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Determination of molding characteristics of Dindima river sand with Alkaleri clay as a binder

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ABSTRACT

This work is aimed at determining the suitability of Dindima river sand with Alkaleri clay as a binder for foundry applications. Various standard test samples were produced from the mixtures containing 2 to 16% water with 10% and 12% clay addition respectively. The standard test specimens were used to determine molding properties: green/dry compression strengths, green/dry shear strengths, gas permeability, shatter index, flowability and compactibility. Other laboratory test carried out include determination of clay content of the sand, sieve analysis and bulk densities for each of the various mixtures. The mixtures that produce the optimum result for compatibility, flow ability and shatter index was used to produce cast machine component part such as grinding plate (ferrous alloy) and Peugeot automobile engine seat (non- ferrous alloy). The laboratory results showed that the optimum strength for both 10% and 12% clay additions is attained with the addition of 4% water. Other properties such as gas, permeability, shatter index flowability and compatibility attained their optimum values for both 10% and 1% clay with 6% water additions. In the process of our investigation, it was discovered that molding time has significant effect on the properties of the molding sand. Generally, Dindima river sand with Alkaleri clay was found to be suitable for foundry applications as the results of the required properties from both the laboratory tests and practical application are within the standard specifications for molding sand requirements.

INTRODUCTION

In sand casting, sand is mixed with clay and water (with small quantities of carbonaceous material) in appropriate proportion to prepare mold for the production of industrial, agricultural, automobile and municipal cast components.

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Molding sand is classified into natural bonded and synthetic molding sand. Synthetic sand exist in the form of silica or quartz sand (SiO_2); Zirconium ($ZrsiO_4$), Chromites ($FeOCr_2O_3$), Magnetite ($MgCO_3$), Chamotte ($ZrAl_2OSiO_2$), etc [10].

Silica sand has remained the single most important mold aggregate in all countries of the world. Silica, the most abundant mineral in nature, is a universally accepted foundry molding applications. It is a product of disintegration of rocks [1]. Pure silica has fusion point of 1715 °C but foundry silica sand which contains some impurities such as fe_2O_3, Al_2O_3, CaO, and other oxides has fusion temperature range of 1680 –1690 **oC**. Silica sand is acidic in nature and is therefore no attacked by acid slag. It is readily attacked by bases and oxides of iron at higher temperature. Hydro fluoric acid attacks silica in cold while phosphoric acid attacks in hot (400^{O}C) [4].

Foundry industries tend to utilize available local materials to save cost of transportation thereby reducing production cost [8]. There is need, therefore, to identify and characterize the local raw materials for foundry applications in Nigeria.

Clay, which are colloids of platelet shape that is formed by weathering and decomposition of rocks are used in foundry for sand molding. These clays are:

- Bentonite or montmorillonite ($MgO.Al_2O_3.SiO_2.nH_2O$;
- Kaolinite ($Al_2O_3.2SiO_2.2H_2O$) and
- Illite ($K_2O.Al_2O_3.2SiO_2.H_2O$) (Joseph Datsco, 1966).

The mixing of molding sand could be either manually or mixed with sand mixing machine.

Manual mixing consists of mixing the required quantity of sand and clay in dry state with hand trowel or spade/shovel. When these are properly mixed, proportional quantity of water is added and then mixed properly. In most cases, the mixed sand is covered with water-proof sheet for a period of 16-24 hours before use as practiced in DOZIK Foundry Limited and CASTMASTER Foundry Limited both in Kano, Nigeria. This facilitates the clay-water absorption, which enhances the grain binding potential for greater strength.

In the mechanized sand mulling of molding, a weighed quantity of sand is charged into the machine while the machine is running. Then other additives, such as clay and sometimes anti-burn-on are weighed accordingly and charged onto the sand in the machine. Water is added by means of a time-water sprinkler that is incorporated into the machine. Test samples are taken for analysis periodically while the mixing lasts as practiced in Bamfords International Limited, Jos. This practice is essential to confirm the conformity of the molding sand with the standard specification.

A good molding sand should retain its shape after molding and the pattern withdrawn from the mold (green strength) and should be able to withstand the casting temperature of the required alloy (hot strength).

When the property is ascertained, the mixed sand is then discharged and delivered to the molding floor.

Some of the foundries in Nigeria produce parts for local consumption. In most cases, the qualities of the products are impaired with certain defects arising from the use of poor molding materials. This is so because the source of good molding sand had not being properly characterized by their various properties.

Sand casting, being one the most economical methods of parts production is practiced in most of Nigerian foundry industries. Quality sand, therefore, needs to be identified and properly characterized for use in the foundry industries to enhance quality production of component parts at reasonable cost.

This work is therefore aimed at:

- Determining the molding properties of Dindima river sand;

- Characterizing the sand based on the results of determined molding properties;

- Determining the suitability of Alkaleri clay for use as a binder in foundry industries;

- Identifying a location of good sand for foundry applications;

- Creating awareness in the society that good molding sand can be sourced locally at reasonable cost.

MATERIALS AND METHODS

Materials

The silica sand used for this work is sourced from Dindima River while the clay was from Alkaleri clay deposit and both are located in Bauchi State of Nigeria.

Methods

Several test samples were prepared with varying percentages of water for 10% and 12% clay addition respectively as shown in tables 1-2 below:

Table I: **Sample (%) of 10% clay addition**

	SAMPLES							
Mold Mixtures	A	B	C	D	E	F	G	H
Clay	10	10	10	10	10	10	10	10
water	2	4	6	8	10	12	14	16
Sand	88	86	84	82	80	78	76	74

Table II: **Sample (%)of 12% clay addition**

	SAMPLES							
Mold Mixtures	A	B	C	D	E	F	G	H
Clay	12	12	12	12	12	12	12	12
water	2	4	6	8	10	12	14	16
Sand	86	84	82	80	78	76	74	72

TEST SAMPLE PREPARATION

Each sample of the mold mixtures A – H were measured in accordance with the varying proportion and was charged and mixed into the laboratory mixer and then mixed for (5) minutes.

The mixed sand was used to prepare the test sample specimens in accordance with the standard specification for the preparation of molding sand test samples using Rids Dale standard sand rammer, conforming to imperial (2" diameter x 2" height) or DIN (5cm diam x 5cm height).

The test sample specimen is required to test for the green compression strength, green shear strength, Dry compression strength, Dry shear strength. Gas permeability, flow ability, shatter index x etc. of the sand (Rids Dale Dietert, No622) Author to provide date

The standard values for the various parameter are as shown in tables III and IV [11,12]

TABLES OF STANDARDS

Federal Government Steel Companies (1994)

Physical Properties	Standard Range of Value
G.C.S.	8.5 – 9.5N/cm2
Shear Strength	1.5 – 1.7N/cm2
Dry Compression Strength	19.0 – 21.0N/cm2
Compactibility	45%
Permeability	150 – 180

Foseco Foundryman's Handbook (1994)

Physical Properties	Standard Range of Value
Water	3 – 4%
Green strength	70 – 100 kpa (10-15Psi)
Compactibility	45 – 52%
Permeability	80 – 110
Live Clay	5 – 5.5%

MECHANICAL ANALYSIS

The green/dry compression strengths, and green/dry shear strengths of the samples were determined using the standard strength-testing machine as described in Ridsdale Dietart, No. 622.

SIEVE ANALYSIS

The sieve analysis was determined according to the methods of [3] using the sieve analyzer. Dried sand sample weighing 100g was poured onto the top of the sieve stack and set to vibrate for a standard specified period of 15 minutes. The quality of sand remaining on each sieve after the 15 minutes of vibration was weighed and recorded against the corresponding sieve mesh number. The weight remaining on each sieve was multiplied by the proceeding sieve mesh number. The sum total of the product was divided by the total weight of the sample and the result is the grain fineness number [3].

The determination of the clay content, permeability, flow ability, compatibility, and bulk density as well as the mechanical analysis and the sieve analysis were performed according to the methods of Burn in the foundry laboratory of the National Metallurgical Development Centre, Jos, Plateau State.

CLAY ANALYSIS

The clay content of the sand was determined according to the method of [7] 1%Noah solution was added to 50g of dried sand sample in a beaker containing 250ml of distilled water. The content was stirred using the mechanical stirrer then allowed to rest for about 10 minutes. The suspended clay particles in the solution were decanted by means of siphon. Additional was introduced followed by stirring and decantation. This procedure was repeated until clear water; free from suspended clay particles was observed. The water was drained completely and dried in an oven at about 110^{0}c. The percentage clay was calculated.

RESULTS

The result of the grain size distribution of Dindima river sand is shown in Table III while figs. 1-4 shows the result of the 10% and 12% of the clay mould mixture analysis.

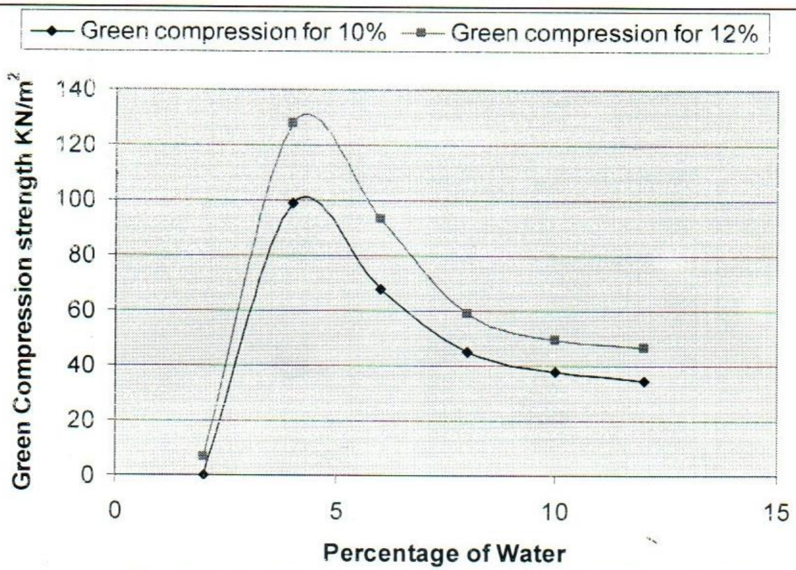

Fig. 1 Green Compression Strength for 10% and 12% clay addition

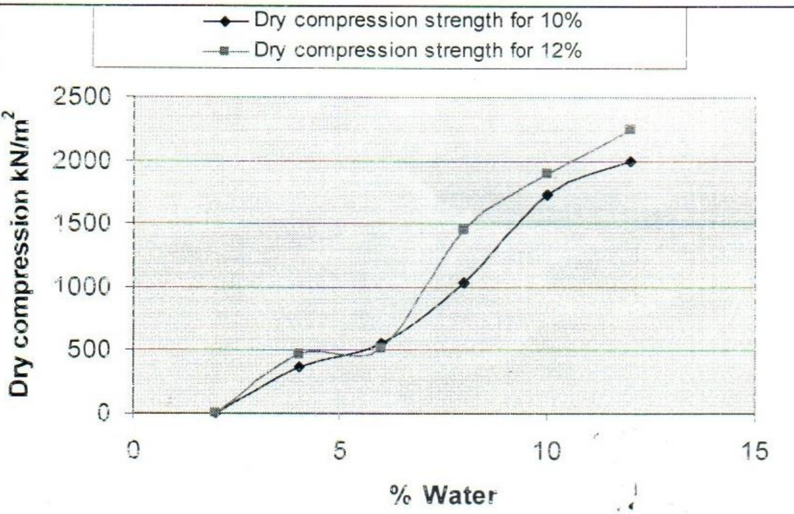

Fig.2: Dry compression strength for 10% and 12% clay addition

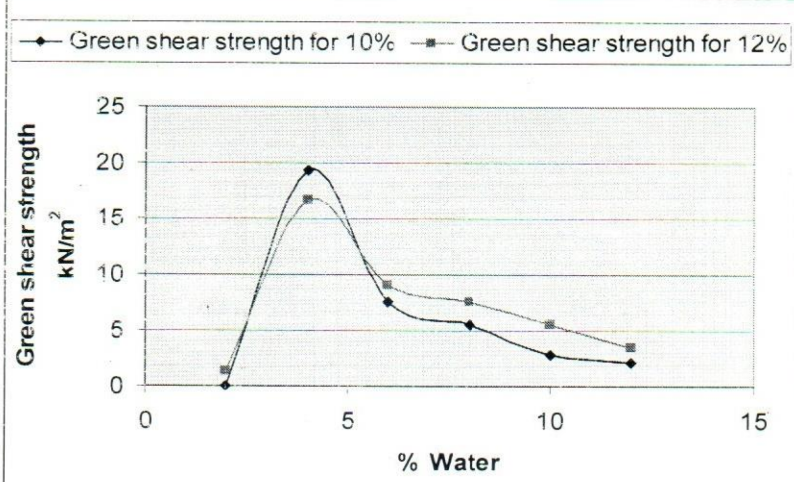

Fig.3: Green shear strength for 10% and 12% clay addition

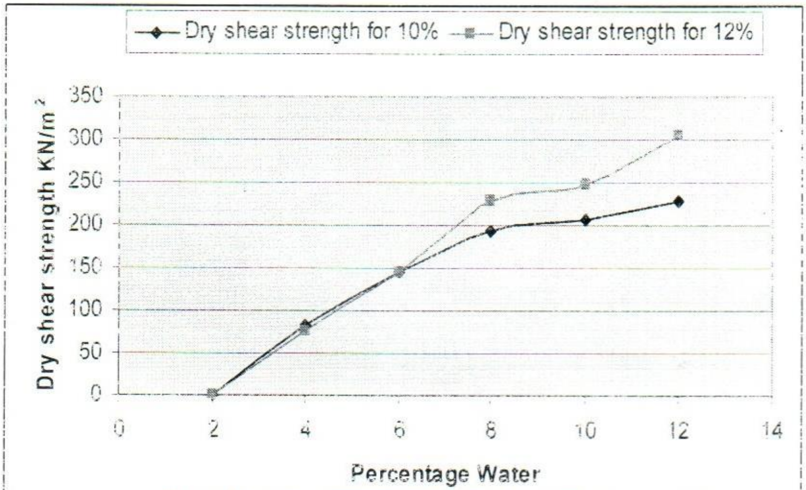

Fig. 4 Dry shear strength for 10% and 12% clay addition

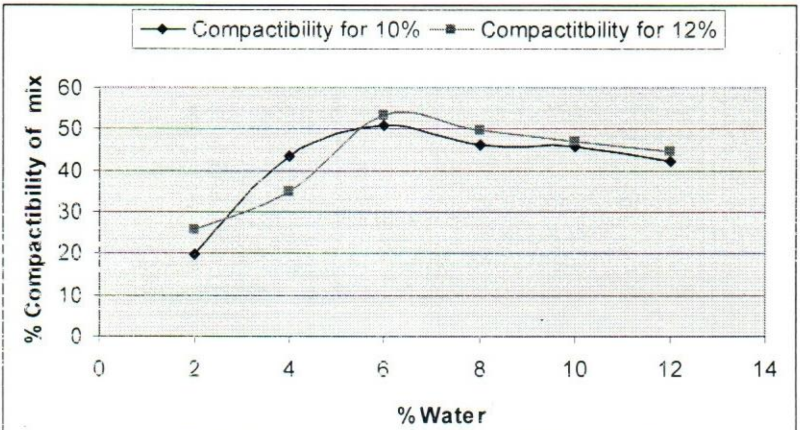

Fig.5: Compactibility for 10% and 12% clay addition

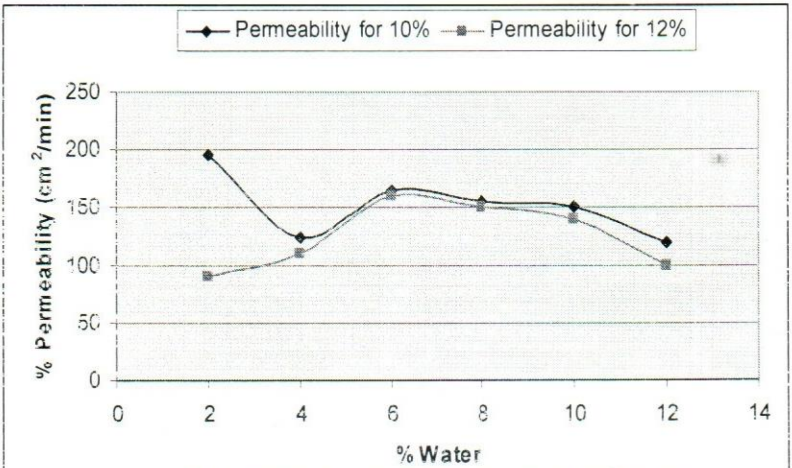

Fig 6: Permeability for 10% and 12% clay addition

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