DEPARTMENT OF

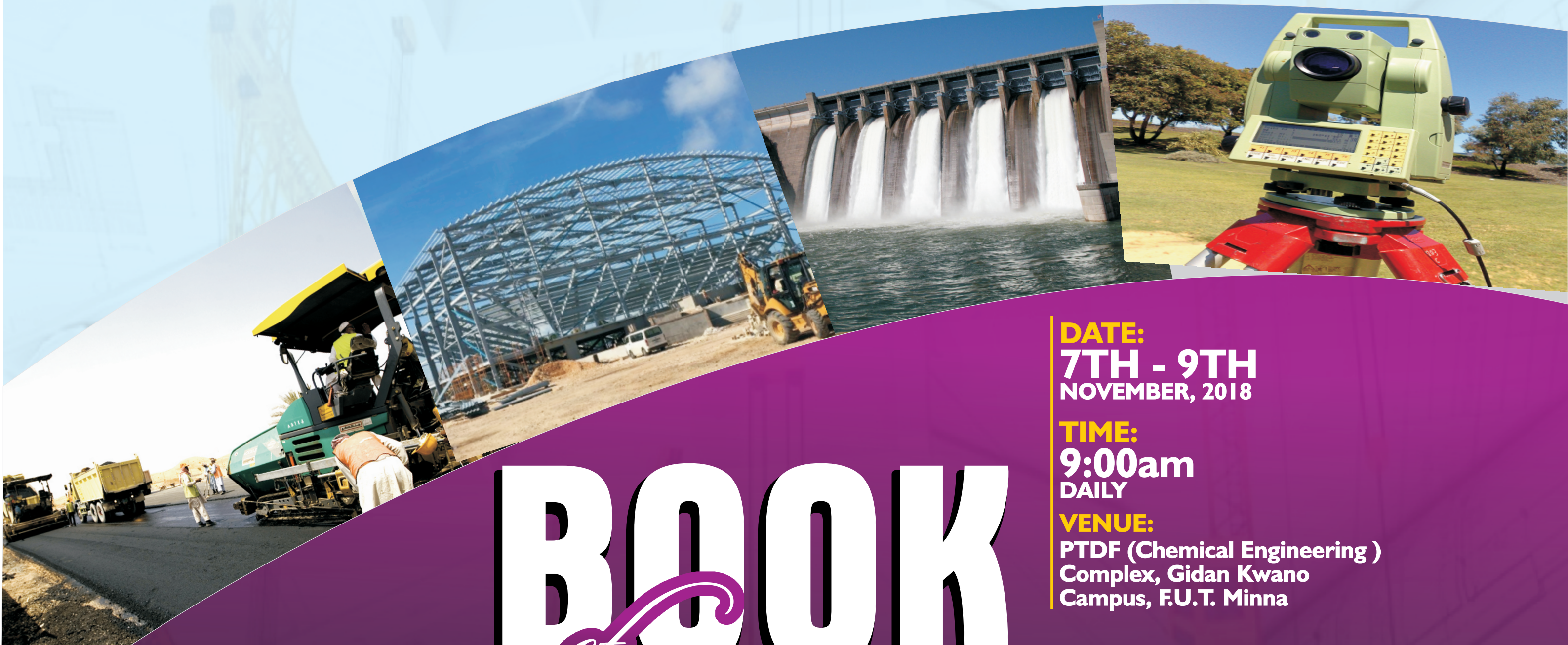
CIVIL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

1st INTERNATIONAL CIVIL ENGINEERING CONFERENCE (ICEC)

Theme:

INFRASTRUCTURE DEVELOPMENT IN THE CONTEXT OF CONTEMPORARY ECONOMIC CHALLENGES



DATE:
7TH - 9TH
NOVEMBER, 2018

TIME:
9:00am
DAILY

VENUE:
PTDF (Chemical Engineering)
Complex, Gidan Kwano
Campus, F.U.T. Minna

BOOK of PROCEEDINGS

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FOREWORD

The First International Civil Engineering Conference (ICEC) being held in the Main Campus of the Federal University of Technology, Minna, Nigeria on 7th – 9th of November, 2018 derives from the necessity to provide a suitable forum for the interaction of a wide spectrum of stakeholders including the academia and practitioners in the industry for the purpose of advancing the frontiers of knowledge in the Civil Engineering profession and allied sciences and technology. It is sheer truism to state that economic vicissitudes are rapidly becoming the major determinant in the rate and size of infrastructure development in any modern nation. By implication, therefore, the practice of civil engineering is subject to the vagaries of the nation's economy with particular reference to Nigeria. Accordingly, the Conference theme, "Infrastructure Development in the Context of Contemporary Economic Challenges" has been carefully chosen to address myriads of problems that are re-defining the scope and solution techniques applicable in the contemporary practice of civil engineering.

In order to ensure a wide coverage of the domain of civil engineering, we broke the theme down to eight sub-themes encompassing such areas as: (a) Structural Engineering Practice (b) Transport Systems including Planning, Development, Operation and Maintenance (c) Water Resources Management (d) Geo-Sciences and Geo-Engineering (e) ICT in Infrastructure Development (f) Energy (g) Engineering Materials, and (h) Project Management. Thrillingly, responses were received in all the sub-themes.

Manuscripts received were subjected to blind peer-review, carried out by researchers who have in-depth knowledge and experience in the specialization, to ensure that our threshold minimum standard was met – the standard being consistent with any other similar international academic fora. Thus, out of the total eighty submissions received, sixty-five (representing 81% of the total submissions) were adjudged acceptable while the remaining fifteen could not meet the minimum acceptable quality level and therefore rejected. However, in the long run sixty of the accepted sixty-five registered for the conference. Interestingly, going by the accepted papers and subsequent registration, the participating countries include Nigeria, Niger Republic, India and Malaysia.

We, the entire members of the Conference Organizing Committee (COC), heartily welcome all participants to the ICEC and trust that you would maximally utilize the opportunity to peer-interact and establish contacts for possible future research collaborations and linkages. We also seize this opportunity to express our profound gratitude to all – authors, reviewers, supporting individuals and agencies, and above all the Management and staff of the Federal University of Technology, Minna, Nigeria, whose efforts have culminated in successfully holding the conference.

As the maiden edition of the biennial conference, this edition places us on the learning curve. We are therefore open to suggestions and constructive criticisms that would improve our future outings. We wish you all happy and fruitful academic and professional interactions.

Engr. Prof. S. Sadiku

Chairman (Conference Organizing Committee)

TABLE OF CONTENT

Content **Page**

Properties and Microstructure of Concrete Containing Iron ore tailings

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ABSTRACT
Successful utilization of waste materials such as agro, urban and industrial waste in concrete depends on its use being economically competitive with the alternate natural material. In this study, Iron ore tailings (IOTs), an industrial waste product, generated during the production of iron ore, is used in its natural state as fine aggregate to partially replace sand, for the production of normal strength concrete. The use of this waste material brings about conservation of declining natural resources, the utilization of valuable land for more profitable use and economic advantage in comparison to the conventional material. The physical properties of the Iron ore tailings were determined and compared with that of natural sand. Fresh and hardened properties of concrete were evaluated. Field emission scanning electron microscopy (FESEM) images of fine aggregate materials and the hardened concrete produced, were also studied. The microstructure of IOTs concrete samples shows a tighter interface between the cement gel and the aggregate when compared with those of the control concrete sample having no IOTs. The outcomes of mechanical properties tests and the microstructure analysis reveals that the IOTs was able to improve the strength and denseness of concrete. Based on findings from this research, it can be concluded that IOTs can be used to partially replace sand as fine aggregate in concrete, in order to improve the mechanical properties and the pore structure of the concrete.

Keywords: *Concrete properties, Industrial waste, Iron ore tailings, Normal strength concrete, Pore structure*

1 INTRODUCTION

By visual examination, the Iron ore tailings resembles natural sand and X-ray fluorescence reveals that for most Iron ore tailings, the major component is silicon dioxide (SiO_2) (Oritola et al., 2015) as shown in Figure. This suggests the need for research into how best the Iron ore tailings can be utilized in concrete. By physical examination, the fineness and angular nature of the Iron ore tailings also suggest that it can improve the denseness of concrete. In severe climates, the surfaces of concrete sidewalks, parking decks, bridges, canals, dams and other structures deteriorate progressively due to different kinds of causes (Jahangir et al., 2014). Due to the fineness of Iron ore tailings, it can also be considered as a promising material for the repair and maintenance of these concrete structures.

Previous research revealed that Iron ore tailings was utilized as fine aggregate to produce ultra-high performance concrete (Zhao et al., 2014). Iron ore tailings from different origins do not have the same geotechnical behaviour. The tailings may even show similar grading, but the parameters cannot be generalized for mines in terms of mineralogy or beneficiation process (Oritola et al., 2015). The IOTs was also used to produce green engineered cementitious composites (GECC) (Haung et al., 2013) and it was mentioned that mortar’s compressive strength was improved due to tighter interface between aggregate and hard cement paste and the enhanced structure related to the finer nature of the Iron ore tailings compared to the reference sand (Yu et al., 2012). Toxicity leaching procedure tests for concrete sample also revealed that the hydraulic binder arrests metal mobility from the iron ore mine wastes (Yellishetty et al., 2008).

The sustainability of the construction industry would be enhanced if the utilization of IOTs in concrete is fully established based on outcomes of research. Plant covers can be saved thereby promoting the greenness of civil infrastructure. This industrial waste can therefore be turned into a major economic gain.

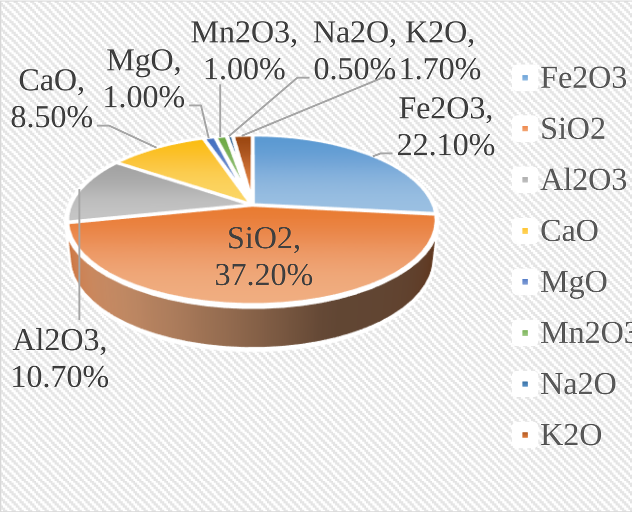

Figure 1: Chemical Composition of Iron ore tailings

2 METHODOLOGY

Materials used for Production of Concrete Samples.

The ordinary Portland cement brand with strength class of 42.5 in accordance with the British standard was used as binder for preparing the concrete samples. The natural sand used as fine aggregate and granite used as coarse aggregate were obtained from a local quarry in Johor. The research focused on the use of three different types of iron ore tailings as fine aggregate serving as partial replacement for the natural sand. These tailings were obtained from ZCM Minerals Kota Tinggi, Landas Seketa Mines Kota Tinggi and Honest Sam Development, Batu Pahat, all in Johor state, Malaysia. The tailings were denoted as ZIOT, LIOT and HIOT respectively.

The experimentally determined physical properties of the aggregate are given in Table 1 while the particle size distribution for all the fine aggregates is shown in Fig. 2. The iron ore tailings HIOT 30% partial replacement of sand in concrete produced the highest compressive strength, the microscopic image of sand is therefore compared with that of HIOTs at 500µm as revealed in Fig. 3 and Fig. 4 correspondingly. The energy dispersive x-ray spectroscopy of sand and HIOTs are shown Figure 5 and Figure 6 respectively.

Table 1, Physical properties of fine aggregate

Physical properties	Fine aggregates			
	Sand	ZIOT	LIOT	HIOT
Size Passing 600µm %	44	95	96	93
Coef of uniformity	3.7	4.7	4.0	3.9
Coef of curvature	0.02	0.01	0.01	0.01
Porosity %	14	12.1	12.4	11.4
Specific gravity	2.65	2.91	2.74	2.79
Fineness Modulus	3.2	1.4	1.3	1.4
Loose unit wt kg/m^3	1459	1598	1554	1629
Compacted unit wt kg/m^3	1696	1817	1774	1839

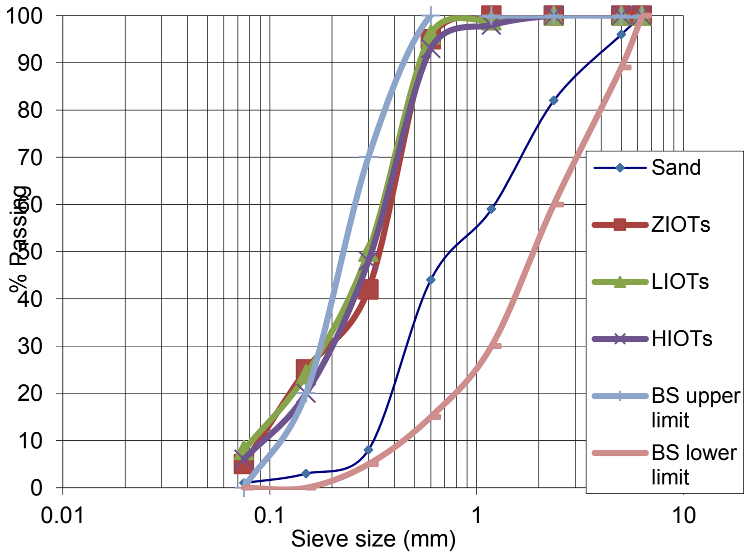

Figure 2. Particle size distribution of fine aggregates

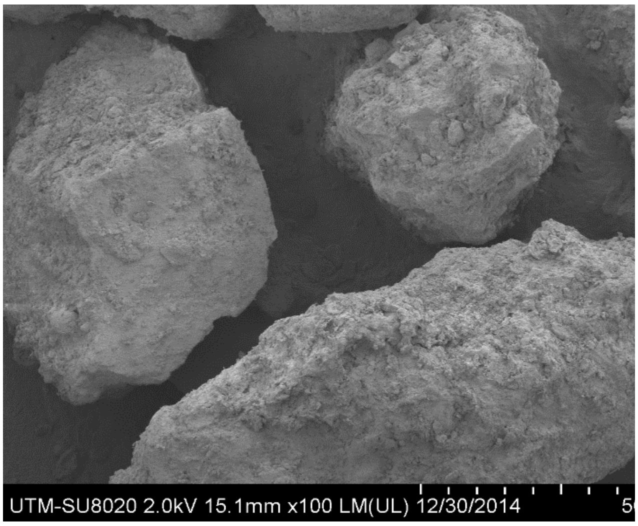

Figure 3: Microscopic image of sand at 500µm

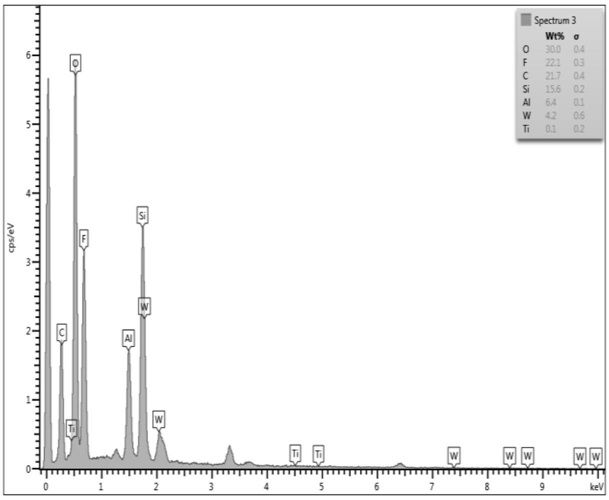

Figure 6: Energy dispersive x-ray spectroscopy of HIOTs

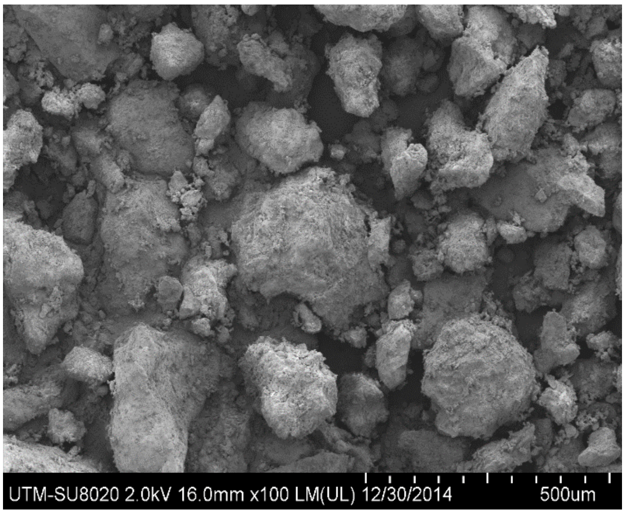

Figure 4: Microscopic image of HIOTs at 500µm

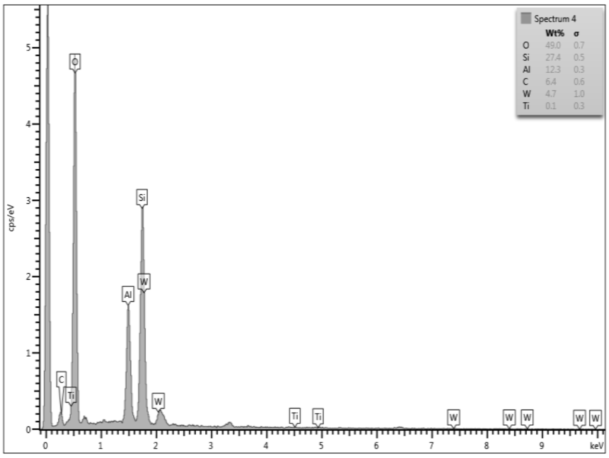

Figure 5: Energy dispersive x-ray spectroscopy of sand

Mix proportion and preparations of concrete samples.

Uniform concrete can be obtained only through proper quality control of all operations from selection and production of materials through batching, mixing, transporting, conveying, placing, consolidation, finishing, and curing (Lambert & James, 2013). The British method for the design of normal strength concrete made with Portland cement as outlined by the Building Research Establishment was used to design normal strength concrete.

Based on the procedure of the concrete mix design and using the appropriate design tables and figures, a normal strength concrete with water content 250 Kg/m^3, cement content 463 Kg/m^3, fine aggregate content 769 Kg/m^3 and coarse aggregate content of 868 Kg/m^3 was designed using water-cement ratio of 0.54. The reference mix adopted is that, which contain sand as the only fine aggregate. For each of the IOTs collected from three different mines, the sand replacement level among the concrete samples that gave the highest compressive strength were selected for further comparison with the control sample. These selected concrete samples are denoted as CZT30 (concrete containing 30% ZCM iron ore tailings as fine aggregate), CLT40 and CHT30 accordingly. The reference concrete sample with 0% tailings is denoted as CTO.

3 RESULTS AND DISCUSSION

The summary of test results, revealing the properties of the fresh concrete is shown in Table 2. There was significant decrease in the workability of the IOTs concrete samples, because of its much greater particle surface area, but concomitantly there was improvement in cohesiveness. This result is in agreement with the findings of Zhao et al., (2014).

There are several reasons for choosing compressive strength as representative index for concrete. First, concrete is used in a structure to resist compression force. Second, the measurement of compressive strength is easier and lastly, other properties of concrete can be related to it (Oritola et al., 2014). The incorporation of IOTs improves concrete compressive strength up to 30% optimum level for the CZT and CHT concrete samples. This result is in line with the findings of Yunfen, (2014) and Zhang et al., (2014).

The flexural strength test is a strong indicator of how porous or dense a concrete sample is, and it's very sensitive to defects in the microstructure, like micro-cracks in the concrete, than compressive strength and splitting tension tests. Similar trend of results was obtained for the flexural strength test, as it was with the compressive strength and splitting tension tests. Table 3, gives the results of the mechanical properties of hardened concrete samples.

The ultrasonic pulse velocity (UPV) test checks the uniformity of concrete samples. The values of pulse velocity for all the concrete samples falls within the range 3.5 – 4.5 Km/s which is considered good. Table 4, indicate the UPV test results for the concrete samples.

The FESEM morphology of materials at magnification of 500µm as shown in Figure 3 and Fig. 4 clearly reveals the particle size effect between iron ore tailings and sand. Within the same area, fewer particles of sand were seen compared with those of IOTs. This implies that the iron ore tailing has larger particles per surface area and can therefore combine effectively with cement to reduce the pores within the cement gel. This will also, drastically reduce the formation of capillary cavities. The microstructure of the concrete samples revealed that more pore space can be seen in concrete with no IOTs compared with those with IOTs. Figure 7 shows the FESEM morphology of concrete sample with no IOTs compared with that containing 30% iron ore tailings, in Figure 8. The structure of this concrete is characterized by the structure of the cement paste and by the structure of the aggregate. Since IOTs is the only variable in the concrete samples production, the crystalline nature of the tailings in terms of void less crystals or fragments of crystals, would have been responsible for the reduction in concrete pores and dense structure of the concrete samples containing iron ore tailings.

TABLE 2: PROPERTIES OF THE FRESH CONCRETE

Fresh Properties	**Concrete Samples**			
	CT0	CZT30	CLT40	CHT30
Slump [mm]	81	59	55	57
Compacting Factor	0.92	0.9	0.89	0.9

TABLE 3: PROPERTIES OF HARDENED CONCRETE

Concrete Samples	**Compressive Strength N/mm^2**		**Flexural Strength N/mm^2**		**Tensile Strength N/mm^2**	
	7	28	7	28	7	28
	(Days)					
CTO	27.2	35.4	3.0	4.5	2.8	3.5
CZT30	31.8	43.7	3.6	4.8	3.4	3.9
CLT40	33.5	42.5	4.2	5.2	3.5	3.6
CHT30	34.5	45.0	4.2	5.3	3.0	3.5

TABLE 4: ULTRASONIC PULSE VELOCITY OF CONCRETE

Property	**CT0**	**CZT30**	**CLT40**	**CHT30**
Ultrasonic pulse velocity Km/s	4.35	4.39	4.37	4.41

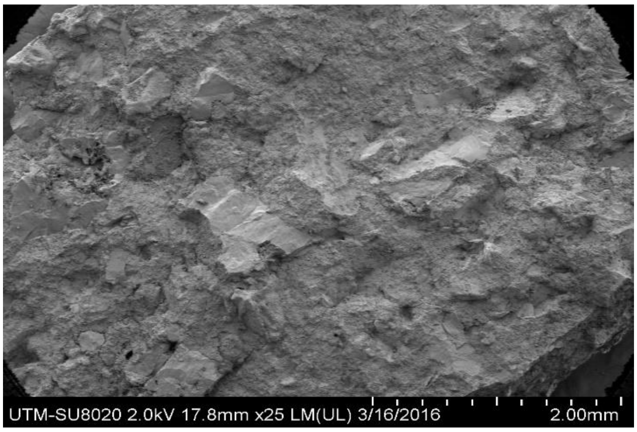

Figure 7: FESEM Morphology of conventional concrete

Figure 8: FESEM Morphology of HIOTs concrete

4 CONCLUSION

This study has brought to focus the utilization in concrete, of three types of iron ore tailings sourced from different locations. Based on the outcome of study, the tailings improved the mechanical properties of concrete. This is an indication that iron ore tailings can be used as fine aggregate in concrete for structural applications. Therefore the material rather than being discarded can be effectively utilized in making concrete.

Considering the performance of concrete containing iron ore tailings in terms of modulus of rupture and splitting tensile strength tests results, this research has revealed that, the tailings can be used in concrete to improve the tensile behaviour of concrete.

The field emission scanning electron microscopy morphology of the concrete samples further confirms the intimate combination between the aggregate interface and the cement paste, due to no transition zone and no feasible cracks around the aggregate in concrete containing the tailings. This suggest that, this concrete can find applications where dense and water resisting concrete are required, such as dam, swimming pool and water retaining tanks.

The pore structure of concrete samples containing iron ore tailings, also indicate that, the material is capable of satisfying the aesthetic requirement of concrete as well as improving the strength.

ACKNOWLEDGEMENTS

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