

# An Assessment of Mechanical and Physical Properties of Coarse Aggregate Produced in some Quarry Sites in Taraba State

Bala, M. A.<sup>1</sup>, Salamatu, K. B.<sup>2</sup>, Junaidu A.,<sup>3</sup> Unamba, K.U.<sup>4</sup>, Kobiba, H. A.<sup>5</sup>.

<sup>1,2,3,4,5</sup> Department of Civil Engineering, Taraba State University, Jalingo, Nigeria,

[bmatsayi@gmail.com](mailto:bmatsayi@gmail.com), [salmatkwarra@gmail.com](mailto:salmatkwarra@gmail.com), [3idameen10@gmail.com](mailto:3idameen10@gmail.com), [udokanma@tsuniversity.edu.ng](mailto:udokanma@tsuniversity.edu.ng)  
(+ 234-703-291-6871)

## ARTICLE INFO

### History:

**Received:** 1<sup>st</sup> July, 2020

**Accepted:** 1<sup>st</sup> August, 2021

### Received in revised form:

10<sup>th</sup> August, 2021

**Published:** 28<sup>th</sup> September, 2021

## Keywords

Aggregate, Concrete, Taraba State, Quarry Site, Mechanical Properties.

## ABSTRACT

The study assesses the compliance of the mechanical and physical properties of coarse aggregate produced in some quarry sites in Taraba State to relevant codes and standards. The sample size used for the study ranged from 5, 7.5, 12.5 and 19 mm aggregates which were collected from four different quarry sites, spread across the state. The samples were tested for four parameters ranging from Water Absorption test, Aggregate Crushing Value test, Moisture Content test, and Specific Gravity test. These tests were carried out in accordance to relevant standards. The results obtained revealed the value of the specific gravity of the different quarry sites to be between 2.1 - 3.0. The values are above the minimum figure specified in the relevant code, the water absorption rate of the various aggregate sizes fall within the accepted standards for all the quarry sites. The aggregate crushing value in all the quarry site is below 35% which allows for concreting work according to (BS EN 1097-6:2000). The average crushing value for the aggregate in this study is between 21.7% for Sibre, 22% for Barkin dutse, 22.3% for Kashimbilla and 21.9% for Jalingo. Generally the mechanical and physical properties of the aggregates from the various sites show suitability for usage in construction work.

© 2021 TAJET All rights reserved

## Introduction

Aggregates of various sizes are required for most of the construction activities such as construction of roads, buildings, bridges, canals, tunnels, dams, airfields and other concrete structures [1]. They make up to 70-80 percent of the total volume of concrete and tends to heavily influence the cost of construction projects [2]. Aggregates are mixed with asphalt binding medium to make a compound material for infrastructure development. It can also be used with a stabilizer for base and subbase courses [3]. In buildings, it is combined with cement and sand to form concrete, ballast or rip rap thereby giving body and strength to the concrete ballast. Concrete strength is affected by many factors, such as quality of raw materials, water/cement ratio, coarse/fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete. Consequently, aggregates quality, size, shape, texture, strength etc, determines the strength of concrete. The presence of salts (chlorides and sulphates), silt and clay also reduce the strength of concrete [4], to this end, the properties of aggregates like toughness, hardness, shape, size, soundness, density, and specific gravity affect the strength of concrete [5]. Hence the importance of using the right type and quality of aggregates cannot be overemphasized, therefore fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy [6].

Furthermore, according to [7] aggregate moisture content plays a part in concrete workability because if aggregates are too dry, they will absorb water from the mix; and if they are too wet, the excess moisture must be subtracted from the intended mix water quantity. The mere fact that aggregate occupy 70-80 percent of the volume of concrete and 40 percent of asphalt concrete, has an impact on various characteristics and properties of concrete and asphalt. These and other numerous reasons make the study of aggregates (their types, properties and test) of great importance to construction projects [8].

Although in Nigeria there still are vast areas where suitable aggregates for concrete manufacture can be obtained, it is certainly true that in many cases large distances have to be travelled to obtain good quality natural aggregates. Besides, because of their composition, certain types of natural rocks may cause different durability-related problems such as the alkali-aggregate reaction in rocks containing reactive minerals or the occurrence of expansive clays in the microstructure of some basalts, which would further add to the damage caused by the use of natural aggregates [9]. Naturally occurring aggregates are particles resulting from the weathering of rocks. They can be gotten from rivers, say gravels and sand stone or crushed rock called chippings. To know more about concrete, it is important that one should know more about aggregate, which constitute the major volume. In Taraba State, the basic sources of aggregate either for concrete work or road constructions are from

those occurring naturally which are cheaper and readily available [2]. This research work will study natural aggregates from four locations in Taraba State to ascertain the different properties of aggregates used in construction works from these sources. The process of testing provides or establishes a common basis for comparison of aggregates from different sources.

On the other hand, regulatory bodies like British Standard Institute BSI, American Association of State Highway and Transportation officials AASHTO and Standards Organization of Nigeria SON has formulated standard testing methods for investigating the physical and chemical properties of aggregate. Based on these, some of the tests include; Aggregate Impact Value test, Specific Gravity and Water Absorption tests, grading test (sieve analysis) and Compression test and the likes. These tests give a clear information about the physical and mechanical contents of the materials used to produce the aggregates.

## Literature Review

### Aggregates

According to [10] an aggregate is a collective term for sand, gravel and crushed stone mineral materials in their natural or processed state. To [11], Aggregates are the granular filler material such as sand, stone dust, gravel, crushed stone, crushed blast-furnace slag, etc. that are used with binder such as Portland cement to produce concrete or mortar. It includes boulders, cobbles, crushed stone, gravel, air-cooled blast furnace slag, native and manufactured sands, and manufactured arid natural lightweight aggregates [12]. The aggregate (both fine and coarse) makes up about 80% of the volume of the concrete [13]. [13] generalized the volume of aggregate in concrete production but [12] was more specific. According [12], in a Portland-cement, concrete mix, coarse and fine aggregates occupy about 60 to 75% of the total mix volume and for asphaltic concrete, aggregates represent 75 to 85% of the mix volume. But [14] state that in any Concrete, aggregates (fine sand and coarse) usually occupies about 70-75%. Thus, aggregate generally occupy about 60-80% of the total concrete volume. Aggregates are used in concrete to; increase its volume, increase strength and durability, reduce ice shrinkage, reduce creep, reduce overall cost, imparts sound and thermal properties, imparts density, increase chemical resistance etc [11]. Aggregate to be selected for concrete work require the following properties, chemical inertness, strength, cleanliness, cost, availability in required size, grading, shape and surface texture are considered [11]. Also, [14] opined that while selecting aggregate for a particular concrete, the economy of the mixture, the strength of the hardened mass and durability of the structure must first be considered.

## Methods and Methodology

The map of the study area is in Figure 1 which is Taraba State in Nigeria. It is located between longitude  $23^{\circ}89'10''$  latitude  $37^{\circ}89'22''$ . The aggregates were collected in the following locations; Sibre quarry, Kashimbilla quarry , Bakin Dutse quarry, and Jalingo quarry site which consist of both Northern Taraba and Southern Taraba, so as to have a wide spread over the state. Different aggregate sizes were collected ranging from 5, 7.5, 9.5, 12.5, and 19 mm. The locations are all in Taraba State of Nigeria.

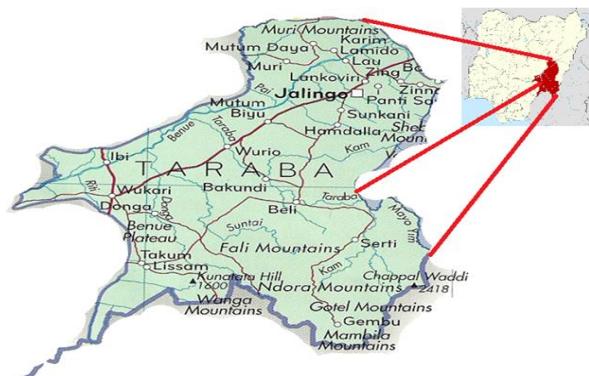


Fig. 1: The study Area, Map of Nigeria showing Taraba State.

## Results and Discussion

### Specific Gravity

The figure below (figure 2) specifies the value of the specific gravity of the various aggregates in the different quarry sites. The results obtained reveals the value of the specific gravity of the different quarry sites to be between 2.1-3.0mm. The values are above the minimum figure specified in [15] (BS EN 1097-6:2000, Tests for mechanical and physical properties of aggregates. Determination of particle density and water absorption, British Standard Institution, London.). By comparism aggregates from Kashimbilla has the specific gravity of 2.67 which is the highest while that of Bakin dutse has the least value of 2.54 for 5mm aggregates. In the case of 9.5mm, the highest value of 2.99 was recorded for aggregates from Sibre while that of Bakin dutse recorded the least value of 2.16. The highest value of 2.96 was obtained for aggregates from Kashimbilla with that of Bakin dutse recording the least value of 2.58 for 12.7mm aggregates. For 19mm aggregates, aggregates from Sibre has the highest specific gravity of 2.88 while that of Jalingo has the least with the value of 2.64.

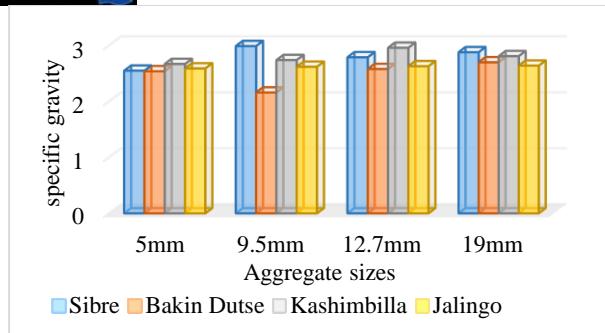


Figure 2: Value of Specific Gravity of different Aggregate Sizes from Various Quarry Sites.

#### Water Absorption

Work The figure below Figure 3 specifies the water absorption of the different aggregate from various quarry sites. The water absorption are within the range of 0.2% - 1%, it therefore implies that all aggregates from these quarry sites have very low absorption rate hence suitable for concrete since it complies with BS EN 1097-6:2000. Conversely the quarry site in Barkin Dutse has the lowest water absorption value while that of Kashimbilla has the highest value for 5mm aggregate size. For 7.5mm aggregate size that from Barkin Dutse has the lowest value while that of Sibre has the highest value. In the case of 12.7mm aggregates, that from Sibre has the highest value while that from Jalingo has the lowest value. For 19mm aggregates, aggregates sizes from Sibre have the highest value while that from Jalingo has the lowest value.

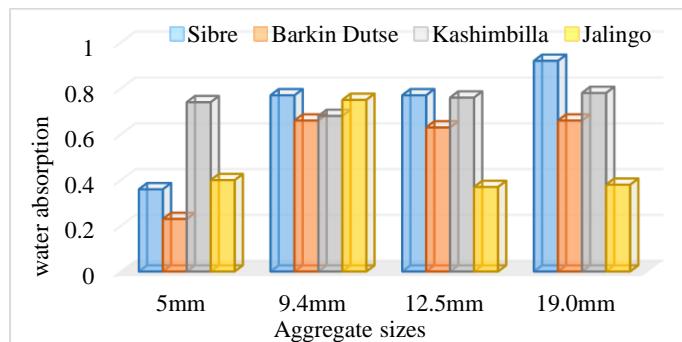


Figure 3: Water absorption of different Aggregate sizes from various quarry sites.

#### Moisture Content.

The moisture content values from the various quarry site differ from one another depending on the quarry site. For 5 mm aggregates size, the aggregates from Sibre has the highest moisture content

value of 2.3% while that of Jalingo has the lowest value of 1.3%. In the case of 9.5mm aggregates, aggregates from Sibre has the highest value of 2.9% while that of Barkin Dutse has the lowest value of 1.4%. For 12.5mm, aggregates from Kashimbilla has the highest value of 2.25% while that of Barkin Dutse has the lowest moisture content of 1.7%. For that of 19 mm Barkin Dutse has the highest value of moisture content of 1.9% while Sibre has the lowest value of 1.6%.

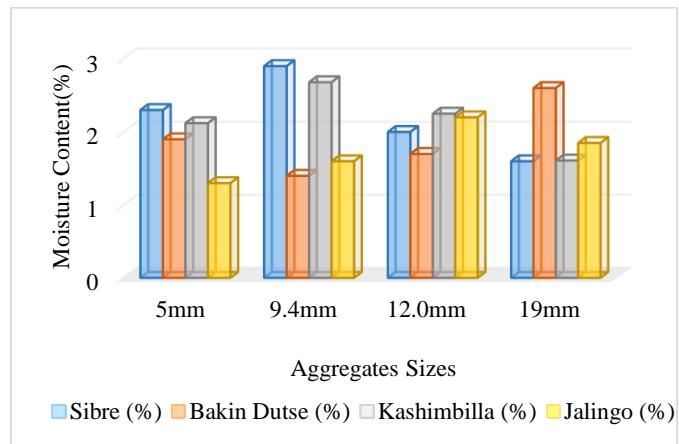


Fig. 4: Moisture content of the samples

#### Aggregate Crushing Value

The aggregate crushing value in all the quarry site is below 35% which allows for concreting work according to (BS EN 1097-6:2000). The average crushing value for the aggregate in this study is between 21.7% for Sibre, 22% for Barkin dutse, 22.3% for Kashimbilla and 21.9% for Jalingo.

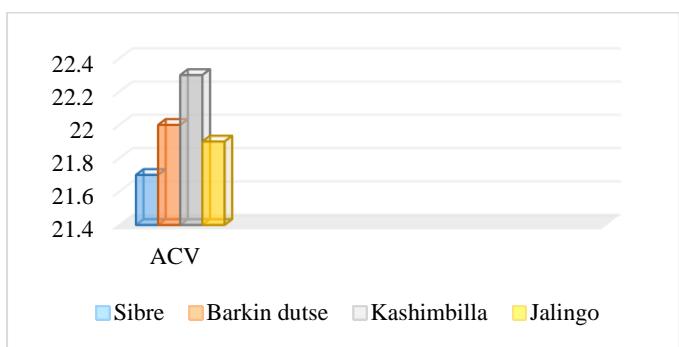


Fig. 5: Aggregate Crushing Values for the Samples



## AN ASSESSMENT OF MECHANICAL AND PHYSICAL PROPERTIES OF COARSE AGGREGATE PRODUCED IN SOME QUARRY SITES IN TARABA STATE, TAJET

2(1), AUGUST 2021: 18-21

### Conclusion

Aggregates is one of the dominant constituents in concrete work making up to 70% - 80% of concrete works, the aggregates tested for this work shows that the values for aggregates for specific gravity is above the minimum standard stipulated in BS EN 1097-6:2000. The water absorption tested for the aggregates falls within the required range of 0.2%-1% which is acceptable based on the relevant code of practice. About 50% of the aggregates falls within the acceptable moisture content which is between 1-2% by relevant codes. The crushing value in all the quarry site is below 35% which allows for concreting work according to (BS EN 1097-6:2000), the aggregates satisfy most of these criteria that will be suitable in construction of different concrete grades, such as grade 20, grade 25, grade 30, grade 40 etc. Contractors are therefore recommended to take advantage of these quarry sites by procuring the required aggregates sizes so as to enhance quality control, in the construction process.

### References

- [1] Sharma, S.C. Construction Engineering and Management of Projects, New Delhi: Khanna Publishers, 2013, p. 774.
- [2] Omopariola S.S. Jimoh, A.A., "A Comparative Study of the Physical and Mechanical Properties of Coarse Aggregates Produced in Ogun State.,," *Nigerian Journal of Technology*, vol. 37, no. 1, pp. 67-70, 2018.
- [3] Souvic,R. Amen, P. Dipankar, S., "A Feasibility Study of Replacing Conventional Base Course Layer in Flexible Pavement with Locally Available Materials," in *International Conference on Recent Advances in Transport Infrastructure*, Manit Bhola., 2018.
- [4] Gopal. M. "How concrete is made," <https://www.cement.org/cement-concrete/how-concrete-is-made..>, 2009.
- [5] Ajamu .S.O, Ige . J.A., "Effect of Coarse Aggregate Size on the Compressive Strength and the Flexural Strength of Concrete Beam," *International Journal of Engineering Research and Application.*, vol. 5, no. 1, pp. 67- 75, 2015.
- [6] Mamura. D., "Suitability of Crushed Manufactured Sand for Replacement of Natural River Sand to Produce C-25 Concrete," 2020.
- [7] Rao, G.A. Prasad, B.K.R., "Fracture Energy and Softning Behaviour of High Strength Concrete," *Cement and Concrete*, vol. 32, no. 2, 2002.
- [8] Bing, C. Jerry, L, "Effect of Aggregate on the Strength behaviour of High Strength Concrete," *Construction and Building Material*, vol. 18, no. 8, pp. 585-590, 2004.
- [9] Claudio, Z. Yurry, V. Di Maio,A.A., "Effect of natural coarse aggregate type on the physical and mechanical properties of recycled coarse aggregates," *Materials and Structure*, vol. 43, no. 1, pp. 195-202, 2010.
- [10] Neville.A.M, Brooks.J. J. , Concrete Technology, Prentice Hall, 1987.
- [11] Council of Registered Builders of Nigeria(CORBON) and Nigeria Institute of Building (NIOB)., "Improving the Core Practice Area for Builders IV,," in *MCPDP*, Abuja, Portharcourt, Gusau and Lagos, 2014.
- [12] Aker, D. "Building Materials," in *Design and Construction Handbook*, New York , Mc Graw- Hill, 2000, pp. 4.1- 4.105.
- [13] Reed, P. Schoones, K. Salmond, J., *Historic Concrete Structures in New Zealand; Overview, Maintenance Management.*, New Zealand: Science and Technical Publishing, 2008.
- [14] Anosike, M. N. *Parameters for Good Site Concrete Production Management Practice in Nigeria*, Covenant University, Ota, Nigeria, 2011.
- [15] British Standard Institutes, "Tests for Mechanical Properties of Aggregates, Determination of Particle Density and Water Absorption," British Standard Institute, London, 2000..