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Engineering Geological Evaluation of Gravel Deposits around Amoyo Area, Kwara State

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ABSTRACT

Evaluation of petrological characteristics and engineering analyses of gravel deposits were carried out around Amoyo area Kwara state to assess its suitability as construction materials. The petrological characteristics were done out through visual inspection and measurement of the particles axes. Representative samples were subjected engineering analyses such as Specific Gravity, Water Absorption Value, Aggregate Abrasion Value, Aggregate crushing Value and Aggregate Impact Value. Petrology characteristics of the aggregates (particle shape and size) revealed that the gravel deposit consists of particles ranging from clay to boulders which are essentially poorly sorted with variable mixtures of pebbles, cobbles and boulders. The engineering analyses carried out suggests that Specific Gravity of gravel aggregates ranges from 2.58 to 2.63 with an average of 2.60, Water Absorption Value ranges from 1.66% to 1.98% with an average of 1.80%.Aggregate Abrasion Value ranges from 27.20% to 38.91% with an average of 31.74%. Aggregate Crushing Value and Aggregate Impact Value ranges from 26.30% to 30.10% with an average of 28.70% and aggregate impact value falls within 26.65% and 28.70% with an average of 27.55% The results of petrological study and engineering analysis revealed that all the rocks favourable conform with standards used for construction purpose but can also be suitable with good workability for road, concrete and filter aggregates.

Keywords: Geological, Engineering, Gravel, Aggregates, Construction.

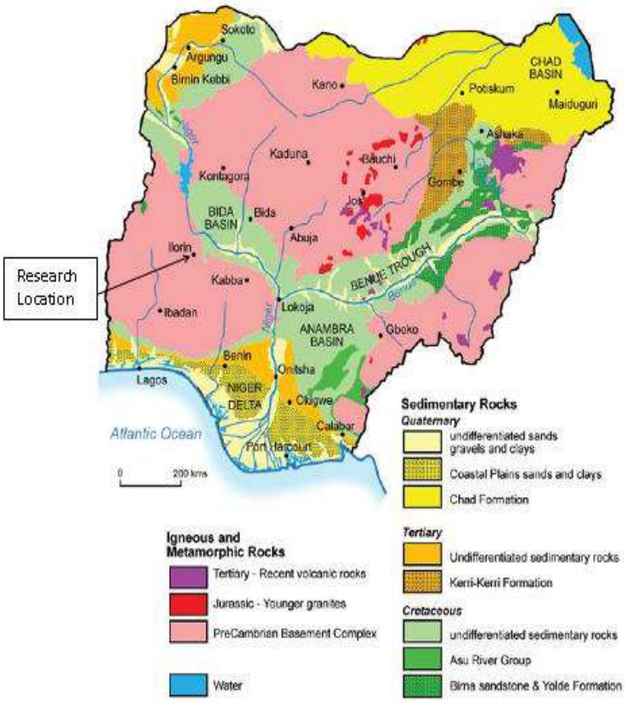
1.0 INTRODUCTION

Gravel are formed from natural weathering of parents rocks and eventual transportation of the weathered products by wind and erosion. They are obtained by dredging from pit, lake, river and seabed (Brady *et al.*, 2002). It comprises of different particle sizes which includespebbles, cobbles and boulders. It is part of clastic sediments resulting from the physical disintegration and chemical decomposition of weathered rocks. Gravel deposit may be residual, alluvial or alluvial.

They are often locally derived and accumulate close to or for from source having been transported by running water, ice, wind or shear gravity. In sedimentary formation of Nigeria and particularly in area of thick vegetable cover, rock outcrop is rare and local geology is not often well elucidated (Ananaba *et al.*, 1993). According to Raji, 2004 and Olasehinde and Raji, 2007 gravel deposit can be found in the basement complex areas of Nigeria, close to or far from river channels banks. However, it can be commercially exploited for various uses including concrete and highway pavement aggregate in construction industry (Okeke and Agbasoga, 2001). It is also one of the industrial and building raw materials available to mankind because of its usefulness in the construction of roads, bridges, houses, dams etc. This paper examines the results of petrological and experimental study carried out on indigenous locally sourced gravel deposit for construction purposes.

2.0 LOCATION OF THE STUDY AREA

More than half of the surface of Nigeria is covered by crystalline rocks and other less than 50% by sedimentary rocks (Fig.1). The study area is part of the Basement Complex of Nigeria considered by various workers to be Precambrian to lower Paleozoic in age (Oyawoye, 1970 and Rahman, 1976). It is situated in North-central Nigeria and comprises of igneous and metamorphic rock units such as Migmatite, Gneiss, Granite Gneiss, and some minerals such as quartz, feldspar, muscovite, and biotite. The co-ordinates of the area (Fig. 2) are of latitude 08^{0} 24^{1} 10.0^{11} and longitude 04^{0} 39^{1} 26.2^{11}. The climatic condition in the area is influenced by both wet and dry seasons.Due to the alteration in wet and dry seasons, the water table fluctuates in response to the seasonality of the rainfall.



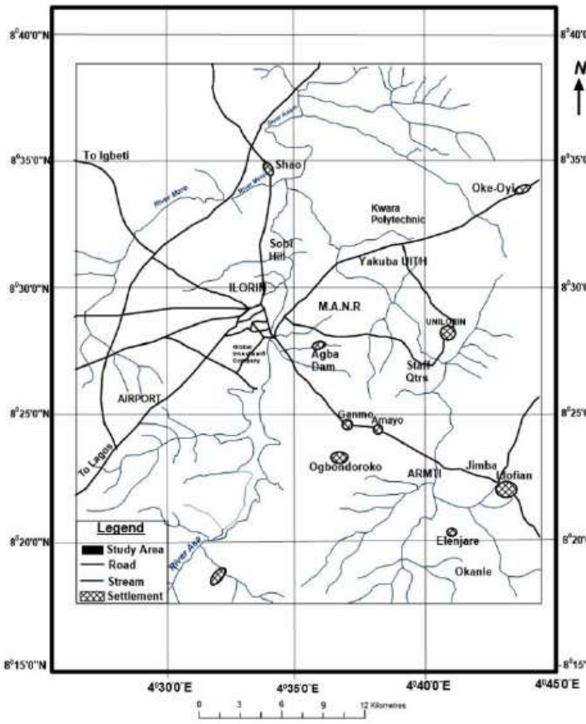


Figure.1: Geological Map of Nigeria

Figure 2: Location Map of the study area

(After Rahaman, 1988) (Modified after Olasehinde *etal.*, 1998)

3.0 MATERIALS AND METHOD

Geological mapping was conducted to identify rock types and their distribution. Petrology of fresh samples of gravel were studied with particular emphasis on sizes, shape and roundedness. The shape analysis was carried out through visual inspection and measurement of the particles axes while the grain size distribution was obtained through dry sieving which gives detailed textural features and descriptive properties. However, the randomly selected gravels were prepared for strength tests according to International Society of Rock Mechanics Commission (ISRM, 1989). All the rocks were subjected to mechanical (LAAV, ACV and AIV) and physical (water absorption and specific gravity) tests which were carried out on all the samples in accordance to standard specifications. The analyses were carried out at the Civil Engineering Laboratory University of Ilorin, Nigeria

3.1 Aggregate Abrasion Value (A.A.V) Determination

The Los Angeles machine with twelve (12) balls were used to determine the Aggregate Abrasion Value determination.500g of the sample retained on the 1.80mm sieve were poured in a large rotating drum of Los Angeles with twelve (12) balls and allowed to rotate 500 revolutions at the speed of 30 – 35 revolutions per minute. The materials were later extracted and separated into materials passing 1.80mm. the retained materials were then weighed and compare to the original sample weight. The difference in weight is recorded as a percent of original weight. The British standard recommends that rock materials with aggregate abrasion value below 30% are regarded as strong while those above 35% would normally be regarded as too weak for use in road surface.

3.2 Aggregate Crushing Value (A.C.V) Determination

The Aggregate Crushing Value (A.C.V) determination is the ability of rock material to resist crushing under gradually applied compressive load (a California Bearing Ratio (CBR) machine or Concrete Crushing apparatus) over a period of 10 minutes, after passing through sieve 14.0 mm and retained on 10mm sieve. The retained materials were poured into a mould in three layers and tamped for 25 minutes in each layer. After compression the fire materials (materials passing through the sieve number 2.36mm) produced, expressed as a percentage of the original mass is the Aggregate Crushing Value (A.C.V). The lower the value, (finer particles), the stronger the aggregate, that is the greater the ability to resist crushing. 30 percent and above as crushing value is not good for road construction.

3.3 Aggregate Impact Value (A.I.V) Determination

The Aggregate Impact Value (A.I.V) measures the resistance of aggregates to gradual disintegration due to impact. Oven dried aggregate that pass through 13.2mm and are retained on 9.5mm. British standard sieves were used for the test. A cylindrical cup of known weight is filled with the aggregates in 3 layers with each layer receiving 25 gentle blows using the tampering rod. The weight of the cup and sample is noted after which the aggregates are transferred to the impact mould in one layer and then placed firmly in position of the base of the impact machine. The samples are then given 15 blows using the impact machine rammer. The crushed materials are removed from the mould and passed through 2.36mm sieve. The fraction passing through 2.36mm sieve are weighed and readings noted. The impact value is calculated as the ratio of the weight of the fraction passing 2.36mm sieve to the weight of the sample expressed in percentage. The procedure is repeated a second time and the average is taken.

3.4 Water Absorption Value (W.A.V) Determination

Water Absorption Value determines the amount of water an aggregate can absorb. It tends to be an excellent indicator to determine the strength or weakness of the aggregates. Sample of a retained 1.75mm aggregate is immerse in water for approximately 24 hours to essentially fill the pores. It is then in both saturated surface dry condition, submerged in water and oven dried conditions. Strong aggregate will have a very low absorption value that is below 1.0 percent. Therefore, the aggregate moisture content will affect the water content (and thus impact the water cement ratio) and the water content affects aggregate proportioning because it contributes to aggregate weight.

4.0 RESULTS AND DISCUSSION

The results of physio – mechanical properties of Amoyo gravel aggregates compared with standard specification are summarized in table 1 and table 2 respectively.

Table 1: Physico – Mechanical Properties of Amoyo Gravel Aggregates

S/no	Sample	Specific Gravity (S.G)	Aggregate Abrasion Value (A.A.V %)	Aggregate Crushing Value (A.C.V %)	Aggregates Impact Value (A.I.V %)	Water Absorption Value (W.A.V %)
1.	A	2.61	38.91	29.70	28.70	1.98
2.	B	2.58	27.20	26.30	26.65	1.66
3.	C	2.63	29.10	30.10	27.30	1.75
4.	Standard Specification for Aggregates British Standard 882, 1983 and Flaherty, 1974		< 30	< 30	< 30	< 1.0

Petrographic study

The gravel deposit comprised of rock clast derived from various subsurface lithologies in the area. These lithologies consists majorly quartizites, banded gneiss and granite gneiss with mineralogical composition such as quartz, feldspar and muscovite. It consists of particles ranging from clay to boulders which are essentially poorly sorted. The coarse particles have variable mixtures of pebbles, cobbles and boulders. The gravels in the area are made up intrinsic properties such as shape, grading, composition and other physical features. This correspond to Smith and Collis (1993) assertion that gravel aggregate behaviour are influenced in various operational and environmental conditions based on their inherent properties. The gravel deposits in the area are coarse in texture and are mostly sub- rounded to sub-angular with rough to rarely smooth surface texture (Dawadi, 2015). As aggregate materials, the gravel consist significantly of pebble (4mm – 64m) sized angular rocks and mineral particles (Raji and Bale, 2008). However, petrology of the aggregates (Particle shape and size) revealed that the gravel deposit favourable conform with standards used for construction purpose but can also be suitable with good workability for road, concrete and filter aggregates (Bista, 2014).

Particle size

Particle size analysis of Amoyo gravel deposit (Fig. 3) suggest that it consist essentially of sand (5 – 20%) and gravels (82 – 99%). These may be may be appropriately described as sandy gravel (Bell, 1992). All the representative samples are collected from land and it is discovered to be well graded in nature (Okeke and Agbasoga, 2001). The particle sizes of the gravel ranges from fine particle of 0.06mm, 4mm to 64m with irregular shape.

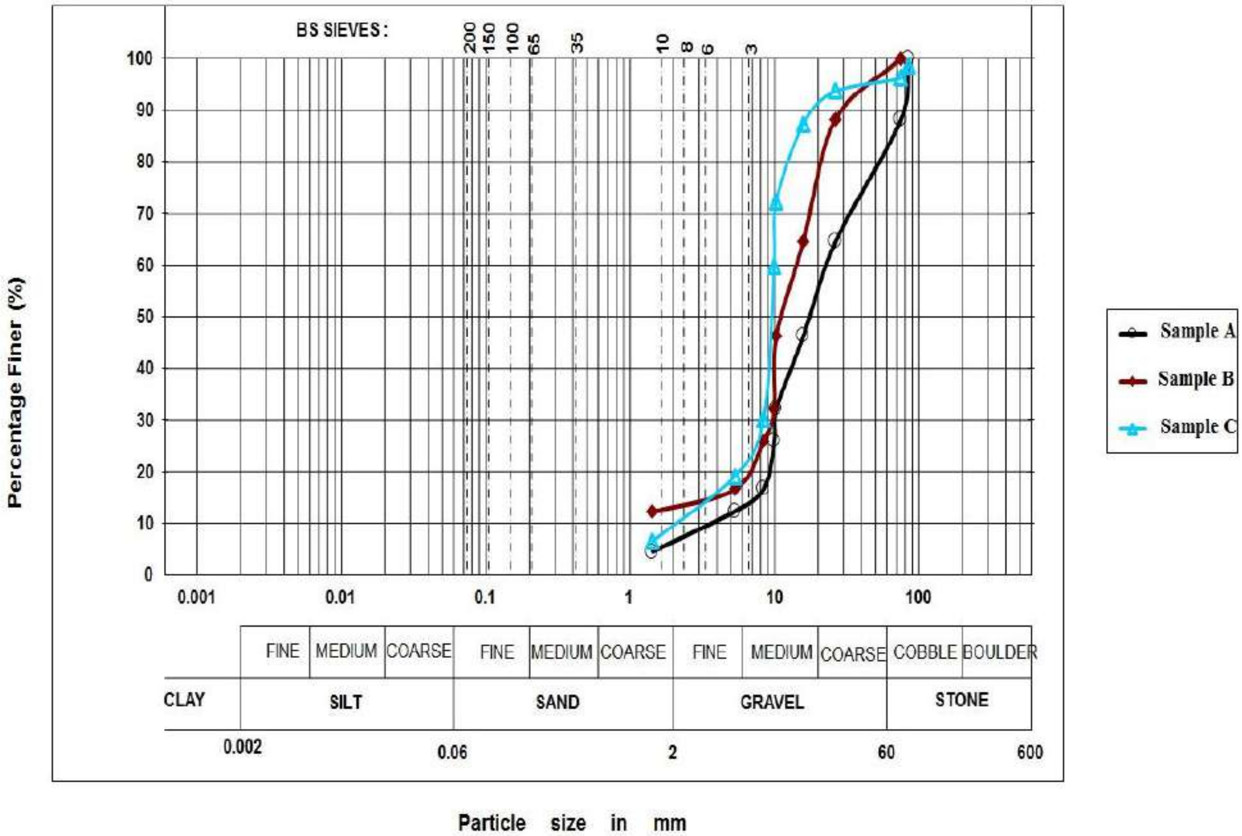


Figure 3: Particle – size Distribution Curves of Samples from Amoyo Gravel Deposit.

Specific gravity

The values of the specific gravity of gravel aggregates ranges from 2.58 to 2.63 with an average of 2.60 (Table 1). These values are within the ranges for the specific gravity of aggregates based on BS 882 (1983). Specific gravity which are generally less than 2.65 can be used for roadstone but not less than 2.50for filter aggregates. Shetty (2005) reported that an average normal weight of aggregates varies between 2.6 and 2.8. According to Komatka et al. (2003) most natural aggregate have relative densities between 2.4 and 2.9 while Neville (2011) also reiterates that the specific gravity for natural aggregates ranges from 2.5 to 3.0.

Water Absorption Value (WAV%)

The pointer to higher strength is the low water absorption rate of aggregates. The values of water absorption value (Table 1) ranges from 1.66% to 1.98% with an average of 1.80%. According to the specification of BS 882: (1983), WAV should be <3% for overall usage as aggregates. AASHTO M-132 (1987) specifies WAV<5% for the general use. But ASTM C 127 (2001) has specified required standard of <2.0 for coarse aggregates. However, all the sample aggregates recorded are below 2% indicating low effective porosity which is a pointer to wide possibilities of applicability of these aggregates in construction particularly in foundations and embankments.

Aggregate Abrasion Value (A.A.V)

Aweda et al. (2019) reported that one of the fundamental aspect in assessing aggregate resistance to wearing is the determination of Los Angeles abrasion value.The value ranges from 27.20% to 38.91% with an average of 31.74%. Los Angeles abrasion value below 30% can be used for bituminous mix, below 50% for base course. Based on the results obtained, Sample B and Sample C attained the required standard specification for bituminous mix and base course whilesample A is suitable for base course only according to ASTM C 131. However, Sample B and Sample C can also be good for wearing and fragmentation course (Shetty, 2005).

Table 1. Standard Specification and Applications

S/n	Tests	Standard Specifications	Application
1.0	Specific gravity	Specification [BS 882:1983]	Specific gravity generally less than 2.65 for road stone and less than 2.5 for filter aggregates
2.0	Los Angeles Abrasion Value (LAAV)	Specification [ASTM C 131]	<30% for Bituminous mix, <50% for base course
3.0	Aggregate Crushing Value(ACV %)	Specification [BS 882: 1983]	<25% for heavy-duty concrete floor finishes, <30% for concrete pavement wearing surfaces and <45% in other concrete
4.0	Aggregate Impact Value (AIV %)	Specification [BS 882: 1983]	<25% for heavy-duty concrete floor finishes, <30% for concrete pavement wearing surfaces and <45% in other concrete
5.0	Water Absorption Value (WAV %)	Specification [BS 882:1983]	Generally, <3%, 2% for roadstone aggregate. Not usually limited, but a recommended max. value of 2.5% is sometimes specified for concrete aggregate and less than 3% for filter aggregates.

Aggregates Crushing and Impact Value

The Aggregate Crushing Value is a value which indicates the ability of an aggregate to resist crushing under a gradually applied compressive load (Egesi and Tse, 2012) while the Aggregate Impact Value (A.I.V) gives a relative measure of the resistance of an aggregate to sudden shock or impact, which in some aggregates differs from its resistance to a slow compressive load. (IS, 1963). The results of aggregate crushing value ranges from 26.30% to 30.10% with an average of 28.70% while that for aggregate impact value falls within 26.65% and 28.70% with an average of 27.55%. Less than 40% is desirable for wearing surface and less than 45% is for normal concrete (NS 297- 1994). Since all the values fall within the recommended range (BS 882: 1983), it can be used for heavy-duty concrete floor finishes, for concrete pavement wearing surfaces and in other concrete works. However, all the samples have a higher value as regards aggregates crushing and impact values which can be used for all construction works.

5.0 CONCLUSION

Gravel aggregates are important index materials and detailed assessment of its properties will go a long way in designing and establishing a high quality structures in construction works. However, the gravel can be screened to secure the size proportion that suites a particular purpose based on construction demand but considering the petrological characteristics of the deposit and engineering analyses are essentially within the allowable limits for optimum use in construction industries.

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