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PRELIMINARY ASSESSMENT OF IRON ORE TAILINGS STABILIZED WITH QUARRY FINES AND CEMENT FOR PAVEMENT SUBBASE

*[1]Igbadumhe O. A., [2]Amadi A.A., [3]Alhassan M.
[1,2,3]Department of Civil Engineering, School of Infrastructure and Process Engineering, Federal University of Technology, Minna, Niger State Nigeria.
*Corresponding author email:tonyoshio@gmail.com

ABSTRACT
This study examined the preliminary assessment of Iron Ore Tailings (IOT) stabilized with Quarry Fines and cement for road pavement construction. As a result, index properties and compaction tests of the IOT were prepared with 0,5,10,15 and 20% Quarry fines and 0, 3, 6, 9 and 12% cement and evaluated. The results indicate that the materials fall short of standard in gradation, the IOT and Quarry Fines were found to have specific gravity of 3.68 and 2.53 respectively. The mixtures were found to be non – plastic (NP). From compaction, it was observed that the optimum moisture content reduces with increase in cement from 18 to 6% whereas the maximum dry densities increased from 2.07 to 2.42g/cm^3 with increase in cement content.

Keywords:, *IOT, Quarry Fines, Subbase Pavement, Cement*

1 INTRODUCTION

Tremendous quantities of materials are used annually in the construction and maintenance of highway pavements at all levels of the roadway network. A subbase is that layer of aggregate material laid on a subgrade on which the base course layer is located. Rising energy costs and depletion or shortages of conventional quality paving materials in many areas have contributed to a helical financial burden on highway agencies (Yellishetty, 2009). As a result, there is accretive interest in making optimal use of available resources (resources include money, materials, manpower, etc.). Optimal use of available resources can imply the development of "new" materials and/or the use of hitherto considered "marginal or unacceptable" locally available materials.

In this context, Marginal materials can be defined as materials which do not in their present form possess quality levels as defined by current highway standards sufficient for their use as various pavement structural components including surfaces, bases, and/or subbases. Waste materials such as iron ore tailings belong to this category. Iron ore tailings are waste materials obtained as an end product of mining activities of iron ore (Kuranchie, 2014).

Soil stabilization is a general term for any physical, chemical, biological or combined method of changing a natural soil to meet an engineering purpose. Improvements arising from this include increasing the weight bearing capabilities, tensile strength, and overall performance of in-situ subsoils, sands, and other waste materials in order to strengthen road surfaces. The use of stabilization means that a wider range of soils can be improved for bulk fill applications and for construction purposes. The most common method of stabilization involves the incorporation of small quantities of binders, such as cement, lime, fly ash, to the aggregate (Pandey 2017).

Cement is a binder used to improve geotechnical properties of soils for engineering purposes. Cements used in construction are usually inorganic, often lime or calcium silicate based and can be considered hydraulic or non – hydraulic depending on its ability to set in the presence of water. Cement bound materials comes in multiple of types ranging from soil cement through lean mix to mass and reinforced concrete. Cement modified soils contains relatively small proportion of Portland cement the result is caked or slightly hardened material similar to soil but with improved mechanical properties such as lower plasticity, increased bearing ratio and shear strength and decreased volume change (Venkatramaiah, 2006).

MATERIALS

Iron Ore Tailings (IOT). The IOT was obtained from the Nigeria Iron Ore Mining Company, Itakpe, Kogi State, Nigeria.

Quarry Fines; Quarry Fines were obtained from Maitumbi quarry, Minna, Nigeria. Only fraction passing through BS. Sieve No. 4 (4.76mm) was used in the study.

Cement; Ordinary Portland cement (OPC) type – 1 (Dangote Cement from Obajana) was locally sourced within Minna Metropolis to comply with BS12: 1996; specification for Portland cement

Water; Clean portable drinking water was used in this work.

2 METHOD

Index Properties

Particle size distribution, Atterberg limit and specific gravity tests were conducted in accordance with BS 1377 and BS 1924 (1990).

Compaction Tests

Compaction tests were carried out on the IOT – Quarry fines mixtures stabilized with cement using the BS Heavy compactive effort in accordance with BS 1377 (1990) and BS 1924 (1990).

3 RESULTS AND DISCUSSION

Particle Size Distribution

The particle size distribution curves presented in Figure 1a and 1b shows that the IOT and Quarry Fines contains about 21.9 and 16.58% fines respectively. This indicates that the IOT and Quarry Fines may be classified as A – 3 in accordance with AASHTO classification or Poorly Graded Sand (SP) under the USCS. In view of this, it was observed that from local specifications (Nigeria General Specification (NGS)), the IOT do not meet the minimum requirements of fines of less than 20% which makes it in the natural form unsuitable for use as subbase material (NGS).

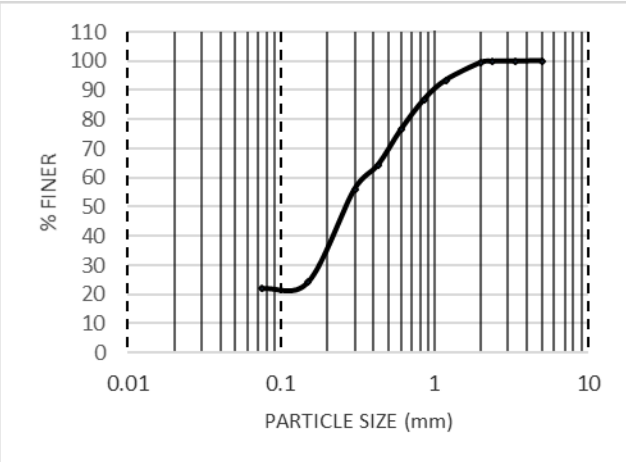

FIGURE 1A: PARTICLE SIZE DISTRIBUTION OF IOT

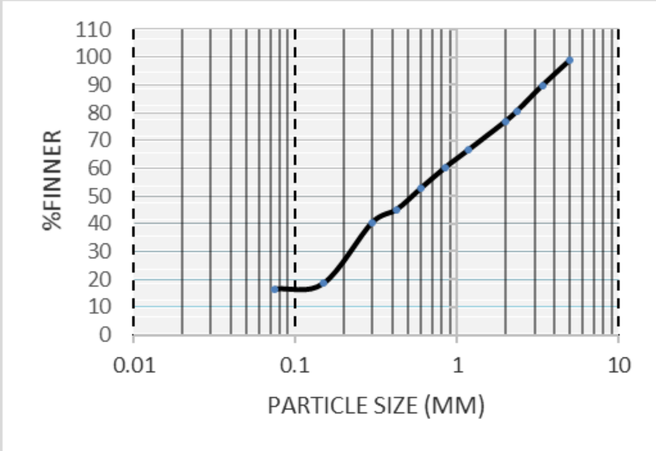

FIGURE 1B: PARTICLE SIZE DISTRIBUTION OF QUARRY FINES

Atterberg Limit

The mixtures were observed to be non – plastic nevertheless, IOT was found to fall short of liquid limit requirement of not more than 35% for subbase as outlined in NGS. Introduction of quarry fines initially increased the liquid limit to 60% at 10 % QF and then reduced then liquid limit 27% at 20% QF. With introduction of cement, it was discovered that the liquid limit further reduced to 26% at 12%cement content of the mixtures. Thus liquid limit of the mixture satisfies the requirement for pavement subbase and base as outlined in the specification NGS (1997).

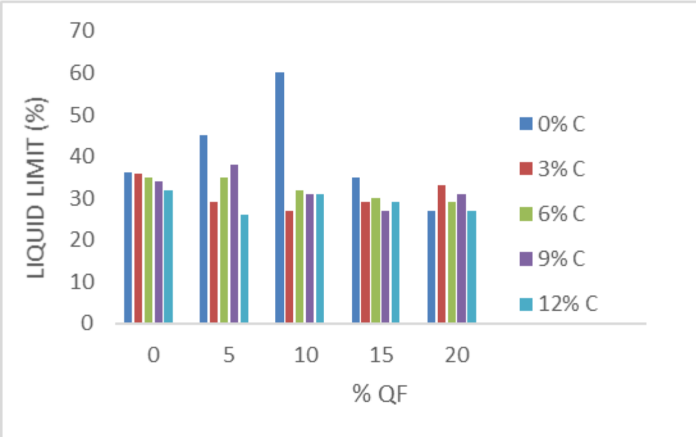

FIGURE 2: ATTERBERG LIMIT

Compaction Characteristics

The Maximum Dry Density and Optimum Moisture Content compacted with BS Heavy effort were evaluated. Dry densities are found to be on the increase with addition of quarry fines from 2.07 to 2.29 g/cm^{3}at 20% quarry fines.

Effect of Quarry Fines and Cement on MDD

The introduction of quarry fines – IOT mixture resulted in an increase in the maximum dry density from 2.24g/cm^3 at 5% QF to 2.29g/cm^3 at 20% QF. The introduction of cement to the mixture further resulted in an increase up to 2.42g/cm^3 at 20% QF 12% Cement. In soils stabilized with non-plastic quarry fines or similar materials, the introduction of fines usually causes increase in angle of internal friction consequently decreasing cohesion but with increase in quantity in excess of the required amount to fill the voids, lesser strength properties results (Amadi, 2011).

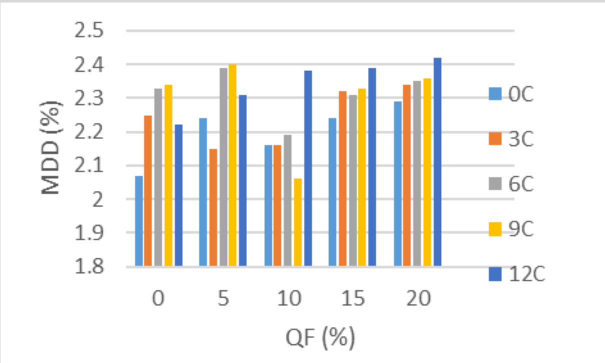

FIGURE 3: EFFECT OF QUARRY FINES AND CEMENT ON MAXIMUM DRY DENSITY

Effect of Quarry Fines and Cement on Optimum Moisture Content

From the fig 4, it was observed that the moisture content increased with increase in quarry fines and decreased with increase in cement content from 12% at 0% cement to 6% at 12% cement content. Less amount of water is usually required for a reduced efficient surface to attain optimum moisture content. This can be attributed to the continuous decrease in optimum moisture content with increase in cement content (Meshiba and Akanbi 2007).

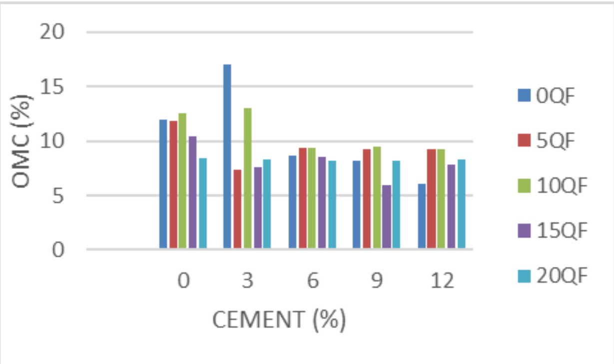

Fig. 4. Effect of Quarry Fines and Cement on Optimum Moisture Content

4 CONCLUSION

This investigation was carried out in an attempt to study the compaction characteristic of IOT – Quarry Fines and Cement mixture using the BS Heavy energy. IOT was modified with quarry fines in proportions (0 – 20%) strided at 5%. These mixtures were evaluated for Atterberg limits, specific gravity, as well as compaction. The results obtained shows that all the mixtures were non – plastic (NP), the dry density increased with increase in quarry fines from 2.07 to 2.29 at 20% as well as increase in cement content up to 2.42 at 12% while the optimum moisture content (OMC) decreased from about 13% to 6%. The IOT was found to have specific gravity of 3.68 and the quarry fines 2.53.

In terms of compliance with specifications as stipulated by local standards, the gradation, liquid limits and plastic limits for the mixture gratifies specification requirements for use of cement stabilized soils for road pavement construction.

Data from this study could provide baseline information for highway Engineers in the use of this material for stabilization of IOT for effective delivery of serviceable roads in rural areas.

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