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ICEC 2020

THEME

REPOSITIONING CIVIL ENGINEERING PRACTICE FROM THE PERSPECTIVE OF ICT

3RD DECEMBER, 2020

BOOK OF PROCEEDINGS

EDITED BY:
ENGR. PROF. A.A. AMADI, ENGR. PROF. J.I. AGUWA, ENGR. DR. T.W.E. ADEJUMO
ENGR. DR. M. SAIDU, ENGR. DR. A.R. ADESIJI, ENGR. M. ABUBAKAR, ENGR. A. YUSUF

Forward

The Second International Civil Engineering Conference (ICEC 2020) titled **'Repositioning Civil Engineering Practices from the Perspective of ICT'** was held online on 3rd December, 2020. The conference is part of the biennial conference series by the Department of Civil Engineering, Federal University of Technology, Minna, Nigeria. This year, the conference brought together international researchers, academics and industry professionals from different countries to exchange views, share ideas and explore feature research themes in order to meet current challenges in relation to the use and implementation of ICT in Civil Engineering.

This *Proceedings* contains 74 peer reviewed papers from the conference. It is hoped that the papers will provide engineers, scientists, and planners state-of-the-art information on digital technologies/strategies relevant to the transformation of Civil Engineering Practice.

On behalf of the conference organizing committee, I would like to thank the authors for contributing their research results to the conference and the reviewers for making valuable suggestions in improving the authors' works.

Engr. Prof. A. A. Amadi
Chair, Conference Organizing Committee
ICEC 2020

Sponsorship

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3.5 Relationship between soil mixture shrinkage strain and moisture loss

The relationship between specimen shrinkage strain and moisture loss was demonstrated by plotting the variation of volumetric shrinkage data with moisture loss in Figure 5. The information in Fig. 5 indicate that volumetric shrinkage strain of specimens increased with moisture loss and are correlated non-linearly within the 28 day period of measurement. The measurement of moisture loss can thus be a good indicator for shrinkage of soil mixtures with R^2 values that range from 0.89 – 0.99 as shown in Table 3

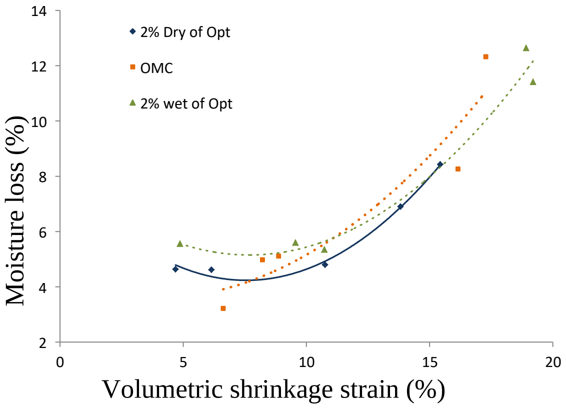

FIGURE 5: CHANGE IN VOLUMETRIC SHRINKAGE STRAIN WITH MOISTURE LOSS IN SOIL MIXTURES

TABLE 3: RELATIONSHIP BETWEEN VOLUMETRIC SHRINKAGE AND MOISTURE LOSS IN SOIL MIXTURES

Specimen	Equation	R^2
2% Dry of optimum	$y = 0.067x^2 - 1.017x + 8.084$	0.99
Optimum	$y = 0.041x^2 - 0.320x + 4.220$	0.89
2% wet of optimum	$y = 0.052x^2 - 0.810x + 8.264$	0.97

4.0 Conclusion

The aim of this study was to examine the relationship between compaction moisture content and shrinkage strains during laboratory desiccation experiments of specimens of lateritic soil treated with recycled waste plastic dust (RPD). Soil mixtures were prepared by mixing the lateritic soil with 0, 2, 4, 6 and 8% by weight to form five compositions. Results of tests indicate that the liquid limits of soil mixtures decreased slightly from 45% to 39%, whereas plasticity indices reduced from 26.16 % to 21.99% as RPD content varied from 0 – 8%. Similarly, the maximum dry density of soil mixtures decreased from 1.65g/cm^3 for the natural soil to 1.51 g/cm^3 on introduction of 8% RPD with corresponding increase in the OMC as higher amount of RPD is introduced into the mixture.

All the specimens exhibited shrinkage on drying, with the amount of shrinkage of mixtures increasing with higher moisture content during compaction. Furthermore, at any compaction moisture content, mixtures with higher RPD content (6 and 8%) shrunk more than the mixtures with lower RPD percentage. Furthermore, greater moisture loss was found in specimens prepared wet of optimum than in specimens compacted at the optimum and dry of optimum conditions which is consistent with the high drying shrinkage value for wet of optimum specimens.

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Department of Civil Engineering
Federal University of Technology, Minna, Nigeria

Utilisation of Itakpe Iron Ore Tailings in Normal Weight Concrete: An Overview

*Adesina, M. A.; & Oritola, S. F.
Department of Civil Engineering Federal University of Technology, Minna
*Corresponding author email: mojeedadewumi@gmail.com

ABSTRACT

Some previous studies have reported findings about the possibilities of using Itakpe Iron Ore Tailings (IIOTs) to partially replace sand in the production of concrete. Based on the outcome of previous findings, there is a need for further research to determine the degree of the suitability of using the IIOTs in concrete. This becomes inevitable because some studies reported positive contribution to the properties of concrete while some reported adverse effects. This study highlights the chemical and physical properties of IIOTs as reported by previous studies and compared these properties to those of sand. The properties of fresh and hardened concrete that were produced using IIOTs as partial replacement for sand, as reported in previous works are presented and discussed in this study. Based on the outcome of this study, it has been found that, huge amount of IIOTs is available and there is a need for large volume consumption of the waste material. Discrepancies in the outcomes of previous experimental studies from different researchers also prompted the need for more studies about the use of IIOTs in concrete. If more studies are carried out about the Itakpe Iron ore tailings, the suitability of using it in concrete and the extent of application can be established. Furthermore, there would be sufficient record of researches to back up the findings.

Keywords: *Concrete properties, Itakpe Iron Ore Tailings, Sustainability, Waste material*

1 INTRODUCTION

The most common material for construction in the world today is concrete. This is due to the fact that, concrete is about the cheapest material for construction, it can also be easily moulded into different shapes and sizes. The tallest building in the world today Burj Khalifa was built using about 330,000 cubic metres of concrete (Nurul Fasihah *et al,* 2017). Due to the high consumption of concrete, natural sand which is one of the main constituent of concrete is also consumed in large quantity. As a result of large consumption of natural sand for concrete production, this could lead to depletion of the natural resources. Hence there is a need to seek for supplementary material to partially replace sand as fine aggregate in concrete production.

A look at Table 1 (Zhu *et al,* 2015), shows that iron ore tailings (IOTs) has very close similarity with silica sand and natural sand in terms of the physical properties mentioned in the table. This suggest there is high possibility of using iron ore tailings as fine aggregate in concrete. The iron ore reserve in Nigeria is depicted in Table 2 (Adebimpe and Akande, 2011). The huge deposit of iron ore that was found in Itakpe, Kogi state triggered the establishment of a steel complex at Ajaokuta, a town which is just some kilometers away from the source of the raw material. The establishment of Ajaokuta steel complex in Ajaokuta, Kogi State has made the mining of the iron ore in Itakpe an important activity. The Nigerian iron ore mining company which was established in 1971 was saddle with the responsibility of mining this ore and provide same for the running of Ajaokuta steel complex and Delta steel company Aladja. The plant that was installed then was designed to process a minimum of 2400 tons of ore per day and is operated for an average of 300 days per year. The waste material generated from the processing plant is about 64% of the installed capacity (Ajaka, 2009).

Currently researchers are exploring alternative ways to produce concrete in a more environmental friendly ways by the use of waste material. Recent research works have been geared towards effective utilization of iron ore tailings in the production of concrete and other related construction products. The use of iron ore tailings as construction material has found application in the production of self-compacting concrete (Kiran *et al,* 2014), as fine aggregate in concrete production (Vale *et al.*, Kumar *et al.,* 2014; Kuranchie *et al,* 2015), as material in autoclaved concrete (Ren *et al,* 2013) production of interlocking bricks and paving blocks (Carassco et al, 2013; Ravi *et al,* 2012), polypropylene and epoxy composite (Adedayo and Onitiri, 2012) and foam concrete (Ren *et al*, 2012).

Although quite some works have been done about the Itakpe Iron Ore Tailings (IIOTs), there is still a need for more researches regarding the utilization of the material in concrete or any other construction product. The chemical and physical properties of the IIOTs is similar to that of sand as depicted in tables 3 and 4, this suggests that the IIOTs can be used for similar application that sand is being used for, in concrete or any other construction product.

TABLE 1: PHYSICAL PROPERTIES OF THREE KINDS OF SANDS

Properties	Kinds of Sands		
	Iron ore tailings	Silica Sand	River Sand
Clay Lump	0.0	0.0	0.7
Water Absorption	0.9	0.6	0.8
Roughness	14.2	10.7	12.4
Crushing Value	11	10	13
Robustness	7.8	5.8	6.2
MB	0.3	0.0	0.8

Source: Zhu *et al*, 2015

TABLE 2: IRON ORE RESERVE IN NIGERIA

Location	**% F_e content**	**Reserve (tons)**
Agbaja	45-54	2 billion
Itakpe	36	200 million
Ajabanako	35.61	62.5
Chokochoko	37.43	70 million
Agbade - Okudu	37.43	70 million
Nsude Hills	37.43	60 million

Source: Adebimpe and Akande, 2011

2 COMPARATIVE PROPERTIES OF IIOTS AND SAND

The physical and chemical properties of the Itakpe Iron Ire Tailings as reported by different researchers are compared to those of sand.

2.1 PHYSICAL PROPERTIES OF IIOT$_S$

Most of the important properties of hardened concrete are related to the quantity and the characteristics of the various types of materials in the concrete. Within the permitted standard limits, the grading of fine aggregate has a greater influence on the properties of concrete than that of coarse aggregate (Neville, 2011; Ollivier *et al,* 2012). It is expected that IIOTs which serves as fine aggregate in concrete, will have a significant impact on the property of concrete so produced. Table 3 represents the physical properties of sand and IIOTs based on the outcome by previous researchers. As deduced from the table, the bulk density of sand is lower than those of the IIOTs. The percentage difference ranges between 8.5 – 11.6 %. The bulk density of sand and those of IIOTs can be considered to fall within a comparable close array. The fineness modulus value of IIOTs is lower compared to that of the sand, this shows that the average particle size of the IIOTs is smaller than that of the sand. The specific gravity values of the IIOTs are greater than that of the sand. This further indicate that the particles of IIOTs are finer than that of sand. The percentage of particles passing the 600µm sieve as revealed by the table, further support that the IIOTs is a finer material compared to sand.

TABLE 3: PHYSICAL PROPERTIES OF SAND Vs IIOTs

Physical Properties	Materials			
	Sand	Itakpe iron ore tailings		
		Ugama et al, 2014	Elinwa et al, 2014	Abdul-rahman, 2015
Bulk density kg/m^3	1459	1594	1650	-
Fineness modulus	3.2	2.53	-	-
Moixture content	-	-	0.22	0.06
Specific gravity	2.65	2.85	3.51	3.49
% passing 600µm	44	73	67	71

2.2 CHEMICAL CONSTITUENTS OF IIOT$_S$

Table 4 depicts the major oxide composition of the Itakpe iron ore tailings as reported by previous researchers. The table revealed that the dominant oxide in the Itakpe iron ore tailings is silicon dioxide (SiO_2). The table shows, close similarity in the oxide composition of IIOTs, based on the outcome of previous researches. It can also be deduced that the common oxides in Itakpe Iron Ore Tailings with high percentages are silicon dioxide, iron oxide and aluminium oxide in descending order.

TABLE 4: CHEMICAL CONSTITUENTS OF IIOTs AS REPORTED IN PREVIOUS RESEARCH

Chemical constituents	Percentage of constituents according to previous research (%)				
	Ajaka et al, 2009	Ugama et al, 2014	Elinwa et al, 2014	Abdulr'man, 2015	Bola et al, 2015
Fe_2O_3	35.7	47.8	15.0	15.0	15.0
SiO_2	42.1	45.6	71.0	66.0	71.0
CaO	1.3	0.6	1.2	1.8	1.2
Al_2O_3	3.2	3.3	2.6	3.8	2.6
MgO	0.4	0.4	0.3	1.0	0.3
TiO_2	0.2	0.2	0.2		0.2

S	0.1			0.8	0.1
P	1.0			1.0	0.1
Na_2O	0.5		1.2		1.2
SO_3	-		0.1		
K_2O	0.6		0.1		

3 PROPERTIES OF IIOTS CONCRETE

3.1 PROPERTIES OF FRESH CONCRETE

Consistency, mobility and compactibility are basic characteristics of fresh concrete which affects its full compaction. The fresh concrete can maintain its uniformity if it's relatively stable. The stability of the fresh concrete depends mainly on the consistency and the cohesiveness. The quality of the fine aggregate strongly influence the uniform distribution of constituent's materials that make up the concrete. The consistency, mobility and compactibility of the fresh concrete is collectively known as the workability of the concrete. The workability of IIOTs concrete as reported in previous research is depicted in Table 5.

The percentage replacement of sand by IIOTs as reported by Ugama *et al* (2014) are 0, 20, 40, 60, 80 and 100. Elinwa (2014) substituted sand with IIOTs at 0, 5, 10 and 20 percent replacement levels. The workability values of 53 and 60 mm recorded by these researchers respectively, differs by 11.7 %. The values of workability recorded by Ugama *et al*, (2014) indicates a gradual decrease in workability with increasing quantity of IIOTs. In the case of values of workability recorded by Elinwa, (2014), the reverse is the case. The addition of IIOTs in the fresh concrete gave higher values of workability.

TABLE 5: WORKABILITY OF IIOTs CONCRETE

Percentage of IIOTs in Fine Aggregate (%)	Recorded Slump (mm)	
	Ugama et al 2014	Elinwa 2014
0	55	50
5		55
10		60
20	53	60
40	52	
60	47	
80	43	
100	36	

3.2 PROPERTIES OF HARDENED CONCRETE

The monitoring of the properties of hardened concrete is important throughout the life span of the concrete. Some of the important properties of hardened concrete are strength, durability, permeability, deformation under load and shrinkage. However, strength is considered to be the most significant property of hardened concrete used to classify the quality of the concrete. In terms of the strength also, the compressive strength is considered to be the most important because almost all properties of concrete, can be related to it. Previous researches to-date on IIOTs concrete have reported about its compressive and tensile strength.

Compressive Strength of IIOTs Concrete

The compressive strength is commonly used in the construction industry for specifications and quality control. The test is easy to perform and in most cases very reliable. Concrete structures are designed on the basis that the concrete is capable of resisting compression forces. The compressive strength of IIOTs concrete as reported in previous research is recorded in Table 6.

The values of compressive strength recorded by Ugama *et al* (2014) varies from 45 to 31 N/mm^2 based on sand replacement by IIOTs which varies from 0 to 100 % respectively. In the case of Elinwa (2014) the values of compressive strength recorded varies from 21.2 to 24.2 N/mm^2 based on sand replacement by IIOTs which varies from 0 to 30 % respectively. The outcome of Ugama et al (2014) research shows that there is gradual decrease in the compressive strength of IIOTs concrete as a result of increasing the quantity of Itakpe iron ore tailings up to a minimum value of 31 N/mm^2 at 100 % replacement level. In the case of Elinwa, 2014, the research shows that there is gradual increase in the compressive strength of IIOTs concrete as a result of increasing the quantity of Itakpe iron ore tailings up to an optimum value of 24.2 N/mm^2 at 30 % replacement level.

TABLE 6: COMPRESSIVE STRENGTH OF IIOTs CONCRETE

Percentage of IIOTs in Fine Aggregate (%)	Compressive strength recd. (N/mm^2)	
	Ugama et al 2014	Elinwa 2014
0	45.0	21.2
5		21.7
10		22.0
20	43.7	23.1
30		24.2
40	41.0	
60	37.0	
80	32.5	
100	31.0	

Tensile Strength of IIOTs Concrete

In concrete structures, tensile stresses can develop due to restraint from contraction as a result of drying or temperature variation. This tensile stresses are expected to be resisted by concrete. In the construction industry, the tensile strength of concrete is of paramount significance in the design of concrete roads and runways. The tensile strength is used for distributing the concentrated loads over a wider area of the road pavement. The tensile strength of IIOTs concrete as reported in previous research is depicted in Table 7.

The values of tensile strength recorded by Ugama *et al* (2014) varies from 2.64 to 1.92 N/mm^2 based on sand replacement by IIOTs which varies from 0 to 100 % respectively. The outcome of this research shows that there is gradual decrease in the tensile strength of IIOTs concrete as a result of increasing the quantity of Itakpe iron ore tailings up to a minimum value of 1.92 N/mm^2 at 100 % replacement level.

TABLE 7: TENSILE STRENGTH OF IIOTs CONCRETE

Percentage of IIOTs in Fine Aggregate (%)	Tensile strength recorded (N/mm^2)
	Ugama et al 2014
0	2.64
20	2.69
40	2.54
60	2.48
80	2.15
100	1.92

4 CONCLUSION

The need to determine the properties, of waste tailings that are generated during the process of producing iron ore at Itakpe Iron ore smelting company, Itakpe is highlighted in this paper. Previous studies that reported about the chemical and physical properties of the Irakpe Iron Ore Tailings are brought to focus and these properties were compared. The recorded values for the chemical and physical properties of IIOTs, on the average, are similar based on the outcome from previous studies. There is no clear guideline on the contribution of IIOTs to the workability of the fresh concrete, because previous studies reported different effect when IIOTs is used to partially replace sand as fine aggregate in the production of concrete. Also, there is no clear indication on the effect of IIOTs on the properties of hardened concrete. Based on outcome of previous studies, adverse and positive effects on the strength of concrete were reported. In addition to all these, some important properties relating to dimensional stability of concrete have not been determined by previous studies. Furthermore, the number of available scholarly works, which studied the contribution of Itakpe Iron ore tailings, to the properties of concrete is scanty. Based on all these shortfalls, there is a need for further and more comprehensive research, to find out the effect and contribution of Itakpe iron ore tailings on the compressive strength, tensile strength, flexural strength and dimensional stability of normal weight concrete.

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