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# Investigation into the Suitability of Miya Natural Sand for Foundry Application

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**ABSTRACT:** The research work was conducted to investigate the suitability of Miya natural sandfor mould making in casting processes. Sand sample was collected from Miya deposit sites inGanjuwa local Government of Bauchi state. The Chemical composition was determined using X-ray fluorescence spectrometer. The result indicates $SiO_2$ has the highest percentage in the sand sample of 79.44%. American Foundry men's Society standard laboratory tests equipmentwere used to analyze the physical and mechanical properties. The results of physical and mechanical test were found to be dark brown, angular in shape with the following values; Clay content 22%, Grain fineness number 36.90GFN. Other mechanical properties were determined at varying percentages of moisture content such as; green compressive strength 100kN/$m^2$, dry compressive strength 200kN/$m^2$, permeability 220 $cm^3$/min, shatter index 90%, thermal shock resistance 12cycle and refractoriness up to$1500^0$ at 3% water addition was optimal. The results of chemical, physical and mechanical tests conducted revealed that Miya naturalmoulding sand is suitable for mould production in foundry for casting malleable iron, light grey iron, light steel, medium grey iron, brass, bronze, aluminium and its alloy at 3% moisture content without addition of binder.

**Key words:**Green compressive strength, Chemical composition, Shatter index, Thermal shock resistance and Refractoriness.

## I. INTODUCTION

Most metal casting sand, that is foundry sand (F.S) is high quality silica sand with uniform physical characteristics. It is a by-product of the ferrous and non-ferrous metal in casting industry, where sand has been used for centuries as a molding material because of its unique engineering properties (Muhammadetal., 2021). In modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates that approximately 100 million tons of sand is used in production annually, in which four to seven million tons are discarded annually and are available to be recycled into other products in an industry.The most metal cast are iron, aluminium, steel, brass, bronze, magnesium, and zinc alloy (Shuaib-babata, 2014). In Bauchi, the most frequent isaluminium, of which aluminum is known to possessed high strength to weight ratio, high thermal and electrical conductivity, high toughness with good strength at low temperature, high resistance to corrosion, non-toxic, excellent reflection of radiant energy, ease to form and fabricate etc. (Muhammadetal., 2021). It is lightest metal than magnesium, with a density of about one-third of that of steel. Whereas, iron has high strength, rigidity, low shrinkage, and ease to control this makes it suitable for casting.The sand used in foundry must meet the physical/mechanical properties as well as chemical composition required by (AFS) standard because poor quality sand results in casting defect. Foundries and sand producers invest significant resources in quality control of their sand system, with extensive testing to maintain consistency (Ndaliman, 2019). As a result, foundry sand from an individual facility will generally be very consistent in composition; which is an advantage for most end use application.

Aluminium pots production by small scale is a common practice trade in Bauchi State. This trade contributes a lot to the economic development of the town, job creation and business for self-reliance. Miya Natura moulding sand is currently used for casting Aluminium and its alloys in Ganjuwa Local Government of Bauchi by small scale foundries but is not reported in literature.The

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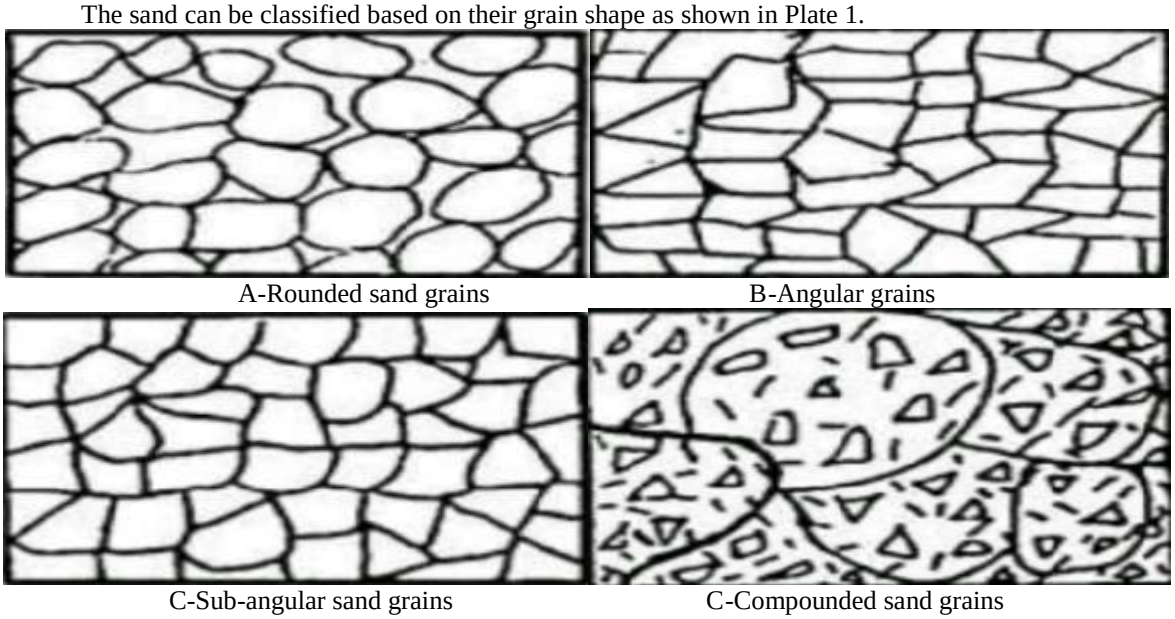
sand properties are not only determined by chemical composition, but also amount of clay, moisture content as well as shape and size of silica grains in the sand (Agbo etal., 2018). To ascertain if sand in a certain location is suitable for foundry uses, periodic sand test are required. These tests include grain shape and grain fineness number (sieve analysis), permeability test, moisture content, refractoriness, clay content, green compressive strength, dry compressive strength and shatter index. The information from these tests would be compared to the (AFS) standard values to determine the suitability of thesand for mould application (Njoku and ocheri, 2020). In this research, determination ofnatural foundry sand from Miyadeposit site used in the foundry for mould application will be carried out. Generally the foundry workers from these location as well as other locations employ visual test to judge the sand samples without due consideration of its chemical composition and mechanical/physical properties.

**1.1 Moulding sand**

Moulding sand is defined as granular particles resulting from the breakdown of rock or disintegration of rock due to the action of natural force, such as frost, wind, rain, heat and water current. Rock has a complex composition and sand contain most of the element of the rock (Tokan and Mohammad, 2007). Silica sand is made up silicon dioxide ($SiO_2$); is commonly used in foundry but not all sand is suitable for casting (Mahmoud et al., 2016). This is because there are certain properties that are required such as green compression strength (45 - 105 $kN/m^2$), dry compression strength (200 - 2000 $kN/m^2$), moisture content (4.5 - 8%), permeability (40 - 300 mmWs), Shatter index (12% and above), refractoriness (1100$^oC$ and above), clay content (10 - 14%) etc. before they can be used as a moulding sand.

**1.2Classification of foundry sand**

The sand can be classified based on their grain shape as shown in Plate 1.



A-Rounded sand grains B-Angular grains

C-Sub-angular sand grains C-Compounded sand grains

Plate I: Classification based on grain shapes**.** (Source: Muhammad et al., 2021).

The shape of the sand grains also influences the mouldingcharacteristics of the sand (Mbindael al., 2017). The shape varies from round to angular. Whereas in some sands; almost all the grains are of one type, in others, the grains of varying shape are present. From the point of view of grain shape, foundry sands are classified into four types as shown in Plate I. Round grains have least contact with each other in a rammed mixture and therefore, produce moulds which may have high permeability and law strength. Angular grains have defined edges; they give more strength and low permeability and can interlock more easily. Compound and sub-angular grains have an intermediate permeability and strength respectively. Furthermore, moulding sands composed of angular grains need higher amounts of binder and moisture (Dansaraiet al., 2020).

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## II. REVIEW OF OTHER RELATED WORK

Muhammad et al. (2021) study the potential of rumba and kafi sands as moulding materials. They revealed that Rumba and Kafi sands are found to be silica sand because of their higher percentage of $SO_2$ obtained as 65.23% and 59.90% respectively. The physico-mechanical properties of Rumba and Kafi sands- grain fineness number (35.59 and 39.73 GFN), green compressive strength (85and 85 kN/m$^2$), clay content (14 and 20%), refractoriness (1350$^o$C and 1260$^0$C) and permeability (104 cm$^3$/min and 100 cm$^3$/min) respectively, at 2.8% moisture content are suitable for non-ferrous alloy casting.

Moses et al. (2020) studied the effect of moisture content on Nasaruwu natural foundry sand. They found that the sand has natural clay content of 25.5%, Refractoriness of 1400$^0$C and grain fineness number of 138.73 GFN which is within the range of 150 – 400um recommended by AFS Standard for casting various metals. Other mechanical properties were tested at a varying percentage of moisture and discovered to be suitable for casting metals components such as Brass, Bronze, Aluminium and it alloy at 6% moisture content, but not suitable for casting high temperature metal such as iron and steel. The result of the Aluminium casting produced from the mould made from Nasaruwu sand was found to have good surface finish and of good guality.

Mahmoud et al. (2016) investigated the Gwange natural sand as a mould material. In the study, Dry compressive strength showed a low value of 152.5 kN/m$^2$ at exactly 1.9% moisture content. This showed that, the lower the value of dry compressive strength the higher the value of the moisture content. The Gwangemoulding sand indicated poor dry compression strength and therefore, it does not have the required property to be used as dry mould, rather it can be used in green state in accordance with the (AFS) standard. The sand contains 30%to 40%natural clay in it and showed a high value of green compression strength of 57.27 kN/m$^2$ at 2.2%and 4.7% moisture content at the less value of green compression strength of 33.95 kN/m$^2$. This result indicated that Gwange natural sand without additives (bentonite) can be used to cast non-ferrous metals, such as, aluminium, brass, bronze, malleable Iron and light grey Iron, since as the green compression strength was found within the acceptable range values recommended by AFS standard. The permeability number increases with decrease in value of moisture content and it indicated the higher value of 440 mmWs at 1.9%. This shows that, the moulding sand has the required value that will prevent the casting from minor and major defects, such as blow holes, porosity and scars.

Shuaib-babataet al. (2017) studied the suitabity of Ado-Ekiti (Nigeria) natural moulding sands for use as foundry sands in manufacturing of Aluminium alloy cast. They revealed that the sands sample are of high proportion of silica, with 75.22% - 79.23% silica oxide and flowability values between 67.25 and 68.50% which varies in sand with moisture and clay contents. The permeability test results recorded for the tested sand range between 86.2 and 87.5 which indicated that the sand samples had good natural green permeability for casting number of ferrous and nonferrous metal. The green and dried shatter index of the sand specimens is between 0.03 – 0.50 and 0.05 – 0.22 respectively. The shatter value indicated that the sand sample was tough enough to aid satisfactory lift during pattern with-drawal. The green sands strength was within the recommended range of 70 - 100 kN/m$^{2,}$ which showed an adequate green strength of sand to retain it shape without distortion or collapse even after the pattern is removed. The study revealed that all sand samples at green state were suitable for casting aluminum alloy.

Mshelia etal. (2016) studied on the characterization of Dala Lawanti, Pompomari, Gwange, Gamhoru and Universty of Maiduguri natural moulding sand for foundry application. Due to the high range of clay content between (21.8%and 47.2%) which is far above the standard range (10 - 12%) recommended by (AFS) for natural moulding sands required for manufacturing good quality aluminum casting. However it does not mean the sand cannot be used for casting but its reusability should be closely observed to timely reconditioning in order against the production of defective casting.

Mbinda and Samuel (2017) investigated the suitability of Lere river bank sand for green sand casting. They revealed that Lere river sand is Alumino-silica with physio-chemical properties suitable for non-ferrous casting because silica $SiO_2$ is dominant of the oxide present and sodium oxide is high causing reduction in the refractoriness as it fluxes at high temperature. It also responds well to bentonite clay binder that gave good mechanical properties to sand mould specimens. The result of the mechanical properties analysis of the sand was found to be suitable to all types of nonferrous alloy casting at 2.5% bentonite clay with about 2.0% moisture content.

Msheliaet al. (2017) determined the grain size of Biliri and Damaturu moulding sands for

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foundry application. They found that the natural sand samples collected from biliri and Damaturu deposits showed variation in grain fineness number with respect to change in depth of samples collection. The Biliri and Damaturu sands samples found to have an acceptable grain fineness number of 99.30 and 88.05AFS at a depth of 1.5m and 1m respectively. The result will provide adequate permeability and good compression strength compared to the samples collected at other depth. These samples can also be utilized effectively in casting of malleable iron and non-ferrous metals.

Ibrahim (2018) investigated the moulding properties of Gurara Bed sand in Niger State using Kaolin and Bentonite as binder. He revealed that the result of physico-chemical properties showed that the sand has high silica and high refractoriness which make it suitable for casting of all forms of non-ferrous metal and ferrous of melting point less than $1500^0$C. The result of mechanical properties of the sand when compared with the Foundry standard was discovered to be suitable for non-ferrous alloy and some ferrous alloy such as heavy steel casting, light steel casting with 0.1% to 3% bentonite and for heavy grey iron with 2.0% to 3.0% bentonite and 2% moisture content. While that of Kaolin clay was suitable for malleable and light grey iron from 2.0% to 3.0%, at 3.0% suitable for heavy grey iron and medium grey iron and at 2% moisture content suitable for all non-ferrous alloy.

Shuaib-Babataet al. (2019) evaluated the foundry properties Oyun River (Ilorin) moulding sand. They found that Oyun moulding sand is a Silica Sand with chemical composition within the accepted range values by AFS standard and capable of casting metals with low melting temperature. While the test of physico-mechanical properties such as Grain fineness number, Moisture content, Clay content, Permeability, Green compressive strength, Dry compressive strength, Shatter index, and Refractoriness having a value of 8.15% to 8.48%, 14.96% to 15.79%, 0.072 to 0.075 $cm^3/s$, 71.31 to 79.73 $kN/m^2$, 200.25 to 214.65 $kN/m^2$, 25.33% and $1300^oC$ respectively. These results showed that the sand is favorably within the AFS standard recommended for casting non- ferrous metals.

## III. METHODOLOGY

Sand sample was collected from Miya natural deposit sites at the depth of 1.5m mixed thoroughly and finally kept in the Discators for further test to be conducted. Foundry rammer was used in breaking the grain pebbles and then sieved through 3mm British standard sieve to obtain the required grain size. The standard test specimens of 5cm in diameter by 5cm height in a smooth surface tube were produced using sand compacting machine which delivered a blow of 6.5Kg from a height of 45mm. the specimens were used in determining the mechanical properties of the sand samplein line with the AFS standard guideline as shown below.

Plate 2: Sand samples in the Lab

Plate 3: Standard cylindrical Sand samples in a furnace

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Plate 4:Sand compacting MachinePlate 5:Standard specimen on permeability testing Machine

## IV. RESULTS AND DISCUSSION

Table 1: Results of the chemical composition test of Miya Natural Sand

| Elements | $SiO_2$ | $AL_2O_3$ | CaO | MgO | $Na_2O$ | $Fe_2O_3$ | $TiO_2$ | $K_2O$ | MnO | LOI |
|---|---|---|---|---|---|---|---|---|---|---|
| (Miya) (%) | 79.44 | 2.20 | 0.32 | 0.04 | 0.30 | 14.26 | 1.20 | 0.19 | 0.02 | 3.00 |

The results of the chemical composition analysis of Miya Natural sand from was presented in Table 1, Its revealed that $SiO_2$ is the main constituent of the moulding sand with value of 79.44%. Miya natural moulding sand was discovered to be silica sand because of the large quantity of silica present in the sand which is within the American Foundry men's Society standard for casting various metals. This showed that, the result of the chemical composition of Miya is safe for casting of metals with low and moderate pouring temperature. Naturalmoulding sand for metal casting is highly silica sand with uniform physical/mechanical characteristics Muhammadet al.(2021).

Table 2: Grain color, Shape, GFN, Clay and Moisture content of Miya Natural Sand.

| Sand Samples | Color | Grain Shape | GFN | Clay content | Moisture content |
|---|---|---|---|---|---|
| Miya | Dark-Brown | Angular | 36.90 | 22% | 6% |

Table 2: Showed the result of grain color, shape, Grain fineness Number, Clay content and Moisture content of sand sample. The sand sample was found to be dark-brown in color and Angular in shape. This indicated that the sample has good interlocking properties which will give high strength and moderate permeability. The sand has 22% clay content which is above the recommended standard ranged of 10 - 12% for ferrous metal casting and 8 - 15% for non-ferrous casting. Hence, the natural moulding sand from this deposit site has to be used with caution to minimize the production of defective castings because permeability decreases with increase in clay content and excess clay burn at high temperature which lead to casting defects.The natural moisture content is 6% which required addition of water so as to activate the effect of clay in the moulding sand for adequate strengthAgboet al. (2017).

Table 3: Result of Refractoriness and Thermal Shock Resistance Miya Natural Sand Samples

| Sand Samples | Refractoriness | Thermal Shock Resistance |
|---|---|---|
| Miya Natural Sand | $1500^0$ | 12 Cycles |

The refractoriness and thermal shock resistanceof Miya natural moulding sand was $1500^0$C and 12 cyclesas presented in Table 3: respectively. Itindicated that the refractoriness was within the accepted range for casting various metals such asaluminium, brass, bronze, malleable

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cast iron, light steel, medium grey cast iron and light grey cast iron.Moulding sand with poor refractoriness may burn, break or fused when pouring the molten metal and no smooth surface of casting can be achieved, hence the degree of refractoriness of moulding sand depended on its $SiO_2$ content.The thermal shock resistance test indicated thatthe sand sample can be used to cast a component up to 12 times before rejection.

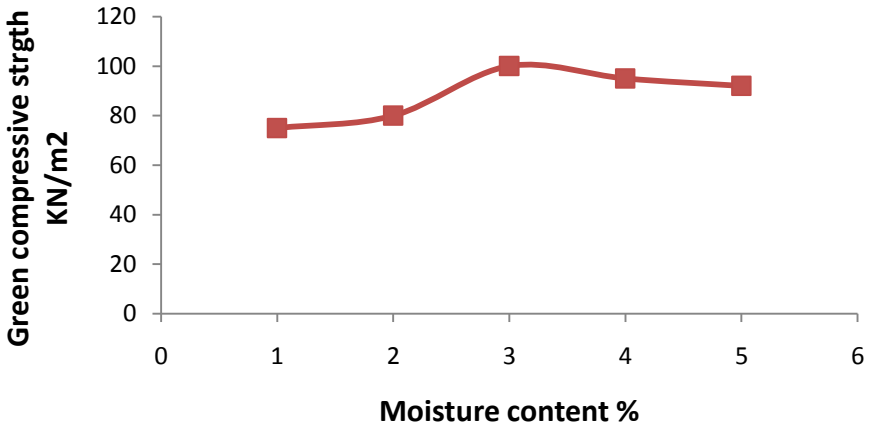


**Figure 1:** Result of Green compressive strength of Miya natural moulding Sand

The green compressive strength of Miya natural sand sample indicated a high value of 100kN/$m^2$ at 3% moisture content and a low value of 75kN/$m^2$ at 1% moisture content. The GCS of Miya natural sand increases with increase in moisture content, but decreases at 5% moisture content which decides the presence of excess moisture in the sand sample. These values were within the AFS Standard values for various metals casting. From the result obtained, MiyaNatural sand samples at 3% moisture content is suitable for casting metals, such as aluminium, brass, bronze, malleable iron, medium grey iron, light grey iron, Heavy grey steel etc. The results showed the sand can be used to produce a mould at all percentage of moisture and can retain its strength at wet stage without addition of binder materials.

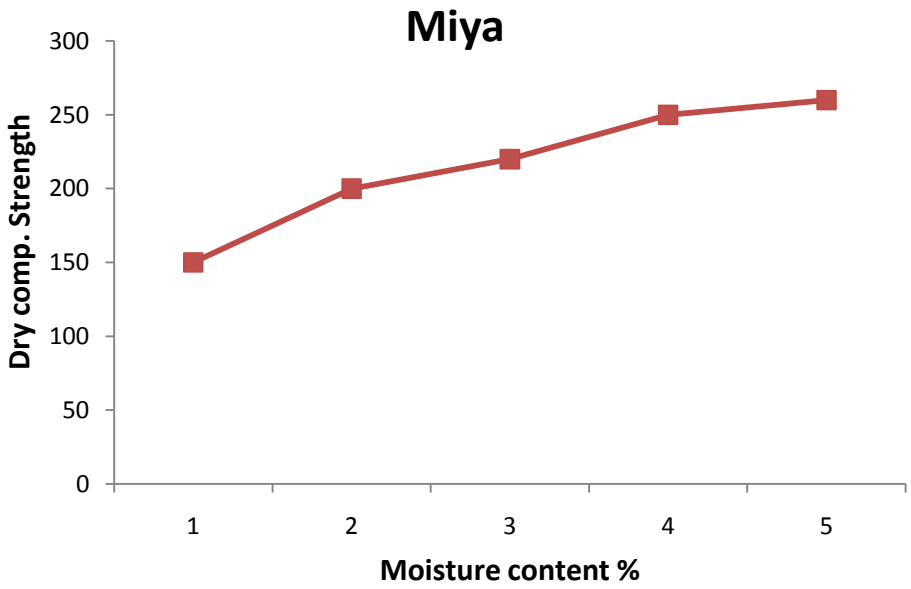


**Figure 2:** Result of dry compressive strength of Miya natural moulding Sand

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The results of dry compressive strength of Miya natural sand samplesshowed high value of DCS of 255kN/m$^2$ at 5% moisture content. Miya natural sand sample at 2%, 3% 4% and 5% moisture content has a value of DCS within the recommended range for casting heavy steel, heavy grey steel, light grey iron, malleable iron, aluminium and its alloy. This result testified that the sand has good dry compressive strength and capable of withstanding fusion and tearing during pouring of moulten metal at dry stage.

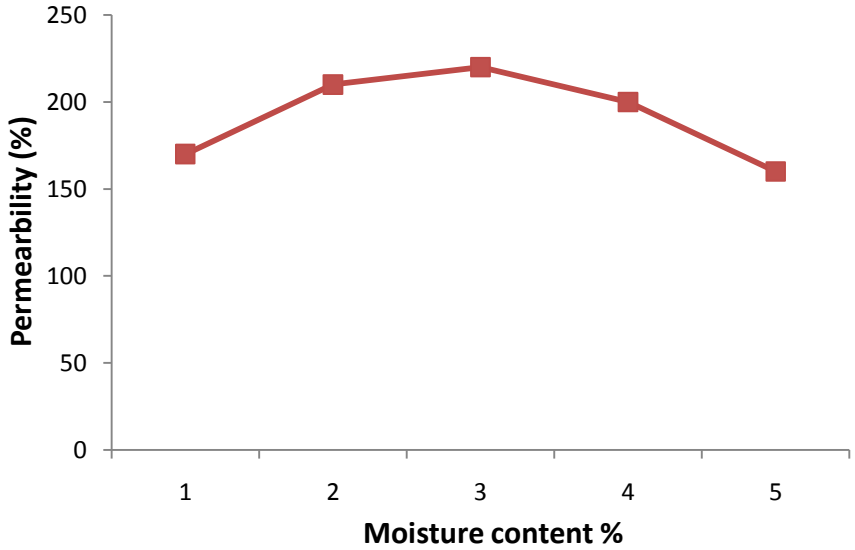


**Figure 4:** Result of Permeability of Miya natural moulding Sand

The results of the permeability test of Miya natural sand showed a maximum value of 220 cm$^3$/min at 3% moisture content there after decreased with increase in moisture content. It revealed that at 3%, moisture content, the sand sample can be used for casting large variety of component(s) (heavy or light)which will be free from minor and major defect.

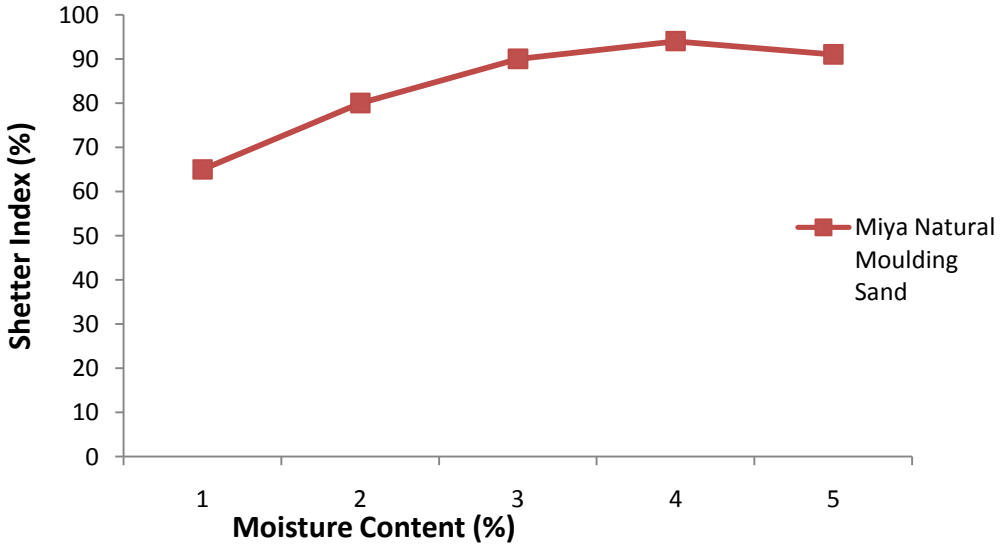


**Figure 5:** Result of Shatter index of the Miya natural moulding Sand

The Shatter index values of Miya natural Sand samples are presented in figure5 above. The results indicated an increase in value from 65% at 1% moisture content to 94% at 4% moisture content there by decrease to 91% at 5% moisture content respectively. The results indicated an

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increased in values of the shatter index with increased in moisture content. The specimens exhibited an improved plasticity due to the improved shatter index response with increased in moisture content. All the values were consistent for used in mould making in casting process.

**Plate 6: Cast components**

**Plate 7:Mould**

**Plate 1& 2:Mould and Cast product of Aluminium Alloy at 650$^0$C and 700$^0$C pouring temperature**

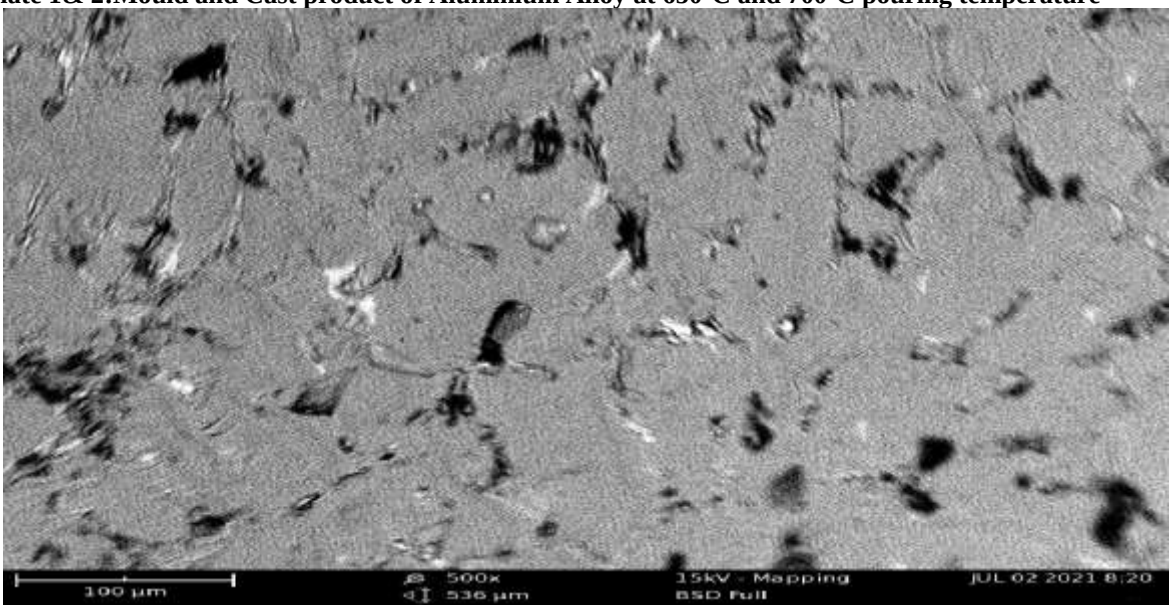


**Plate 8: Micro-graph of the Cast product at 100 u m**

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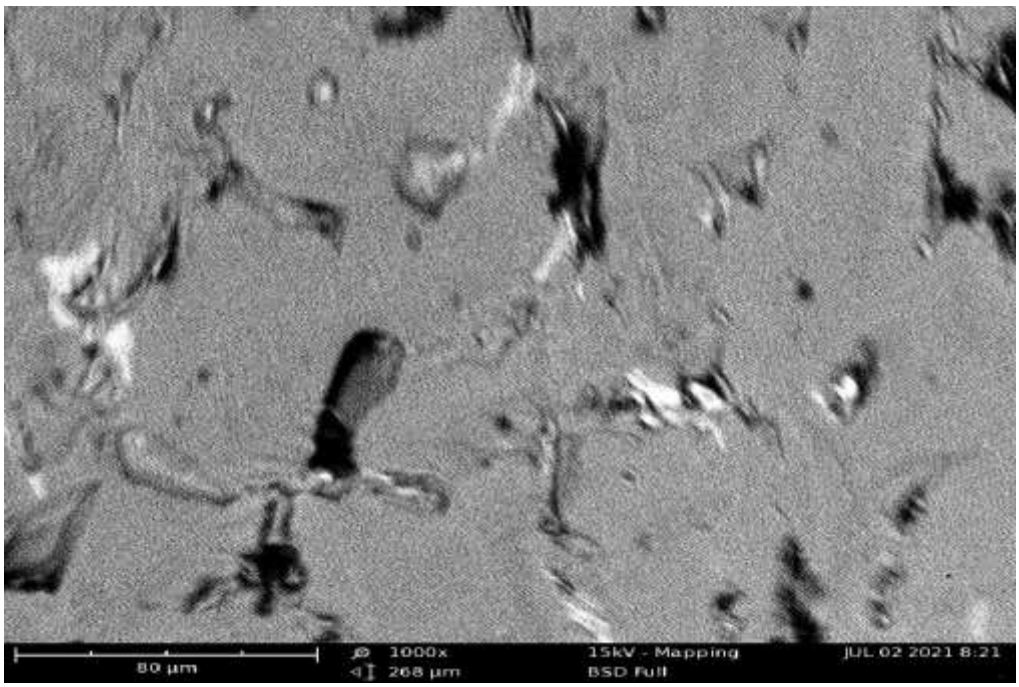


**Plate: 9 Micro-graph of the cast product at 80u m**

**4.1 Micro-structural Analysis of the as-cast Component**

The morphologies of the cast component (Auminium Alloy) produced from mould made from Miya Natural sand sample at varying pouring temperature were shown in Plate 7 & 8. Each sample was viewed under magnifications of 100um and 80um. The micrographs revealed that the primary solid solution of silicon in aluminium, (Si) is shown as white patches while the eutectic is indicated as dark patches and ash patches as Aluminium (Al). The results of micro-structure showed that the cast components were characterized by grains boundaries due to slow cooling. Solidification is a process of nucleation and growth and it is affected by the rate of heat transfer which in turn affects the structure and properties of the casting.

## V. CONCLUSION

In this research work, the properties of the natural moulding sand were investigated. Standard cylindrical sand samples were prepared and experiment was conducted for chemical, physical and mechanical properties. The results were compared with American Foundry Men's Society (AFS) Standard to ascertain as to whether the sand can be conveniently used for the production of mould in casting process. Miya natural sand is silica sand with 79.44 percentage of $SO_2$. The physical and mechanical test revealed that the sands- grain fineness number 36.90, green compressive strength 100kN/$m^2$, refractoriness $1500^0$C, shatter index 90% and permeability 220 $cm^3$/min at 3% moisture content is suitable for malleable iron, light grey iron, light steel, brass, bronze, aluminium and its alloy. The cast components have a good surface finish and the result of the SEM showed a good micrographs.

## REFERENCES

[1]. Agbo, A.O., Ameh E.M., and Idenyi, N.E., (2018). Influence of bentonite on the foundry moulding properties of river Niger Onitsha beach sand. American Journal of Engineering research (AJER). (7): 104-111.

[2]. Agbo, A.O., Nwankwo, N.E., and Nnuka, E.E., (2017). Efficiency of Moisture Content on the Moulding Properties of River Niger Onitsha Beach Sand using Ukpor Clay as a Binder. International journal of multidisciplinary research and development, (4), 16 – 20.

[3]. Dansarai, M. M., Bawa, M. A., and Tokan, A. (2020). Nigerian Clay Deposits for use as Refractory Meterials in Metallurgical Industries. AReview. international journal of engineering research and technology (IJERT). (9), ISSN: 2278-01381.

[4]. Garba, E., Raji, A., Hamza, S., Usman, A.B., Donald, A.O., and Aliyu R., (2018). Effect of Moisture and Clay on the

Moulding Properties of Composite Sand of River Gongola Ashaka for foundry use. International journal of scientific & Research. (9), 2229-55518.

[5]. Ibrahim, A.O., (2018). Investigation of the Moulding Properties of Gurara River Bed Sand in Niger State using Kaolin and Bentonite as Binder. International journal of science & Engineering Research. (9), 2229-5518.

[6]. Mahmoud, L.U., Apech FI., Shuaibu, S.I., Isheni, Y., (2016). Application of Gwange Natural sand as foundry moulding material. American Scientific Research journal for Engineering Technology, and sciences (ASRJETS), 2313 – 4402.

[7]. Mbinda, A., Mbishida, S., and Samuel, A., (2017). Investigation into the suitability of Lere sriver bank sand for green sand casting. American Journal of engineering research (JOER). (6), 01 – 05.

[8]. Moses G., Tokan A., and Robinson E. (2020) Effect of moisture content on Nasaru foundry sand. International Journal of Recent Engineering Science (IJRS), (7), 2349-7159.

[9]. Mshelia, Z.A., Abolarin, M.S., Abubakere, O.K., and Ademoh, N.A., (2016). Characterisation of natural moulding sand from selected Deposits in Maiduguri Nigeria for casting Application. Arid zone Jornal of Engineering Technology and Environment, (12), 110-121.

[10]. Muhammad, I. A., Muhammad M. H., Tokanc A., Bawad M. A., and Sintalie S. I. (2021) The Potential Of Rumba And Kafi Sands As Moulding Materials, International Journal Of African Sustainable Developme Journal Of African Sustainable Development. 2(16) ISS: 0081-3998.

[11]. Ndaliman, M.B., (2019). Effect of some additives on the Refractory properties of Oniboda clay, Nigerian journal of technological Research. 1(1), 9-12.

[12]. Njoku, R.E., and Ocheri, C. (2020). Influence of particle size and clay content on some moulding properties of Ehalumona blended with Nkpologu clay for sand casting application. Research Article. 7(5), 40-47.

[13]. Shuaib-Babata, Y.L., abegunde, A.J., and Abdul, J.M., (2017). Suitability of Ado-Ekiti (Nigeria) Natural mouldrg. Sand for use as foundry sand in production of Aluminum Alloy Cast. Journal of production Engineering. (JPE), 20(2), 02-91.

[14]. Shuaib-Babata, Y.L., Ibrahim, H.K., Ajao, K.S., Ambali, I.O., and Bello, M.O., (2019). Evaluation of the foundry properties Oyun River (Ilorin) mouiding sand. Adeleke University journal of Engineering and Technology. (AUJET). (12) 2672- 5932.

[15]. Shuaib-Babata, Y. L., (2014). Analysis of IIorin Sand foundry Properties for Foundry Applications. International of engineering Research & Technology (IJERT), (3) 2278-0181.

**[16].** Tokan, A., and Mohammad S.U., (2007). Determination of moulding sand characteristics of Dindima river sand with Alkaleri clay as a binder. JORMAR 4(1&2), 1597-3204 – 88.