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Study on Signal Warrant and Signal Design at Prithvi Chowk, Pokhara

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Abstract
This research addresses the analysis of traffic signal warrants and the design of traffic signals at the critical Prithivi Chowk intersection in Pokhara, a vital nexus of Prithivi Highway and Siddhartha Highway. With a burgeoning population growth rate of 4.33% annually and heavy vehicular and pedestrian traffic due to its strategic location, traffic congestion and delays are prevalent. Utilizing vehicular data extracted from CCTV footage and manually collected pedestrian data, this study meticulously examines Federal Highway Administration's highway signal warrants. Subsequently, the saturation flow is computed as per Highway Capacity Manual (2000) guidelines upon satisfying the signal warrants. The designed signal implementation employs Webster's method to enhance traffic flow efficiency at this critical junction.

Keywords
Traffic Signal Warrant, Traffic Signal Design

1. Introduction

The burgeoning global population has led to an unprecedented increase in urbanization, accompanied by a sharp rise in vehicular traffic. Urban centers have become critical hubs of economic, social, and cultural activities, attracting a significant influx of residents and visitors. Among these urban centers, Pokhara, a rapidly growing city in Nepal, has witnessed remarkable growth in population and tourism over recent years. This surge has brought about a surge in traffic, leading to traffic-related challenges such as congestion, delays, and safety concerns at crucial intersections. One such vital intersection experiencing escalating traffic issues is the Prithvi Chowk intersection, situated at the confluence of Prithivi Highway and Siddhartha Highway. This intersection serves as a critical junction within Pokhara, connecting two major national highways. The intensifying vehicular and pedestrian volume at this intersection necessitates a comprehensive traffic management strategy to maintain a smooth, safe flow of traffic.

1.1 Background and Rationale

Pokhara, often hailed as the "tourist capital" of Nepal, is renowned for its breathtaking natural beauty, attracting a significant number of tourists annually. Additionally, the city's appeal as a bustling economic and cultural center continues to lure residents, contributing to a constant growth in the population. This surge in population, coupled with an influx of tourists, has led to a notable rise in vehicular traffic, especially at major intersections like Prithvi Chowk[1].

The Prithvi Chowk intersection serves as a vital transportation node, connecting Prithivi Highway, a lifeline for transportation across Nepal, and Siddhartha Highway, a crucial route connecting the city with the southern regions. This intersection, due to its strategic location, experiences substantial vehicular and pedestrian traffic, making it a critical area for effective traffic management and signal control.

1.2 Statement of the Problem

The escalating vehicular volume at the Prithvi Chowk intersection has resulted in a host of traffic-related problems. Traffic delays, congestion, conflicts, and challenges at crosswalks have become commonplace, causing frustration among commuters and risking pedestrian safety. The traffic situation at this intersection requires immediate attention and intervention to ensure a well-organized and smooth flow of vehicles and pedestrians. One of the fundamental solutions to alleviate these issues is the strategic design and implementation of an efficient traffic signal system.

2. Research Objectives

The main objective of the study is to check traffic signal warrant and design traffic signal at Prithvi Chowk, Pokhara. The specific objectives are:

- Analyze the current traffic volume at Prithvi Chowk intersection.
- Examine the traffic signal warrant.
- To design traffic signals at the intersection.

3. Methodology

3.1 Data Collection and analysis

3.1.1 Site Selection

The study site, Prithivi Chowk intersection, was chosen due to its high vehicular and pedestrian volume, attributed to its strategic location at the junction of Prithivi Highway and Siddhartha Highway within the growing Pokhara metropolitan city.

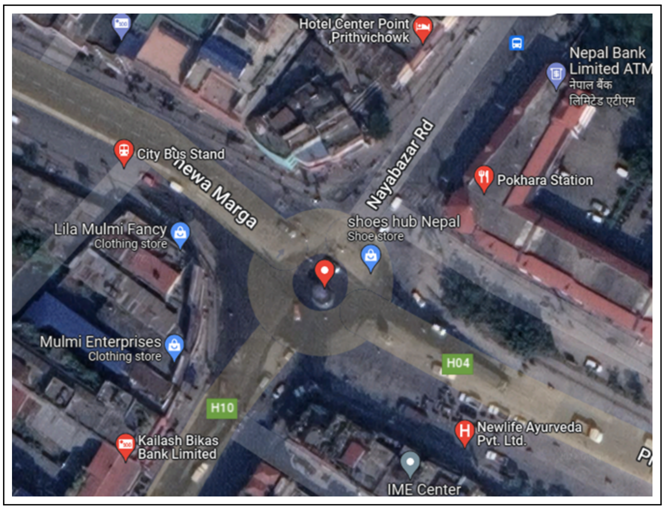

Figure 1: Prithvi Chowk Intersection

3.1.2 Data Collection

To efficiently gather data, CCTV footage provided by the Province Police Office was utilized to count vehicular traffic, categorized into Motorcycle, Car-Taxi-Pickup, and Bus-Truck. Additionally, manual data collection methods were employed to count pedestrians and school crossing children.

3.1.3 Traffic Count Calculation

CCTV footage data was utilized to manually count and categorize vehicles into specific types, facilitating traffic count calculations. Data sheets were created to record this information.

3.1.4 Warrant Analysis and Signal Design

Traffic signal warrants were analyzed based on the vehicular and pedestrian data collected. The analysis followed the guidelines of the Federal Highway Administration, Edition 2009. After warrant satisfaction, saturation flow was calculated using the Highway Capacity Manual (HCM) guidelines, leading to the application of Webster's Method[2][3] for signal design.

3.1.5 Documentation

The entire process, from data collection to signal design, was thoroughly documented, including the results obtained.

3.2 Detailed Data Collection

3.2.1 Sources of Data

Data is primarily sourced from:

Analysis of CCTV Footage: Vehicular count data categorized into Motorcycle (MC), Car-Taxi-Pickup, and Bus-Truck were manually collected based on the provided CCTV footage.

Manual Pedestrian Count: Data for pedestrian and school crossing children counts were collected manually during peak hours and school-going times.

3.2.2 Nature of Data

The data consisted of vehicular counts over an 8-hour period on a weekday, while pedestrian volumes were counted during peak hours and school-going times.

3.3 Data Processing and Analysis

Using the Federal Highway Administration guidelines, Chapter-4: Traffic Signals Design, traffic signal warrants were analyzed. Following warrant satisfaction, saturation flow was calculated according to the Highway Capacity Manual (2000)[4] guidelines. The saturated flow data guided the application of Webster's Method for signal design.

4. Result and Discussion

4.1 Traffic Warrant Analysis

Warrant 1: Eight Hour Vehicular Volume

Table 1: Eight Hour Vehicular Volume on Major Street

From	To	SC to BP	BP to SC	Total (Both Dir)
8:00 AM	9:00 AM	613	382	995
9:00 AM	10:00 AM	714	710	1424
10:00 AM	11:00 AM	1044	921	1965
11:00 AM	12:00 PM	1049	1006	2055
12:00 PM	1:00 PM	750	614	1364
1:00 PM	2:00 PM	791	668	1459
2:00 PM	3:00 PM	1059	679	1738
3:00 PM	4:00 PM	952	518	1470

The hourly through volume on major street is 1059 which is greater than 900vph So the warrant 1 is satisfied.

Warrant 2: Four Hour Vehicular Volume

Table 2: Four Hour Vehicular Volume on Major Street and on Higher Volume Minor Street

From	To	SC to BP	BP to SC	Total (Both Dir)	NG to NB
10:00 AM	11:00 AM	1044	921	1965	360
11:00 AM	12:00 PM	1049	1006	**2055**	**316**
12:00 PM	1:00 PM	750	614	1364	366
1:00 PM	2:00 PM	791	668	1459	399

The hourly through volume for any 4 hours of an average day on the minor street are found to be 1965, 2055, 1364 and 1459. Similarly, the hourly through volume for any 4 hours of an average day on the higher-volume on minor streets are found to be 360, 316, 366 and 399. Since all these coordinates ((1965,360), (2055,316), (1364,366) and (1459,399)) lie above the applicable curve in Figure 4C-1 in HCM. So the warrant 2 is satisfied.

Warrant 3: Peak Hour

The peak hour volume is found to be at 11am to 12pm which is 2055 vehicles on major streets and corresponding higher-volume minor streets (one direction only) is 316.. The coordinate (2055, 316) lies above (1800, 150). So the warrant 3 is satisfied.

Warrant 4: Pedestrian Volume

Table 3: Pedestrain Volume

From	To	Pedestrain Crossing
11:00 AM	11:15 AM	65
11:15 AM	11:30 AM	57
11:30 AM	11:45 AM	55
11:45 AM	12:00 PM	43
	Total	220

The number of pedestrians in 1 hour crossing the major street is found to be 220 from 11am to 12pm which is greater than 190pph. So warrant 4 is satisfied.

Warrant 5: School Crossing

Table 4: No of students crossing Major Street

From	To	Total	Major Street
8:00 AM	8:15 AM	7	2
8:15 AM	8:30 AM	12	4
8:30 AM	8:45 AM	10	3
8:45 AM	9:00 AM	22	7
9:00 AM	9:15 AM	9	3
9:15 AM	9:30 AM	12	4
9:30 AM	9:45 AM	10	**3**
9:45 AM	10:00 AM	15	**5**
10:00 AM	10:15 AM	21	**7**
10:15 AM	10:30	17	**6**
		135	44

The number of students crossing the major street in 1 hour is 21 which is greater than 20. So warrant 5 is satisfied.

Warrant 6: Coordinated Signal System

This warrant is not applied since the distance between Prithvi Chowk and Sabhagriha Chowk is less than 1000ft.

Warrant 7: Crash Experience

Since exact crash data at the intersection area is not obtained, warrant 7 is not checked.

Warrant 8: Roadway Network

The intersection has a total existing entering volume greater than 1000vph during a peak hour in a typical weekday. Also the intersection satisfies Warrant 1, 2 and 3. So warrant 8 is also satisfied.

Warrant 9: Intersection near a Grade Crossing

Since no grade crossing exists near this intersection, warrant 9 is not satisfied.

Hence, 6 out of 9 warrants are satisfied. So the signal design is required.

4.2 Traffic Signal Design

Table 5: Input parameters for saturation flow

Input Data	Unit							
So	1900.00							
Lane Group	EB TH	WB TH	NB TH	SB TH	EB RT	WB RT	NB RT	SB RT
N	2	3	3	2	2	3	3	2
W=	3.65	3.8	3.6		3.65	3.8	3.6	3.2
HV(%)	29.0	30	5.0	10	15.0	17	9.0	13
HV, Et	3.00							
G%	0.00							
P	1.00							
BS	0	31	18	17	0	13	14	11

N = Number of Lane in the lane group
W = Lane width
HV = Fraction of Heavy Vechicles
HV,Et = Number of PCU for each HV
P = Number of parking manoeuvres
BS = Number of Buses Stopping per hour

Base Saturation flow rate, So = 1900
Grade factor,fg = 1.000
Parking factor,fo = 1.000
Adjustment factor for area type, fa = 0.9
Adjustment factor for pedestrian/bicycle blockage for left, flpb = 1.000
Adjustment factor for pedestrian/bicycle blockage for right, frpb = 1.000

Table 6: Calculation of saturation flow (Through)

Lane	EBTH	WBTH	NBTH	SBTH
N	2	3	3	2
fw	0.999	1.016	0.994	0.950
fHV	0.633	0.625	0.909	0.833
fbb	1.000	0.959	0.976	0.966
fLU	0.908	0.908	0.908	0.908
S	1964	2834	4107	2375

Table 7: Calculation of saturation flow (Right Turn)

Lane	EBRT	WBRT	NBRT	SBRT
N	2	3	3	2
fw	0.999	1.016	0.994	0.950
fHV	0.769	0.746	0.847	0.794
fbb	1.000	0.983	0.981	0.978
fLU	0.908	0.908	0.908	0.908
S	2387	3469	3849	2290

fw = Lane width adjustment factor
fHV = Heavy Vechicle factor
fbb = Bus blockage factor
fLU = Lane utilization adjustment factor
S = Saturation flow

Table 8: Signal Design Using Webster's Method [5]

	Flow (q)	Design Flow (q/PHF= 0.85) (q')	S	q'/s	Max q/s in a phase
EBTH	1049	1166	1964	0.594	0.594
WBTH	1006	1118	2834	0.355	
NBTH	316	351	4107	0.077	0.077
SBTH	99	110	2375	0.042	
EBRT	305	339	2387	0.128	0.128
WBRT	190	211	3469	0.055	
NBRT	285	317	3849	0.074	0.074
SBRT	40	44	2290	0.017	
				Total	**0.872**

Lost time = (2+3) x 4 = 20
Pedestrian Walking Speed :- 1.1m/s
Initial walk period = 4
Time required to cross road, R = (3.8 x 6)/1.2 + 4 = 23s
C = (1.5 x 20+25)/(1-0.872) = 228
C - L = 212

Table 9: Phases and corresponding green time

	Green time (s)		
Phases	Computed	Adjusted for pedestrian flow	Final
Phase 1	144	144	145
Phase 2	19	23	23
Phase 3	31	32	33
Phase 4	18	18	19
Total	212	216	219
Cycle Time	228	232	**240**

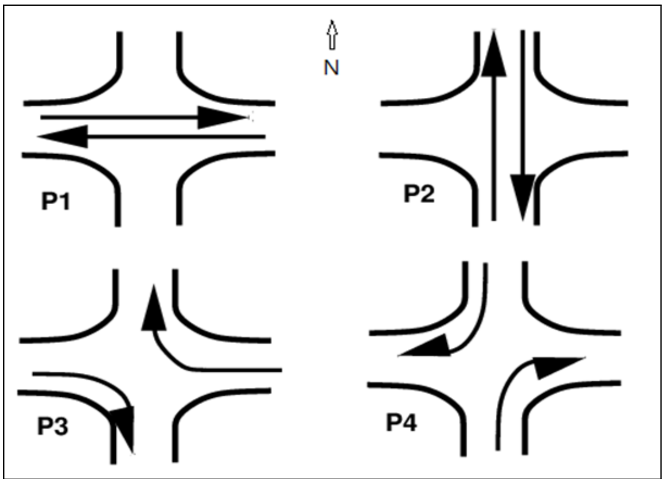

Figure 2: Phase Diagram

5. Conclusion

In conclusion, this study has established the necessity of implementing a traffic signal system at Prithvi Chowk intersection, evidenced by the satisfaction of six (6) traffic signal warrants. The design of the traffic signal, employing Webster's method, has yielded a cycle time of 240 seconds. This signal design incorporates four phases along with a dedicated pedestrian phase, ensuring a comprehensive and efficient traffic management strategy for the busy Prithvi Chowk intersection. These findings pave the way for improved traffic flow, reduced delays, and enhanced safety at this critical junction within Pokhara metropolitan city. Further implementation and monitoring of the designed signal system will be vital to realizing the anticipated benefits and optimizing the intersection's traffic management.

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