SEVERITY INDICES OF VARIABLES CAUSING ROAD COLLAPSE IN NIGERIA – A CASE STUDY OF BENIN CITY

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Abstract
The paper identified some problems militating against maintenance of roads which lead to road and highway failures in Benin City, with a view to raising the awareness of stake holders to mitigate them. Data was acquired through a carefully structured questionnaire randomly administered to stake holders such as: contractors, consultants and labourers and associated workmen in the highway construction Industry. A total of 120 questionnaires were randomly distributed and a recovery rate of 83.33% was observed. A statistical approach was adopted in the analysis of the results obtained using severity index method. The highest severity was ranked 5, from a scale of 1-5. The results showed that indiscriminate dumping of waste in drainage was the most severe problem and ranked 3.64 on the scale and was followed by the use of substandard materials for highway construction which ranked 3.55. The paper concludes that, the attitude of citizens who dump refuse in drains need to change. Highway contractors compromising the quality of jobs will also need to change. The relevant professional associations and the government agencies should jointly work to stem the trend.

Keyword: Severity index, Highway, Construction, Materials and Supervision.

Introduction

Infrastructure is a key area in a nation's economy since it provides the main thrust and impetus area in the growth of a developing nation (Maniar, 2013). Roads are gateways to development as they create access to facilities (Musa and Okovido, 2004). In Nigeria, the collapse of engineering facilities such as roads has attracted a number of opinions on the causes (Oyewande, 1992). Benin City was chosen for this study because of its strategic position. It is located between 6.19N and 5.37E (James, 1972).

A basic objective of road maintenance is to ensure that the road that has been constructed is sustained in its original condition. In practice regular and timely maintenance will increase the life span of the road. Due to reasons that are difficult to

access, road maintenance is often viewed as an activity that is carried out only when the road is damaged. The situation is particularly critical with unsealed roads which is the case with the majority of provincial, district and commercial roads. This means that the road once constructed in such areas has to be looked after on a regular bases. This is why routine maintenance is so important and is the core of effective maintenance system.

The term recurrent maintenance is sometimes used over certain activities (such as light grading) which are carried out the year over and above the activities of routine maintenance. Periodic maintenance is an activity that is undertaken every 3-5 years and is concerned with rectifying defects which are outside the scope of routine maintenance.

Maintenance being a recurrent activity should be financed from the recurrent budget. The funds allocated to it should relate to a maintenance plan which defines those roads in maintenance condition.

The present description of road maintenance reflects the curvatures rather than preventative approach maintenance. Roads are essential to a countries economic and social development (Maniar, 2013). For most sectors of the economy, they form vital links between production centers and market. Their multiple function of providing access to employment social and health services and education, makes them key element in the fight against poverty by opening up rural areas. Societal failure often occurs where there is no access and stimulating economic and this leads to poor social development. It has been discovered that urban road network in Nigeria is inefficient and grossly inadequate (Ogunbodede, 2008).

Ajayi (1982) noted that road pavement is founded on coprolite rather than the strong lateritic horizons. The deterioration results helps to aim for recalibration of a number of known relationships for roughness and gravel loss developed by Paige and Visser (1991). Failure of roads in Nigeria is a rule, not the exception. History has shown that roads, even if the proper design has been prepared, it is unlikely that the road will be constructed to this standard due to poor quality control resulting in inadequate compaction rates, thicknesses and pavement quality (Pollit, 1950). It was observed by Jegede (1994) that the soil material properties at failed sections of the road had not been thoroughly investigated. Little or no consideration was given to the effect of clay mineralogy and associated engineering soil behavior, as highway foundation materials and the weakening of pavements was likely to be induced by the surface water ingress through cracks and joints that developed in highway pavements Jegede (2000). The existing bitumen hardening model (Oliver,1987) described the rate of which the bitumen binder in a sprayed seal hardens in different areas of Australia and was based on information from 10 special arranged full scale road trials and 13 non trial sites. Effective road maintenance can hardly exclude the use of cold asphalt. The use of cold asphalt for potholes of a square metre to be patched. Hot asphalt would not

readily be available for such a small square metre patch, since no asphalt plant will batch asphalt for a one square metre patch (Ferma Cold Asphalt, 2013). A wild variety of chemicals are commonly used to treat road surface to minimize wear, reduce dust or de-ice. However many of these products give only minimal benefits and represent a potential hazard to water quality (United States Environment Protection Agency, 1975).

Adeyemi (1992) investigated some geotechnical properties of the residual lateritic soils adjacent to some sections of the Lagos-Ibadan expressway and concluded that the degree of stability of the flexible road pavement increased with both the amount of kaolinite present in the sub-grade soils and their California bearing ratio (CBR) and unconfined compressive strength (UCS). The need to take future climate change into account in road drainage design has been suggested (Kalantari and Folkenson, 2013). The work also made suggestions concerning drainage system construction, operation and maintenance, including increment of the capacity of drainage facilities, stabilizing ditch slopes and various measures to prevent clogging of culverts.

Severity index is a mathematical method of assessment of the contribution of a particular factor to the sum total of a function. This has been used in the present work to evaluate the effect of variables ranging from design to utilization of roads in Nigeria. There exist other methods of analysis such as chi- squared and the t-test. Severity index has been applied because of its adaptability and it readility suited the work.

Method

The work applied questionnaire survey method, since the study was aimed at identifying the problems associated with road maintenance. The sample population consisted of practicing consultants in the construction industry. These include the civil engineers, and workman/laborers.

The questionnaire was structured to reveal the problems causing road failure and respective maintenance. It also seeks to reveal the level of diligence of consultants to their work as well as both the contractors and the workman/laborers in the field. The questionnaire used was divided into three sections. Section A, sought the background or subject area, status with respect to this profession, as well as the familiarity with the roads of the responder.

Section B was directed to the civil engineers with supervisory duties. This section helped to reveal the level of diligence the contractors have regarding their duties. This section consists of questions like; has work been done according to specification, does the civil engineer on site insists that work should be checked or not. Section C examined problems associated with highway maintenance. The data was analyzed according to the structure of the questionnaire, determining the severity index for each variable. This was obtained by assigning weights to the responses. The weights were;

Strongly Agree = 4
Agree = 3
Disagree = 2

Strongly disagree = 1
No response = 0

The severity index was determined by;

$$S.I = \frac{\sum_{w-1}^{5} R_w W}{R_t} \text{ ---------- (1)R}$$

where R_w is the number of respondents,
w is the weight or points assigned, and
R_t is the total number of responses.

If a respondent did not fill a particular variable, it was still be counted among the total respondents and added to the divisor to determine S.I.

Results

A total of 120 questionnaires were randomly distributed and the following recovered and found usable; Contractors = 76, Consultant = 21 and Workmen = 3. This gave a recovery rate of 83.33%.

Table 1: Time spent in Benin

	<5yrs	**6-10yrs**	**11-15yrs**	**>16yrs**	**Total**
Contractors	24	9	5	38	76
Consultants	3	8	2	8	21
Workman/laborers	1	2	0	0	3
Total	28	19	7	46	100
Percentage	28%	19%	7%	46%	100%

Table 2: Knowledge of the roads in Benin

	No of respondents	**%**
Yes	93	93%
No	7	7%
Total	100	100%

Table 3: Professional Registration

	No of respondents	**%**
Yes	60	60%
No	40	40%
Total	100	100%

Table 4: Active Participation in the Industry

	<5yrs	**5-10yrs**	**10yrs**	**Total**
Contractors	33	34	9	76
Consultants	4	9	8	21
Workman/laborers	1	1	1	3
Total	38	44	18	100
Percentage	38%	44%	18%	100%

Table 5: Type of supervision

	No of respondents	**%**
Permanent	36	43.37%
Periodical	25	30.12%
Occasional	22	26.50%
Total	83	100%

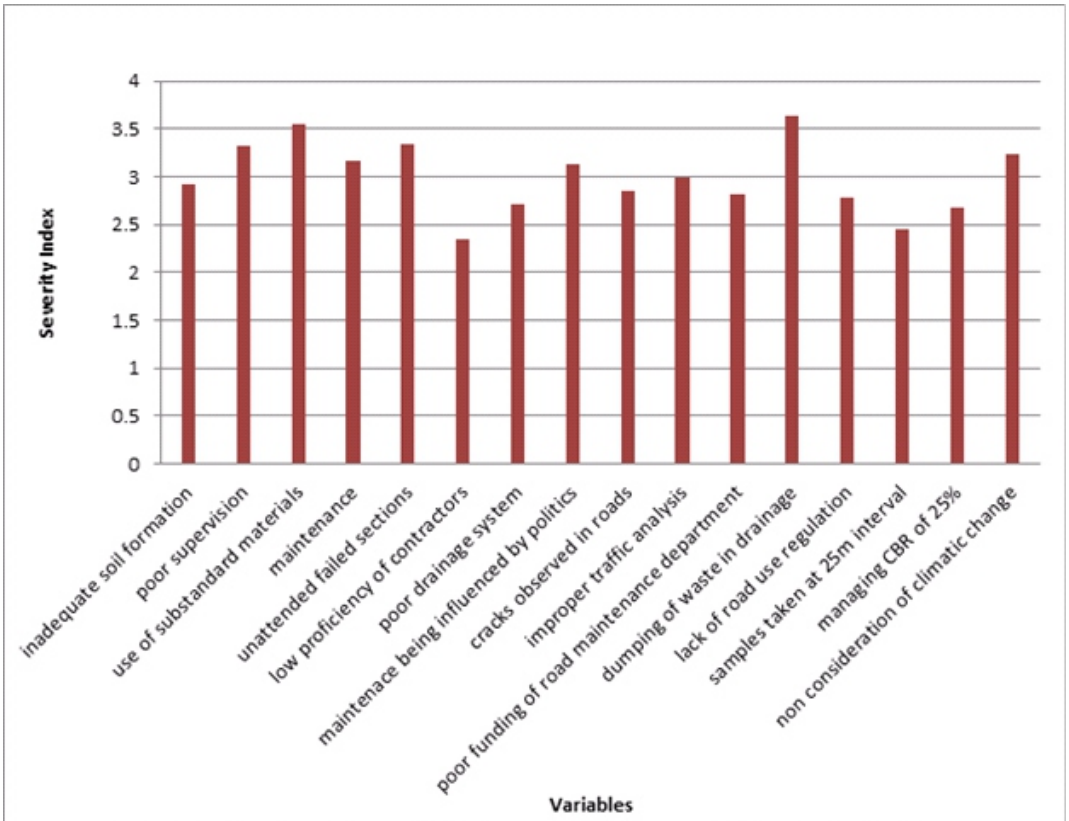

Fig.1: Relationship between Variables causing Highway failure in Benin City

Discussion of Results

The tables contained only one type of question asked and the information desired except in section C which contained numerous questions. Table 1 showed that the percentage of respondent that have spent over 16 years in Benin City is 46%. This reveals that majority of the respondents have spent reasonable number of years in the city to have known much about the roads. Table 2 showed that 93% of the respondents were conversant with the roads in Benin City. Less than half (40%) of the respondents are not registered with their professional

Table 6: Variables causing Highway Failure

	Strongly agree (%)	**Agree (%)**	**Disagree (%)**	**Strongly disagree (%)**	**Seventy index**
Inadequate soil formation from soil expert	36	32	20	12	2.92
Poor supervision leads to non-adherence to specification	53	32	10	5	3.33
Substandard construction material contribute to road failure	63	31	4	2	3.55
Maintenance in Benin is more of rehabilitation than prevention	33	54	10	3	3.17
Failed sections are left unattended to for a long time	45	47	6	2	3.35
Low proficiency of road contractors	12	33	33	22	2.35
Poor drainage system in road as a result of flat terrain	25	26	44	5	2.71
Decision for road maintenance are influenced by politics which are not necessarily in the actual maintenance	40	38	18	4	3.14
The edge cracks observed in roads are due to excessive traffic load plying the road	18	54	23	5	2.85
Improper traffic analysis led to most causes of failure	24	51	25	0	2.99
Poor funding of road maintenance department	16	59	16	9	2.82
Indiscriminate dumping of waste in drainage	68	29	2	1	3.64
Lack of road- use regulation in Benin City	17	49	29	5	2.78
It is advisable to take samples at every firm rather that 25m to reduce cost	14	27	50	9	2.46
A CBR of 25% for sub grade can be manageable for any road project in Benin City	15	44	35	6	2.68
Non consideration of climate change, the design of drainage leads to over flooding on the road	40	45	14	1	3.24

body (Table 3). Table 4 showed that the percentage of respondents actively engaged in their profession in less than 5 years was 38% and within 5-10 years 44%, while in more than 10years was 18%. This revealed that bulk of the respondents were experienced consultants. About 80% of the consultants would check to ensure that no defective work has been done in their absence. Most consultants (43.37%) were engaged in permanent supervisory duties while 30.12% and 26.50% were engaged in periodical supervision, particularly after specific stages of construction (Table 5). It was observed that indiscriminate dumping of waste in drainage system is ranked the highest with a S.I of 3.63 in Table 6 (see Figure 1) This could also have led to the blockage of drainage outlet which in turn can resulted in over flooding of the roads and thereby weakened the subgrade due to water ingress. This factor was closely followed by the use of poor quality materials for road construction which ranked 3.55. Figure 1 also revealed that unattended failed sections eventually leading to total collapse of the road infrastructure was a major problem. It ranked 3.35 on the severity index. The figure showed that the least causative factor with a severity index of 2.35 was low proficiency of road contractors. This can only thrive when there is little or no expert supervision. However, the rating of this showed that it is not a major problem in the highway industry of Nigeria. It may be suggestive also that the industry is not lacking in the area of trained manpower.

Conclusion

Thus, the following conclusion is hereby drawn from the fore going:

1. Indiscriminate dumping of waste has been shown to be a major cause of road collapse with a severity index of 3.63. Relevant agencies should monitor and remove waste deposits from road drainages.
2. The use of substandard materials has also been shown to be a major cause of road collapse in Nigeria, with a ranking of 3.55. All effort must be made to ensure that only materials that meet high strength and durability requirement are produced and sold, and where possible construction materials including soil, are tested before use. There is no doubt that if relevant precautions are observed in the stated problems, there would be less occurrence of highway failure in the country. The relevant professional associations and the government agencies should jointly work to stem the trend of highway failure due to this variable.
3. The least road failure causative factor is low proficiency of contractors.

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