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EVALUATION OF WET AND DRY METHODS OF SIEVE ANALYSIS FOR TROPICAL LATERITIC SOILS IN GHANA

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ABSTRACT

Purpose: This paper compares and analyses the results from various soils' wet sieving and dry sieving methods, emphasising lateritic soils.

Design/Methodology/Approach: A laboratory study involving soils from six (6) different sources was designed to investigate the disparity between the wet and dry sieve methods of particle distribution of soils. The samples were subjected to wet sieve analysis. Then, dry sieve analysis was performed on the same samples. Following analysis, the soil was categorised using the USCS and the AASHTO classification scheme. The results were then compared for disparities or similarities.

Findings: The results indicated a significant disparity in the classification of the same soil using both methods for cohesive lateritic soils. In contrast, the non-cohesive soils showed little to no considerable disparity. In one of the cohesive lateritic soil samples analysed, dry sieving results were used to categorise the soil as well-graded gravel soil, GW, according to the USCS. In contrast, wet sieving results identified the same soil as clayey gravel or gravel-sand-clay mixtures, GC also according to the USCS. According to the AASHTO classification scheme, the same soil was categorised as granular materials with group symbol A-2-6(0) using results from the dry sieving method. Conversely, wet sieving classified the soil as silt-clay material with group symbol A-6(5).

Research Limitation: This research focused on the dry and wet methods used to analyse the distribution of particle sizes in soils in Ghana.

Practical Implication: This study will assist practising engineers in selecting the appropriate sieve analysis method for design and soil analysis for civil engineering structures.

Social Implication: The research contributes to building more resilient and sustainable communities by better understanding and utilising local soil resources.

Originality/Value: This research represents a significant advancement in geotechnical testing methodology tailored explicitly to Ghanaian conditions, filling a crucial gap in tropical soil analysis techniques.

Keywords: *Dry sieving. index property. lateritic soil. particle size. wet sieving*

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INTRODUCTION

The foundation of every civil engineering structure is the soil or the earth (Roy & Bhalla, 2017). The soil is also a significant construction material in many civil engineering structures such as buildings, roads and dams (Sule et al., 2021; Roy & Bhalla, 2017; Laskar & Pal, 2012). Engineering classification of soils involves grouping the natural individual soil units according to their basic engineering properties to remember their properties and their usefulness easily (Powrie, 2018).

It is expected that soils of the same class possess similar engineering properties. As such, simple foundation and material problems are solved by classifying soils into their respective groups according to a specified soil classification system. A preliminary soil classification may help plan and direct the detailed investigation and analysis when a detailed soil investigation is required. The basic tests needed to be performed on the soils for soil classification are called index property tests (Sule et al., 2021; Mathur et al., 2017; Laskar & Pal, 2012).

Many studies have been done to relate other soil properties, such as compaction characteristics, permeability, and soil shear strength, to these index properties (Yousif & Mohamed, 2022; Tizpa et al., 2015; Wroth & Wood, 1978). Thus, accurately determining soil index properties cannot be over-emphasised.

One such index property is the particle size distribution (PSD) performed by sieve analysis. Two methods are usually specified: wet sieving and dry sieving (British Standards Institution, 1990). Both methods involve sieving the soil over a set of sieves with different apertures arranged from the largest to the smallest. The wet sieve method differs essentially from the dry sieve method in that it uses a dispersing agent and is stirred for some time before washing to obtain the separation of the individual grains.

Both approaches are often specified for different soil types, per British Standards Institution's BS 1377 (1990). However, due to the dry sieve method's rapid nature and the dispersing agent's unavailability in institutional laboratories, the dry method is usually preferred over the wet method. This study compares the grading results obtained and subsequent soil classification using both methods to highlight their discrepancies and the need to select an appropriate sieving method for particle distribution analysis.

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LITERATURE REVIEW

Soil Classification Schemes

It has not been easy to develop one fit-for-all soil classification system that properly caters for the various needs of different classes of people who deal with the soil, such as civil engineers, construction engineers, material engineers, mining engineers, geologists, agricultural scientists and ceramists. This is mainly due to the high degree of soil variability and the vast number of properties each of these soil scientists look for or are interested in. Thus, many soil classification schemes have been developed for various purposes. Examples of the early standard textural classification systems include the Bureau of Soils Classification System (1890-1895), the Atterberg Classification System (1905), the MIT Classification System (1931) and the US Department of Agriculture Classification System (1938).

The tenets of soil classification for geotechnical engineering purposes worldwide are based on index properties of soils, which can be easily determined. This enables geotechnical engineers to predict the behaviour and properties of soils using the index property to group the soils according to similar response categories (Park & Santamarina, 2017). The index property tests must necessarily be simple, quickly reproducible, inexpensive and reliable (Powrie, 2018)Useful systems based on one or two index properties have been devised. However, the soil classification systems that are most commonly used for engineering purposes are Casagrande's Extended Classification System, Unified Soil Classification System, and AASHTO Soil Classification System.

Many advanced nations have developed their classification systems, such as the Indian soil classification system, the British soil classification system, and the German soil classification system. However, the tenets of all these engineering soil classification systems are the index properties of the soils. Determination of these properties follows the same principle, with slight changes tailored to the local conditions.

Soil Index Properties

Soil index properties for engineering purposes include mainly Particle Size Distribution (PSD) and Consistency (Atterberg) Limits.

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Particle Size Distribution

Mechanical analysis reveals the distribution of particles of various sizes in soil. A material may comprise boulders, cobbles, gravels, sand, silt, or clay based on the range of particle sizes. Table 1 illustrates the general system of classifying soil particles based on their size.

Table 1: General Classification of Soil Particles based on Their Size

Designation	Category	Particle Size (mm)
Boulders		>200
Cobbles		60 – 200
Gravels	Coarse	20 – 60
	Medium	6 – 20
	Fine	2 – 6
Sand	Coarse	0.6 – 2
	Medium	0.2 – 0.6
	Fine	0.06 – 0.2
Silt	Coarse	0.02 – 0.06
	Medium	0.006 – 0.02
	Fine	0.002 – 0.006
Clay		<0.002

For coarse-grained soils, particle size analysis is carried out by determining the weight percentage of particles or grains retained on a set of sieve sizes. The finest sieve size commonly used in the laboratory or field is the No. 200 (in both the US and Britain) with an aperture of 0.075 mm. Therefore, 0.075 mm is accepted as the boundary between coarse-grained and fine-grained soils.

Particles larger than 75 micrometres

Sieving separates particles greater than 75 µm (coarse-grained soils). Usually, the material is treated to remove organic matter (hydrogen peroxide, H2O2) and intergranular cement (sodium hexametaphosphate). The soil is then sieved through a set of sieves. The material retained on each sieve is weighed, and the percentage passing each sieve is calculated and then plotted on a semi-log graph.

Particles less than 75 micrometres

The material passing the 75 µm sieve is considered too fine to further separate by sieving. These "fines", as they are termed, are further separated into different sizes by sedimentation. All

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sedimentation methods are based on Stoke's Law, which states that the velocity at which a spherical particle will sink in a suspension due to gravity is directly proportional to the distance covered and inversely proportional to the time taken to cover the distance. Mathematically, this is stated as

$$v = \frac{h}{t} = \frac{2}{9} r^2 \frac{\gamma_g - \gamma_f}{\eta} = \frac{1}{18} D^2 \frac{\gamma_g - \gamma_f}{\eta}$$

where
v = velocity of particle in the still fluid
h = distance/ height / depth to which particle sank
t = time taken to sink to the depth of h
r = radius of particle and D= diameter of particle (r=D/2).
γ_g, γ_f = unit weight of particle and fluid respectively
η = viscosity of fluid.

Uses of particle size distribution

Very relevant and valuable information may be obtained from particle distribution curves such as (i) a total percentage of particles finer or coarser than a given size and (ii) the range in grain-size distribution (uniformity coefficient and coefficient of curvature). Particle size distribution is a widely used parameter in the classification of soils (Apparao & Rao, 1995). Data from particle size distribution charts is helpful in the determination of suitable materials for airfields, roads, dams, levees, and embankment construction, as well as filter design for earth dams (Raj, 2008; Bowles, 1992).

Information obtained from particle size analysis can be used to predict soil-water movement and frost susceptibility, a significant phenomenon in colder climates. According to Dafalla (2013), the soil shape, whether rounded, subrounded, or angular, will affect the shearing strength. The gradation and size of the soil affect the shear resistance. Angular grains offer more interlock and improved shear resistance, while well-graded materials provide more grain-to-grain area contact than poorly graded materials (Roy & Bhalla, 2017).

Atterberg Limits

Particle size distribution gives little information about the engineering properties of very fine-grained soils in which clay minerals are predominant. Therefore, the Atterberg limits provide further details on the engineering properties. Depending on water content, the limits are based on the concept that fine-grained soil can exist in any of the four states (solid, semi-solid, plastic, and

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liquid). The limits are shrinkage limit, which is the water content at the boundary of the solid state and semi-solid state; plastic limit, which is the water content at the boundary of the semi-solid state and the plastic state; and the liquid limit, which is water content at the boundary of the plastic state and the liquid state. The Casagrande apparatus and the Cone Penetrometer device are generally used to determine the plastic and liquid limits.

Determination of other soil properties from index properties

Many studies have related other soil properties, such as compaction characteristics, permeability, and soil shear strength, to the index properties (Yousif & Mohamed, 2022; Tizpa et al., 2015; Wroth & Wood, 1978).

Relation of soil's hydraulic properties to its index properties

Soil hydraulic properties such as effective size (d_{10}) and coefficient of permeability (k) can be empirically determined from the soil's gradation. Many scientists have produced empirical formulae for determining k from effective size (d10), uniformity coefficient (Cu), and void ratio (e). Generally, all these empirical correlations can be summarised in the formula below.

$\boldsymbol{K = C \cdot d_{10}{}^{a} \cdot C_u{}^{b} \cdot e^{c}}$, where ***C, a, b*** and ***c*** are constants.

An example is the Hazen's formula, given as:

$\boldsymbol{k = C_k d_{10}^2}$ ***(m/s),*** where $\boldsymbol{C_k}$ is an experimental coefficient.

Capillary rise is a phenomenon that depends, among others, on effective porosity, which is essentially a function of the particle distribution of the soil (Stãnciucu, 2018). Fine-grained soils are known to exhibit higher capillary rise than coarse-grained soils. Well-graded soils achieve higher densification and are less permeable than gap-graded or poorly graded soils. Fine-grained soils are also less permeable than coarse-grained soils. According to Tizpa et al., (2015) six input variables, namely fineness modulus (FM), liquid limit (LL), gravel content (Gc), sand content (Sc), fines content (Fc), and compaction degree (Cd), were used for the Artificial Neural Network (ANN) model to predict the permeability coefficient. Five of these variables are index properties, with four (4) derived from gradation analysis.

Relation of soil's erodibility properties to its index properties

The erodibility of soils can also be determined from the gradation of soils. Well-graded soils achieve higher densification and, consequently, higher resistance to erosion than gap-graded or poorly graded soils (Wagner, 1957). According to Ghana Standard Specification for Roads and Bridge Works (GSSRB), material specification for the wearing course of gravel roads depends mainly on gradation and Atterberg limits. Thus, the erodibility potential of the gravel-wearing

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course can be determined from the gradation coefficient and the shrinkage product (Ministry of Transportation, 2007). According to O'geen, (2006) soil erodibility is controlled by four major soil properties, the first of which is particle size distribution (texture). Another of the four governing properties of erodibility is permeability, a function of particle size distribution.

Relation of shear strength to index properties of soils

Well-graded soils achieve higher densification and, therefore, higher shear strength than gap-graded or poorly graded soils. Coarse-grained soils achieve most of their shear strength by intergranular friction, whilst most fine-grained soils depend mainly on cohesion between the soil grains to achieve shear strength.

Using five input variables, namely coarse content (Cc), fine content (Fc), liquid limit (LL), soil bulk density (γ), and shearing rate (Sr), Tizpa et al., (2015) the ANN model predicted the effective friction angle of shearing, a shear strength parameter, with high accuracy.

Index properties such as particle size distribution, the shape of the particles, and soil consistency affect the shearing strength (Khaboushan et al., 2028). There is, therefore, a direct correlation between the shear strength parameters of granular soil on the one hand and the maximum particle size, the uniformity coefficient, and the gravel and fines content of the soil on the other hand. The shear strength parameters could be said to be a result of the frictional forces of the particles, as they slide and interlock during shearing (Guo & Yu, 2023; Yagiz, 2001). Soil containing high angular particles tends to resist displacement and hence possess higher shearing strength in comparison with soils having fewer angular particles (Ranjan & Rao, 2011).

Relation of soil's compaction characteristics to index properties of soils

The type of soil, determined by the particle size distribution, affects the equipment and compaction effort required to achieve maximum compaction. Well-graded soils achieve higher densification than gap-graded, uniformly graded or poorly graded soils (Bedja et al., 2022).

Tizpa et al., (2015), uses artificial neural network prediction models to show that soils' maximum dry density and optimum moisture content relate very well to index properties of soils, especially particle size distribution. Specifically, gravel content, sand content, fines content specific gravity, liquid limit, and plastic limit correlate very well with both maximum dry density and optimum moisture content of soils.

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MATERIALS AND METHODS

Research design

This study utilised the experimental approach to investigate the grading properties of some soils using analyses from both the dry and wet sieving approaches. The procedure adopted was to perform sieve analysis on six different soils using the wet sieving method, analyse the results and categorise the soils using both USCS (ASTM, 1985) and AASHTO system of classification (AASHTO M145-91, 2012). The same soils were subjected to the dry sieving method, the results analysed, and the soil was again classified using both the USCS and AASHTO classification schemes. The dry and wet sieve analysis results were then compared and analysed.

Six soils from different sources and locations were sampled and used in the grading analysis. Three of these soils are presumed lateritic gravel materials, while the other three are sandy soils. The soils are labelled Soil 1 up to Soil 6, with the location attached to the names.

Wet Sieve Analysis

For cohesionless soils down to the fine sand size, the wet sieving method is the specified and definitive technique (British Standards Institution, 1990). BS1377 1990 part 2 procedures were essentially followed for the wet sieving test. A representative soil sample was prepared according to BS 1377 1990, part 1, section 7 for sieve analysis. The material used for all wet sieves had a starting dry weight of 300g. This was added to water containing 2g/L of sodium hexametaphosphate. The mixture was stirred mechanically for at least one hour and then washed over a 0.075mm sieve nested in a 2mm sieve until the water coming out was clear. All material retained over the 0.075mm and 2mm sieve sizes was collected into a pan using sufficient water and dried in the oven overnight. The soil was then sieved over a set of sieves, and the various percentages retained and passing were calculated and plotted to obtain the grading curve.

Dry Sieve Analysis

The dry sieving method is appropriate for soils with small amounts of clay or silt particles (British Standards Institution, 1990) part 2 of BS 1377 1990 procedures were followed for the dry sieving test. A representative soil sample was prepared for sieve analysis according to BS1377 1990, part 1, section 7. The original dry weight of the material used for all dry sieves was 250g. The soil was sieved over a set of sieves, and each sieve's weight retention was noted. The percentages retained and passing were then calculated and plotted to obtain the grading curve.

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Sedimentation Analysis Using the Hydrometer Method

Materials finer than 75 µm sieve are better separated using the sedimentation method. All sedimentation methods employ Stokes law, which stipulates that there is a direct proportionality between the travel velocity of a spherical particle in a fluid medium to the distance covered and inverse proportionality between the time taken for travelling and the distance.

In this research, the hydrometer approach was employed to establish the density of the soil suspension at specific time intervals. The procedure for the sedimentation analysis using the hydrometer method conducted in this research work was basically according to BS 1377 1990, part 2. Fifty (50) grams of material finer than 0.5mm sieve size for sandy soils and 0.1mm for the lateritic soils were mixed with a dispersant solution and distilled water and stirred for at least one hour using a mechanical stirrer. The material was then transferred to the 1000ml measuring cylinder, and the test was carried out.

(a) (b)

Figure 1: Sieve Analysis tests – (a) Grading and (b) Sedimentation Analysis

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Materials Employed

The materials used in this study are listed below.
Lateritic Soils from around Sunyani in the Bono region of Ghana were labelled with the following locations: Soil_1: Agyei Ano South_Sunyani, Soil_4: CUC-Fiapre_Sunyani, and Soil_5: STU AVIC Lab_Sunyani.

Sand from Bechem in the Ahafo region of Ghana was labelled as Soil_3: Bechem_Ahafo. Sand from the seashore of Tegbi in the Volta region of Ghana was labelled as Soil_2: Tegbi_Keta. Sand from another source in Bechem in the Ahafo region of Ghana labelled as Soil_6: Bechem_Ahafo.

Portable Water for washing.
Distilled *water* was used to prepare the dispersant solution and the sedimentation analysis.
Sodium hexametaphosphate for the wet sieve analysis and preparation of the dispersant solution.

Tools and Equipment

Tools and equipment used included stopwatches, scales, buckets, soil sieves, 1000-ml measuring cylinders, a long-stem soil hydrometer, a thermometer, a trowel, a shovel, a scoop, pans, metal brushes, a riffle box, glass beakers, water bottles, mechanical stirrers, and a mechanical sieve shaker.

Analysis and Comparison of Results

The results of the gradation tests for each soil were analysed using particle distribution curves. Grading characteristics were determined and used to classify the soils, which were then compared.

RESULTS AND DISCUSSION

Soil_1: Agyei Ano South_Sunyani

The soil is reddish brown lateritic soil. Figure 2 presents particle size distribution (PSD) charts for both sieving methods. Table 2 provides details of both wet and dry sieve analysis.

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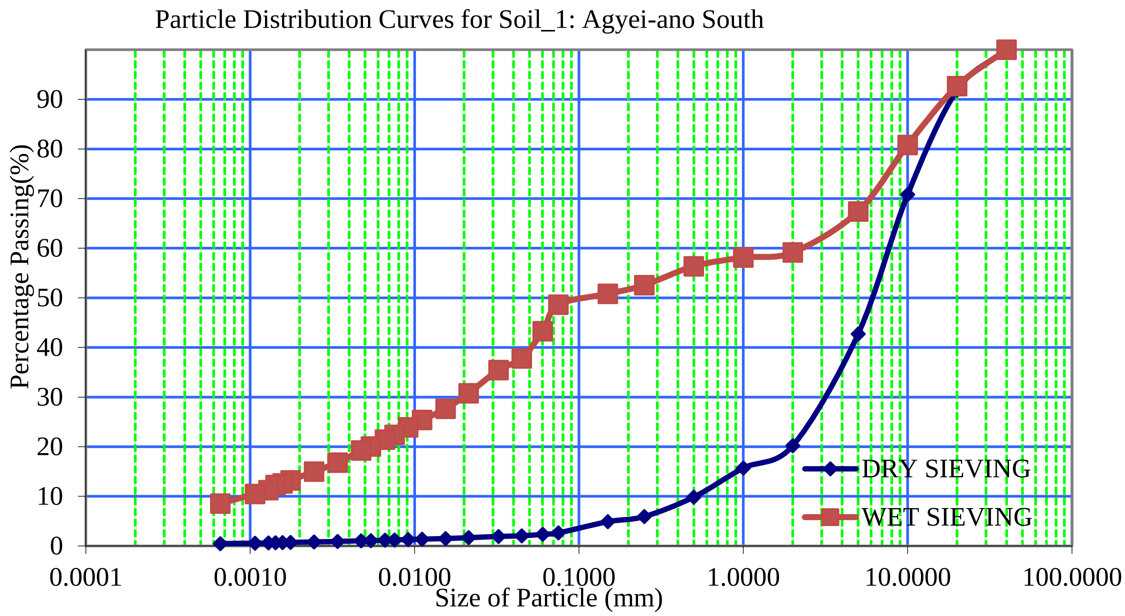

Figure 2: Gradation Charts for Both Wet and Dry Sieving of Soil_1: Agyei Ano South

Table 2: Grading characteristics of Soil_1: Agyei Ano South

Characteristic	Wet Sieving	Dry Sieving
D_{10} (mm)	0.001	0.5
D_{30} (mm)	0.02	2.8
D_{60} (mm)	2.2	6.9
Cu	2200.00	13.80
Cc	0.18	2.27
F_{200}	48.6	2.3
LL	38.25	38.25
PL	22.44	22.44
PI	15.81	15.81
Passing 4.75mm	65	46
Passing 2.0mm	59.2	21.1
Passing 0.075mm	48.6	2.3
Passing 0.06mm	40	1.8
Passing 0.002mm	14	0.65

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Gravel	35	54
Sand	16.4	43.7
Silt	34.6	1.65
Clay	14	0.65

Classification Using the USCS

Wet Sieving

The percentage of material passing the 75µm sieve was 48.6%. Thus, the soil is coarse-grained. The gravel portion was 35%. Therefore, the soil is a gravel material. The percentage of fines was 48.6%. Therefore, the soil is gravel with fines. The uniformity coefficient was determined as 2200, and the coefficient of curvature was found to be 0.18. Hence, the soil is poorly graded. The silt content is 34.6%, and the clay content is 14%; thus, the soil is silty gravel. The sand content is also 16.4%; therefore, based on the unified system of soil classification and the wet sieving method, poorly graded silty gravel with sand and clay with the group symbol GM can be used to describe the soil.

Dry Sieving

The percentage finer than 75µm was 2.3%. Thus, the soil is coarse-grained. The gravel portion was 54%. Therefore, the soil is a gravel material. The percentage of fines was 2.3%. Therefore, the soil is gravel with minimal fines. The uniformity coefficient (Cu) was determined as 13.80, and the coefficient of curvature (Cc) was found to be 2.27. Therefore, the soil is well-graded. The sand content was also 43.7%; thus, according to the USCS and the dry sieving method, the soil fits the description of well-graded sandy Gravel with very little silt and clay. The group symbol is GW.

Comparison of Classification of Soil 1 under USCS using Wet and Dry Sieving Methods

Using the wet sieve analysis, Soil 1_Agyei Ano South is a poorly graded silty Gravel with some sand and clay, GM. On the other hand, using dry sieving analysis, Soil 1 is a well-graded sandy Gravel with little fines, GW. A closer look at the gradation analysis indicates that the soil is gravel soil with a fine content of 48.6% (excess fines) under the wet sieving method, whilst under the dry sieving method, the fine content is 2.3% (little or no fines). Thus, more fines are observed under the wet sieving method. This could be attributed to the effect of the dispersing agent used (sodium hexametaphosphate) and the stirring and washing employed in the wet sieving method. Thus, it could be said that the processes of wet sieving properly ensure the separation of the various particle sizes of the soil.

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Again, the Cu and Cc were 2200 and 0.18 under wet sieving, respectively, whereas the Cu and Cc values were 13.80 and 2.27 for the dry sieving. This indicates that the dry-sieving method gives a more uniform result. In contrast, wet sieving gives a broader range of particle sizes because individual grains of the sample are well separated.

Classification Using the AASHTO Classification System

Wet Sieving

The percentage of material passing the 75µm sieve was 48.6%, indicating that the soil is a Silt-Clay material. The liquid limit (LL) was found to be 38.25, and the plasticity index (PI) was 15.81, indicating that this soil classifies as A-6. The group index was determined to be 5. Therefore, based on the AASHTO classification and the wet sieve analysis, the soil is a Silt-Clay material under A-6(5). These are silty or clayey materials with a fair to poor rating as subgrade materials.

Dry Sieving

The percentage of material passing the 75µm sieve was 2.3%, indicating that the soil is granular. With an LL of 38.25 and PI of 15.81, the soil classifies as A-2-6. The group index was determined to be zero (0), indicating that, by the AASHTO classification and the dry sieve analysis, the soil is granular under A-2-6(0). These are silty or clayey gravel and sand materials with good ratings as subgrade materials.

Comparison of Classification of Soil 1 under AASHTO using Wet and Dry sieving Methods

Using the wet sieve analysis, Soil 1_Agyei Ano South is a Silt-Clay material with group symbol A-6(5), which has a fair to poor rating as a subgrade material. On the other hand, using the dry sieving method, Soil 1 is classified as a granular material with group symbol A-2-6(0), which is rated as suitable for use as a subgrade material.

The disparity between the results of the two sieving methods is vast and significant, and depending on the sieving method employed in the analysis, it can affect the use or otherwise of the material. This vast disparity could be linked to the presence of interstitial clay and the bonding of several soil particles together by soil cement, which the dispersing agent, coupled with the mechanical stirring, was able to break down into individual soil grains during the wet sieving method.

Soil_2: Tegbi_Keta

The sandy soil from the sea shore is very light or creamy brown and non-plastic. Figure 3 presents the PSD charts for wet and dry sieving methods. Details of both wet and dry sieve analyses are presented in Table 3.

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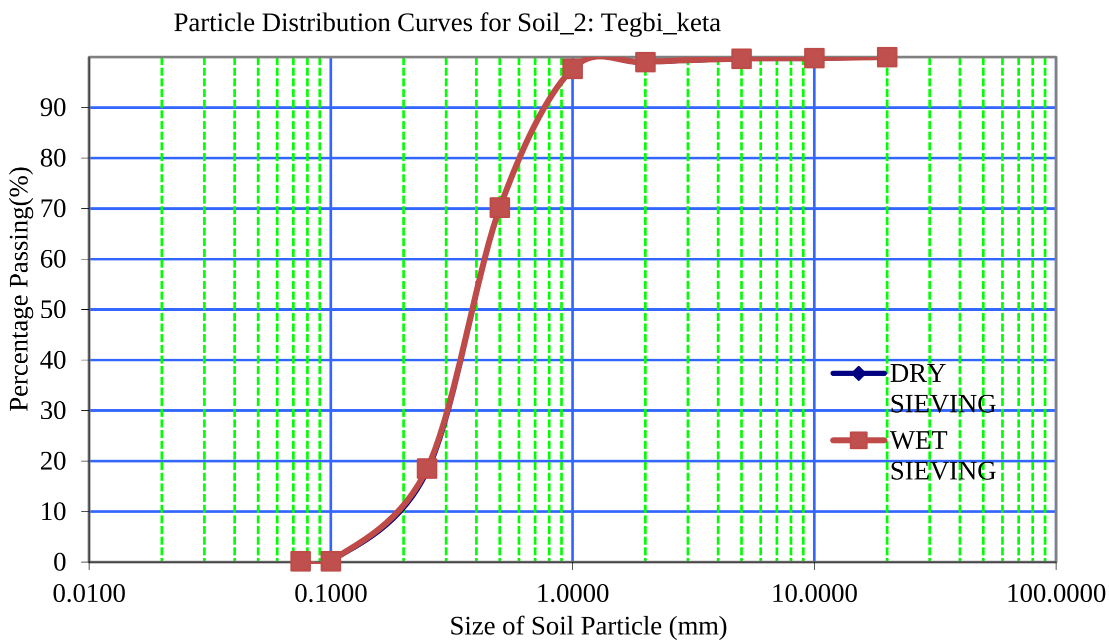

Figure 3: Gradation Charts for Both Wet and Dry Sieving of Soil_2: Tegbi_Keta

Table 3: Grading characteristics of Soil_2: Tegbi_Keta

Characteristic	Wet Sieving	Dry Sieving
D_{10} (mm)	0.22	0.18
D_{30} (mm)	0.33	0.3
D_{60} (mm)	0.48	0.44
Cu	2.18	2.44
Cc	1.03	1.14
F_{200}	0.38	0.1
LL		
PL		
PI		
Passing 4.75mm	99.5	99.5
Passing 2.0mm	99	99
Passing 0.075mm	0.38	0.1
Passing 0.06mm	0	0
Passing 0.002mm	0	0

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Gravel	0.5	0.5
Sand	99.12	99.4
Silt	0.38	0.1
Clay	0	0

Classification Using the USCS

Wet Sieving

The percentage of material passing the 75µm sieve was 0.38%. Thus, the soil is coarse-grained. The gravel portion was 0.5%. Therefore, the soil is a sand material. The percentage of fines was 0.38%. Therefore, the soil is sand with little or no fines. The uniformity coefficient was determined to be 2.18, and the coefficient of curvature was found to be 1.03; therefore, the soil was poorly graded. The silt content is 0.38%, and the clay content is 0%; thus, the soil is pure sand. Therefore, based on the USCS and the wet sieving method, the soil can be classified as poorly graded pure sand with little fines. The group symbol is SP.

Dry Sieving

The percentage finer than 75µm sieve was 0.1%. Thus, the soil is coarse-grained. The gravel portion was 0.5%. Therefore, the soil is a sand material. The percentage of fines was 0.1%. Therefore, the soil is sand with little or no fines. The Cu was determined as 2.44, and the Cc was found to be 1.14. Thus, the soil is poorly graded. With a silt content of 0.1%, Soil 2 can be classified as poorly graded Sand with a minimal fine based on the unified soil classification system and the dry sieving method. The group symbol is SP.

Comparison of Classification of Soil 2 under USCS using Wet and Dry Sieving Methods

A closer look at the gradation analysis indicates that the soil is poorly graded pure sand with little fines when both wet and dry sieving methods were used. The difference in the fine content is also minimal, 0.28%, and the dry sieving generated lesser fines of 0.1%. Thus, more fines are observed under the wet sieving method. This could be attributed to the effect of the dispersing agent used (sodium hexametaphosphate) and the stirring and washing employed in the wet sieving method. Thus, it could be said that the processes of wet sieving properly ensure the separation of the various particle sizes of the soil.

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Classification Using the AASHTO Classification System

Wet Sieving

The percentage of material passing the 75µm sieve was 0.38%, indicating that the soil is granular. The percentages passing the 2mm and 0.425mm sieve sizes are 99% and 60%, respectively. The soil is also nonplastic, so it is classified as granular material under A-3 using the AASHTO classification system and the wet sieving method. It is sand and rates as excellent to good for use as a subgrade material.

Dry Sieving

The percentage of material passing the 75µm sieve was 0.1%; thus, the soil is granular. The percentages passing the 2mm and 0.425mm sieve sizes are 99% and 62%, respectively. The soil is also nonplastic; therefore, it classifies as granular material under A-3 using the AASHTO classification system and the dry sieving method. The soil is sand and rated as a subgrade material from good to excellent.

Comparison of Classification of Soil 2 under AASHTO using Wet and Dry Sieving Methods

Using the wet sieve analysis, Soil 2_ Tegbi-Keta is a granular material with group symbol A-3, rated excellent too good for use as a subgrade material. On the other hand, using the dry sieving method, Soil 2 is classified as a granular material with group symbol A-3, rated excellent and too good for use as a subgrade material.

The disparity between the results of the two sieving methods is very insignificant. Depending on the sieving method employed in the analysis, it cannot affect the material's use. The insignificant disparity between the wet and dry sieving methods results could be due to the clean nature of soil two and the fact that the individual grains of the soil were already separated before the tests were carried out.

Soil_3: Bechem_Ahafo

The soil is light and creamy brown sandy soil. Figure 4 presents the PSD charts for wet and dry sieving methods. Table 4 details the gradation characteristics of both wet and dry sieve analysis.

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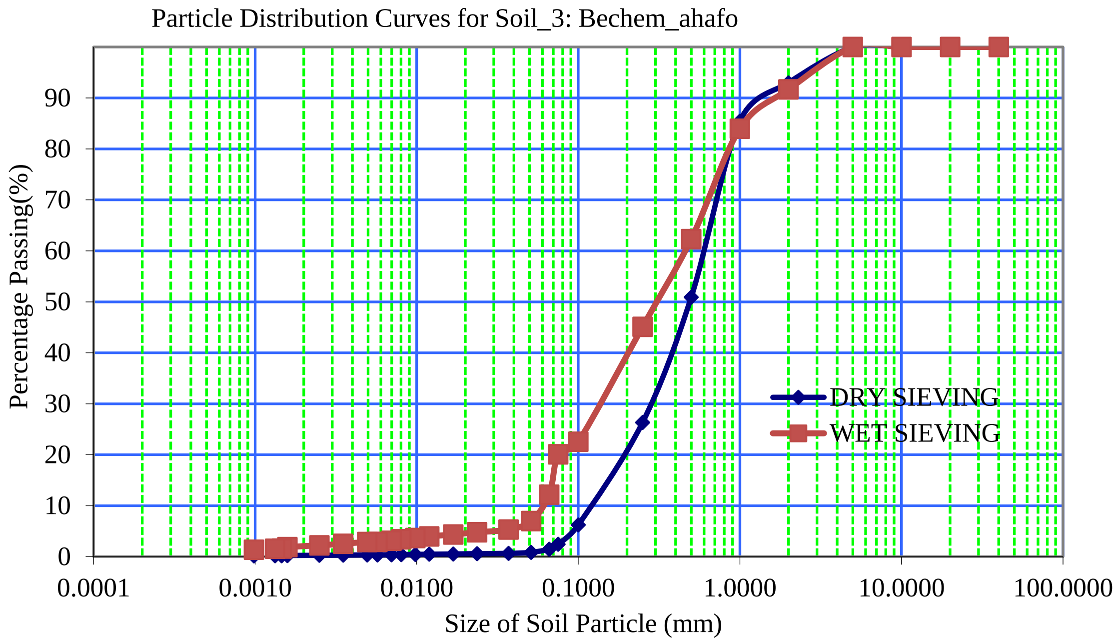

Figure 4: Gradation Charts for Both Wet and Dry Sieving of Soil_3: Bechem_Ahafo

Table 4: Grading characteristics of Soil_3: Bechem_Ahafo

Characteristic	Wet Sieving	Dry Sieving
D_{10} (mm)	0.062	0.12
D_{30} (mm)	0.14	0.28
D_{60} (mm)	0.47	0.6
Cu	7.58	5.00
Cc	0.67	1.09
F_{200}	20.1	2.4
LL	14.36	14.36
PL	9.68	9.68
PI	4.68	4.68
Passing 4.75mm	99.5	99.5
Passing 2.0mm	91.7	93
Passing 0.075mm	20.1	2.4
Passing 0.06mm	8	1.2

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Passing 0.002mm	2.1	0.7
Gravel	0.5	0.5
Sand	79.4	97.1
Silt	18	1.7
Clay	2.1	0.7

Classification Using the USCS

Wet Sieving

The percentage of material passing the 75µm sieve was 20.1%. Thus, the soil is coarse-grained. The gravel portion was 0.5%. Therefore, the soil is a sand material. The percentage of fines was 20.1%. Therefore, the soil is sand with excess fines. The uniformity coefficient was determined as 7.58, and the coefficient of curvature was found to be 0.67. Thus, the soil is poorly graded. The silt content is 18%, and the clay content is 2.1%; therefore, the soil is silty Sand with some clay. Hence, based on USCS and the wet sieving method, the soil can be categorised into poorly graded silty Sand with some clay. The group symbol is SM.

Dry Sieving

Material passing the 75µm sieve was 2.4%; thus, the soil is coarse-grained. The gravel portion was 0.5%. Therefore, the soil is a sand material. The percentage of fines was 2.4%. Therefore, the soil is sand with minute fines. The uniformity coefficient was determined as 5.00, and the coefficient of curvature was found to be 1.09. Thus, the soil is poorly graded. The silt content was also 1.7%, with clay content being 0.7%; therefore, utilising the unified system of soil classification and the dry sieving method, the soil description is poorly graded, with minimal fines. The group symbol is SP.

Comparison of Classification of Soil 3 under USCS using Wet and Dry Sieving Methods

Using the wet sieve analysis, Soil 3_Bechem is a poorly graded silty Sand with excess fines, SM. However, using dry sieving analysis, soil 3 is poorly graded sand with little or no fines, such as SP. A closer look at the gradation analysis indicates that the soil is poorly graded Sand and has excess fines under the wet sieving method, with a fine content of 20.1%. The fine content under the dry sieving method was 2.4. The difference in the fine content was 17.3%, which is significant. Thus, more fines are observed under the wet sieving method. This could be attributed to the effect of the dispersing agent used (sodium hexametaphosphate) and the stirring and washing employed in the wet sieving method. Thus, it could be said that the processes of wet sieving properly ensure the separation of the various particle sizes of the soil.

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Again, the Cu and Cc were 7.58 and 0.67 under wet sieving, respectively. In comparison, the Cu and Cc values were 5.00 and 1.09, respectively, for dry sieving. This indicates that the dry sieving method gives a more uniform result, while wet sieving gives wide particle size ranges because of the separation of individual grains.

Classification Using the AASHTO Classification System

Wet Sieving

The percentage of material passing the 75µm sieve was 20.1%, indicating that the soil is granular. The percentages passing the 2mm and 0.425mm sieve sizes are 91.7% and 58%, respectively. With a liquid limit (LL) of 14.36 and a plasticity index (PI) of 4.68, the soil classifies as A-2-4. The group index was determined to be 0, indicating that the soil is granular material under category A-2-4(0). These are silty sand with a good rating as a subgrade material.

Dry Sieving

The percentage of material passing the 75µm sieve was 2.3%; thus, the soil is granular. The percentages passing the 2mm and 0.425mm sieve sizes are 93% and 46%, respectively. With an LL of 14.36 and PI of 4.68, the soil classifies as A-1-b. The group index was determined to be 0; the soil is a granular material under A-1-b (0). These are stone fragments, gravel, and sand materials with excellent ratings as subgrade materials.

Comparison of Classification of Soil 3 under AASHTO using Wet and Dry sieving Methods

Using the wet sieve analysis, Soil 3_ Bechem is a granular material with group symbol A-2-4(0) and a good subgrade material rating. On the other hand, using the dry sieving method, Soil 3 is classified as a granular material with group symbol A-1-b (0), which is rated as excellent for use as a subgrade material.

The disparity between the results of the two sieving methods is slightly significant. The sieving method employed in the analysis may affect the material's use. This disparity could be attributed to the bonding of several soil particles together by soil cement, which the dispersing agent, coupled with the mechanical stirring, was able to break down into individual soil grains during the wet sieving method.

Soil_4: CUC-Fiapre_Sunyani

The soil is greyish to dark brown lateritic material. Figure 5 presents the gradation charts for both the wet and dry sieving methods. Table 5 provides details of both wet and dry sieve analysis.

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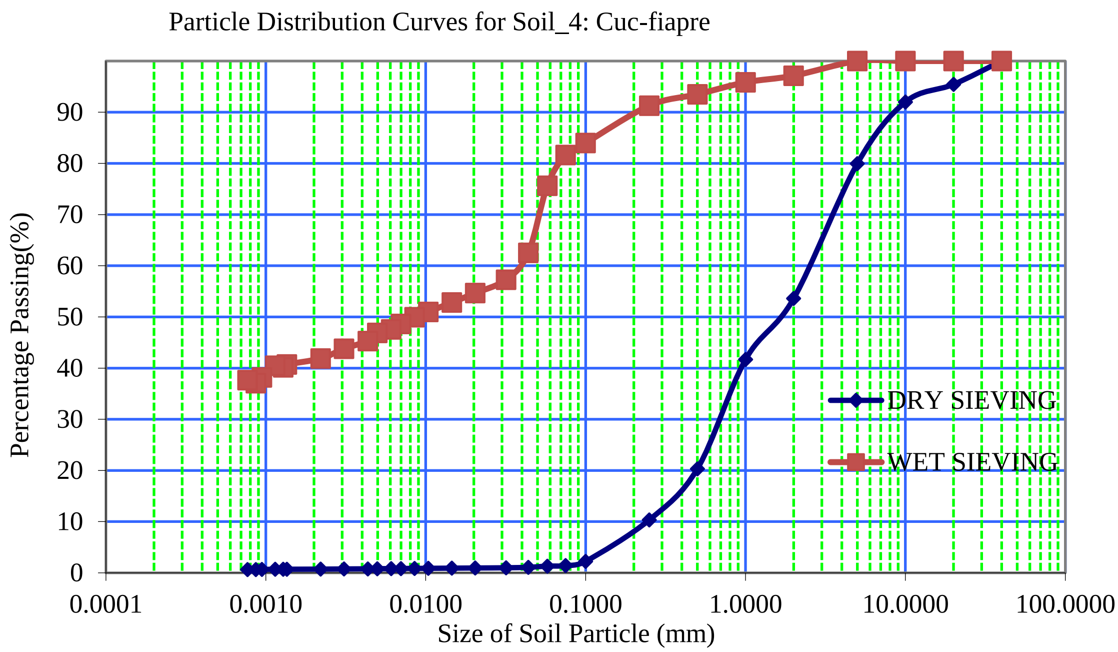

Figure 5: Gradation Charts for Both Wet and Dry Sieving of Soil_4: CUC – Fiapre

Table 5: Grading characteristics of Soil _4: CUC – Fiapre

Characteristic	Wet Sieving	Dry Sieving
D_{10} (mm)	-	0.24
D_{30} (mm)	-	0.7
D_{60} (mm)	0.04	2.5
Cu	-	10.42
Cc	-	0.82
F_{200}	81.6	1.4
LL	49.54	49.54
PL	32.90	32.90
PI	16.64	16.64
Passing 4.75mm	99.5	78
Passing 2.0mm	97.1	53.6
Passing 0.075mm	81.6	1.4

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Passing 0.06mm	78	1.3
Passing 0.002mm	41	0.6
Gravel	0.5	22
Sand	17.9	76.6
Silt	40.6	0.8
Clay	41	0.6

Classification Using the USCS

Wet Sieving

The percentage of material passing the 75µm sieve was 81.6% (fine content). Thus, the soil is fine-grained. The silt portion was 40.6%, and the clay portion was 41%. Therefore, the soil is a clay material. The LL and PI were 49.96 and 21.90 respectively. Since LL was less than 50 and PI plots above the A-Line, the soil can be described as low plasticity silty Clay. The sand content is also 17.9%; therefore, utilising the unified system of soil classification and wet sieving method results, the soil fits the category of poorly graded low plasticity silty Clay with sand. The group symbol is CL.

Dry Sieving,

Material finer than 75µm was 1.4%. Thus, the soil is coarse-grained. The gravel portion was 22%. Therefore, the soil is a sand material. The percentage of fines was 1.4%. Therefore, the soil is sand with an insignificant quantity of fines. The uniformity coefficient was determined as 10.42, and the coefficient of curvature was found to be 0.82. Therefore, the soil is poorly graded. The silt and clay contents were 0.8% and 0.6%; therefore, the soil is poorly graded gravelly sand with minimal fines. The group symbol is SP.

Comparison of Classification of Soil 4 under USCS using Wet and Dry Sieving Methods

Using the wet sieve analysis, Soil 4_ CUC-Fiapre_Sunyani is a low plasticity silty Clay with sand, CL. On the other hand, using dry sieving analysis, soil 4 is a poorly graded gravelly sand with little fines, SP. A closer look at the gradation analysis indicates a significant difference of 80.2% in the quantity of fines between the wet method and the dry method. Thus, just by a change in the sieve analysis method, the soil moved from fine-grained soil in the wet method to coarse-grained soil in the dry sieving method. Again, more fines are observed under the wet sieving method. This could be attributed to the effect of the dispersing agent used (sodium hexametaphosphate) and the stirring and washing employed in the wet sieving method. Thus, it could be said that the processes of wet sieving properly ensure the separation of the various particle sizes of the soil.

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Also, in wet sieving, Cc and Cu were indeterminate as the D_{10} and D_{30} cannot be determined due to the very fine nature of the soil. Cu and Cc values were 10.42 and 0.82 for the dry sieving, respectively. This indicates that the dry sieving method gives a more uniform grading result. In contrast, wet sieving gives a wider range of particle sizes because of the separation of the individual grains.

Classification Using the AASHTO Classification System

Wet Sieving

The percentage of material passing the 75µm sieve was 81.6%; thus, the soil is a Silt-Clay Material. With an LL of 49.54 and PI of 16.64, the soil classifies as A-7. LL – 30 is less than PI, and the Group index was determined to be 16; therefore, the soil is a Silt-Clay material under A-7-5(16). These are silty or clayey materials with poor ratings as subgrade materials.

Dry Sieving

The percentage of material passing the 75µm sieve was 1.4%, so the soil is granular. With LL of 49.54 and PI of 16.64, the soil classifies as A-2-7. The group index was determined to be 0, so the soil is granular under A-2-7(0). These are silty or clayey gravel and sand materials with good ratings as subgrade materials.

Comparison of Classification of Soil 4 under AASHTO using Wet and Dry sieving Methods

Using the wet sieve analysis, Soil 4_ CUC-Fiapre_Sunyani is a Silt-Clay material with group symbol A-7-5 (16), with a poor subgrade material rating. On the other hand, using the dry sieving method, Soil 4 is classified as a granular material with group symbol A-2-7(0), which is rated as good for use as a subgrade material.

The disparity between the results of the two sieving methods is very wide and significant, and depending on the sieving method employed in the analysis, it can affect the use or otherwise of the material. This vast disparity could be credited to the presence of interstitial clay and the bonding of several soil particles together by soil cement, which the dispersing agent, coupled with the mechanical stirring, was able to break down into individual soil grains during the wet sieving method.

Soil_5: STU AVIC Laboratory Sunyani

The soil is very reddish-brown lateritic. Figure 6 presents the PSD charts for dry and wet sieving methods. Table 6 provides details of both wet and dry sieve analysis.

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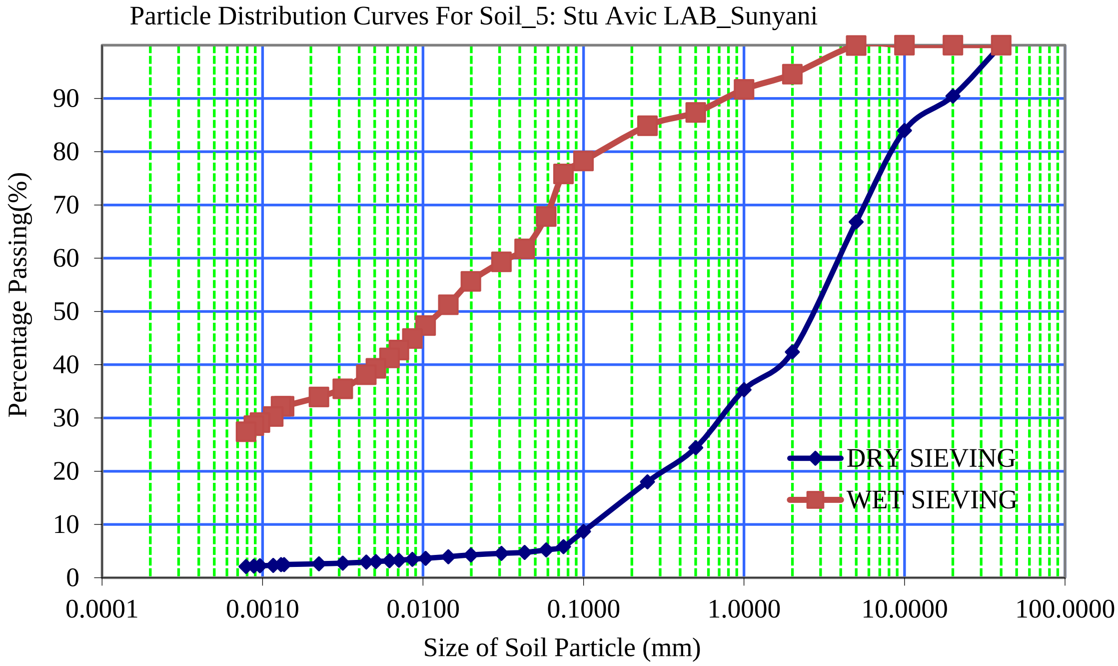

Figure 6: Gradation Charts for Both Wet and Dry Sieving of Soil_5: STU AVIC Lab

Table 6: Grading characteristics of Soil_5: STU AVIC Lab

Characteristic	Wet Sieving	Dry Sieving
D_{10} (mm)	-	0.11
D_{30} (mm)	0.0011	0.7
D_{60} (mm)	0.032	3.9
Cu	-	35.45
Cc	-	1.14
F_{200}	75.9	5.8
LL	49.58	49.58
PL	27.09	27.09
PI	22.50	22.50
Passing 4.75mm	99.5	65
Passing 2.0mm	94.6	42.4
Passing 0.075mm	75.9	5.8
Passing 0.06mm	68	4.9
Passing 0.002mm	33	2

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Gravel	0.5	35
Sand	23.6	59.2
Silt	42.9	3.8
Clay	33	2

Classification Using the USCS

Wet Sieving

The percentage of material passing the 75µm sieve was 75.9%. Thus, the soil is fine-grained. The silt portion was 42.9%, and the clay portion was 33%. Therefore, the soil is a silt material. The LL and PI were 48.56 and 17.59, respectively. Since LL was less than 50 and PI plots below the A-Line, the soil was low plasticity clayey Silt. The sand content is also 23.6%; therefore, according to USCS, the soil category is poorly graded with low plasticity clayey Silt with some sand. The group symbol is ML.

Dry Sieving,

Material passing the 75µm was 5.8%. Thus, the soil is coarse-grained. The gravel portion was 35%, and the sand portion was 59.2%. Therefore, the soil is a sand material. The percentage of fines was 5.8%. Therefore, the soil is gravelly Sand with some fines (a borderline soil requiring dual classification). The uniformity coefficient was determined as 35.45, and the coefficient of curvature was found to be 1.14. Therefore, the soil is well-graded. Atterberg limits plot below the A-line and PI>7; thus, the soil is silty. Therefore, the soil fits the category of well-graded gravelly Sand with some silt and clay. The group symbol is SW-SM.

Comparison of Classification of Soil 5 under USCS using Wet and Dry Sieving Methods

Using the wet sieve analysis, Soil 5_ STU AVIC Lab_Sunyani is a low plasticity clayey Silt with sand, ML. On the other hand, using dry sieving analysis, Soil 5 has a dual classification of a well-graded gravelly Sand or Sand with some fines, SW-SM. A closer look at the gradation analysis indicates a significant difference of 70.1% in the quantity of fines between the wet method and the dry method. Thus, just by a change in the sieve analysis method, the soil moved from fine-grained soil in the wet method to coarse-grained soil in the dry sieving method. Again, more fines are observed under the wet sieving method. This could be attributed to the effect of the dispersing agent used (sodium hexametaphosphate) and the stirring and washing employed in the wet sieving method. Thus, it could be said that the processes of wet sieving properly ensure the separation of the various particle sizes of the soil.

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Again, under wet sieving, the coefficients of uniformity and curvature were indeterminate as the D10 cannot be determined due to the very fine nature of the soil. Cu and Cc values were 34.45 and 1.14, respectively, for the dry sieving. This indicates that the dry sieving method gives a more uniform result compared with wet sieving, which gives a wide particle size range due to the further separation of the individual grains.

Classification Using the AASHTO Classification System

Wet Sieving

The percentage of material passing the 75µm sieve was 79.5%, so the soil is a Silt-Clay Material. LL and PI were 49.58 and 22.50, respectively, so the soil was classified as A-7. LL – 30 is less than PI, and the Group index was determined to be 15. Therefore, the soil is a Silt-Clay material in the group A-7-5(15). These are silty or clayey materials with poor ratings as subgrade materials.

Dry Sieving,

The percentage of material passing the 75µm sieve was 5.8%, indicating that the soil is granular. With an LL of 49.58 and PI of 22.50, the soil classifies as A-2-7. The group index was determined to be 0, indicating that the soil is a granular material in group A-2-7(0). These are silty or clayey gravel and sand materials with good ratings as subgrade materials.

Comparison of Classification of Soil 5 under AASHTO using Wet and Dry sieving Methods

Using the wet sieve analysis, Soil 5_ STU AVIC Laboratory_Sunyani is a Silt-Clay material with group symbol A-7-5(15), which has a poor rating as a subgrade material. On the other hand, using the dry sieving method, Soil 5 is classified as a granular material with group symbol A-2-7(0), which is rated as good for use as a subgrade material.

The disparity between the results of the two sieving methods is vast and significant, and depending on the sieving method employed in the analysis, it can affect the use or otherwise of the material. This vast disparity is attributable to the presence of interstitial clay and the bonding of several soil particles together, which the dispersing agent, coupled with the mechanical stirring, was able to break down into individual soil grains during the wet sieving method.

Soil_6: Bechem_Ahafo

The soil is light, creamy brown, sandy material. Figure 7 presents the gradation charts for both the wet and dry sieving methods. Table 7 details the gradation characteristics of both wet and dry sieve analysis.

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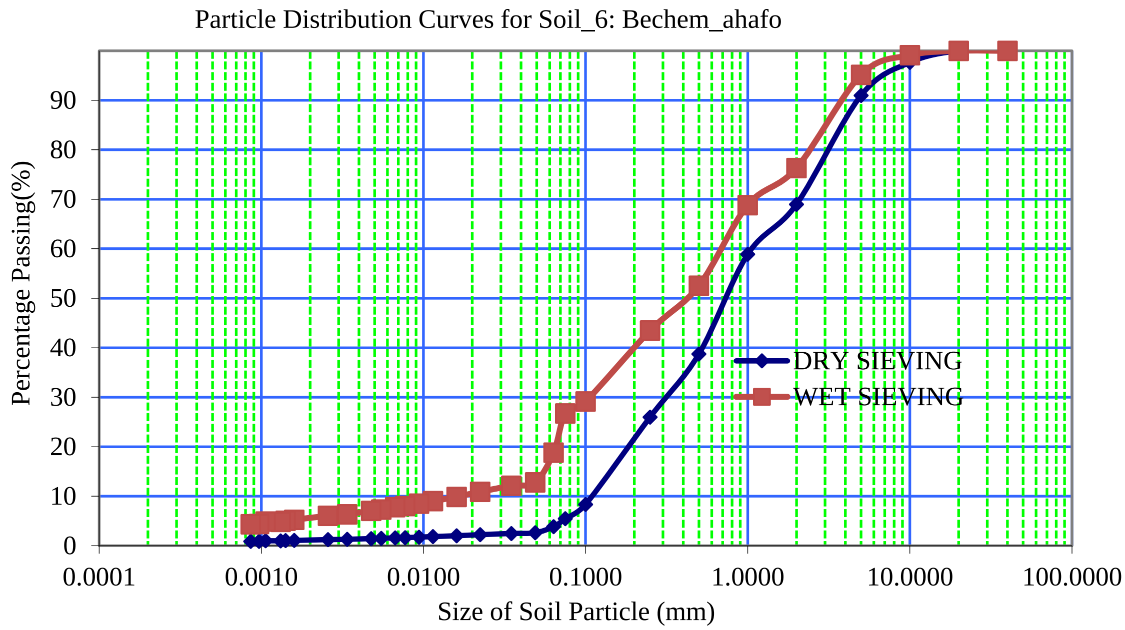

Figure 7: Gradation Charts for Both Wet and Dry Sieving of Soil_6: Bechem_Ahafo

Table 7: Grading characteristics of Soil_6: Bechem_Ahafo

Characteristic	Wet Sieving	Dry Sieving
D_{10} (mm)	0.016	0.11
D_{30} (mm)	0.11	0.31
D_{60} (mm)	0.7	1.1
Cu	43.75	10.00
Cc	1.08	0.79
F_{200}	26.7	5.5
LL	21.02	21.02
PL	15.97	15.97
PI	5.06	5.06
Passing 4.75mm	95	90
Passing 2.0mm	76.3	69
Passing 0.075mm	26.7	5.5
Passing 0.06mm	17	3.5

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Passing 0.002mm	5.5	1.6
Gravel	5	10
Sand	68.3	84.5
Silt	21.2	3.9
Clay	5.5	1.6

Classification Using the USCS

Wet Sieving

The percentage of material passing the 75µm sieve was 26.7%. Thus, the soil is coarse-grained. The gravel portion was 5%. Therefore, the soil is a sand material. The percentage of fines was 26.7%. Therefore, the soil is sand with an excess of fines. The uniformity coefficient was determined as 43.75, and the coefficient of curvature was found to be 1.08. Therefore, the soil is well-graded. The silt content is 21.2%, and the clay content is 5.5%; thus, the soil is sand with excess fines and some gravel. Therefore, the soil is well-graded silty Sand with some gravel. The group symbol is SM.

Dry Sieving

Material finer than 75µm was 5.5%. Thus, the soil is coarse-grained. The gravel portion was 10%. Therefore, the soil is a sand material. The percentage of fines was 5.5%. Therefore, the soil is sand with some fines but with dual classification. The uniformity coefficient was determined as 10, and the coefficient of curvature was found to be 0.79. Therefore, the soil is poorly graded. The silt content was also 3.9%, and the clay content was 1.6%. Hence, the soil was classified as poorly graded gravelly Sand with some fines. The group symbol is SP-SM.

Comparison of Classification of Soil 6 under USCS using Wet and Dry Sieving Methods

Using the wet sieve analysis, Soil 6_Bechem is a well-graded silty sand with some gravel and excess fines, SM. However, using dry sieving analysis, Soil 6 is a poorly graded gravelly sand with some fines, such as SP-SM. A closer look at the gradation analysis indicates that the difference in the fine contents of the two methods was 21.2, which is significant. The dry sieving generated lesser fines of 5.5%. Thus, more fines are observed under the wet sieving method. This could be attributed to the effect of the dispersing agent used (sodium hexametaphosphate) and the stirring and washing employed in the wet sieving method. Thus, it could be said that the processes of wet sieving ensure the proper separation of the various particle sizes of the soil.

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Vol. 10, No. 2 (2024), pp.569-602
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Again, under wet sieving, the uniformity coefficient and coefficient of curvature were 43.75 and 1.08, respectively, whilst Cu and Cc values were 10.0 and 0.79, respectively, for the dry sieving. This indicates that the dry sieving method gives a more uniform gradation result, while wet sieving achieves a variety of particle sizes due to proper grain separation.

Classification Using the AASHTO Classification System

Wet Sieving

The percentage of material passing the 75µm sieve was 26.7%. Thus, the soil is a granular material. The percentage passing the 2mm and 0.425mm sieve sizes is 76.3% and 51%, respectively. The evaluated value of the liquid limit was 21.02, and the plasticity index (PI) was 5.06. Thus, the soil is classified as A-2-4. The group index was determined to be 0; according to the AASHTO classification and the wet sieve analysis, the soil is a granular material under A-2-4(0). These silty sands have a good rating as a subgrade material.

Dry Sieving

The percentage of material passing the 75µm sieve was 5.5%. Thus, the soil is a granular material. Percentages passing the 2mm and 0.425mm sieve sizes are 69% and 36%, respectively. The determined liquid limit was 21.02, and the plasticity index was 5.06. Therefore, this soil classifies as A-1-b. The group index was determined to be 0; thus, based on the AASHTO classification system and the dry sieve analysis, the soil is a granular material under group A-1-b (0). These are gravel and sand materials and stone fragments with excellent ratings as subgrade materials.

Comparison of Classification of Soil 6 under AASHTO using Wet and Dry sieving Methods

Using the wet sieve analysis, Soil 6_ Bechem is a granular material with group symbol A-2-4(0) and a good subgrade material rating. On the other hand, using the dry sieving method, Soil 6 is classified as a granular material with group symbol A-1-b (0), which is rated as excellent for use as a subgrade material.

The disparity between the results of the two sieving methods is slightly significant and can affect the use or otherwise of the material depending on the sieving method employed in the analysis. This disparity could be attributed to the bonding of several soil particles together by soil cement, which the dispersing agent, coupled with the mechanical stirring, was able to break down into individual soil grains during the wet sieving method.

Discussions

From the results, the wet sieving method generally gives particle size distribution, which has finer particles and fines than the dry sieving method. Thus, for the same percentage passing, the wet

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sieving method produces a particle distribution curve, mainly to the left, while the particle distribution curve is generally to the right for the dry sieving method. For the same sieve size, the wet sieving method is above the dry sieving method, signifying a higher percentage and, therefore, higher, finer material content than the dry sieving method. This deduction can be drawn for all the soils tested.

For sandy soils, the difference in percentage of fines obtained from the two methods could be attributed to the deflocculation action of the dispersant solution, the stirring and the washing of the soil before sieving in the wet sieving method. All the fines bonded to the coarser aggregate grains by intergranular cement were thus released to take part in the gradation analysis. Therefore, one could say that the wet sieving method reflects the distribution of particle sizes of the discrete grains in the soil.

The above argument applies to lateritic soils, resulting in more fines in wet sieving than in dry sieving. However, the difference in the percentage of fines from the two methods in the case of lateritic soils was enormous. The additional fines could be attributed to the release of interstitial clay that is present in most tropical lateritic soils (British Standards Institution, 1990). This interstitial clay could also be released by the action of the dispersant solution, stirring and washing the soils in the wet sieving approach.

Using the dry sieving method, all three lateritic soils tested were classified as granular soils, namely, A-2-6(0) for soil 1, A-2-7(0) for soil four and A-2-7(0) for soil 5. These classes of soils are very good or good for road works (AASHTO M145-91, 2012). Using the wet sieving method, however, these same soils were classified as silt clay materials [A-6(5) for soil 1, A-7-5(16) for soil four and A-7-5(15) for soil 5. These classes of soils are deemed not suitable for road works (AASHTO M145-91, 2012)Thus, an engineer who based his pavement design on dry sieving analysis could have his supposedly “well-designed road” failing within no time as a result of the sieving method employed in the study, bringing about indescribable hardship, damage to properties and even loss of lives, as put forward by. Eze et al. (2017) and (Sule et al., 2021).

Comparing the gradation curve of the three lateritic soils with the G60 grading envelope of the Ghana standard specifications for roads and bridges (GSSRB) of the Ministry of Roads and Highways in Ghana shows clearly that soil one and soil five meet the grading requirements when considering the dry sieving method. (Ministry of Transportation, 2007). Soil 4, on the other hand, may need some slight modification to meet the requirements of the G60 grading envelope. However, the grading curves of the wet sieve method for all three lateritic soils did not even come

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close to the G60 envelope specified by the Ministry of Transportation (2007) in the GSSRB, as seen in Figures 8, 9, and 10. This reinforces that using the dry sieving method for lateritic soils leads to errors in determining the grading characteristics. Engineers may have designed rigorously, but an essential criterion for the analysis (gradation characteristics) was entirely inaccurate, rendering the entire design flawed. This could account for some rampant road pavement failures on our roads.

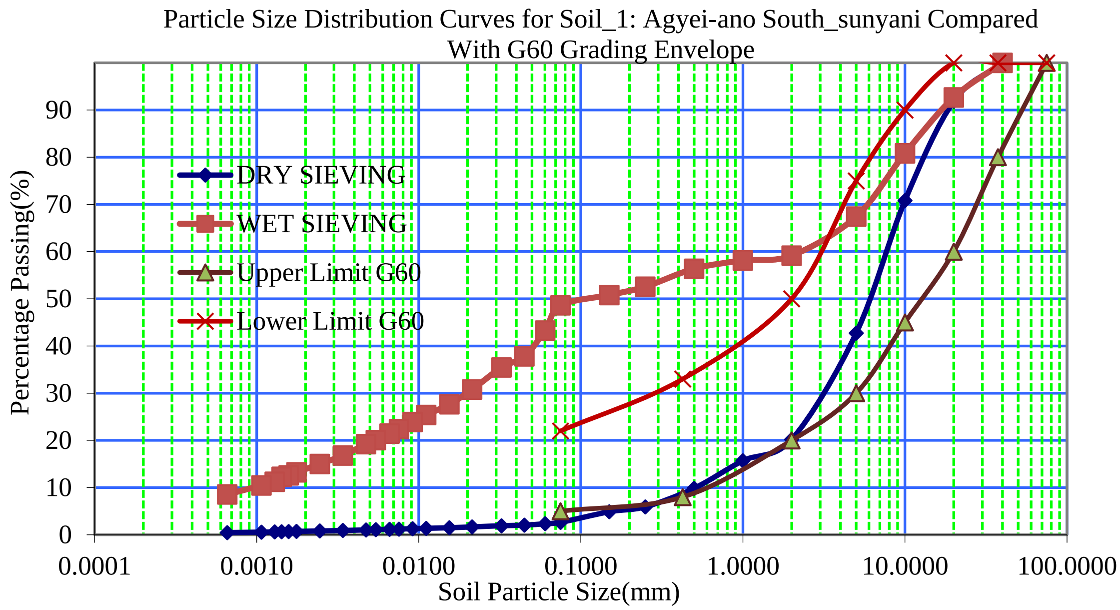

Figure 8: PSD Curves for Soil_1: Agyei Ano South Compared with G60 Grading Envelope

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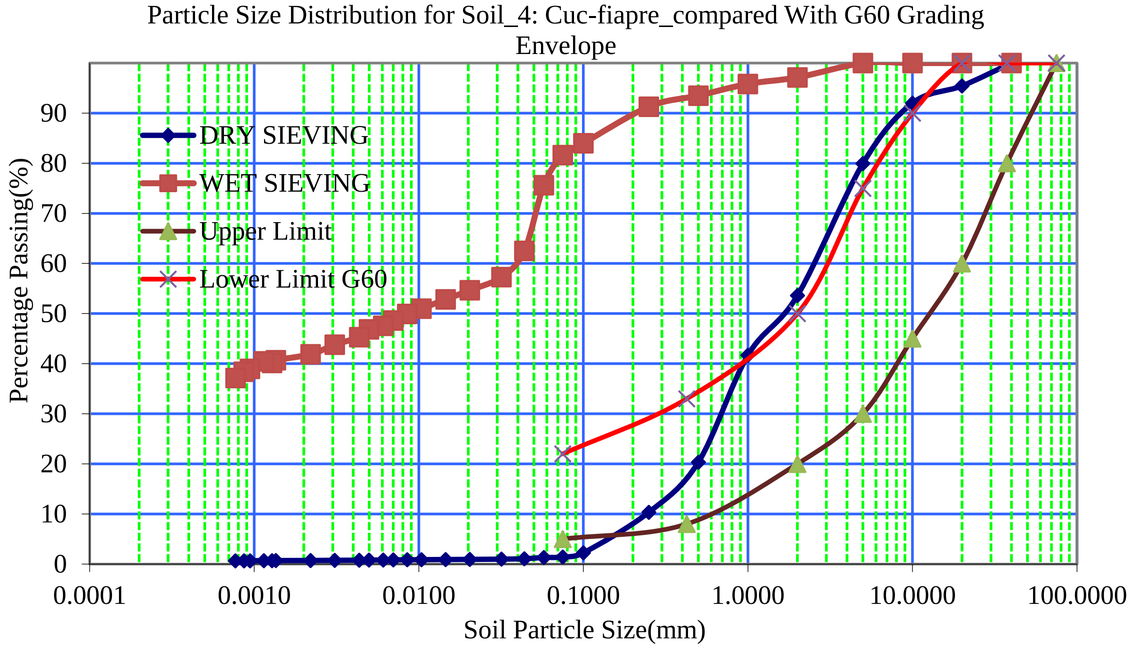

Figure 9: PSD Curves for Soil_4: CUC – Fiapre Compared with G60 Grading Envelope

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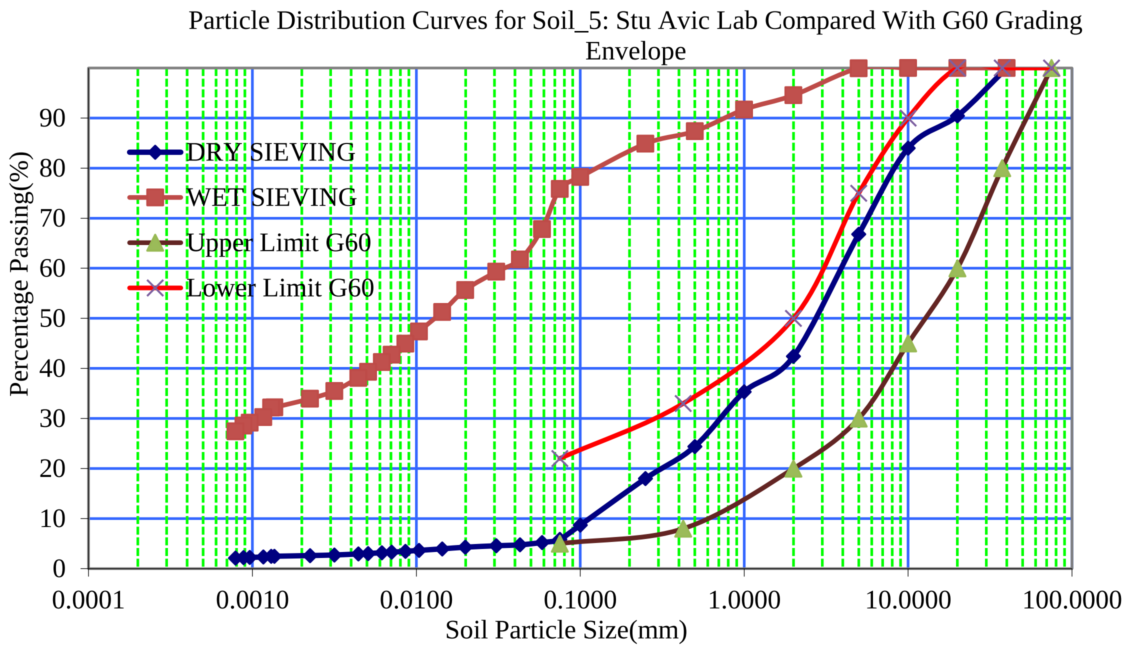

Figure 10: PSD Curves for Soil_5: STU AVIC Lab Compared with G60 Grading Envelope

CONCLUSION

Wet sieving method reflects the various particle size distributions of the individual grains in a particular soil due to the effect of the deflocculating agent, stirring and washing of the soil samples before sieving. Even though quick to perform, the dry sieving method should not be used for lateritic soils such as soil one, four, and five because it tends to give erroneous or apparent gravel-sized particles or bigger particles. The same argument applies to sandy soils, which have appreciable cohesive fines, or sandy soils, which lump up when dry, as evident in Soil 3 and Soil 6 results. For clean sandy or gravelly soils and non-plastic soils such as river sand and gravels, as well as seashore sand and gravels, the dry sieving method is quite suitable, as can be seen from the results of soil 2.

This study will assist practising engineers in selecting the appropriate sieve analysis method for design and soil analysis for civil engineering structures.

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These social implications demonstrate how technical improvements in soil testing methodology can have far-reaching effects on Ghana's community development, safety, and quality of life. The research contributes to building more resilient and sustainable communities by better understanding and utilising local soil resources.

This research represents a significant advancement in geotechnical testing methodology tailored to Ghanaian conditions, filling a crucial gap in tropical soil analysis techniques. It involved quantifying result variations between wet and dry methods for tropical soils.

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