Production of Standard Sandcrete Blocks Using Itakpe Iron-Ore Tailings

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Abstract:* - The fundamental aim of this project was aimed to verify the processes of block moulding using iron ore tailings, sand, cement and water to compare the compressive strength between the use of iron ore tailings in moulding of blocks and ordinary sharp sand in moulding of sand crate blocks. The iron ore tailing that was test run for this research are of various types and sizes this includes: soft rocks tailings, hard rocks tailngs, fine tailings and course tailings. And size ranges between 1.6mm, 1.0mm, 0.63mm, 0.315mm, 0.8mm and 0.16mm.0.8mm size of iron ore tailing was found suitable for this research.150mm x 225mm x 450mm hollow blocks were produced at the concrete laboratory and the quality of the various components were obtained from the mix and weighed using weighing balance. slump test and compressive strength test was conducted to measure the workability and to meet up with standard procedure for concrete production .The samples blocks were crushed each at 7,14,21, and 28 days after casting and cured . The test results showed that the lower the replacement of the fine aggregates the greater the compressive strength; there was increase in the percentage replacement of using conventional fine aggregates with iron ore tailings; 25-30% replacement of iron ore tailings is more appropriate, quality and economical in the production of sand crate blocks. The research recommends that itakpe iron ore (IOT) is a suitable materials for most engineering constructions works and materials like heavy weight concrete, high density blocks and stabilization of lateritic soil; more research should be conducted on using iron ore tailings to improve engineering properties of very expensive soils such as black cotton.

***Keywords:* Iron ore tailing, Moulding, Sand crete block, Compressive strength, Curing**

I. INTRODUCTION

Sand crete blocks are blocks made from a mixture of sand, cement and water. They are commonly used in Nigeria and virtually in all African countries. For a long time until perhaps a few years ago these blocks were manufactured in many parts of Nigeria without any reference to specifications either to suit local building requirements or for good quality work. It is bolstering to observe that the situation in Nigeria has changed as the standard organization of Nigeria now have document in place providing the specifications both for the manufacture and use of these blocks in Nigeria. After compaction normal concrete is likely to contain about 1% of air voids. This unwanted entrapped air being evenly distributed and consisting of bubbles of irregular shape and size. Sand crate blocks constitute a unique class amongst man –made construction component for building walls are constructed (using blocks), as either load bearing or non-load bearing to provide shelter, protection, convenient space and privacy to ensure security for man and his properties .This means that the important of these blocks cannot be over emphasized due to their importance in the construction industry. The strength of sand crate blocks is affected by the mix proportion, quality of material used in making them ,size ,shape and the mode of manufacture (i.e hand or machine mould), physical conditions such as method and days of curing ,duration of time ,temperature etc will also contribute to the strength of the units for which is used in a structure .for example wall built with poor quality blocks that falls short of standard strength are likely to fail or collapse causing severe damage to the structure and sometimes even loss of lives and properties.

Metal occurring in their natural state as ore are found in rock mass, to extract such metals; the rocks are mined, crushed and processed .The amount of metallic minerals extracted are relatively small if not insignificant when compared to the volume of rock mass from which it is derived, hence leaving large amount of crushed rock or soil known as tailings. Iron ore tailings (IOT) is the soil like substance formed from the crushing and extraction of iron from the ore. Large amount of toxic contaminants are being released to the environment around the globe from rapid urbanization .Among such containments are industrial wastes and iron ore tailings that result from world widemining operations during the processing of low grade ores, significant quantities of waste or tailings are produced (Mohanty et al 2010).The over burden material(also known as waste) generated during surface mining of minerals which cause serious environmental hazards to surrounding flora and fauna not properly protected .It has been roughly estimated that for every ton of metal extracted from ores, roughly 2-12 tons of over burden material s are being removed. Tailings are materials left over of separate valuable fraction from worthless of an ore (Shetty et al 2010) and the process of mineral extraction used in processing the ore. The stages involved in iron ore tailings processing are crushing ,grinding ,leaching ,heating ,dewatering , tailings and slurry disposal (Araujo et al,2003

).Tailings are categorized into general character : soft rocks tailings coal refuse , potash , contain sand and slime fraction. Slimes dominate overall properties because of clay present Hard rock tailings (lead/zinc, copper/nickel, gold/platinum, Iron ore contain both sand slimes of low plasticity. Sand control overall properties of engineering purpose) fine tailings (bauxite red muds, slimes form tar sands tailings, slimes from kimberlite, slimes from mineral sands, sand fraction small/absent sedimentation and consolidation characteristics dominated by silt /clay size particles. May pose disposal volume prodder), coarse trailing (tar sand tailings, uranium. Contain principally sand with favorable engineering characteristics).Tailing are used in many ways for example ,in moulding blocks , for road construction ,for making sand paper for glass making and blasting .

Aim: To examine the suitability of Itakpe iron ore tailings as partial substitute for sand in moulding block in construction industry

Objectives of the Research

- Characterizing the properties of sand crate blocks in fresh and hardened state using iron ore tailings as compared with the properties of using conventional sand
- Ascertain the test plan on sand crete blocks which includes: workability, drying shrinkage, water retentiveness, strength, and stress – strain characteristics.

II. METHODOLODY

The iron ore tailing sample used for this research was obtained from the National iron ore mining company, Itakpe kogi state Nigeria. The iron ore sample was collected from the heaps on the ground surface and equipment used for the collection of the sample was shovel .the sample was wrapped and packed in polythene bag to avoid moisture loss because it was collected during wet season. The materials used for the production of the blocks were sharp sand, iron ore tailings; cement and water.150mm x 225mm x450mm hollow blocks were produced at the concrete laboratory of the department civil engineering Kogi state polytechnic. The mix ratio of 1:10 was used at different levels of sharp sand and iron ore tailings .for each replacement level 15 blocks samples were moulded. Sixty (60) sand crete blocks were produced. The quantity of the various components obtained from the mix were measured in each case with the aid of weighing balance .The tailings ,sand , water and cement was mixed thoroughly to obtain homogenous mixture .The mixture was turned with shovels until a mix of required workability was obtained . Slump test was conducted to determine the workability of the mix. Compressive strength test was also conducted with sample blocks and were crushed each at 7, 14, 21 and 28days after casting at different replacement levels using compressive testing machine in the concrete laboratory.

III. RESULT ANALYSIS AND DISCUSSION

Test results for25% ,50%,75% and 100% replacement of iron tailings with block sample A, B, and C were obtained for 7, 14, 21 and 28days using crushing machine as shown in Table 1.0

Area of block = Area of rectangular hollow block – Area of the hollow. Where area of the rectangular hollow blocks = 450mm x 150mm = 67500mm^2

Area of the hollow = 180mm x 100mm = 36000mm^{2}Area of the block = 67500-3600 = 31500mm^2

Results of 25% replacement of iron tailings

Result for 7days

Sample block A

Weight of block = 17.2kg

Load at failure = 110 KN (110 x 1000) = 110000N

Compressive strength of Block A $\frac{110000}{31500}$ = 3.5 N/mm^2

Sample block B

Weight of block = 17.4kg

Load at failure = 120 KN (120 x 1000) = 120000N

Compressive strength of Block B $\frac{120000}{31500}$ = 3.5 N/mm^2

Sample block C

Weight of block = 17kg

Load at failure = 120 KN (120 x 1000) = 120000N

Compressive strength of Block C $\frac{120000}{31500}$ = 3.2 N/mm^2

Average of the weight of the blocks $= \frac{17.2+17.4+17.0}{3}$ = 17.2kg

Average of compressive strength

$\frac{3.5+3.8+3.2}{3}$ = 3.5N/mm^2

Results @ 14days

Sample block A

Weight of block = 17.6kg

Load at failure = 180 KN (180 x 1000) = 180000N

Compressive strength of Block A $\frac{180000}{31500}$ = 5.71 N/mm^2

Sample block B

Weight of block = 17.0kg

Load at failure = 160 KN (160 x 1000) = 160000N

Compressive strength of Block B $\frac{160000}{31500}$ = 5.08 N/mm^2

Sample block C

Weight of block = 17.6kg

Load at failure = 180 KN (180 x 1000) = 180000N

Compressive strength of Block C $\frac{180000}{31500}$ = 5.71 N/mm^2

Average of the weight of the blocks $= \frac{17.6+17.0+17.4}{3}$ = 17.2kg

Average of compressive strength

$\frac{5.71+5.08+5.71}{3}$ = 5.5N/mm^2

Results @ 21days

Sample block A

Weight of block = 16.9kg

Load at failure = 240 KN (240 x 1000) = 240000N

Compressive strength of Block A $\frac{240000}{31500}$ = 7.61 N/mm^2

Sample block B

Weight of block = 17.2kg

Load at failure = 250 KN (250 x 1000) = 250000N

Compressive strength of Block B $\frac{250000}{31500}$ = 7.90 N/mm^2

Sample block C

Weight of block = 17.0kg

Load at failure = 230 KN (230 x 1000) = 230000N

Compressive strength of Block C $\frac{230000}{31500}$ = 7.30N/mm^2

Average of the weight of the blocks $= \frac{16.9+17.2+17.0}{3}$ = 17kg

Average of compressive strength

$\frac{7.62+7.90+7.30}{3}$= 7.60N/mm^2

Results @ 28days

Sample block A

Weight of block = 17.0kg

Load at failure = 240 KN (240 x 1000) = 240000N

Compressive strength of Block A $\frac{240000}{31500}$ = 7.62 N/mm^2

Sample block B

Weight of block = 17.0kg

Load at failure = 200 KN (200 x 1000) = 200000N

Compressive strength of Block B $\frac{200000}{31500}$ = 6.35 N/mm^2

Sample block C

Weight of block = 17.0kg

Load at failure = 240 KN (240 x 1000) = 2340000N

Compressive strength of Block C $\frac{240000}{31500}$ = 7.62N/mm^2

Average of the weight of the blocks $= \frac{17.0+17.2+17.0}{3}$ = 17.1kg

Average of compressive strength

$\frac{7.62+6.35+7.62}{3}$= 7.20N/mm^2

Results of 50 % replacement of iron ore tailings

Results @ 7days

Sample block A

Weight of block = 17.4kg

Load at failure = 80 KN (80 x 1000) = 80000N

Compressive strength of Block A $\frac{80000}{31500}$ = 2.54 N/mm^2

Sample block B

Weight of block = 17.4kg

Load at failure = 70 KN (70 x 1000) = 70000N

Compressive strength of Block B $\frac{30000}{31500}$ = 2.22 N/mm^2

Sample block C

Weight of block = 17.8kg

Load at failure = 40 KN (40 x 1000) = 40000N

Compressive strength of Block C $\frac{40000}{31500}$ = 1.27N/mm^2

Average of the weight of the blocks $= \frac{17.4+17.4+17.8}{3}$ = 17.5kg

Average of compressive strength

$\frac{2.54+2.22+1.27}{3}$ = 2.00N/mm^2

Results @ 14days

Sample block A

Weight of block = 18.0kg

Load at failure = 120 KN (120 x 1000) = 120000N

Compressive strength of Block A $\frac{120000}{31500}$ = 3.81 N/mm^2

Sample block B

Weight of block = 17.8kg

Load at failure = 190 KN (190 x 1000) = 190000N

Compressive strength of Block B $\frac{190000}{31500}$ = 6.03 N/mm^2

Sample block C

Weight of block = 17.8kg

Load at failure = 200 KN (200 x 1000) = 200000N

Compressive strength of Block C $\frac{200000}{31500}$ = 6.35N/mm^2

Average of the weight of the blocks $= \frac{18+17.8+17.8}{3}$ = 17.9kg

Average of compressive strength

$\frac{3.80+6.03+6.35}{3}$ = 5.40N/mm^2

Results @ 21days

Sample block A

Weight of block = 17.4kg

Load at failure = 190 KN (190 x 1000) = 190000N

Compressive strength of Block A $\frac{190000}{31500}$ = 6.03 N/mm^2

Sample block B

Weight of block = 17.4kg

Load at failure = 160 KN (160 x 1000) = 160000N

Compressive strength of Block B $\frac{160000}{31500}$ = 5.08 N/mm^2

Sample block C

Weight of block = 18.0kg

Load at failure = 160 KN (160 x 1000) = 160000N

Compressive strength of Block C $\frac{160000}{31500}$ = 5.08N/mm^2

Average of the weight of the blocks $= \frac{17+17.4+18.0}{3}$ = 17.6kg

Average of compressive strength

$\frac{6.30+5.08+5.08}{3}$ = 5.40N/mm^2

Result @ 28days

Sample block A

Weight of block = 17.4kg

Load at failure = 200 KN (200 x 1000) = 200000N

Compressive strength of Block A $\frac{200000}{31500}$ = 6.35 N/mm^2

Sample block B

Weight of block = 17.6kg

Load at failure = 140 KN (140 x 1000) = 140000N

Compressive strength of Block B $\frac{140000}{31500}$ = 4.44 N/mm^2

Sample block C

Weight of block = 18.6kg

Load at failure = 140 KN (140 x 1000) = 140000N

Compressive strength of Block C $\frac{140000}{31500}$ = 4.44N/mm^2

Average of the weight of the blocks $= \frac{17.4+17.6+17.6}{3}$ = 17.5kg

Average of compressive strength

$\frac{6.35+4.44+4.44}{3}$ = 5.10N/mm^2

Result of 75% replacement of iron tailings

Result @ 7days

Sample block A

Weight of block = 18kg

Load at failure = 80 KN (80 x 1000) = 80000N

Compressive strength of Block A $\frac{80000}{31500}$ = 2.54N/mm^2

Sample block B

Weight of block = 18.2kg

Load at failure = 100 KN (100 x 1000) = 100000N

Compressive strength of Block B $\frac{100000}{31500}$ = 3.19 N/mm^2

Sample block C

Weight of block = 18kg

Load at failure = 110 KN (110 x 1000) = 110000N

Compressive strength of Block C $\frac{110000}{31500}$ = 3.26N/mm^2

Average of the weight of the blocks $= \frac{18.0+18.2+18.0}{3}$ = 18kg

Average of compressive strength

$\frac{2.54+3.17+3.26}{3}$ = 3.00N/mm^2

Result @ 14days

Sample block A

Weight of block = 18.4kg

Load at failure = 130 KN (130 x 1000) = 130000N

Compressive strength of Block A $\frac{130000}{31500}$ = 4.13N/mm^2

Sample block B

Weight of block = 18.4kg

Load at failure = 250 KN (250 x 1000) = 250000N

Compressive strength of Block B $\frac{250000}{31500}$ = 7.94 N/mm^2

Sample block C

Weight of block = 18.4kg

Load at failure = 220 KN (220 x 1000) = 220000N

Compressive strength of Block C $\frac{220000}{31500}$ = 6.98N/mm^2

Average of the weight of the blocks $= \frac{18.4+18.4+18.4}{3}$ = 18.4kg

Average of compressive strength

$\frac{4.13+7.94+6.98}{3}$ = 6.4N/mm^2

Result @ 21days

Sample block A

Weight of block = 18.8kg

Load at failure = 300 KN (300 x 1000) = 300000N

Compressive strength of Block A $\frac{300000}{31500}$ = 9.52N/mm^2

Sample block B

Weight of block = 18.8kg

Load at failure = 200 KN (200 x 1000) = 200000N

Compressive strength of Block B $\frac{200000}{31500}$ = 6.35 N/mm^2

Sample block C

Weight of block = 18.8kg

Load at failure = 350 KN (350 x 1000) = 350000N

Compressive strength of Block C $\frac{350000}{31500}$ = 11.1N/mm^2

Average of the weight of the blocks $= \frac{18.8+18.8+18.8}{3}$ = 18.8kg

Average of compressive strength

$\frac{9.52+6.35+11.11}{3}$ = 9.00N/mm^2

Result @ 28days

Sample block A

Weight of block = 19.0kg

Load at failure = 260 KN (260 x 1000) = 260000N

Compressive strength of Block A $\frac{260000}{31500}$ = 8.30N/mm^2

Sample block B

Weight of block = 18.8kg

Load at failure = 240 KN (240 x 1000) = 240000N

Compressive strength of Block B $\frac{240000}{31500}$ = 7.62N/mm^2

Sample block C

Weight of block = 19.0kg

Load at failure = 260 KN (260 x 1000) = 260000N

Compressive strength of Block C $\frac{260000}{31500}$ = 8.30N/mm^2

Average of the weight of the blocks $= \frac{19.0+18.8+19.0}{3}$ = 18.9kg

Average of compressive strength

$\frac{8.30+7.62+8.30}{3}$ = 8.10N/mm^2

Result of 100% replacement of iron tailings

Result @ 7 days

Sample block A

Weight of block = 18.4kg

Load at failure = 40 KN (40 x 1000) = 40000N

Compressive strength of Block A $\frac{40000}{31500}$ = 1.27N/mm^2

Sample block B

Weight of block = 18.4kg

Load at failure = 60 KN (60 x 1000) = 60000N

Compressive strength of Block B $\frac{60000}{31500}$ = 1.90N/mm^2

Sample block C

Weight of block = 18.4kg

Load at failure = 50 KN (50 x 1000) = 50000N

Compressive strength of Block C $\frac{50000}{31500}$ = 1.59N/mm^2

Average of the weight of the blocks $= \frac{18.4+18.4+18.4}{3}$ = 18.4kg

Average of compressive strength

$\frac{1.27+1.90+1.59}{3}$ = 1.59N/mm^2

Result @ 14days

Sample block A

Weight of block = 18.4kg

Load at failure = 130 KN (130 x 1000) = 130000N

Compressive strength of Block A $\frac{130000}{31500}$ = 4.13N/mm^2

Sample block B

Weight of block = 18.6kg

Load at failure = 100 KN (100 x 1000) = 100000N

Compressive strength of Block B $\frac{100000}{31500}$ = 3.17N/mm^2

Sample block C

Weight of block = 18.6kg

Load at failure = 90 KN (90 x 1000) = 90000N

Compressive strength of Block C $\frac{90000}{31500}$ = 2.86N/mm^2

Average of the weight of the blocks $= \frac{18.4+18.6+18.6}{3}$ = 18.5kg

Average of compressive strength

$\frac{4.13+3.17+2.86}{3}$ = 3.39N/mm^2

Result @ 21days

Sample block A

Weight of block = 18.4kg

Load at failure = 140 KN (140 x 1000) = 140000N

Compressive strength of Block A $\frac{140000}{31500}$ = 4.44N/mm^2

Sample block B

Weight of block = 18.8kg

Load at failure = 140 KN (140 x 1000) = 140000N

Compressive strength of Block B $\frac{140000}{31500}$ = 4.44N/mm^2

Sample block C

Weight of block = 18.6kg

Load at failure = 150 KN (150 x 1000) = 150000N

Compressive strength of Block C $\frac{150000}{31500}$ = 4.76N/mm^2

Average of the weight of the blocks $= \frac{18.4+18.8+18.6}{3}$ = 18.6kg

Average of compressive strength

$\frac{4.44+4.44+4.76}{3}$ = 4.60N/mm^2

Result @ 28days

Sample block A

Weight of block = 17.6kg

Load at failure = 100 KN (100 x 1000) = 100000N

Compressive strength of Block A $\frac{100000}{31500}$ = 3.71N/mm^2

Sample block B

Weight of block = 18.0kg

Load at failure = 120 KN (120 x 1000) = 120000N

Compressive strength of Block B $\frac{120000}{31500}$ = 3.81N/mm^2

Sample block C

Weight of block = 18.0kg

Load at failure = 100 KN (100 x 1000) = 100000N

Compressive strength of Block C $\frac{100000}{31500}$ = 3.17N/mm^2

Average of the weight of the blocks $= \frac{17.6+18.0+18.0}{3}$ = 17.9kg

Average of compressive strength

$\frac{3.20+3.81+3.20}{3}$ = 3.40N/mm^2

Table 1.0 Summary of test results of average weight and Average compressive strength conducted with 25%, 50%, 75% and 100% replacement of iron ore tailings with crushing age

Result with 25% replacement of iron ore tailings		
Crushing Age (Days)	Average weight (kg)	Average compressive strength (N/mm^2)
7	17.2	3.50
14	17.3	5.50
21	17.0	7.60
28	17.1	7.20
Result with 50% replacement of iron ore tailings		
Crushing Age (Days)	Average weight (kg)	Average compressive strength (N/mm^2)
7	17.2	2.00
14	17.3	5.40
21	17.0	5.40
28	17.1	5.10
Result with 75% replacement of iron ore tailings		
Crushing Age (Days)	Average weight (kg)	Average compressive strength (N/mm^2)
7	18.0	3.00
14	18.4	6.40
21	18.8	9.00
28	18.9	8.10
Result with 100% replacement of iron ore tailings		
Crushing Age (Days)	Average weight (kg)	Average compressive strength (N/mm^2)
7	18.4	1.60
14	18.5	3.40
21	18.6	4.60
28	17.9	3.60

Table 2.0 Total compressive strength analysis with crushing Age at 25%,50%,75% and 100%

Crushing Age (Days)	Compressive strength (N/mm^2)			
	25%	50%	75%	100%
7	3.50	2.00	3.00	1.60
14	5.50	5.40	6.40	3.40
21	7.60	5.40	9.00	4.60
28	7.20	5.10	8.10	3.40

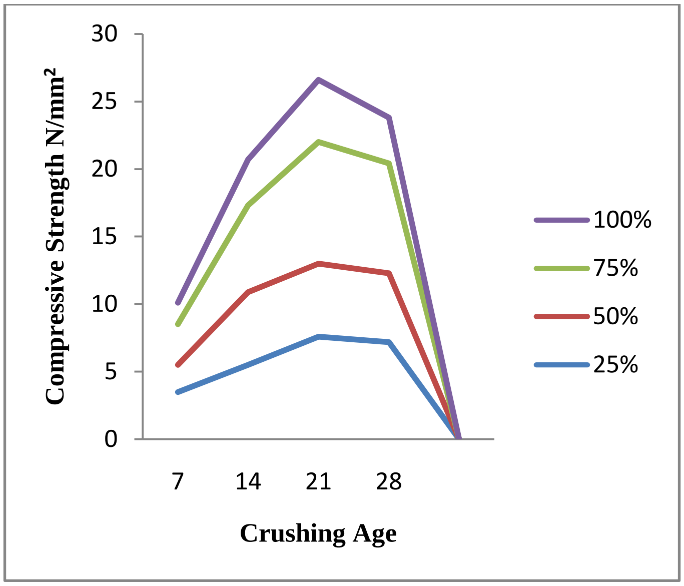

Fig 1.0 Compressive strength against Crushing Age at 25%, 50%, 75% and 100% replacement of iron ore tailing

IV. CONCLUSION

The results conducted to evaluate the suitability of iron ore tailings collected from Itakpe iron ore mining company and the effect on the strength of sand crete blocks when use to replace the conventional fine aggregates shows that the lower the replacement of fine aggregates the greater the compressive strength. There was reduction in the compressive strength of the sand crete blocks produced with increased percentage replacement of the conventional fine aggregate with iron ore tailings. 25% replacement of iron ore tailings is more appropriate in terms of quality strength, and economical in production of sand crate blocks as compared to 50, 75% and 100%.Therefore iron tailings meets with British standard requirements for fine aggregates as replacement in conventional use of fine aggregates as specified in BB882:1992.

V. RECOMMENDATIONS

- Iron ore tailings can be recommended to block moulding industries within kogi state ,Nigeria and the globe at large who strictly adhered to standard practice to incorporate iron tailings not less than 25% of aggregates used into their sand crete block production as this will increased the quality of sandcrete block within the market of block manufacturers as well as re use of iron ore tailings at Itakpe into production of quality building materials
- Further research should be conducted on using iron ore tailings to improve the engineering properties of very expansive soils such as black cotton soil.
- There should be a field test to simulate the laboratory test result on the use of iron ore tailings for the base course of flexible pavements.

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