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A study on Non Signalized Junctions and Its Effect to Traffic Flow and Safety: a case Study along Parit Raja Main Road

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Abstract
Highway traffic safety is an important field in transportation engineering. Highway intersections are nodes of road networks and accident-prone locations. These are places where vehicles coming from different directions, moving in different directions, interact and conflict with each other. Due to conflicts from all users, more traffic accidents can occur at unsignalized intersections than on other road segments. This study evaluates the effects of intersections on traffic flow and safety. The assessment was based on data collected at three unsignalized intersections on Jalan Kluang. Data on traffic volume, traffic conflicts, and delays were collected using a video camera and stopwatch during the start of monitoring in the morning rush hour and evening rush hour. Data collected includes traffic volume, traffic conflicts, and delays. The level of service (LOS) values for the intersections for this study was D. The developed model shows that the incremental increase in traffic conflicts can be represented by a negative exponential trend concerning the volume of approaching traffic. This negative exponential model shows a better explanation than other models. Therefore, this study was able to correlate the parameters that were determined by the characteristics of the studied non-signal intersections.

Keywords: Traffic, Safety, Highway, Delays, Non-signal

1. Introduction

The rapid development of Malaysia increases the cost of living of the citizen. It influences the travel pattern of the community from their origin to any destination. Transportation system is also affected by the annual increase in the number of vehicles on roads. Intersections in the multi highway network have a significant effect on the operation and performance of the traffic system. With the rapid growth and increasing population in Parit Raja that has occurred in recent years, and increasing the number of vehicles, it caused the occurrence of congestion on the roads. The intersections are the most affected part of the road congestion and therefore increase the waiting period and vehicles conflicts.

Highway intersections are nodes of road networks and accident-prone locations. They are the places where vehicles coming from different approaches and moving towards different directions interact and conflict with each other. Due to the conflicts from all users, more traffic crashes could happen at unsignalized intersection as compared with roadway segments. With the rapid growth of the number of various vehicles, the ratio of the traffic accidents to vehicle number is increasing greatly.

Parit Raja Main road was chosen as a location of the study case. The increase of traffic volume during morning and evening peak hour is a typical case and most of the road users are getting used with the condition. For priority intersection, the road users of minor arm need to allow the major arm users pass by the junction. In such case traffic queues and delay always happen at intersection during the peak hour. This will lead to traffic congestion and the worst case may happen is accident as the road user will tend to forget the rules that need to follow at the intersection. The intersections A, B, and C are roads junction selected from different location in ParitRaja main road. Intersection A is three legged linked between Jalan kluang and Jalan Persiaran Cempaka this area comprised of Residential units , commercial, institutions, parks, shops, restaurants, banks and college. Intersection B is three legged linked between Jalan Kluang and Jalan Sri Indah 2, this area comprised of Residential units, commercial and parks. Intersection C is four legged linked between Jalan Kluang and Jalan Manis – Jalan Pt Hj.Ali, this area comprised of Residential area. These intersections experience congestion at the peak hours, It is frequently observed in a rapidly growing Parit Raja that traffic congestion and long queues at intersections occur during peak hours. No signs Warning for speed reduce that making it a critical spots for the occurrence of accidents, and does not provide adequate safety of road. This problem is mainly due to the vehicle conflicts and long delay for those vehicles from main road to turn right or left into junction.

At the three intersections selected, and at the peak hours there is a higher traffic volume that due to increase the delay, as well as increase the traffic conflicts, by calculating Average Control Delay can assess the level of service and therefore evaluate the effect the intersection on the flow of traffic, and by traffic conflicts study can evaluate the safety.

This study aims to analyze the intersections on the Parit Raja main road and link their impact on traffic and safety. This is done by determining the level of service (LOS) at the selected intersections. And considering safety regarding vehicle conflicts and traffic volume at the chosen intersections.

2. Scope of Study

The study was conducted on the Parit Raja main road. It started from Parit Raja Town KM 24 (Jalan Manis) to Km 23 (Jalan Persiaran Cempaka). The number of junctions selected has been determined after a preliminary site survey was conducted. The duration of the study will be 10 months. Average stop delay is a principal performance measure that enters into the determination of intersection (LOS), traffic volume and vehicle conflicts have been correlated and the equipment used during the survey was video recording and wheel measuring.

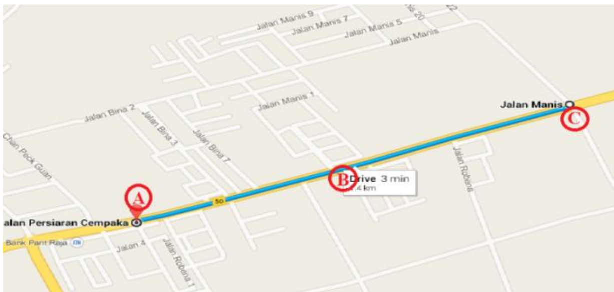

Fig 1: Location of study [Source: google map (2022)]

3. Literature review

John Lu and Juan C. Pernia 2004 studied the safety evaluation of right turns followed by U-turns at signalized intersection (6 or more lane arterials) as an alternative to direct left turns - conflict analysis in the state of Florida to evaluated safety and operational impact right turn followed by U-turn at a signalized intersection, data was collected with the help of video recording equipment at a total of eight sites for over 300 hours, data analysis was conducted by following procedures. The average number of daily traffic conflicts was calculated for each site and evaluated by conflict type. The analysis of RTUT at signalized intersection and DLT from driveways on six and eight lane arterials using traffic conflicts resulted in several conclusions. These are presented in the following paragraphs. The comparison of the number of conflicts per hour of RTUT and DLT movements shows that RTUT movements generate three times less conflicts than DLT movements per hour. Also, the conflict rate which was used to analyze the effect of volumes, results also showed the effectiveness of RTUT movements had 35 percent lower conflict rate on six or eight lane roads. The comparison of severity for both alternatives shows that RTUT movements reduce the number of conflicts, and also the severity of them. Results of this study indicated that the overall severity of RTUT related conflicts 37 percent lower than that of DLT related conflicts.

JoewonoPrasetijo 2007 studied the Capacity and Traffic Performance of Unsignalized Intersections under Mixed Traffic Conditions in the city of Pontianak, West Kalimantan and in a secondary set of data from Yogyakarta (West Java) in Indonesia. The study has investigated 14 unsignalized intersections. The intersections were chosen among places where a rule of priority is not really existent and where all streams seem to have an equal rank in the hierarchy of departure mechanism. Every stream was observed by using two camcorders (DCR–TRV 270E with additional cassette Hi8) which were placed at a 3.5 meter high tripod and each was positioned at the edge of the road near the corners of the intersection. . Each intersection was investigated during two hours in the morning (06.30 – 08.30) and in the afternoon (14.30 – 16.30). These periods were considered as the peak period times. Viewing the monitor, time instants when the vehicles arrive at specified points of the intersections were transferred into a personal computer using specific software. Times of arrival and departure were recorded for each vehicle from each stream. Based on the arrival and departure time as well as the traveled distance of each movement, we can simply find the speed of each vehicle. Traveled distance for each movement were measured based on reference lines which were drawn at the intersections and which could also be seen at the monitor (cassette recorded). Furthermore, speed and volumes were aggregated in 1–minute and 5–minute intervals. In addition, intersection occupancy was counted in 20–second intervals. From data recorded, relationships between the three parameters were developed, e.g. the speed and flow relationship and the flow and intersection occupancy relationship. The results showed that there was a good correlation between speed – flow and flow – intersection occupancy in each group of conflict.

The pervious study conducted by (GunalaanVasudevan , 2013) about Study On Traffic Conflict At Unsignalized Intersection In Malaysia, to study accident data used as an identification of hazardous location leads to less accurate countermeasures. That was because accidents are not always reported especially accident involving damage only and this situation can reduce good comparative analysis. To overcome these lacks of accident data, many ways of employing non-accident data have been suggested. One of the ways using non-accident data is traffic conflicts, which is defined as critical incidents not necessarily involving collisions. The traffic conflict technique was originally set up to provide more reliable data and information of traffic problems at intersections which actually would replace the unclear and incomplete recorded data accident. The conflict study was done at the selected unsignalized intersection where types of traffic conflict can be identified and classified. Various road users involved in the conflict at the unsignalized intersection were also observed. Then conflicts data captured were analyzed using the computer program to observe for any conflicts at the intersections. The linear regression graph was used to show the relationship between conflict and accident data where two different equations were derived from the graph. This equation may be used to make a prediction for the relationship that might exist between those two variables at another location. And the found results shows that value of correlations for data compared between conflict and accident for different types of vehicles is enough to show the inconsistencies relationship between those two variables. Overall, the study showed a weak accident and conflict relationship. It also might influence by short period of observation for the conflict data.

However, this study provides useful insight into the correlation between accident and accident where two equations derived for relationship between those two variables. This equation may be used to make a prediction of total accident that might occur when conflict amount are known. This can be the good starting to do a more detail study of this relationship with the traffic situation at the intersection in Malaysia by study others aspect related to this conflict and accident at the location. The important conclusion of this study was that using conflict data at a location for a treatment planning may not immediately result in reducing accident rates at an unsignalized intersection.

4. Location of Field Observation

Investigations at three junctions which all consist of various widths of lanes have been undertaken. However, all the junctions have been measured and analyzed. Unsignalized junctions have been investigated with various average widths. Based on investigation, each road has a large different width even at the main road (e.g. approach A differs from approach C at the junction).Three–leg and four-leg junctions have been investigated which have typical layouts that approach A and B as the major road and approach C and D as the minor road. As shown in Figure 2 each approach would have large different widths. However, in further analysis, it does not matter where the major and the minor roads are placed, because analysis would only use several vehicles (flows). This study requires an area where there are straight paths with successive nodes. So the selection of the study area is based on the following criteria:

1. Roads with a high traffic volume, long queues, and long delays.
2. Good access and safety for the enumerators and equipment during the data collection process.
3. Good overhead vantage points for video recording purposes.

Traffic calculation at junctions identified is one obligation in study analysis.

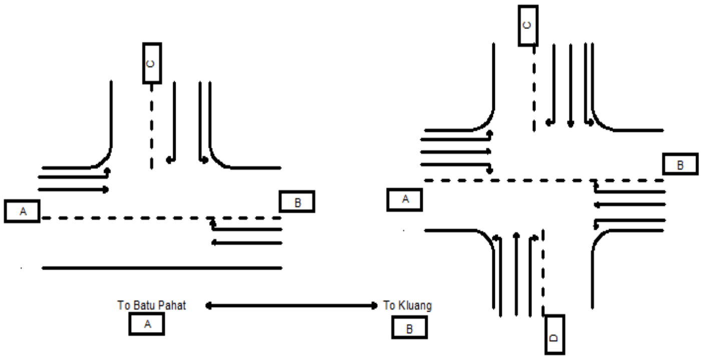

Fig 2: Junction approaches

5. Data Collection

- **Equipment for Monitoring**

Field data collection has been carried out at selected sites using two types of equipment which are a video camera, and a stopwatch. To have detailed information on the traffic volume, used a camera and chose the junctions whose geometric design was classified as a medium category. Ordinary camcorder and two hours duration used to monitor each junction. The camera is positioned at the edge of the road nearly at the junction to have a very good view of the junction. This camera is placed at the edge of the roads or junctions with a good view for monitoring the traffic movement; the stopwatch is used for counting sampling intervals for vehicles stopped.

- **Data Collection Time**

Data was collected in peak hours in case the weather is suitable to be a clear visibility.

Peak times are as follows:

1. Morning: from 7 am to 9 am.
2. Evening: from 5 pm to 7 pm.

6. Data extraction

- **Data extraction of traffic volume**

The video from the study locations were initially played back to retrieve the relevant data. The data extracted from the recorded videos are as follow:

1. Volume using 15 minutes interval for every approach.
2. Vehicle classification with respect to data.

Table 1: Shows A simple Example for Data Collection

Section	**A**				
Time	**7:00 AM – 7:15AM**				
Type of vehicles	**Cars**	**Motorcycles**	**light lorries**	**Buses and Heavy lorries**	**Traffic Volume Veh/h**
A ➜ B	132	63	16	15	226
B ➜ A	167	107	18	8	300
A ➜ C	14	5	-	-	19
C ➜ A	17	7	-	-	24
B ➜ C	11	3	1	-	15
C ➜ B	2	1	-	-	3
					587

- **Data extraction of intersection delay**

To perform the study, the first observed counts and records the number of vehicles stopped on the approach for each sampling interval by using a stopwatch. A vehicle is counted more than once in the delay determination if it is stopped during more than one sampling time. That is, particular vehicles have been counted in all sample periods during which they remain stopped on the intersection approach. The second observed performs a separate tabulation of the approach volume for each period by classifying the vehicles as either stopped or not stopping. This period is also applicable for the evaluation of delays to pedestrian traffic at an intersection. Table 2 presents an example of the data collected.

Table 2: Shows Intersection Delay Study

Delay study intersection B						
Location: JalanKluang		City: BatuPahat		County: Johor Bahru		
Approach: North				Time:6pm-7pm		
Time Minute Starting At	Total number of vehicle stopped In the approach at time				Approach volume	
	+0 sec	+15 sec	+30 sec	+45 sec	Number stopped	Number not stopped
1800	1	1	0	0	1	0
1801	0	1	1	2	2	0
1802	1	1	1	2	1	1
1803	1	0	0	1	1	0
1804	1	1	2	2	2	1
1805	2	1	0	0	0	0
1806	0	0	1	1	1	0
1807	2	2	1	1	2	1
1808	1	1	0	1	1	1
1809	0	0	0	0	0	0
1810	1	1	2	1	3	0
1859						
Subtotal	10	9	8	11	14	4
Total	38				18	

7. Data analysis

a) Determine Level of Service (LOS)

The level of service (LOS) for TWSC intersection is determined by the computed or measured average delay per stopped vehicle. The Intersection Delay Study is used to evaluate the performance of intersections in allowing traffic to enter and pass through or to enter and turn onto another route. This study used an intersection delay study to evaluate the level of service (LOS) at the intersection.

❖ **Intersection Delay Study**

1. Calculations should be completed by computing the Total Delay and average Delay per Stopped vehicle. When conducting this study at an intersection with stop sign control, the number of vehicles stopping (Number Stopped sub-column) should only be those vehicles that stopped completely. Vehicles that "roll" through the stop should be counted in the Number Not Stopped sub-column.
2. The study involves counting vehicles stopped in the intersection approach at successive intervals. A typical duration for these intervals is 15 seconds, although other interval lengths can be selected. The sampling interval should be selected so that it will not be a multiple of the traffic signal cycle length of 45, 60, 75, 90, 105, 120, 135, or 150 seconds, a 15-second interval between samples is used. (MUTS, 2000).

b) Relationships between traffic Volumes and Traffic Conflicts

The relationship between hourly traffic volumes as independent with hourly traffic conflict as a dependnt variable was done by statistical analysis of regression (SPSS software). In this study, ten models have been studied to describe a range of variations in different types of traffic conflict due to the relation with traffic volume with significance. The models that have introduced a less standard error, coefficient of determination (R^2) more than 0.7 with a significance of 0.05 or less, those models are the best alternative to explain the relation between traffic conflict and traffic volume.

8. DATA OBSERVATIONS AND ANALYSIS

This part of the analysis conducted in this chapter deals with the result of this study which is based on three different investigated areas, this study focused on the relationship between traffic volume and traffic conflict, and the level of service (LOS) of each intersection. The investigated junction is divided into three which are junction A (merge and cross), junction B (merge and cross), and Junction C (merge and cross), all of these junctions are located in Parit Raja. After collecting the data it was used in manual calculation and SPSS to determine the desired values to achieve the objectives of this.

- **Observations on the number of traffic vehicles at junctions**

As shown in Figure 6 traffic volume against time for three unsignalized junctions have been monitored during the peak hour time period, morning period (7 am-9 am) and evening period (5 pm-7 pm) for two days.

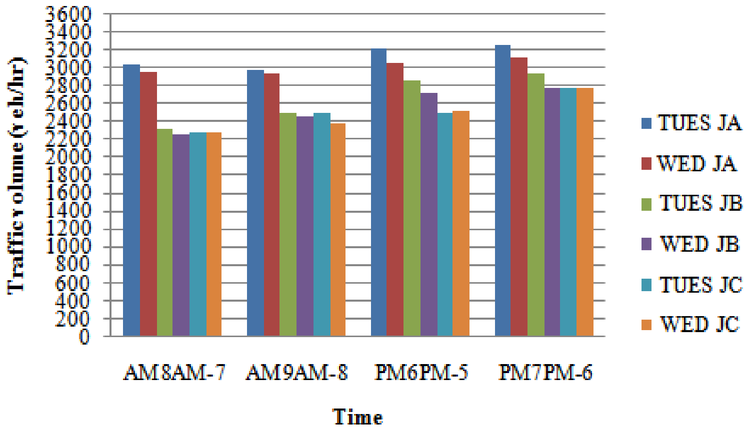

Fig 3: Graph Traffic volume against time

- **Analysis level of service (LOS)**

The level of service for unsignalized intersections is based on the assumption that major street traffic is not affected by minor street movements. The capacity of the intersection to accommodate minor street movements is based on the amount of traffic on the major street and the configuration of the intersection. LOS is based on the average total delay, defined as the total elapsed time from when a vehicle stops at the end of the queue until the vehicle departs from the stop line (this time includes the time required for the vehicle to travel from the last-in-queue position to the first-in-queue position. The average total delay for any particular minor movement is a function of the service rate or capacity of the approach and the degree of saturation. LOS criteria are given in Table 3.

Table 3: Level of service criteria for TWSC intersection (HCM, 2000)

Level of service (LOS)	Average Control Delay (sec/veh)
A	0 – 10
B	10 - 15
C	15 – 25

D	25 - 35
E	35 – 50
F	> 50

a. Analysis level of service (LOS) at junction A

After collection, the total number of vehicles stopped in the peak hour at the intersection approach at successive intervals and several stopped vehicles determine the Average delay per approach vehicle to evaluate the level of service.

Total delay=361×15=5475 veh. Sec

Average delay per approach Vehicle= 5475/195=28.08 sec/veh

From Table 3 and Average Control Delay 28.08 sec/veh, the classification level of service is D.

b. Analysis level of service (LOS) at junction B

After collection, the total number of vehicles stopped in the peak hour at the intersection approach at successive intervals and several stopped vehicles, determine the Average delay per approach vehicle to evaluate the level of service.

Total delay=185×15=2775veh.sec

Average delay per approach vehicle= 2775/87=31.90sec/veh

Table 3 describes the level of service criteria for the TWSC intersection and through Average control delay (31.90 sec /veh) the level of service LOS at this junction is D.

c. Analysis level of service (LOS) at junction C

At this junction, there is a two-way stop control. However, each approach has an Average delay per approach vehicle separately:

❖ **South approach**

Total delay=127×15=1905 veh. Sec

Average delay per approach vehicle= 1905/59=32.29 sec/veh

Table 4.1 describes the level of service criteria for the TWSC intersection and through Average control delay (32.29 sec /veh) the level of service LOS at this junction is D.

❖ **North approach**

Total delay=181×15=2715 veh. sec

Average delay per approach vehicle= 2715/87=31.21 sec/veh

From Table 3 and Average Control Delay 28.08 sec/veh, the classification level of service is D.

Level of Service D: This level of service approaches unstable flow, with tolerable operating speeds being maintained, though considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operating speeds. Drivers have little freedom to maneuver, and comfort and convenience are low. These conditions can be tolerated, however, for short periods.

- **Analysis of Relationship between vehicle conflicts and traffic volume**

In this study, based on the condition that the number of traffic conflicts is positively related to traffic volume, the relationship between traffic volume and traffic conflict is studied, and the relationship model between traffic volume and conflict at three intersections area is built based on the found results.

a. Analysis of the Relationship between merges conflicts and traffic volume at Junction A

Ten types of equations have been used to determine the relationship between the traffic volume and merge conflicts at junction A, from the results of the study show that the traffic volume has a great relationship with traffic conflicts that is because when the traffic volume is high it gives a big value of traffic conflicts, exponential and Growth models introduces a less standard error than the rest of the models which are (Linear, Logarithmic, inverse, quadratic, cubic, compound, and power). Hence, the exponential model is the best alternative to explain the relationship between traffic conflict and traffic volume. The best model which is Exponential gave a range of 98.4% and a significance of 0.081 with the same traffic conflicts.

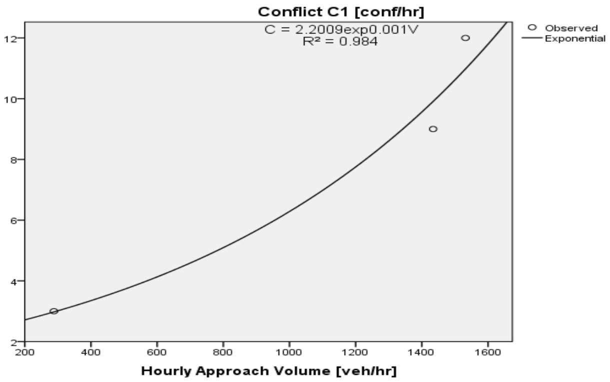

Fig 4: Exponential relationship between hourly merge conflict & traffic volume

b. Analysis of the Relationship between crosses conflicts and traffic volume at junction A

From10 the types of models that have been used for this study to determine the relationship between the traffic volume and cross conflicts at junction A, the results of the study show that the traffic volume has a great relationship with traffic conflicts that is because when the traffic volume is high it gives a big value of traffic conflicts, exponential, Growth and Compound models introduces a less standard error than the rest of the models which are (Linear, Logarithmic, inverse, quadratic, cubic, and power). Hence, exponential Growth and Compound models are the best alternatives to explain the relationship between traffic conflict and traffic volume. The chosen model which is Exponential gave a range of 99.3% and a significance of 0.052 with the same traffic conflicts.

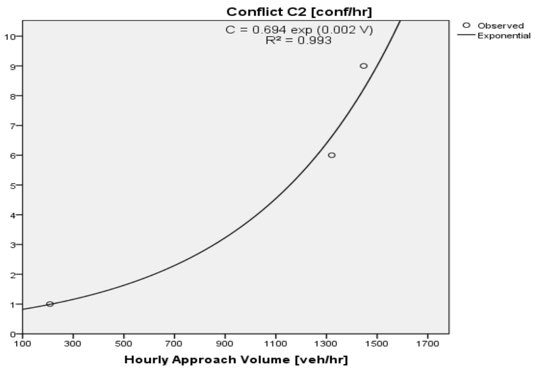

Fig 5: Exponential relationship between hourly cross conflict & traffic volume

c. Analysis of the Relationship between merges conflicts and traffic volume at junction B

The result used 10 types of models for this study to determine the relationship between the traffic volume and merge conflicts at junction B, from the results of the study show that the traffic volume has a great relationship with traffic conflicts, Logarithmic, model introduces a less standard error than the rest of the models which are (Linear, Growth and Compound, inverse, quadratic, cubic, and power). Hence, the Logarithmic model is the best alternative to explain the relation between traffic conflict and traffic volume. The chosen model which is Linear gave a range of 99.9% and a significance of 0.021 with the same traffic conflicts.

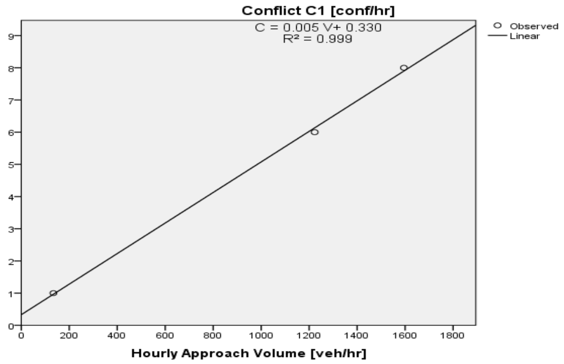

Fig 6: Linear relationship between hourly merge conflict & traffic volume

d. Analysis of the Relationship between crosses conflicts and traffic volume at junction B

After using 10 different types of models to determine the relationship between the traffic volume and cross conflicts at junction B, the results of the study show that the traffic volume has a great relationship with traffic conflicts that is because when the traffic volume is high it gives a big value of traffic conflicts, exponential, Growth and Compound models introduces a less standard error than the rest of the models. Hence, exponential Growth and Compound models are the best alternatives to explain the relationship between traffic conflict and traffic volume. The chosen model which is Exponential gave a range of 99.7% and a significance of 0.035 with the same traffic conflicts.

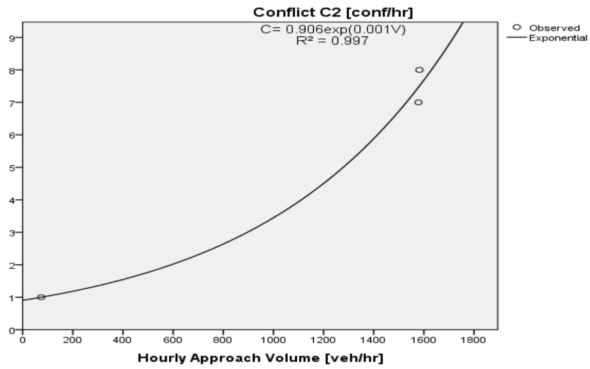

Fig 7: Exponential relationship between hourly cross conflict & traffic volume

e. Analysis of the Relationship between merges conflicts and traffic volume at junction C

Ten different types of models for this study to determine the relationship between the traffic volume and merge conflicts at junction C, from the results of the study show that the traffic volume has a great relationship with traffic conflicts and exponential, Growth, and Compound models introduce a less standard error than the rest of the models which are (Linear, Logarithmic, inverse, quadratic, cubic, and power). Hence, exponential Growth and Compound models are the best alternatives to explain the relationship between traffic conflict and traffic volume. The chosen model which is Exponential gave a range of 96.2%, and a significance of 0.002 with the same traffic conflicts.

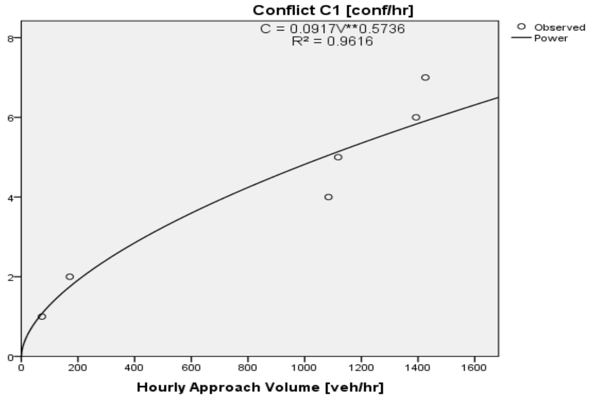

Fig 8: Power relationship between hourly merge conflict & traffic volume

f. Analysis of the Relationship between crosses conflicts and traffic volume at junction C

In this study it's been used 10 different types of models to determine the relationship between traffic volume and cross conflicts at junction C, from the results of the study show that the traffic volume has a great relationship with traffic conflicts. The developed model shows that models introduce less standard error than the rest of the models which are (Linear, Logarithmic, inverse, quadratic, cubic, exponential, Growth, Compound, and power). Hence, the (S) model is the best alternative to explain the relationship between traffic conflict and traffic volume. The chosen model which is (S) gave a range of 92.8.1% and a significance of 0.000 with the same traffic conflicts.

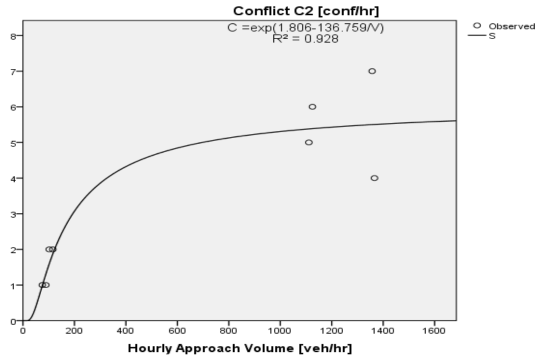

Fig 9: (S) relationship between hourly cross conflict & traffic volume

g. Analysis of the Relationship between merge conflicts and traffic volume at three combined junctions

The resulting statistical analysis of regression by SPSS software was between hourly traffic conflicts and hourly traffic volume. It can be seen that Exponential relationships are significantly appropriate to explain the relation between hourly traffic conflict and hourly approach traffic volume with a coefficient of determination of 88.9% at (0.000) level of significance.

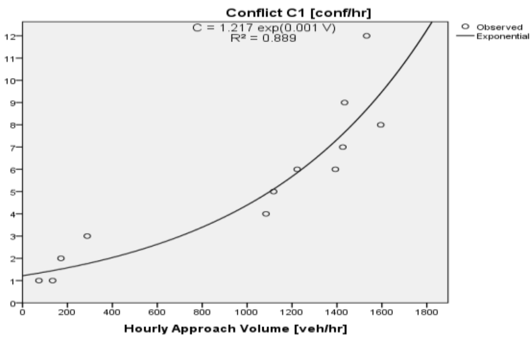

Fig 10: Exponential relationship between hourly merge conflict & traffic volume

h. Analysis of the Relationship between crosses conflicts and traffic volume at three combined junctions

After calculating traffic volume and traffic conflict, this research uses (SPSS software) to develop the relationship between them for three unsignalized junctions. Linear Regression, Logarithmic Regression, Inverse Regression, Quadratic Curve Regression, curve regression, compound regression, power regression, SR regression, growth regression, and exponential regression. After analysis and comparison of this ten regression, it is easy to find that the Exponential Regression model matches traffic volume and traffic conflict best in these ten regression models with a coefficient of determination 89.5% at (0.000) level of significance as shown in Figure 11.

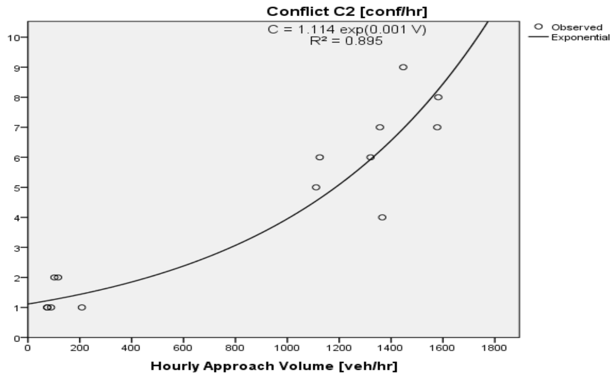

Fig 11: Exponential relationship between hourly cross conflict & traffic volume

9. Conclusion

The analyses presented showed that for each peak hour, the variables derived from travel time, traffic volume, delay, level of service, and conflicts accounted for the percentage of the ability to improve in both peak hours. This study found that the current problems in the study area are safety and flow at intersections this problem faced by the drivers during the travel time may be related, to the volume of traffic flow at the intersection as well as the capacity of the main road unable to absorb vehicles that waiting to turn right -left in peak hour. Therefore the long queue at junctions means to reduce the safety on the main road.

The following findings can be drawn from the study:

1. Average delays at the three intersections between 28.08 sec/veh - 32.29 sec / veh, and the level of service at these intersections is D. At level D, the influence of congestion becomes more noticeable. Many vehicles stop, and the proportion of vehicles not stopping declines. Unsignalized intersection stopped time continues to increase. Traffic flow is unstable.
2. The exponential model describes a range of variation (83.1% - 99.7%) in different types of traffic conflict due to the relation with traffic volume with a significance of 0.081 or less. Further, the exponential model introduces a less standard error than the other models. Hence, the exponential model is the best alternative to explain the relationship between traffic conflict and traffic volume.
3. The exponential model reveals that an extra increase in traffic conflict resulted due to a further increase in traffic volume.
4. The correlation between traffic conflicts and volume is independent of the type of unsignalized intersections (three or four legs). In consequence, the data of three-leg intersections and that of four-leg intersections can be considered as one set of data without serious effect on the safety analysis at the sites.

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