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A methodology for resourceful design of traffic signal control

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Abstract

This paper discover the different issues of transportation from various methods and focused on the efficiency of the overall transportation. I have tried to focus on three most important issues i.e traveling cost, travelling time and travelling efficiency of Transportation engineering and then effort to resolved these issues by using proposed method.

The future work sets forth a flexible plan that will guide us in our efforts to improve traffic signal synchronization along our heaviest traveled arterial streets. Over the years, traffic flow along these streets has grown rapidly due to community growth and dependence on the automobile.

Transportation engineering or transport engineering is the application of technology and scientific principles to the planning, functional design, operation and management of facilities for any mode of transportation in order to provide for the safe, efficient, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods transport.

Keywords: Transportation Engineering, Travelling Cost, Travelling efficiency.

1. Introduction

In civil engineering, Transportation is one of the essential components of the profession from its early days. As we see, the building of roads, bridges, pipelines, tunnels, canals, railroads, ports, and harbors has shaped the profession. Civil engineering is involved in developing, building, and operating transit facilities, including street railways and elevated and underground systems and so on. The role of civil engineering is to providing transportation infrastructure to accommodate a growing population and economy of city. If we look back towards history, transcontinental railroads, national highways, canals, petroleum and natural gas pipelines, as well as major urban transit systems, are testimonials to the achievement of civil engineering.

In the last 200 years, railroads, transit lines, ports, and airports have helped to increase the range of cities and reduce the isolation of rural areas. They have brought the nation closer together.

The assessment on traffic network routine has been worried by traffic managers, traffic planning designers and traffic engineers. The assessment on travel time of traffic network shows great meaning. Since it can neutrally reflect the service level of road network.

Traffic engineering is a branch of transportation engineering that uses engineering techniques to achieve the safe and efficient movement of people and goods. It focuses mainly on research and construction of the immobile infrastructure necessary for this movement, such as roads, railway tracks, bridges, traffic signs and traffic lights.

Traffic engineering is also defined as phase of engineering which deals with planning & geometric design of streets, highways, abutting lands & with traffic operation thereon, as there use is related to the safe, convenient & economic transportation of persons & goods. Traffic engineering is a science of measuring traffic & travel, study of the basic laws relating to traffic flow & generation & application of this knowledge to the professional practice of planning, designing & operating traffic system to achieve safe & efficient movement of persons & goods.

Instead of building additional infrastructure, dynamic elements are also introduced into road traffic management. These use sensors to measure traffic flows and automatic, interconnected guidance systems to manage traffic, especially in peak hours.

The relationship between lane flow (Q , vehicles per hour), maximum speed (V , kilometers per hour) and density (K , vehicles per kilometer) is $Q = KV$. Observation on limited access

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facilities suggests that up to a maximum flow, speed does not decline while density increases, but above a critical threshold, increased density reduces speed, and beyond a further threshold, increased density reduces flow as well. Therefore, managing traffic density by limiting the rate that vehicles enter the highway during peak periods can keep both speeds and lane flows at bottlenecks high. Ramp meters, signals on entrance ramps that control the rate at which vehicles are allowed to enter the mainline facility, provide this function. With this plan, we are focusing on efforts to improve traffic signal coordination. Such signal coordination ranks as one of the most cost effective and successful strategies to reduce congestion problems. Each dollar spent optimizing signal timing and implementing system improvements can yield up to \$40 in fuel savings. Additionally, signal coordination can also have a dramatic impact on the drivers themselves. As most of us realize, delays and frustrations caused by the operation of traffic signals can lead to accidents and road rage. By bettering our equipment, maintenance practices, and signal programming methods, we can improve the lives of our motoring public by shortening their travel times and providing easier drives. This paper provides a brief discussion on the benefits of coordinating traffic signals, signal timing efforts, influencing factors, complementary system operations, and short range improvements.

Benefits of Signal Coordination

We coordinate traffic signals to insure optimum travel speeds, reduced delays, and minimal stops. As national studies indicate, coordinating previously uncoordinated signals can result in a reduction in travel time ranging from 10% to 20%.

- Improved mobility and access
- Bolstered local economies
- Reduced vehicular accidents
- Reduced energy and fuel Consumption
- Eliminated or delayed street widening needs
- Reduced vehicle emissions
- Real-time traffic monitoring

Literature Review

Congestion is the travel time or delay in excess of that normally incurred under light or free flow traffic condition. Unacceptable congestion is travel time or delay in excess of agreed upon norm which may vary by type of transport facility, travel mode, geographical location, and time of the day.

In this paper we have taken effort to study the real time traffic of pune city and implemented the our work methodology. First of all we will discuss about the geographical status of pune city and then explore the vehicular scenario of the city.

Pune Municipal Corporation (PMC) has embarked on the preparation of a new Development Plan (DP) for the period 2007 – 2027 by revising the existing DP for 1987 – 2007. This is an ongoing project conducted by the Corporation. PMC would also like to take up the development of a sustainable transport strategy for Pune, based on land use plans for the future and projections of population and economic development as proposed and envisaged in the development plan.

Several studies, relating to traffic and transportation aspects in Pune Metropolitan Area, have been carried out in the recent past by various organisations. These studies covered

transport systems like metro, bus rapid transit, tram, non-motorised transport and aspects like mobility, traffic management and road improvement schemes.

A comprehensive mobility plan (CMP) was also got prepared by PMC. The CMP suggested several transportation infrastructure and system improvements necessary for the future. Around the same time, IIT Bombay has developed a transportation planning model for the study area covering Pune and Pimpri – Chinchwad Areas for the purpose of forecasting passenger demand on the proposed metro rail lines.

sustainable transport strategy for Pune city, has upgraded the transport planning model developed for the metro study based on the enormous data available from previous transport plans and it is fully integrated with the revised development plan. Hence this work includes evaluating the impacts of various development scenarios proposed in the development plan on the Transportation infrastructure. The evaluation is carried out considering the concepts of sustainability. The boundary of a larger area which includes Pune Municipal Corporation Area and Pimpri Chinchwad Municipal Corporation Area, Pune and Khadki Cantonments and other areas within the outer cordon as worked out based on the requirements has been considered as the study area for the development of the transportation planning model.

III. Methodology

Traffic Signals:-

Traffic Signals are one of the more familiar types of intersection control. Using either a fixed or adaptive schedule, traffic signals allow certain parts of the intersection to move while forcing other parts to wait, delivering instructions to drivers through a set of colorful lights (generally, of the standard red-yellow (amber)-green format). Some purposes of traffic signal is to

- (1) improve overall safety
- (2) decrease average travel time through an intersection, and
- (3) equalize the quality of services for all or most traffic streams.

Traffic signals provide orderly movement of intersection traffic, have the ability to be flexible for changes in traffic flow, and can assign priority treatment to certain movements or vehicles, such as emergency services.

At intersection where there are a large number of crossings and right turn traffic, there is possibility of several accidents as there cannot be orderly movement. The earlier practice has been to control the traffic by means of traffic police by showing stop signs alternately at the cross roads so that one of the traffic streams may be allowed to move while the cross traffic is stopped. Thus the crossing streams of traffic flow are separated by time, segregation. Traffic signals are control devices which could alternately direct the traffic to stop and proceed at intersection using red and green traffic light signals automatically. The main requirement of traffic signals are to draw attention, provide meaning and time respond and to have minimum waste of time.

Traffic Signal Characteristics:-

Modern traffic signals allocate time in a variety of ways, from the simplest two-phase pretimed mode to the most complex multiphase actuated mode. There are three types of traffic signal controllers:

Pretimed, in which a sequence of phases is displayed in repetitive order. Each phase has a fixed green time and

change and clearance interval that are repeated in each cycle to produce a constant cycle length.

Fully actuated, in which the timing on all of the approaches to an intersection is influenced by vehicle detectors. Each phase is subject to a minimum and maximum green time, and some phases may be skipped if no demand is detected. The cycle length for fully actuated control varies from cycle to cycle. Semi actuated, in which some approaches (typically on the minor street) have detectors and some of the approaches (typically on the major street) have no detectors. While these equipment-based definitions have persisted in traffic engineering terminology, the evolution of traffic control technology has complicated their function from the analyst's perspective. For purposes of capacity and level-of-service analysis, it is no longer sufficient to use the controller type as a global descriptor of the intersection operation. Instead, an expanded set of these definitions must be applied individually to each lane group. Each traffic movement may be served by a phase that is either actuated or nonactuated. Signal phases may be coordinated with neighboring signals on the same route, or they may function in an isolated mode without influence from other signals.

Nonactuated phases generally operate with fixed minimum green times, which may be extended by reassigning unused green time from actuated phases with low demand, if such phases exist.

Actuated phases are subject to being shortened on cycles with low demand. On cycles with no demand, they may be skipped entirely, or they may be displayed for their minimum duration. With systems in which the non actuated phases are coordinated, the actuated phases are also subject to early termination (force off) to accommodate the progression design for the system.

Not only the allocation of green time but also the manner in which turning movements are accommodated within the phase sequence significantly affects capacity and operations at a signalized intersection. Signal phasing can provide for protected, permitted, or not opposed turning movements.

A permitted turning movement is made through a conflicting pedestrian or bicycle flow or opposing vehicle flow. Thus, a left-turn movement concurrent with the opposing through movement is considered to be permitted, as is a right-turn movement concurrent with pedestrian crossings in a conflicting crosswalk. Protected turns are those made without these conflicts, such as turns made during an exclusive left-turn phase or a right- turn phase during which conflicting pedestrian movements are prohibited.

Permitted turns experience the friction of selecting and passing through gaps in a conflicting vehicle or pedestrian flow. Thus, a single permitted turn often consumes more of the available green time than a single protected turn. Either permitted or protected turning phases may be more efficient in a given situation, depending on the turning and opposing volumes, intersection geometry, and other factors.

Turning movements that are not opposed do not receive a dedicated left-turn phase (i.e., a green arrow), but because of the nature of the intersection, they are never in conflict with through traffic. This condition occurs on one-way streets, at T-intersections, and with signal phasing plans that provide complete separation between all movements in opposite directions (i.e., split-phase operation). Such movements must be treated differently in some cases because they can be accommodated in shared lanes without impeding the through traffic. Left turns that are not opposed at any time should be

distinguished from those that may be unopposed during part of the signal cycle and opposed during another part. Left turns that are opposed during any part of the sequence will impede through traffic in shared lanes.

Intersection:

In the field of road transport, an intersection is a road junction where two or more roads either meet or cross at grade. Such a road junction may also be called a crossroads. Intersection is an area shared by two or more roads. This area is designated for the vehicles to turn to different directions to reach their desired destinations.

Classification of Intersection:

Some may classify intersections as 3-way, 4-way, 5-way, 6-way, etc. depending on the number of road segments (arms) that come together at the intersection.

•3-way intersection - A junction between three road segments (arms) is a T junction (two arms form one road) or a Y-junction.

•4-way intersections- are the most common, because they usually involve a crossing over of two streets or roads. In areas where there are blocks and in some other cases, the crossing streets or roads are perpendicular to each other.

•5-way intersections are less common but still exist, especially in urban areas with non-rectangular blocks.

•6-way intersections usually involve a crossing of three streets at one junction; for example, a crossing of two perpendicular streets and a diagonal street is a rather common type of 6-way intersection.

IV. Base of System Methodology

Pune City Profile:

Pune is a bustling medium sized city in Maharashtra, roughly 99 miles Southeast of Mumbai. There is a highway and railway connecting Mumbai and Pune, and both arteries go all the way down to various parts of South India. Pune is famous for its IT industry. New IT parks have blossomed in the last decade or so, with new IT companies opening up daily offering various software services and other services as well. Population of Pune city is approximately 3.4million in the year 2007, and the two neighboring cities Pune and Pimpri-Chinchwad form an urban agglomeration with almost 5.0 million inhabitants. The annual population growth has been 3.5-4.0 per cent since 1981 and the driver of migration is the economy and especially the Information Technology (IT) Sector.

Three classes of cities/urban agglomerations have been identified for assistance under

Jnnurm:

Category A: Cities/urban agglomeration with population of 4 million and above as per 2001 census.

Category B: Cities/urban agglomeration with population of 1 million and above as per 2001 census.

Category C: Other selected cities/urban agglomeration, including state capitals and cities/UA of religious/historic and tourist importance.

Pune city, with a population, of 1 million plus is one of cities identified under Category B, entitling it to 50 percent capital grant from the Central Government, 20 percent grants from the State Government, and 30 percent from Financial Institutions, as per JNNURM funding pattern.

The city of Pune is the second most industrialized city of the State of Maharashtra after Mumbai As per the JNNURM strategy for achieving its objectives, each eligible city intending to Access assistance under the Mission is expected to formulate a comprehensive City Development Plan (CDP) indicating policies, programs and strategies and financing plans, before seeking funding for specific projects. The CDP is to be formulated through a consultative process, articulating the stakeholders'.

Population:

Pune District is situated in Maharashtra state of India. Pune city is the district headquarters. In the most recent census on 2011, the total population of the district was 9,426,959, making it the fourth most populous district in India (out of 640). Urban population comprises 58.08% of the total population. The current population of Pune urban agglomerate is over 5 million.

The increase in the 1991 population of PMC only on account of natural increase was estimated by using proper life table and estimates of ASFR from the age-Distribution, this three age distribution (naturally grown population of PMC, merger villages and merged town) were estimated. i.e 9.7 lacks (21%) was due to natural growth, 41% was due to territorial expansion and remaining 38% was due to net in migration.

As seeing the above situation the management of traffic regulation is an urgent requirement to proper coordination the vehicle management

Methods of Designing Intersections

In this section we have tried to give basic alternative way to provide more efficient and cost effective signal management of traffic signaling. There are two ways to felicitate the vehicle automation

1. F.V.Webster's Method
2. Highway Capacity Manual Method (HCM)

F.V.Webster's method: In the 1950s, Webster conducted a series of experiments on pretimed isolated intersection operations (1). Two traffic signal timing strategies came from

his study. One is signal phase splits. Webster demonstrated, both theoretically and experimentally, that pretimed signals should have their critical phases timed for the equal degrees of saturation for a given cycle length to minimize the delay. The other is the minimum delay cycle length equation In developing the equation for the optimal minimum delay cycle length, it was assumed that the effective green times of the phases were in the ratio of their respective y values (Flow ratios)

$$C_0 = [(1.5L + 5) \div (1 - Y)]$$

Where c_0 = the optimal minimum delay cycle length, sec;

L = total lost time within the cycle, sec; and

Y = the sum of critical phase flow ratios (2).

The above two strategies are very useful for traffic design and planning. When the two rules are applied together, one can practically minimize the resulting delay at an isolated pretimed signalized intersection.

Phase Design:

The objective of phase design is to separate the conflicting movements in an intersection into

Various phases, so that movements in a phase should have no conflicts. If all the movements

Are to be separated with no conflicts, then a large number of phases are required. In such a situation, the objective is to design phases with minimum conflicts or with less severe Conflicts.

There is no precise methodology for the design of phases. This is often guided by the Geometry of the intersection, flow patterns especially the turning movements, the relative magnitudes of flow. Therefore, a trial and error procedure is often adopted. However, phase design is very important because it affects the further design steps. Further, it is easier to change the cycle time and green time when flow pattern changes, where as a drastic change in the flow pattern may cause considerable confusion to the drivers. To illustrate various phase plan options, consider a four legged intersection with through traffic and right turns. Left turn is ignored. See figure 4.1. However, in the first phase flow 7 and 8 offer some conflicts and are called permitted right turns. Needless to say that such phasing is possible only if the turning movements are relatively low. On the other hand, if the turning movements are significant, then a four phase system is usually adopted.

Design of Intersection of Traffic Signal:

The design hour traffic volumes in PCU/hr collected can be tabulated

- 1) As per the roadway width time taken for pedestrian to cross the street is calculated. If there is a large width of streets it is desirable to have a central pedestrian refuge of at least 1m width. Time that will be needed by pedestrian to reach the pedestrian refuge from the kerb will then be:

$$\begin{aligned} \text{Time} &= \text{Distance/velocity} & (1) \\ &= X \text{ seconds} \end{aligned}$$

This will be the pedestrian clearance interval during which no signal is displayed to the pedestrians and those who have just left the kerb or the central refuge before the termination of the pedestrian green signal can reach safely the central refuge of the kerb as the case may be. The pedestrian clearance interval is followed by amber of the next vehicular phase and by the red signal in pedestrian phase.

For the "average" and level sites with the parking prohibited, no corrections are needed for the

Saturation flow obtained from the below formula.

$$S = 525 W$$

Where, W = width of approach road in Meters

$$S = \text{saturation flow}$$

- 2) We have to consider straight moving vehicles for that purpose following corrections are applied to the left and right turning vehicles. The effect of left turning traffic will be accounted for it constitute more than 10% of the traffic by counting each left turner as equivalent to 1.25 straight ahead vehicles. Since no exclusive right turning lanes are provided, The effect of right turning traffic will be accounted for by counting each right turner as equivalent to 1.75 straight ahead vehicle.

Maximum Y (Y_{max}) for two different phases is calculated by the following formula:

$$Y = (q/s)$$

Where, q = flow in arm after applying corrections

s = saturation flow

3) Calculate Intergreen time as follows:

Intergreen period= Amber period (a)+ All red period

4) Calculate Lost time as follows:

Lost time (L) = (Pedestrian Phase+ Amber following Pedestrian Phase)+ (Intergreen period- Amber time) + delay per vehicular phase (2)

5) Calculate optimum cycle time:

Optimum cycle time, $C0 = [(1.5L+5) \div (1-Y)]$ (3)

6) Apportioned Green time for each phase by using following formula:

GEW= -----For N-S Phase-----For N-S Phase

GEW=-----For E-W phase

Where,

GNS= green time for N-S phase

GEW= green time for E-W phase



Fig: 1(a) Traffic scenario of signal methods



Fig: 2(b) Traffic scenario of Proposed flyover method

IV. Conclusion and future Work

We have find out that our proposed method is able to provide a most efficient traffic signaling method till now. We can definitely conclude that design of traffic signal will help in advancing transportation network to provide ease & safety to the using it. They will provide easy & efficient control over the movement of vehicles at Intersections. It will lead to minimum time delay resulting in saving in fuel & hence the cost of travelling will minimize achieving economy. Also there will be less pollution as vehicles have to wait for no such longer time than before. Traffic signals will also reduced the conflict points at intersections will minimize the accident. Thus resulting in overall efficiency & economy will assist the road user for better experienced.

We have given a brief ideology for the different aspects of signal methodology and provide our proposed method to resolve the three most important issues related with traffic i.e cost, time and fuel saving of vehicle .We can achieve a better prospect by using the proposed method.

As future work we can proceed towards the vehicle automation of vehicle especially heavy vehicle by using the wireless sensor network and internet protocol

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