

Optimisation of a Smart Road Junction

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Abstract :- 21st century India needs planned, technologically sound and sustainable development. A crucial aspect of this development is road transportation. The infrastructure facilities play major role in developing any zone of a country in the modern era and globalization. A smart and efficient road network enhances the progress of that region. A fresh outlook is needed if these road networks and new developing ones are to be truly a part of the modern world. This project highlights on optimising the construction and execution aspect of a road network. It also focuses on analysing the current and future demand for designing a very efficient and smart road junction with aim to have a free and speedy movement for all categories of traffic. For our project, we have chosen a 3-km stretch and an intersection in PCMC. This project will assist in redefining the design parameters for any infrastructure project.

Keywords: - Design, Materials, Optimisation, Road Transportation Network, Time.

I. INTRODUCTION

We started by conducting various standard tests on materials to determine the type and grade of the materials to be used, and to design the cross-section of the 3-km stretch. Then, we moved on to optimisation in terms of the next parameter, time, by listing out the various construction activities, and compressing the same to get an optimum schedule. Having collected data and experience about abroad construction process, we expanded our project to design a road intersection (Bhakti Shakti Chowk, Nigdi, PCMC, Maharashtra). For this purpose, we carried out traffic surveys to study the existing traffic situation at the intersection. We intend to design a grade-separated, cyclist and pedestrian friendly, preferably signal-free intersection. This will result into easing congestion at the junction, reducing accident and casualties, making it more accessible for pedestrians and cyclists. Our ultimate aim is to design the complete intersection such that all the aids applied together will induce discipline with minimum effort on part of the users.

II. LITERATURE REVIEW

The many literature reviews highlight the various parameters associated with road network design and construction. The paper by Ibrahim Mahamid, et al. investigates the time performance of road construction projects in the West Bank in Palestine to identify the causes of delay and their severity according to contractors and consultants. The main causes of delay were found to be: Segmentation

of the West Bank and limited movement between areas; Award project to lowest bid price; Political situation; Progress payments delay by owner; and Shortage of equipment.

Several research papers focus on road transportation and traffic in a developing country like India and are prepared after conducting studies in the cities of Vijayawada, New Delhi, and Ettumanoor. The study by Consulting Engineering Services (India) Private Limited on Comprehensive Traffic and Transportation Study for Vijayawada City (2006) discusses various traffic surveys in major road networks, zones and intersection of Vijayawada City. The study by CSIR – Central Road Research Institute on Traffic and Transportation Planning (Annual Report) (2011-12) concludes that learner drivers should be compulsorily tested for the basic psychophysical traits or capacities and they should get passing marks before appearing for the learner license. The research study by Geethu Lal et. Al, (2016) on Sustainable Traffic Improvement for Urban Road Intersections of Developing Countries examines the traffic problems and sustainable improvement of road intersection at Ettumanoor, India. Analysis of the collected data revealed that the improper planning of the junctions, lack of traffic signals and unauthorized parking are the major factors contributing to the traffic congestions. Various remedial measures are also proposed, focusing on junction improvement, alternative operation plan and junction signalization. Finally, paper by Romi Satria and María Castro (2016) on road safety recommends various tools and techniques to prevent road accidents. Several GIS tools used to model accidents have been examined. The understanding of these tools will help the analyst to

make a better decision about which tool could be applied in each particular condition and context. next study by Qiang Guo et. Al,(2016) particularly focuses on the role of different road network patterns on the occurrence of crashes involving pedestrians. The results indicated that higher global integration was associated with more pedestrian-vehicle crashes; the irregular pattern network was proved to be safest in terms of pedestrian crash occurrences, whereas the grid pattern was the least safe.

Gap Analysis

The above literature reviews helped us understand dynamics of road transportation design, construction and maintenance, that we would later encounter in our project. We learned about causes of delay in road construction; study of various Indian cities and their road junctions and intersections; prediction and mitigation of road accidents involving vehicles and pedestrians; and use of modern applications like GIS to road design. The information from these literature reviews will surely assist us in carrying out our objectives of studying an ongoing road project, testing of materials and design of intersection.

Methodology

This research paper starts by studying an under construction 3 km road stretch in PCMC. This study consists of survey, material testing, cross-section design, scheduling and cost analysis. We then move onto studying an intersection (Bhakti Shakti Chowk, PCMC, Maharashtra). We intend to design a grade-separated, cyclist and pedestrian friendly, preferably signal-free intersection. Also, we intend to introduce "smart-aids" to make this intersection truly smart. This can be done using various traffic controlling devices, using in-built GPS in vehicles and connecting them to the intersection network. The aim is to completely optimise the intersection in terms of materials, process, time cost. This will result into easing congestion at the junction, reducing accident and casualties, making it more accessible for pedestrians and cyclists. Our ultimate aim is to design the complete intersection such that all the aids applied together will induce discipline with minimum effort on part of the users.

Experimental Work

Road Construction Project

We started by working on the Development and Construction of 45m wide road from Mumbai Pune Express Highway to Bhakti Shakti Chowk (Up to ROB Railway Line) Package – I: Ch. 0/000 to 2/850 Km under the guidance of Ajwani Infrastructure

Private Limited. The project package includes design and construction of 45m 6-lane road along with 2 lanes of BRTS, water supply network, sewage network and electrification. Work on the project commenced on 11.09.2014.

Testing of materials

Various tests were conducted on aggregates and bitumen for the finalisation of cross-section. The results of the same are tabulated as follows:

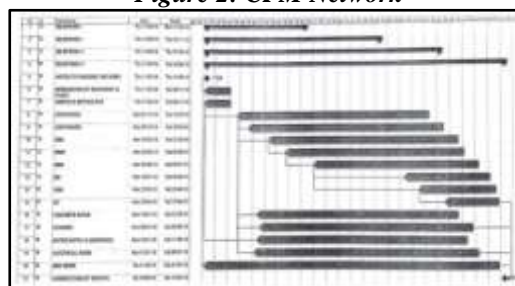
Table 1: Test Results

Test	Date of Sampling	Date of Testing	Result
Compaction Test	15/07/2016	16/07/2016	MDD – 2.049 gm/cc OMC – 12.10%
CBR Test	16/07/2016	18/07/2016	2.5 mm penetration, 7 N/mm ²
Ductility Test	22/07/2016	22/07/2016	> 70 cm
Softening Point Test	22/07/2016	22/07/2016	47°C
Penetration Test	22/07/2016	22/07/2016	60/70 Bitumen

CPM Network Analysis - Further the quantities and corresponding costs of materials were calculated and the activities involved in the project listed down.

Notice to Proceed the Work -- Mobilization of Machinery and Plant -- Survey and Setting Out -- Excavation – Earthwork – GSB -- WMM -- BBM -- BM – DBM – BC -- Concrete M15/M20 -- CD Work -- Water Supply and Sewerage -- Electric Work -- Miscellaneous Work -- Handing Over of Site

Figure 2: CPM Network



Intersection Project

We then extended our project to the Design, Development and Construction of Bhakti Shakti Chowk Intersection (Which includes Bhakti Shakti Junction and Transport Nagar Junction).

The Bhakti Shakti Chowk Intersection is located at the crossing of Pune-Mumbai Highway and Nashik Road (Spine Road) which are two major roads in the city. Vehicles coming from Dehu Road and other areas along the Mumbai-Pune Highway enter PCMC limits at Nigdi through this Chowk to go ahead to Pune or different parts of Pimpri-Chinchwad.

Figure 3: Location Map

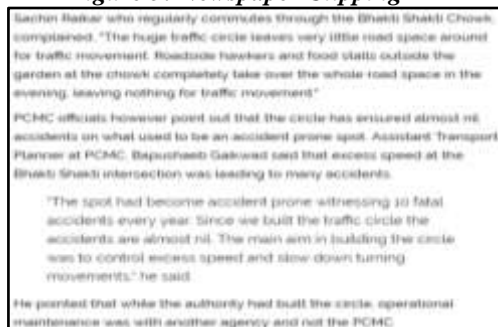


Figure 4: Junction Layout



The junction has signals but heavy vehicle movement from all directions still leads to congestion. The highway has already been widened to 61m (as many as 10 lanes). The civic body has started construction of the Bhakti Shakti Chowk – Mukai Chowk BRTS which will further increase the traffic passing through the junction.

Figure 5: Newspaper Clipping - 1



Traffic Surveys

Traffic surveys were conducted on the intersection to find out the peak hours (Morning and Evening), turning movement count, traffic characteristics at both the junctions, traffic projections for 20 years. After the surveys, short term and long term traffic solutions at both the junctions were proposed.

Intersection Turning Movement Count Survey

The purpose of the survey is to summarize the counts of vehicle movements through an intersection during certain time periods. This type of volume summary is used in making decisions regarding the geometric design of the roadway, sign and signal installation, signal timing, pavement marking, traffic circulation patterns, capacity analysis, parking and loading zones, and vehicle classification. This data is used in making decisions at a planning-level (e.g., traffic impact analyses), as well as operational analyses-level (e.g., signal installation and timing). Pedestrian and bicycle movements may be included during the intersection volume studies.

Traffic Volume Count Survey

These studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. These data can help identify critical flow time periods, determine the influence of large vehicles or pedestrians on vehicular traffic flow, or document traffic volume trends. The length of the sampling period depends on the type of count being taken and the intended use of the data recorded. For example, an intersection count may be conducted during the peak flow period. If so, manual count with 15-minute intervals could be used to obtain the traffic volume data.

Table 3: Traffic Surveys and Schedule

Survey	Location	Duration	Date(s)
Turning Movement Count (TMC)	Bhakti - Shakti Junction	8 AM – 2PM and 4 PM – 9PM	4 th – 5 th Dec 2016
Turning Movement Count (TMC)	Transport Nagar Junction		
Traffic Volume Count	Service Road		

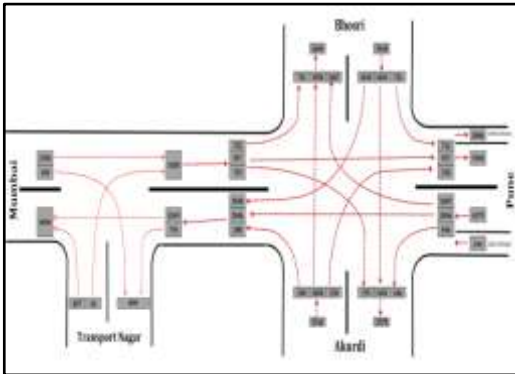
Bhakti Shakti Junction					
Approach	Direction	Peak Hour Traffic		% of total PCUs	Type
		Vehicles	PCUs		
Pune	Pune to Mumbai	1,628	2,046	16%	Through
	Pune to Bhosri	1,679	1,687	13%	Right
	Pune to Akurdi	531	446	3%	Left
Mumbai	Mumbai to Pune	859	957	7%	Through
	Mumbai to Bhosri	869	752	6%	Left
	Mumbai to Akurdi	710	729	6%	Right
Bhosri	Bhosri to Pune	581	726	6%	Left
	Bhosri to Mumbai	1,055	1,810	14%	Right
	Bhosri to Akurdi	1,484	1,403	11%	Through
Akurdi	Akurdi to Pune	337	258	2%	Right
	Akurdi to Mumbai	263	208	2%	Free
	Akurdi to Bhosri	1,530	1,850	14%	Through
	Total	11,522	12,871	100%	

Table 4: Traffic Survey Analysis and Results at Bhakti Shakti Junction

Transport Nagar Junction				
Approach	Direction	Peak Hour Traffic		% of total PCUs
		Vehicles	PCUs	
Pune	Pune to Transport Nagar	680	795	11%
	Pune to Mumbai	2,615	3,269	44%
Mumbai	Mumbai to Transport Nagar	75	104	1%
	Mumbai to Pune	2,139	2,396	32%
Transport Nagar	Transport Nagar to Pune	32	42	1%
	Transport Nagar to Mumbai	833	827	11%
	Total	6,374	7,433	100%

Table 5: Traffic Survey Analysis and Results at Transport Nagar Junction

- Morning Peak Hours: 9:00AM to 10:00AM, Vehicles 8,856 (9,480 PCUs)
- Evening Peak Hours: 6:00PM to 7:00PM, Vehicles 11,572 (12,876 PCUs)
- Major movement at this junction is in Pune-Mumbai direction which is 76 per cent of the total movement.
- Free left movement (Pune to Transport Nagar and Transport Nagar to Mumbai) are 22 per cent of the total.
- Peak hour traffic at Transport Nagar junction is 6,374 vehicles (7,433 PCUs)

Figure 7: Turning Movement Diagram


Inferences

After studying the intersection and conducting various traffic surveys several problems were observed. Low turning visibility due to existing traffic rotary, which leads to accidents; Deficient Junction Geometry; Delay due to shape of rotary, due to right turning larger trucks from Bhosri needing more time in weaving; Increased signal time as traffic from Mumbai to Pune direction has to stop twice at Bhakti Shakti Junction and Transport Nagar Junction. To aid in solving these problems, we have decided to design an alternative efficient, pedestrian-friendly, preferably signal-free intersection.

CONCLUSION

The infrastructure facilities play major role in developing any zone of a country in the modern era and globalization. With the advent of the concept of smart city, it has become crucial to study all aspects of a smart city, particularly road transportation network. Focused with this aim, we studied in detail an ongoing project and decided to design and efficient intersection. Furthermore, a fresh outlook is needed if these road networks and new developing ones are to be truly a part of the modern world. To achieve this, computer-aided systems or "smart aids" to the intersection (using GIS, GPS) can be applied. To truly realize the results of this efficient design, multiple intersections in the vicinity will have to be designed and then the combined effect observed. This analysis can assist the current and future demand for designing a very efficient and smart road junction with aim to have a free and speedy movement for all categories of traffic. This project highlights on optimising the construction and execution aspect of a road network, thus redefining the design parameters for large scale infrastructure projects.

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