Article title: Comparison of Method of Stabilization of Laterite Using Sharp Sand and Quarry Dust
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Preprint statement: This article is a preprint and has not been peer-reviewed, under consideration and submitted to ScienceOpen Preprints for open peer review.
DOI: 10.14293/PR2199.001254.v1
Preprint first posted online: 04 November 2024
Keywords: Laterite, Construction , Stabilization , California Bearing Ratio , Compaction, Sharp Sand, Quarry Dust, Grading, Durability , Atterberg

Comparison of Methods of Stabilization of Laterite Using Sharp Sand and Quarry Dust

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Abstract

Due to its high plasticity, poor compressive strength, and moisture vulnerability, laterite soil—which is frequently found in tropical areas like Nigeria—is widely available but has limited use as a building material. Therefore, it is crucial to stabilize laterite soil in order to increase its longevity, load-bearing capability, and resilience to environmental factors. The usefulness of two substitute stabilization materials—quarry dust and sharp sand—as reasonably priced, locally available stabilizing agents for laterite is examined and contrasted in this study. While quarry dust, a by-product of crushing stone, is predicted to increase compressive strength and decrease plasticity because of its finer particles and higher filling capacity, sharp sand, with its coarse, angular particles, is thought to improve the soil's compaction characteristics and bulk density. The effects of each stabilizer on laterite properties at different mix proportions were evaluated using a battery of tests, including Compaction, California Bearing Ratio (CBR), and Atterberg limits. The stability and strength of laterite soil are found to be positively impacted, albeit to varying degrees, by both sharp sand and quarry dust. While quarry dust greatly increases compressive strength and decreases plasticity, making it more suitable for load-bearing applications, sharp sand improves compaction and workability, making it appropriate for general fill applications. According to the results, sharp sand provides an affordable option for projects with moderate strength requirements, whereas quarry dust would be better for high-strength requirements. This work contributes to the production of affordable, sustainable building materials in tropical areas by offering insightful information about the relative advantages of employing quarry dust and sharp sand for laterite stabilization.

Keyword: Quarry dust. Sharp sand, Compaction, California bearing ratio, stabilizer, construction, laterite, grading, Atterberg, durability.

Introduction

Nigeria and other parts of West Africa, Southeast Asia, and South America are examples of tropical and subtropical climates that typically have laterite soil, a weathered soil that is rich in iron and aluminum (Snellings, 2023). Laterite, which forms during extended weathering processes, acquires a special structure and mineral makeup that make it unique and accessible in tropical regions (Abate, 2015). Hematite and gibbsite are among the minerals found in laterite, which is usually reddish or brownish in color due to its high iron oxide content (Yang, 2013). But despite its natural occurrence and abundance, laterite's intrinsic qualities frequently prevent it from being used in building without alteration (Limeira, 2011). When utilized as a building material in its natural state, laterite has a number of disadvantages, especially for load-bearing structures (Awadh, 2023). Due to its high porosity, low compressive strength, and poor moisture resistance, laterite soil is prone to considerable swelling and shrinking (Nawaz, 2020). This implies that laterite may deteriorate or distort under wet and dry cycles, leading to instability in buildings that are supported by or built upon it (Hearty, 2007). Because structures constructed with untreated laterite are prone to cracking, erosion, and collapse over time, these restrictions become especially troublesome in regions with distinct wet and dry seasons. As a result, stabilizing laterite to improve its structural qualities has emerged as a crucial study topic (Skaf, 2016).

The process of improving soil qualities to make it acceptable for building is known as stabilization. Roads, buildings, and other infrastructure can be built on the stabilized soil because of its increased strength, longevity, and decreased sensitivity to moisture (Gavali, 2019). Stabilization provides a useful method for producing locally produced building materials that promote sustainable and economic development in areas like Nigeria, where laterite is widely available and reasonably priced (Jackson, 2017). Enhancing laterite's properties makes it feasible to use it for a wider variety of purposes, such as load-bearing walls in affordable housing projects, embankments, and road sub-bases. However, the process's efficacy and the final soil's characteristics are significantly impacted by the stabilization method and material selection (Lehmkuhl, 2020).

Objectives of the Study

i. To evaluate the physical and engineering properties of soil when stabilized with sharp sand and quarry dust.

ii. To compare the strength improvement (e.g., compressive strength, shear strength) of soil stabilized with sharp sand versus quarry dust.

iii. To determine the optimum mix ratios of sharp sand and quarry dust for maximum stabilization performance.

iv. To evaluate the economic and environmental viability of each method for large-scale construction or infrastructure projects.

v. To conduct a cost-benefit analysis comparing the use of sharp sand and quarry dust as soil stabilizers.

Methodology

The purpose of this study's technique is to methodically assess how quarry dust and sharp sand affect laterite soil stabilization. The process include gathering and preparing samples of laterite soil, choosing the right amounts to mix, and carrying out a number of laboratory tests to evaluate how each stabilizer affects the soil's essential qualities, such as compaction, strength, and plasticity. The steps and specifics of each methodological phase are listed below.

1. Material Collection and Preparation
   Laterite Soil: Laterite samples were collected from a selected site in tundu Abu stock pile. The soil was air-dried to remove excess moisture and sieved to achieve uniform particle sizes, ensuring consistency across all test samples. The laterite was then stored in airtight containers to maintain a controlled moisture level.

   Sharp Sand: Sharp sand was sourced from a local supplier, ensuring that it had a coarse, angular particle structure suitable for improving compaction. The sand was also sieved to remove any oversized particles and impurities. Key physical properties such as particle size distribution, specific gravity, and moisture content were recorded.

   Quarry Dust: this material was taken at a quarry site here in lafia a by-product of a stone-crushing. It was sieved to a fine particle size. Prior to use, the quarry dust's specific gravity and moisture content were determined in order to comprehend how it would behave in the soil mixture.

2. Mix Proportioning
   The laterite was mix with 20 percent sharp sand, and quarry dust. The mix percentage were chosen in light of prior studies and practical viability. The proportions of the blend included:

   Sharp Sand Mixtures: Laterite was mixed with sharp sand at 20% by weight.

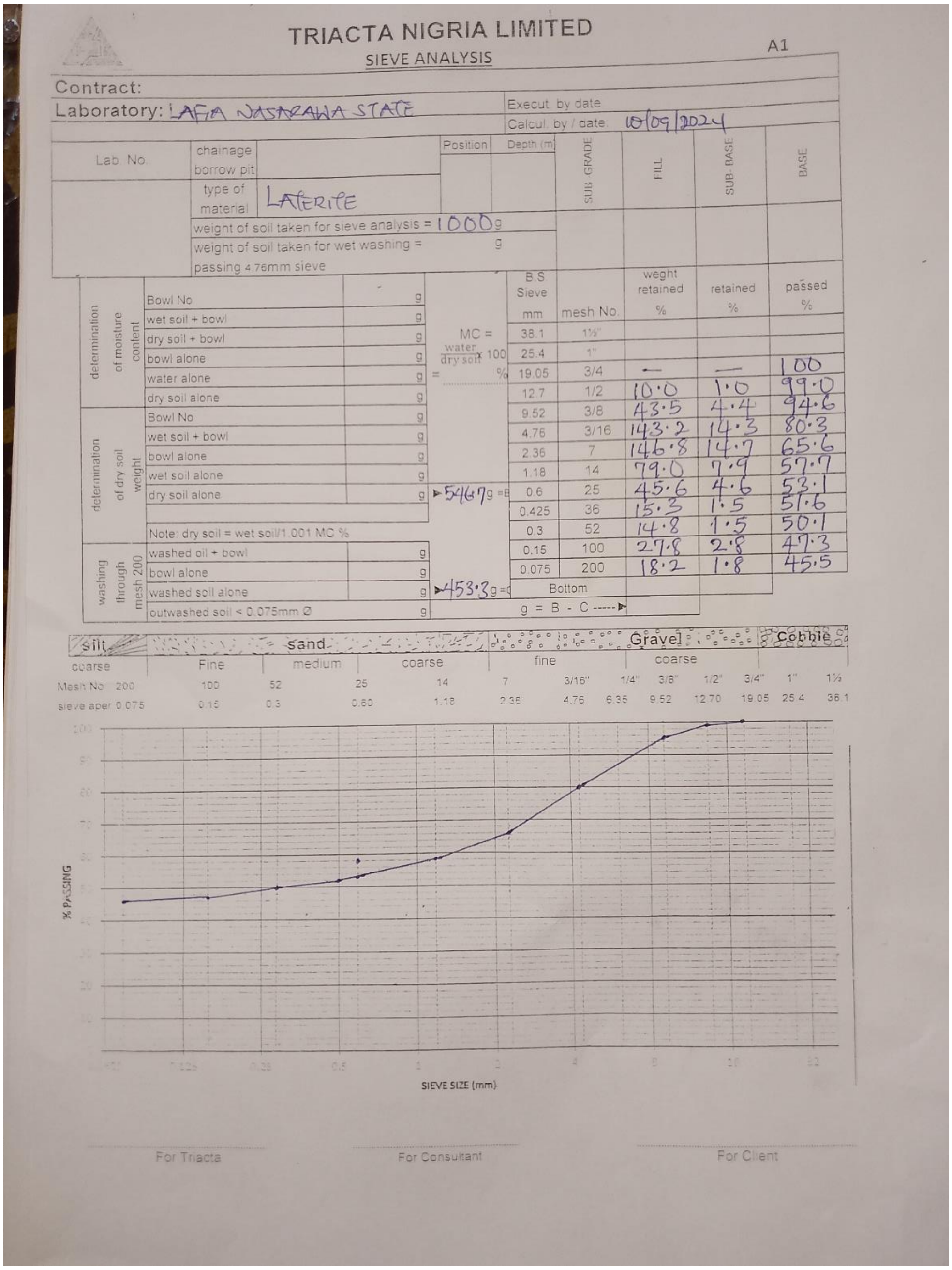
   Quarry Dust Mixtures: Laterite was mixed with quarry dust at 20% by weight.

   Each mix was prepared by thoroughly blending the laterite and stabilizer (sharp sand or quarry dust) to achieve uniformity before testing. A control sample of untreated laterite was also prepared as a baseline for comparison.

3. Laboratory Testing Procedures

   A series of tests were conducted on each sample to assess the impact of sharp sand and quarry dust on key soil properties. The tests were performed following the ASTM and Nigerian Standards for soil stabilization. Testing procedures as detailed below.

   Gradation Test: Sharp sand, quarry dust and laterite were subjected to grading and the following results were obtained as shown below



TRIACTA NIGRIA LIMITED

SIEVE ANALYSIS

A1

Contract:

Laboratory: LAFIA NASARAWA STATE

Execut. by date

Calcul. by / date 10/09/2024

type of material: LATERITE

weight of soil taken for sieve analysis = 1000g

weight of soil taken for wet washing = g passing 4.76mm sieve

dry soil alone ▶ 546.7g = B

washed soil alone ▶ 453.3g = C

g = B - C

B.S Sieve mm	mesh No.	weight retained %	retained %	passed %
38.1	1½"			
25.4	1"			
19.05	3/4	—	—	100
12.7	1/2	10.0	1.0	99.0
9.52	3/8	43.5	4.4	94.6
4.76	3/16	143.2	14.3	80.3
2.36	7	146.8	14.7	65.6
1.18	14	79.0	7.9	57.7
0.6	25	45.6	4.6	53.1
0.425	36	15.3	1.5	51.6
0.3	52	14.8	1.5	50.1
0.15	100	27.8	2.8	47.3
0.075	200	18.2	1.8	45.5
Bottom				

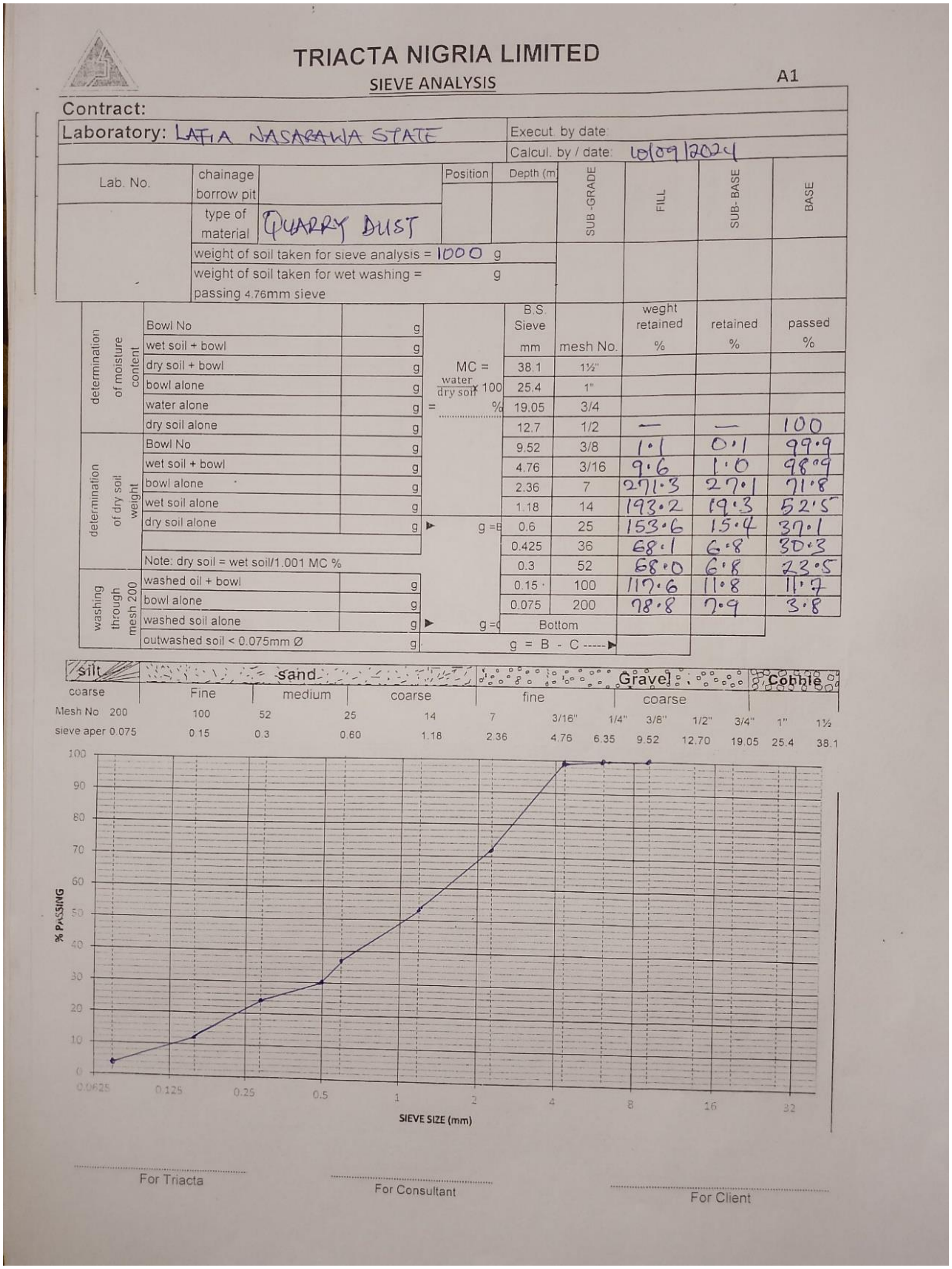
silt | sand (Fine, medium, coarse) | Gravel (fine, coarse) | Cobble

% PASSING

SIEVE SIZE (mm)

For Triacta | For Consultant | For Client

Figure 1: Laterite material



TRIACTA NIGRIA LIMITED

SIEVE ANALYSIS

A1

Contract:

Laboratory: LAFIA NASARAWA STATE

Execut. by date:

Calcul. by / date: 10/09/2024

Lab. No. | chainage / borrow pit | Position | Depth (m) | SUB-GRADE | FILL | SUB-BASE | BASE

type of material: QUARRY DUST

weight of soil taken for sieve analysis = 1000 g

weight of soil taken for wet washing = g passing 4.76mm sieve

determination of moisture content: Bowl No; wet soil + bowl g; dry soil + bowl g; bowl alone g; water alone g; dry soil alone g; MC = water / dry soil x 100 = %

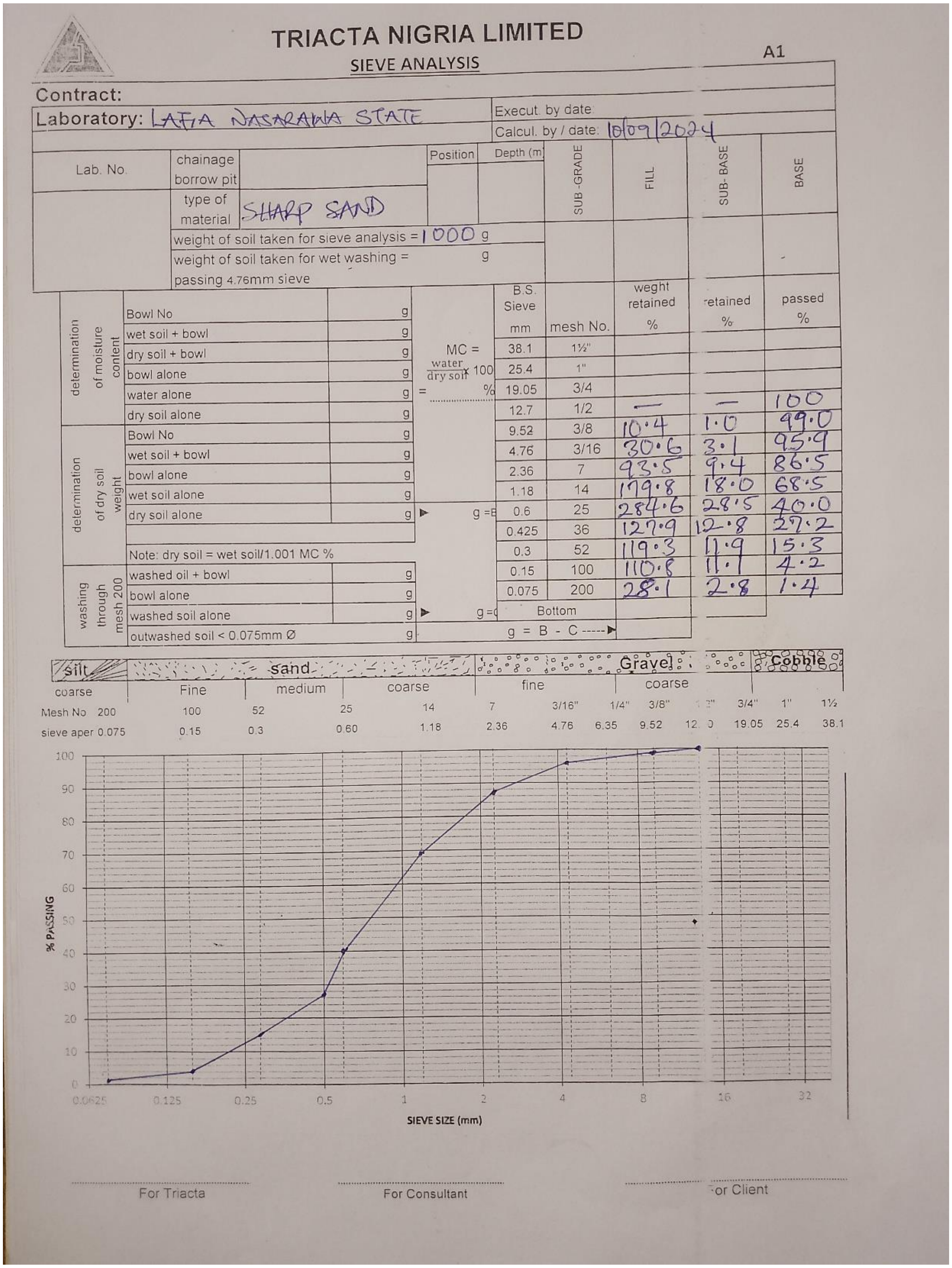
determination of dry soil weight: Bowl No; wet soil + bowl g; bowl alone g; wet soil alone g; dry soil alone g; g = B

Note: dry soil = wet soil/1.001 MC %

washing through mesh 200: washed oil + bowl g; bowl alone g; washed soil alone g; g = C; outwashed soil < 0.075mm Ø g; g = B - C

B.S. Sieve mm	mesh No.	weght retained	retained %	passed %
38.1	1½"			
25.4	1"			
19.05	3/4			
12.7	1/2	—	—	100
9.52	3/8	1.1	0.1	99.9
4.76	3/16	9.6	1.0	98.9
2.36	7	271.3	27.1	71.8
1.18	14	193.2	19.3	52.5
0.6	25	153.6	15.4	37.1
0.425	36	68.1	6.8	30.3
0.3	52	68.0	6.8	23.5
0.15	100	117.6	11.8	11.7
0.075	200	78.8	7.9	3.8
Bottom				

Figure 2: Quarry dust



TRIACTA NIGRIA LIMITED

SIEVE ANALYSIS

A1

Contract:

Laboratory: LAFIA NASARAWA STATE

Execut. by date:

Calcul. by / date: 10/09/2024

Lab. No.	chainage borrow pit		Position	Depth (m)	SUB-GRADE	FILL	SUB-BASE	BASE
	type of material	SHARP SAND						

weight of soil taken for sieve analysis = 1000 g

weight of soil taken for wet washing = g

passing 4.76mm sieve

determination of moisture content	
Bowl No	g
wet soil + bowl	g
dry soil + bowl	g
bowl alone	g
water alone	g
dry soil alone	g

MC = water / dry soil x 100 = %

determination of dry soil weight	
Bowl No	g
wet soil + bowl	g
bowl alone	g
wet soil alone	g
dry soil alone	g ▶ g = E

Note: dry soil = wet soil/1.001 MC %

washing through mesh 200	
washed oil + bowl	g
bowl alone	g
washed soil alone	g ▶ g = C
outwashed soil < 0.075mm Ø	g

B.S. Sieve mm	mesh No.	weght retained %	retained %	passed %
38.1	1½"			
25.4	1"			
19.05	3/4			
12.7	1/2	—	—	100
9.52	3/8	10.4	1.0	99.0
4.76	3/16	30.6	3.1	95.9
2.36	7	93.5	9.4	86.5
1.18	14	179.8	18.0	68.5
0.6	25	284.6	28.5	40.0
0.425	36	127.9	12.8	27.2
0.3	52	119.3	11.9	15.3
0.15	100	110.8	11.1	4.2
0.075	200	28.1	2.8	1.4
	Bottom			

g = B - C -----▶

For Triacta

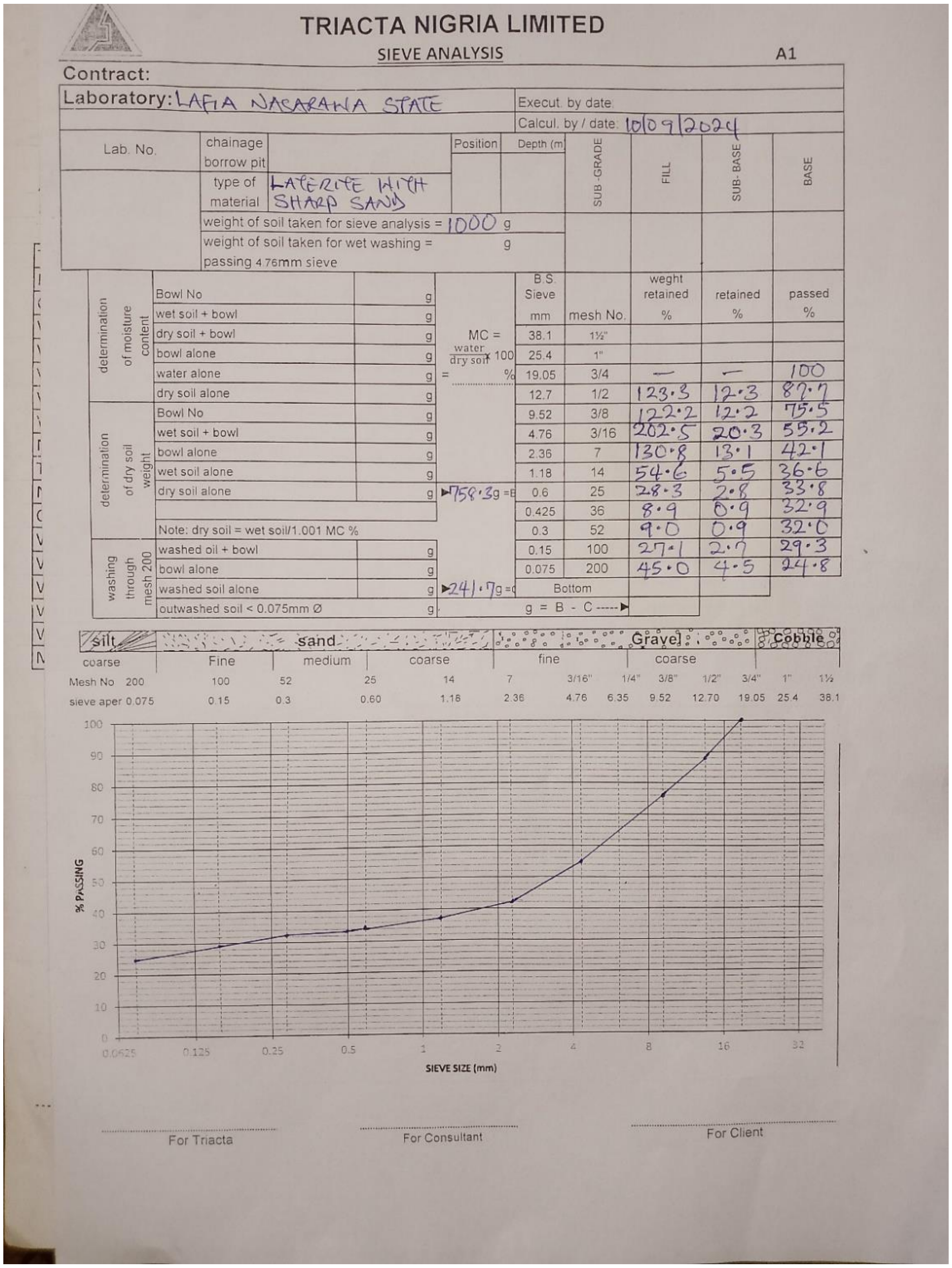
For Consultant

For Client

Figure 3: Sharp Sand

After mixing quarry dust with laterite and sharp sand with laterite, the following tests were carried out and the results obtained are shown below;

Gradation Test: the figure blow shows the result of sharp sand mix with laterite .



TRIACTA NIGRIA LIMITED

SIEVE ANALYSIS

A1

Contract:

Laboratory: LAFIA NASARAWA STATE

Execut. by date:

Calcul. by / date: 10/09/2024

Lab. No.

chainage borrow pit

Position

Depth (m)

type of material: LATERITE WITH SHARP SAND

SUB-GRADE | FILL | SUB-BASE | BASE

weight of soil taken for sieve analysis = 1000 g

weight of soil taken for wet washing = g

passing 4.76mm sieve

determination of moisture content: Bowl No g; wet soil + bowl g; dry soil + bowl g; bowl alone g; water alone g; dry soil alone g

MC = water / dry soil x 100 = %

determination of dry soil weight: Bowl No g; wet soil + bowl g; bowl alone g; wet soil alone g; dry soil alone g ▸758.3g = B

Note: dry soil = wet soil/1.001 MC %

washing through mesh 200: washed oil + bowl g; bowl alone g; washed soil alone g ▸241.7g = C; outwashed soil < 0.075mm Ø g

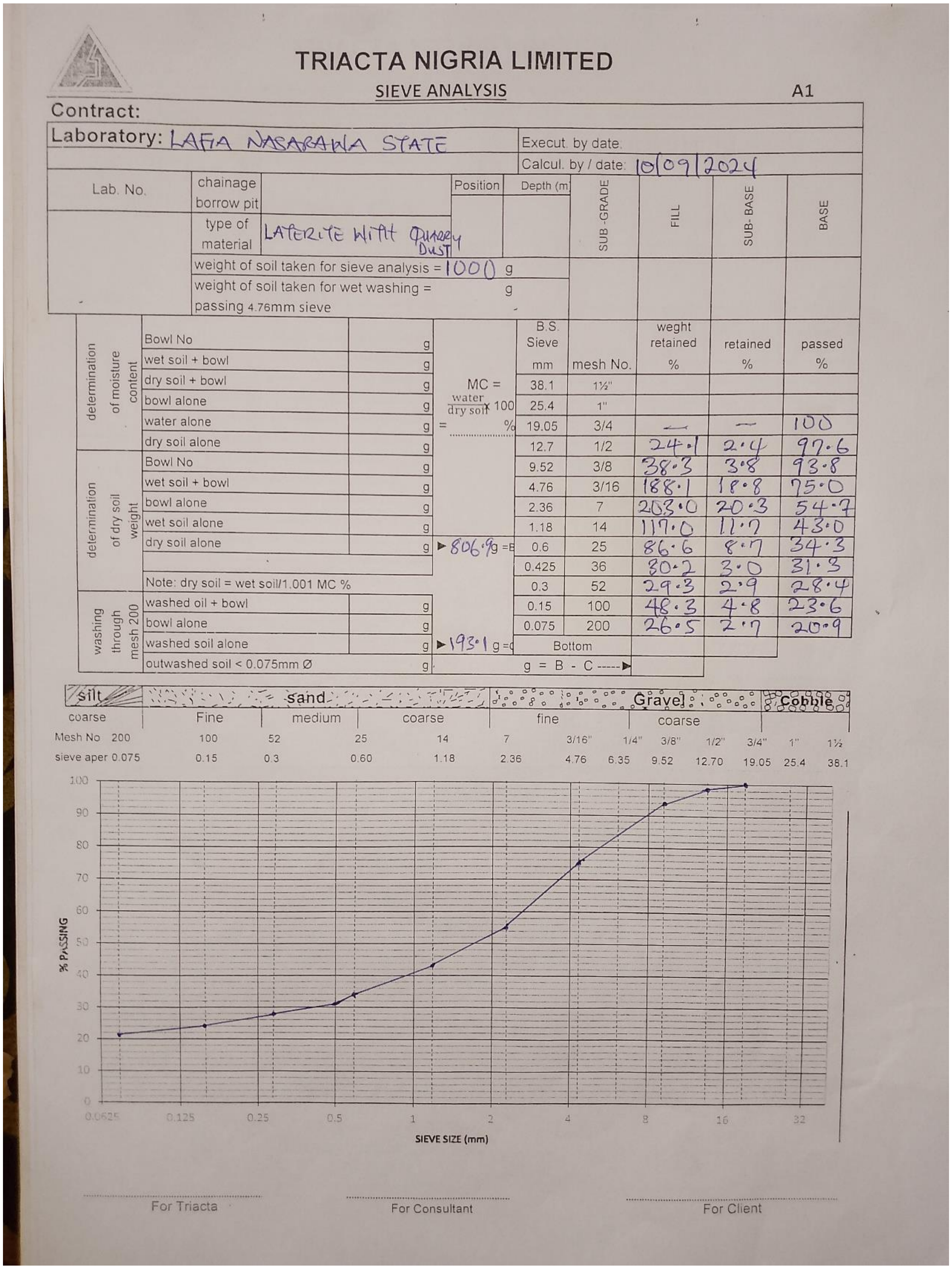
B.S. Sieve mm	mesh No.	weght retained %	retained %	passed %
38.1	1½"			
25.4	1"			
19.05	3/4	—	—	100
12.7	1/2	123.3	12.3	87.7
9.52	3/8	122.2	12.2	75.5
4.76	3/16	202.5	20.3	55.2
2.36	7	130.8	13.1	42.1
1.18	14	54.6	5.5	36.6
0.6	25	28.3	2.8	33.8
0.425	36	8.9	0.9	32.9
0.3	52	9.0	0.9	32.0
0.15	100	27.1	2.7	29.3
0.075	200	45.0	4.5	24.8
Bottom				
g = B - C				

For Triacta

For Consultant

For Client

Figure 4: Laterite Mixed with Sharp sand



TRIACTA NIGRIA LIMITED

SIEVE ANALYSIS

A1

Contract:

Laboratory: LAFIA NASARAWA STATE

Execut. by date:

Calcul. by / date: 10/09/2024

Lab. No.	chainage borrow pit		Position	Depth (m)	SUB-GRADE	FILL	SUB-BASE	BASE
	type of material	LATERITE WITH QUARRY DUST						
	weight of soil taken for sieve analysis = 1000 g							
	weight of soil taken for wet washing = g passing 4.76mm sieve							

determination of moisture content	Bowl No		g
	wet soil + bowl		g
	dry soil + bowl		g
	bowl alone		g
	water alone		g
	dry soil alone		g
determination of dry soil weight	Bowl No		g
	wet soil + bowl		g
	bowl alone		g
	wet soil alone		g
	dry soil alone		g ► 806.9 g = B
	Note: dry soil = wet soil/1.001 MC %		
washing through mesh 200	washed oil + bowl		g
	bowl alone		g
	washed soil alone		g ► 193.1 g = C
	outwashed soil < 0.075mm Ø		g

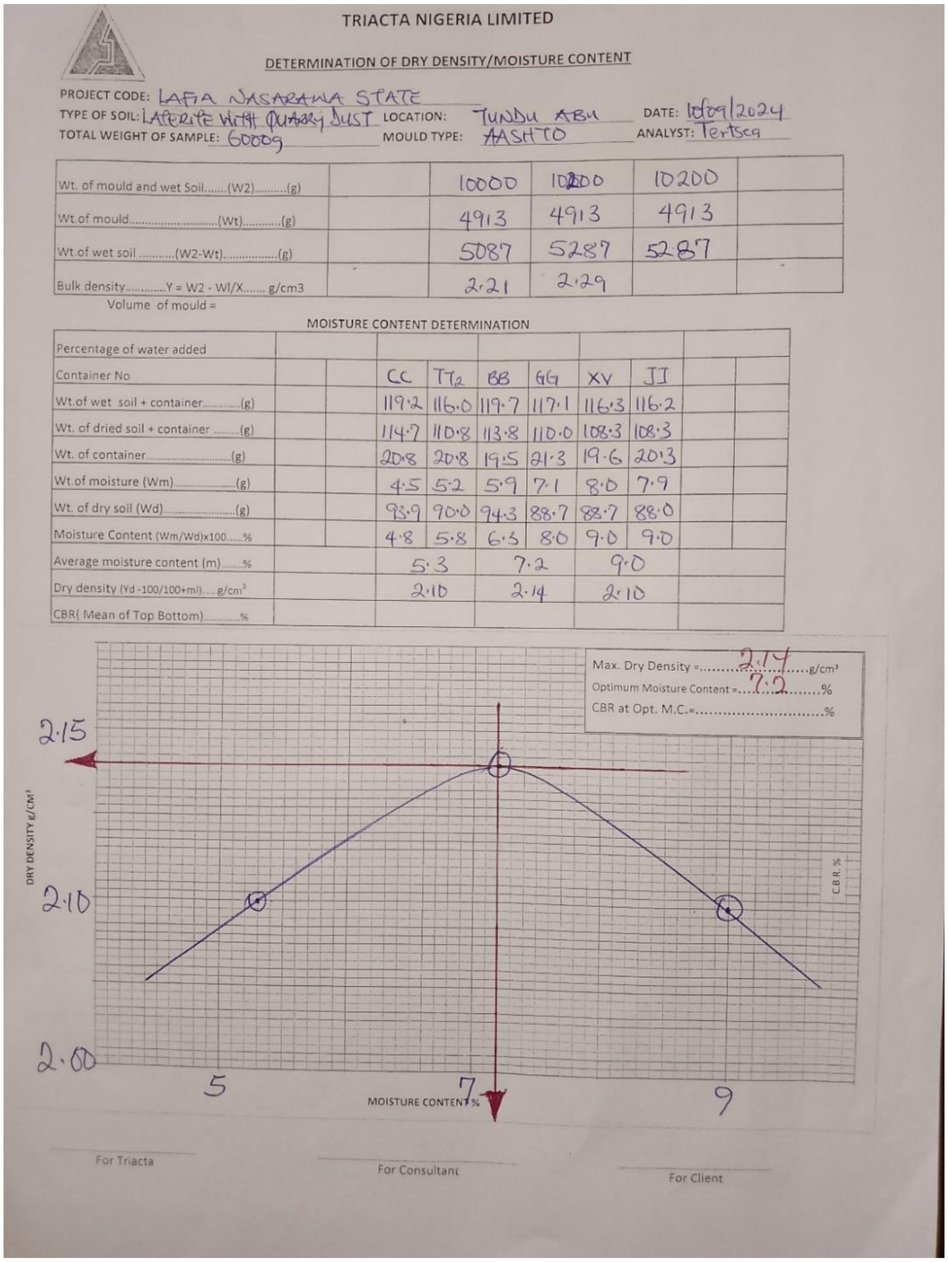
MC = water / dry soil x 100 = ... %

B.S. Sieve mm	mesh No.	weght retained %	retained %	passed %
38.1	1½"			
25.4	1"			
19.05	3/4	—	—	100
12.7	1/2	24.1	2.4	97.6
9.52	3/8	38.3	3.8	93.8
4.76	3/16	188.1	18.8	75.0
2.36	7	203.0	20.3	54.7
1.18	14	117.0	11.7	43.0
0.6	25	86.6	8.7	34.3
0.425	36	30.2	3.0	31.3
0.3	52	29.3	2.9	28.4
0.15	100	48.3	4.8	23.6
0.075	200	26.5	2.7	20.9
Bottom				
g = B - C				

Figure 5: Laterite Mixed with Quarry Dust

Compaction Test

To find each soil mix's maximum dry density (MDD) and optimum moisture content (OMC), which represent the soil's capacity to compress and the moisture content at which this is accomplished, is the goal. Each of the soil mixture was compressed in a mold as part of the Standard compaction test. The OMC and MDD for each blend material were calculated by plotting the data as shown below;



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DETERMINATION OF DRY DENSITY/MOISTURE CONTENT

PROJECT CODE: LAFIA NASARAWA STATE
TYPE OF SOIL: LATERITE WITH QUARRY DUST LOCATION: TUNDU ABU DATE: 10/09/2024
TOTAL WEIGHT OF SAMPLE: 6000g MOULD TYPE: AASHTO ANALYST: Tertsea

Wt. of mould and wet Soil.......(W2)..........(g)		10000	10200	10200	
Wt.of mould..........................(Wt)...........(g)		4913	4913	4913	
Wt.of wet soil ....(W2-Wt)................(g)		5087	5287	5287	
Bulk density............Y = W2 - Wl/X....... g/cm3		2.21	2.29		

Volume of mould =

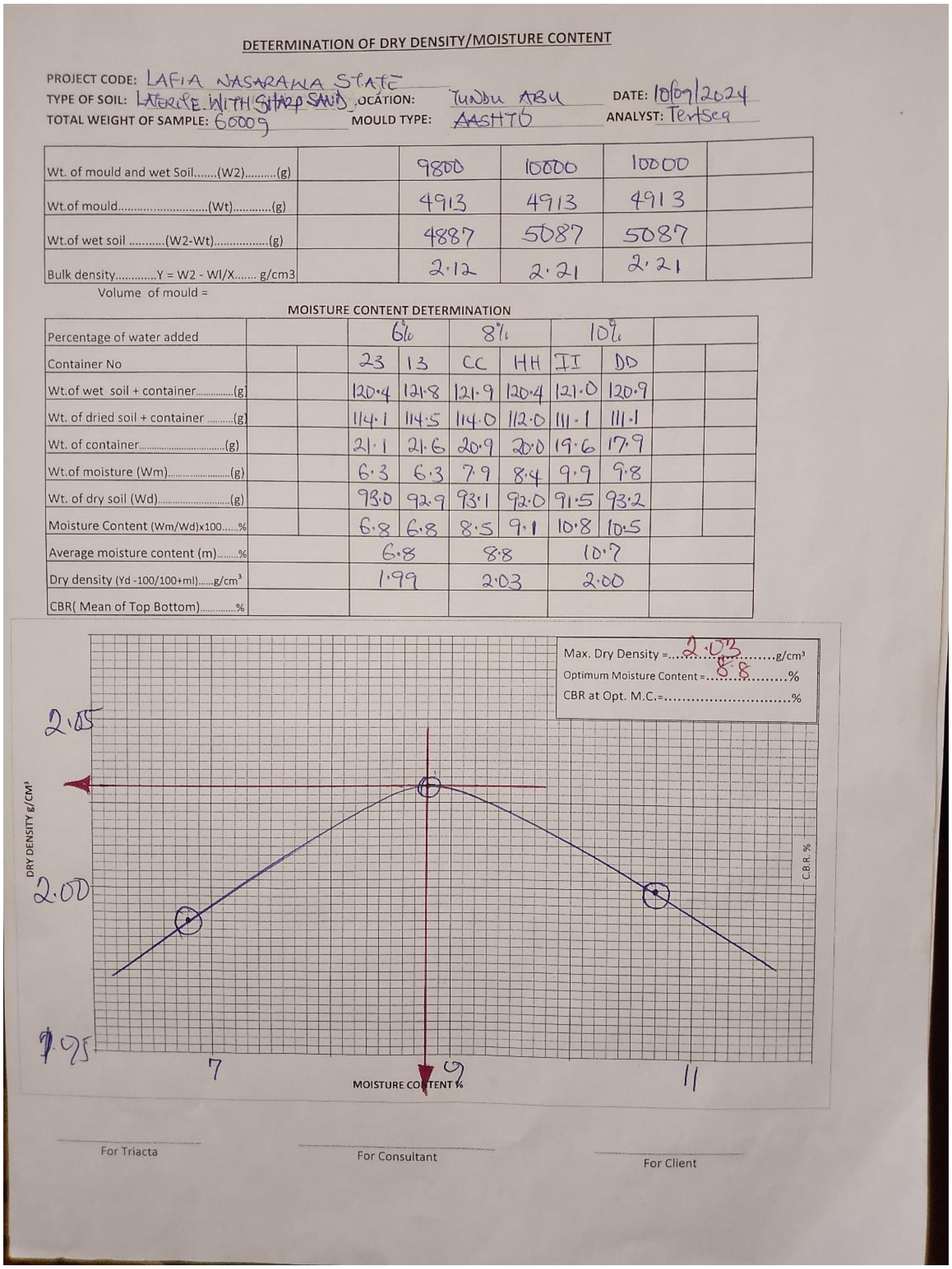
MOISTURE CONTENT DETERMINATION

Percentage of water added										
Container No			CC	TT2	BB	GG	XV	JJ		
Wt.of wet soil + container..............(g)			119.2	116.0	119.7	117.1	116.3	116.2		
Wt. of dried soil + container ....(g)			114.7	110.8	113.8	110.0	108.3	108.3		
Wt. of container.............................(g)			20.8	20.8	19.5	21.3	19.6	20.3		
Wt.of moisture (Wm)......................(g)			4.5	5.2	5.9	7.1	8.0	7.9		
Wt. of dry soil (Wd).........................(g)			93.9	90.0	94.3	88.7	88.7	88.0		
Moisture Content (Wm/Wd)x100......%			4.8	5.8	6.3	8.0	9.0	9.0		
Average moisture content (m).......%			5.3		7.2		9.0			
Dry density (Yd -100/100+ml)..... g/cm³			2.10		2.14		2.10			
CBR(Mean of Top Bottom)............%										

Max. Dry Density =......2.14......g/cm³
Optimum Moisture Content =......7.2......%
CBR at Opt. M.C.=..............................%

For Triacta For Consultant For Client

Figure 6: Compaction Test for Laterite Mixed with Quarry dust



DETERMINATION OF DRY DENSITY/MOISTURE CONTENT

PROJECT CODE: LAFIA NASARAWA STATE
TYPE OF SOIL: LATERITE WITH SHARP SAND LOCATION: TUNDU ABU DATE: 10/09/2024
TOTAL WEIGHT OF SAMPLE: 6000g MOULD TYPE: AASHTO ANALYST: Tertsea

Wt. of mould and wet Soil.......(W2)..........(g)		9800	10000	10000	
Wt.of mould............................(Wt)............(g)		4913	4913	4913	
Wt.of wet soil ....(W2-Wt).................(g)		4887	5087	5087	
Bulk density.............Y = W2 - Wl/X....... g/cm3		2.12	2.21	2.21	

Volume of mould =

MOISTURE CONTENT DETERMINATION

Percentage of water added			6%		8%		10%			
Container No			23	13	CC	HH	II	DD		
Wt.of wet soil + container.............(g)			120.4	121.8	121.9	120.4	121.0	120.9		
Wt. of dried soil + container ....(g)			114.1	114.5	114.0	112.0	111.1	111.1		
Wt. of container..............................(g)			21.1	21.6	20.9	20.0	19.6	17.9		
Wt.of moisture (Wm)......................(g)			6.3	6.3	7.9	8.4	9.9	9.8		
Wt. of dry soil (Wd).........................(g)			93.0	92.9	93.1	92.0	91.5	93.2		
Moisture Content (Wm/Wd)x100......%			6.8	6.8	8.5	9.1	10.8	10.5		
Average moisture content (m)........%			6.8		8.8		10.7			
Dry density (Yd -100/100+ml)......g/cm³			1.99		2.03		2.00			
CBR(Mean of Top Bottom)............%										

Max. Dry Density =......2.03.......g/cm³
Optimum Moisture Content =......8.8........%
CBR at Opt. M.C.=............................%

DRY DENSITY g/CM³
2.05
2.00
1.95
7
9
11
MOISTURE CONTENT %
C.B.R. %

For Triacta
For Consultant
For Client

Figure 7: **Compaction Test for Laterite Mixed with Sharp Sand**

California Bearing Ratio (CBR) Test

To assess the load-bearing capacity of each stabilized soil mix, which is critical for evaluating suitability in road construction and other load-bearing applications Prior to testing, both samples were soaked for 24 hours after being prepared and compressed to their ideal moisture levels. The CBR value was computed as the ratio of the sample's load-bearing capacity to that of standard crushed rock after the penetration of a standard piston was measured under controlled loading as showed below

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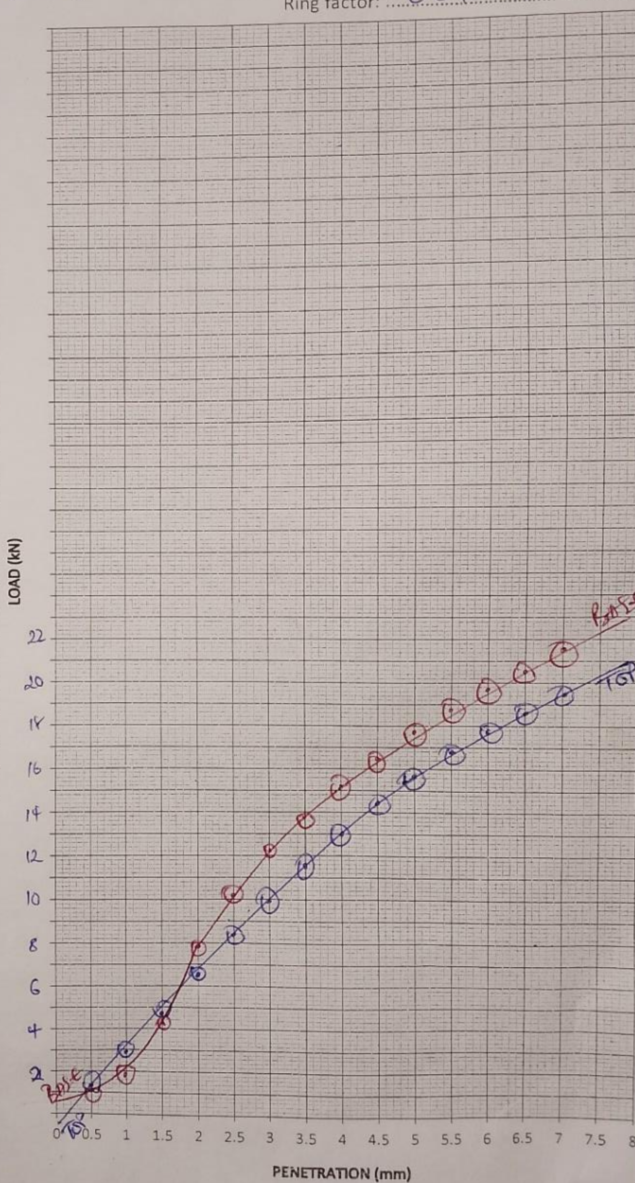
CALIFORNIA BEARING RATIO TEST (BS 1377 - 1975)

Sample no:..
Location and depth: LAFIA NASARAWA STATE (TUNDU ABU)
Soil type: LATERITE MIX WITH QUARRY DUST
Compaction: CBR
Unsoaked/Soaked: 24 hrs
Ring factor: 0.042436

PEN.	BASE		TOP	
MM	DIAL	LOAD	DIAL	LOAD
0.5	26	1.1	30	1.3
1.0	42	1.8	68	2.9
1.5	102	4.3	111	4.7
2.0	185	7.9	153	6.5
2.5	240	10.2	195	8.3
3.0	288	12.2	233	9.9
3.5	325	13.8	274	11.6
4.0	357	15.1	304	13.0
4.5	389	16.5	340	14.4
5.0	417	17.7	370	15.7
5.5	441	18.7	396	16.8
6.0	465	19.7	420	17.8
6.5	438	20.5	439	18.6
7.0	507	21.5	457	19.4

CORRECTED LOAD (kN)		
MM	BASE	TOP
2.5	10.2%	8.3%
5.0	19.7%	15.7%
CORRECTED C.B.R. %		
MM	BASE	TOP
2.5	77.3%	62.9%
5.0	88.5%	78.5%
CBR = 85%		



CBR Calculations:

CBR at 2.5mm = load/13.2

CBR at 5.0mm = load/20.0

Specimen dry density .... kg/mm³

Moisture content at compaction........... %

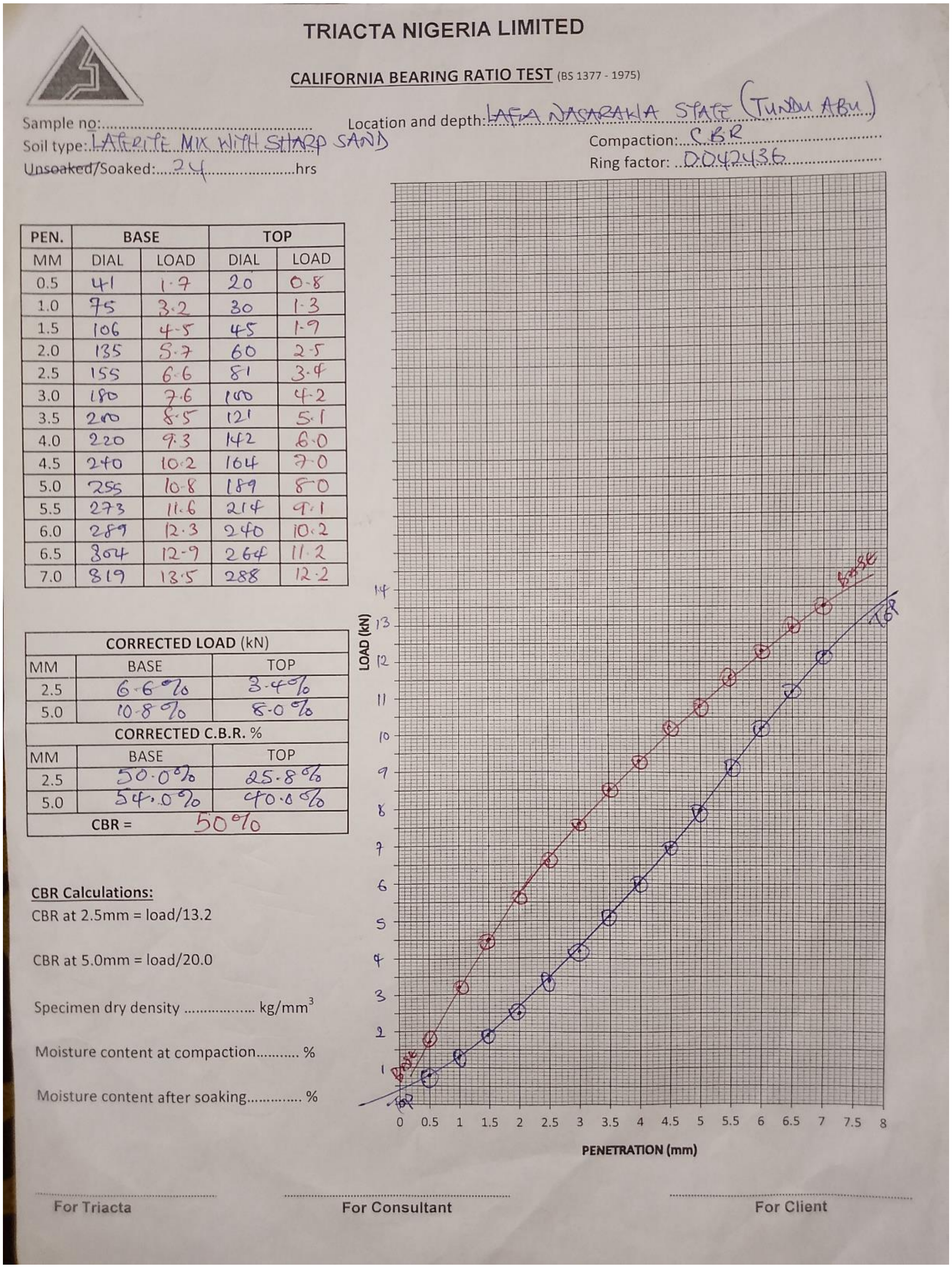
Moisture content after soaking.............. %

For Triacta

For Consultant

For Client

Figure 8: CBR Test for Laterite Mixed with Quarry Dust



TRIACTA NIGERIA LIMITED

CALIFORNIA BEARING RATIO TEST (BS 1377 - 1975)

Sample no:.........................

Location and depth: LAFIA NASARAWA STATE (TUNDU ABU)

Soil type: LATERITE MIX WITH SHARP SAND

Compaction: CBR

Ring factor: 0.042436

~~Unsoaked~~/Soaked: 24 hrs

PEN.	BASE		TOP	
MM	DIAL	LOAD	DIAL	LOAD
0.5	41	1.7	20	0.8
1.0	75	3.2	30	1.3
1.5	106	4.5	45	1.7
2.0	135	5.7	60	2.5
2.5	155	6.6	81	3.4
3.0	180	7.6	100	4.2
3.5	200	8.5	121	5.1
4.0	220	9.3	142	6.0
4.5	240	10.2	164	7.0
5.0	255	10.8	189	8.0
5.5	273	11.6	214	9.1
6.0	289	12.3	240	10.2
6.5	304	12.9	264	11.2
7.0	819	13.5	288	12.2

CORRECTED LOAD (kN)		
MM	BASE	TOP
2.5	6.6 %	3.4 %
5.0	10.8 %	8.0 %
CORRECTED C.B.R. %		
MM	BASE	TOP
2.5	50.0 %	25.8 %
5.0	54.0 %	40.0 %
CBR =	50 %	

CBR Calculations:

CBR at 2.5mm = load/13.2

CBR at 5.0mm = load/20.0

Specimen dry density .... kg/mm^3

Moisture content at compaction........... %

Moisture content after soaking............. %

For Triacta

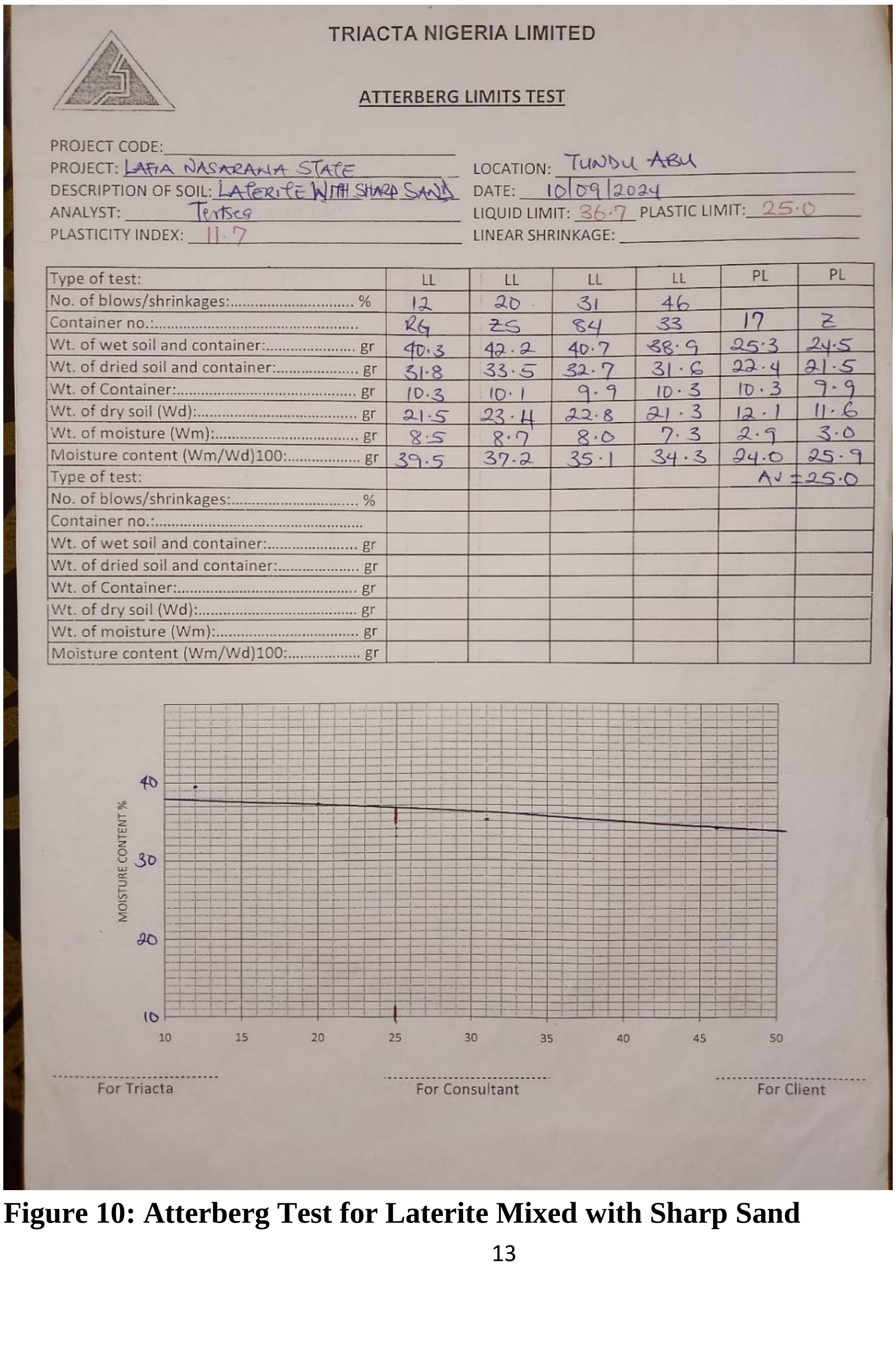
For Consultant

For Client

Figure 9: CBR Test for Laterite Mixed with Sharp Sand

Atterberg Limits (Plastic and Liquid Limits)
To determine the plasticity characteristics of each sample both the sand mix and dust mix laterite were subjected to plastic and liquid limits, which indicate soil workability and sensitivity to moisture.

The plastic limit was established by rolling soil threads until they crumbled, and the liquid limit was established by measuring the water content at which the soil transitions from a liquid to a plastic condition. To compare decreases in plasticity, the Plasticity Index (PI), which shows the difference between the liquid and plastic limits, was computed for every mix and the following result obtained as showed below


TRIACTA NIGERIA LIMITED

ATTERBERG LIMITS TEST

PROJECT CODE:
PROJECT: LAFIA NASARAWA STATE
LOCATION: TUNDU ABU
DESCRIPTION OF SOIL: LATERITE WITH SHARP SAND
DATE: 10/09/2024
ANALYST: Tertsea
LIQUID LIMIT: 36.7 PLASTIC LIMIT: 25.0
PLASTICITY INDEX: 11.7
LINEAR SHRINKAGE:

Type of test:	LL	LL	LL	LL	PL	PL
No. of blows/shrinkages:............................. %	12	20	31	46		
Container no.:..	RG	ZS	84	33	17	Z
Wt. of wet soil and container:..................... gr	40.3	42.2	40.7	38.9	25.3	24.5
Wt. of dried soil and container:................... gr	31.8	33.5	32.7	31.6	22.4	21.5
Wt. of Container:.. gr	10.3	10.1	9.9	10.3	10.3	9.9
Wt. of dry soil (Wd):..................................... gr	21.5	23.4	22.8	21.3	12.1	11.6
Wt. of moisture (Wm):................................. gr	8.5	8.7	8.0	7.3	2.9	3.0
Moisture content (Wm/Wd)100:................. gr	39.5	37.2	35.1	34.3	24.0	25.9
Type of test:						AV ±25.0
No. of blows/shrinkages:............................. %						
Container no.:..						
Wt. of wet soil and container:..................... gr						
Wt. of dried soil and container:................... gr						
Wt. of Container:.. gr						
Wt. of dry soil (Wd):..................................... gr						
Wt. of moisture (Wm):................................. gr						
Moisture content (Wm/Wd)100:................. gr						

For Triacta
For Consultant
For Client

Figure 10: Atterberg Test for Laterite Mixed with Sharp Sand

TRIACTA NIGERIA LIMITED

ATTERBERG LIMITS TEST

PROJECT CODE: ____________________

PROJECT: LAFIA NASARAWA STATE

LOCATION: TUNDU ABU

DESCRIPTION OF SOIL: LATERITE AND QUARRY DUST

DATE: 10/09/2024

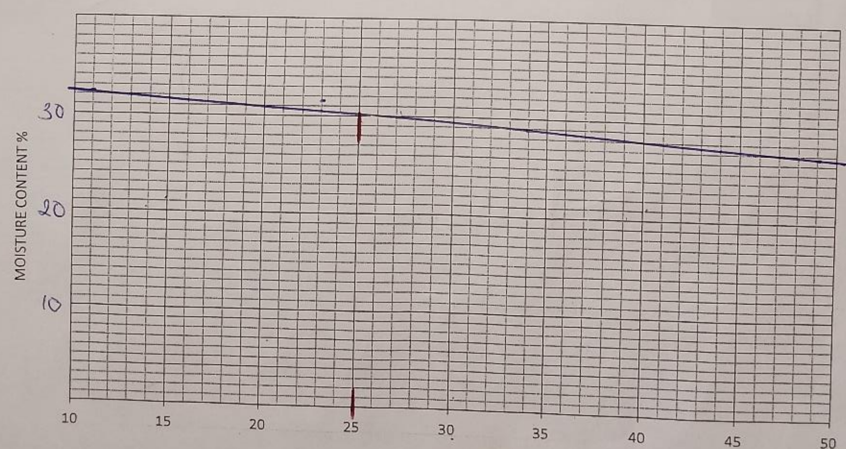
ANALYST: Tenses . D.

LIQUID LIMIT: 30.1 PLASTIC LIMIT: 22.1

PLASTICITY INDEX: 8.0

LINEAR SHRINKAGE: ____________________

Type of test:	LL	LL	LL	LL	PL	PL
No. of blows/shrinkages:............................ %	11	23	34	49		
Container no.:..	MP	33	1B	NK	SZ	34
Wt. of wet soil and container:..................... gr	48.0	48.1	48.4	48.1	28.7	29.4
Wt. of dried soil and container:................... gr	38.8	39.0	39.6	40.0	25.3	25.9
Wt. of Container:.. gr	10.2	10.2	9.1	9.8	10.0	10.0
Wt. of dry soil (Wd):..................................... gr	28.6	28.8	30.5	30.2	15.3	15.9
Wt. of moisture (Wm):................................. gr	9.2	9.1	8.8	8.1	3.4	3.5
Moisture content (Wm/Wd)100:................. gr	32.2	31.6	28.9	26.8	22.2	22.0
Type of test:					Av = 22.1	
No. of blows/shrinkages:............................ %						
Container no.:..						
Wt. of wet soil and container:..................... gr						
Wt. of dried soil and container:................... gr						
Wt. of Container:.. gr						
Wt. of dry soil (Wd):..................................... gr						
Wt. of moisture (Wm):................................. gr						
Moisture content (Wm/Wd)100:................. gr						



For Triacta

For Consultant

For Client

Figure 11: Atterberg Test for Laterite Mixed with Quarry Dust

Results and Discussion

The results of laboratory experiments on laterite soil samples stabilized with different ratios of sharp sand and quarry dust are shown in this section. To determine how each stabilizer affects the performance of laterite soil, the findings are examined in terms of compaction characteristics, load-bearing capacity, compressive strength, and plasticity. To draw attention to important distinctions and trends, comparative tables and graphs are utilized.

1. Compaction Characteristics
   Results: For laterite combined with sharp sand and quarry dust, the maximum dry density (MDD) and optimum moisture content (OMC) were measured at mix ratios of 5%, 10%, 15%, and 20%. The following patterns were noted:

   Sharp Sand: In general, adding sharp sand raised the laterite soil's MDD. At 15% sharp sand, the MDD was maximum, and at 20%, it marginally dropped. The soil needed less water to achieve maximal compaction, as seen by the OMC decreasing as the amount of sharp sand increased.

   Quarry Dust: The MDD was likewise raised by quarry dust, but more so than by sharp sand, particularly at 20% quarry dust, which produced the maximum density. Much like sharp sand, although at a more noticeable rate, the OMC dropped as the amount of quarry dust increased.

   Discussion: Quarry dust had a stronger effect on MDD than sharp sand, but both enhanced the compaction characteristics of laterite soil. The stabilizers' efficient void-filling is what causes the density increase. As opposed to sharp sand, quarry dust's smaller particles fill micro-voids more effectively, producing denser compaction. Because of this property, quarry dust is especially well suited for uses like foundations and road subgrades that need for a higher soil density.

2. California Bearing Ratio (CBR)
   Results: The load-bearing ability of laterite stabilized with sharp sand and quarry dust differed significantly, according to CBR testing.

   Sharp Sand: As the percentage of sharp sand increased, CBR values rose as well, peaking at 15%. The CBR slightly decreased after this point, indicating that adding more sharp sand does not significantly increase load-bearing capability.
   Quarry Dust: There was a constant improvement of up to 20% in the CBR values for laterite mixed with quarry dust. The maximum CBR was obtained from the 20% quarry dust mixture, suggesting a significant increase in load-bearing capacity.

   Discussion: Quarry dust is more effective than sharp sand at boosting the load-bearing capacity of laterite soil, as seen by the higher CBR values obtained with this material. This is probably because quarry dust has finer particles, which enhances bonding strength and interparticle interaction under stress. Because of this, quarry dust is a superior choice for stabilization in heavy-duty applications like base layers for highways or places with significant traffic.

3. Atterberg Limits (Plastic and Liquid Limits)
   Findings: Each mix's Atterberg limits tests revealed the following trends:
   Sharp Sand: As the amount of sand increased, the plasticity index was slightly lowered due to a modest drop in the plastic and liquid limits of laterite combined with sharp sand.

   Quarry Dust: Quarry dust significantly reduced plasticity, as seen by discernible drops in both the plastic and liquid limits across all proportions. At 20% quarry dust, the plasticity index significantly decreased, suggesting increased soil stability against expansion and contraction brought on by water.

   Discussion: Quarry dust successfully lowers the laterite soil's flexibility, reducing its vulnerability to swelling and contraction brought on by variations in moisture content. Quarry dust's tiny particle size and angularity improve stability by lowering the soil's propensity to hold water. While it also decreases plasticity, the effect of sharp sand is less pronounced, indicating that it would be better suited for non-critical applications where plasticity control is not a top priority.

4. Comparative Analysis and Practical Implications
   Sharp Sand: Sharp sand is an economical option for general filling and low-load applications where strong compressive strength and plasticity control are not as important. It also improves compaction and offers a minor strength improvement. The ideal ratio for increasing stability without needless material addition is found to be 15% sharp sand mix.

   Quarry Dust: Quarry dust works better to improve laterite's strength, compaction, and plasticity control. In every test, the 20% quarry dust mixture produced the greatest results, making it perfect for applications that need a high load-bearing capacity and little distortion from variations in moisture. Therefore, in areas with high rainfall or fluctuating moisture levels, this stabilizer is more appropriate for road bases, embankments, and foundations.

Conclusion and Recommendation

The results of this study indicate that, when it comes to enhancing the structural qualities of laterite soil, quarry dust works better as a stabilizing agent than sharp sand, especially in applications that call for high strength and resistance to moisture fluctuations. Although sharp sand is an affordable option for everyday applications, quarry dust is a better option for important infrastructure projects due to its increased strength and longevity. Future studies could investigate mixed sharp sand and quarry dust combinations or look at how long each stabilized blend lasts under actual circumstances.

Based on the results of this study, the following recommendations are proposed to guide the use of laterite stabilized with sharp sand and quarry dust in construction:

1. High-Strength Applications of Quarry Dust

For high-strength applications such road subgrades, embankments, foundations, and other load-bearing structures, quarry dust should be given priority as a stabilizing agent for laterite. According to the study, a 20% quarry dust mix ratio greatly increases moisture resistance, compressive strength, and load-bearing capability, making it perfect for heavy-duty infrastructure projects.

2. Using Sharp Sand for Non-Load-Bearing, Low-Cost Projects

Sharp sand offers an affordable stabilizing option for low-cost building projects where strong compressive strength is not essential, like general fills, walkway subbases, and landscaping applications. It is advised to use a 2% sharp sand mix ratio because it provides a balanced increase in workability and stability without using too much material.

3. Using Sharp Sand and Quarry Dust Together for Optimal Performance

Sharp sand and quarry dust can be used in combination when considerable strength enhancement is still needed but budgetary restrictions are a top concern. A cost-effective approach that strikes a balance between affordability and structural improvement might be obtained by combining the two stabilizers. To determine the ideal ratios for combined stabilizers, more research can be done.

4. Use in Areas Sensitive to Moisture

Because quarry dust has a superior ability to diminish laterite's plasticity, which limits expansion and shrinking under wet and dry cycles, it should be utilized in locations that are susceptible to moisture. Utilizing quarry dust-stabilized laterite will enhance long-term durability and lower maintenance costs in areas with high seasonal rainfall or varying moisture levels.

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