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### Improving the Effectiveness of Roundabout in Enugu State Nigeria ( A Case Study of Market Road/OKPARA Avenue )

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#### Abstracts

Current international research shows that improving the effectiveness of roundabouts improve vehicular and pedestrian safety compared to conventional intersections. However, their effects on pedestrian safety in the market road/Okpara Avenue Enugu can be proved. Complicating this problem is a scarcity of pedestrian accident data at roundabouts, especially at intersection locations that were reconstructed as roundabouts and could potentially provide accident statistics. This research seeks to examine the effectiveness of roundabouts by summarizing the vehicular and pedestrian safety.

#### Keywords:

#### Introduction

##### Background of the study

The continuous road congestion in Nigeria cities which started from the 1970's immediately after Udeoji award which enhanced household income and resulted to increased desired for both private and commercial vehicle ownership is intensity on daily basis. The daily movement of people in Nigeria cities is becoming more difficult and complex. This is reflected in the increasing bumper to bumper traffic being experienced in the major cities during the morning. (7:00am – 9:00am) and after (3:00Pm – 6:00pm) peak hours (Okpala, 2001). In some cases, such as in Market Road/Okpara Avenue in Enugu, some distributors and collectors continue to exhibit traffic congestion throughout the day from 8:00am – 9:00am. It is not uncommon for commuters to spend more than two hours enroute to work, market, hospital etc or back home even when to and fro distance is not much. However, the roundabout located around market road at different junctions has not been effectively mapped out for easy flow of traffic.

A roundabout is a type of circular intersection or junction in which road traffic is showed and flows almost continuously in one the various interesting roads. In a modern roundabout, entering traffic must always yield traffic already in the circle, and roundabouts have additional restrictions on the junction layout to give high safety. Elimination of the opportunity for the most deadly crashes at intersections (perpendicular crashes) is the greatest benefit of the roundabout design, pedestrians are routed away from the intersection to separate crosswalks location at least one full car length outside of the intersection, where they have a refuge between lanes

of traffic that is coming from one direction at atimes, and which is traveling slowly enough for visual engagement with drivers, encouraging difference towards the pedestrians. In view of the above the researcher has keen interest to study improving the effectiveness of roundabout in Enugu using Market Road/Okpara Avenue as a case study.

#### Statement of problem

According to Okpara (2001), the situation so common that it even appears that traffic hold-ups are becoming acceptable excuses for late attendance to work or even formal and informal meetings. The chaotic traffic situation in most of the junctions within the roundabouts in Market Road/Okpara Avenue has been causing people a lot of concern.

It shows that ineffective the roundabouts in the area are. It is posing formidable challenges to state governments and had braced the challenges by rehabilitating and developing most of the roundabouts route ways in Enugu city including the construction of new ones, yet traffic congestion is still quite common. If the Enugu state government has aggressively tackled the issue of the problems associated with roundabouts and improvement without an appreciable decrease in the rate of traffic congestion in Enugu City. It simply draws attention to the fact that there remain some germane issues that are yet to be addressed. Such germane issue relates to transportation planning which ought to proceed the present state government's actions the solution to traffic problems in Enugu city as well as in other Nigerian cities perhaps lies in proper transportation planning and management. However, improving the effectiveness of roundabouts.

This is so because an important phase in the planning processes is exhausting identification of factors militating against free flow of traffic along urban route ways.

Once this place is omitted or ignored, any adopted solution strategy may likely miss the target. This partly explains why the present state government efforts in Enugu to solve traffic flow problems in Enugu city appears not to be yield the expected results.

#### **Aims and objectives of the study**

This study aim at improving the effectiveness of roundabout in Enugu using Market Road/Okpara Avenue as a reference point. This study aims at providing this missing linking way of making good attempt at identifying the factors which are responsible for ineffective roundabouts and traffic problems in Enugu city. In order to do this, the following objectives are as follows:

1. To study the effectiveness of roundabout to traffic
2. To examine the effect of roundabout on vehicular safety and pedestrian safety
3. To identify special types of circular intersections
4. T examine the advantages of roundabouts

#### **Research questions**

1. Do roundabout ease traffic flow?
2. What effects to roundabouts have on vehicular safety and pedestrian safety?
3. What are the special types of circular intersections?
4. What are the advantages of roundabouts?

#### **Significance of the study**

The study will be of benefit to the government agencies that are in charge of town planning and road map. It will show the benefits derived from effective roundabout.

It will capture the attention of contemporary traffic engineers. While roundabouts are relatively common throughout the world, the Enugu state traffic engineers will presently turned to them as potentially safe, traffic claming roadway treatments.

The search for an enduring solution to the traffic problems will necessarily commence will in veil the factors responsible for such problems. This is what the study intends to do.

#### **Scope of the study**

The scope of this study revolves around improving the effectiveness of roundabouts in Enugu and it is limited to market Road/Okpara Avenue Enugu.

#### **Limitation of the study**

The limitation of this research work includes;

1. Time constraint: The availability time for carrying out this research work is highly limited. The short duration of time is not enough for a study of this kind.
2. Availability of relevant textbook and materials: The relevant textbooks and materials on the subject of study were difficult to obtain. Most of the library does not have textbooks or the subject of the study.
3. Attitude of the respondents was another major challenge, some refused to collect the questionnaires, while other did not answer some of the questions. Many of them have to be convinced that the questionnaires will be used for purely academic purpose before they cooperate.
4. The risk and transport cost involved during the research.

#### **Definition of terms**

1. **Round about:** This is a type of circular intersection or junction in which road traffic is slowed and flows almost continuously in one direction around a central Island to several exits onto the various intersecting roads.
2. **Effectiveness:** When something is said to be effective.
3. **Vehicular:** Consisting of vehicles
4. **Pedestrian:** A person walking along the road side and not using a vehicle.
5. **Location:** A place where a town exist
6. **Residence:** People living in an area
7. **Mobility:** People moving easily from one place to another.

#### **Brief history of roundabouts**

Numerous circular junctions existed before the advent of roundabouts, including the bath circus world heritage site completed in 1768, the 1907 place de l'Etoile around the Arc de Triomphe in Paris, the 1904 Columba's circle in Manhathan, and several circles within Washington, D. C, however, the operating and entry characteristics of these circles differs considerable from modern roundabouts. The first British circular junction was built in Letch worth Garden city in 1909. contrary to modern roundabouts, its centre originally was intended partly as a traffic Island for pedestrian.

According to British Broadcasting Corporation (BBC) News (2004), in the early twentieth century, numerous

traffic circle junctions were constructed in the United State, particularly in the North-East state, there are many instances of traffic circle in the U. S that predate the modern roundabout, such as the ones that can be found in Atherton, Carlifonia.

Although numerous circular junction existed before the advent of modern roundabouts, the widespread use of the modern roundabout began when transport research laboratory engineers re-engineered circular intersections during the 1960s and Frank Blackmore led the development of the offside priority rule and subsequently also invented the mini roundabout to overcome its limitations of capacity and for safety issues. The rule was adopted as mandatory in Britain for all new roundabouts in November 1966. unlike traffic circle, traffic approaching roundabouts is normally required to give priority to circulating and exiting traffic (this yield requirement has, however, been the law in the U. S state of New York since the 1920s) and to eliminate much of their drivers confusion associated with junctions that have traffic lights. Roughly the same size as signaled intersections with the same or sometimes a higher capacity, they separate incoming and outgoing traffic, sometimes with pedestrian Islands, to encourage slower and safer speeds.

As of the beginning of twenty-first century, roundabouts are in widespread use in Africa. For instance, in 2001 Nigeria had more than 10,000 roundabouts British Broadcasting Corporation (BBC) News (2004).

### **The effect of roundabouts on vehicular safety and pedestrian safety.**

The Enugu state situation is also complicated by the interest of architects and planners. Increasingly they propose using roundabouts as the centerpieces of pedestrian oriented new development and redevelopment of older neighborhoods, business corridors, and urban centers. Such locations typical have both high vehicular and pedestrian volumes and their interactions at roundabouts require careful consideration. Consequently, the effectiveness of roundabouts cannot be promoted solely on the basis of demonstrated safety improvements for vehicular traffic pedestrian safety at roundabouts.

#### ***Roundabouts and vehicular safety***

Roundabouts reduce vehicle speed, minimize vehicle and reduce conflict points to 8 according to the FHWA roundabout Guide (2000). The circulatory vehicle movements at roundabouts eliminate or drastically reduce the critical conflicts resulting from led light running, left turns against opposing traffic, right angle

conflicts at corners, and rear-end collisions. As a result roundabouts significantly reduce vehicular crashes.

According to Persaud (2000), modern roundabouts are safer than other methods of intersection traffic control. After examining 24 intersection that were converted to roundabouts in eight states in a variety of urban, suburban and rural settings, he concluded that roundabouts reduced all vehicular crashed by 39 percent and injury crashed by 76 percent.

He estimated reductions in the numbers of fatal and incapacitating injury crashed to be about 90 percent. Other U. S. investigators have found similarly promising results Garder (1997) vehicular safety improvements area also reported by the international literature. As a result of the documented reductions in vehicle crashes and injuries at roundabouts compared to conventional intersections in similar settings, some professionals strongly promote roundabouts as effective safety treatments for interactions.

#### ***Roundabouts and pedestrian safety***

What professional discussion lack, however, are definitive statistics for pedestrian safety at roundabouts in Enugu state. Indeed, the magnitude of the problem remains undefined, though appreciated. Subsequently in mid 2001 NCHRP announced the project applying roundabouts in the United States (NCHRP, 2001). A major effort to apply data and results from international sources to U. S drivers, pedestrians and the highway environment. For example, a typical roundabout reference likes the FHWA Roundabout Design Guide (2000) gives explicit vehicular crash reduction statistics that are similar to those by Persaud (2000). Yet, the Guide has no such data for pedestrians. The consultant for the Guide relies on the indirect surrogate measure of speed. The consultant presents information showing that at the lower 20mph speed of most roundabouts, the chances of a pedestrian being killed if hit by a vehicle is 15%. On the other hand, at conventional intersections where the speeds are typically 30 to 40mph the chances of being killed if hit by a vehicle range from 45% to 85% (figure 2.2). Persaud reports that for his 24 case study intersections the pedestrian crash sample was too small to estimate safety effects. An Australian study and a Scandinavian study, however, report that roundabouts are safe for pedestrians. The Swedish Road Administration commissioned VTI (Swedish – National Road & Transport Research Institute) to study accident and injury risks at roundabouts with different layouts in different traffic environments.

The limited amount of market road pedestrian safety data may be explained by the relative infrequency of pedestrian – vehicle crashes compared to vehicle-vehicle crashed. For example, this studies show that the heavily

traveled market road near Holy Ghost Cathedral and Main Market (Ogbete) has an average of about seven pedestrian crashed annually compared to about 300 vehicles crashed. The panicky of pedestrian safety data may also be explained by documented intersection being located where little pedestrian activity occurs.

Furthermore, unconventional intersections like roundabouts do not have easily identifiable categories in accident reports. Hence what that may exist cannot be identified in Enugu state accident databases.

But there in lies the quandary. Relatively little pedestrian data exist compared to vehicle crash data; even less pedestrian crash data exists for roundabouts treatments. Yet, roundabouts are often proposed for traffic calming in high pedestrian areas like Market Road/Okpara Avenue. Similar high activity, pedestrian – oriented roundabout sites are in Otigba junction, Ogui junction and Abakpa junction, yet, they are relatively new and there is little or no history of pedestrian accidents. However, some advocates for roundabouts points to the scarcity of pedestrian accident data as evidence of their efficacy as a safety treatment. In any event, there is a need to obtain more information about how roundabouts affect pedestrian safety. By doing so, the intent is to clarify pedestrian safety issues at roundabouts. Subsequently in 2001, TRB similarly recognized the need for more pedestrian safety information at roundabouts Lang. J. (2000).

### Modern roundabouts

The modern roundabout is a type of intersection that indirectly provides traffic control without the use of stop signs or traffic signals. These roundabouts, if properly designed, can provide safety and traffic flow benefits when compared to stop controlled and signal controlled intersections. Due to the safety and operational benefits that roundabouts provide, they have become increasingly popular in Nigeria in recent years. This increase in roundabout construction has prompted an increase in research regarding roundabouts effectiveness and how they affect the various aspects of transportation system.

In another development a “modern roundabout” is a type of circular junction that was development by the United Kingdom Transport Research Laboratory in the mid-twentieth century according to (Wikipedia), in which road traffic must travel in one direction around a central Island and priority is given to the circulating flow. Signs usually direct traffic entering the circle to slow down and to yield that right of way, the centre of a modern roundabout provides a visual barrier across the

intersection to the drivers entering it. This functions to assist the drivers into focusing only on the traffic coming toward them in the path of the circle (right in clockwise flow of traffic, and left in anti-clockwise flow).

This significantly reduces the conflicts of concern encountered at conventional intersections. When drivers can see across a roundabout, if there are other vehicles in any other part of the devices, drivers tend to stop outside the roundabout rather than merging, awaiting for the vehicles (even on the opposite side) to come around to pass them. This interferes with the flow of traffic through the intersection, where many vehicles should be able to circulate in the roundabouts at the same time. The high barrier may be a landscape mound, a raised wall, or thickly planted very tall Shrubs. Flag poles at the top of a landscaped mound in a roundabout are popular items.

In Enugu state roundabouts are used in some areas for monuments, the display of range public art, and in a few, for a fountain, but caution must be exercised for these in case the feature might attract pedestrians into the intersection, which is very dangerous. Any lightly should focus carefully on the centre, but not shine out from the feature might attract pedestrians into the intersection, which is very dangerous. Any lightly should focus carefully on the centre, but not shine out from the feature in the centre of the circle into the eyes of oncoming drivers. Including light-coloured and variegated plants and a good proportion of white flowered plants among those chosen for landscaping makes the mound visible at a greater distance for drivers, especially to those roundabouts without lighting.

Statistically, roundabouts are safe for drivers and pedestrians than both traffic circles and traditional intersections. Because low speeds are required for traffic entering roundabouts they usually are not used on controlled access highways, but may be used on lower grades of highway such as limited access roads. When such roads are redesigned to take advantage of roundabout principles, steps are taken to reduce the speed of traffic, such as curving the approached sometimes the flow through the roundabout exceeds the level anticipated.

### Operational characteristics of roundabouts

The research conducted in the NCHRP report 572 analyzed the delay experienced by roundabouts and compared it to the delay experienced by signalized intersections with similar turning volumes. The results were that when at signal warrant volume thresholds, as



defined in the MUTCD, the roundabouts intersection experiences approximately 12 seconds less overall delay, than the signalized intersection (roundabout Guide, Wisconsin department of transportation, 2011), with roundabouts being a relating new intersection type in Enugu state; they may not be operating as efficiently as they are capable of because of driver unfamiliarity. As drivers become more accustomed to how roundabouts operate, the operations of the roundabout will continue to improve.

Recent research has showed that roundabouts contain benefits and concerns in the aspect of traffic and pedestrian operations. The NCHRP report 672 provided general information for a planning level, operational comparison of control modes:

- A roundabout will always provide a higher capacity and lower delays than all-way stop control (AWSC) operating with the same traffic volumes.
- A roundabouts is unlikely to offer better performance in terms of lower overall delays than two way stop control (TWSC) at intersections with minor movements (including cross street entry and major street left turns)

that are hot experiencing, nor predicted to experienced, operational problems under TWSC.

- A single lane roundabout may be assumed to operate within its capacity at any intersection that does not exceed the peak hour volume warrant for signals.
- A roundabouts that operates within its capacity will generally produce lower delays than a signalized intersection operating with the same traffic volumes. One common concern with roundabouts is capacity. A roundabout's capacity is based on its geometry (i.e. number of entering lanes, diameter, entry angle, land width, etc) and its peak hour traffic volume and turning patterns. The MDOT roundabout Guidance Document, November 2007 provides approximate maximum capacities for various types of roundabouts. It is also noted in the MDOT roundabout Guidance Document that the table is only a general guide and there is no substitute for an intersection specific capacity analysis.

| TYPES OF ROUNDABOUT | APPROXIMATE PEAK HOUR CAPACITY (COMBINED CUTTERING VOLUME FOR ALL APPROACHED) |
|---------------------|---|
| Single lane         | Up to 7,000 vehicle per hour  |
| Two lane            | Up to 4,000 vehicle per hour  |
| Three lane          | Up to 7,000 vehicle per hour  |

*Table 2.1: Approximate peak hour capacity for roundabouts.*

The wiseDot Roundabout Guide (February in transportation, 2011) outlines typical daily service Roundabout Guide. Wisconsin Department of volumes for various roundabout types.

| TYPES OF ROUNDABOUT                 | TYPICAL DAILY SERVICE VOLUMES (VPD) 4, LEG ROUNDABOUTS |
|-------------------------------------|--|
| Urban single lane                   | Less than 25,000                                       |
| Urban multilane (2 lane entry)      | 25,000 to 55,000                                       |
| Urban multilane (3 or 4 lane entry) | 55,000 to 80,000                                       |
| Rural single lane                   | Less than 25,000                                       |
| Rural multilane (2 lane entry)      | 25,000 to 55,000                                       |
| Rural multilane (3 lane entry)      | 55,000 to 70,000                                       |

*Table 2.2: Typical daily service volumes for 4 leg roundabouts.*

Note: Capacities vary substantially depending on entering traffic volumes and turning movements.

Roundabout capacity can be analyzed using many different models. The model that is used by both MDOT and WisDOT is the empirical formula method.

The RODEL and ARCADY software programs are typically used in determining roundabouts optimized conditions for the various traffic characteristics. The

RODEL and ARCADY software packages allow for the design to be optimized rather than allowing for the minimum criteria to be met in order to satisfy the capacity and delay criteria ULF, B and L, Jorgen (1999).

**Advantages of roundabout**

Below are some advantages of an effective roundabout;

- Roundabouts are safer than signal controlled junctions and at a slight angle instead of right-angle or rear end collisions at junctions.
- Roundabouts allow U-turns within the normal flow of traffic, which often are not possible at other form of junction.
- In general, roundabouts substantially reduce congestion, delays and pollution as vehicles are not required to perform a complete stop.
- Compared to intersection, roundabouts operate more efficiently and thus reduce delays and congestion as they are not at the whim of an artistically induced delay by traffic signals. Efficiency is gained by a direct response from the driver to the traffic conditions without any restrictions set by traffic signals, i.e. drivers may proceed when traffic is clear without the delay incurred by a traffic signal.
- The mound of land inside a roundabout may be used for monument, civic art, or landscaping, thus contributing to the urban environment while at the same time solving a traffic problem features that might encourage pedestrians to cross the circulating road way in order to approach whatever is in the centre of the circle should be avoided completely, however, as pedestrians should not be on the central Island at anytime.

**Research methodology**

This is a descriptive concerned with the collection, presentation, analysis and interpretation of data for the purpose of deciding vividly the prevailing study on improving the effectiveness of roundabouts in Enugu. To effectively carryout this work carefully deliberations was made from different data generating sources aimed at efficient collection and collation of relevant data from various sources so as to form the basis for the establishment of my findings.

**Research design**

**Sample size and sample technology**

A sample is the specimen of the real population, a sample from the population is obtained a qualitative study. The opinion of the sample chosen would be equal random sampling technique was used to give every respondent equal chance of being selected.

$$n = \frac{N}{1 + N(e)^2}$$

When  $n = \text{sample size}$

- N = population
- E = margin of error (5%)
- I = constant (k)
- n = 200

$$E = 0.05$$

$$1 = 1$$

$$n = 200$$

$$= \frac{1 + 200(0.05)^2}{200}$$

$$= \frac{1 + 200 \times 0.0025}{200}$$

$$= \frac{1 + 0.05}{200}$$

$$= \frac{1.5}{200} = 133$$

Yaro Yamane formular

**Sources of data**

In order to obtain as much information as possible for successful completion of this research work, two main generating sources were used.

Primary and secondary sources.

**Primary sources:** under these sources, questionnaires were distributed to practicing urban and regional planners, drivers and pedestrians. The researcher also conducted oral interviews with some private surveyors to ascertain their practical opinions findings and recommendations on the provisions of improving the effectiveness of roundabouts.

**Secondary sources:** they are, the data obtained from libraries, published and unpublished text books, journals, estate gazette and the internet, also materials from the Nigeria urban and regional planning law (Decree No 88 of 1992) document from government department like ministry of land survey and urban planning (MLSUP) and Enugu urban department authority(EDA).

**Instrument of data collection**

In collecting the data for this study, the use of questionnaires was design in there parts, namely. Those distributed to Enugu urban development authority (EDA), those distributed to some drivers and pedestrian within the case study.

**Method of data presentation and analysis**

The method adopted for data collection was the use of questionnaire distributed to the study area, oral interview and personal observations and analyzed by the use of frequency distribution tables and percentage and statistical charts.

**Data presentation and analysis**

**Data presentation**

This chapter focused on the presentation and interpretation of data collected. The data collected emphasized objectively on the questionnaires administered.

A total of 133 questionnaire were distributed 100 were returned. The table shows clearly how the questionnaire was distributed to agencies, drivers and pedestrian staffs of the various planning and development control bodies are grouped as staff of agencies.

**Table 1**

| Groups                 | No. issued | No. returned | % Response |
|------------------------|------------|--------------|------------|
| Drivers                | 80         | 52           | 54.9%      |
| Pedestrian             | 30         | 25           | 24.8%      |
| Control agencies staff | 23         | 23           | 20.3%      |
| Total                  | 133        | 100          | 100%       |

Sources: Field Survey 2013

**Analysis of the questionnaire response**

Respondent to my questionnaire form the mass of data (information) as property tabulated and analyzed in the result.

The statistical technology employed here allow for easy distribution of data.

**Result**

Table 1-3 showed the demographic characteristic of the respondents that formed the study sample.

**Table 2: Sex of respondents**

| Sex    | Frequency | Percentage |
|--------|-----------|------------|
| Male   | 70        | 70%        |
| Female | 30        | 30%        |
| Total  | 100       | 100%       |

Sources: Field Survey 2013

Table 2 showed that 70% of the respondents are male while 30% of them are female.

**Table 3: Age of respondents**

| Age         | Frequency | Percentage |
|-------------|-----------|------------|
| 18-27yrs    | 10        | 10%        |
| 28-39yrs    | 30        | 30.0%      |
| Above 39yrs | 60        | 60.0%      |
| total       | 100       | 100%       |

Sources: Field Survey 2013

Table 3 showed that 10% of the respondents fell within the age group of 18-27yrs, 30% fell within the age group of 28-29yrs and 60% are above 39yrs

**Table 4: Occupational status of respondents (drivers and pedestrian)**

| Occupational status    | Frequency | Percentage |
|------------------------|-----------|------------|
| Civil servant          | 30        | 42.5%      |
| Trader/artisan/drivers | 50        | 32.5%      |
| Others e.g. student    | 20        | 25%        |

|       |     |      |
|-------|-----|------|
| total | 100 | 100% |
|-------|-----|------|

Sources: Field Survey 2013

Table 4 showed that 30% of the respondents are civil servant, 50% are traders/artisans/drivers and 20% of them are students.

**Question1:**

Do the effectiveness of roundabout impact easy to flow of traffic?

**Table 5:**

| Options | Frequency | Percentage |
|---------|-----------|------------|
| Yes     | 100       | 10%        |
| No      | -         | -          |
| Total   | 100       | 10%        |

Sources: Field Survey 2013

The table above shows that the entire respondent said yes that an effective roundabouts impact easy flow of traffic.

**Question 2**

Would roundabouts contribute to pedestrian safety?

**Table 6:**

| Option   | Frequency | Percentage |
|----------|-----------|------------|
| Agree    | 70        | 70%        |
| Disagree | 30        | 30%        |
| Total    | 100       | 100%       |

Sources: Field Survey 2013

From the table above it is shown that 70% of the respondents agreed that roundabout would contribute to pedestrian safety and 30% disagree to it.

**Question 3:**

Roundabout does contribute to safety of vehicles in the area?

**Table 7:**

| Age   | Frequency | Percentage |
|-------|-----------|------------|
| Yes   | 60        | 60%        |
| No    | 40        | 40%        |
| Total | 100       | 100%       |

Sources: Field Survey 2013

From respondents said 60% yes that roundabouts do contribute to the safety of vehicles in the area, while 40% of the respondents said no.

**Question 4:**

Do you think roundabouts have any significance advantage in market road/Okpara Avenue to agencies, drivers and pedestrian?

**Table 8:**

| Age   | Frequency | Percentage |
|-------|-----------|------------|
| Yes   | 50        | 50%        |
| No    | 50        | 50%        |
| Total | 100       | 100%       |

Sources: Field Survey 2013

From table 8 it was shown that 50% of the respondents said yes and no respondent.

### Summary of findings, recommendations and conclusion

#### Summary of findings

In the findings of the research work, it was observed that more drivers ply market road than any other group of people that pass through the road. Also it was found that traders, artisan and drivers were the common group of people that made use of the road. Finally, it was shown that effective roundabouts do contribute to vehicles and pedestrian safety.

#### Recommendations

A primary objective of future work should be to develop a broader and better pedestrian accident database for roundabout. As roundabouts replace signalized and unsignalized intersections in Market Road/Okpara Avenue Enugu .

Accident data base before and after the reconstruction should be collected and evaluated. This will be a long term study because of the relative infrequency of pedestrian accidents. The Enugu data base should be complemented by appropriate international data. And new terminology and methods appropriate to roundabouts need to be developed for accident reports prepared by policemen.

The stimulations developed in this project is a first step toward operational and design of roundabouts much like simulation is used to plan and design conventional intersections. In that regard appropriate simulation packages need to be indentified and procedures standardized to ensure consistent design practice across Enugu. In evaluations the concept of maximum pedestrian capacity should be further developed as a surrogate for safety, and the effects of pedestrian queues and wait times need to be added.

#### Conclusion

Results of this study indicate that converting signalized intersections to modern roundabouts may reduce pedestrian vehicle crashes and conflicts according to available literature and three independent approached. The literature suggests that lower speeds and fewer conflict points of roundabouts are the primary contributors to the safety increase. The simulation for this research shows that if traffic diversion occurs than the conventional intersection it replaced. It can also produce a reduction in pedestrian accidents, at least in terms of measured pedestrian capacity, a surrogate for safety. In particular for typical pedestrian reaction times

and welling speeds, when a 30% traffic diversion occurs, a single lane roundabout can handle more pedestrians more safely than a four lane signalized intersection.

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