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Strength Behavior of Concrete Produced with Foundry Sand as Fine Aggregate Replacement

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***Abstract*— This study investigated the strength behavior of concrete produced with foundry sand. The objective was to find a viable use for this waste in order to both minimize cost as well as achieve sustainable construction. Fine aggregate was replaced with foundry sand in varying percentages of 0,20,40,80 and 100% in grade 20 concrete. Concrete cubes (100 x 100 x 100 mm) and cylinders (150 x300 mm) were cast and cured. Compressive strength tests were conducted on concrete cubes at curing ages of 7, 14, 21, and 28 days while split tensile tests were carried out on cured specimens at 28 days. The result showed an increase in both compressive and split-tensile strength in replacement specimens, furthermore, the strength increased as the percentage replacement increased. It could be concluded that foundry sand can be safely used to replace fine aggregates in concrete without strength impairment.**

***Keywords*-- Foundry Sand Concrete Aggregate, Compressive Strength**

I. INTRODUCTION

A foundry is a manufacturing facility that produces metal castings by pouring molten metal into a preformed mold to yield the resulting hardened cast. The primary metals cast include iron and steel from the ferrous family and aluminum, copper, brass and bronze from the nonferrous family (U.S. Environmental protection agency, 2004) [1].

Foundry sand is high quality silica sand that is a byproduct from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates [1].

Foundries purchase high quality size-specific silica sands for use in their molding and casting operations. The raw sand is normally of a higher quality than the typical bank run or natural sands used in fill construction sites.

These sands normally rely upon a small amount of bentonite clay to act as the binder material.

Foundry sand is produced by five different foundry classes [1. The ferrous foundries (gray iron, ductile iron and steel) produce the most sand. Aluminum, copper, brass and bronze produce the rest. The 3,000 foundries in the United States generate 6 million to 10 million tons of foundry sand per year.

While the sand is typically used multiple times within the foundry before it becomes a byproduct, only 10 percent of the foundry sand was reused elsewhere outside of the foundry industry in 2001. The sands from the brass, bronze and copper foundries are generally not reused. While exact numbers are not available, the best estimate is that approximately 10 million tons of foundry sand can beneficially be used annually.

The grain size distribution of spent foundry sand is very uniform, with approximately 85 to 95 percent of the material between 0.6 mm and 0.15 mm (No. 30 and No. 100) sieve sizes. Five to 12 percent of foundry sand can be expected to be smaller than 0.075 mm (No. 200 sieve). The particle shape is typically sub angular to round. Waste foundry sand gradations have been found to be too fine to satisfy some specifications for fine aggregate.

Spent foundry sand has low absorption and is non-plastic. Reported values of absorption were found to vary widely, which can also be attributed to the presence of binders and additives. The content of organic impurities (particularly from sea coal binder systems) can vary widely and can be quite high. This may preclude its use in applications where organic impurities could be important (e.g., Portland cement concrete aggregate). The specific gravity of foundry sand has been found to vary from 2.39 to 2.55. This variability has been attributed to the variability in fines and additive contents in different samples.

Typically, there is some variation in the foundry sand chemical composition from foundry to foundry. Sands produced by a single foundry, however, will not likely show significant variation over time. Moreover, blended sands produced by consortia of foundries often produce consistent sands. The chemical composition of the foundry sand can impact its performance. Spent foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Silica sand is hydrophilic and consequently attracts water to its surface. This property could lead to moisture-accelerated damage and associated stripping problems in an asphalt pavement. Antis tripping additives may be required to counteract such problems.

Depending on the binder and type of metal cast, the pH of spent foundry sand can vary from approximately 4 to 8.

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It has been reported that some spent foundry sands can be corrosive to metals. Because of the presence of phenols in foundry sand, there is some concern that precipitation percolating through stockpiles could mobilize leach able fractions, resulting in phenol discharges into surface or ground water supplies. Foundry sand sources and stockpiles must be monitored to assess the need to establish controls for potential phenol discharges.

Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed "foundry sand." Foundry sand production is nearly 6 to 10 million tons annually. Reddi et al. [2] reported that compressive strength of stabilized foundry sands decreases as the replacement proportion of foundry sand increases in the mixes and the strength is achieved relatively faster with fly ash than with cement. Cement and fly ash mixtures were prepared using 0%, 25%, 50%, with class F fly ash were unsuccessful because it lacked cementitious properties to form a stable mix therefore subsequent experiments were restricted to class C fly ash only. The ratio of water to the cementitious binder was chosen to be 1.0 in the case of Portland cement and 0.35 in the case of fly ash.

Naik et al.[3] performed an investigation to develop technology for manufacturing cast-concrete products using Class F fly ash, coal-combustion bottom ash, and used foundry sand. A total of 18 mixture proportions with and without the by-products were developed for manufacture of bricks, blocks, and paving stones. Tests for compressive strength were performed according to ASTM C140 for which 3-6 specimens were tested for each brick or paving stone mixture at 5, 28, 56, 91 & 288 days. Three compression specimens were tested for each block mixture at 7, 14, 28, & 91 days.

The bricks with partial replacement of cement with fly ash (FA) show slightly higher strength than the control while considerable reduction in strength was observed when a part of sand was substituted with bottom ash (BA). Substitution of part of the sand with use foundry sand (UFS) in brick mixtures caused a small reduction in strength.

Omowumi [4] in his investigation concluded that the properties of refractory clay samples from Onibode, Ara-Ekiti, Ibamajo and Ijoko compare favourably with imported fire clay refractories. Hassan and Adewara [5] found that Onibode refractory clays are suitable for the production of refractory bricks for furnace building. Matthew [6] investigated the properties and processing of synthetic foundry mixtures prepared from Kankara clay. He found that Kankara clay was suitable for use in preparation of synthetic foundry sand.

Akinbode [7] carried out an investigation on the properties of termite hills as refractory material for furnace lining. In his report, Matthew observed that the refractory property of termite hill possesses a close relationship between porosity, density, dimensional change and permeability of the known refractory materials for furnace lining. Aniyi and Adewara [8] investigated the refractory properties of clay from Kankara and found that the clay was suitable for the production of 239 refractory bricks possessing good shrinkage.

II. Materials And Methods

All the materials used for this project work was sourced and purchased from Ibadan, Nigeria except foundry sand that was sourced from Ife iron and steel Nigeria Limited, plot 39 Ogunwusi village, along Ife-Ibadan expressway, Fashina, Ile-Ife, Nigeria. These materials includes; sharp sand, Ordinary Portland cement**,** foundry sand, water**,** granite

A. Methods

The methods adopted in the study included the following, preparation of specimens, testing of specimens

(1). Preparation of Specimen: The concrete grade adopted in the study was grade 20. The replacement of sharp sand with foundry sand was done at 0% (control), 20%, 40%, 60%, 80% and 100%.

The concrete was produced and poured into appropriate moulds (Cubes and Cylinders) which were oiled for easy removal and thoroughly tamped to avoid honey-combs and left to dry.

The concrete was removed from the molds after 24 hours and placed in a water filled tank for curing for 7, 14, 21 and 28 days respectively.

(2).Testing of Specimens: The cube specimens were subjected to compressive strength tests at 7, 14, 21, and 28 days while the cylinders were subjected to split-tensile tests at 28days.

III. Results And Discussion

A. Compressive Strength test result and analysis

Table I:
Shows Compressive Strength Of Varied Percentages Of Foundry Sand Concrete With Varied Curing Days

Foundry sand content (%)	TAG	Compressive Strength (N/mm^2)			
		7 Days	14 Days	21 Days	28 Days
0	A	15.56	21.00	22.15	25.65
20	B	17.64	22.55	23.85	26.75
40	C	17.88	22.59	24.75	28.05
60	D	18.20	23.50	24.95	28.55
80	E	18.75	22.45	25.00	28.50
100	F	19.70	22.30	23.75	28.70

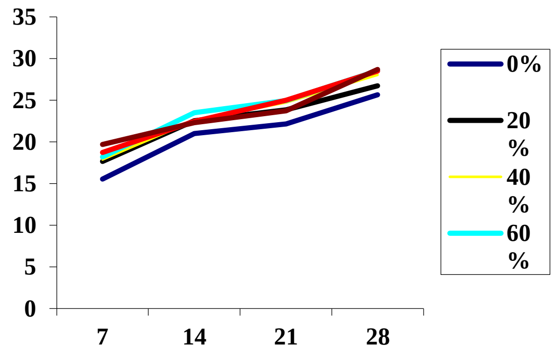

Fig.1. Compressive Strength of varied percentages of foundry sand concrete with varied curing day

Table I. Shows the relationship of compressive strength with varied percentages of foundry sand replacements up to 28days curing age.

It is evident from figure1 that compressive strength of concrete mixtures with 20%, 40%, 60 %, 80%, 100% of foundry sand as sand replacement was higher than the control mixture (A).

It could also be observed that the compressive strength of the concrete mixtures increase as the curing ages increase.

It also shows that the compressive strength at 28 days for various foundry sand replacements increases with increase in percentages of sand replacement with foundry sand.

It is deduced that compressive strength increases by 4.3%, 9.4%, 11.3%, 11.1%, and 11.89% for 20%, 40%, 60%, 80%, and 100% sand replacement with foundry sand respectively when compared with ordinary concrete mix with pure sand as fine aggregate.

It was also observed in table I that, at 14days and 28days, compressive strength at 80% sand replacement with foundry sand is lower than 60% sand replacement with foundry sand. The shows that compressive strength increases with the increase in foundry sand percentage replacement.

B. Split-Tensile Strength Test Result and Analysis

Table II
Split-Tensile Strength Of Varied Percentages Of Foundry Sand Concrete At 28 Days.

Foundry sand content (%)	Tag	Age (days)	Split tensile strength (N/mm2)
0	J1	28	2.35
20	J2	28	2.63
40	J3	28	2.76
60	J4	28	2.82
80	J5	28	2.84
100	J6	28	2.95

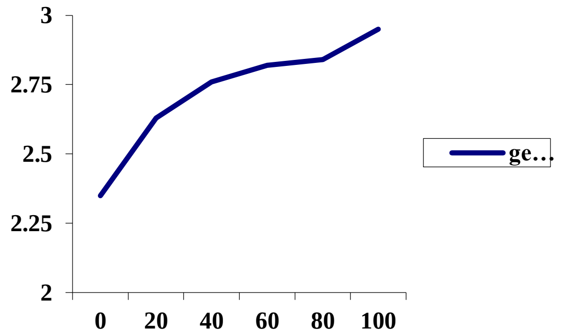

Fig. 2. Split-Tensile Strength of varied percentages of foundry sand concrete at 28days.

From table II and figure 2, it is obvious that the split tensile strength increases as the percentages of sand replaced with foundry sand increases, and the split tensile strength increase by 11.91%, 17.44%, 20%, 20.85%, and 25.53% for 20%, 40%, 60%, 80%, and 100% sand replacement with foundry sand respectively when compared to ordinary concrete mix with pure sand as fine aggregate

IV. CONCLUSIONS

The following conclusions can be deduced from the research work:

Figure 1 shows the relationship between compressive strengths of 20%, 40%, 60%, 80%, and 100% replacements of fine aggregate(sharp sand) with foundry sand and curing ages which have same behaviour compared to compressive strength of control mix(0%) and its curing ages, therefore foundry sand in also good as fine aggregate in concrete.

The compressive strengths at varied curing ages (7, 14, 21, and 28 days) for every percentage replacement of sand with foundry sand is higher than compressive strength of control mix at corresponding curing age, and this shows that foundry sand produce concrete of higher grade compare to sharp sand.

The compressive strengths of 21day foundry sand concrete of 80% replacement is almost equivalent to 28 days compressive strength of ordinary concrete, therefore construction can continue on foundry sand concrete of 80% replacement after 21 days instead of the normal 28days in ordinary mix with sharp sand.

The compressive strengths at 28 days for foundry sand concrete. increases by 4.3%, 9.4%, 11.3%, 11.1%, and 11.89% for 20%, 40%, 60%, 80%, and 100% sand replacement with foundry sand respectively when compared with the control mix, this shows a high variation of increase as the percentage replacement increases, buttressing the point that foundry sand can produce a concrete of higher grade compare to sharp sand.

From table 2, it is evident that the split tensile strength of foundry sand concrete increases as the percentage replacements increases, therefore foundry sand concrete produces a higher tensile strength at all levels of replacement compare to the control mix.

The split tensile strength increases by 11.91%, 17.44%, 20%, 20.85%, and 25.53%, for 20%, 40%, 60%, 80%, and 100% respectively when compared to the slit tensile strength of control mix.

REFERENCES

[1] United State department of transportation, Federal highway administration 2004.Foundry sand facts for civil engineer, FHWA-IF-04-004.

[2] Reddi, N. Lakshmi, Rieck, P. George, Schwab, A. P., Chou, S. T. and Fan, L.T., May 1995. Stabilization of Phenolics in foundry sand using cementious materials. Journals of Hazardous Materials,V. 45, pp 89-106

[3] Naik, T.R.; Kraus, N. Rudolph; Chun, Yoon-moon; Ramme, W. Bruce; and Singh S. Shiw, August 2003.Properties of Field Manufactured Cast-Concrete Products Utilizing Recycled Materials. Journals of Materials in Civil Engg., V.15,No. 4,pp 400-407.

[4] Omowumi, O.J. 2001.Characterization of some Nigerian clays as refractory materials for furnace lining. Nigerian J. Eng. Management. 2(3): 9-13.

[5] Hassan, S.B; and Adewara, J.O.T. 1993. Refractory properties of some Nigerian clays. Nigerian Soc. Eng. Trans. 28(3): 21-5.

[6] Matthew, P. 1977. Investigation of the properties and processing of synthetic foundry sand mixture prepared from local material. B. Sc Project, Ahmadu Bello University, Zaria, Kaduna, Nigeria.

[7] Akinbode, F.O. 1996. An investigation on the properties of termite hill as refractory material for furnace lining. Indian Foundry J. 42(9): 10-30.

[8] Aniyi, J.A.; and Adewara, J.O.T. 1986. Refractory properties of Kankara clay. Proc. Ann. Conf. Nigeria Metal. Soc.

[9] BS 1881- 120 (1983).Method for determination of compressive strength of concrete cores