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Contribution to Refined Basalt in Modern Nigerian Civil and Structural Engineering

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https://doi.org/10.26782/jmcms.2019.03.00056

Abstract

This paper looked into the effectiveness of refined basalt in the Nigerian civil and structural engineering world. Current technology has been in search in the development of new type of composites which are made to measure the required conditions. A general problem of new types of structures made from high performance materials is their behavior in certain specific conditions and situations. Temperature in Nigeria keeps increasing every season. The specific gravity, tensile strength, elastic modulus, rupture strain and melting point of basalt materials are the properties in consideration for the use of the basalt material listed below in use. This increase in temperature has been an issue of concern to scientists and engineers. This concern brought about the use of basalt made materials in the construction of utilities and buildings. Basalt which is a natural resource with the ability to contain high and low temperature was looked into in this paper. The three basalt formations discussed in this paper out of other formations found in Nigeria are: Bachit Basalt Rock Formation, Kahwang Rock Formation and Ikom Columnar Basalt. Basalt fiber wool, rebar, sandwich panels, roving and roofing sheet are the basalt materials discussed in this paper for proper utilization in the Nigerian structural construction.

Keywords : basalt rock, refined basalt, high performance material, basalt for construction

I. Introduction

Nigeria having the highest GP the highest population in Africa, has a great potential to the invention of new structural materials that could substitute or help diversify the high rate of structural material needed and in high demand in Nigeria. With recent decline in the world economy which has affected so many construction companies and caused some of this construction companies to close down because, some of the building materials they utilize are expensive, and are even imported into the country. These materials imported are as a result of the inability to manufacture the needed quantity that could serve the high rate of infrastructures coming up in Nigeria on daily basis.

Based on the above issues, lots of researches are going on to provide a remedy to these current situations. One of the results derived from the research is the use of basalt made materials in civil and structural engineering. Nigeria being a country with virtually 80% of most of the natural resources needed in the production of building materials, has basalt in its natural state in large quantity. The production of these raw materials would help in the market availability of building materials for civil and structural purposes.

This basalt made materials go along with some conditions and situations. Real example of such specific situation is fire; lack of fire resistance can be expected especially in case of very subtle concrete and steel structures. Concrete and steel undergo sequences of structural changes by actual thermal load level. First phase in concrete is the evacuation of physically bonded water taking place up to 200℃. Low permeability of high performance concrete (HPC) causes internal stresses incurred by accumulated steam.

In the last two decades, fiber-reinforced polymer (FRP) materials have been successfully applied in the area of civil engineering for reinforcing concrete structures to overcome the issues and problems of corrosion and durability. Fiber-reinforced polymer materials are associated with many advantages over steel reinforcement like its lightweight, high specific strength and stiffness ratios, non-corrosive materials and neutrality to electrical and magnetic disturbances(Benmokrane et al., 2006, 2007).

Basalt Formation in Nigeria

In this section, some basalt formations found in Nigeria will be looked into. This paper will not be going into the chemical components and formation of these basalts as the focus of this paper is on the civil and structural engineering value basalt in the Nigerian environment.

Bachit Basalt Rock Formation

Bachit Basalt Formation is located near Jos, towards the south of Barkin Ladi, Plateau State, Nigeria(Fig. 1). Most of it is visible in the dry season but submerged in the raining season. The location size is about 2-3 soccer fields large. These basalt rocks formed by cooling lava millions of years ago, Basalt formations are a sight to behold. Fig. 2 shows the raw basalt rock which when refined would give products that are highly needed in the structural environment. Later, these products will be discussed.

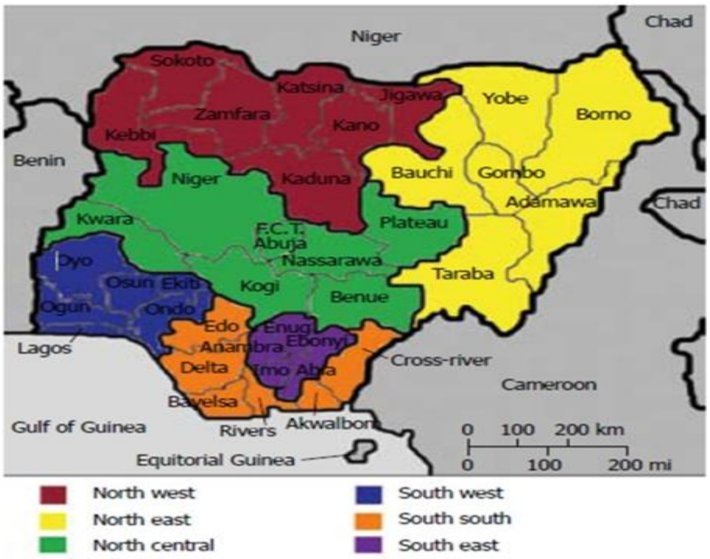

Fig. 1: Nigerian Map indicating all the 36 states

Fig. 2: Bachit Basalt Formation

Ikom columnar basalt

The Ikom columnar basalt is located in the western part of Nigeria of the Ikom-Mamfe basin. This polygonal basalt shows a unique geometry with a colonnade which has well defined polygonal facesoverlain by an entablature with irregular geometry (Fig. 3). Ikom as a city is located in Akwa- Ibom State of Nigeria. These polygons show the dominance of pentagonal, hexagonal polygons with the preponderance of pentagonal polygons. The polygonal or columnar structures are well defined in the Ikom basalt. Columnar joints and polygonal faces are spectacular geological phenomena observed in many parts of the world and are thought to be formed by the solidification of basaltic lava (Sosman, 1916; Singh et al., 2011).

The materials derived from the processed basalt from its natural state are discussed below. These materials are needed for its durability, effectiveness and properties.

Fig. 3: Polygons of the Ikom basalt

The Kahwang Rock Formation

The Kahwang Rock Formation is found in Bangai village of Bachi District Riyom local government of Plateau State Nigeria. A long dwindling stream locally known as "didi" passes through the formation. A glance on the picture (Fig. 4), we will notice the stark contrast of the rock colors. Most of the basalt on widely exposed on earth was due to "decompression melting" and the basalt commonly erupts on the third largest moon of the planet Jupiter.

Fig. 4: Exposed Basalt rock

II. RODUCTS OF BASALT

Basalt Fibers

Fundamental advance of nonmetal fibers production dated its start during fifties of the twentieth century with development of aviation and according to special requirements of army (ACI Committee 440, 2008; ASTMD4475, 2008). Natural basalt is the worldwide known spread material of volcanic origin, primarily resistant to corrosion in acid and also in alkaline environment, and is characterized by excellent resistance to high and low temperatures from −260℃ to +960℃. A plus to the advantage of basalt is its high hardness (8.5 by Mohs), which greatly affects the increase in concrete resistance to abrasion. Basalt tilesare indispensable part of numbers of pieces of technology equipment in the chemical and metallurgical industry. Igneous rocks as basalt have a high sufficient melting temperature, just about 1500–1700℃, which allows their great industry application in form of fibers (Jiang et al., 2014; Slivka and Vavro, 1996).

Fig. 5: Basalt Fiber Chopped Strands

The base cost of basalt fibers varies in dependence of the quality and type of raw material, production process and characteristics of the final product. This aspect of availability of the basalt fibers is an advantage to the economy of Nigeria as an increase is the manufacturing of this material for structural engineering will reduce the import rate of some of the building and construction materials.

Basalt fibers are predominantly produced in form of continual length fiber which is cut to required length. Constant close development of basalt fibers in form of textiles, bars, roving, and so for this also caused by the absence of health risks when compared to toxic asbestos fibers (Mateo et al., 2013). With respect to current requirements for building materials the low price of basalt fibers when compared to glass or steel fibers is interesting and overwhelming.

Substance of present fact lies in quite easy production process where it is not necessary to add other additives or admixtures or any necessary surface treatment (Landucci et al., 2009; Dhand et al., 2015). High dose of fibers reduces workability of fresh mixture (Jogl et al., 2015).

Due to high temperatures resistance, alkali-resistance, and extremely low absorbability allow wide application of basalt fibers on building industry and technical practice, it is of good use in Nigeria, mostly in the northern part of Nigeria where he temperature and too high.

Generally, basalts contribute to improved properties of concrete because of similar physical properties as traditional aggregates, for example, bulk density (Krassowska and Lapko, 2012). Optimal and effective dose of basalt fibers for fine grained concrete is about 0.5% in volume. The use of 1 to 2% of the fiber volume may be beneficial in structural application where there is a requirement of high energy absorption capability, improved resistance against delamination, spalling and fatigue, modulus of rupture, impact resistance, and the fracture toughness of the concrete (Mehta and Monteiro, 2006). Basalt fiber segments of complex basalt fiber can be gotten in different length. Basalt fiber can be supplied both in the form of diffused monofilaments and in the form of segments of joined together complex basalt fibers depending on the customer's need.

Basalt Rebar

In the search for a substitute to steel bar for concrete reinforcement, the invention and use of Basalt bars for concrete reinforcement called Basalt Fiber Reinforced Plastic (BFRP) is employed. This is a new material, to the Nigerian structural world and the general structural engineers at large. Therefore, it is necessary to identify the differences and limitations of their uses in the concrete structures in relation to traditional steel reinforcement of concrete structures. Basalt rebar is a bar with continuous spiral ribbing formed by means of winding by basalt strip oiled in highly durable polymeric compound.

Basalt rebar is a perspective composite material with a very wide range of application in construction. The rebars are resistant to corrosion and aggressive chemical compounds, is very light in weight and durable.

Fig. 6: Basalt Rebars

Research has proven that long life of constructions where basalt rebars were used considerably exceeds the life of similar constructions where other materials were used.

Some experiments have already been carried out using a simply supported beam as the focus. Examples are shown in (Urbanskia et al., 2013) where some chosen results of pilot research on the series of simply supported beams under flexure, reinforced with BFRP bars, compared to the reference beams with steel reinforcement. The analysis of the beam deflection and cracking behavior is also seen in (Urbanskia et al., 2013) furthermore, showing the results of different character of the load-deflection relationshipof basalt reinforced beams compared to traditionally steel reinforced beams, as well as the significant influence of the type and quality of anchoring on the process of basalt bars tensile process. According to ACI 440.1R-06 Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars, the properties (Table 1) are guaranteed for the stipulated diameter of rebars (Basalt Rebar ManufacturerKODIAK).

Basalt rebar is a highly needed material in Nigeria. Its ability to glue to cement, asphalt will be very good to use in road construction and bridges. Compared to steel rebars which easily give way to tracks when on high temperature and longtime durability. With a population of over 160million people with over 100million vehicles in Nigeria, Basalt rebar is a solution to long quality road durable construction and not just in buildings.

Table 1. Guaranteed Properties–BASALT Rebar Series

Diameter		Nominal Area	Guaranteed Tensile	Tensile Modulus
size	mm	mm^2	Psi	Gpa
2	6	31	125,000	40.8
3	10	86	115,000	40.8
4	13	139	105,000	40.8
5	16	211	100,000	40.8
6	19	295	95,000	40.8
7	22	391	90,000	40.8
8	25	505	85,000	40.8
9	29	670	80,000	40.8

Basalt Roving

In Nigerian coastal regions where high wind force is experienced, Basalt roving will be a perfect material for use in bridge tenders and electric pole tenders. Basalt roving (Fig. 7), is bundle of continuous monodirectional complex basalt fibers. Roving possesses high natural strength, long service life resistance to aggressive environments and excellent electric insulating properties. Basalt roving is extremely heat resistant: long withstanding temperature range is -260°C to +680°C. In temporal occasions, it can work in up to 1000°C.

Fig. 7: Basalt Roving Material

III. Application of Basalt

Some of the places where Basalt can be applied are:

- Polymer Reinforcement
- Auto, Aircraft And Ship Building
- Woven And Non-Woven Materials
- Concrete Reinforcement
- Fireproof Products
- Asphalt-Concrete Reinforcement

IV. Conclusion

Basalt rooks when refined could be used in the production of Basalt sandwich panels, Basalt roofing sheets, Basalt Roving etc. These products are in high demand in Nigeria. As the nation grow and expand, citizens look out for ways to promote and solve their problems. This was what led to the new search of construction materials to help substitute the shortage or high cost of the present building materials. Thanks to great scientists who started the experiments on Basalt rocks. After proper investigations and researches, Nigerian soil still have this natural resource untouched which citizens are searching for solutions to the high costs in construction materials. Basalt rocks and formations when refined could give more products than the ones in circulation.

V. Acknowledgement

This research work was supported by the Ministry of Education and Science of the Russian Federation (Agreement No. 02.A03.21.0008).

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