ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering | e–ISSN: 2067 – 3809
Tome XVIII [2025] | Fascicule 1 [January – March]

[1.]S. L. AKINGBONMIRE, [2.]A. E. ONI, [3.]F. T. SHITTA, [4.]S. P. AKANDE

PHYSICO–CHEMICAL PROPERTIES OF SOME FINE AGGREGATES IN AKURE, ONDO STATE, FOR BUILDING CONSTRUCTION

[1–4.]Department of Civil and Environmental Engineering, Federal University of Technology, Akure, Ondo State, NIGERIA

Abstract: The goal of this study is to determine the physical and chemical characteristics of the fine aggregates used for building constructions in Akure, Ondo State, Nigeria. Samples of fine aggregates were taken from six different locations in Akure, Ondo State for the investigation. The test results revealed that Sample E has the highest value of moisture content. The organic matter test indicates that all of the samples are appropriate for use in construction while the soil samples were found to have specific gravities ranging from 2.27 to 2.67, with only samples B and D meeting the needed value. The silt level of all the sample was higher than the 8% standard value, with sample B having the closest figure of 11.3%. The aggregates bulk compacted densities ranged from 1573$\mathrm{kg/m^3}$ to 1756 $\mathrm{kg/m^3}$, whereas the loose, uncompacted (loose) bulk densities ranged from 1646$\mathrm{kg/m^3}$ and 1902 $\mathrm{kg/m^3}$. No sample has the necessary distribution of silt and sand content. For the chloride ion, sample F recorded the highest ppm of 48.99 while sample C has the lowest ppm of 19.17. No presence of sulphate was identified in the soil samples.

Keywords: aggregates, concrete, compacted, silt

INTRODUCTION

Cement, aggregates, and water are mixed to make concrete. The primary ingredient of concrete is aggregates which consists 60 to 80 percent of the volume of the concrete [1]. Aggregates should not contain any components that may cause the concrete to deteriorate and should have sufficient strength and resilience to exposure [2]. Aggregates characteristics largely affects the cost–effectiveness, and also the performance of concrete, since approximately 80 percent of the total volume of concrete consists of aggregates (fine and coarse aggregates) [3]. Aggregates are important constituents in concrete containing about 70 – 80 percent of the volume of concrete [4]. It gives body and strength to the concrete, affects economy and undoubtedly has considerable impact on the properties of concrete. This makes it very important to know more about the aggregates which constitutes major volume in concrete so as to know more about concrete and its properties [5].

It has been said that the concrete's compressive strength depends on some fundamental factors such as water to cement ratio, ratio of cement to aggregate, ratio of fine aggregate to coarse aggregate, degree of compaction, the bond between mortar and aggregate, and grading, shape, strength, and size of the aggregate [6]. The two types of aggregate are fine and coarse. The diameters of coarse aggregates are commonly larger than 4.75mm (retained on a number 4 screen), whereas the sizes of fine aggregate particles usually range from 4.75 mm and 0.75 mm (retaining on sieve number 200 but clearing the number 4 sieve).

An aggregate's mineralogy, weathering, and resulting changes all influence its physical and chemical properties. These factors frequently result from the aggregate's geologic origin. Shape, texture, and grading of aggregates can affect fresh concrete's workability, bleeding, pumpability, finishing, and segregation. These factors can then affect the hardened concrete's strength, shrinkage, creep, stiffness, density, and durability and permeability. Therefore, in order to prevent issues with construction and durability, proper combination, proportioning, and grading variation are required [7]. According to reports, fine aggregate qualities play a crucial role in predicting whether a structure would fail before it reaches the ultimate design years or the serviceability threshold.

To determine the soil's chemical and physical properties, a number of tests should be conducted. In contrast to silt, which is only marginally malleable, and sand and gravel, which exhibit negligible plasticity, clay has been observed to be quite plastic. Owing to the various management choices available, the aggregate stability of the soil is frequently used to gauge changes in soil structure, which in turn define the pattern of failure under stress [8]. Generally speaking, sand has particles with diameters between 0.0025 and 0.08 inches (0.063 and 20 mm). If the size of the particle is more than that of sand, it is called gravel or granular, and if it is smaller, it is called silt. All aggregates in the building industry come with particles up to 6.0 in (15.2 cm) and larger than 0.25 in (64 mm) categorized as coarse aggregates. According to reports, the retained water content in sand causes significant variations in its density, which spans from 0.063 mm to 20 mm in diameter [9]. Corrosion of the steel rebar contained in the concrete is one of the main reasons of RC degradation, which typically results in expensive repairs or a structure that does not last the service year. Steel becomes passive when buried in concrete because a thin, protective oxide layer (approximately 10 nm thick) forms. In the alkaline pH values found in concrete pores (pH of about 12.5), this layer is incredibly stable. This pH of this region is high enough to encourage the formation of the protective layer [10]. This shielding protective film may be harmed by carbonation of the concrete or by chloride attack [11], [12] and [13], which lowers the pH of the pore electrolyte and jeopardizes the integrity of the passive film [14]. Even though the rebar is externally protected from aggressive chemical agents by the concrete, the protective film on the surface of the steel reinforcements becomes depassivated and damaged when water, oxygen, chlorides, or carbon dioxide from the RC reaches it [15]. This is because the pH level drops to about 9, which causes expansive corrosion products to form and accumulate at the interface between the concrete and reinforcements, which leads to concrete cover cracks [16]. Furthermore, it has been acknowledged that the cementitious binders and chemical makeup of the components in the concrete mix are essential elements that ascertain the microstructure of concrete and hydration products, and as a result, are crucial in determining how reinforcements corrode [17]. Another important issue that might cause the corrosion of reinforcement in concrete is the presence of sulphides in the pore solution, as this can drastically lower the pore solution's redox potential [18]. Measuring redox potential is just a reflection of the activities involved in oxidation and reduction [19] and [20]. The increase in the reduction atmosphere causes a decrease in the redox potential, which would, in part, shield the embedded steel from oxidation and slow down the steel's rate of corrosion. Additionally, elemental sulfur is formed by the oxidation of chemically reduced sulphides and is deposited in the pores of the damaged passive coating, restoring some passivation to the corroded steel [21]. Nevertheless, [22] proposed that sulphides also contribute to the deterioration of the passive coating on steel surfaces, exposing the steel to corrosion. Fine aggregate prevents shrinkage of the cement. When surrounded with cement, which also causes the components to connect, it becomes more mobile and can fill in the gaps between coarse particles. It adds solidity to concrete by filling up the voids. Denser concrete becomes more durable. Shape, surface roughness, specific gravity, and particle size distribution all have a significant impact on the characteristics of new concrete and mortars. In contrast, it is usually found that the toughness, elastic modulus, degree of alteration, and mineralogical composition of aggregates affect the characteristics of mortars and concrete in their hardened state. Determining the physical and chemical characteristics of fine aggregates at certain sites in Akure, Ondo State, Nigeria, is the main goal of this study since it is crucial to make sure that the suitable kind and quality of fine aggregates are utilized in construction.

MATERIALS AND METHODS

▦ Materials

— Overview of the Site

Every sample was sourced from Ondo State's Akure Local Government Area, as seen in Figure 1. The western part of Nigeria contains the inland state of Ondo. Akure is its capital city. The surroundings of Akure have yielded rock drawings that predate the Mesolithic era. In addition, the earliest specimen of Homo sapiens ever uncovered in West Africa was found there; it dates to around 11,000 years ago. Among the sixteen ancient Ekiti kingdoms, the Akure Kingdom is considered to be one.

In the southern part of the wooded Yoruba Hills, it is close to the intersection of the routes that go from Ondo, Ilesha, Ado–Ekiti, and Owo. The agricultural commodities that are traded in Akure include cassava, corn (maize), bananas, rice, okra, coffee, rubber, and pumpkins. Palm goods, Cotton, teak are also farmed for export, although cocoa is the primary commercial crop in the region.

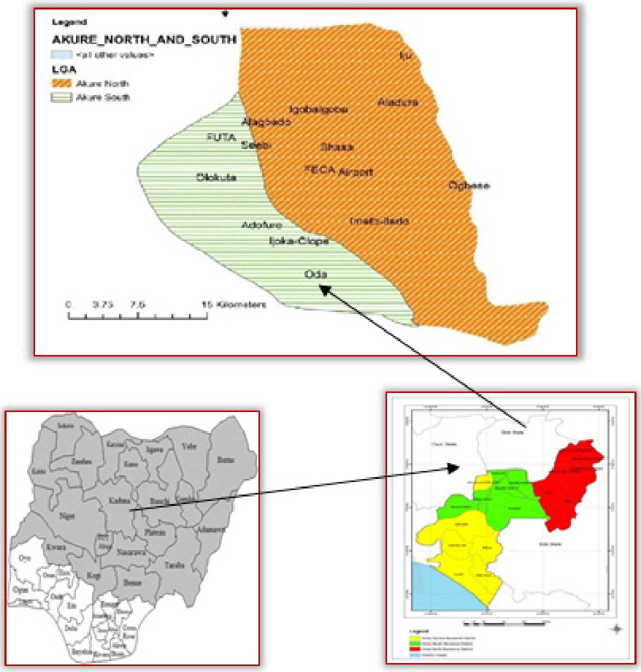

Figure 1: Map of Akure L.G.A., Ondo State Nigeria

In this study, Samples of disturbed soil were taken from six different locations in Nigeria's Ondo State's Akure Local Government Area. The sites are displayed as follows in Figure 2;

- Ilara mokin: Longitude 7.337672, Latitude 5.040302
- Owo road: Longitude 7.226332, Latitude 5.37327
- Igbatoro road: Longitude 7.159359, Latitude 5.288387
- Ado road: Longitude 7.338975, Latitude 5.282668
- Ondo road: Longitude 7.21742, Latitude 5.043804
- Oda road: Longitude 7.163995, Latitude 5.277211

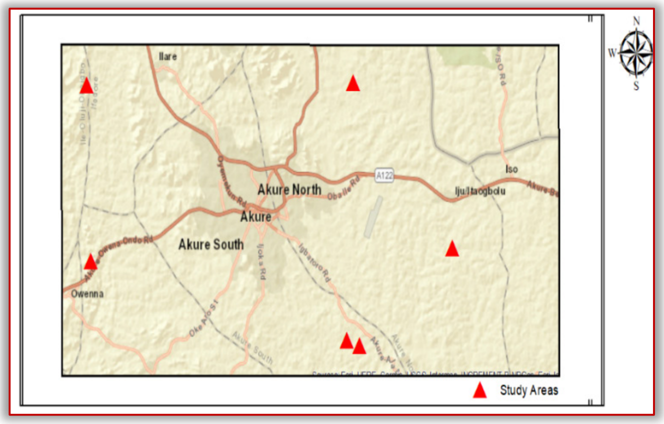

Figure 2: The map showing the sampling points

— Sampling points

The carefully gathered fine particles were meant for building and block moulding. The size distribution of the fine aggregates ranges from 150 μm to 4.75 mm. Depending on where they were collected, the fine aggregates were grouped as indicated in Table 1.

Table 1: Sample locations

Sample	Location
A	Ilara mokin
B	Owo road
C	Igbatoro road
D	Ado road
E	Ondo road
F	Oda road

Methods

— Moisture Content

A sizable portion (10 g) of the fine aggregate was then added to the moisture content can its weight was measured and reported as W_1. After both were weighed, the new weight was recorded as W_2. Following that, the sample and container were oven–dried for around twenty–four hours in the lab oven. Before calculating and noting the new weight (W_3), the oven–dried sample was left to cool for a few minutes. The moisture content (%) was computed using the formula below:

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_3 - W_1} \times 100 \qquad (1)$$

The ASTM C566 standard was followed in the execution of the test [23].

— Organic Matter

A solution of sodium hydroxide (caustic soda) was prepared. The clear container was left empty and a sizable amount of aggregate was placed inside. The sodium hydroxide solution was then poured into the container where the sample is put and shaken vigorously to release any trapped air. The homogeneous sample was then allowed to settle for 24 hours and the color of each sample is observed in accordance to soilsafe AOTEAROA color test chart for organic matter [24].

— Specific Gravity

250 grams of a clean sample were added to the dry, clean specific gravity bottle and weighed as W_2. The weight of the specific gravity bottle was then recorded as W_1. The sample was shaken vigorously to release any trapped air by using a finger to press against the aperture at the top of the sealed specific gravity bottle. The specific gravity bottle was carefully weighed after being filled to the brim with water and all trapped air was released. W_3 is the recorded weight of the saturated aggregates. According to standard, the specific gravity bottle's contents are removed and cleaned appropriately. Following this, it was completely filled with water, weighed, and recorded as W_4 because no trapped air was

present. The specific gravity was calculated using the formula:

$$\text{Specific Gravity} = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} \qquad (2)$$

— Silt and Clay Content

A portion of the aggregate was put in the measuring cylinder. Water was then poured into the cylinder. The cylinder was then given a good shake to get rid of any trapped air, and it was left to settle for around twenty–four hours. The layers of sand, silt, and clay that was formed in the cylinder were seen and suitably recorded.

— Bulk and Loose Densities

The cylindrical metal volume was calculated and recorded as 'V' in liters. Then, using the tamping bar, the cylindrical metal was tamped 25 times after being loaded with fine aggregates to nearly one–third of its capacity. A third of the sample was added and tamped 25 times more. When the cylindrical metal was full, it was tamped down twenty–five times, and any extra material was then cut off with a straightedge.

The weight of the aggregate was computed and recorded as "W" in kilograms.

By adding water to the cylindrical metal, the volume of the metal was calculated and recorded as 'V' in liters. With the aid of a shovel or scoop, the cylindrical metal was then filled until it was completely filled, and a straightedge was used to trim it. The aggregate's weight was calculated and entered as "W" in kilograms. The following formula was used to obtain the bulk and loose densities:

$$\text{Density} = \frac{\text{Weight of Aggregate (W)}}{\text{Volume (V)}} \qquad (3)$$

— Particle Size Distribution

The soil was classified based on its gradation, and the curve was utilized to determine the coefficient of uniformity. The ASTM C136 / C136M – 19 standards were followed in conducting the particle size distribution test [25].

— Determination of Chloride ion (Cl^-)

After being oven–dried to eliminate any remaining moisture, the soil sample was let to cool. After weighing the sample, 10 g was put into the beaker. To make an aqueous solution, 100 milliliters of distilled water were added to dilute it. The solution was acidified by adding a few drops of diluted nitric acid (HNO_3). This is to guarantee that the chloride test won't be hampered by any interfering ions (such as carbonate ions) forming insoluble precipitates. After being mixed, the solution was let to settle. To get rid of any remaining solids, it was filtered through filter paper.

In a conical flask, the transparent filtrate was gathered. 25 ml of the recovered filtrate were mixed with two drops of the chromate indicator. The solution will turn yellow due to the chromate ions. 0.03 M silver nitrate ($AgNO_3$) solution was added to the burette and slowly titrated against the 25 ml filtrate. $AgNO_3$ is continually added until a red–brown color appears.

This indicates the formation of silver chromate (Ag_2CrO_4), showing that all the chloride ions have reacted and the endpoint has been reached. The experiment was carried out twice and the average volume of the silver nitrate was used. The concentration of the chloride ion in the sample was determined using the formula below:

$$\text{Molar concentration of } Cl^- = \frac{\text{Molar conc. of } AgNO_3 \times \text{Vol. of } AgNO_3}{\text{Vol. of } Cl^-} \qquad (4)$$

Also, the chloride ion concentration was determined in parts per millions.

— Determination of Sulphate (SO_4^{2-})

After being oven–dried to eliminate any remaining moisture, the soil sample was let to cool. The sample, weighing 10g, was put into the beaker. To make an aqueous solution, 100 ml of distilled water were added to dilute it. After being agitated, the mixture was left to settle for the night. The suspended particles are flocculated by adding 1.0 g of pure potassium nitrate (KNO_3), which has been weighed. To get rid of the flocculated particles, the solution was filtered. To the beaker, 25 ml of the filtrate were added. In order to neutralize the solution, 2 ml of strong hydrochloric acid were added. The solution was made extremely acidic by adding an additional 4 ml of HCl.

Barium chloride solution ($BaCl_2$) was added to the boiled solution and vigorously agitated until no more precipitate formed. For a minimum of four hours, the beaker was submerged in a steam bath to enable the precipitate to completely settle. The precipitate was removed using a filter paper that was free of chloride ions and had no ash. Filtration was done dry and ignited in a sintered glass crucible that had been previously weighed. In a muffle furnace, the precipitate was then burned for 30 minutes at a temperature of about 6000°C. Following cooling, the residue, which was indicative of the weight of the barium sulphate, was weighed and noted. The weight of the corresponding sulfate was determined using the following formula:

$$\text{Sulphate } (SO_4) \text{ percentage by mass} = 41.15\,\frac{W_1}{W_2} \qquad (5)$$

$$\text{Sodium Sulphate } (Na_2SO_4) \text{ percentage by mass} = 60.85\,\frac{W_1}{W_2} \qquad (6)$$

where: W_1 is mass (g) of the precipitate
W_2 is mass (g) of the soil in the precipitation solution.

RESULTS AND DISCUSSION

Moisture Content

In Depending on the project specifications, the fine aggregate with the lowest moisture content is selected for a fair degree of workability in the standard concrete mix % design. An ideal moisture content range for most aggregates falls between 5% and 8% [26]. It is possible for moisture to exist in thin aggregates as capillary condensed water in tiny holes or as adsorbed moisture at interior surfaces. The sample with the highest moisture content in Figure 3 is Sample E. This shows that it has the highest microfine of all the samples and satisfies the necessary moisture level. The fact that Sample B has the lowest number implies that it is the group's sandiest.

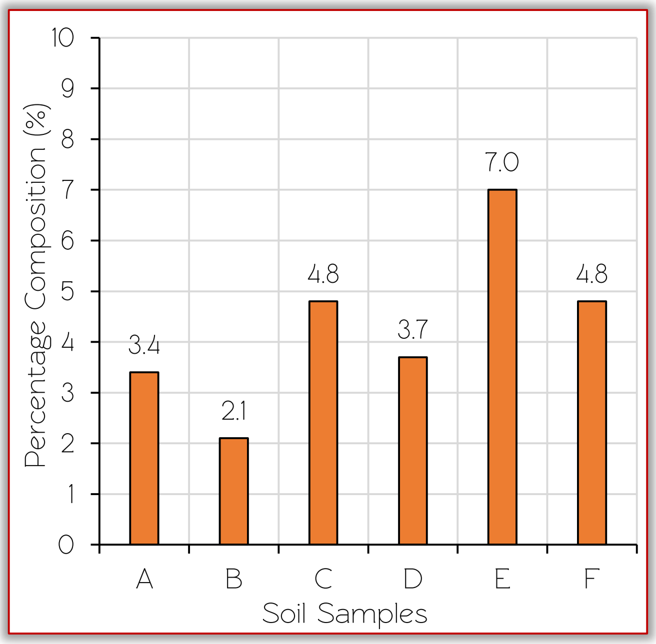

Figure 3: Moisture content of the soil samples

Organic Matter

Fine aggregates' physical, chemical, and biological characteristics can be affected by organic matter. Table 2 shows that, in comparison to all other samples, Sample E has the highest amount of organic materials. This means that the strength of building materials like concrete may be slightly impacted by the presence of organic material. By adsorbing calcium ions released during hydration, it influences the cement's setting.

For most highland soils, the concentration of soil organic matter (SOM) in fine aggregates usually ranges between 1% and 6% of the topsoil's total mass, as mentioned specifically. Since all of the samples collected from Akure LGA have SOM concentrations within the allowed limit, they are all highland soils suitable for construction use [27].

Table 2: Organic matter content of the soil samples

Sample	% of average organic matter content	% range of organic matter
A	1.5	1 – 2
B	1.5	1 – 2
C	1.5	1 – 2
D	2.5	2 – 3
E	3.5	2.5 – 4
F	2.5	2– 3

Specific Gravity

It is stated that the allowable specific gravity ranges from 2.6 to 2.9 [28]. The results displayed in Figure 4.1 reveal that the soil samples' specific gravities range from 2.27 to 2.67, meaning that samples B and D fall within the designated range. The values in every other sample are within the limits of the allowed range. It is crucial to test samples for specific gravity before using them for any kind of building activity because specific gravity is a measure of contaminants in the sand. It is also another essential component of data for figuring out air and empty spaces in mineral aggregates.

The quantity of impurities or voids in a given soil sample is inversely proposal to the specific gravity of that sample. A soil sample's specific gravity would be less than 2.6 if it consists a lot of organic content or porous particles. According to the results above, sample E and F has the lowest specific gravity, indicating that, in comparison to the other samples, they have more contaminants, such as organic materials or voids.

Samples A, E, and F would be susceptible to chemical reactions such carbonation and sulfate attack if utilized during construction.

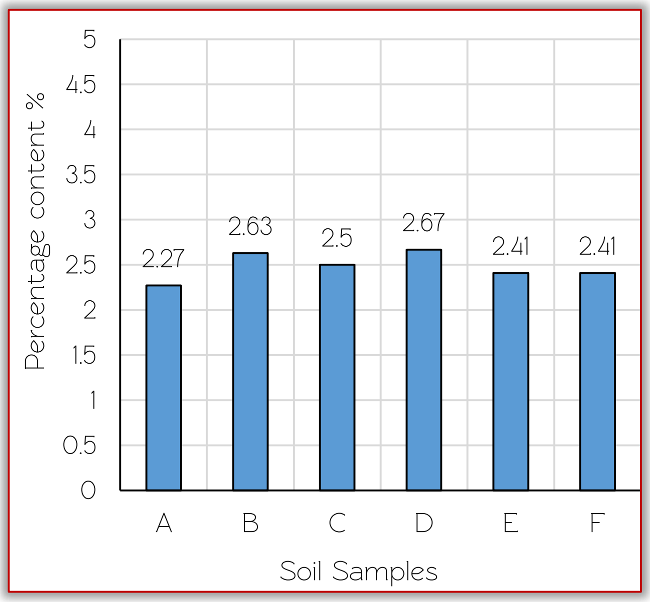

Figure 3: Specific gravity of the soil samples

Silt and Clay Content

It is said that permits for silt concentrations fall between 3% and 8%. Silt is a substance with a size range of 2 µm – 60 µm. The silt content percentage of each sample is more than 8%, as shown in Table 3 and Figure 4. This showa that each sample has a high microfine. Samples of fine aggregates with less than 3% silt content have inadequate fines and will need extra water and cement for effective workability. Such soils must be mixed with appropriate finer aggregates from other sources if they are to be utilized for building projects.

Samples of fine aggregate with a silt concentration of 3% – 8% percent are ideal for use in building construction. For optimum workability, the ideal mixture of water and cement will be needed. Any more than 8% silt concentration is unsuitable since it increases the amount of water required for moistening the mixture's components.

As a result, the mixture has high slump and high dry shrinkage, which makes the concrete weak and undoable. Sample C in Table 3 contains the largest proportion of silt and clay content. However, sample B had the lowest silt and clay percentage.

Table 3: Silt and clay content of the soil samples

Samples	Overall height of the sample (cm)	Content of sand (%)	Content of clay & silt (%)
A	8.4	77.4	22.6
B	8.0	88.7	11.3
C	7.3	71.2	28.8
D	7.7	84.4	15.6
E	8.4	77.4	22.6
F	8.9	84.3	15.7

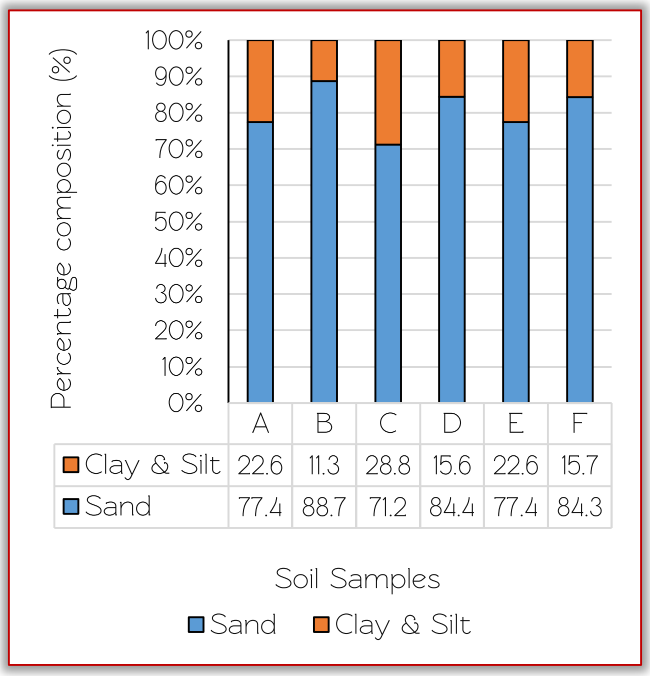

Figure 4: Silt and clay content of the soil samples

Bulk and Loose Densities

The fine aggregate's bulk densities range from 1573 $\mathrm{kg/m^3}$ to 1756 $\mathrm{kg/m^3}$. The aggregates' uncompacted (loose) densities range from 1646 $\mathrm{kg/m^3}$ to 1902 kg/m^3. It is stated that the bulk densities can range from 1538 $\mathrm{kg/m^3}$ to 1842 $\mathrm{kg/m^3}$ [29].

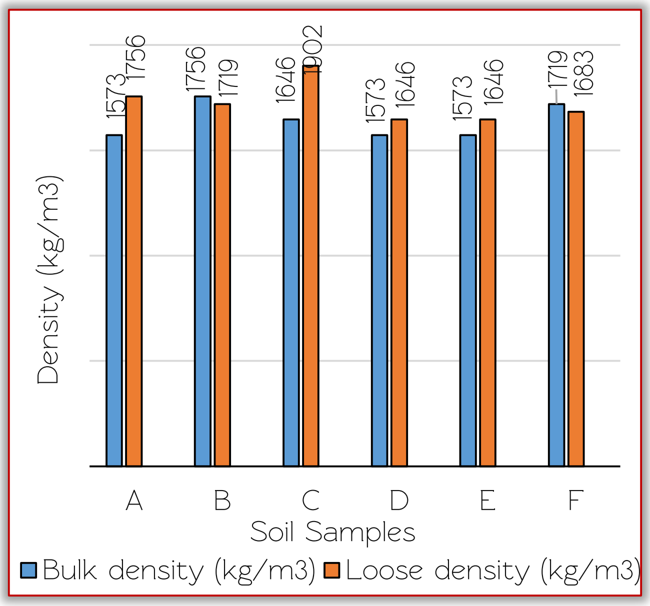

Figure 5: Bulk and loose densities of the soil samples

All samples fall within the range according to the data shown in Figure 5. It has been noted that the density of concrete affects its mechanical characteristics. Fine aggregates having a higher bulk density are denser and will have more strength with fewer voids and porosity. Water and other soluble components may pass through the aggregate less readily the fewer voids there are. Furthermore, concrete that contains these aggregates will be less water–absorbing and more resilient. The concrete's dead weight would increase if the bulk density exceeded the allowed range.

Particle Size Distribution

With regard to sieves of 5.0 mm, 4.0 mm, 3.0 mm, 2.36 mm, 1.70 mm, 500 μm, 150 μm, and 75 μm, Figure 6 indicates that every sample satisfied the BS 882 standard. When the samples reached a sieve of 150 μm, no sample satisfied the minimum required percentage that ranges from 0 – 20%. Consequently, this suggests that no sample has the necessary distribution of silt and sand content. Additionally, based on the particle size distribution graph, all samples were identified as coarse–graded sandy soil.

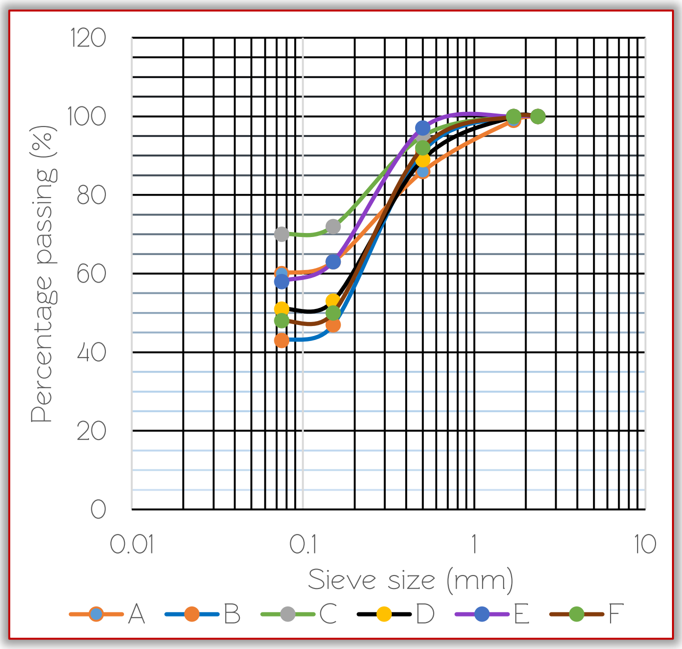

Figure 6: Sieve analysis for the soil samples

Determination of Chloride ion (Cl^-)

Since the samples' ppm values remain below the 500 ppm threshold, it was concluded from the data in Table 4 that all of the samples are fit for usage.

Table 4: Chloride ion concentration of the soil samples

	A	B	C	D	E	F
Average volume of sample	25 ml	25 ml	25 ml	25 ml	25 ml	25 ml
Average volume of $AgNO_3$	0.80 ml	1.00 ml	0.45 ml	0.65 ml	1.05 ml	1.15 ml
Molar conc. of $AgNO_3$	0.03	0.03	0.03	0.03	0.03	0.03
Molar conc. of Cl^-	0.00096	0.001	0.00054	0.00078	0.00126	0.00138
ppm of Cl^-	34.08	42.6	19.17	27.6	44.73	48.99

Chlorides do their damage by attacking the reinforcements. Excessive chloride in soil can cause the corrosion of the steal reinforcements. Sample F recorded the highest ppm of 48.99 while sample C has the lowest ppm of 19.17.

Determination of Sulphate (SO_4^{2-})

It was observed during the course of the analysis that no precipitate occurred when barium chloride solution ($BaCl_2$) was added after the solution was boiled. This implies that no presence of sulphate was identified in the soil samples.

CONCLUSION

Soils should have their physical and chemical characteristics examined before being utilized for building construction. This will help users to be able to combine materials precisely, guaranteeing great strength, low dry shrinkage, durability, and workability. Sample E has the highest moisture content, indicating that it contains the most microfine particles.

The organic matter test indicates that all of the samples are appropriate for use in construction. The soil samples were found to have specific gravities ranging from 2.27 to 2.67, with only samples B and D meeting the needed value. The silt level of all the sample was higher than the necessary 8%, with sample B having the closest figure of 11.3%.

The aggregates bulk compacted densities ranged from 1573 kg/m^3 to 1756 kg/m^3, whereas the loose, uncompacted (loose) bulk densities ranged from 1646 kg/m^3 and 1902 kg/m^3.

When the samples reached a sieve of 150 μm, no sample satisfied the minimum required percentage that ranges from 0 – 20%. This suggests that no sample has the necessary distribution of silt and sand content. Sample F recorded the highest chloride content ppm of 48.99 while sample C has the lowest ppm of 19.17. No presence of sulphate was identified in the soil samples.

Refrences

[1] Rached M. M., De Moya M., and Fowler D. W. (2009). Utilizing aggregates characteristics to minimize cement content in portland cement concrete. International Center for Aggregates Research (ICAR). National Technical Information Service. Springfield, Virginia.

[2] Abdullahi, M. Properties of Some Natural Fine Aggregates in Minna, Nigeria and Environs. Leonardo Journal of Sciences, 8(1), 1–6, 2006.

[3] Rocco C. G. and Elices M. Effect of aggregate shape on the mechanical properties of a simple concrete, Engineering Fracture Mechanics, 762(2), 286–298, 2009

[4] Shetty M. S. Concrete Technology Theory and Practice S. Chand and Company Ltd. Ram Nagar, New Delhi, 2006.

[5] Purushothama R. Soil Mechanics & Foundation Engineering, 278, 2008. [Online]

[6] Meddah M. S., Zitouni S., and Belâabes S. Effect of content and particle size distribution of coarse aggregate on the compressive strength of concrete, Construction and Building Materials, 24(4), 505–512, 2010

[7] Lafrenz, J. L. *Improving constructability of concrete pavements by assuring consistency of mixes*. Transportation Research Board, 1997.
[8] Aziz S. A. and Karim S. M. The Effect of Some Soil Physical and Chemical Properties on Soil Aggregate Stability in Different Locations in Sulaimani and Halabja Governorate, Open journal of Soil Science, 6, 81–88, 2016
[9] Beshr H., Almusallam A. A., and Maslehuddin M. Effect of coarse aggregate quality on the mechanical properties of high strength concrete. Construction Building Materials, 17(2), 97–103, 2003
[10] Morozov Y., Castela A. S., Dias A. P. S., and Montemor M. F. Chloride–induced corrosion behavior of reinforcing steel in spent fluid cracking catalyst modified mortars. Cement Concrete Research, 47, 1–7, 2013
[11] Ustabas I. The effect of capillarity on chloride transport and the prediction of the accumulation region of chloride in concretes with reinforcement corrosion, Construction and Building Materials, 28(1), 640–647, 2012
[12] Li C., Chen Q., Wang R., Wu M., and Jiang Z. Corrosion assessment of reinforced concrete structures exposed to chloride environments in underground tunnels: Theoretical insights and practical data interpretations, Cement Concrete Composition, 112, 103652, 2020
[13] Cao Y., Gehlen C., Angst U., Wang L., Wang Z., and Yao Y. Critical chloride content in reinforced concrete — An updated review considering Chinese experience, Cement Concrete Research, 117, 58–68, 2019
[14] Pacheco Torgal F., Miraldo S., Labrincha J. A., and De Brito J. An overview on concrete carbonation in the context of eco–efficient construction: Evaluation, use of SCMs and/or RAC, Construction and Building Materials, 36, 141–150, 2012
[15] Angst U., Elsener B., Larsen C. K., and Vennesland Ø. Critical chloride content in reinforced concrete — A review, Cement Concrete Research, 39(12), 1122–1138, 2009
[16] Yuan X., Wang X., Cao Y., and Yang H. Natural passivation behavior and its influence on chloride–induced corrosion resistance of stainless steel in simulated concrete pore solution, Journal of Materials Research Technology, 9(6), 12378–12390, 2020
[17] Monticelli C. Corrosion behavior of steel in alkali–activated fly ash mortars in the light of their microstructural, mechanical and chemical characterization. Cement Concrete Research, 80, 60 – 68, 2016
[18] Ma Q., Nanukuttan S. V, Basheer P. A. M., Bai Y., and Yang C. Chloride transport and the resulting corrosion of steel bars in alkali activated slag concretes. Material Structure, 49(9), 3663 – 3677, 2016
[19] Claisse P. A. Corrosion of steel in concrete – understanding, investigation and repair 2nd edition, Broomf. J. P., Taylor Fr. London, 978(4), 296, 2008.
[20] Schuring J., Schulz H. D., Bottcher J., and Duijnisveld W. H. M. Redox: Fundamentals, Processes and Applications Illustrate. Springer Science and Business Media, 251, 2013.
[21] Qu J., Xie H., Song Q., Ning Z., Zhao H., and Yin H. Electrochemical desulfurization of solid copper sulfides in strongly alkaline solutions, Electrochemistry communications, 92, 14–18, 2018
[22] Shoesmith D. W., Taylor P., Bailey M. G., and Ikeda B. Electrochemical behaviour of iron in alkaline sulphide solutions, Electrochimica Acta, 23(9), 903–916, 1978
[23] American Society for Testing and Materials C566–19. Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying. West Conshohocken, PA, 2019
[24] Soilsafe AOTEAROA, soil organic matter: Colour test, Accessed on October 11, 2024.
[25] American Society for Testing and Materials C136/C136M–19. Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates. West Conshohocken, PA, 2019
[26] Tayabji S. Designers' Guide for UFGS 32 13 16.16 Roller Compacted Concrete (RCC) Pavement, 2010
[27] Troeh F. R. and Thompson L. M. Soils and soil fertility. New York: Oxford University Press, 1993.
[28] Sood H. Specific gravity and water absorption of fine aggregates, 2015.
[29] Iffat, S. Relation between density and compressive strength of hardened concrete. *Concrete Research Letters, 6*(4), 182–189, 2016.

ISSN: 2067-3809

copyright © University POLITEHNICA Timisoara,
Faculty of Engineering Hunedoara,
5, Revolutiei, 331128, Hunedoara, ROMANIA
http://acta.fih.upt.ro