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DESIGN AND ANALYSIS OF TRAFFIC SIGNAL AT SIGNALIZED JUNCTION

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ABSTRACT
Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. These data can help to identify critical flow time periods, determine the influence of large vehicles or pedestrians on vehicle traffic flow. The length of the sampling period depends in the type of count being taken and the intended use of the data recorded. Webster method is a rational approach for signal design. The design is simple and is totally based on formulas laid down by Webster, in this method, the total cycle of the signal is determined which forms a total least delay occurring at signal.
Signal timing involves deciding how much green time the traffic lights shall provide at an intersection approach. How long the pedestrian walk signal should be, and many numerous other factors. The design of traffic signal nowadays has become an important factor for major intersections of towns and cities. Traffic signal controls the movement of traffic and not only reduces accidents but enables the road safety users to effectively use the area of road at intersection. The important parameters in the planning, design and control of a signalized intersection are saturation flows, lost times and passenger car units (PCU).

Keywords — Signal Design, Webster method, Traffic control, PCU, Intersection, Simulation, Traffic field studies.

I.INTRODUCTION

The city of Hyderabad is one of the fastest growing metropolitan cities with a decadal growth rate of 32%. The urban agglomeration of Hyderabad spread over an area of 650sq. km which comprises Hyderabad, and twelve other municipal entities surrounding it. This indicates a potential demand for investment in transport infrastructure. Such need-based developments include determination of the required capacity expansion, provision of additional road infrastructure, improvement of existing roads, prioritization of different development phases and forecasting of which is possible upon collection of traffic data. This is done in order to eliminate bottlenecks in both international and local inter-urban road transport towards providing an efficient and effective road transport system. The techniques used have become almost standard in both developing and developed countries. The accuracy of traffic data collection and the subsequent predictions are of paramount importance in the fulfillment of an appropriate planning, design, maintenance monitoring and management of the road network.
In the past, routine collection of traffic data in this country was not considered important forthe development and management of the road network. In the early 1970's it was realized that a wide variety of information is required in respect of traffic characteristics for proper maintenance, planning, design, maintenance and management of the national road network. This realization

emanated from concerns raised with regard to the amount of traffic, the composition of the different types of vehicles, their speed, and total gross weight, number of axles, axle loads and origin and destination of the journeys. This includes the use of both manual and automatic traffic counters, together with computer analysis of the collected traffic data. During the planning, design, construction and maintenance period of the road network, traffic data becomes an essential element in decision-making, and therefore the format and the accuracy of data collection and analysis is critical. Most of the urban roads in Hyderabad are static in behavior during peak hours. This is leading to traffic congestion and in-turn to endless transportation gridlocks which has a direct impact on economy. It is with this view that this guideline on traffic data collection and analysis has been prepared.

II.LITERATURE REVIEW

M. Bhagyaiah, B. Shrinagesh (2011)

Globalization and urbanization has increased the vehicles since last 10 years has put lot of pressure on the existing roads and ultimately resulting in road accidents. It is estimated that since 2001 there is an increase of 202 percent of two wheeler and 286 percent of four wheeler vehicles with no road expansion. Motor vehicle crashes are a common cause of death, disability and demand for emergency medical care. Globally, more than 1 million people die each year from traffic crashes and about 20–50 million are injured or permanently disabled. There has been increasing trend in road accidents in Hyderabad over a few years. GIS helps in locating the accident hotspots and also in analyzing the trend of road accidents in Hyderabad.

Udit Batra, Mandar V.Sarode (2013)

Rapid Industrialization and the consequent urbanization have brought about an unprecedented revolution in the growth of motor vehicles all over the world and India is no exception. This created scope for increase in travel and transportation analysis. The growing urbanization, combined with rising number of vehicle ownership, has led in recent years to an increased demand of traffic survey and analysis, for both long term and short term period. Traffic analysis is basically the process of intercepting and examining the number of vehicles on the road and deducing the pattern of traffic moment.

Dr Awari Mahesh Babu (2017)

Road traffic delay and overcrowding have become recurrent problems worldwide. This is mainly since transportation growth is sluggish compared to increase in quantity of vehicles, owing to gap and expenditure restriction. Traffic being non-lane based and disordered, is mainly unusual with different types of vehicles. Metropolitan region roads are under mixed traffic conditions. The road user physiological behavior also causes delay and congestion.

Adepu Ramesh, Kumar Molugaram (2018)

In our country traffic flow is heterogeneous and is governed by traffic characteristics as driver behavior, road geometry etc. Increase in traffic volume and limited road way width should be promptly addressed by traffic engineers who shall provide solutions which shall be more competent than traditional signalized designs. The recommendations suggested by the traffic engineer for improving signalized intersection shall be less expensive than providing interchanges. Metropolitan cities like Hyderabad are also experienced with delay and congestion due to ineffective traffic signal operation. Non lane based traffic behavior, varying pavement width and driver characteristics are a few reasons for delay and congestion on our city roads. Improvement in the above context can be achieved through lane prioritization, alternative routes etc. These improvements will certainly reduce the impact on fuel consumption, improves safety and Level of Service at signalized intersection.

Samrat Mukhopadhyay, Pramod M.J (2015)
Mixed vehicular traffic comprising small cars and two-wheeled vehicles arrive at a lane of a signalized road intersection. The traffic does not follow lane-discipline, in that the arriving vehicles do not necessarily queue up one behind the other. The motorcycles are small enoughto stand side-by-side with cars or other motorcycles, so as to fill up the width of the lane. With such queue joining behavior, the waiting vehicles form batches, comprising motorcycles and at most one car. During the green signal period the vehicles in the head-of-the-line batch exit the intersection together. In this paper, assuming a Poisson point process model for vehicle arrivals, we have provided an approximate analysis of such a queuing system. Our approach is to use an assembly queue model for the batching process. The batches generatedby the assembly queue enter an interrupted M/Semi Markov/1 (or M/SM/1) queue. By analyzing the assembly queue we characterize the batch input process for the interrupted M/SM/1 queue. We then develop an extension of the Webster mean delay formula for obtaining the approximate mean delay in the interrupted M/SM/1 queue. Numerical results from the analysis are compared with simulation.

III.METHODOLOGY

The equations developed by Webster in his famous 1958 report are still the basis of traffic signal planning today. They are being used in handbooks like the HCM and similar instruments world-wide. However, the handbook approach typically works with approximations to the original equations which have stood the test of time, but may nevertheless not be the best to be done today. This work analyzes Webster's approach and advocates a more modern use of it which utilizes the tremendous advances in computer hardware and software. This is being done by comparing approximations to exact solutions, and by a comparison between various models and Webster's equations itself. It is shown that there can be significant differences in the calculation of optimal cycle times and consequent delay times.
Webster published his famous report in which the working of a fixed cycle traffic signal is analyzed in depth. Especially the formula for the optimum cycle time of an n-phase intersection is still used in every day's work and is put into handbooks like the Highway Capacity Manual and similar works. A large amount of research has been put into the comparison of Webster's equations with micro-simulation tools and to comparing them to real data and into the theoretical description of what happens at a signal controlled intersection. Nevertheless, there are still open questions in this field, a few of them will be highlighted in the current study. In this study we compare Webster's theory with results obtained from a micro-simulation model. The deterministic model by Webster fits fairly well with a host of different deterministic modeling approaches. For the stochastic part, however, differences between theory and simulation reality have been found. It is shown that there can be significant differences in the calculation of the optimal cycle times and the resulting delay times.

3.1Webster's Method of Traffic Signal Design

It has been found from studies that the average delay and the overall delay to the vehicles at a signalized intersection vary with the signal cycle length. The average delay per vehicle is high when the cycle length is very less, as a sizable proportion of vehicles may not get cleared during the first cycle and may spill over to subsequent cycles. As the signal cycle time is increased, the average delay per vehicle decreases up to a certain minimum value and thereafter the delay starts increasing, indicating that there is an 'optimum signal cycle time' corresponding to least overall delay. The optimum cycle time depends on the geometric details of the intersection and the volume of traffic approaching the intersection from all the approach roads during the design hour. Webster's method of traffic signal design is an analytical approach of determining the

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optimum signal cycle time, corresponding to minimum total delay to all the vehicles at the approach roads of the intersection.

3.1.1Study Magnitude

• Time of the day

The traffic flow was seen varying during the peak hours and the non- peak hours. The peak hours (8:30AM to 10:00AM and 5:30PM to 7:30PM) were taken into consideration for the recording of the maximum traffic movements. The peak hours are defined by the buses office going people, shopkeepers, school and college going people majorly. This is the time at which traffic movement is maximum and therefore the actual capacity of the road under consideration is measured.

• Morning/Evening

The recordings at a signal place were taken twice that is once in the morning and again in the evening respectively. The morning data was directly compared to the evening, giving better estimate for the study.

• Inflow/Outflow

The inflow as well as the outflow of the same road was recorded so that the total no of vehicles on that road on that particular time were recorded accordingly.

• Vehicle type

The types of vehicles running during these hours were also observed. For example, no of buses, cars, auto, rickshaws, two wheelers and bicycles were head counted separated and compared according.

3.1.1 TRAFFIC FLOW

• Frequency of Traffic counts

In order to predict traffic flow volumes that can be expected on the road network during specific periods, cognizance should be taken of the fact that volumes changes considerably at each point time.

There are three cyclical variations that are of particular interest:

• Hourly pattern: The way traffic flow characteristics vary throughout the day and night.

• Daily pattern: The day-to-day variation throughout the week.

• Monthly pattern: The season-to-season variation throughout the year.

When analyzing the traffic one must also be aware of the directional distribution of traffic and the manner in which its composition varies.

• Hourly patterns

Typical hourly pattern of the traffic flow, particularly in urban areas, generally show a number of distinguishable peaks. Peak in the morning followed by a lean flow until another peak in the middle of the afternoon, after which there may be a new peak in the late evening. The peak in the morning is often more sharp by reaching the peak over a short duration and immediately dropping to its lowest point. The afternoon peak on the other head is characterized by a generally wider peak. The peak is reached and dispersed over a longerperiod then the morning peak. However, in urban satellite towns, the morning peak may be too early and evening peak may be too late in comparison to the principal towns without significant midday peak.

3.2.2.1 Automatic Traffic Counting Equipment:

In essence, typical automatic traffic data collection equipment consists of a detector to detect vehicles and a counter to records the information, some of which are shown below.

Automatic Count Recording Methods:

Automatic counts are recorded using one of three methods:

- **Portable Counters:**

Portable counting is a form of manual observation. Portable counters serve the same purposeas manual counts but with automatic counting equipment. The period of data collecting using this method is usually longer than when using manual counts. The portable counter method is mainly used for 24-hour

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counts. Pneumatic road tubes are used to conduct this method of automatic counts.

These are tubes placed on the top of road surface at locations where traffic counting is required. As vehicles pass over the tube, the resulting compression sends a burst of air to an air switch, which can be installed in any type of traffic counting devices. Air switches can provide accurate axle counts even when compressions occur more than 30m from the traffic counter. Although the life of the pneumatic tubes is traffic dependent as they directly drive over it, it is used worldwide for speed measurement and vehicle classification for any level of traffic. Care should be exercise in placing and operating the system, to ensure its efficient operation and minimize any potential error in the data.

Fig 3.4: Portable Counters

- Inductive loops:

Inductive loop detector consists of embedded turned wire from which it gets its name. It includes an oscillator, and a cable, which allows signals to pass from the loop to the traffic counting device. The counting device is activated by the change in the magnitude filed when a vehicle passes over the loop. Inductive loops are cheap, almost maintenance-free and are currently the most widely used equipment for vehicle counting and detection. Single loops are incapable of measuring vehicular speed and the length of a vehicle. This requires the uses of a pair of loops to estimate speed by analyzing the time it takes a vehicle to pass through theloops installed in series. An inductive loop can also to a certain degree, be used to detect the chassis height and estimate the number of axles.

By using the inductive loops, the length of the vehicle is therefore derived from the time taken by the vehicle to drive from the first to the second loop (driving time) and the time during which the vehicle to drive from the first to the second loop (cover loop). The resulting length is called the electrical length, and is in general less than actual length of the passing vehicle. This is caused by the built in detector threshold, the rood surface material, the feeder length, the distance between the bottom of the vehicle and the loop, but also to a large extent, the synthetic materials used in modern cars. The system could be used for any level of traffic.

Fig 3.5: Inductive loops

IV.DATA COLLECTION

General Assessment of available resources prior to commencement of any activity is critical to any assignment at hand. For traffic data collection, it is important that proper assessment of the extent or scope of the envisaged quality level of data required is undertaken. This is aimed at ensuring that the planned and organized exercise is achieved at optimal cost and with the expected accuracy. The exact number of persons and equipment to undertake a specific traffic counting assignment is dependent, among others on:

- The location of the station.
- The quality of data to be collected.
- The level of traffic flow.
- The nature of the road section and traffic flow characteristics within which the station falls.
- Traffic composition.

Time of the day: The traffic flow was seen varying during the peak hours and the non peak hours. The peak hours (8:30 AM to 11:30 AM and 5:30 PM to 7:30 PM) were taken into consideration for the recording of the maximum traffic movements. The

peak hours are defined by the buses, office going people, shopkeepers, school and college going people majorly. This is the time at which traffic movement is maximum and therefore the actual capacity of the road under consideration is measured.

Morning / Evening: The recordings at a single place were taken twice that is once in the morning and again in the evening respectively. The morning data was directly compared to the evening, giving better estimate for the study.

Inflow / Outflow: The inflow as well as the outflow of the same road was recorded so that the total no of vehicles on that road on that particular time were recorded accordingly.

Vehicle Type: The types of vehicles running during these hours were also observed. For example, no of buses, cars, auto, rickshaws, two wheelers and bicycles were head counted separately and compared accordingly.

4.1PASSENGER CAR UNIT:

• It is common practice to consider the passenger car as the standard vehicle unit toconvert the other vehicle classes and this unit is called passenger car unit or PCU.

• The PCU may be considered as a measure of the relative space requirement of a vehicle class compared to that of a passenger car under a specified set of roadway,traffic, and other conditions.

• The PCU value of a vehicle class may be considered as the ratio of capacity of a roadway where there are passenger's cars only to the capacity of the same roadwaywhen there are vehicles of that class only.

4.1.1 Factors Affecting PCU Values:

- Vehicles characteristic
- Transverse and longitudinal gaps
- Traffic stream characteristic
- Roadway characteristic
- Regulation and control of traffic
- Environmental and climatic conditions
- Based on the above factors, a set of PCU values have been worked out for:

Bikes	0.25
Cars	1
Heavy Vehicles	2.8
Buses	3.6
Auto	0.6

Table no:4.1 Passenger Car unit

4.2 Steps for taking traffic data

In order to evaluate the proposed methodology, data with regard to delay, volume, etc. of a signalized intersections which are advantageous to observing at Barkatpura x road were applied. The locations are near PF office bus stop and HP petrol station, etc. The entire data were collected under a condition of clear weather, dry pavement, and low magnitude of wind on May 2022.

All study approaches have two lanes in each direction. The lane widths for all locations are 3.50 (m), 3.50 (m) for the inner and outer lanes, respectively.

The measurement of delay was made by observing the traveling of vehicles to intersections. According to IRC. It needs at least two people for measuring average delay. The first onestood at the head of the queue and the second one stood at the stop line. The first one countedthe number of vehicles approaching the intersection, while the second one counted the number of vehicles passing the stop line. Both of them started counting simultaneously and inthe same time interval.

• Step 1 - Identify Traffic Flow Volumes, Traffic flow volumes are identified, including turning movements.

• Step 2 - Identify Junction Layout, Lane Geometry and Site Characteristics The junction layout, including lane geometry and site characteristics are identified. It may be necessary, if revealed in Step 4 or Step 7, to modify the layout to cater for turning

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movements, pedestrians or to enhance capacity and/or safety.

• Step 3 - Identify Signal Phasing and Method of Control The method of control to be used for analysis is identified.

• Step 4 - Check Turning Movements and Pedestrians Adequate provision for turning movements and pedestrians should be checked. It may be identified at this stage that the assumed method of control would need adjustment before continuing. Adequate allowance in calculations for parallel pedestrian minimum green crossing times should be made.

• Step 5 - Estimate Saturation Flows The saturation flows for various approaches / movements are identified. In critical cases the saturation flows for important movements may have to be measured on site.

4.3 STUDY AREA

The study area is located at Barkatpura X road as shown in figure. It is four legged intersection. The locations are near PF office bus stop and HP petrol station, etc. The entire data were collected under a condition of clear weather, dry pavement, and low magnitude of wind on April 2023.

Figure 4.1: Barkatpura Junction

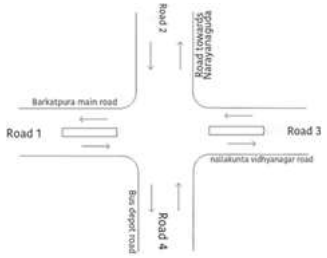

Fig 4.1.1 Road directions

V.RESULTS AND DISCUSSION

- The paper proposes the modified Webster's model to estimate delay for heterogeneous traffic conditions at pre-timed signalized intersections. Traffic volumes approaching the signalized intersection are classified into four groups: Motorized two-wheeler, Car, Minibus, and Bus.
- The passenger car unit (PCU) is estimated by using the linear multiple regression analysis. The regression function expresses the relationship between the saturated green time and the total number of vehicles of all groups passing the approach. Saturation flows are estimatedwith the consideration of different types of vehicles traveling together. Distributions of saturation flow are computed to follow the normal distribution at all observed intersections.
- The road number 3 which was named as Nallakunta-Vidyanagar Road have the highest green time because of higher approach volume of vehicles compared to other roads in all the hours, that is, in peak hours and non peak hours. The green time for road-3 is 57 seconds at peak hours.

Fig 7 : Barkatpura X -Road Signal

VI.CONCLUSION AND RECOMMENDATIONS

Intersections are the critical component of roadway system and frequently act as a choke point on the transport system.

The current data shows the increment in traffic as well as site constraints. The engineer needs to design methods and criteria based on fundamental relationship between capacities, flow of traffic, geometry design, safety that will enable users to get directly from proposed geometry to the realistic estimates of operating conditions. The result of this study gives the idea that what measures are suggested to remove such kind of problems and the precautions to be used to remove congestion at intersection. The traffic study and analysis at Barkatpura intersection reveals the conclusion as following:

• The numbers of cars travelling are more when compared to bikes on Saturday & Sundays.
• The number of cars is more when compared to buses.
• So, if numbers of buses are increased, then the dependency on public transports increase.
• This will make decrease in number of personal vehicles.
• Thus, the traffic situation in the Barkatpura intersection is critical in the peak hours as the optimum cycle length is about to expand and escalate the standard value of optimum.
• The road extension of road no 3 is required, if the vehicles approach volume is increased in the peak hours.
• It is very essential to recommend an alternative transportation infrastructure in the Barkatpura intersection so as to abate the delay in the traffic and thereby congestion gets reduced and free Flow of Traffic shall be achieved.

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