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Investigation of the Causes of Flexible Pavement Failure along Three Selected Roads in the Niger Delta Region of Nigeria

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ABSTRACT

This study investigated the causes of flexible pavement failure along three major roads in the Niger delta region of Nigeria. The three selected roads are Ogbia-Nembe road, East-West road and Port Harcourt-Aba. Different types of failure such as alligator cracks, rutting, corrugations, etc, were observed on the selected road alignments. Pavement condition and traffic surveys were carried out on the selected road locations to ascertain their causes of failure. The study method involved the use of structured questionnaires which were distributed mostly to civil engineers and other construction stakeholders. A 5-point Likert scale was used to analyze the questionnaires retrieved from the respondents. The results of data analysis of the questionnaires and traffic survey showed that lack of laboratory investigation of construction materials, poor quality of the construction materials, lack of maintenance culture, poor soil condition of the road, inadequate drainage systems and overloading of road pavements are the major factors that are responsible for flexible pavement failures of the three selected roads in the Niger delta.

Keywords: Flexible pavement, Condition surveys, 5-point Likert scale, questionnaires, poor soil condition

1, INTRODUCTION

Road infrastructure plays a key role in national development as it improves both the social and economic wellbeing of its citizenry, improving the general transportation means of a nation, easing the processes of movement of goods and services and also connect people among others. In a developing country like Nigeria, the measure of economic growth is tied to the means and how the country is able to connect with the other neighboring countries in the area of transportation. The current state of the roads in the Niger Delta region of Nigeria is worrisome as it reduces the pace of infrastructural development in the region. Roads and Highways forms part of the notable means of land transportation together with the likes of railways, pipelines, suspended cables and other human

aided means. Roads provide access to employment, social health and education service for which reasons, they are being considered as the most important of all public assets (Giddings et al., 2013).

The framework for evaluating a typical road pavement structures should incorporate asset functionality, technical applications, environmental effects, safety, economic and institutional considerations (Oyibo and Ugwu, 2017). Over the years, it has been observed that road pavements constructed at the same time and subjected to similar traffic and climatic exposure performs differently. This responsiveness is as a result of varying conditions which may include assumptions in the designs, environmental conditions, construction approach, the type of pavement structures and maintenance system adopted. According to the Federal Road Safety Corps (FRSC), the major causes of the accidents that occur on highways can be attributed to the unsafe nature of the highways within the nation with the Niger Delta region having the worst roads conditions. This bad narrative of high accident incident cases attributed to pavements failures can be avoided if the road networks are in good and serviceable condition and are properly maintained with little or no failures on the pavements.

Niger Delta lies within the delta belt of Nigeria and is characterized with dynamic soil condition, and unpredictable soil formation which have impacted negatively on the road infrastructures of the region. The deteriorated condition of the roads has claimed many lives and has produced a huge economic impact on the economy of the region. Notable among the roads within the Niger Delta region of Nigeria with massive failures on their pavements is the Port Harcourt-Aba expressway. The road is currently in a very deplorable state and calls for serious attention. In the absence of a detailed study of ground water movement, and other related geological and geophysical investigation, the application of general engineering principal of pavement design and construction based on code provisions will not sufficiently take care of early failure of pavement structures, As these early failures are a major factor leading to accidents, increasing road user cost and subsequent negative impact on the general economy (Farouq et al., 2017). With the scarcity of resources and the need for the quick development of the Niger Delta region, there is an urgent need to forestall the early failure of its road pavement infrastructures This is what the stakeholders and other responsible agencies must identify as priorities for the design, construction, maintenance and rehabilitation of pavement structures that will leave their design life. (Haas et al., 1994).

As the road pavement structures are open to traffic, their deterioration would start. At the early stage of the opening of the road to traffic, the rate of deterioration is slow but deteriorates faster after a period of time. According to Hass et al. (1994), poor road condition can make the maintenance cost to be 4 to 5 time higher than the initial cost of construction. Maintenance cost is also reduced when the road is in good condition. Studies have been carried out to determine the thickness of the base,

subbase and subgrade materials by imposing an Equivalent Single axle load of 80KN on the flexible road pavement structure to determine the structural responses such as stresses, strains and deformations generated on the multi-layered flexible pavement structures at different chainage points along the length of the road using Visual Basic program (Emmanuel and Eme, 2009). However, the road pavement structures still suffer durability problem. Given the procedural processes in developing a typical road pavement infrastructure and the peculiar conditions of the Niger Delta region, together with the paucity of funds to realizing the developmental mandate of the Niger Delta region, it has become very important that existing road infrastructures are adequately monitored and maintained to avoid early failure while measures be put in proper perspective to ensure that adequate considerations are made during the design, construction and maintenance of road pavement infrastructures in the Niger Delta region. According to Reza et al. (2006), a comprehensive assessment of the environment and exposure conditions of such infrastructure must be considered.

In this paper, pavement condition survey, traffic density surveys were carried out on the three study pavements also stakeholders opinion were gathered through the administration of structured questionnaires development to ascertain the major factors responsible for the failure of the road on the selected alignments and by extension, the Niger Delta Region.

2. METHODOLOGY

2.1 STUDY AREA

Three road locations consisting of: Ogbia-Nembe road, section of East-West road from Eleme Junction to Etteh Junction in Akwa Ibom and a section of Port Harcourt-Aba road from Eleme Junction to Osisioma Junction in Abia State respectively were considered as part of the busy and major roads in the Niger Delta region of Nigeria and hence can be a better representation of roads in the region. The Niger Delta region lies along the delta of the Niger River and considered as sitting directly on the Gulf of Guinea on the Atlantic Ocean transversing Nigeria. The area is rich in oil deposits and therefore plays an important role in the economy of Nigeria due to the nation's high dependence on oil mineral deposits. The Niger Delta extends over about 112,000 Kilometers and constitutes 7.5% of the Nigerian landmass considering the size of the nine states that forms part of the region. From the Niger delta Map shown in Figure 1, the region is located more on the southern part of the Nigerian map and flanges from the South South is, Delta, Rivers, Bayelsa, Edo, Cross River and Delta and to the South East having Imo and Abia State. The region lies within the geographical coordinates of Latitude 5^0 19'20.40"N and Longitude 6^0 28'8.99"E. In line with the projection from the 1991 National population census with a projected growth rate of 2.9% of the population of the Niger Delta Region, it is expected that the population of the region will be above

45million people by the end of 2022. Figures 2 is the Maps showing the three selected alignments under study**.**

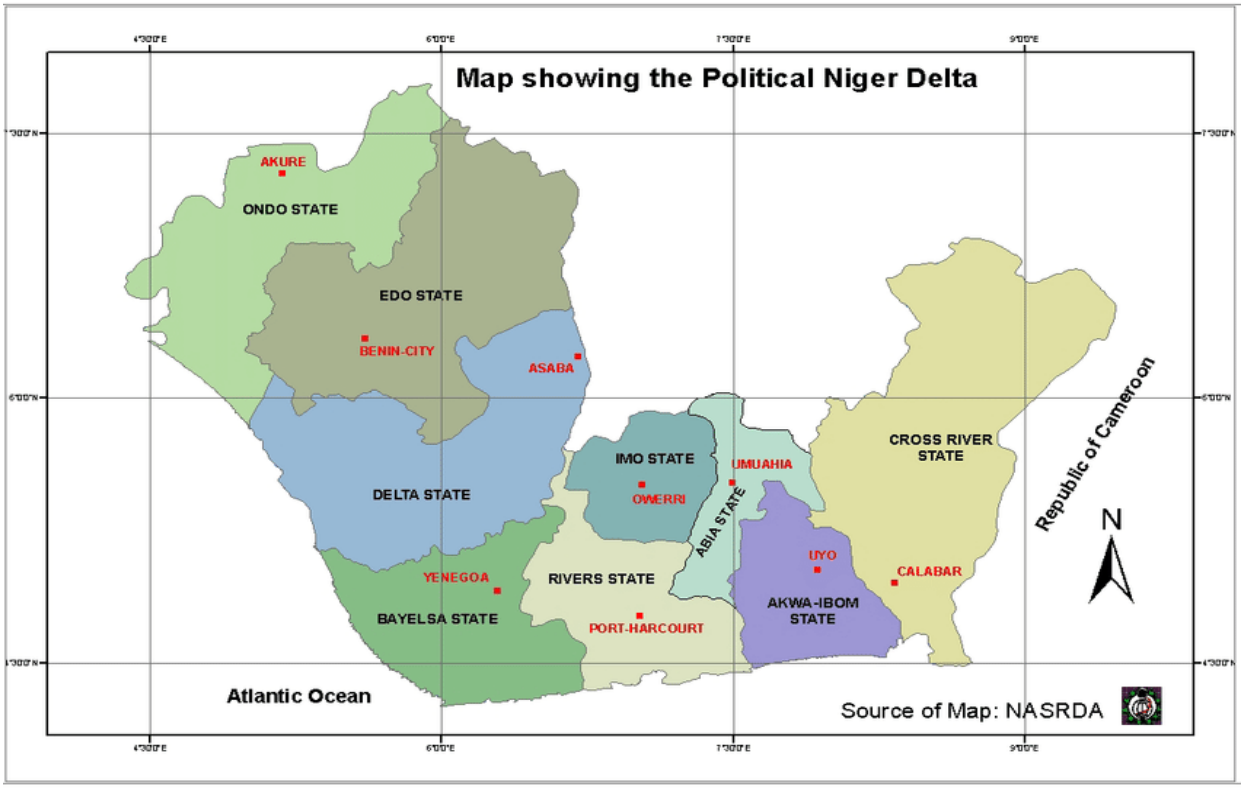
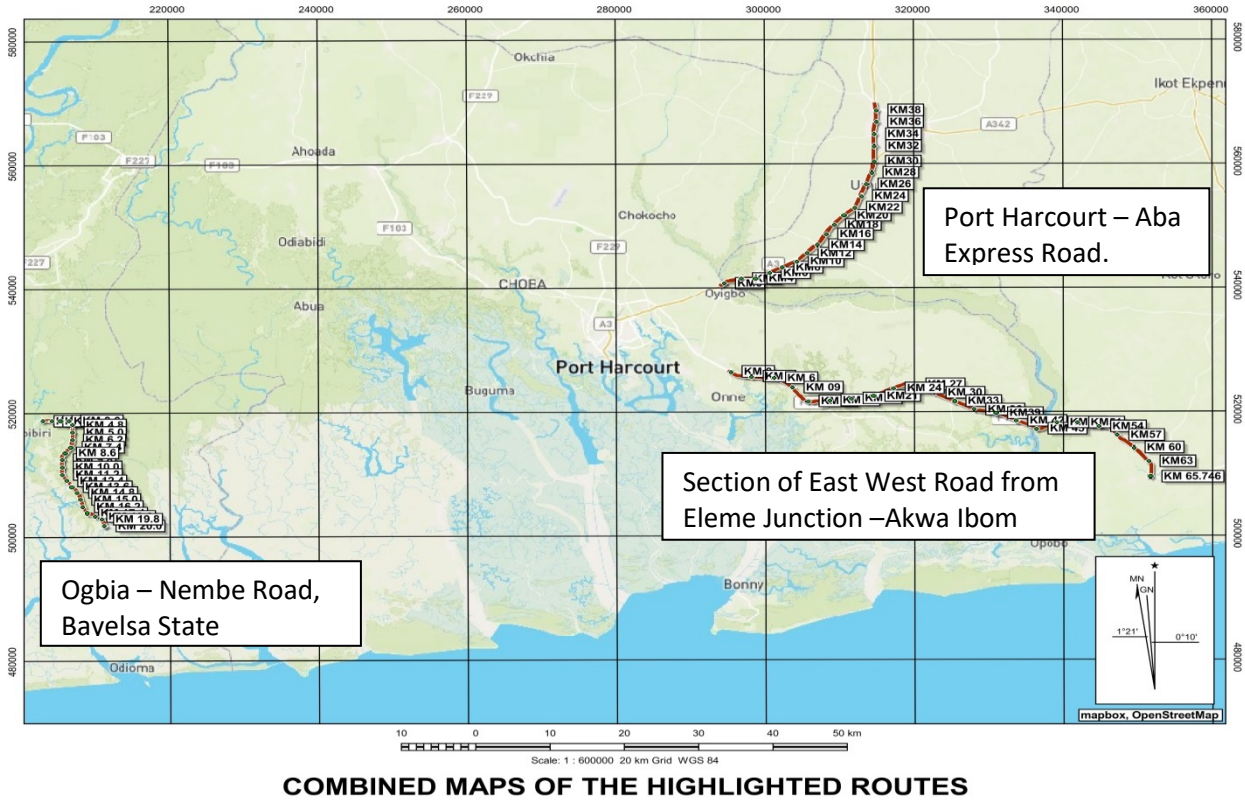


Figure 1: Map Showing States in the Niger Delta Region of Nigeria



COMBINED MAPS OF THE HIGHLIGHTED ROUTES

Figure 2: Map showing the three selected alignments under study

Structured questionnaire administrated to various construction stakeholders such as project managers, consultants, site engineers, research engineers and laborers was used in data collection together with the conduct of Pavement condition Survey and road traffic density survey on the three study alignments. Validity of the questionnaire was made by interviewing selected members of the road construction professionals in the construction industries, researched and academia.

2.2 Sample size

The sample size was chosen from the list of all the construction stakeholders of Port Harcourt-Aba expressway, Ogbia-Nembe road and East-West road located in the Niger delta area of Nigeria. The sample size of this study was limited to five categories of individuals and organizations. These were those involved in the design of roads, those involved in the construction of roads, those involved in the maintenance of roads, those involved in the administration and management of road construction work and those who are very familiar with the road construction/design/maintenance and management processes either by frequency of use or living within the neighbourhood of the study alignment. This is due to the qualitative and technicality nature of this study. The sample size was also extended to commuters on the respective roads and also laborers who participated in the construction of the three selected roads in order to obtain more reliable results on the causes of flexible pavement failures. The population of the five categories of the groups marked for questionnaire interview are shown in Table 1.

Table 1: Population of different categories of stakeholder group for this study drawn from the three study location

Categories	Identified Group	Estimated Population of Participants	Percentage %
Road Design	**40 Companies**	200	7.4
Road Construction	**100 Companies**	500	18.5
Road Maintenance	**100 Companies**	500	18.5
Road Administration	**203 Officers**	609	22.4
Road Management/Related Practitioners		900	22.2
Total		**2,709**	**100**

The estimated population size is about 2,709 for the entire three road locations with specific knowledge based on the requirements that would account for specific objectives of the study.

The population size of the study is significantly large (2,709) this is occasioned by the specific criteria of non-random sampling method for the population selection and the sensitivity of the information required as it only concerns major players with very good knowledge of pavement structure in areas of design, construction, maintenance, administration and management. Hence the Taro Yamane sample size determination equation, equation (1) was applied to determine the sampling size used in this study.

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

Where n = Sample Size, N = Population Size = 2,709, α = Level of precision = (0.05)

Substituting the above values into equation (1) yields:

$n = 348.54 \approx 350$

To ensure good representation of the population and reliability of the data, an additional Two Hundred and Fifty (250) respondents were added to the calculated sample size to ensure that participants were evenly distributed across the study locations. This brought the total sample size for this study to Six hundred (600) respondents. This is about 22% of the total population of 2,709 for the study and in agreement with Israel G.D (1992) which stated that an assessment of 20% the entire population is appropriate for generalization.

Traffic count was also conducted on the three study roads using manual count to determine the traffic volume for the respective roads. The numerical count of the various vehicular types using the road was part of the data used in this research.

2.2 Weighted Mean

The weighted mean method was used to analyse the research questions rated on the 5-point likert scale.

The results of data analysis provided answers to the following questions:

i. What are the factors responsible for flexible pavement failure in the three selected roads of the Niger delta?
ii. What are the top ranked factors responsible for flexible pavement failure in the three selected roads of the Niger delta?

The data used for this analysis are the responses of the respondents on the likely causes of pavement failure in the three selected roads of the Niger delta measured on a 5-Point Likert scale which are represented by the following rating value, 5- Major cause (MC), 4- Cause (C), 3- Neutral (N), 2- Least cause (LC), 1- Not cause (NC).

Using the weighted mean method, factors having weighted mean value of 3.0 and above were regarded as top factors responsible for pavement failure while factors that have the weighted mean value of 2.0 and below were regarded as least factors responsible for pavement failure.
The mean score for each cause of the flexible pavement failure for a 5-Point Likert scale was obtained using:

$$\overline{X} = \frac{1*N_1 + 2*N_2 + 3*N_3 + 4*N_4 + 5*N_5}{\sum N} \quad (2)$$

Where N_1, N_2, N_3, N_4, N_5 = number of respondents to the study of the causes of flexible pavement failure of a particular road in the three selected roads of the Niger delta, $\sum N$ = the total number of respondents

The weighted mean benchmark used for decision making on factors responsible for flexible pavement failure is calculated as:

$$\overline{X} = \frac{5+4+3+2+1}{5} = \frac{15}{5} = 3 \quad (3)$$

3. RESULTS AND DISCUSSION

3.1. Questionnaires Analysis

In order to understand the major causes of flexible pavement failures in the three selected road sections in the Niger delta, structured questionnaires were administered to construction stakeholders that understood the causes of flexible pavement failures in the selected road sections. Respondents who participated in the survey were also familiar with the road sections. The results of the questionnaire survey are presented in Table 2, and shows that 200 copies of the questionnaires were distributed to various construction stakeholders on each of the selected roads. Out of the 200 copies distributed for the Ogbia-Nembe Road in Bayelsa State. One hundred and sixty-six (166) copies were retrieved but only one hundred and fifty-eight (158) copies were accurately filled. The 158 copies accurately filled represent the response rate of seventy-nine percent (79%). In the case of the section of East-West Road from Akwa Ibom to Eleme Port Harcourt, one hundred and eighty-eight (188) copies were retrieved but only one hundred and eighty-five (185) copies were accurately filled. The 185 copies accurately filled represent the response rate of ninety-two and a half percent (92.5%). While on the Port Harcourt-Aba-Umuahia expressway, one hundred and eighty-five (185) copies were retrieved but only one hundred and eighty (180) copies were accurately filled. The 180 copies accurately

filled represent the response rate of ninety percent (90%). The data collected from the three studied road alignments were analysed together with consideration given to the accurately filled questionnaires amounting to five hundred and twenty three (523) out of a total six hundred (600) distributed questionnaires representing 87%, while the various copies of the retrieved questionnaires that were not accurately filled were not considered in the analysis. Tables 3 shows the demography of the respondents. Data from the questioner on the causes of failure was analysed using the simple weighted mean average statistical method with a bench mark of 3 which is interpreted as 3 and above being a cause of failure and below 3 not considered a major cause. Table 4 represent the ranking.

3.2. Responses to Causes of Failure of Flexible Pavement of the Three Road Locations

The main objective of conducting the survey was to understand what construction stakeholders in the Niger delta region think are the probable causes of failure of flexible pavements in the region. The result is presented in Table 4 and figure 3. From Table 4, it can be seen that lack of laboratory investigation of construction materials was ranks first and is likely to be the reason why most flexible pavements fail. About 91% of the respondents agreed that lack of laboratory investigation of construction materials might be the cause of failure of flexible pavement. The next probable cause of the failure of flexible pavement, ranking second was the quality of construction materials. About 85% of the respondents were in agreement that the quality of construction materials might be the cause of the failure of flexible pavements in this region. The next three probable causes of flexible pavement from the ranking were Lack of maintenance culture, poor soil condition of the road (in-situ soil), and inadequate drainage supply system which were ranked 3rd, 4th, and 5th respectively. The above-mentioned causes of flexible pavement failure have a weighted mean score value above the benchmark value of 3.0 and are therefore regarded as the causes and major causes of flexible pavement failures in the three selected study roads. Factors such as deliberate sabotage, duration of the project execution, and absence of plantation at places prone to land sliding were the least likely to cause the failure of flexible road pavement in the three selected study roads.

From the statistical survey, it can be implied that the failure of the three study flexible pavement, namely: The Ogbia-Nembe road in Bayelsa State; the section of East-West road from Akwa Ibom to Eleme, Rivers State and the Port Harcourt-Aba expressway are majorly due to poor quality of construction materials, lack of laboratory investigation of construction materials, lack of maintenance culture, poor soil condition of the road, inadequate drainage supply system, heavy traffic and quality control of construction materials lapses.

3.3. Pavement Condition Survey and Analysis.

Understanding the condition of any given pavement requires the conduct of pavement condition survey to evaluate the failure type and the fuctionality of the pavement using a pavement condition checklist. The three selected roads were visited and a list of failure modes on the flexible pavement was evaluated and the result of the checklist which includes the following list of known failure partern nameily: Alligator cracking, Bleeding, Block cracking, Bump and sags, Corrugation, Depressions, Edge cracking, Joint reflection cracking, Lane/ Shoulder drop off, Longitudinal and Transversal cracking, Patching and utility cut patching, Polished aggregate, Potholes, Railroad crossing, Rutting, Shoving, Slippage cracking, Swell, Weathering and revelling; shows that out of the 19 failure mode investigated, 13 of the pavement failure mode conditions were observed on the three selected roads. Pavement failure modes like alligator cracking, bleeding, block cracking, bump and sags, corrugation, depressions, edge cracking, lane/shoulder drop-off, rutting, and shoving were all observed on the three selected roads. Joint reflection cracking, polish aggregate, slippage cracking, and swell were observed at East-West road and Port Harcourt-Aba road but was not observed at Ogbia-Nembe road. Railroad crossing was not observed at any of the selected study roads. The result from the checklist showed that Ogbia-Nembe road had the least number of pavement condition failure type.

The most significant and predominant of all the failure mode on the three study pavement is alligator cracks. The results from Table 5 show that more alligator cracks were found on East-West Road than the other two roads selected for the study. Ogbia-Nembe road had the least number of cracks compared to the other two roads.

3.4. Traffic Survey Result and Analysis

12 days manual vehicle traffic count were conducted using – tallies on visually observed vehicles on the respective roads to estimate the daily traffic and average daily traffic (ADT) taken by directions as a result of non-availability of a weighing bridge. This manual count was conducted for 12 hours. 6am to 6pm on daily basis for the period of the traffic count using six enumerators on each of the study roads. The results of the traffic survey on each of the respective study roads are presented in Tables 6, 7 and 8 respectively. It can be seen thus that, the average daily traffic (ADT) for the studied roads are above the threshold in the specifications of the FGN Highway Design Manual. This indicates that there is significant degree of overloading on the road which is one of the major causes of pavement deterioration see figure 11.

Table 2: Responses to the distributed questionnaires to stakeholders on causes of flexible pavements

Survey Parameters	Ogbia-Nembe		East-West		Port Harcourt-Aba	
	Frequency	(%)	Frequency	(%)	Frequency	(%)
Questionnaires Distributed	200	100	200	100	200	100
Questionnaires Retrieved	166	83	188	94	185	92.5
Questionnaires Unreturned	34	17	12	6	15	7.5
Questionnaires Not Used	8	4	3	1.5	5	2.5
Questionnaires Used	**158**	79	**185**	92.5	**180**	90

Table 3: Results of statistical study of all respondents to the questionnaires on the studied alignments

Demographic Criteria	**Gender**	**Frequency**	**Percentage (%)**	**Cumulative Percentage (%)**
Gender	Male	488	93.3	93.3
	Female	35	6.7	100
Educational Qualification	Doctorate Degree	12	2.30	2.30
	Master's Degree	57	10.90	13.20
	Bachelor's Degree/HND	276	52.80	66.00
	National Diploma	105	20.00	86.00
	SSCE	73	14.00	100
Work Experience (Years)	1 - 5	87	16.63	16.63
	6 - 10	226	43.21	59.84
	11 - 15	160	30.59	90.84
	16 - 20	38	7.26	97.69
	21 and Above	12	2.31	100
Profession	Engineers	291	55.64	55.64
	Technologists	87	16.63	72.27
	Marketers	29	5.55	77.82
	Others	116	22.18	100

Table 4: Ranking of the possible causes of pavement failure based on a 5-Point Likert Scale for the responses obtained from the distributed questionnaires

Probable Causes of Pavement Failure	Responses					Weighted Mean	Rank
	NC 1	LC 2	N 3	C 4	MC 5		
Poor Quality of design	11.10 % 58	46.65 % 244	16.63% 87	13.3 % 70	12.24% 64	2.69	8
Poor Quality of construction Work	27.72 % 145	50.10 % 262	5.54 % 29	11.10% 58	5.54 % 29	2.17	10
Poor Workmanship	33.23 % 174	48.76% 255	1.55 % 8	9.99 % 52	6.50 % 34	2.08	12
Quality of Construction Materials	1.72 % 9	12.81 % 67	0 % 0	30.40% 159	55.07 % 288	4.24	2
Duration of project Execution	66.73 % 349	22.18 % 116	11.09 % 58	0 % (0)	0 % (0)	1.44	15
Poor Soil Condition of the Road (In-situ soil)	16.67 % 87	2.66 % 14	5.56 % 29	32.78% 172	42.33% 221	3.84	4
Inadequate Drainage Supply System	0 % 0	21.11 % 111	10 % 52	35.56% 186	33.33% 174	3.81	5
Use of specific Technology	32.22 % 168	60.56 % 317	7.22 % 38	0 % 0	0 % 0	1.75	13
Heavy Traffic	12.22 % 65	21.11 % 110	5.56 % 29	44.44% 232	16.67% 87	3.32	6
Poor Weather condition of Environment	15.56 % 81	69.44 % 363	5.56 % 29	7.22 % 38	2.22 % 12	2.11	11
Lack of Maintenance Culture	5.56 % 29	8.33 % 44	0 % 0	52.78% 276	33.33% 174	3.94	3
Poor Supervision	0 % 0	71.11 % 372	0 % 0	18.89% 99	10 % 52	2.68	9
Deliberate Sabotage	66.11 % 346	30 % 157	3.89 % 20	0 % 0	0 % 0	1.38	16
Lack of laboratory Investigation of construction materials	2.22 % 12	6.67 % 35	0 % 0	36.67% 192	54.44% 284	4.34	1
Quality Control Lapses	13.33 % 70	31.12 % 163	0 % 0	33.33% 174	22.22% 116	3.2	7
Absence of Plantation at places prone to land sliding	57.77 % 302	36.67 % 192	0 % 0	5.56 % 29	0 % 0	1.53	14

Key: **MC**: **Major Cause**; **C**: **Cause**; **N**: **Neutral**; **LC**: **Least Cause**; **NC**: **Not Cause**

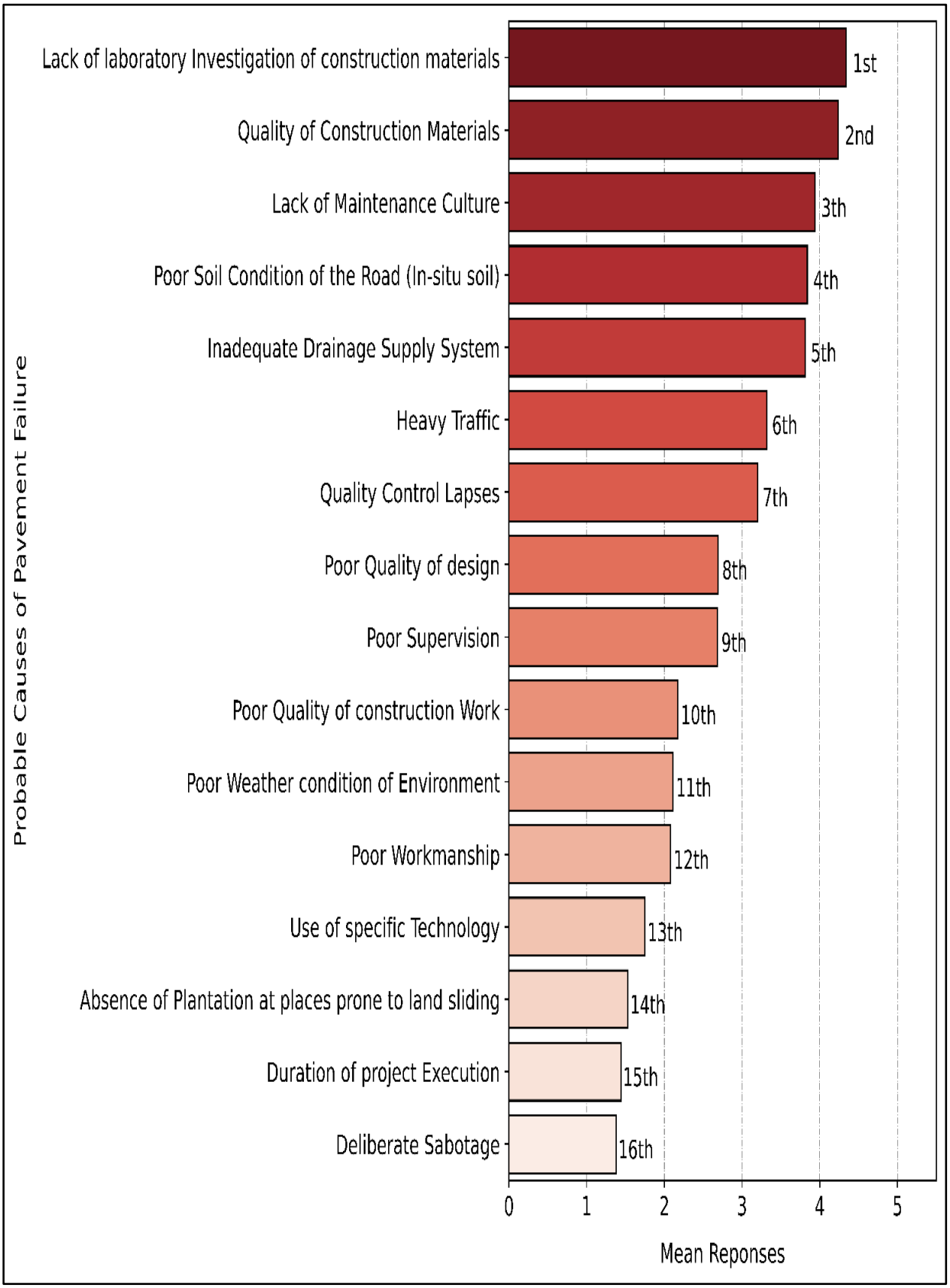


Figure 3: Ranking of the possible causes of pavement failure based on 5-Point Likert scale for the responses obtained from the distributed questionnaires

Table 5: Alligator Cracks found on the road sections

Sample Point	Alligator Cracks on Ogbia-Nembe Road	Alligator Cracks on East-West Road	Alligator Cracks on Port Harcourt-Aba Road
A	18	86	52
B	17	72	74
C	16	81	65
D	11	106	54
E	38	63	65
F	19	79	63
G	22	76	55
H	13	90	76
TOTAL	154	653	504

Table 6: Results of the three count station on Ogbia-Nembe road

Type of Vehicle	Elebele Junction		Otuabgagi Junction		Akipilai Junction		TOTAL	
	Nembe Bound	Ogbia Bound	Nembe Bound	Ogbia Bound	Nembe Bound	Ogbia Bound	Nembe Bound	Ogbia Bound
Heavy Vehicles	53	32	51	26	63	41	167 (1.16%)	99 (0.69%)
Passenger Car	2,384	2,426	2,212	2,234	3,005	3,103	7601 (52.86%)	7763 (54.03%)
Mini Bus / Pickup	2,189	2,253	2,102	2,212	2,321	2,042	6612 (45.98%)	6507 (45.28%)
TOTAL	4,626	4,711	4,365	4,472	5,389	5,186	14,380	14,369

Total Traffic Volume on both directions: 28, 749

Average Daily Traffic (ADT): 2,396

Number of Heavy Vehicles on each lane: 167/99

Percentage of Heavy vehicles on each lane: 1.16% &0.6%

Overall Percentage of Heavy Vehicle: 0.09%

Table 7: Results of the three count station on section of East/West Road from Eleme junction to Akwa Ibom State

Type of Vehicle	Eleme Junction		Onne Junction		Etim Junction		TOTAL	
	PH Bound	Akwa Ibom Bound	PH Bound	Akwa Ibom Bound	PH Bound	Akwa Ibom Bound	PH Bound	Akwa Ibom Bound
Heavy Vehicles	47,332	48,924	49,243	38,433	24,453	21,073	121,028 (40.8%)	108,430 (41.6%)
Passenger Car	49,263	44,927	39,401	30,103	25,228	25,471	113,892 (38.4%)	100,500 (38.5%)
Mini Bus / Pickup	28,439	26,989	18,424	12,444	15,033	124,349	61,896 (20.8%)	51,872 (19.9%)
TOTAL	125,034	120,840	107,068	80,980	64,714	58,983	296,816	260,803

Total Traffic Volume on both directions: 557,619

Average Daily Traffic (ADT): 46,468.25

Number of Heavy Vehicles on each lane: 121,028 / 108,430

Percentage of Heavy vehicles on each lane: 40.8% / 41.6%

Overall Percentage of Heavy Vehicle: 41.15%

Table 8: Results of the Three Count Station on Section of Port Harcourt-Aba Road From Eleme Junction to Osisioma, Abia State

Type of Vehicle	Imo Gate Junction		Obehie Junction		Ariara Junction		TOTAL	
	PH Bound	Aba Bound	PH Bound	Aba Bound	PH Bound	Aba Bound	PH Bound	Aba Bound
Heavy Vehicles	26,557	21,912	34,580	32,762	32,943	31,824	94,080 (35.6%)	86,498 (34.2%)
Passenger Car	28,618	26,684	41,428	41,392	38,680	37,923	108,726 (41.2%)	105,999 (41.9%)
Mini Bus / Pickup	18,765	17,868	21,057	22,164	21,524	20,424	61,346 (23.2%)	60,456 (23.9%)
TOTAL	73,940	66,464	97,065	96,318	93,147	90,171	264,152	252,953

Total Traffic Volume on both directions: 517,105

Average Daily Traffic (ADT): 43,092

Number of Heavy Vehicles on each lane: 94,080 / 86,498

Percentage of Heavy vehicles on each line: 35.6% / 34.2%

Overall Percentage of Heavy Vehicle: 34.9%

Table 9: **Comparison of the CBR and the Average Daily Traffic volume**

Road	Average CBR	Total Traffic of Heavy Vehicle	Average Daily Traffic for Heavy Vehicle
Ogbia-Nembe	17.91	266	23
East-West	6.3	229458	19122
PH-Aba	7.64	180578	15049

Table 10: The Federal Republic of Nigeria Highway Design Manual Part 1; 2006 specified in schedule 1:203:02 (Average Daily Traffic)

TYPE OF HIGHWAY	NUMBER OF LANES	PASSENGER CAR UNIT
Secondary	1No. (3.66m)	330
Primary	2No. (3.66m)	5,000
Dual way	3No. (Divided by Median)	30,000

Table 11: Comparison of ADT of the various roads with the limits of the Federal Republic of Nigeria Highway Design Manual Part 1; 2006 specified in schedule 1:203:02 (Average Daily Traffic)

Road	Type of highway	FGN Highway Design Manual Part 1; 2006 (car unit limit}	Average daily traffic	% exceeded limit
Ogbia – Nembe Road	Primary	5,000	2,396	Less By (52%)
Section of East / West Road from Eleme to Akwa- Ibom	Dual Way	30,000	46,468.25	54.8%
Section of Port Harcourt - Aba Express Road	Dual Way	30,000	43,092	43.64%

4. CONCLUSION

From the results of the various surveys conducted in finding the cause(s) of failures on the three selected flexible pavements structures in the Niger Delta Region, the following are identified as the remote causes of the failures in other of severity: Quality of Construction Materials, Poor Soil Condition of the Roads (In-situ soil), Inadequate Drainage Supply System, Lack of Maintenance Culture, Lack of laboratory Investigation of construction materials, Poor Quality of design, Heavy Traffic. This findings gives further credence to the importance of Geotechnical investigation to all engineering works mostly in the Niger Delta Region and the Nigeria Institute of Geotechnical Engineers most be on the forefront to champion this worthy course.

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