Journal of Engineering and Applied Sciences 3 (3): 239-241, 2008
ISSN: 1816-949X

Road Pavement Failure Caused by Poor Soil Properties along Aramoko-Ilesha Highway, Nigeria

Ogundipe, Olumide Moses
Department of Civil Engineering, University of Ado-Ekiti, Ado-Ekiti, Nigeria

Abstract: This study looks at the effects of poor soil properties on highway pavement failure on critical locations along Aramoko-Ilesha road, Nigeria. Laboratory soil tests on the sample collected showed the moisture content range 8.44-21.63%, specific gravity from 2.30-2.80, liquid limit from 27.30-42.50%, linear shrinkage from 8.9-9.9%, plasticity index from 1750-2050 kg m^{-3}, optimum moisture content from 10.00-18.00% and California bearing ratio from 5.45-36.64%. The liquid limit and the plasticity index do not conform to specification and the CBR values were far below the values specified for subbase and base course of road pavement. It was discovered that the use of materials with poor properties was responsible for the failure of these locations.

Key words: Road pavement failure, poor siol properties, liquid limit, Aramoko-Ilesha road, Nigeria

INTRODUCTION

A pavement section may be generally defined as the structural material placed above a subgrade layer (Woods and Adcox, 2002). In asphaltic pavement, it is typically a multi-layered system comprising the subgrade (support), subbase, base course and surfacing. Its principal function is to receive load from the traffic and transmits it through its layers to the subgrade (Kadiyali, 1989). A pavement is said to be defective, when it can no longer perform this function during its design life.

Most roads in Nigerian cities toady are characterized by failure of all kinds like potholes, cracks, depression, ruts, etc. and there is not just one reason for each type of failure. The state of our roads stands out like a sore thumb and their national picture is simply scandalous (Komolafe, 2006). This makes it difficult for people to meet their access needs, because they are confronted with delays resulting from traffic congestion and accidents that have claimed lives of breadwinners of many homes.

In previous research, it was discovered that roads failed due to the following reasons:

- Negligence of road maintenance (Madedor, 1992; Adeniran, 2007).
- Inadequacies in design and poor workmanship (Ogundipe, 2001).
- Poor soil properties like low CBR (Jegede, 2004).

This situation has crippled our economy and it requires urgent attention. Therefore, this research aims at examining the geotechnical properties of the materials at failed sections of the road, with a view to proffering solution to failures of our roads shortly after construction.

MATERIALS AND METHODS

The disturbed soil samples for the work were collected at three locations along the highway. Some of the samples were sealed in a polythene bags to preserve the insitu moisture condition of the soil. The 3 samples were labeled A-C.

Sample A : Ekiti West Local Government, Aramoko, Ekiti-State.
Sample B : Efon Alaaye, Ekiti-State.
Sample C : Alawada Hotel, Ilesa, Osun-State.

The samples were subjected to the following laboratory tests.

Mechanical sieve analysis: The test was carried out in accordance with BS 1377 (1990).

$$\text{Percentage retained (kg)} = \frac{\text{Weight of soil retained}}{\text{Total weight of sample}} \times 100\% \quad (1)$$

$$\text{Percentage passing (kg)} = \text{100-Cummulative precent retained} \quad (2)$$

Specific gravity: The test was carried out in accordance with BS 1377 (1990).

$$\text{Specific gravity} = \frac{\text{Density of soil particles}}{\text{Density of water}} \quad (3)$$

Moisture content: The test was carried out in accordance with BS 1377 (1990).

$$\text{Moisture content (\%)} = \frac{Ww}{Wd} \times 100\% \quad (4)$$

Where,
Ww = Weight of water.
Wd = Weight of dry soil.

Atterberg limit: The test was carried out in accordance with BS 1377 (1990).

$$\text{Linear shrinkage (\%)} = \frac{Lo - Lf}{Lo} \quad (5)$$

Where,
Lo = Length of wet soil bar.
Lf = Length of dry soil bar.

$$\text{Plasticity index} = \text{Liquid limit-Plastic limit} \quad (6)$$

Compaction test: The test was carried out in accordance with BS 1377 (1990).

$$\text{Bulk density, } \ell \text{ (kg m}^{-3}) = \frac{Ma - Mb}{\text{Volume of mould}} \quad (7)$$

Where,
Ma = Weight of mould + compacted soil.
Mb = Weight of mould.

$$\text{Dry density (kg m}^{-3}) = \frac{\ell}{1 + w} \quad (8)$$

Where,
ℓ = Bulk density.
w = Moisture content.

California bearing ratio (CBR): The test was carried out in accordance with BS 1377 (1990).

$$\text{California bearing ratio} = \frac{\text{Test load}}{\text{Standard load}} \times 100\% \quad (9)$$

RESULTS AND DISCUSSION

Table 1 shows the summary of the test results. The values represent the average for the three replicates of each sample tested.

Table 1: Results of laboratory soil tests

Test	Sample A	Sample B	Sample C
Natural moisture content (%)	21.63	8.440	16.51
Specific gravity	2.590	2.800	2.30
Liquid Limit (LL) %	42.50	27.30	40.80
Plastic Limit (PL) %	23.54	NP	15.55
Plasticity Index (PI) %	17.16	-	24.53
Linear shrinkage (%)	9.000	9.90	8.90
Maximum Dry Density (MDD) kg m^{-3}	18000	2050	1750
Optimum moisture Content (OPC) %	18.00	10.00	16.50
California Bearing Ratio (CBR) %	5.450	36.64	13.41

Mechanical sieve analysis: American Association of State Highway and Transportation Official (AASHTO) classification of soils shows that Sample A falls within A-2 (A-2-7) and Samples B and C within A-2 (A-2-6) indicating they are silty or clayey gravel and sand.

Natural moisture content: As shown in Table 1, the moisture content ranges from 8.44-21.63%. These were considered adequate.

Specific gravity: The values of the specific gravity of the three samples are shown in Table 1. They are appropriate for subgrade, subbase and base course materials.

Atterberg limits: Sample A has liquid limit (LL) and Plasticity index of 42.50 and 17.16%, respectively. These values do not meet the requirement that the LL and PI of Subbase should not be more than 35 and 12%, respectively (FGN, 1997). Sample B which has LL of 27.30% and non-plastic conforms partially with specification, while Sample C with LL of 40.08% and PI of 24.53% do not meet the specified requirement. The three samples have shrinkage limit greater than 8% indicating that all the samples are susceptible to shrinkage failure (Brink *et al*., 1982; Jegede, 1994).

Compaction characteristics: As shown in Table 1 Maximum Dry Density, (MDD) and Optimum Moisture Content, (OMC) of the samples range from 1750-2050 kg m^{-3} and 10.00-18.00%, respectively. These values are considered good, if 100% of the MDD and OPC are attained during field compaction.

California bearing ratio (CBR): The California bearing ratio of the samples range from 5.45-36.64%. These values do not meet the requirement that subbase and base course should have CBR of not less than 30 and 80%, respectively (FGN, 1997). The presence of illite in the soil may be responsible for the low CBR (Jegede, 1997).

CONCLUSION

From the study, it was discovered that poor geotechnical properties of the subbase and base course were responsible for the failure of the road pavement. The liquid limit and the Plasticity index do not conform to specification. The shrinkage limits of the materials were high indicating the materials would experience shrinkage failure. The low values of the CBR could cause the failure of the road.

Therefore, it is important that materials that conform to specification are used in the construction of the road pavement. In some cases, appropriate correction measures could be adopted to make the materials suitable, such measures include stabilization with bitumen, Portland cement, lime, fly ash and other pozolans. Also, the road pavement can be prevented from failing before its design life by providing good drainage. This prevents ingress of water into the road pavement, thus reducing the risk of decreasing the CBR value on which the road pavement was designed.

Lastly, adequate routine, periodic and emergency maintenance will help prevent our roads from failing before their design life.

REFERENCES

Adeniran, M.S., 2007. Highways: Challenges of Maintenance and Development. A Technical Paper Presented at the meeting of Nigerian Society of Engineers, Ado-Ekiti Branch.

Brink, A.B.A., J.C. Partridge and A.A.B. Williams, 1982. Soil Survey for Engineering. Claredo, Oxford.

BS 1377, 1990. Method of Test for Soils for Civil Engineering Purposes, London.

FGN, 1997. Government of the Federal Republic of Nigeria, General Specification (Roads and Bridges), Vol. II.

Jegede, G., 1994. Engineering Geotechnical Significance of Suoerficial Deposits in the Carrightohil area co.cork, Ireland. Nig. J. Sci., 2 (8): 153-158.

Jegede, G., 1999. The Effect of Groundwater and Soil Properties on Hoghway Pavement Failure at Ayewa locality along Ikere-Ado-Ekiti, stretch of the F209 Highway, South Western, Nigeria Journal of Technoscience, Vol. 3.

Jegede, G., 2004. Highway Pavement Failure Induced by Poor Geotechnical Properties along a section of F209 Okitipupa-Igbokoda Highway Southwestern, Nigeria. Ife J. Sci., 6(1): 41-44.

Kadiyali, L.R., 1989. Principle and Practice of Highway Engineeering. 2nd Edn. Delhi Khanna Technology Publication.

Komolafe, K., 2006. The Shame of Nigeria's Roads. Thisday Newspaper, Edition.

Madedor, A.O., 1992. Common road maintenance problems, causes and possible slutions. Engineering Focus-A. Mag. Nig. Soc. Eng., Vol. 4, No. 4.

Ogundipe, O.M., 2001. Causes of Highway failure in South Western Nigeria. A Project Report Submitted to Civil Engineeering Department, University of Ado-Ekiti. Unpublished.

Woods, W.R. and J.W. Adcox, 2002. A general characterization of pavement system failures with emphasis on a method for selecting repair process. J. Construction Edu., 7 (1): 58-62.