Review on Analysis and Design of Intersection

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ABSTRACT

The extreme growth rates of automobiles have caused considerable traffic overcrowding on roads and intersections and it worsens at peak time traffic. An intersection which is not well designed, particularly traffic flow on state highways with high speed, when mixed up with local traffic at crossings, traffic congestion is likely to occur. This causes many negative effects like pollution, delay and improper traffic management at crossings. Intersections represent potentially dangerous locations from point of view of traffic safety. It's believed that well over half the fatal and serious road accidents in built-up areas occur at junctions, Therefore, it is essential to design or re-design the intersections in a further reasonable way. The basic methods considered for the design includes the principles of Uniformity and Simplicity, Minimizing conflict points and smoothing the traffic flow are possible by means of space and time sharing. The purpose of this paper is to review a number of methods that encompass of design of intersection. And it helps intersection design and evaluation of different design options' suitability and checks the intersection's performance.

Keywords: *- Intersection, Conflict Points, Time Share and Space Share.*

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1. INTRODUCTION

An intersection is where two or more roads join or cross at-grade. The intersection comprises the areas required for all means of travel: pedestrian, bicyclist, motor vehicle, and transit. Thus, the intersection includes not only the pavement area, but typically the adjacent sidewalks and pedestrian ramps. At the intersection there are through, turning and crossing traffic and these traffic movements may be handled in different ways depending on the type of intersection its design and control of traffic. Generally, intersection problems are unavoidable except in case of expressways or freeway systems where such problems are avoided by providing grade separated intersection and controlled access. Signal control is a frequently used remedy of capacity shortage in urban areas. A sufficiently accurate method of predicting the capacity of signalized intersections is important for correct road way design and for effective traffic management. Signal control is generally considered to be the highest type of control possible at an at-grade intersection. If the signal control plan is not designed properly, the signal control may become counterproductive. The ill effects of improper signal plan can be congestion, undue delays, fuel wastage, air pollution, reduced intersection capacity and tremendous inconvenience for the road user. To avoid such a situation, it becomes mandatory on the part of the traffic engineer to study the traffic situation thoroughly, to understand it properly and to evolve the optimum cycle time and proper phasing to suit the requirements of the traffic with due consideration to the location geometrics.

Intersections are a key feature of road design in four respects:

i. Focus of activity: The land near intersections often contains a concentration of travel destinations.

ii. Conflicting movements: Pedestrian crossings and motor vehicle and bicycle turning and crossing movements concentrated at intersections.

iii. Traffic control, At intersections, movement of users is assigned, through traffic control devices such as yield signs, stop signs, and traffic signals. Traffic control often results in delay to users travelling along the intersecting roadways.

iv. Capacity, In many cases, traffic control at intersections limits the capacity of the intersecting roadways, defined as number of users that can be accommodated within a given time period.

1.1 INTERSECTION USERS

All roadway users are affected by intersection design such as:
i. Pedestrians: Key elements affecting intersection performance for pedestrians are:(a) The amount of right-of-way provided for the pedestrian including both sidewalk and crosswalk width;(b) The crossing distance and resulting duration of exposure to motor vehicle and bicycle traffic;(c) The volume of conflicting traffic; and (d) the speed and visibility of approaching traffic.
ii. Bicyclists: Key elements affecting intersection performance for bicycles are: (a) the degree to which pavement is shared or used exclusively by bicycles; (b) the relationship between turning and through movements for motor vehicles and bicycles; (c) traffic control for bicycles; and (d) the differential in speed between motor vehicle and bicycle traffic. iii. Motor vehicles: Key elements affecting intersection performance for motor vehicles are: (a) the type of traffic control, (b) the vehicular capacity of the intersection, determined primarily from the number of lanes and traffic control; (c) the ability to make turning movements; (d) the visibility of approaching and crossing pedestrians and bicycles; and (e) the speed and visibility of approaching and crossing motor vehicles.
iv. Transit: Transit operations usually involve the operation of motor vehicles (buses), and therefore share the same key characteristics as vehicles as outlined above. In addition, transit operations may sometimes involve a transit stop in an intersection area, thereby influencing pedestrian, bicycle, and motor vehicle flow and safety. Additionally, in some cases, the unique characteristics of light-rail transit must be taken into account.
In addition to the users of the street and intersections, owners and users of adjacent land often have a direct interest in intersection design. This interest can be particularly sensitive where the intersection is surrounded by retail, commercial, historic or institutional land uses. The primary concerns include: maintenance of vehicular access to private property; turn restrictions; consumption of private property for right-of-way; and provision of safe, convenient pedestrian access.

1.2 INTERSECTION TYPES AND CONFIGURATIONS

Intersections can be categorized into four major types, depending on their basic configuration:
i. Simple Intersections - Simple intersections maintain the street’s typical cross section and number of lanes throughout the intersection, on both the main and minor streets. Simple intersections are best-suited to locations auxiliary (turning) lanes are not necessary to achieve the desired level-of-service, or are infeasible due to nearby constraints.
ii. Flared Intersections - The characteristic feature of flared intersections is an expansion of the typical cross section of the street (main, cross or both). The flaring is often done to accommodate a left-turn lane, so that left-turning bicycles and motor vehicles are removed from the through-traffic stream for reasons of capacity at high-volume locations, and safety on higher speed streets. Right-turn lanes, less frequently used than left-turn lanes, are usually a response to large volumes of right turns.
iii. Channelized Intersections - Channelized intersections use raised islands to designate the intended vehicle path. The most frequent use is for right turns, particularly when accompanied by an auxiliary right-turn lane. At skewed intersections, channelization islands are often used to delineate right turns, even in the absence of auxiliary right turn lanes. At intersections located on a curve, channelization islands can help direct drivers to and through the intersection. At large intersections, short median islands can be used effectively for pedestrian refuge.
iv. Roundabouts - The roundabout is a channelized intersection with one-way traffic flow circulating around a central island. All traffic through as well as turning enters this one-way flow. Although usually circular in shape, the central island of a roundabout can be oval, or irregularly shaped. Roundabouts can be an appropriate design alternative to both stop controlled and signal-controlled intersections. At intersections of two-lane streets, roundabouts can usually function with a single circulating lane, making it possible to fit them into most settings.

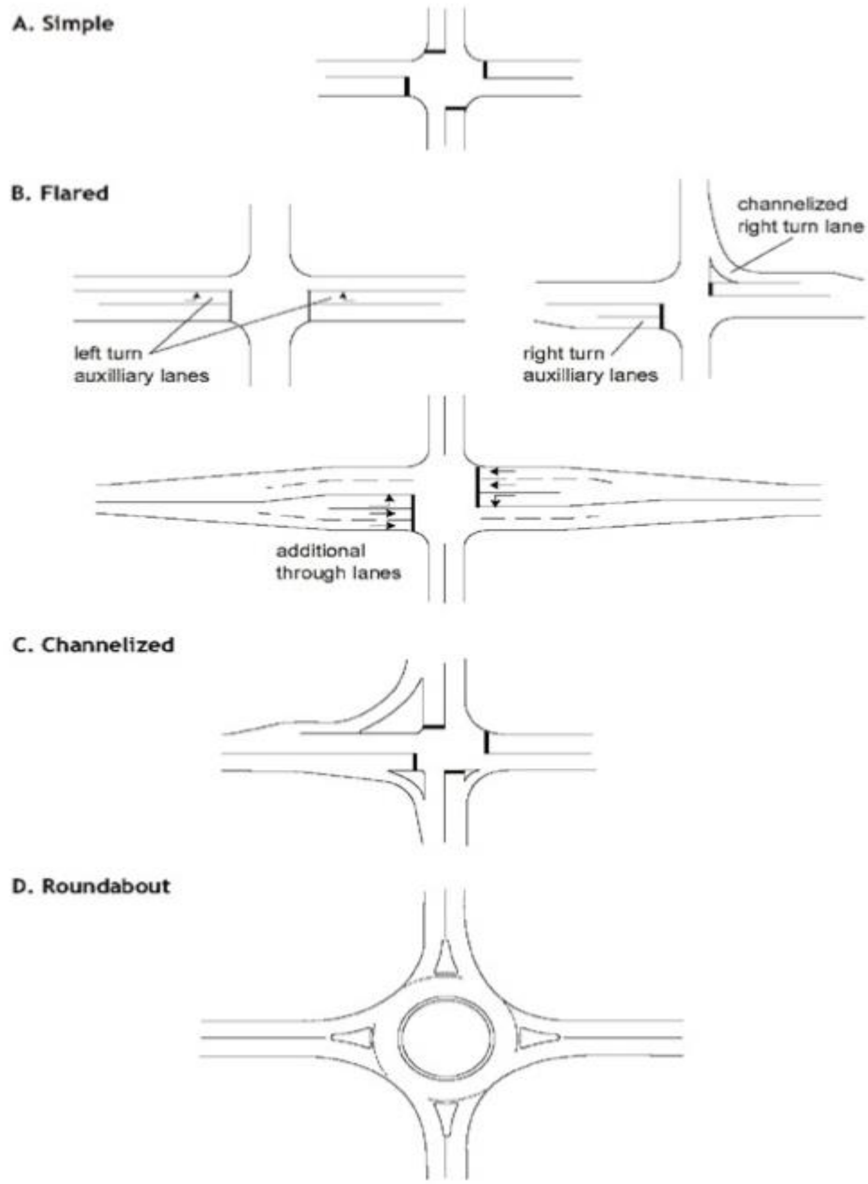

Fig -1: Various Types of Intersection

2. OBJECTIVES

The objectives of this study are:

To analyze and evaluate intersections performance and recommend enhancing measures:

1. To minimize the number and severity of potential conflicts.
2. To check whether the road has adequate capacity to accommodate future traffic volume.
3. To design the intersections on the basis of outcomes of traffic volume survey.

3. Literature Review

S. Darmoul, and his fellows said that Urban transport is subject to disturbance that cause long queues and extended waiting time at signalized intersections. They rely on concepts and mechanisms inspired by biological immunity to design a distributed, intelligent and adaptive traffic signal control system. They suggest a heterarchical multi agent architecture, where each agent represents a traffic signal controller assigned to a signalized intersection. Each agent communicates and coordinates with neighboring agents. And achieves learning and adaptation to disturbances based on an artificial immune network. The suggested Immune Network Algorithm based Multi Agent System (INAMS) provides intelligent mechanisms that capture disturbances-related knowledge explicitly and take advantage of previous successes and failures in dealing with disturbances through an adaptation of the reinforcement principle. The network simulated with VISSIM, a state of-the-art traffic simulation software. [1]

U. Illahi, Dr. M.S. Mir, researched about suitability of different options as solution to the specific intersection and Their research is intended to check the efficiency and control of flow of traffic at "Mahjoor Chowk: Y-intersection", point out flaws (if any) in the geometric design and work out the possible solutions. They come up with a result that as capacity is much less than the volume specially during peak hour traffic therefore the roundabout or signalized intersection cannot handle the traffic, thus they recommend design of flyover as a long term solution. [2]

Y. Zakariya and S. I. Rabia, Estimating the minimum delay optimal cycle length based on a time-dependent delay formula, for fixed time traffic signal control, the well-known Webster's formula is widely used to estimate the minimum delay optimal cycle length. However, this formula overestimates the cycle length for high degrees of saturation. They proposed two regression formulas for estimating the minimum delay optimal cycle length based on a time –dependent delay formula as used in the Canadian Capacity Guide and the Highway Capacity Manual (HCM). For this purpose, the developed a search algorithm to determine the minimum delay optimal cycle length required for the regression analysis. Numerical results show that the proposed formulas give a better estimation for the optimal cycle length at high intersection flow ratio s compared to Webster's formula. [3]

M. Ghanbarikarekani and her colleagues provide a timing optimization algorithm for traffic signals using internal timing policy based on balancing queue time ratio of vehicles in network links. In the proposed algorithm, the difference between the real queue time ratio and the optimum one for each link of intersection was minimized. To evaluate the efficiency of the proposed algorithm on traffic performance, the proposed algorithm was applied in a hypothetical network. By comparing the simulating software (Aimsun) outputs, before and after implementing the algorithm, they concluded that the queue time ratio algorithm has improved the traffic parameters by increasing the flow as well as reducing the delay time and density of the network. [4]

X. Chen and M. S. Lee worked on comparison of different software's result on multi-lane roundabout their study shows that unbalanced entrance flow patterns (i.e., one entrance has significant higher flow than others) can intensify the queue and delay for the overall roundabouts. Then various software packages including RODEL, SIDRA and VISSIM were used to estimate several performance measurements, such as capacity, queue length, and delay, compared with the collected field data. With the comparison, it is found that all the three software packages overestimate multi-lane roundabout capacity before calibration. With default parameters, SIDRA and VISSIM tend to underestimate delays and queue lengths for the multi-lane roundabouts under congestion, while RODEL results in higher delay and queue length estimations at most of the entrance approaches. [5]

V. Gomasta with his friends made an attempt to suggest measures for improving and easing traffic flow at two of the intersections The signal timings have been redesigned for afternoon peak flow optimum cycle time of the signal is calculated using the data of traffic volume and saturation volume [Webster method]. Improvement by widening of road is recommended for first intersection named Jyoti Talkies. At the other intersection called "Vallabh Bhawan roundabout", capacity of rotary is calculated whether it is within its permissible limits or not. Introduction of Signalized rotary is suggested. [6]

W. Sun and his fellows proposed a simplified continuous flow intersection (called CFI-Lite) design that is ideal for arterials with short links. It benefits from the CFI concept to enable simultaneous move of left-turn and through traffic at bottleneck intersections, but does not need installation of sub-intersections. Instead, the upstream intersection is utilized to allocate left-turn traffic to the displaced left-turn lane. It is found that the CFI-Lite design performs superiorly to the conventional design and regular CFI design in terms of bottleneck capacity. [7]

M. Patel purposed **v**arious alternatives like redesigned roundabout, traffic signal, flyover, underpass, cloverleaf and uplifted roundabout checked for their suitability. Change of the geometry in redesign of roundabout has discussed, different phase for signal design also has been discussed which were not suitable for the mentioned intersection then the option of FOB and interchange has discussed to evaluate their suitability at last the uplift roundabout stated to be a suitable option for the mentioned roundabout, the method used for designing the signal is Webster's method and Webster's modified method and by SIDERA INTERNATIONAL the proposed solution has been justified.[8]

Rokade S. with friends have done a 12 hours" traffic volume survey as well as geometry survey and matched the current situation of the intersection with the IRC Code and based on the outcomes of traffic and geometry survey recommend some enhancing measures which few of them are mentioned below:
i - As far as possible the intersections should be located on level ground. A rotarised intersection may be sited to lie on a plane which is inclined to the horizontal at not more than 1 in 50.
ii - The intersection influence area must be overlaid with mastic asphalt as per MoRTH specifications.
iii - Encroachment on all the three legs of the intersections should be removed. This enhances the capacity of the junction. [9]

J. Autey, and the rest of their team studied, evaluated and compared the operational performance of four unconventional intersection schemes: the crossover displaced left-turn (XDL), the upstream signalized crossover (USC), the double crossover intersection (DXI), and the median U-turn (MUT). The micro-simulation software VISSIM (PTV Planning Transport Verkehr AG, Karlsruhe, Germany) was used to model and analyze the four unconventional intersections as well as a counterpart conventional one. The results showed that the XDL intersection constantly exhibited the lowest delays at nearly all tested balanced and unbalanced volume levels. The operational performance of both the USC and the DXI was similar in most volume conditions. The MUT design, on the other hand, was unable to accommodate high approach volumes and heavy leftturn traffic. The capacity of the XDL intersection was found to be 99% higher than that of the conventional intersection, whereas the capacity of the USC and the DXI intersections was about 50% higher than that of the conventional intersection. [10]

A. Klibavičius and G. M. Paliulis [11] tried to construct the methodology for calculation and modeling of traffic lane capacity considering the length of a short traffic lane, and the findings they point out are:

- The required length of short traffic lanes depends on the saturation level STL and the length of max possible vehicle queue on the STL.
- Recommended longer cycle duration for the intersections with STL.

4. CONCLUSIONS

Design of a safe intersection depends on many factors. The major factors can be classified as under: (1) Human Factors (2) Traffic Considerations (3) Road and Environmental Conditions.
If maximum volume of traffic is ≤3000 Vehicles/hour rotary can handle efficiently, entering from all intersection legs. Rotaries are advantageous in locations where the proportion of right turning traffic at a junction is high.

- When traffic volume is less than capacity the solution to manage the traffic is to design signals for intersection, if it's vice versa then….
- Traffic engineers should think of 3 dimensional solutions which are grade-separate intersection design, it will handle traffic up to 10000PCU/hr.
- Additional to the conventional solution there are unconventional solution to reduce the potential conflict point and minimize the congestion at intersection unconventional intersections e. g. DRT, DXT, MUT etc...
- To overcome to the problems of unexpected situation and disturbances which leads traffic congestion at the controlled intersection, suitable solution will be application of intelligent systems like MAS, Definition of algorithm to the signal system to arrange the phase timing according to the situation creates by disturbance.

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