Journal of Mining and Environment (JME), Vol. 15, No. 2, 2024, 427-438

Shahrood University of Technology

Journal of Mining and Environment (JME)

Journal homepage: www.jme.shahroodut.ac.ir

Iranian Society of Mining Engineering (IRSME)

Geotechnical Evaluation of Mine Wastes for Utilization in Embarkment Construction in Jos, Central Nigeria

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Article Info

Received 31 August 2023
Received in Revised form 6 November 2023
Accepted 1 December 2023
Published online 1 December 2023

DOI: 10.22044/jme.2023.13550.2503

Keywords

Tailings
Overburden
Mining activities
Embankment

Abstract

Nigeria is abundantly blessed with solid mineral resources such as copper, gold, and tantalite, which are essential for the economic growth of the country. The extraction of these mineral resources comes with the generation of huge amount of waste. This study examines the possibility of utilizing some mine wastes from Jos, Nigeria, in embankment construction by subjecting them to relevant laboratory geotechnical experiments. The results indicates that the overburden materials contain clay-sized fraction ranging 5-20%, while the sand fraction ranged 42-82%, which is an indication of the predominance of sand size particles. On the other hand, the clay-sized particles in the tailings range 5-21%, while the sand fractions range 65-80%. The overburden materials recorded liquid limit values ranging 26-48% and plasticity index ranging 6.3-21%, while the liquid limit and plasticity index of the tailings range 23-32.8% and 6.2-11.6%, respectively. The maximum dry density (MDD) and optimum moisture content (OMC) of the overburden materials vary 1.84-1.98 mg/m3 and 1.4-17.2%, respectively, with an average of 1.89 mg/cm3 and 16%. On the other hand, the tailings recorded MDD ranging 1.88-2.06 mg/m3 with their OMC ranging 14.4-16% with an average 14.86%. The soaked California bearing ratio (CBR) of the overburden materials range 27-32%, while that of tailings ranges 25-32%. The geotechnical evaluation of the overburden materials and tailings reveals that most of the materials are suitable for embankment construction. However, the high linear shrinkage of some wastes renders them unsuitable.

1. Introduction

The necessity to diversify the economy of Nigeria from a full oil-based type has been emphasized in the recent times. This has come with various suggestions towards looking in different directions, and solid mineral sector has been prominently explored with a view to fulfil this mission. Mining activities plays a significant role in the Nigerian economy by contributing to foreign exchange earnings, revenue, and employment. However, the sector faces notable challenges related to enviromeental impacts and inadequate infrastructure. Nonetheless, mining remains a crucial driver of economic growth and diversification in Nigeria. However, a very huge amount of waste is usually associated with mining activities and ore milling processes [1]. These various materials and methods of disposing these waste materials includes surface, reservoir and tailing dams, among others. These methods lead to the consumption of lands, and also impacts the environment negatively thereby, unsettling the human settlements around the disposal sites [2, 3]. For example, Oluwasola *et al.* [4] stated that 17 people died from the failure of Merriespruit tailings dam, and a massive damage to residential buildings was recorded in South Africa in 1994. A similar occurrence in the Philippines led to the displacement of over 250 families when tailings spilled into Mapanuepe Lake in 2002 [5].

Geotechnical, physical, and chemical instability of the ecosystem is another problem that mine wastes of these volume could pose. There could also be water and soil pollution. Pollution of ground and surface water by toxic substances that

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may be present in these wastes are major negative impacts that mine tailings stored in tailings dam brings to the environment. The continuous accumulation of mine waste in the environment has contributed to the numerous environmental problems such as loss of land fertility, dust, erosion, and effects on ecosystems [6, 7]. The situation is worsened when tailings dams or heaps collapse due to high rainfall; possible earthquakes that may have negative effects on the environment, human health, and safety is inevitable [8, 9]. With the continued rise in the quantities of mine waste shortage of dump sites, escalating dumping and transportation costs, harmful influence of these wastes on the environment, there is need to investigate the possibility of viably utilizing these wastes. Accordingly, recent developments in sustainable construction practices have led to innovative ways of utilizing mine wastes. One prominent application is the construction of embankments [10, 11, 12, 13, 14, 15]. The utilization of mine wastes in embarkment costuction will potentially lead to a sustainable and cost-effective approach to road construction. Additionally, it also provide a sustainable and cost-effective solution for the utilization of these waste materials and contribute to environmental and natural resource conservation and efficient road infrastructure development as well as waste reduction.

The Jos area of Nigeria is a hotspot of mining activities that is endowed with several types of solid minerals such as tin, columbite, uranium, monazite, wolframite, niobium, and zircon [16, 17]. The extraction of tin and columbite leaving uranium, monazite, wolframite, niobium, and zircon in concentrated form in the wastes could lead to the release of radiation into the environment [1]. Exposure to these radiations through ingestion, inhalation, and dermal contact could cause leukaemia, chromosomal breakage, bone necrosis, cancer, mutation of genes, and cataract of the eye lens among other diseases [18]. These minerals are being exploited with little concern about the waste utilization and its impacts on the environment [1, 19].

This paper characterizes and evaluates the potential of mine overburden materials and tailings for embankment construction using laboratory geotechnical methods in order to ensure the stability and long-term performance of embankments. This is crucial to the appropriate utilization of mine wastes with the aim of avoiding the risks and hazards associated with mine tailing dams. Moreover, assessing the potentials of the mine wastes for embankment construction reduces waste disposal costs and minimizes environmental impacts. Thus undertaking a geotechnical evaluation of mine waste will not only promotes resource efficiency, but also safeguards against potential hazards, making it a responsible and prudent practice in construction projects.

2. Studied Area

2.1. Location and human settlement

The investigated area, as shown in Fig. 1, comprises of two Local government areas (Jos South and Barkin Ladi) in Plateau State, Nigeria. Jos South, a local government area in Plateau State, Nigeria is home to the Governor's office in Rayfield, and hence, serves as the state capital. It is located between latitudes 9° 36' 41.5915" N and 9° 51' 14.2973" N and longitudes 8° 38' 24.4785" E and 8° 57' 14.0240" E. It has its headquarters in Bukuru, some 15 km from Jos, the state capital, in the north-western portion of the state. Kuru, Gyel, Du, and Vwang are the four districts of Jos South. It has a population of 306,716 people [20] and a total land area of around 1,037 km^2.

Barkin Ladi is a local government area in Plateau State, Nigeria, with latitudes ranging from 9° 19' 0.0890" N to 9° 50' 4.2664" N and longitudes ranging from 8° 40' 27.6936" E to 9° 5' 11.1122" E. Barkin Ladi, Kuru Jenta, Heipang, Bisichi, Foron, and Kassa are among the communities that make up this local government area. It is about 47 km from Jos, the state capital. It covers an entire land mass of 1,032 km^2 and has a population of 175,267 [13]. The climate of Jos Plateau is dominantly influenced by its relatively high altitude and position along the Inter Tropical Convergence Zone (ITCZ), and is situated at an altitude of 1,217 m (3,993 ft) above sea level; its climate is closer to temperate than that of the vast majority of Nigeria [21]. Average monthly temperatures range from 21–25 °C (70–77 °F), and from mid-November to late January, night-time temperatures drop as low as 7 °C (45 °F) [22]. Jos receives about 1,400 millimeters of rainfall annually, the precipitation arising from both convectional and orographic sources, owing to the location of the city on the Jos Plateau [23].

2.2. Geology

The Jos Plateau is part of Nigeria's largest region with a height of over 1,000 meters, which comprises a clearly defined highland area, standing above surrounding lowlands [24]. The investigated area is part of the Jos-Bukuru Complex, which is dominated by biotite-granite. Precambrian to late Paleozoic Pan-African granite (Older Granite), diorite, charnockite, and other minerals have been intruded in various locations.

The Jos Plateau is dominated by three (3) classes of rocks. The Basement complex (Precambrian), which includes older granites, gneisses, and migmatites, is the earliest group. The Jos Plateau is mainly comprised of granites that are part of the Precambrian Basement Complex [25]. Distinctive alkaline younger granites (Jurassic to Triassic) comprise the second group. The older and newer basalts (quarternary) make up the third group [26]. The Younger Granite is the source of economic quantities of tantalite, cassiterite, columbite, zircon, monazite, ilmenite, thorite, molybdenite, and pyrochlore [18].

3. Materials and Methods

3.1. Reconnaissance survey

Reconnaissance survey of the entire studied area was carried out to assess the overall conditions of the mining site and their waste dump site.

3.2. Sampling

Representative samples of mine wastes containing two overburden and two tailing materials were collected from six different mining sites by the simple random sampling technique. About 1 kg of each sample was collected from each sampling point, and carefully packed in a polythene bag, sealed and labelled in alphanumeric notations accordingly. The locations of all sampling points were taken using the hand held Etrex-Garmin GPS, recorded in the field note book, and located on the map (Figure 1). After complete drying, the samples were pulverised, sieved, and weighed for further analysis. Precautions were taken to avoid cross-contamination.

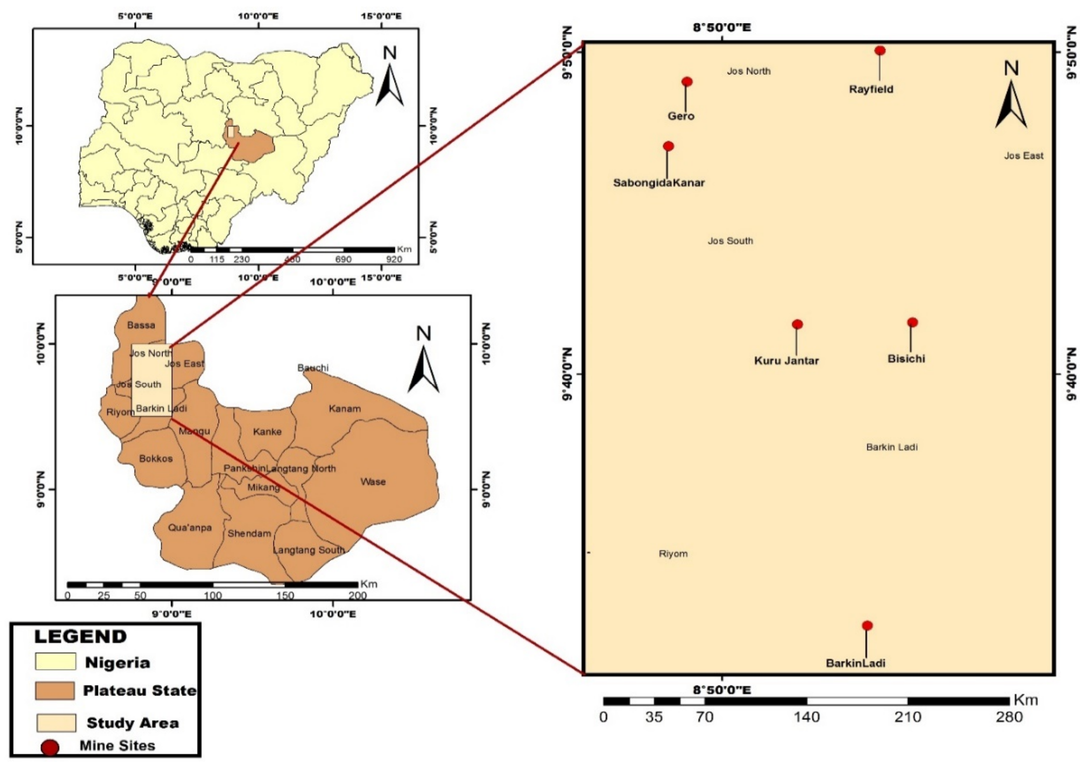

Figure 1. Map of the studied area showing the sampling points.

3.3. Geotechnical analyses of mine wastes

The geotechnical analyses of the mine wastes (overburden and tailings) were carried out at the Engineering Geology laboratory of the Federal University of Technology Akure, Ondo State, Nigeria. The sample was classified by the American Association of highway Transport organisation (AASHTO) based on the grain-size distribution analysis and Atterberg limits (liquid and plastic limits) of the materials. According to their size, the forces that will interfere in the behavior of the soils will be different, while in the particles with a diameter lower than 0.075 mm, the predominant forces are the electrical ones, in the coarse soils the predominant forces are the own weight and the degree of accommodation of the grains; hence, the determination of the grain size distribution characteristics of a sample is important to define their engineering properties [27, 28]. The granulometric analysis of the samples was carried out according to ASTM [29] in order to evaluate the particle size distribution, while the determination of the size of the particles smaller than 0.075 mm (Sieve No. 200) was carried out by the hydrometer analysis [30]. The liquid limit was obtained by the cone penetrometer test [31], while the plastic limit was determined using the rolling method.

The standard Proctor test was performed to determine the compaction characteristics of the mine wastes that will be used as material for pavement support layers. The maximum dry density and optimum water content were obtained from this test, performed in accordance to ASTM [32].

The California Bearing Ratio (CBR) is an important parameter for evaluating the possibility of a material to be employed in an embankment [33]. It relates the shear strength of a material for given compaction and moisture conditions, and is expressed as the percentage of load required to insert a piston at a given depth into a soil sample compared to that required to insert it at the same depth into a standard material, thereby classifying the material according to its possible uses within the pavement structure [33]. Having compacted them at optimum moisture content earlier determined during the compaction test, the CBR of samples was determined in accordance with the provision of ASTM [34].

3.4. Group index and classification of mine wastes

The group indices (GI) of mine wastes were determined using Equation 1 to determine suitability of mine wastes as highway subgrade materials [35]. It is assigned to road construction materials based on its grating characteristics and constency limts to refer the quality of highway construction materials.

$$GI = (F - 35)[0.2 + 0.005(LL - 40)] + 0.01(F - 15)(PI - 10) \quad (1)$$

GI refers to the group index, F is the percentage passing sieve number 200, LL is the liquid limit, while PI indicates the plasticity index of the mine waste.

The results were further compared with the Federal Ministry of Works specification for embankment materials.

4. Discussion

4.1. Index properties

The determined index parameters of the overburden and tailings are presented in Table 1 with respect to their locations of sampling. In the evluation of materials in the construction of embankments, plasticity is considered as a vital parameter, which assists in determining their workability as well as the drying and shrinking behavior [36-38]. The plasticity of construction materials is controlled by factors such as grain size distribution, mineralogy, and the presence of organic matter [39, 40]. Generally, the overburden materials plot in the low to medium plasticity fields of the Cassagrande plasticity chart with few of the materials falling below the A-line (KO1, KO2, GT1). Therefore, they are expected to have low to medium compressibility, which is favorable for application in embankment construction as they would exhibit the tendency to withstand imposed load. It can also be noticed from this chart that majority of the overburden materials(from Gero, Kuru Juntar, and Bisichi) largely plot in the intermediate class of plasticity. On the other hand, the tailings generally possess low plasticity based on their position on the Cassagrande plasticity chart (Figure 2). This is expected to translate to a higher strength and low compressibility with minimal tendency of swelling. The overburden materials recorded liquid limit values ranging from 26 to 48 and plasticity index ranging 6.3-21, while the liquid limit and plasticity index of the tailings range from 23 to 32.8 and 6.2 to 11.6, respectively. On the average, all the materials fulfill the minimum requirement of 40% for liquid limit and plasticity index of 20% demanded for fill and embankment materials by the Nigerian Federal ministry of works and housing although some individual samples from the overburden fell short of this specification as they recorded liquid limit values greater than the 40% specified.

Table 1. Index properties of the studied mine waste and the Nigerian standard specification.

S/N	Locality	ID	Nature of sample	Clay (%)	Fines (%)	Sand (%)	LL (%)	PL (%)	PI (%)	L/S (%)	AASHTO	GI	Condition of soil fill
1	Rayfield	RO1	Overburden	10	22	73	33.9	24.7	9.2	8.6	A-2-4	0	Excellent
2		RO2	Overburden	9	20	75	28	18.9	9.1	7.1	A-2-4	0	Excellent
3		RT1	Tailings	20	31	67	27.2	19.9	7.3	14.3	A-2-4	0	Excellent
4		RT2	Tailings	5	15	80	30.5	21.2	9.3	7.1	A-2-4	0	Excellent
5	Gero	GO1	Overburden	11	25	73	38.1	20.9	17.2	7.9	A-2-6	1	Good
6		GO2	Overburden	8	16	82	48	27	21	12	A-2-7	0	Excellent
7		GT1	Tailings	15	28	70	32.8	23.2	9.6	8.6	A-2-4	0	Excellent
8		GT2	Tailings	10	22	73	27	18	9	4	A-2-4	0	Excellent
9	Sabongida Kanar	SO1	Overburden	5	30.4	67.6	26	19.7	6.3	7.9	A-2-4	0	Excellent
10		SO2	Overburden	9	24.2	74.8	30.9	15.2	15.7	7.9	A-2-6	1	Good
11		ST1	Tailings	8	18.7	79.3	24.3	18.1	6.2	7.1	A-2-4	0	Excellent
12		ST2	Tailings	9	23	74	30.1	18.9	11.2	6.4	A-2-6	0	Excellent
13	Kuru Jantar	KO1	Overburden	7	27.6	68.4	36.9	27.4	9.5	7.1	A-2-4	0	Excellent
14		KO2	Overburden	20	34	61	35.8	25.9	9.9	9.3	A-2-4	0	Excellent
15		KT1	Tailings	18	30.7	65.3	25.9	16.3	9.6	6.4	A-2-4	0	Excellent
16		KT2	Tailings	19	31	68	30	18.9	11.1	8.6	A-2-6	0	Excellent
17	Bisichi	BO1	Overburden	15	47.2	52.8	42.9	23.4	19.5	10	A-7-5	6	Poor
18		BO2	Overburden	10	29.2	67.8	34.9	23.7	11.2	7.9	A-2-6	0	Excellent
19		BT1	Tailings	16	27.1	70.9	23	11.4	11.6	7.1	A-2-6	0	Excellent
20		BT2	Tailings	21	31.9	65.1	30	20.5	9.5	7.9	A-2-4	0	Excellent
21	Barkin Ladi	BLO1	Overburden		22		41	27	14	14	A-2-7	0	Excellent
22		BLO2	Overburden		26.8		29.9	24.4	5.5	8.6	A-2-4	0	Excellent
23		BLT1	Tailings		31		24	20	4	6	A-2-4	0	Excellent
24		BLT2	Tailings		30		24	14.2	9.8	7.1	A-2-4	0	Excellent
25	FMWH standard				≤ 35		< 40		< 20				

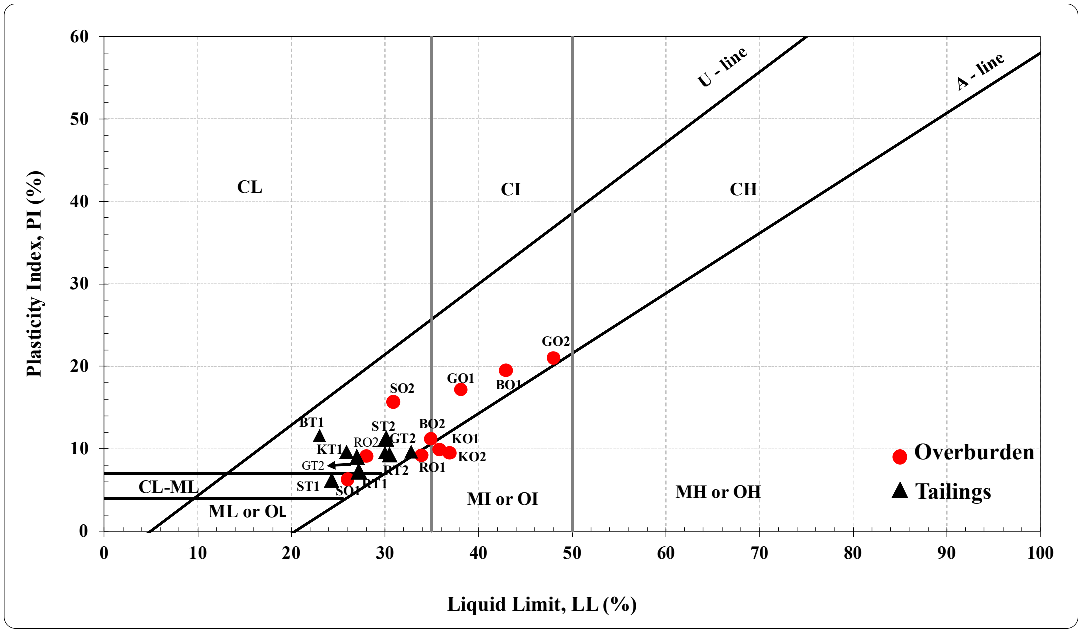

Figure 2. Position plot of the tailings and overburdens on the Cassagrande plasticity chart.

The linear shrinkage is a fundamental property in the selection of materials for fill and embankment [34, 35]. The linear shrinkage of the overburden materials varies from 7.1 to 12%, while that of tailings range from 4 to 14.3. Fill materials are expected to possess linear shrinkage values lower than 10% [37]; majority of the materials fulfill this benchmark as only one material from the overburden and tailing recorded linear shrinkage higher than the specified value. Also the low linear shrinkage values conform with the assertion of [38], which specifies that materials with linear shrinkage higher than 10% will pose field compaction problems. Hence, only three of the materials (two overburden-LO1, BO1 and one tailing -RT1) fall short of this specification (Figure 3). Furthermore, materials with linear shrinkage greater than 8% have the tendency to be active and possess a critical swelling potential and are not good fill materials. Going by this, some of these materials recorded linear shrinkage greater than 8%, and are expected to be poor and unsuitable for use for filling purposes.

The grain size distribution of construction materials plays important role in the selection of embankment construction [36, 39]. It influences the plasticity behavior and other relevant engineering properties that are pertinent to their suitability for embankment construction [40, 41].

Table 1 also depicts the grain size distribution characteristics of the materials, while the grain size distribution curves are shown in Figures 4 and 5. The results indicate that the overburden materials contain clay sized fraction (< 2 µm) ranging from 5 to 20%, while the sand fraction (> 20 µm) ranged from 42 to 82%, which is an indication of the predominance of sand size particles. On the other hand, the clay-sized particles in the tailings range between 5 and 21%, while the sand fractions range from 65 to 80%. Furthermore, the results indicate that despite the predominance of sand-sized particles, the tailings consist of some amount of silt, clays, and slight amount gravel fractions, which suggest that they would exhibit good compaction characteristics with low permeability and low porosity [42, 43]. The fine fractions of the overburden materials range from 16 to 47.2%, while the tailings possess a quantity of fines ranging from 15 to 31.9% with an average of 27.6% and 25.8%, respectively. These values conform to the minimum 35% required by the Nigerian Federal Ministry of Works and Housing. Only one of the samples (BO1) did not meet this specification, thus the materials can be adjudged suitable for fill and embankment. This low quantity of fines in the tailings and overburden suggests that they are less prone to repeated swelling and shrinkage tendencies obtainable during wet and dry seasons prevailing in the studied area.

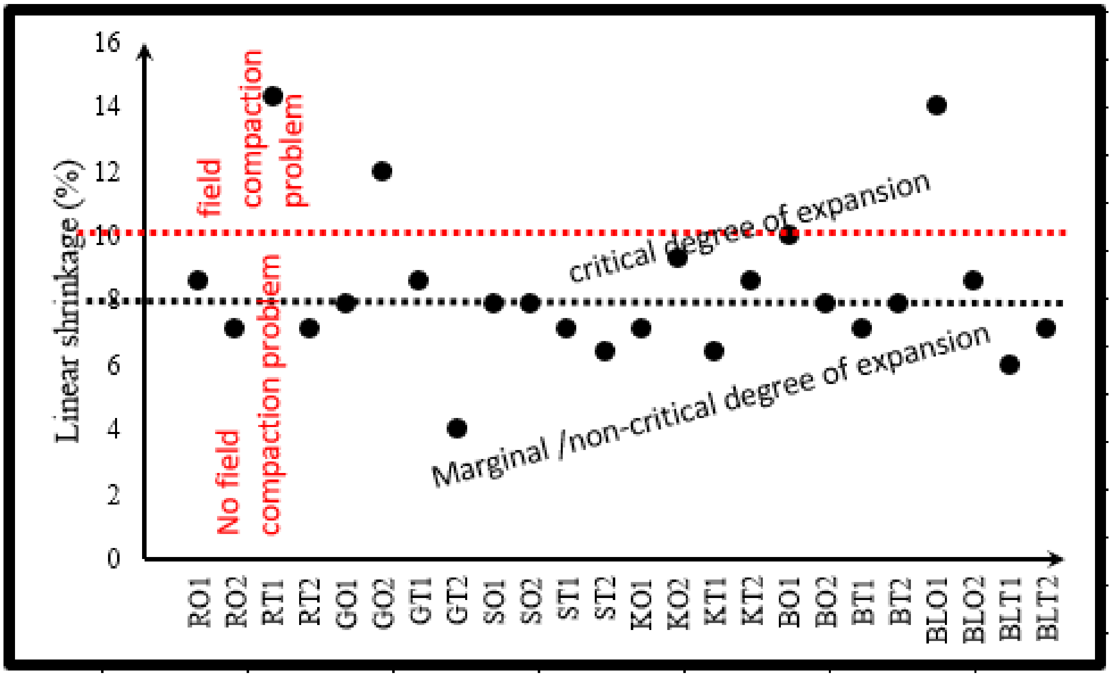

Figure 3. Plot of the suitability of the mine wastes based on their linear shrinkage.

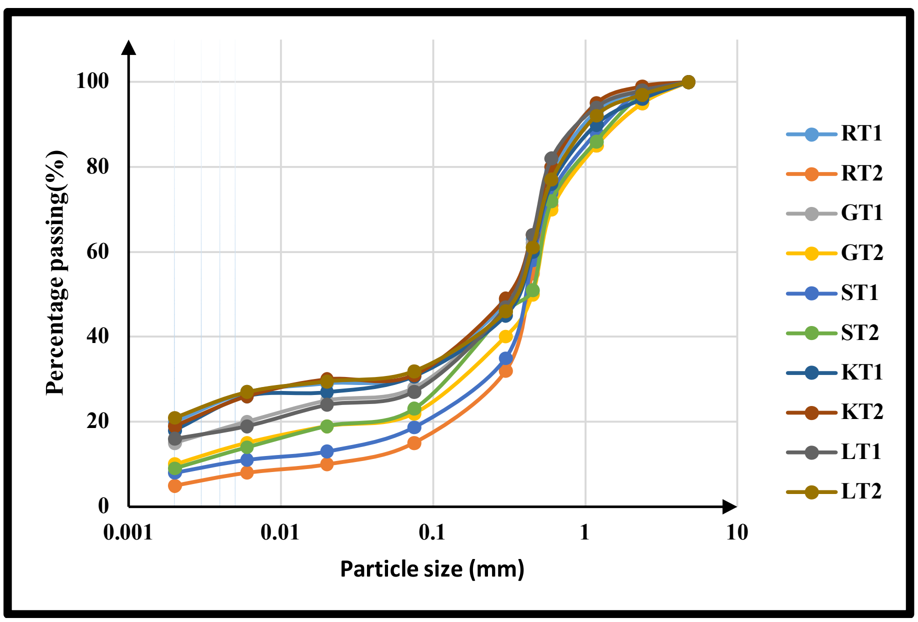

Figure 4. Grain size distribution envelopes of the tailings.

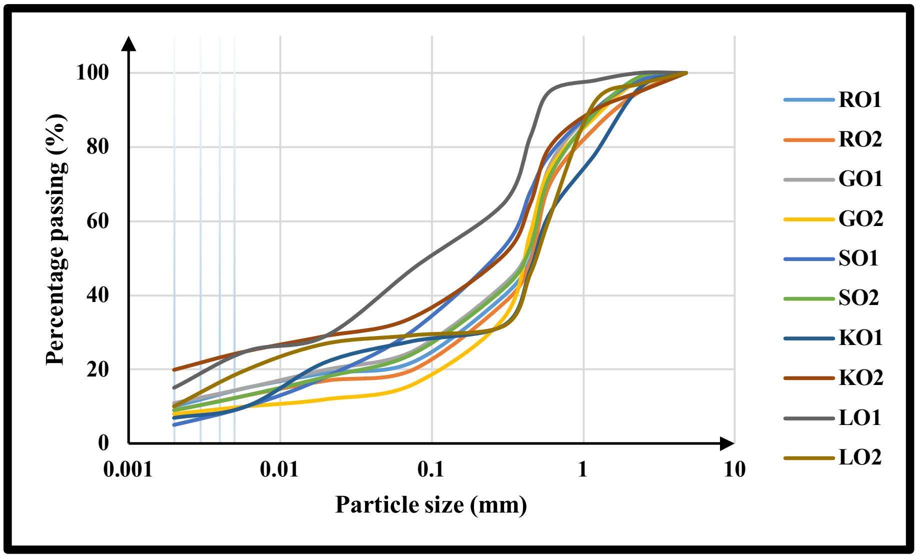

Figure 5. Grain size distribution envelopes of the overburden.

AASHTO classification provides a quantitative means of assessing the construction materials based on their index properties. On this basis, the materials classify as A-2-4, A-2-6, A-2-7, and A-2-5 possess a fair to poor characteristics as subgrade, while the rest possess excellent to good character as road construction materials. This is also consistent with the group index where the majority of the materials recorded values between 0 and 1, while the only materials falling in the A-7-5 category had the highest group index (6). Hence, they indicate a very high load carrying capacities.

4.2. Engineering properties

California bearing ratio (CBR), maximum drying density (MDD), and optimum moisture contents (OMC) of the overburden and tailing materials are shown in Table 2. Figure 6 presents the typical compaction curves of the studied materials. The MDD and OMC of the overburden materials very from 1.84 to 1.98 g/cm^3 and 1.4 to 17.2%, respectively, with an average of 1.89 g/cm^3 and 16%. On the other hand, the tailings recorded MDD ranging from 1.88 to 2.06 g/cm^3 with their OMC ranging from 14.4 to 16% with an average 14.86%. Daramola *et al*. [26] stated that materials with high MDD and low OMC are best for road construction, therefore the tailings can be adjudged as better fill materials than the overburden constituents. It is also worthy to note that the MDD and OMC all the materials fulfill the Nigerian specification for general filling and embankment resources as stipulated by the federal ministry of works and housing. The CBR is the most common list usually employed to assess the strength of fill materials as the soaked test provides an insight into the behavioral tendencies of materials when in contact water. The soaked CBR of the overburden materials range from 27 to 32%, while that of tailings ranges from 25 to 32. Notably, the average CBR value of the tailing 28.5 is lesser than that of overburden (29.5). This is likely due to the presence of some materials with high affinity for water, thereby leading to a reduction in strength. However, all the materials fulfill the soaked CBR of 4% minimum required for general filling and embankment materials.

Table 2. Geotechnical properties of the mine wastes in relation to the standard requirement of FMWH.

S/N	Locality	ID	Nature of sample	CBR (%)	MDD (mg/m^3)	OMC (%)
1	Rayfield	RO1	Overburden	28	1.87	16.6
2		RO2	Overburden	32	1.92	15.5
3		RT1	Tailings	28	1.88	16.1
4		RT2	Tailings	31	1.87	14.4
5	Gero	GO1	Overburden	27	1.86	14.5
6		GO2	Overburden	28	1.85	14
7		GT1	Tailings	32	2.05	14.4
8		GT2	Tailings	29	2.06	16
9	Sabongida Kanar	SO1	Overburden	30	1.84	17.2
10		SO2	Overburden	31	1.98	16.5
11		ST1	Tailings	28	1.88	14.5
12		ST2	Tailings	27	1.89	14.5
13	Kuru Jantar	KO1	Overburden	31	1.84	17.2
14		KO2	Overburden	28	1.98	16.5
15		KT1	Tailings	26	1.87	14.5
16		KT2	Tailings	25	1.89	14.5
17	Bisichi	BO1	Overburden			17
18		BO2	Overburden			17
19		BT1	Tailings			14.2
20		BT2	Tailings			17.2
21	Barkin Ladi	LO1	Overburden	28	2.15	13
22		LO2	Overburden	29	1.83	14.7
23		LT1	Tailings	29	1.83	16
24		LT2	Tailings	28	1.81	16.9
25	FMWH standard			> 5	> 0.047	< 18

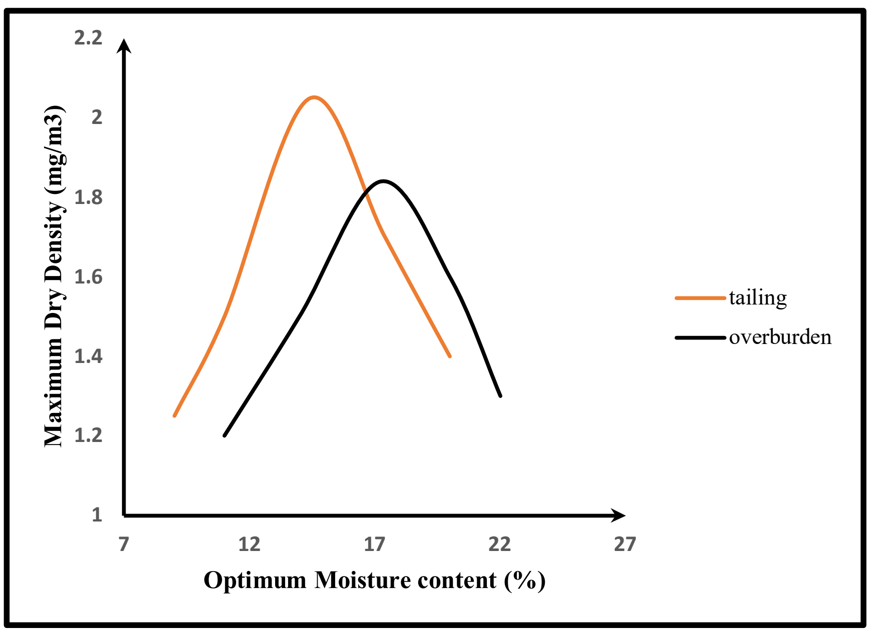

Figure 6. Moisture density relationship of the studied materials.

5. Conclusions

The geotechnical characterization of overburden and tailing materials for applications in embankment construction revealed that the waste materials contains substantial amount of clay, silt, sand, and minor amount of gravel size particles. This low quantity of fines in the mine wastes indicates that they wont be highly prone to prevalent repeated swelling and shrinkage tendencies commonly observed during wet and dry seasons in the studied area. Based on the AASHTO classification scheme for road construction materials, the materials classify as A-2-4, A-2-6, A-2-7, and A-2-5 possess a fair to poor characteristics as subgrade, while the rest possess excellent to good character as road construction materials. Moreover, the overburden materials plot in the low to medium plasticity fields of the Cassagrande plasticity chart with few of the materials falling below the A-line. Therefore, they are expected to have low to medium compressibility, which is favorable for application in embankment construction as they would exhibit the tendency to withstand imposed load. However, the tailings exhibit low plasticity, which implies a higher strength and low compressibility with minimal tendency of swelling. The average CBR value of the tailing is lesser than that of overburden, which is attributable to the presence of some materials with high affinity for water causing a reduction in strength. Overall, the geotechnical evaluation of the overburden materials and tailings from the studied area reveals that most of the materials are suitable for the construction of fills and embankments as they compare favorably with the nierian standard specification for such purpose. However, the high linear shrinkage of some overburden and tailings renders them unsuitable as these might result in field compaction problems and some critical swelling tendencies, which could be detrimental. A chemical and mineralogical characterization will be necessary to ascertain their mineralogical composition in order to establish for water and their tendency to hasten the corrosion of construction materials.

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ارزیابی ژئوتکنیکی ضایعات معدن برای استفاده در ساخت و ساز کشتی در جوس، نیجریه مرکزی

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ارسال ۲۰۲۳/۰۸/۳۱، پذیرش ۲۰۲۳/۱۲/۰۱

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چکیده:

نیجریه سرشار از منابع معدنی جامد مانند مس، طلا و تانتالیت است که برای رشد اقتصادی این کشور ضروری هستند. استخراج این منابع معدنی با تولید مقدار زیادی زباله همراه است. این مطالعه امکان استفاده از ضایعات معدنی Jos، نیجریه، در ساخت خاکریز را با قرار دادن آنها در آزمایش‌های ژئوتکنیکی آزمایشگاهی مربوطه بررسی می‌کند. نتایج نشان می‌دهد که مواد روباره حاوی کسر اندازه رس در محدوده ۵-۲۰ درصد است در حالی که کسر ماسه در محدوده ۴۲-۸۲ درصد است که نشان دهنده غلبه ذرات اندازه ماسه است. از سوی دیگر، ذرات به اندازه خاک رس در باطله ۵- ۲۱ درصد، در حالی که بخش ماسه محدوده ۶۵-۸۰ درصد است. مواد روباره مقادیر حد مایع در محدوده ۲۶-۴۸ درصد و شاخص پلاستیسیته در محدوده ۶.۳-۲۱ درصد، در حالی که حد مایع و شاخص پلاستیسیته باطله‌ها به ترتیب ۲۳-۳۲.۸ درصد و ۶.۲-۱۱.۶ درصد است. حداکثر چگالی خشک (MDD) و رطوبت بهینه (OMC) مواد روباره به ترتیب ۱.۸۴-۱.۹۸ mg/m3 و ۱.۴-۱۷.۲ درصد با میانگین ۱.۸۹ mg/cm3 و ۱۶ درصد متغیر است. از سوی دیگر، باطله‌ها MDD در محدوده ۱.۸۸-۲.۰۶ mg/m3 با OMC خود در محدوده ۱۴.۴-۱۶ درصد با میانگین ۱۴.۸۶ درصد ثبت کردند. نسبت باربری خیس شده کالیفرنیا (CBR) مواد روباره بین ۲۷ تا ۳۲ درصد است، در حالی که نسبت باطله‌ها بین ۲۵ تا ۳۲ درصد است. ارزیابی ژئوتکنیکی مواد روباره و باطله نشان می‌دهد که بیشتر مصالح برای ساخت خاکریز مناسب هستند. با این حال، انقباض خطی بالا برخی از زباله‌ها آنها را نامناسب می‌کند.

کلمات کلیدی: باطله، اضافه بار، فعالیت های معدنی، خاکریزی.