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EVALUATION OF TRAFFIC SAFETY BY USING TIME TO COLLISION: A CASE STUDY

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Abstract: Traffic safety is extremely important, especially on city streets where traffic volumes are high and traffic conflicts are common. As a result, it is critical to design a methodology for assessing traffic safety. The study's issues are as follows: The common roadway is used by a large number of venerable road users and vehicular traffic. Driving standards are poor, and traffic safety is limited along that section of the road. The time to collision (TTC) samples from traffic videos taken from kotecha circle to indira circle with different locations and traffic conditions are first analyzed in this paper. However, according to field survey data, a lateral separation between the leader and the follower occurs frequently in complex traffic conditions. As a result, we redefined the time-to-collision equation by taking in lateral separation (TTC). TTC samples can be categorized into three groups: risky scenarios, relative safe situations, and absolute safe situations. Following that, the proposed traffic safety indictor is used to represent the assessment results of urban road traffic safety.

Keywords: Time to collision, traffic safety, traffic volume study, spot speed study

1. INTRODUCTION

Any vehicle accident occurring on a public roadway is referred to as a traffic collision. A vehicle accident is assumed to have occurred on a public highway, with the exception of accidents involving only off-road motor vehicles, which are categorized as non-traffic accidents unless otherwise mentioned. When a vehicle collides with another vehicle, pedestrian, animal, road debris, or other, it is known as a traffic collision. The collision is the difficult for the technology to recognize every possible scenario that can happen on the road. There are many factors affecting collision like vehicle design, speed and operation road design, road environment, driver skill impairment due to alcohol and drugs, behavior speeding and street racing etc. Every year, traffic collisions are a major cause of deaths, injuries, and property damage in India. According to the National Crime Records Bureau's (NCRB) 2016 report, there were 496,762 traffic collisions involving roads, trains, and railway crossings in 2015. Road crashes accounted for 464,674 collisions in India, resulting in 148,707 traffic-related deaths.

1.1 TRAFFIC SAFETY

Most car manufacturers are currently focusing on vehicle technology to improve driver comfort, which may have an impact on traffic flow characteristics and traffic safety. Recent technical improvements in the field of automated driving activities, such as the development of Autonomous Intelligent Cruise Control (AICC) or Collision Avoidance Systems, as well as their proper implementation, justify the safety impact assessments. The introduction of new technologies is projected to have a positive impact. The impact of vehicular technologies on traffic safety will be both good and bad.

Direct safety indicators such as accident and death frequencies cannot be collected in many situations because intelligent driver support systems are not yet widely used in the car traffic flow. Because empirical accident data collection is not currently possible, different safety assessment methods are required.

1.2 NEED AND OBJECTIVE OF THE STUDY

This research is beneficial for improving road traffic safety. It aids in the reduction of traffic accidents on urban roads. It's also useful for analyzing various traffic features and parameters in research studies. The following are some of the common traffic survey studies: speed study, traffic volume study, vehicle headway study, and so on. The scope of this research is limited to urban areas.

Only speed and headway were used to calculate the time to collision in this research. The objective of the study is to determine time to collision on urban road and to reduce accident from remedial measures on urban road.

2. LITERATURE REVIEW

In Sheng Jin[1], They examine time to collision (TTC) samples from traffic videos gathered from the Beijing expressway with various locations, lanes, and traffic conditions in this paper. The results of the expressway traffic safety assessment are then presented using the proposed traffic safety indictor. According to the results, traffic safety on the weaving section is lower than on mainlines, and the percentage of significant traffic conflicts on the median lane is higher than on the middle and shoulder lanes. The TTC is calculated using visual angle data that is directly observable by drivers based on the best-fit analysis and the K-S goodness of fit tests; we conclude that the Gaussian mixture model distribution is the best-fitted distribution to TTC samples. Car-following theory is important in microscopic traffic flow theory, according to Sheng Jin[2]. Current car-following theory is based on the assumption that vehicles travel in the middle of a single lane. This assumption, however, is unrealistic and does not accurately Characterize driving behavior in a complicated traffic environment. The time-to-collision equation is modified using visual angle information and introduced into the General Motors model when the lateral separation characteristics between the following and the leader are taken into account. Simulations under various driving situations were used to test the suggested concept. The results suggested that introducing lateral separation into a staggered car-following model considerably improved the realism of car-following behavior. The standard car-following theory is based on the assumption that vehicles will move along the centre line of lanes, according to Sheng Jin[3]**.** However, according to field survey data, a lateral separation between the leader and the follower occurs frequently in complex traffic conditions. As a result, we redefined the time-to-collision (TTC) equation using visual angle information by taking lateral separation into consideration. The findings suggest that the steady-state traffic flow property and each lane's capacity are highly relevant to microscopic staggered car-following behavior, and that the suggested model considerably improves the practicality of the human driving behavior model.

3. METHODOLOGY

The TTC is a common vision feature that is used to avoid obstacles and is widely used in driving behavior analysis and conflict evaluation. The following driver's perception of the safety of the leading car in a traffic situation is referred to as TTC. TTC refers to the following driver's perception of the LV's safety in a driving environment. It is defined as "the time required for two vehicles to collide if they continue at their present speed and on the same path. Hayward11 defines TTC as "the time remaining until a collision between two vehicles would have occurred assuming the collision direction and speed difference are maintained," while Hydén18 goes into great detail about it. TTC is calculated by dividing the distance between a following and a leading vehicle by the relative velocity of two consecutive vehicles at a given period. As a result, the following is the formulation:

$$TTC_i(t) = \begin{cases} \dfrac{x_{i-1}(t) - x_i(t) - VL_{i-1}}{v_i(t) - v_{i-1}(t)} & \text{if } \ v_i(t) > v_{i-1}(t) \\ \infty & \text{otherwise} \end{cases}$$

where TTCi(t) is the TTC of following vehicle i at time t, xi − 1(t) and xi(t) is the position of leading vehicle i − 1 and following vehicle i at time t, respectively, vi − 1(t) and vi(t) is the speed of leading vehicle i − 1 and following vehicle i at time t, respectively, and VLi − 1 is the vehicle length of leader i − 1.

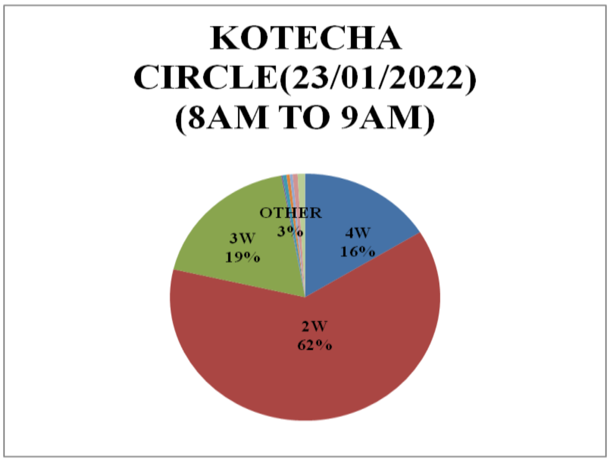
When the distance between two consecutive vehicles is large, it is difficult for video to collect the positions and speeds of the following vehicle and the leading vehicle at the same time. As a result, TTC should be calculated using.

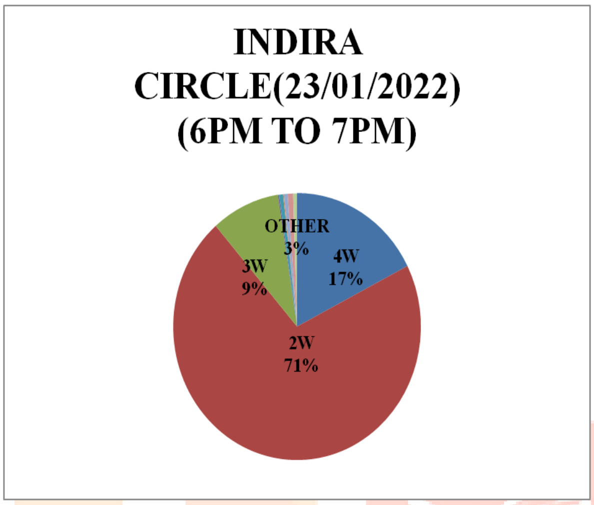
4. DATA COLLECTION

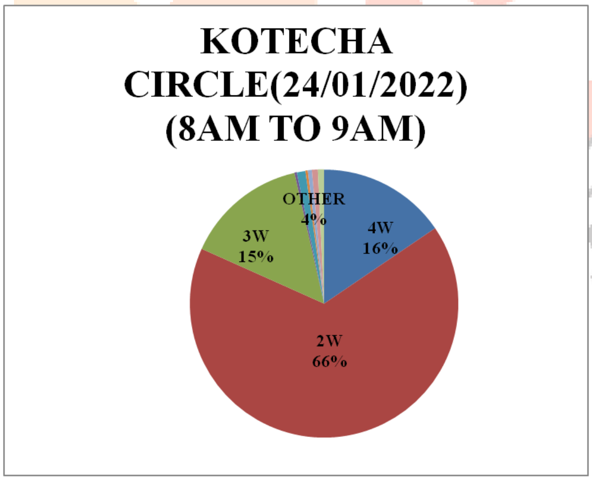
The field data presented in this research came from a video study taken in Rajkot between the kotecha and indira circles (Gujarat). The urban road process works from Kotecha circle to Indira circle and is 1 kilometer long. On January 23rd to 27th (Sunday to Thursday), 2022, data was collected with various traffic conditions from 7:00 a.m. to 10:00 a.m. (including morning peak hour) and from 17:00 p.m. to 20:00 p.m. (including evening peak hour). The study locations are chosen from three options. Location 1 is on the kotecha circle's entry side, location 2 is on the indira circle's exit side, and location 3 is midway between the kotecha circle and the indira circle. It is simple to obtain traffic data, such as speed, traffic volume, and time occupancy, using video image processing technologies.

The dataset for calculating TTC is obtained in a similar method, and includes speed, headway, vehicle length, and classification of vehicle types fixed traffic parameters at each station. When cars travel at a constant speed through a fixed station in a short time interval, the distance headway xi-1(t) - xi(t) after following a vehicle through the detector can be calculated by multiplying the follower speed by the time headway13.

4.1 TRAFFIC VOLUME STUDY


KOTECHA
CIRCLE(23/01/2022)
(8AM TO 9AM)
OTHER 3%
4W 16%
3W 19%
2W 62%


INDIRA
CIRCLE(23/01/2022)
(6PM TO 7PM)
OTHER 3%
4W 17%
3W 9%
2W 71%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CIRCLE(24/01/2022)
(8AM TO 9AM)
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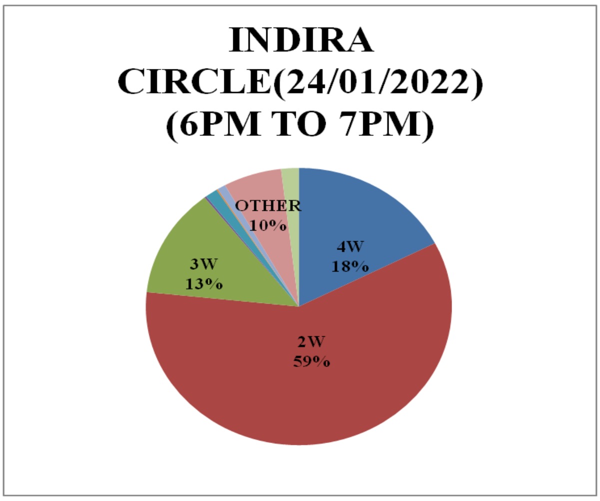
3W 15%
2W 66%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CIRCLE(24/01/2022)
(6PM TO 7PM)
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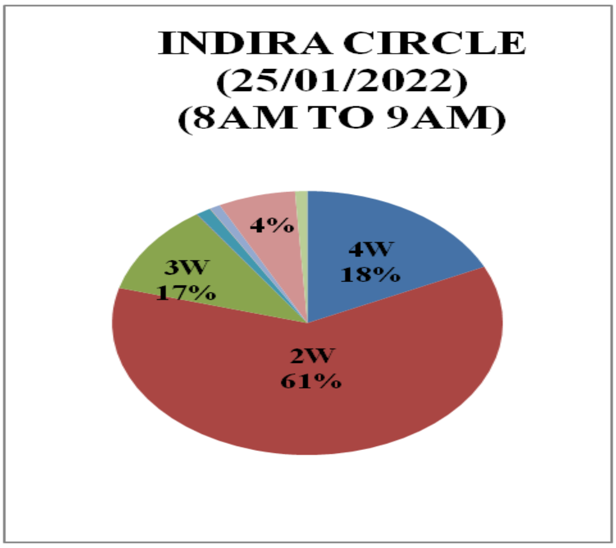
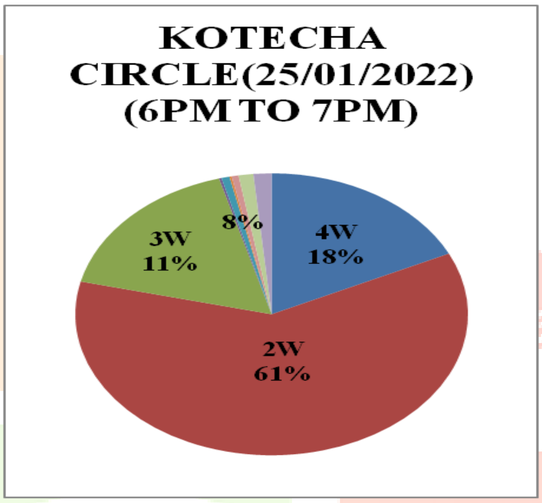
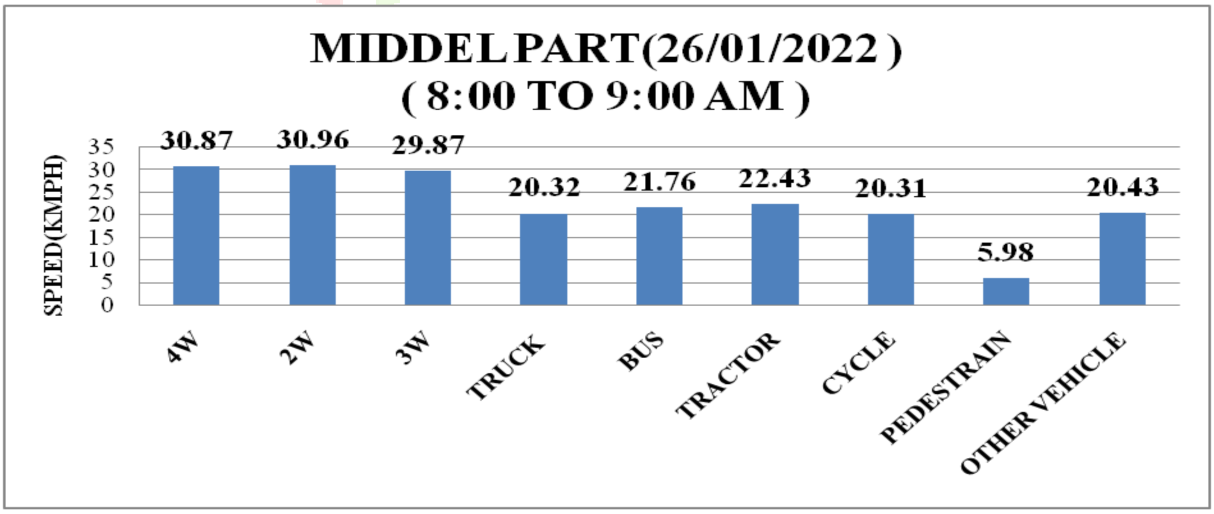
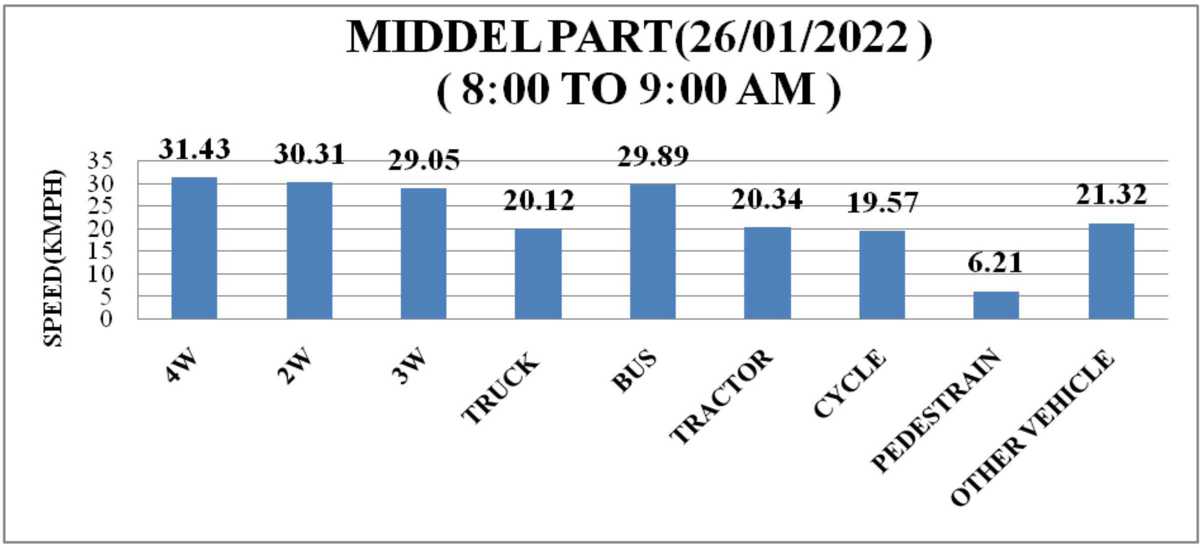
4W 18%
3W 13%
2W 59%

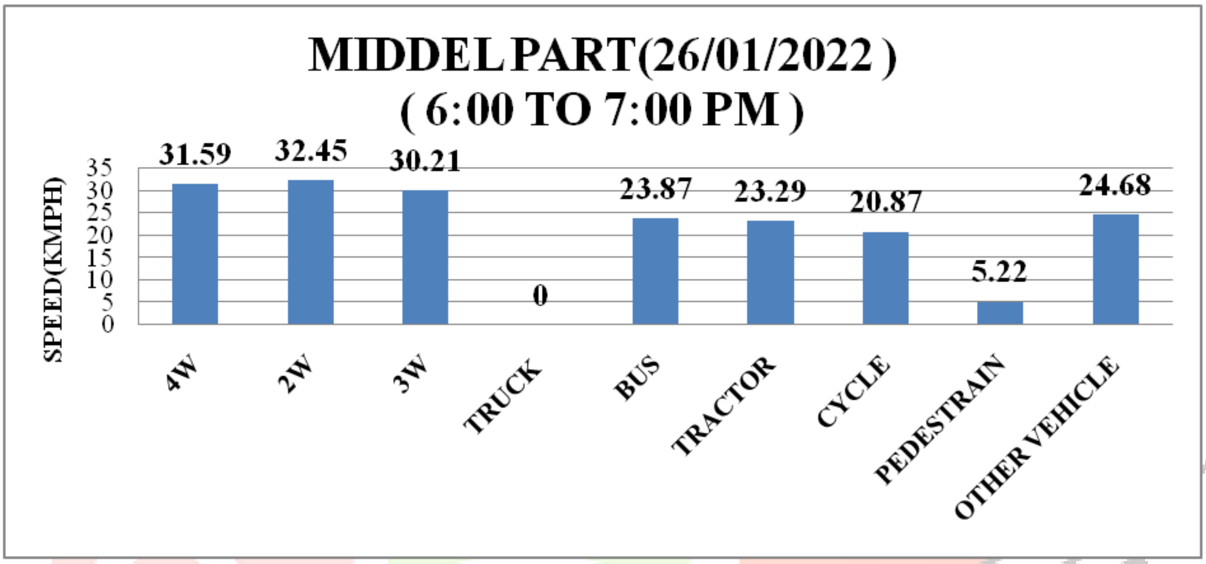


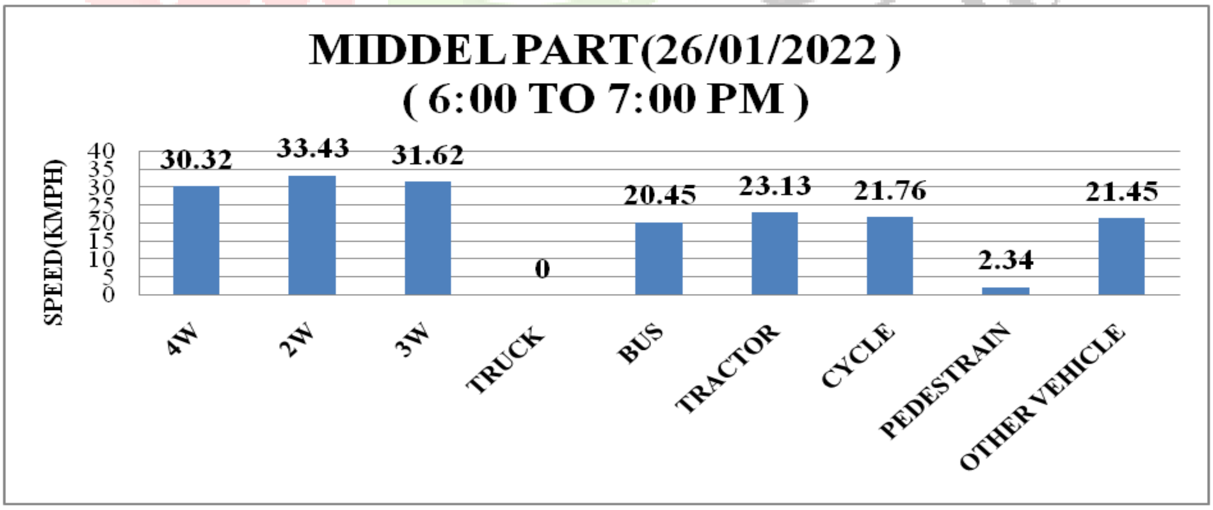


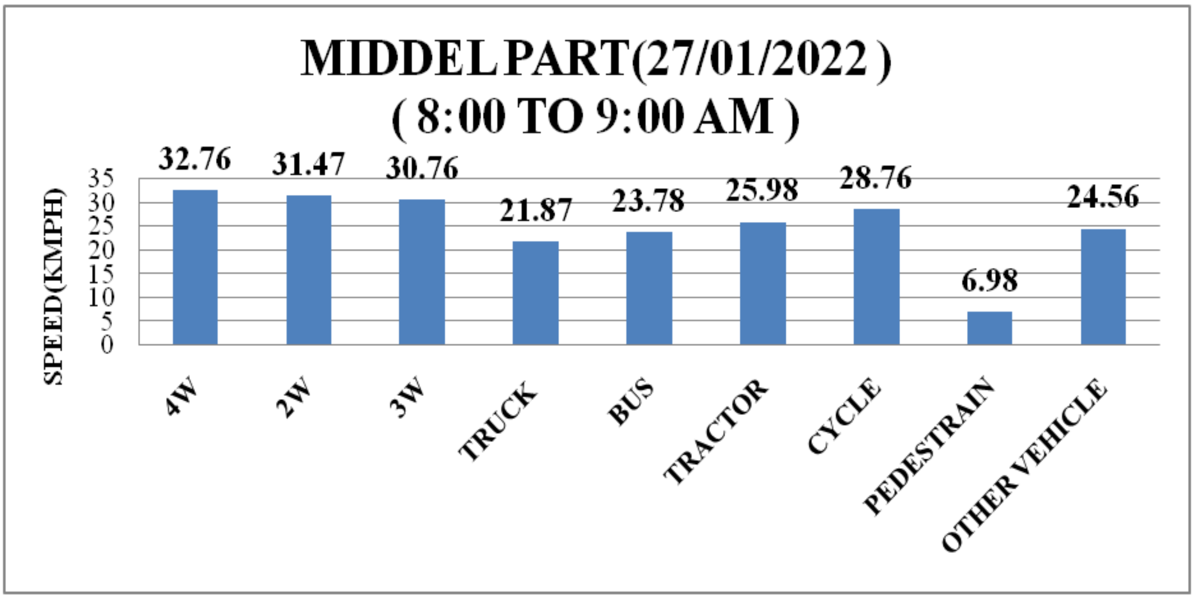
4.2 SPOT SPEED STUDY

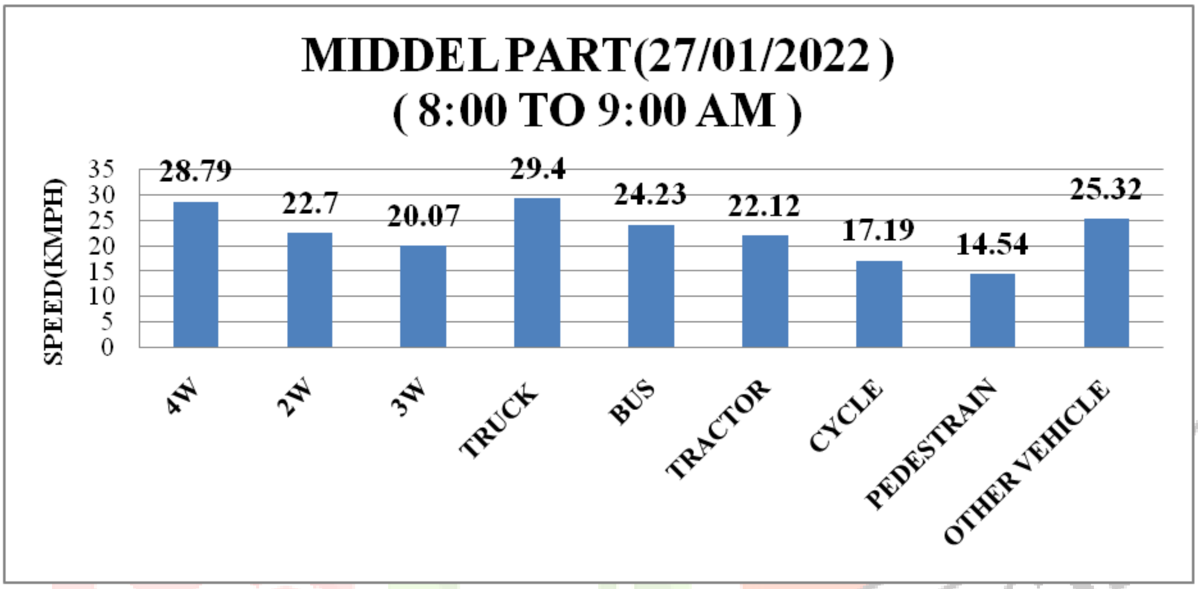


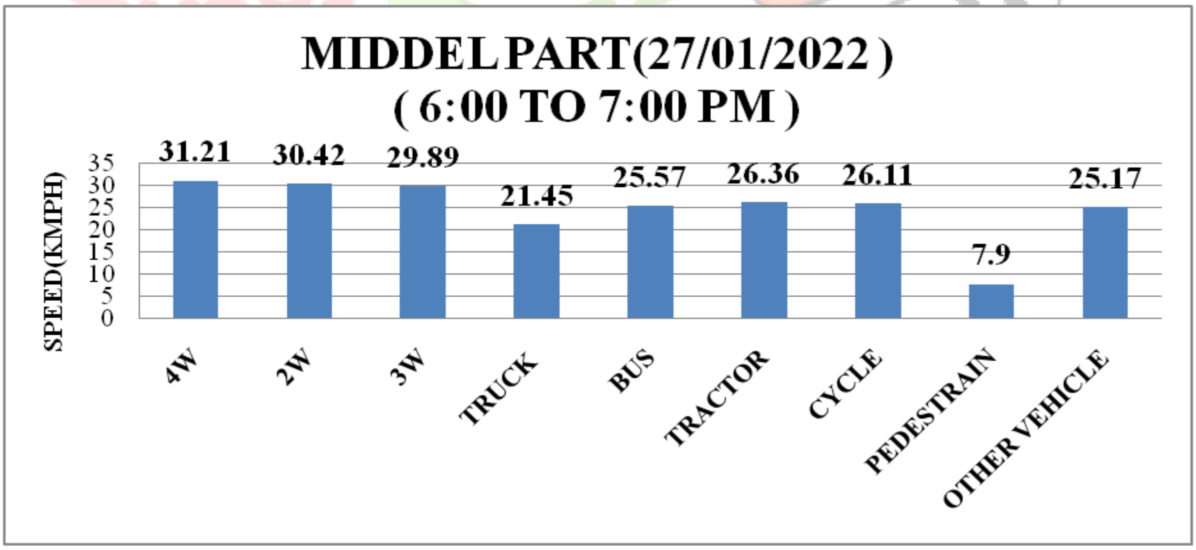

MIDDEL PART(26/01/2022)
(8:00 TO 9:00 AM)
SPEED(KMPH)
35
30
25
20
15
10
5
0
31.43
30.31
29.05
20.12
29.89
20.34
19.57
6.21
21.32
4W
2W
3W
TRUCK
BUS
TRACTOR
CYCLE
PEDESTRAIN
OTHER VEHICLE

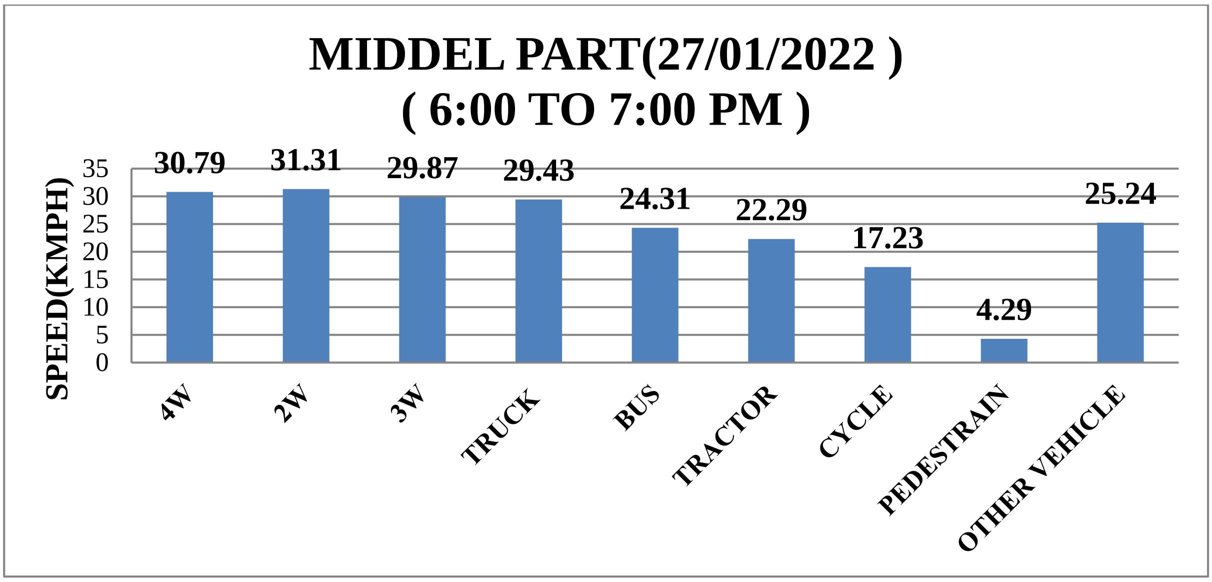

MIDDEL PART(26/01/2022)
(6:00 TO 7:00 PM)
SPEED(KMPH)
35
30
25
20
15
10
5
0
31.59
32.45
30.21
0
23.87
23.29
20.87
5.22
24.68
4W
2W
3W
TRUCK
BUS
TRACTOR
CYCLE
PEDESTRAIN
OTHER VEHICLE


MIDDEL PART(26/01/2022)
(6:00 TO 7:00 PM)
SPEED(KMPH)
40
35
30
25
20
15
10
5
0
30.32
33.43
31.62
0
20.45
23.13
21.76
2.34
21.45
4W
2W
3W
TRUCK
BUS
TRACTOR
CYCLE
PEDESTRAIN
OTHER VEHICLE


MIDDEL PART(27/01/2022)
(8:00 TO 9:00 AM)
SPEED(KMPH)
35
30
25
20
15
10
5
0
32.76
31.47
30.76
21.87
23.78
25.98
28.76
6.98
24.56
4W
2W
3W
TRUCK
BUS
TRACTOR
CYCLE
PEDESTRAIN
OTHER VEHICLE


MIDDEL PART(27/01/2022)
(8:00 TO 9:00 AM)
SPEED(KMPH)
35
30
25
20
15
10
5
0
28.79
22.7
20.07
29.4
24.23
22.12
17.19
14.54
25.32
4W
2W
3W
TRUCK
BUS
TRACTOR
CYCLE
PEDESTRAIN
OTHER VEHICLE


MIDDEL PART(27/01/2022)
(6:00 TO 7:00 PM)
SPEED(KMPH)
35
30
25
20
15
10
5
0
31.21
30.42
29.89
21.45
25.57
26.36
26.11
7.9
25.17
4W
2W
3W
TRUCK
BUS
TRACTOR
CYCLE
PEDESTRAIN
OTHER VEHICLE



(2W- two wheeler, 3W – three wheeler, 4W- four wheeler)

4.3 TIME TO COLLISION CALCULATION

CAR TO BIKE

$$TTC_i = \frac{TH_i \cdot v_i - VL_{i-1}}{v_i - v_{i-1}} \quad \forall v_i > v_{i-1}$$

Where, Total Vehicle headway(TH_i) =1.56, car speed (v_i)= 36.61 kmph, bike speed(v_{i-1})=27.63, standard vehicle length of car(VL_{i-1})=3.7m, so as per the formula,

TTC_i= (1.56*36.61)-3.7 / (36.61-27.63) =5.95sec

SR NO	DATE	TIME	CAR TO BIKE	BIKE TO CAR	RICKSHAW TO CAR	RICKSHAW TO BIKE	BIKE TO RICKSHAW	CAR TO RICKSHAW
1	26/1/2021 Wednesday	9-10 Am	5.01	-3.52	3.20	5.02	9.51	3.20
2	26/1 /2021 Wednesday	6-7 Pm	5.79	-3.30	8.79	5.47	10.27	8.87
3	26/1/21 Wednesday	6-7 Pm	8.94	-4.57	10.07	10.19	4.06	3.35
4	26/1/2021 Wednesday	9-10 Am	8.84	6.59	-4.29	6.48	6.6	3.15
5	27/1/2021 Thursday	6-7 pm	6.22	5.61	8.42	-4.43	8.40	7.77
6	27/1/2021 Thursday	6-7 pm	6.37	6.47	4.83	8.56	7.44	-1.80
7	27/1/2021 Thursday	9-10 am	5.75	4.24	8.88	-7.52	7.07	3.34
8	27/1/2021 Thursday	9-10 am	5.95	10.28	3.86	6.28	3.88	-3.22

5. CONCLUSION

An assessment approach for urban road traffic safety is proposed in this work to evaluate the incidence of vehicle crashes in various conditions. TTC sample data was collected in two locations on urban road. I conclude that all the vehicle headway samples are greater than 2 so it should be consider safe enough to prevent possible conflicts. Vehicle headway is divided into four categories: comfortable, danger, minimum safe and should not be considering safe enough. Vehicle headway critical situation between 1.1 and 1.7 is comfortable, greater than 0.6 is danger and greater than 0.7 is minimum safe.

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