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The Role of Geometric Design of Road Intersection in the Frequency of Traffic Conflicts and Accident Severity Atedet Akpan/Oron Road Intersection

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ABSTRACT
Highway intersections are prone to traffic conflict arising from intersecting traffic streams or the geometric design of the intersection. This paper evaluated the adequacy of the Edet Akpan / Oron Road intersection in Uyo Akwa Ibom State regarding traffic conflict. The traffic volume at the intersection was assessed during peak hours over seven days. Traffic accident data was collected from the Nigeria Police Force, as-built surveys were undertaken to produce the as-built drawings for the intersection. With the current design of the intersection, 56 traffic conflicts points were identified, poor sight distance, inadequate signalization were identified as significant constraints. A rotary intersection was designed, leading to a reduction resulting in greater flexibility of geometric features to enhance flow, higher sight distance, and a decrease in traffic conflicts points to an acceptable level of 8. To further improve the efficiency of the new design, alternative routes were introduced.

KEYWORD: Highway Safety, Geometric Design, Traffic Accident, Traffic Conflict

I. INTRODUCTION

The geometry of any good road network has to do with the design or proportioning of the visible elements of a highway. It provides the framework for the design of other highway elements and also establishes the basic nature and quality of the vehicle path, which has primary effect on the overall safety characteristics of the highway. The design of a highway basically deals with the dimension and layout of physical features of the highway, these comprises of cross-sectional elements, sight distances, alignment, curves, superelevation, gradient and other allied features. Proper geometric design will help in there re duction of accidents and their severity. In recent years, vehicular traffic in the Uyo city metropolis has been increasing at a tremendous rate with a corresponding growth in traffic volumes and as a result of this, accidents and bottlenecks occur at several intersections within the city (Webb etal,1955). This unexpected happening occurs or are caused by a combination of several factors. This includes human factors which is predominant, road way factor and vehicle factor. The geometric design of any road influences its safety performance and poor geometric design could be a contributing factor to the frequency and severity of this occurrences in this regard. A point where the paths of two through or turning vehicles diverge, merge or cross is called Traffic Conflict (Peterson, 1965). This conflict points are associated with increased levels of road way crashes and accidents and tend to occur more frequently on roadways with sudden changes in their character (i.e., sharp curves at the end of long tangent road way sections). A successful intersection design addresses all mobility and is a critical aspect of road design where motorist, bicycle, and pedestrian movements converge while enhancing public movement. However, there exists a relationship between traffic safety and geometric design consistency. By all means, alignment consistency represents a key issue in modern highway geometric design. A consistent alignment would allow most drivers to operate safely at their desired speed along the entire alignment. Existing design speed-based alignment policies permit the selection of a design speed that is less than the desired speeds of majority of drivers. Much of the research in highway safety is focused on the different factors that affect road way safety. These factors are categorized as traffic characteristics, road geometrics, road surface condition, weather and human factors. Research has shown that geometric

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design inconsistency of roads, operations (traffic volume and speed), environment, and driver behavior are the common causes of accidents. The second section of this paper discussed about the method used in collecting data for this research and data for the study area. The third sections show how the bottleneck and traffic conflict from conflicting streams were resolved. Lastly the conclusion and recommendation discussed in the last section

II. STUDY AREA AND DATA COLLECTION

The basic goal of a highway engineer has always been to design a facility that will satisfy expected transportation needs safely, efficiently, and in a cost-effective manner. To satisfy public demand for better facilities, highway engineers have developed a vast highway system that reflects the needs, technology, and resources of the times. Design standards are progressively changed to accommodate increasingly greater traffic volumes, speeds, larger trucks, and higher safety standards. The Edet Akpan/Nsikak Eduok/Oron Road intersection is been assumed designed to standard specifications but this paper provides and analyses detailed methods and relevant data used in evaluating the current geometric design at this location in a bid to addressing the current problem of accidents and traffic conflicts. The location for this study is the Edet Akpan/Nsikak Eduok/Oron Road intersection which is within the Uyo Metropolis. Uyo is the state capital of Akwa Ibom, a major oil producing state in South-South Nigeria with Latitude 5°1 ' 60N (5.0333) and Longitude 7°55 ' 36E (7.9266) coordinates and an estimated population of 436,873 since the last Nigerian census in 2006. There is many traffic that passes through this point because it is a major intersection and an access route to several key places within the state capital such as the Ibom Le Meridien and Golf Resorts and the Victor Attah International Airport. And as such, it is a busy route and bottlenecks are bound to occur at several points within this intersection. Thus, it has become necessary to examine the geometric design.

Source: Google Earth

Various method was used in collection of data for this research work, which includes;

I. Field Study/Site Investigation

Extensive field studies are carried at the study area to obtain data on accident and on traffic conflicts at various points of the intersection. Primary data are obtained from geometry data gathered, as well as a visual observation of the area covered by road networks under focus. In order to achieve the objectives of this research, the researcher and a surveyor will be involved in field surveying of the intersection to obtain data from the existing geometric design. Secondary data include taking traffic counts at the intersection, the Nigerian Police Force-B Division and the Federal Road Safety Command accidents report and As-

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built survey of the intersection. From the various data gotten, the geometric design details of the intersection are studied and as well cross-examined–comparing it with the Nigeria highway design code (standards) to check if the geometric design (lane width, curve, sight-distances etc.) of the existing road is appropriate and to specifications.

II. Traffic Volume Data Collection

The intersection was observed from two opposing arms. The number of traffic lanes of each arm, the presence/absence of signalization (traffic control devices), the geometric configuration and the speed limits of vehicles on the observed arms are important characteristics of each arm of the intersection and will be used as parameters. Traffic volumes will also be monitored. Turning movement counts was made by alternately viewing
from opposing arms of the intersection every half-hour (30minutes) for three hours consecutively with each observer collecting data at specified points. These hourly counts were converted into average daily traffic (ADT) counts and will be used to develop an estimate of the traffic volume using each arm of the intersection.

III. Collection Of Road Traffic Accident Data

The files of reports of traffic accidents maintained by various Law Enforcement Agencies served as the source of accident data. This accident data was sourced from the local Police and Traffic Departments–B Division and the Federal Road Safety Commission, Akwa Ibom State who oversee this intersection and has its viability and safety under their command. Accident data to be used are collected from the accident reports on all accidents which occurred at the intersection or within 200 feet of the intersection. Data obtained was for a period of approximately 3 to 5 years most especially in the situation where the Traffic control devices or signals were not working. From here, the number of casualties will be categorized into three degrees of severity such as the fatality, serious injury, and minor injury. The data collection form at gotten is developed in an Excel sheet which enables the researcher to collect, separate and edit the required variables for the survey. Traffic accident data will be processed using descriptive statistics like tables, graphs, and figures to show variations of traffic accidents by year. These data served as the method to know the characteristics and variation of accidents.

III. RESULTS AND DISCUSSION

I. ANALYSI SOF ACCIDENT FREQUENCY AND SEVERITY USING ACCIDENT REPORT FROM 2017-2019

Accident risks gotten from the traffic conflict analysis occur more frequently on the crossing and left turn traffics. Vehicles approaching the intersection from the four arms of the road have a high tendency of a head on collision because motorists will want to get to the other arms of the intersection and vehicles making left turns and right turns have a tendency of colliding with the through traffic movements (See Appendix14).

Accident data collected from the accident reports on all accidents occurred at the intersection or within 200 feet of the intersection. Accidents occurred were linked to excessive speed, driver carelessness, improper overtaking,
recklessness and negligence on the part of the driver. Mechanical defects, defective traffic light sand signals and the entry curvature or radius to each arm of the intersection were major contributing factors to accidents. Data obtained ranges from a period of approximately 3 years (2017–2019) most especially in the situation where the Traffic control devices or signals were not working. From here, the number of casualties was divided into three degrees of severity such as the fatality, serious injury, and minor injury as shown in table 4.1 below.

Table 4.1 Showing a Summary of the Degree of Severity of Accidents at Edet Akpan/Nsikak Eduok/Oron Road Intersection from January 2017-August 2019.

DEGREEOFSEVERITY	NUMBERREPORTED
MinorMotorAccident	1
SeriousMotorAccident	10

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Fatal MotorAccident	2
TOTAL	13

Source:Traffic Department Nigerian Police Force–B Division

Traffic accident data gotten is processed and analyzed using descriptive statistics like tables, graphs, and figures to show variations of traffic accidents by year (See figure 4.1 and figure 4.2). These data served as the method to know the characteristics of the accident as shown in the graph below;

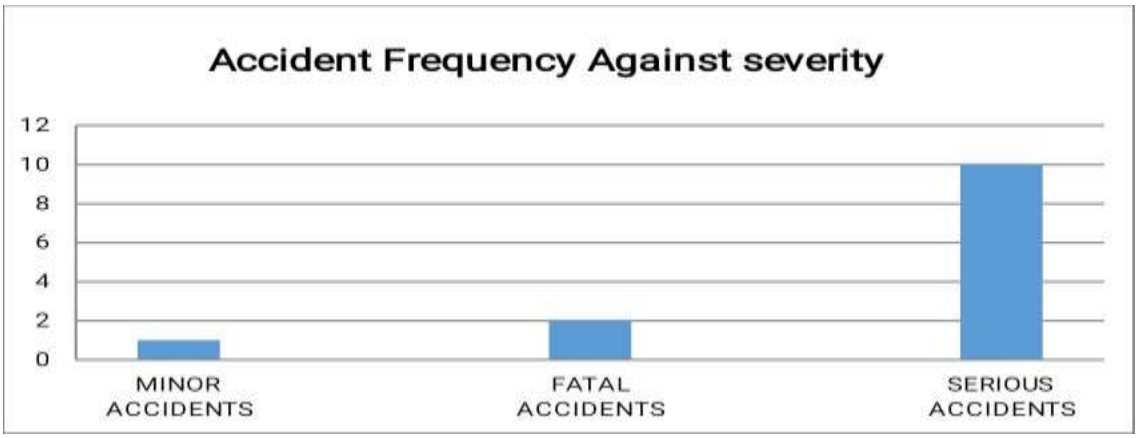

Figure 4.1: Level of severity of accident at the intersection from 2017-2019

From the Bar chart above, one person was involved in a minor accident, 2 persons in a fatal accident and 10 persons in a serious accident at the intersection between the years 2017 to 2019.

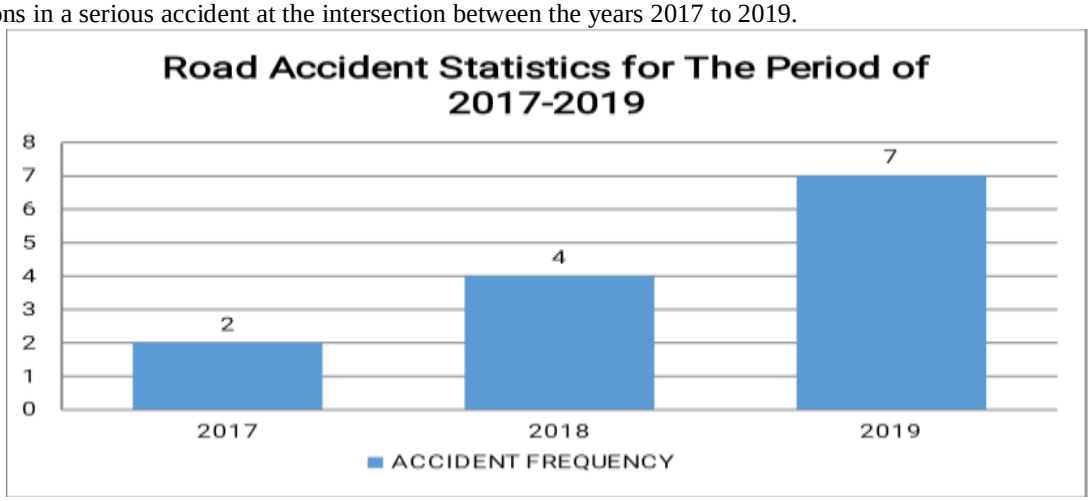

Figure 4.1.2: Bar chart showing the summary of accidents over the year from the bar chart above, the intersection experienced a low level of accident frequency as of the year 2017 and as the year progressed from 2018 to 2019 it increased from 4 to 7. This is due to the increase in vehicular movement as a result of increased migration of people and vehicles into the capital city, Uyo.

3.2TRAFFIC CONFLICTS RESULTING FROM THE INTERSECTION

The intersection under review is a signalized four arm at grade intersection with 4 lanes on 3 arms and 8-lanes on the other arm of the road. Using data collected from survey, the conflicts points resulting from this multi-lane highway is 54 on the as built-design (See Appendix 14) compared to the conventional 32 different types

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of conflicts points on a conventional four arm intersection with 4 lanes on each arm.

In any intersection, the usual scenario is that vehicles are coming from all direction. Vehicles, which are trying to make U-turn, are responsible for causing traffic congestion at the intersection. Again, vehicles making left or right turn can also be held responsible for causing congestion. For both cases, reason behind the congestion is slowing down of the vehicles. We can see that these are the two types of problem, which are directly responsible for causing congestion at the intersection.

Depending on these two facts, the flow pattern is divided into three groups. They are: Merging Flow, Diverging Flow and the crossing or intersecting Flow. Along with the vehicle movement, pedestrians also contribute to generating congestion. They are marked as the in direct but very important fact for traffic conflicts. Through the analysis of the study area, similar types of problem are identified that are responsible for creating bottlenecks at the intersection.

Table 4.2 shows the number of conflict point generated at the intersection. These conflicts are sub-divided into three groups; the crossing, the diverging and the merging conflicts as shown in the table below;

Table4.2Different Types and Number of Traffic Conflicts

TYPEOFCONFLICTS	NUMBEROFCONLICTPOINTS
Crossing	24
Merging	16
Diverging	16
TOTAL	56

Source: See Appendix 14–Existing Geometric Design showing traffic movements and conflicts generated at the Intersection.

Congestion at this location occur due to the vehicles that tend to travel to commercial locations mainly. Left turning and right turning movements occurs more acutely in this location, which is the seed of all congestion problems. This conflict points are identified and outlined as follows;

First one is at Oron Road where vehicles arriving from Nsikak Eduok Avenue (Arm-1) take left turn and enters Oron Road (Plaza, Arm-4). Second one occurs where vehicles from Arm-2 crosses the intersection and takes left turn to enter Arm-1. At the third point, vehicles from Oron Road (Arm-4) takes left turn and enters Edet Akpan Avenue (Arm-3) and its service lanes. The fourth point, vehicles arriving Arm-3 and its service lanes take left turn and enters Arm-2. Vehicles from Nsikak Eduok Avenue making right turn into Oron Road (Arm-3Plaza) via the inter section merges with the incoming vehicle flow from Edet Akpan Akpan Avenue (Arm-3) and vehicles moving straight towards Arm-2 from Arm-4. At the last point, vehicle flow from Arm-3 making right-turn en route Arm-1 merges with the flow from Arm-2 to Arm-3. For the crossing traffic movements, through vehicles from Arm-3, 1 meets with through vehicles from Arm 4, 2 and left turn movements from Arms 1, 2, 3 and 4. From the vehicle movement flow diagram in Appendix 14, the points where these flows intersect are clearly analyzed. The improved intersection design as shown in Appendix15, the number of traffic conflicts has been drastically reduced significantly to 8 conflict points with the introduction of a rotary of 16 mm radius and an island to divert traffic. The table below shows the different types and number of conflicts generating from the improved design of the intersection.

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Table 4. 3 Different Types and Number of Traffic Conflicts Generating from The Improved Design

TYPEOFCONFLICTS	NUMBEROFCONLICTPOINTS
Crossing	4
Merging	2
Diverging	2
TOTAL	8

IV. SUMMARY, CONCLUSION AND RECOMMENDATION SUMMARY

Based on the results of the research and, most especially, on the assessments of standards in the Highway Design Manual (Part1) in conjunction with the geometric design of the Edet Akpan/Oron Road intersection, there is a need to focus the safety evaluation on projects involving intersection or reduce the level of traffic conflicts and accidents. This section brings together some of the key findings and analysis from the study presented in the previous chapters based on the theory and aim of the research work and draws conclusion.

CONCLUSION, RECOMMENDATION:

To reduce the accident frequency and severity in effect solve the existing problem originating from the intersection understudy, the following are recommended from the study; (i) An alternative route or road on approach to the intersection on each arm or create new ones were non-existent. (ii) Extension of all right- turn radius. (iii) A round-about and a right-turn channelizing island on approaching the intersection should be provided on each arm to aid in right turn movements. (See Appendix15). (iv) Provision of a speed breaker (speed bumps) in each arm of the intersection at 500m away from the intersection at 100m intervals can safely maintain speeds of 15 - 20 miles per hour. (v) Provide traffic management techniques (Traffic signs and Road markings) at approach to the intersection. (vi) Introduction of a grade separated intersection by way of channelization (Flyover)–A diamond or clover leaf interchange. These interchanges have been used where one highway terminates at another i.e., for highways terminating at another highway, forming a four-way connection. This interchange allows vehicles to move on and off the ramp without any intersection interruption. These involve at least one loop ramp connecting traffic either entering or leaving the terminating expressway with the far lanes of the continuous highway. (vii) The improved design be used or implemented by the Akwa Ibom State Government and the Ministry of Works in a bid to reduce traffic and accident.

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