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THE RELATIONSHIP BETWEEN ARCHITECTURAL DESING AND URBAN ROAD TRAFFIC CONGESTION IN ENUGU, NIGERIA.

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ABSTRACT

The interaction between urban architecture and urban transportation cannot be overemphasized in attaining functionality of the urban system. There is a seeming connect between urban road traffic congestion and urban architecture especially in most cities like Enugu. The National Transport Document, (NTD, 2010) as in the National Economic Empowerment and Development Strategy (NEEDS) framework to be driven by the private-sector and with the fundamental objective of developing an adequate, safe, environmentally sound and efficient transport system in the context of a progressive and competitive market economy. This study therefore aims to determine the relationship between architectural design and urban traffic congestion with a view to enhancing transportation architecture using the case of Enugu metropolis. The study utilized a survey design method. Primary and secondary data were collected and analyzed. A sample size of 400 respondents comprised of Architects. The findings identified prominent areas of traffic congestion to include the Okpara Avenue axis, Ogbete Main Market area, Old Park area, Agbani Road axis, Keyantta area, coal camp area and Abakpa area. Findings showed that the neglect of various architectural design considerations in the urban design of Enugu city has a relationship with the perennial traffic congestion in the city. This was also agreed to by 100% of the respondents who further lamented delay in travel time, difficulty in transportation and

stress in their movement from one part of the city to the other. The identified prominent areas of perennial traffic congestion were observed at 100% response rate to have concentration of various transport companies. The study therefore recommended for transportation architecture and the adoption of architectural design considerations in the urban transportation design in Enugu metropolis and beyond.

1.0 INTRODUCTION

The National Economic Empowerment and Development Strategy (NEEDS) framework constitutes a transport development strategy that is private-sector driven, providing an environment capable of addressing the issues of wealth creation, employment generation and poverty reduction. This overarching strategy formed the basis of the fundamental objective of the country's National Transport Policy which is to develop an adequate, safe, environmentally sound and efficient transport system in the context of a progressive and competitive market economy (The Draft National Transport Document, 2010). According to the national transport policy document, the transport sector would take advantage of the private sector initiative to do the following: Improve efficiency of operatives and management of transport parastatals, achieve the desired reduction in the cost of providing transport services, facilitate further development in the nation's transport infrastructure, eliminate congestion both in the intercity and intra-city traffic flows, encourage the emergence of Nigeria as a transport hub for West and Central Africa Sub-region (Abdulkareem, 2009; Adesina, 1987; Ahukannah, Ndinaechi & Arukwu, 2003; Ajiboye & Afolayan, 2009; Botha and Filani, 2006; Carapetis, Beenhakker & Howe, 1984; Adler, 1999; Ighodaro, 2008; Mallon, 1960; Muktar, 2011; Onakomaiya, 1980).

1.1 Impact of Road Transportation on Local Economic Development in Nigeria

The Nigerian economy is a developing one. The inter-connection between her road transport system and her local economy has long been recognized as it has impacted her severally. The process of development requires goods, services and people to be moved for one reason or the other and from one place to another. As the people move, they help to generate economic activity which enhances economic development. This assertion is justified by Ighodaro (2008) who affirmed that the potential significance of road development for investment, trade, growth and poverty alleviation has long been recognized. Not only does road transport infrastructure facilitate the direct provision of services to consumers, it also provides intermediate inputs that enter into the production of other sectors and raise factor productivity. This is exemplified by the opening of many residential areas across the nation as a result of road construction or improvement.

Road transport services facilitate and help to maintain an economic balance through the distribution of resources (such as labour, equipment and raw materials) and finished goods across the nation. According to Carapetis et al (1984), adequate, reliable and economic transport is essential for the social and economic development of rural areas especially in developing world. They further noted that the absence of regular and reliable transport services condemns remote communities to subsistence production in perpetuity. Moreover, Mallon (1960) argues that transportation has an important role to play not only in serving the productive sectors such as agriculture and industry but also in bringing about economic growth. He points out that it was no coincidence that the period of intensive railway construction in Britain, the USA, Pre-Soviet Russian, Italy and other countries were also their periods of most rapid economic development.

Unlike other means of transport such as rail (train), water (ship) and air (airplane), the flexible nature of road transportation facilities opens up remote and rural areas, making them more and easily accessible, thereby stimulating economic growth. The items of trade (whether raw materials or manufactured goods) need to be moved from the areas where they are produced to the area where they are demanded. Farm products are usually produced in the rural areas and traded in the cities. Where there is a good transport link between the

producing areas and the market, the prices of products are reduced. Otherwise, they become expensive and middlemen usually capitalize on the poor transportation to inflate prices of agricultural products to the urban markets (Ahukannah et al, 2003). This advantage extends to delivery of goods to the door-step of consumers. An efficient transport system lowers the cost and reduces the time of moving goods and service to where they can be used more efficiently. Since roads penetrate more into such areas (with relative greater flexibility) their development adds value and spurs growth. Overtime, this process has resulted in increasing the size of market which is a pre-condition for realizing economies of scale. Good road projects have clearly contributed to poverty reduction in the country by improving the living conditions of people and by augmenting the opportunities available for trade and employment. The economic development of Nigeria has reflected the development of her transport systems. This is particularly true of the road transport system, which is by far the most widely used mode of transport in the country. Of all commodity movements to and from the sea-ports, at least two thirds are now handled by road transport while up to 90% of all other internal movement of goods and persons take place by roads (Onakomaiya, 1980).

In a study on the impact of transportation on agricultural production in a developing country which focuses on kolanut production in Nigeria, it was revealed that an improved transportation will among other things have positive impact on farmers' productivity, income, employment and reduce poverty level in the rural areas (Ajiboye and Afolayan, 2009). Transport infrastructure is critical to sustain economic growth because people want to improve their standard of living and they see increased income as the way to achieve that goal. Transportation system enhancement is in turn a means of maintaining or improving economic opportunities, quality of life and ultimately income for people in a particular region. Investment in transport infrastructure is critical to sustain economic growth. Mobility studies show that transportation is absolutely essential to economic productivity and remain competitive in the global economy. An international study found that for every 10 percent increase in travel speed, labour market expands by 15 percent and productivity by 3 percent.

It is universally recognized that road transport is critical for sustained economic growth and modernization of a nation. Adequacy of this vital infrastructure, Muktar (2011) reiterates, is an important determinant of the success of a nation's effort in diversifying its production base, expanding trade and linking together resources and markets into an integrated economy. It is also necessary for connecting villages with towns and market centres and in bringing together remote and developed regions closer to one another. Road transport, therefore, forms a key input for production processes and adequate provision of transport infrastructure and service helps in increasing productivity and towering production costs in Nigeria. The provision of road transport infrastructure and services helps in reducing poverty. It needs no emphasis that various public actions aimed at reducing poverty cannot be successful without adequate road transport infrastructure and service. It is difficult to visualize meeting the country's targets of universal basic education and health care without first providing adequate transport facilities.

2.0 EXISTING TRANSPORT SITUATIONS AND CHALLENGES IN NIGERIA

Road transport is the dominant mode of transportation in Nigeria. It also presents the most complex situation in that the body that is responsible for the provision of the supporting infrastructure including the roads/highways- is not responsible for road transport operations, or the regulation of road transport. We should therefore distinguish between the road network and transport operators who use the network. Road transport operation is largely in the private sector. Its growth has, however, been encouraged through what is relatively a massive investment program on roads compared to investment in railways and inland waterways. It can therefore be argued that the road sector has taken advantage of the government's relative neglect of the other modes of transport to gain a competitive edge

in the market. As a result of the predominance of road transport, Nigeria's transport system is clearly imbalanced. Over 90 percent of internal goods and passengers are moved by road. Current transport operations are characterized by large-scale movements of goods and passengers that could have been moved more cost effectively by other modes, such as railways and inland waterways. The predominance of truck transportation accounts for the excessive damage of the road infrastructure and the attendant cost imposition on the economy, estimated recently in the order of 21 billion Naira or USD 156 million at 2008 prices, by BPE Report on Axle Load Study of Nigeria (BPE, 2008).

Some transport corridors are very heavily travelled, showing patterns of linkages that are strategic to planning and investments within the sector. Such corridors include:

1. Lagos - Ibadan/Lagos – Shagamu
2. Lagos – Ibadan – Kaduna - Kano
3. Port Harcourt – Aba – Abuja – Kaduna - Kano
4. Lagos – Shagamu - Benin city
5. Lagos - Onitsha
6. Port Harcourt – Aba - Enugu
7. Kano – Maiduguri - Ngala.

According to Botha and Filani (2005), one of the major problems associated with the overreliance on road transport in Nigeria is illustrated by the dominant role played by the Lagos ports in Nigeria's foreign trade. Most of Nigeria's traffic still originates in Lagos as Lagos accounts for almost 90 percent of containerized cargo through put (441,040TEU). Also, about 60 percent of general dry and liquid cargoes are handled in Lagos. This accounts for the current congestion costs which are a significant burden on the economy of the nation. Average port calls are still longer for Lagos compared to other West African ports. The response of shipping lines is to impose steep congestion charges on all cargoes destined for Lagos (about $660/TEU at 2005 prices). Additional charges are imposed on cargoes destined for Apapa (about $ 108 at 2005 prices); with the result that port charges are over 35 percent higher in the Lagos port complex than those of other West African states.

Other problems associated with the overconcentration on road transport include:

1. Misallocation of bulk traffic which could have been carried by rail and inland waterways.
2. Low safety levels and poor service quality provision.
3. Lack of regulation of the industry
4. A proliferation of enforcement agencies.

In particular, the lack of axle load regulation seriously affects the ability of the railways to compete with road transport. It also contributes to road pavement damage in the country. Indeed, the BPE Axle Load Study showed that 51.9% of the vehicles studied were overloaded and the average percentage overload per axle was 48.8 for the 5,563km of the Federal Roads included in the study (Abdulkareem, 2009; Adesina, 1987; Ahukannah, Ndinaechi & Arukwu, 2003; Ajiboye & Afolayan, 2009; Botha and Filani, 2006; Carapetis, Beenhakker & Howe, 1984; Adler, 1999; Ighodaro, 2008; Mallon, 1960; Muktar, 2011; Onakomaiya, 1980). These are shown in Table 1.

Heavy Vehicle Class	% Vehicle O/L	Average % O/L per axle
2 Axle	30.7	36.1
3 Axle	61.7	57.4
4 Axle	58.9	51.1
5 Axle	53.6	46.8
6 & more Axle	46.7	35.4
Total	51.9	48.8

Source: BPE Axle load study, 2008

In view of the cost to the economy due to truck transportation and excessive axle loads, efforts must be made to actualize the road sector reforms, which will regulate the sector, revitalize rail links, and improve rail performance and logistics in the transport sector.

3.0 THE STUDY AREA

"Infrastructure Enugu, usually referred to as Enugu State to distinguish it from the city of Enugu, is a state in south-eastern Nigeria. Its capital is Enugu, from which the state - created in 1991 from the old Anambra State - derives its name. The principal cities in the state are Enugu, Agbani, Awgu, Udi, Oji-River, and Nsukka.

Plate 3.1: Map of Nigeria showing Enugu State and neighborings states Source: http://www.blacknaija.com/enugu

Enugu State is one of the states in the eastern part of Nigeria. The state shares borders with Abia State and Imo State to the south, Ebonyi State to the east, Benue State to the northeast, Kogi State to the northwest and Anambra State to the west. Enugu, the capital city of Enugu State, is approximately 2½ driving hours away from Port Harcourt, where coal shipments exited Nigeria. Enugu is also located within an hour's drive from Onitsha, one of the biggest commercial cities in Africa and two hours' drive from Aba, another very large commercial city, both of which are trading centres in Nigeria.

3.1 LOCATION

Enugu State consists of 17 Local Government Areas, among which Enugu-East is one of them. Economically, the state is predominantly rural and agrarian, with a substantial proportion of its working population engaged in farming, although trading (18.8%) and services (12.9%) are also important. In the urban areas trading is the dominant occupation, followed by services. A small proportion of the population is also engaged in manufacturing activities, with the most pronounced among them located in Enugu, Oji, Ohebedim and Nsukka. The state boasts of a number of markets especially at each of the divisional headquarters, prominent of which is the Ogbete Main market in the State capital, Enugu.

The site will be located opposite Naira Triangle along Abakaliki Express Road, Emene, in Enugu East Local Government Area.

3.2 CLIMATIC CONDITIONS

The average temperature in this city is cooler to mild (60 degrees Fahrenheit) in its cooler months and gets warmer to hot in its warmer months (upper 80 degrees Fahrenheit) and very good for outdoor activities with family and friends or just for personal leisure.

Enugu has good soil-land and climatic conditions all year round, sitting at about 223 metres (732 ft) above sea level, and the soil is well drained during its rainy seasons. The mean temperature in Enugu State in the hottest month of February is about 87.16 °F (30.64 °C), while the lowest temperatures occur in the month of December, reaching 60.54 °F (15.86 °C). The lowest rainfall of about 0.16 cubic centimetres (0.0098 cu in) is normal in February, while the highest is about 35.7 cubic centimetres (2.18 cu in) in September.

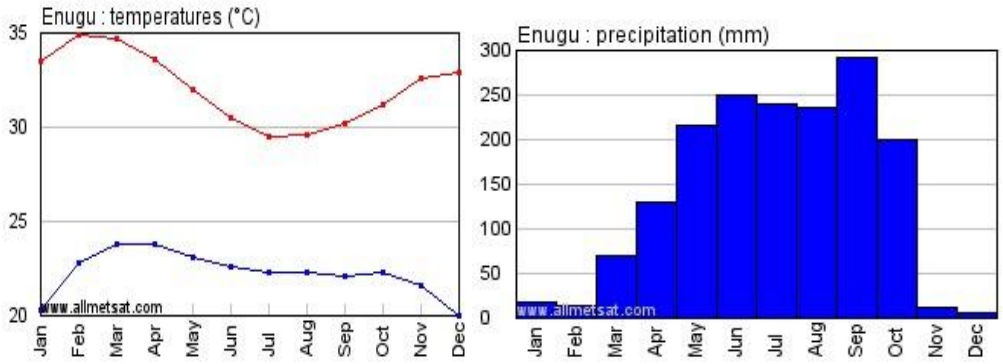

Figure 3.1: Average Temperature and Precipitation in Enugu State

Source: http://www.eldoradocountyweather.com/climate/africa/nigeria/Enugu.html

4.0 METHODOLOGY

The study adopted a survey design approach. A sample size of 400 was determined with the Yamane (1967) formula. Respondents for the study were selected Architects across the 18-formal urban medium, low and high neighbourhoods of the city. Thematic and content analysis was used in the analysis.

5.0 FINDINGS

The findings identified prominent areas of traffic congestion including the Okpara Avenue axis, the Ogbete Main Market area, the Old Park area as well as the Agbani Road axis. The study found that the neglect of various architectural design considerations in the urban design of Enugu city has a relationship with the perennial traffic congestion in the city. This was also agreed to by 100% of the respondents who further lamented delay in travel time, difficulty in transportation and stress in their movement from one part of the city to the other. Incidentally, the identified prominent areas of perennial traffic congestion were the areas observed at 100% response rate to have concentration of various transport companies within a particular part of the city and these areas happens to be the city centre.

6.0 RECOMMENDATION AND CONCLUSION

6.1 RECOMMENDATION

The study therefore recommended for the adoption of architectural design considerations in the urban transportation design in Enugu metropolis and in all other cities of the world. The National Economic Empowerment and Development Strategy (NEEDS) framework constitutes a transport development strategy that is private-sector driven, providing an environment capable of addressing the issues of wealth creation, employment generation and poverty reduction. This overarching strategy formed the basis of the fundamental objective of the country's National Transport Policy which is to develop an adequate, safe, environmentally sound and efficient transport system in the context of a progressive and competitive market economy (The Draft National Transport Document, 2010).

According to the national transport policy document, the transport sector would take advantage of the private sector initiative to do the following: Improve efficiency of operatives and management of transport parastatals, achieve the desired reduction in the cost of providing transport services, facilitate further development in the nation's transport infrastructure, eliminate congestion both in the intercity and intra-city traffic flows, encourage the emergence of Nigeria as a transport hub for West and Central Africa Sub-region.

The National Transport Policy was an attempt to document a transport policy of government in one publication which contains policy statements, objectives and possible implementation strategies. The existing transport policy document was written in 1993; it has been revised twice since then, and the current version is awaiting legislation. The policy covers all modes, but it is not clear whether it should supersede all other existing transport related policy statements, for example, the ones on aviation, and on a separate shipping policy associated with the National Maritime Authority and Safety Agency (NIMASA). There is therefore the need for utmost application of transportation architecture hence the recommendation for the adoption of architectural design considerations in the urban transportation design in Enugu metropolis and in all other cities of the world. The application of various

architectural design in urban traffic and transportation are hereby demonstrated.

6.2 DESIGN CONSIDERATIONS TO ENHANCE SECURITY

To ensure passengers' security within the facility and while using the facility, design strategies were adopted ((Abdulkareem, 2009; Adesina, 1987; Ahukannah, Ndinaechi & Arukwu, 2003; Ajiboye & Afolayan, 2009; Botha and Filani, 2006; Carapetis, Beenhakker & Howe, 1984; Adler, 1999; Ighodaro, 2008; Mallon, 1960; Muktar, 2011; Onakomaiya, 1980). Such design strategies were discussed in the follow.

I. **Ingress and Egress to site:** To ensure checked access in and out of the site, only one entrance gate and one exit gate would be provided for in the design.

II. **Zoning:** Appropriate zoning of facilities and activities would be employed. This is primarily to ensure that restricted zones are clearly separated from public zones.

III. **Security post:** Security post would be made available at every strategic entrance or exit to both the site and other terminal facilities. These security posts are to be sufficiently equipped with CCTV. Surveillance with cameras at strategic positions all over the facility.

ROADWAY WIDTHS: These have great influence on the safety and comfort of driving. Between three. (3) metres to four (4) metres wide lanes will suffice for 2.5 metres wide buses. These are standard lane widths and the tendency is to adopt the larger value with the continued upward trend in traffic volumes, vehicle speed, etc. Lane widths narrower than 3 metres can adversely affect capacity and safety of vehicles and passengers, so their use should be limited to high-speed, high-volume facilities. Double/triple lane (6-10m) wide runways have a greater advantage over single-lane runways in that it provides for a chance where any standing buses could be overtaken by oncoming buses. This enhances flexibility of operation in the entire road system and landscape.

In a situation where the loading berth is designed in such a way that departing buses may pull out from loading docks between standing or berthing buses, the runway width and the mount of lineal space at the bus concourse are directly related for effective pull-out. If for instance, the straight saw-tooth loading is adopted in this design demonstrated, it needed about 18 metres runway width to achieve an effective pull-out from berthing bays.

ROADWAY RAMPS: Roadway ramps if the situation demands it, usually occur at the entrances or exists to runways. It should be devoid of sharp changes as this will result in discomfort to passengers, or rough treatment of the vehicles particularly when heavily loaded. Therefore, in constructing this roadway ramps, it is more pertinent to test the ramps with buses and at the same time create allowances for possible future vehicles having longer wheel base and overhang.

PEDESTRAIN DESIGN/ERGONOMIC: The design of pedestrian facilities for passenger terminals is dependent on the

category of terminal and its pedestrian traffic patterns. However, the delicate character exhibited by any architectural space is supposed to be given adequate attention by designers. When functional spaces are created in buildings, it must integrate those subtle things that influence factor behaviour.

Ergonomic design is simply integrating the human factor into a space requirement during the process of design. This human factor of ergonomic design, is considered in planning the various conveniences for passengers and staff in the terminal complex. The most ideal approach is referred to as the level-of-service concept. Based on this concept, human conveniences are qualitatively evaluated to solve the problems associated with various security and comfort of passengers intended to use the facility. This analysis is later translated into appropriate design parameters. It is a fact that in long distance terminal like the inter-state the users are generally unfamiliar with the facility, and moreover, peak traffic levels may sustain over several hours. Because of this, most human consideration is purposefully needed for this type of terminal. Many of the aesthetics of a design are lost with maximum capacity which coincides with the most crowded pedestrian concentration. In such a situation, pedestrians always encounter the difficulties of close interaction and conflicts of movement with one another to appreciate peculiar aesthetic design elements. The challenge to the terminal designer is to balance the space requirements for a comfortable and aesthetically pleasing human environment against the space restraints caused by building configuration and cost.

CAR PARK

Parking should be provided off streets. The positioning of this parking space should be in relation to the road section for ease of traffic flow. The location and access to this parking area should be such that getting into and out of it will not constitute any traffic conflict to other road users.

BUS LOADING BAYS

This is meant for the loading of both passengers and their luggage. The loading bays serve as links between the buses and the concourse. It could be fully or partly protected from weather as the time required to board the passengers are minimal. There are three (3) main patterns of loading bays viz: shunting pattern, driveway pattern and straight saw tooth pattern. These bays are applied in the design of terminals respectively according to the nature of the terminal and site configuration. They have both advantages and disadvantages therein.

SHUNTING LOADING PATTERN:

This is the type of bay that allows buses to load alongside the platform at kerb height. Duty buses are aligned in a single row beside the platform in such a way that for a bus can manoeuvre through a stationery one, it requires a large amount of space. Otherwise, buses must wait until the first bus moves. In a big terminal, it may require the construction of several bus lanes. This necessitates passengers crossing bus lanes to the numerous platforms – which is a very dangerous practice. To prevent this practice, a pedestrian under/overpass facilities can be introduced to protect passengers while crossing the lanes. This adds to the constructional cost of the terminal. Besides the numerous shortcomings of this type of loading, parallel bay is usually associated with

commuter service stations where speed of movement is required to obtain a high rate of equipment utilization.

Figure 5: Shunting loading pattern

Source: David, (1999).

DRIVE-THROUGH LOADING PATTERN

Drive-through bays are fixed positions for setting down and/or collecting passengers. They are in a line, so a vehicle often has to approach its bay between two stationary vehicles. In practice it is often necessary to have isolated islands for additional bays, with the inevitable conflict between passenger and vehicle circulation This method of loading bay limits the size of the concourse and therefore necessitates the use of a deep bus yard.

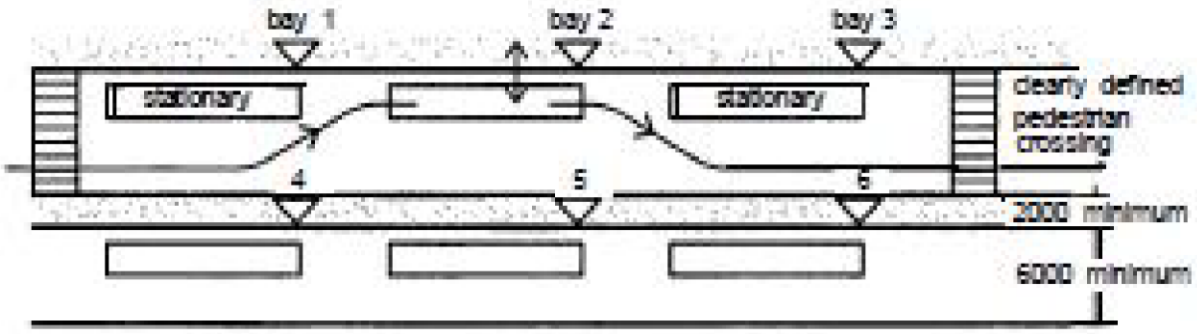

Figure 6: Drive-through loading pattern

Source: David, (1999).

SAW-TOOTH LOADING PATTERN

This type of loading allows buses to park at an inclined angle of about 300, 450. etc, so that their front doors adjoin the platforms which assumes the same saw-tooth profile. Theoretically, the angle of pitch between the vehicle front and the axis of the passenger platform can be anything from one-to-ninety degrees (1 – 900). But practically, it usually falls between 20 and 500. Easy access is provided to the loading doors of the buses for both passengers and the baggage trolley. This loading bay type is considered very efficient and advantageous in that it utilizes a minimum of platform space to achieve numerous bays. It is most economical where lot is comparatively narrow and deep. It underlying shortcomings is that it applies the method of forward and reverse mode.

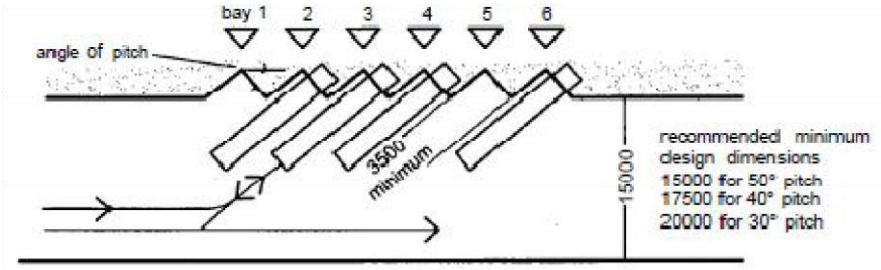

Figure 7: Saw-tooth loading pattern

Source: David, (1999).

6.3 PASSENGER PLATFORM

This is yet a segment of the concourse that is very crucial in the planning of bus loading bays for passengers. This is the main area where passengers enter or disembark from the bus. A considerable space and an overhead canopy is needed here for the convenience and comfort of passengers. Canopy heights which are usually supported by columns or piers should be such that allows for all types of bus operations. It should be best positioned in alignment with the profile shape of the bays they are covering so as to achieve a horizontal and vertical visual harmony for bus drivers as they manoeuvre the buses into and out of the berthing positions. There is also the need for steps and ramps respectively for passengers and trolleys since difference in levels is anticipated in this area. Passenger queuing facilities like the rails can also be provided.

LANDSCAPING

This is where nature is brought closer to man's doorstep. While preserving some features in its natural state, there are some that we can alter by modifying it with architectural elements like fountains, statues, shading trees, etc.

In the forecourt of this design demonstration, emphasis should be laid architecturally on aesthetics and functionality of the landscaping, to uplift the facial value of the terminal. Easy feeling and relaxation attractions like parks should be considered to ease-off vehicle sickness and tension aroused by the danger of road travel.

MOTORWAY

In order to prevent accident, the planning of this vehicular circulation should take cognizance of the loading/off-loading bays, the bus

yard, staff and visitors parking. The motorway should be considered in form of a lane capable of carrying a single row of vehicles. A lane-width of usually not less than 3m is adequate considering a maximum vehicle width of 2.5m. However, since this terminal will allow the use of very long vehicles of greater size, there is need to increase the lane-widths so as to satisfy this purpose, especially on curves.

6.3.1. MANUVERABILITY

Bus geometrics or the physical dimensions and manoeuvrability of the bus, determine the width of roadways, shapes or profiles of loading docks, column spacing, ceiling heights, and other aspects of space and levels in bus terminal design. The usual right-side loading of buses which is mostly associated with insignificant detail often restricts terminal design possibilities and options. An illustration of the geometrics/dimensions of bus models are shown below:

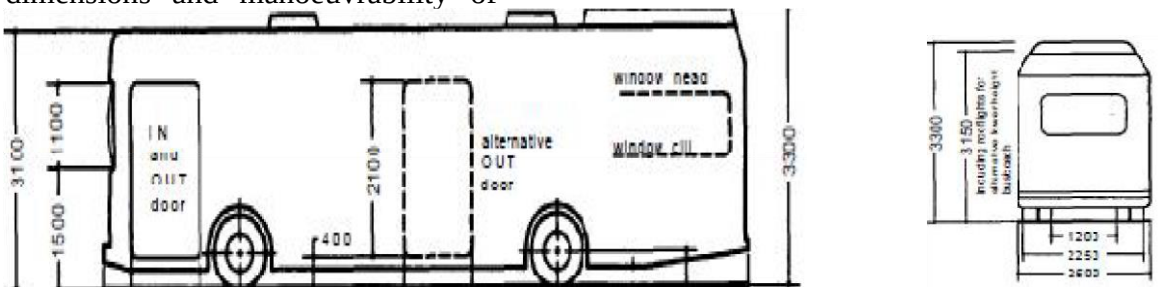

Figure 1: Single decker bus.

Source: David, (1999).

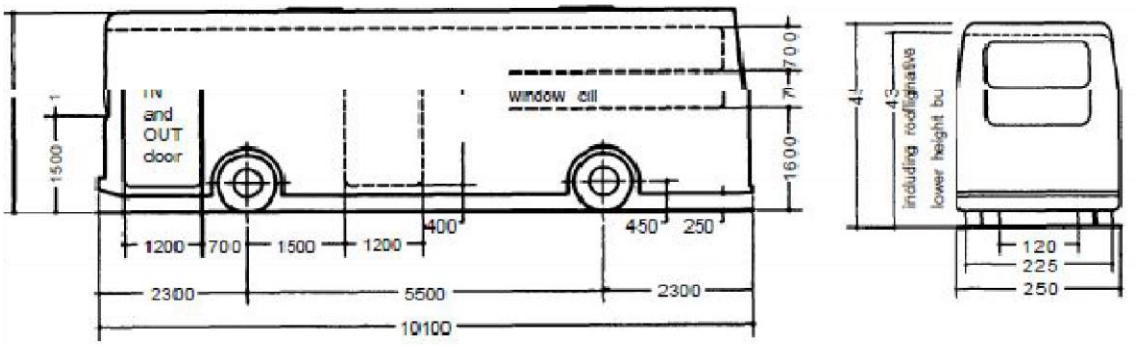

Figure 2: Double decker bus.

Source: David, (1999).

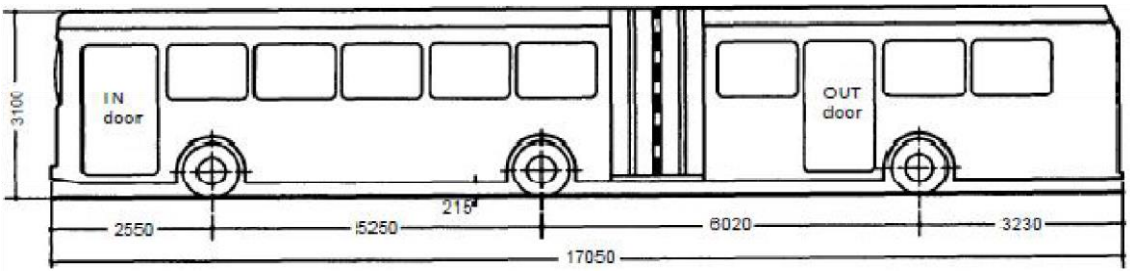

Figure 3: Articulated bus.

Source: David, (1999).

6.3.2. TURNING PATTERN

Incidentally, one could observe that the patterns made by a bus assuming average driving ability in under-going a turn through 900 and 1800 angles is not simply circular. The reason for this is just a technical reason. Generally, the wheels of automobile do not follow exactly the tracks of the front wheels unless driven in a straight line; the reason being that the front wheels are entirely controlled by the steering gear. Therefore, while the front wheels are steered, the rear wheels are virtually dragged around a corner. With the front wheels turning at a radius of 11.8 metres the overhang at the front of the vehicle does not turn in a similar circular pattern until about 90% of the turn is completed. On the other hand, the rear wheels and its overhang moves in a spiral form. The massive size of this bus model requires that a considerable space or distance is required to manoeuvre into and out of its full turning circle. The vehicle does not return to its original straight line of motion until the point after which the turn return of the front wheels has been fully completed.

6.3.3. SWEPT PATH

When a bus turns normally, it always turns about a point which is somewhere on the centre line of the rear axle. This is true whether motion is forward or backward. To make this turn, it is not always as simple as it looks because it depends on the type of automobile or equipment used; its turning template which helps to determine hypothetically the minimum clearances required for turning. The figure below illustrates further on this statement.

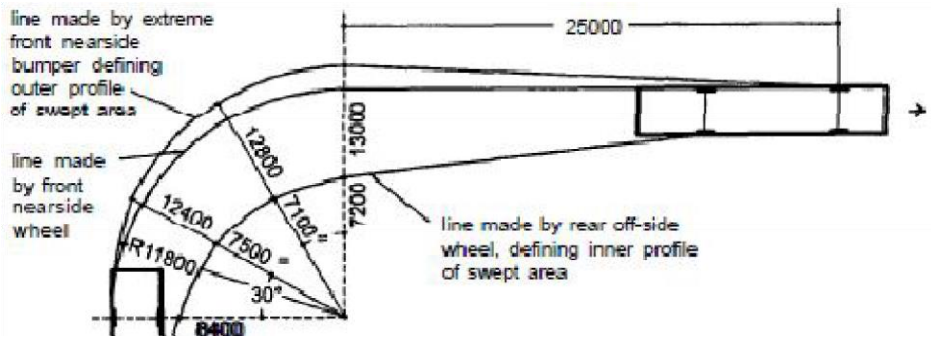

Figure 4: Rigid 12m vehicle turning through 900 showing the swept area/path

Source: David, (1999).

6.3.4. SWEPT AREA

This is the area encompassed by the curves made by the outer point of the front overhang and the track of the inner rear wheels when in motion. It is difficult to determine the curves geometrically because of its irregular track. Therefore, a rough guide method is adopted as illustrated in the drawing in plate 4. above (Abdulkareem, 2009; Adesina, 1987; Ahukannah, Ndinaechi & Arukwu, 2003; Ajiboye & Afolayan, 2009; Botha and Filani, 2006; Carapetis, Beenhakker & Howe, 1984; Adler, 1999; Ighodaro, 2008; Mallon, 1960; Muktar, 2011; Onakomaiya, 1980.

TURNING CIRCLE

To ensure a sufficient space for convenient turns to be achieved by buses, one should start imagining or paring 10 metres turning circle of an average length saloon car. On curved driveways, the inner rear wheel may track off a roadway if the inner-radius of the drive is too great. On the other hand, the outer front wheel also tracks off if the outer radius is too small. The minimum width of driveways for various radii is determined on three properties of an automobile. The properties are: Tread, Wheel-base, Turning radius.

TREAD This is simply the distance centre-to-centre of front or rear wheels.

WHEEL-BASE: This is the distance centre-to-centre between front and rear axles.

TURNING RADIUS: This is the radius of the circular tract of the outer front wheel.

In addition to the above-mentioned properties, inside and outside clearances are considered. This is to provide a margin of safety so that both front and rear bombers', etc. will safely clear boarding. As stated earlier in this chapter, the physical dimensions and manoeuvrability of the bus determine the width of roadways, shapes of platforms, column spacing, ceiling heights and other aspects of bus-level design. When a bus turns, it turns about a point which is somewhere on the centre line of its rear axle. This applies to both forward and backward motion. This point about which the bus turns is termed the turning circle or turning point. This turning circle is affected by the three properties mentioned above, and they all vary according to vehicle type and sizes.

CHANGING LOCKS

When a road network or layout requires that the vehicle must make abnormal movement like an extended spring or a snaking movement, from its straight line of motion, time and distance is necessarily needed to change from one-wheel lock to the other. This change from one-wheel lock to the other and vice versa is known as changing lock. For vehicles moving at a slow pace, a distance of 6 to10 metres should be allowed for changing from one full lock to another.

6.4 CONCLUSION

This work has provoked thoughts on transportation architecture. The study shows that there is a

relationship between architectural design and urban traffic congestion.

It portrayed the existing interaction between urban architecture and urban transportation network as well as the connect between urban road traffic congestion and urban architecture in the city of Enugu. It re-emphasized the relevance of the National Transport Document, (NTD, 2010) as in the National Economic Empowerment and Development Strategy (NEEDS) framework to be driven by the private-sector and with the fundamental objective of developing an adequate, safe, environmentally sound and efficient transport system in the context of a progressive and competitive market economy.

The identified prominent areas of traffic congestion including the Okpara Avenue axis, the Ogbete Main Market area, the Old Park area as well as the Agbani Road axis and postulated that the neglect of various architectural design considerations in the urban design of Enugu city has a relationship with the perennial traffic congestion in the city. It was also able to confirm the delay in travel time, difficulty in transportation and stress in movement across the city and from one part of the city to the other. This study was also able to identify prominent areas of perennial traffic congestion as the areas of concentration of various transport companies within a particular part of the city and these areas happens to comprise the city center. It finally made relevant case for transportation architecture and recommendations such as for the adoption of architectural design considerations in the urban transportation design in Enugu metropolis and in all other cities of the world.

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