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Investigation of Dilemma Zone and Traffic Bottleneck at a Signalised Intersection

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Abstract: *In The Cities Of Densely Populated Countries Like India Road Accidents And Traffic Congestion Problem Are Very Common. The Mobility Needs Of Pune Are Mainly Accounted For By Road Mode And As A Consequence Traffic Density On Road Is Increasing Day By Day. Several Measures Are Being Taken To Address The Problem By Constructing Flyovers, By Pass Road And Creating Ring Road. On The Road Network Of Pune, Majority Of Intersections Are Signalised To Achieve Safe Movement Of Large Traffic Volume. The Signals Are Designed For Passenger Car Unit And Saturation Flow At An Intersection. The Overall Performance Of Signalised Intersection Is Influenced By Road Way Parameters Like Traffic Condition, Operating Parameter, Pedestrian, Motorist Behaviour, Weather Condition Etc. In This Work Present Situation Of Traffic At A Signalised Intersection Of Pune Is Analysed By Collecting Traffic Data During Peak Hours. The Sole Objective Of The Work Is To Mark The Amber Light Dilemma Zone Boundaries And Identify The Factors Responsible For Traffic Bottleneck, Traffic Crashes And Delay.*

Keywords*: Bottlenecks, Delay, Dilemma Zone, Saturation Flow.*

I. Introduction

On The Roads Of Top Metropolitan Cities Of India Management Of Traffic Has Become A Challenge. It Is Noteworthy That Traffic On Roads Of These Cities Is Growing Each Year. Consequently Number Of Road Incidents Has Also Increased. A Road Incident Has Social And Economic Aftermath And It Takes Considerable Time To Recover Full Traffic After An Accident. The Traffic On Majority Of Road Network Of Pune Is Of Mixed Type Composed Of Buses, Autos, Cars, Motorcycles, Bicycles Etc. The Operational Speed Of An Individual Vehicle Is Influenced By Its Neighbouring Environment Also In Addition To The Speed Of Leading Vehicle [1]. Red Light Running And Other Violations Are Major Safety Concerns. Research Conducted [2] To Study The Impact Of Red Light Running Photo Reinforcement At Urban Signalised Intersection Reveals That Red Light Running Photo Reinforcement Is Positive On The Whole. The Spatial And Temporal Regulars Causing Traffic Bottleneck Are Studied [3]. Author Developed A Discrete Time Model To Analyse The Factors. A Particular Road Is Designated As A Bottleneck, Bottleneck Free And Bottleneck Prone Road Depending On The Value Of Bottleneck Parameter Based On Volume Of Entry And Exit Traffic. Signal Time Can Be Adjusted To Turn A Bottleneck Road In To Bottleneck Free Road. The Stop/Run Decision Of A Driver At A Signalised Intersection When Amber Light Starts Depends Upon Various Factors Related To Driver Behaviour, Vehicle, Geometry Of Intersection, Condition (Wet/Dry) Of Road Etc. Different Drivers Take Different Decisions (Stop Or Run) When They Are In Dilemma Zone. It Is Vital To Study The Distribution Of Dilemma Zone For Diverse Drivers And Vehicle Types To Reduce Accidents At A Signalised Intersection.

1.1 Intersection Dilemma Zone Marking:

On A Signalised Intersection When Yellow Light Is On A Driver Has To Take An Important Decision To Keep Moving Or To Stop. The Vehicle May Be At A Critical Point On The Intersection Approach Such That If He Proceeds Right Angled Collision With Traffic In The Right Angled Direction May Result And If He Stops A Rear End Collision May Take Place. Such An Area On The Intersection Where At The Onset Of Yellow Light Neither The Vehicle Can Stop Safely Before The Stop Line Nor It Can Proceed Through The Intersection Before The End Of Yellow Light When Red Light Starts. The Dependence Of Dilemma Zone On Vehicle Arriving Type, Vehicle Type, And Lane Position Needs To Be Further Investigated Some Potential Factors, Such As Traffic Condition, Vehicle Arriving Characteristics, Vehicle Type, Signal Location, And Adverse Weather, May Affect Driver Behaviour Within Yellow Light Dilemma Zone [4]. On Maryland State Routes [5] About 30% Of Total Accidents Are Traffic Signal Related Crashes And Among These 20% Involve Red Light Running. Thus One Of The Main Reasons Of Signal Related Accidents Is The Existence Of Amber Light Dilemma Zone At The Intersection. Empirical Results [6] Revealed That Dilemma Zone Is Dynamic In Nature. Length And Location Of Dilemma Zone May Vary With Speed Of Driver, Driver Reaction Time, Acceleration And Deceleration Of Vehicle Etc. Thus Intersection Dilemma Zone Is A Range Rather Than A Constant.

Understanding The Dynamic Nature Of Intersection Dilemma Zone And Designing The Counter Measures Has Emerged As One Of The Research Area Of Vital Importance [7].

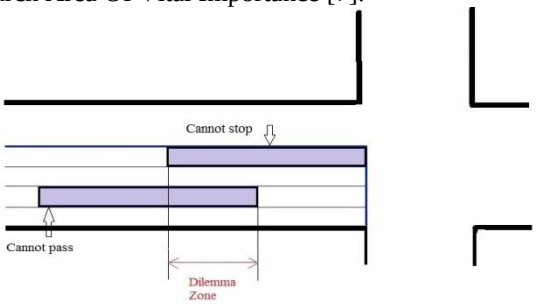

Fig.1 Yellow Light Dilemma Zone.

1.2 Method Of Computation Of Dilemma Zone:

Dilemma Zone, X_{dz} Is The Difference Between Minimum Safe Stopping Distance X_c And Maximum Yellow Passing Distance X_o

According To Ghm Model X_c And X_o Are Given By The Following Equation [8]:

$X_{Dz} = X_C - X_o$ (1)

$X_c = V_O \Delta_1 + (V_o^2 / 2\alpha_1)$ (2)

$X_o = V_o T + 0.5 \alpha_2 (T - \Delta_2)^2 - W - L$ (3)

Where –

V_o = Approaching Vehicle Speed In Ft/Sec.

Δ_1, Δ_2 = Driver's Perception Reaction Time For Stopping And Crossing In Seconds, Respectively.

α_1, α_2 = Vehicle's Maximum Deceleration And Acceleration Rates In Ft/Sec^2, Respectively.

T= Yellow Signal Duration In Seconds.

W = Intersection Width In Ft.

L = Length Of Vehicle In Ft.

When $X_c > X_o$ The Zone Between X_c And X_o Is Type 1 Dilemma Zone As Shown In Fig. 2. When $X_c < X_o$ The Zone Between X_c And X_o Is Type 2 Dilemma Zone Termed As Option Zone As Shown In Fig. 2. A Vehicle Within Option Zone Can Either Pass Through The Intersection Or Stop Before The Stop Line At The Onset Of Yellow Light.

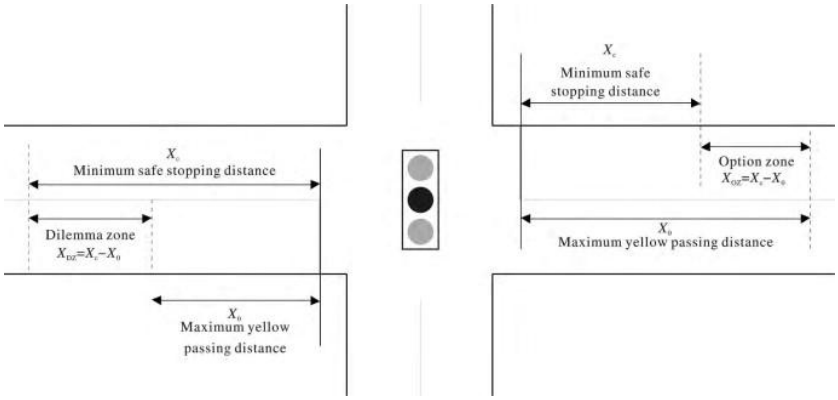

Fig.2 Dilemma Zone And Option Zone. Source: [4]

2. Case Study of A Signalised Intersection

In The Present Work A Signalised Intersection Located On Sinhgad Road Of Pune Is Studied. A Three Phase Signal Is Chosen. The Roads Meeting At The Intersection And The Phase Details Are Shown In Fig. 3. Based On Observation And Data Collected (Video And Manual) At The Intersection Estimations Are Made About Drivers Behaviour, The Reaction Time Of Different Drivers, Speed Of Different Vehicle.

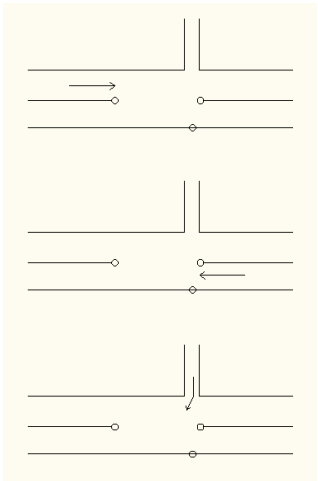

Fig. 3 Phases For Through Traffic At The Intersection Considered In Case Study.

Drivers At The Intersection Are Divided Into Two Types Depending On Their Action When The Amber Light Is Set On.

Type 1: The Drivers Showing Balanced Behaviour Come Under This Category. These Drivers Stop When They Are At A Distance Greater Than Critical Distance For A Smooth Stop And Pass When Their Distance Is Less Than This Critical Distance. Elderly People Come Under This Category.

Type 2: Drivers In The Age Group Between 18 To 30 Years Decides To Pass The Intersection In Amber Time Even If Their Distance Is More Than The Critical Distance For Pass. These Drivers Show Aggressive Behaviour.

The Speeds Of Above Categories Of Drivers Are Assumed As 30 Kmph And 50 Kmph For Type 1 And Type 2 Respectively. Amber Time As Observed At The Intersection Is 4.0 Seconds. Width Of Intersection Is 105.9 Feet. Deceleration And Acceleration Rates Of Different Vehicle Type Are Taken From The Traffic Studies Carried Out [9] At Isolated Urban Intersection And Are Mentioned In Table No 1 (Data Was Collected During The Morning Peak Hour At Selected Four Arm Intersections In The Kolkata Metro City). Details Of Cases Considered For Dilemma Zone Calculation Are Given In Table 2. Values Of Parameter Used In Dilemma Zone Computation At The Signalised Intersection And Calculated Values Of X_c , X_o And Dilemma Zone Are iven In Table.

Table 1. Vehicle Characteristics Data For Modelling Traffic Flows At Intersections

	2 Wheeler	Car	3 Wheeler	Lcv	Truck	Tram
Vehicle Type	Tvsphoen Ix 125	Marutisuzuk Iswift Diesel	Bajajr E Cng	Tataac E Cng	Ashokleyland 1616 Hp	Kolkata Tram
Acceleration Maximum						
0 - 20 Kmph	4.92	5.05	1.17	1.01	1.29	1.0
20 - 40 Kmph	3.22	3.75	1.01	1.17	1.02	1.0
40 - 60 Kmph	2.28	3.22	-	-	0.80	-
Normal	0 -30 (6.7)	0 - 30 (2.77)	0 - 20 (0.89)	0 - 30 (2.77)	0 - 30 (0.83)	0.32
Acceleration			0-30 (0.65)		> 30 (1)	
Deceleration Maximum	3.6	6.5	6.5	6.5	5.94	0.1
Deceleration Normal	3.2	2.62	2.62	2.62	2.46	0.1

Source: [9]

Table 2: Cases Considered For Dilemma Zone Computation

Case No.	Driver Category	Vehicle Type
1	1	Two Wheeler (Motorised)
2	1	Three Wheeler
3	1	Car
4	2	Two Wheeler (Motorised)
5	2	Three Wheeler
6	2	Car

Table 3: Parameters For Dilemma Zone Computation For Different Cases

Case No.	Dece. α_1 Ft/S^2	Acc. α_2 Ft/S^2	Vel. V_o Ft/S	Length L Ft	Rea. Time Δ_1 Sec.	Rea. Time Δ_2 Sec	X_c Ft.	X_o Ft.	X_o Ft.
1	11.8	10.56	27.34	6.2	1.71	1.71	78.3	24.8	53.5
2	21.32	3.31	27.34	9	1.8	1.8	66.7	2.41	64.25
3	21.32	12.3	27.34	12.5	1.8	1.8	66.7	20.72	45.98
4	11.8	7.47	45.56	6.2	1.18	1.18	141.71	99.8	41.91
5	21.32	3.31	45.56	9	1.3	1.3	107.9	66.1	42
6	21.32	10.56	45.56	12.5	1.3	1.3	107.9	102.24	5.661

II. Conclusions

- This Study Conducted By Taking Field Observations At A Signalised Intersection Partly By Taking Video And Partly By Collecting Data Manually. The Work Provides Dilemma Zone Distribution For Two Types Of Drivers.
- Dilemma Zone For Type 1 Driver Ranges From 45 Feet To 65 Feet From The Stop Line.
- Dilemma Zone For Type 2 Driver Ranges From 5 Feet To 45 Feet From The Stop Line.
- The Two Wheeler Drivers Of Both Categories Were More Aggressive Than Three Wheeler And Car Drivers.
- The Ratio Of Mail Driver Was High In Committing Unsafe Driving, Standing Across The Stop Line, Driving On Shoulders And Breaking Other Traffic Laws.
- Since The Percentage Of Type 2 Drivers Is Higher Among All The Drivers It Is Recommended To Take Measures To Improve Driver Behaviour And Reduce The Approach Speed In Order To Reduce Crashes Resulting From Red Light Running.
- The Present Study Is Based On Limited Data Collected At The Intersection And Observation. Further Study Can Be Carried Out By Collecting Extensive Data To Improve The Traffic Regulation And Safety At The Intersection.

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