increase the efficiency of the Interchange, since the time lost for the various phases of the cycle length can be redistributed as green time. As per Xianfeng Yang et al (2014) DDI design significantly reduces the number of traffic Conflict Point thus provides a safer and cost-effective environment.

DDI compared to conventional interchange reduces fatality and crash. According to Claras et al (2016) DDI replaced to CDI reduces 33% of Crashes. Angle and turning crashes were found to decrease more significantly As per Ericj Nelson et.al (2000) deployment of SMART Diamond Controller Actuated Controller, NEMA Controller, Passer III Optimization etc. improve DDI performance. An actuated controller is used to implement three-phase and four-phase on advance -NEMA.

The purpose of this paper is to provide a comprehensive review of the Diverging Diamond Interchange considering a wide range of Research Carried out. It also gives an overview developed by researcher to improve performance of DDI.

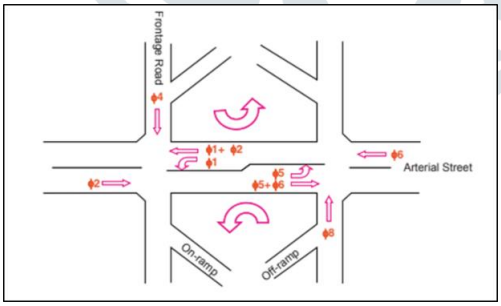


Figure 1

II. LITERATURE REVIEW:

By **Sabyasachee Mishra et al (2013) [1]** an analytical method was developed to analyse the DDI model, in which the author derived the equation for the critical volume of lanes, considering the nodes A and B, in which the merging and divergent traffic is considered from another direction. The resulting CLV is used to calculate the v / c ratio and LOS of the node. Table 1 shows that the result is variable because of calculating the synchronous model based on the HCM analysis procedure. Developed Analytical method help Designer in preliminary stage of Analysis which gives idea about conflicting point, Level of service for accuracy Detail Synchro Tool to be Used [1]

NODE	LOS Obtained from Derived Equations	LOS Obtained from Synchro Model
A	F	F
B	E(0.97)	C(0.92)

Table 1

Hongqiao Songa et al (2006) [2] did the Comparison of diamond Interchange between China and America based on geometric design, signal control, safety aspect. They compared the performances of two Diamonds (i.e. DIO & DTO). In geometric Characteristic Turning Radii, Spacing between two intersections, Left turning angle is compared. DIO has total 12 conflicting points and DIT has 16. Two different Strategies for controlling Signal are introduced by researcher. The detail of Texas Four Phase & Two-Phase strategy is provided. This article presents the operational characteristics of the diamond exchange between China and America. Hope this can help the planner and designer, while evaluating and choosing the interchange.

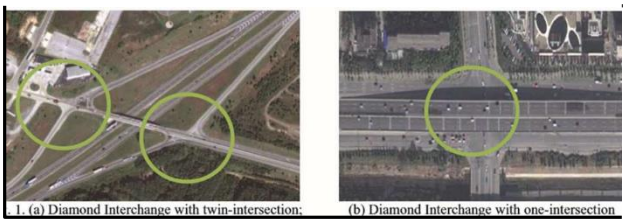


Figure 2

Eric J. Nelson et al (2000) [3] extensively performed study on actuated controllers. This paper shows the process of implementing 3 phase and 4 phase controllers and brief detail control concepts and how the actuated controller is using to control the ramp of diamond interchange. Different Phasing Strategy to be implemented has been shown.

Carroll J. Messer et al (2004) [4] has discussed the performance of DI by implementing actuated signal operation for different ramp spacing and traffic pattern. The parameters which mainly focused are Cycle length, average Delay, Total stops etc. The microscopic model on which study is carried out is CORSIM, SIMTRAFFIC and SYNCHO. Every Model has a different assumption; hence there is variation in results from the same input.

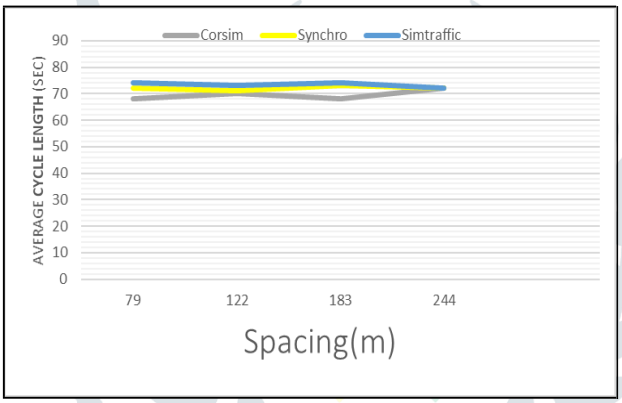


Figure 3

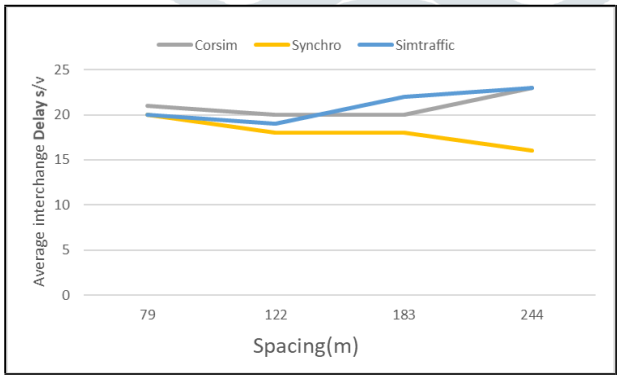


Figure 4

From above graph it is inferred that Simtraffic results are more valid as compares to Syncho and Corsim. As spacing increases, delay also increases in Simtraffic but on other hand in Synchro delay reduces. Stoppage constantly reduces in Synchro as spacing increases.

Thomas Urbanik et al (1995) [5] proposed one method to integrate various technologies into a control system that will improve traffic performance and demonstrated the IVHS concept in advanced traffic management systems. By using video imaging equipment, traffic information processing and optimization, and real-time monitoring, road users will experience fewer delays, less congestion, and fewer security issues in diamond Interchange.

Yao Cheng et al (2018) [6] explicitly concludes that DDI with synchronously optimized crossover spacing and offset can reduce travel time. In This MAXBAND has the basic of design for signal progression. This can reduce queuing spillbacks on crossovers. This model provides an early stage aid to evaluate the relationship between offset and crossover spacing.

Siddharth Sharma et al (2010) [7] has conducted comparative study between DDI and CDI with different volume scenario with the help of micro simulation tool. Different traffic parameter such has delay, travel time,

Max queening length is studied. The snap of comparison table is presented below from which it can be inferred that DDI is better in performance as compared to CDI which shows that in both cases the DDI performance is better. This study will guide planner while selection.

	Delay(sec/veh)		Max Queue(ft)	
	CDI	DDI	CDI	DDI
High 3	118.4	66.7	1457	478
High 2	96.3	46.3	1330	410
High 1	67	35.8	1079	320
Medium	46	28	460	242
Low	31.4	21	273	192

Table 2

Mohommed Balley Madhi et al (2015) [8] conducted a study on the performance of DDI for different signal plan, traffic condition by using simulation tool. An attempt has been made to study traffic parameter after proposing Diamond interchange. The Interchange provides Two Phase Signal instead of Six Phase.

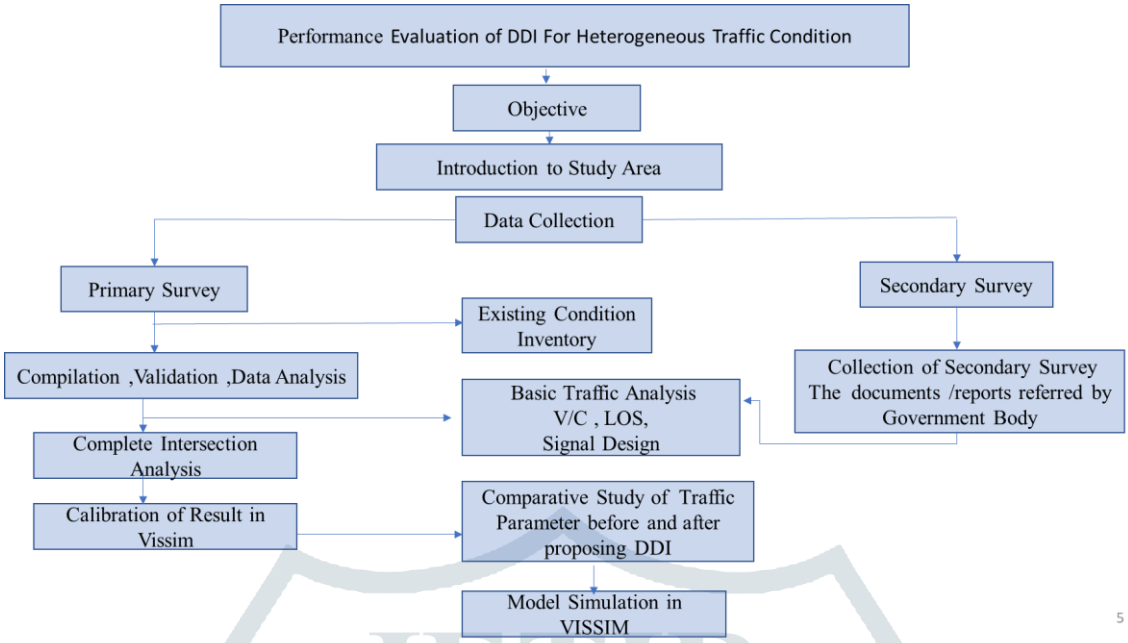
Joe Bared et al (2005) [9] conducted comparison of collisions between Tight Diamond and single point exchange using Wilcoxon signed rank test. This test is nonparametric. In this paper 13 SPI sites and 27 DI sites has analyse. The hypothesis method is used to calculate expected crash / fatal accident injuries. Single point urban exchange was found to be safer than DI comparable for damage / fatality frequencies.

Xian Feng Yang et al, 2014) [10] conducted study by modifying MAXBAND Optimization Model for use in design of signal coordination between intersection Using VISSIM as Simulation Analysis Tool.

Reference	Problem type	Constraints
Joe Bared et al,	Safety, Accident, Crash	Comparative study between Single Point and Tight Diamond interchange
Eric J .Nelson et al,	Signal Timing	Optimization of signal
Sangsoo Lee et al,	Assessment of Simulation	Simulation by SIMTRAFFIC ,SYNCHRO,CORSIM
Avijit Maji et al,	Analysis planning Tools	Critical Lane Volume, Lane Utilization Factor ,Level of Service
Shuxin Jina et al,	Traffic Organization	Avg delay timing , Avg Queue length ,Avg parking times
Hongqiao Songa et al,	Performance Evaluation of DDI	Comparison between Geometrics, Signal Control and safety
Lee Vien Leong	Operational Performance of DDI	Signal Optimization
Siddharth Sharma et al,	Performance Evaluation between DDI & CDI	Comparative Study of DDI and CDI
S.Venglar, et al,	Improving Traffic Performance	Real Time optimization by ITS
Yao Cheng	Optimization of signals	Signal Progression ,Crossover spacing

Table 3

III. Methodology:



IV .Result and Discussion: This study Focus on performance evaluation of Diverging Diamond Interchange (DDI) for Indian Traffic Condition. Implementation of DDI Improves traffic parameter like Vehicle Delay, Number of stops, Queuing length and putdown fuel consumption and Emission. There is noticeable Change in scenario after implementation of DDI and results are summarized for recommendation.

V. Conclusion

The current article is an attempt to provide a comprehensive review of available literature with respect to Diverging Diamond Interchange. The review discussed various kinds of issues related to Diverging Diamond Interchange along with different models being adopted by various researchers. It is found that the different Mathematical formulation and analysis procedure to evaluate for Diverging Diamond Interchange has variety of limitations and they are specific to set of constrains. It is further highlighted that the use of advanced and SMART technology could be very much useful in optimization of signals, Delays, Stops in the Interchange. As reviewed in the Literature DDI is suitable interchange as compared to Conventional Diamond Interchange. Signal optimization is big issue in DDI. The Different Phasing Strategy with actuators and controllers is adopted, and it has positive results.

In many cases Vissim Software is used for simulation, because it has wide Scope of application in different Traffic Scenario. In many articles Vissim is used for calibration of result.

VI Software/ Tools

[1]VISSIM
[2]CORSIM
[3]SIMTRAFFIC
[4]SYCHRO

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