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Assessment of the Impact of Road Dualisation on Adjacent Structures: A Case Study of Iwo-Road – Agodi Gate – Bashorun Road in the Ibadan Metropolis

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1. INTRODUCTION

The problem of traffic congestion has reached an alarming rate in Nigeria especially in many cities. While the cities are getting denser as a result of influx of rural people into the cities to seek for better life, the roads constructed decades ago have become grossly inadequate to contain the large volume of traffic thus hindering free flow of vehicles and of course that of the people, goods and services. One of the solutions to reducing the congestion aside constructing new roads is to dualise existing ones to increase their carrying capacities. In most cases, development has engulfed the existing roads with buildings of various categories and other infrastructures. Consequently, the effort to widen the carriageway of the roads requires the relocation, total or partial demolition, adjustments of buildings and services. This particular effort focused on the impact of such development on the adjacent structures to the dualisation aside from the overall environmental impact, which is usually the global consideration.

Congestion is considered as the major challenge in road transportation and its consequent immeasurable impact on the country's economy, he suggested that, congestion free road will enhance efficient mobility of goods and services and make road transportation as most preferred transportation mode (Jerome, 2005).

Environmental impact refers to the harmful/beneficial consequences of an impending activity. The impacts are considered in terms of their nature, magnitude and significance (Trevor, 2002). Road construction and traffic operations, if undertaken without a proper understanding of the relationships inherent in environmental function, is accompanied by serious disruptions to the environment, from which it may take a long time to regain equilibrium. In human terms, this may mean that generations must function in a debilitated environment and suffer many possible associated socio-economic hardships and financial losses (Hoban, 1997).

It is also important to consider the structures and nature of distresses imposed on them early enough before the partial demolished buildings fail completely and assessment carried out on the building failures (Ayininuola, 2004; Ochshorn, 2006). In a project carried out along the Bashorun area, (Filain, 1976) observed that traffic congestion exists in Ibadan and that the situation is growing worse each day in spite of some steps taken to alleviate the situation. Obviously, a road that is inadequate in carrying capacity will defy other possible transportation solutions.

Making considerations to these realistic suggestions and opinions of these scholars it has become of great importance to consider also the effect of the dualisation of road infrastructure on the adjacent structures. This also guides as proactive measure to forestall possible imminent collapse of buildings which, in recent times, has been a major object of concern in our society or built community (Hussein, 2004; Chinwokwu, 2000)

Origin of Road Project in the State

It was reported that the immediate past governor of the state while marking his sixth year anniversary in office, kicked off various projects of which a higher percentage comprised of reconstruction, repairs, expansions and rehabilitation of roads (Gbenga, 2017). Several roads were earmarked for construction and repairs while some were for dualisation. Iwo-Road – Agodi Gate – Bashorun Road project was one of the roads awarded for dualisation.

Area of Study

The area of study as shown in Plate 1 and Figure 1, is located in the Ibadan North Local Government which is one of the 11 local government areas of the Ibadan metropolitan areas having a total land mass of about 81.37 km² (Ajagbe *et al.*, 2011).

This road section derives its uniqueness due to the centralized nature of the Iwo Road junction. It provides the primary arterial links to different places in Ibadan for people coming from different parts of the country passing through Oyo State and is required to gain their access through the city of Ibadan; it serves as a major access into the city from the other southwestern regions. The road lies within the city of Ibadan and provides a first-hand initial view of what the interior of Ibadan is like and connects to the current urban setting of the locality. This location factor principally influences the socio-economic profile of the environment. Ibadan as the capital city of the state has its central complex and government offices in a centralized location, which is easily accessible from the route taken into consideration in this study.

The project was conceived in order to reduce to the barest minimum, traffic congestion and movement within the state along with the ongoing and anticipated huge industrial revolution to be experienced.

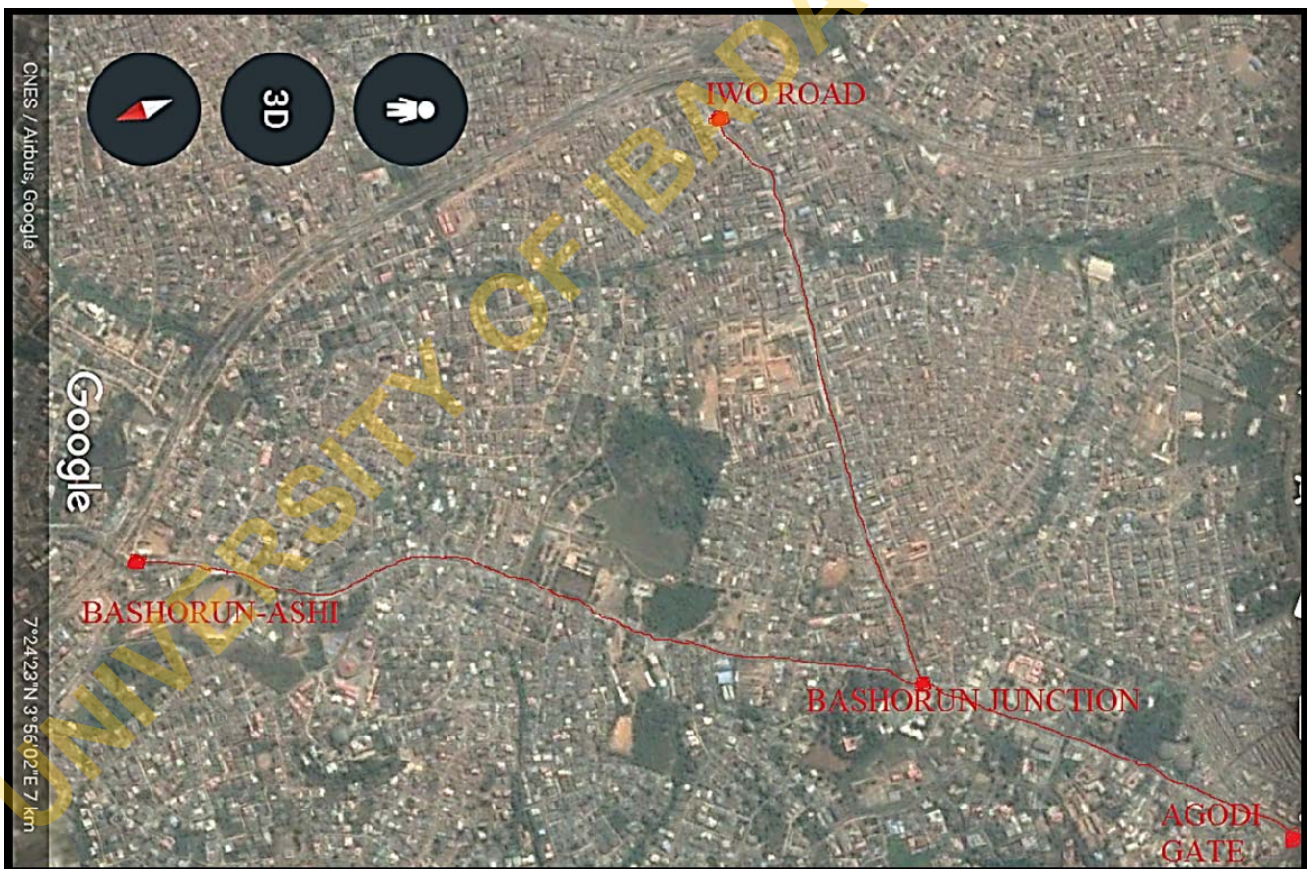


Plate 1. Showing the Aerial Map View and Outline of the Project Area

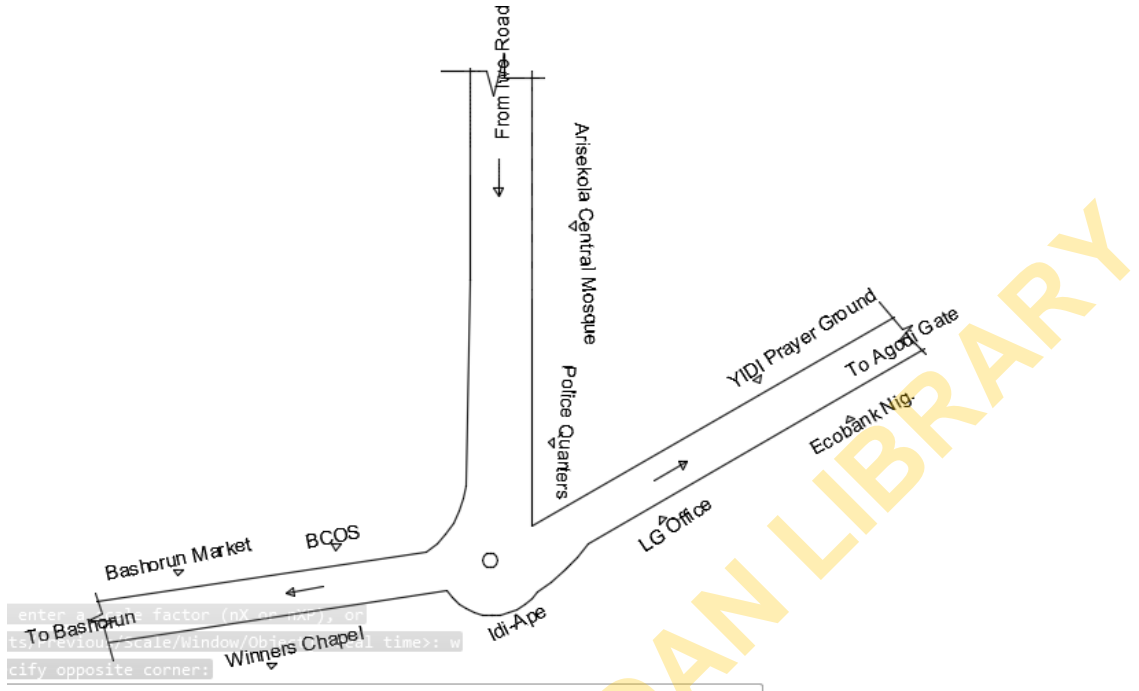


Figure 1: Showing a Sketch of the Road Segments and Notable Locations at Each Segment.

2. METHODOLOGY

The method used in impact assessment is a function of the field or scope of assessing the project impact on environment and biological factors sustained in the environment. Some of the available techniques or approaches include Ad-hoc method; Questionnaire method; Physical Observation; Photogrammetry; the overlay technique, etc. The Overlay Technique was adopted for this study. The method was used in a similar Environmental Impact Assessment of the Ojoo – UI – Sango – Mokola road dualisation in the city of Ibadan (Ajagbe and Bashiru, 2013). This process required subdividing the project area into convenient geographical units or segments. The study area was divided into Iwo Road – Idi-Ape; Agodi Gate – Idi-Ape; and Idi-Ape – Bashorun area.

Three basic approaches were adopted in the study:

Field Survey (Measurement and Data Collection)

Each of the segments was surveyed visually to observe the extent of the impact on the adjoining structures. Data obtained include the numbers and categories of the structures and the level of impact. Then, measurements and photographs were taken at necessary points to aid the assessment. Other relevant information were obtained from the users/inhabitants of the structures and workers on site.

Desk Studies (Analysis and Design Process)

Following the field survey, six different cases were selected for group representation of the affected structures and detailed analysis. The cases were categorized based on building type and failure pattern. The structural layouts of the buildings were obtained where available and regenerated, where the owners were not willing to release it. Patterns of cracks and affected structural members were noted and further subjected to analysis using software packages to assess the level of impact and the possible measures to salvage the building to meet functional and serviceability requirements.

In-situ Concrete Strength Testing

The compressive strengths of concrete of affected structures were ascertained via the non-destructive test method using the Schmidt hammer. Readings were taken on chosen structural members at different positions to determine the average concrete strength of the member parts of partially demolished case study structures.

Impact Assessment

The procedures adopted for the structural impact assessment are as follows:

1. Taking measurements of the dimension and space of demolished parts and analysis to determine alternative methods to provide supports of either columns or simple block levels.
2. Determination of the capacity of the structure to support load for which it was constructed or designed.
3. Determining building status justified by the level of functionality and serviceability by making inference based on the field work and calculations made from the dimensions of building case studies.
4. Identifying the cracks formed in building structural members especially at the tension zones.
5. Defining the nature and cause of the cracks from analysis, modelling and calculations, based on the dimensions and measurement of the building.
6. Determination of residual concrete strength using Schmidt hammer test.

3. RESULTS AND DISCUSSION

Field survey data obtained from the three road segments in the area of study (Iwo Road to Idi-Ape, Agodi Gate to Idi-Ape, and Idi-Ape to Bashorun) are presented in Tables 1 to 3.

The Iwo Road to Idi-Ape section has a high number of private businesses and industries. It has a concurrent high number of commercial activities and it is categorized as an Industrial/Commercial area. Agodi Gate to Idi-Ape axis is predominantly commercial while Idi-Ape to Bashorun is an Industrial/Commercial area similar to the Iwo Road to Idi-Ape axis. No doubt the road traversed a heavily built up and densely populated area and justified the high level of demolition along the routes.

Table 1. Showing the Building Types and Distribution from Iwo Road to Idi-Ape

S/N	Building Type	LHS	RHS	LHS%	RHS%
1	Private Industry	20	9	34.48	37.50
2	Banks	4	3	6.90	12.50
3	Academic Institutions	0	0	0.00	0.00
4	Religious Centre	3	0	5.17	0.00
5	Filling Stations	3	2	5.17	8.33
6	Hospitals	1	0	1.72	0.00
7	Shops and Shopping Complexes	14	7	24.14	29.17
8	Bridges	0	0	0.00	0.00
9	Factories	5	0	8.62	0.00
10	Residences	7	2	12.07	8.33
11	Market	0	0	0.00	0.00
12	Security Stations	0	0	0.00	0.00
TOTAL		58	24		

Table 2. Showing the Building Types and Distribution from Agodi Gate to Idi-Ape

S/N	Building Type	LHS	RHS	LHS%	RHS%
1	Private Industry	5	1	27.78	7.69
2	Banks	3	1	16.67	7.69
3	Academic Institutions	0	1	0.00	7.69
5	Filling Stations	1	2	5.56	15.38
6	Hospitals	0	1	0.00	7.69
7	Shops and Shopping Complexes	6	3	33.33	23.08
8	Bridges	0	0	0.00	0.00
9	Factories	0	0	0.00	0.00
10	Residences	0	3	0.00	23.08
11	Market	1	0	5.56	0.00
12	Security Stations	1	0	5.56	0.00
TOTAL		18	13		

Table 3. Showing the Building Types and Distribution from Idi-Ape to Bashorun

S/N	Building Type	LHS	RHS	LHS%	RHS%
1	Private Industry	14	2	21.88	5.26
2	Banks	0	2	0.00	5.26
3	Academic Institutions	7	2	10.94	5.26
4	Religious Centre	0	0	0.00	0.00
5	Filling Stations	3	1	4.69	2.63
6	Hospitals	0	0	0.00	0.00
7	Shops and Shopping Complexes	18	10	28.13	26.32
8	Bridges	0	0	0.00	0.00
9	Factories	2	1	3.13	2.63
10	Residences	19	19	29.69	50.00
11	Market	1	1	1.56	2.63
12	Security Stations	0	0	0.00	0.00
TOTAL		64	38		

Also presented are the results obtained from the analysis and modelling of the buildings, selected from the three segments of location where field works was carried out. Description of the six case studies is shown in Table 4. Each of the case study is also presented in plates 2-7 below.

Table 4. Description of the Case Studies

Case	Structure Type	Description	Remark
1	Storey Building	A Storey building of Kingdom Schools, Bashorun Akobo Road	Academic institution
2	Basement	A partially demolished shop basement with suspended slab to support water tanks	Store for pipe products
3	Storey Building	A partially demolished Storey building	For business and a mini warehouse
4	Storey Building	A partially demolished Storey building	Residential building
5	Storey Building	A Storey building being demolished completely	Residential building
6	Market Structures, etc.	Structures being demolished completely	Stalls, Retaining walls, drainages, etc.

Case 1:



Plate 2. Showing the Partial Demolition State of Case 1

Calculations to show the mode of stress the building is undergoing due to the partial demolition of the structural members.

Calculated torsional stress:

$$v_t = 7.061 \text{ N/mm}^2; v + v_t = 7.061 + 0.979 = 8.04 \text{ N/mm}^2$$

$$\text{Permissible torsional Stress; } v_{tu} = 0.8\sqrt{20} = 3.58 \text{ N/mm}^2$$

Therefore, since v_t is greater than v_{tmin} and $(v + v_t)$ is greater than 3.58 N/mm^2 or 5.00 N/mm^2 , the beam in the structure experienced additional load away from the plane of bending inducing torsional moment along with the bending and shear forces.

The torsional stress resulted due to the change of initial design and configuration of the extending beams and slabs at the side of the internal continuous beam in distress changing them from simply supported beams to cantilevers.

Case 2:



Plate 3. Showing the Partial Demolition State of Case 2

Calculations show the mode of stress the building is undergoing due to the partial demolition of the structural members.

Where the characteristics shear stress, $v_c = 0.69 \text{ N/mm}^2$

Estimated imposed live and dead load of materials behind tank, on the slab at 500 KN and weight of 2 tanks filled at 250 kN .

At the critical section,

$$\text{Effective diameter} = 3.77/2 + (2 \times 1.5) + 0.149 = 2.33 \text{ m}$$

$$\text{Perimeter, } U = \pi \times 2.33 = 7.326 \text{ m}$$

$$\text{Design Load at} = 13.31 \text{ KN/m}^2$$

The estimated axial force,

$$V = 750 - (2.33 \times 2.33 \times 13.31) = 677.74 \text{ kN}$$

The calculated Punching Stress,

$$v_p = 1.15 \times 677.74 \times 10^3 / 7326 \times 149 = 0.714 \text{ N/mm}^2$$

Comparing the magnitude of both where,

$$v_p \geq v_c$$

Due to the demolition, there was reduction of the effective critical perimeter hence area of the slab, resulting in higher shear stress due to punching.

Cases 3 and 4:



Plates 4 and 5. Showing the partial demolished state of cases 3 and 4

Due to the loss of functionality caused by the demolition of the existing staircase in each building, the stairs helped to provide access to the next floor or storey. Spiral staircases are recommended and designed, for cases 3 and 4 in place of the affected stairs.

Cases 5 and 6:



Plates 6 and 7. Showing the Full Demolition of Cases 5 and 6

In this situation, consideration was made for buildings, infrastructures and market stalls that were completely demolished, though analysis were not made on them as a result of their non-functional states.

Compressive strength of the Selected Case Studies

The average compressive strength readings for the six case studies are as presented in Table 5

Table 5. Average Concrete Compressive Strength of the Structural Members of Case Studies

Samples	Average Compressive Strength (N/mm ²)				
	Stair or Slab	Column	Wall/Partition	Beam	Lintel
1	40.00	24.00	32.75	32.00	Nil
2	33.33	Nil	30.00	Nil	Nil
3	33.33	Nil	30.00	Nil	Nil
4	26.00	32.00	29.75	29.50	36.75
5	Nil	Nil	Nil	Nil	Nil
6	Nil	Nil	Nil	Nil	Nil

4. CONCLUSION

Road dualisation in built up areas require demolition of buildings partially or wholly and it makes them lose their initial purpose for which they were constructed. Partial demolition could result in imminent collapse of building if not attended to. Therefore, the need to employ the service of a structural Engineer to carry out an assessment of the building ahead of the road infrastructure development cannot be overemphasized.

From the calculation analysis and modelling, it was shown that partially demolished buildings are mostly kept in stressful and unstable states thus subjecting them to continuous stresses (like; punching stress and torsional stress). This deplorable state of the affected buildings is evident by the appearance of cracks at the tension zones or surface of the structural member.

Recommendations

Based on the outcome of the research, the following are recommended:

- Conducting Structural Impact Assessment (SIA) before and during road dualisation projects in order to weigh the cause-effect and cost-benefit result on the populace should be encouraged.
- SIA should be a major aspect of Impact Assessment particularly where the project is to be executed in built up areas.
- Well-regulated and controlled demolition process with the supervision of an experienced Structural Engineer should be considered.

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