International Journal of Conceptions on Mechanical and Civil Engineering
Vol. 3, Issue. 2, August' 2015; ISSN: 2357 – 2760

Use of Iron ore Tailings as a Construction Material

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Abstract— **Urbanization and industrialization has caused tremendous problems to environment in the 21st century. Mining plays an important role in harnessing natural ore, but during this operation a lot of the waste is generated. Proper waste management and disposal of this waste is need of the hour so that it can cause minimal damage to the environment Iron ore tailings (IOT) are such waste produced during mining of iron from its ore. Use of IOT will help in finding a new construction material and also help in finding a proper solution for disposal of tailings. In the present study IOT procured from Tata Joda East Iron Ore, Odisha are used as a partial replacement of the fine aggregates. In this study, 15 – 20 % replacement is recommended which can save up to 20 % of fine aggregates and thereby reducing the cost of production and also reducing pollution of environment by using IOT and marching towards sustainable construction.**

Keywords- Iron ore tailings; Sustainable Construction;

I. OBJECTIVES

- Feasibility study of iron ore tailings as a construction material
- The effect of iron ore tailings on the property of concrete as a partial replacement of aggregate
- Effective disposal of iron ore tailings

II. INTRODUCTION

The past two to three decades have witnessed an enormous growth of construction industry in India. The consumption and demand of construction materials has resulted in the production of cement, aggregates and extraction of sand from rivers. The extraction of sand is having adverse effects on rivers, causing degradation of rivers. Some states like Maharashtra had recently banned the extraction of sand from river. Mining results in various environmental problems. Due to massive extraction of iron ore, it pollutes environment [1]. When iron in solution reaches the water table, it pollutes the ground water. Dissolved iron in surface water reacts with soil to cause soil erosion and affects the soil profile. Sometimes minor particles of iron spread in air cause air pollution. Open cast mining results in land sliding due to erosion and removal of top layer. Thus, mining results in soil erosion, formation of sinkholes, loss of biodiversity, and contamination of soil, groundwater and surface water by chemicals from mining processes [2]. For the disposal of tailings, tailing ponds are designed and constructed. Tailings are directly dumped to the ponds without any treatment,this dumping affects the soil quality adversely and the land becomes infertile.Concrete has been used since last century but there has been a tremendous rise in the use of the concrete in India due to industrialization and rapid growth of population. Concrete is a homogeneous material consisting of cement, natural aggregate, water and admixtures, of which aggregate constitutes around 80% of the constituents.Extraction of aggregate from water bodies and quarries leads to various environmental problems [3]. It is also important to make sustainable use of this aggregate. There are various legislation issues regarding extraction of aggregate from natural bodies so there is a dire need to find alternate materials which can be used as aggregate.

III. LITERATURE REVIEW

India is the one of the biggest iron ore producers and exporter in the world. The rapid growth in the surface mines led the production of Iron Ore tailings which remains as overburden. The safe disposal or utilization of such vast mineral wealth in the form of ultra- fine slime remains a major unsolved and challenging task. The rapid growth in production especially from large surface mines has caused ecological imbalance in their respective regions and has emerged as a main source of environmental hazards. Moreover, dumping causes loss of valuable land. Water pollution has occurred in respective region due to polluted ground water table.

In recent decades intensive research and development efforts have been directed towards finding cost effective and economic compatible solutions for minimizing and utilizing the waste produced in Iron Ore mining operations.

BN Skanda Kumar[1] used the IOT as replacement to fine aggregates in cement concrete pavements. The result showed that replacement of 40% IOT gives maximum compressive strength which is more than the reference mix. As the IOT percentage increases workability of mix reduces hence for better workability of concrete super plasticizer is recommended. The overall test result showed that IOT replaced concrete can be used for pavements and recommended for village roads traffic loads.

In the Kogi state of Nigeria T.I. Ugama[2] studied the effect of tailings on the properties of concrete by replacing sand with IOT. The mix with only sand as fine aggregates served as the control mix, while sand was replaced in the other mixes by 20%, 40%, 60%, 80% and 100% Tailings. Based on the experimental investigation they also concluded that increasing percentage of tailing reduces the workability of concrete. IOT performed better in terms of splitting tensile strength in concrete than that of control mix. Hence they concluded that by limiting IOT to 20% (optimum) tailings can be used in concrete.

Mangalpady Aruna[3] used the tailings as the partial replacement to the sand and quarry dust in the manufacture of paving blocks. The blocks that manufactured using quarry dust and Tailings resulted in higher compressive strength at 28 days without much change in water absorption.

Dr. Premakumar W.P [4] performed the experimental work by replacing sand partially or completely with IOT and concluded that due to sand replacement the compression strength increases by about 40% as compared to normal concrete and the flexural strength of reinforced concrete beam is in no way impaired by replacement of sand by IOT. Hence the sand in cement concrete may be replaced by IOT in concrete production without compromising on strength and it greatly reduces the water and land pollution that could otherwise have occurred due to dumping of IOT on land.

Mohan Yelli Shetty [5] examined the stability for reuse of IOT waste in construction. Paper concluded that the particle sizes between 12.5 to 20 mm are suitable for use in concrete.

The possibility of making construction bricks by using hematite tailings from China was investigated by Yonglian Chen [6]. The result showed that the percentage of tailings used in the bricks could come up to 84% (optimum) of total weight and the recommended mass ratio was Tailings : clay : fly ash = 84 : 10 : 6 with a 12.5- 15% forming water content and 20-25 N/mm^2 forming pressure.

IV. METHODOLOGY AND MATERIAL

For the present study, the following material was used.

A. *Cement*

Type 1 Ordinary Portland Cement of 53 grade (Ambuja cement) Conforming to IS 12269-1987.

B. *Coarse Aggregate*

Coarse aggregate passing 20 mm and retained on 4.75 mm IS sieve.

C. *Fine Aggregate*

Natural river sand obtained from the Gujarat with particle passing 4.75 mm IS Sieve and retained on 75μ IS Sieve.

D. *Tailings*

Tailings are the materials left over after the process of separating the valuable fraction from worthless fraction of the Ore. Here the IOT are collected from the mining area of Tata Joda East Iron Ore, Odisha. 5-30 % of the Iron Ore Tailing is used as replacements for fine aggregates.

E. *Admixtures*

Admixtures are materials added to increase the workability of the concrete. In the study water reducing admixture PARPLASTSC240 is used supplied by Par Speciality Polymers Pvt. Ltd**.** It meets the requirement of IS: 9103-1999. It is a Sulfonated Napthalene Formaldehyde base admixture. The proportion of the admixture used is 300ml / 50 kg of cement in all the mixes.

F. *Water:*

Potable water used in the study to have a proper mix and proper hydration of the cement take place.

Methodology:

In this study ten concrete mix proportions were made. M25 concrete is made of proportion 1:1:2 (cement: sand : coarse aggregate).The first mix is control mix with zero replacement of tailing , while the other 9 replacement ranging 5, 7, 10, 13, 15, 17, 20, 25 and 30 percent of the fine aggregates. The proportions of the concrete mixes are as follows:

TABLE I. PROPORTION OF CONCRETE MIXES

Sample No	Cement	Sand	Tailings	Coarse Aggregate
A	1	1	0	2
B	1	0.95	0.05	2
C	1	0.93	0.07	2
D	1	0.9	0.1	2
E	1	0.87	0.13	2
F	1	0.85	0.15	2
G	1	0.83	0.17	2
H	1	0.8	0.2	2
I	1	0.75	0.25	2
J	1	0.7	0.3	2

V. PREPARATION OF SAMPLE

A. *Concrete block*

A set of 3 cubes was cast for each percent replacement of IOT as well as for the control mix. The sizes of concrete block selected were 15x15x15 cm [7] and were cured for 28 days in water.In each set, slump cone test was performed to check the workability. Compression test was performed on the each set to check the strength of the concrete casted.

B. *Cylinders*

The size of cylinder selected is 15cm in diameter and 30 cm long [7] for each % replacement a set of 3 cylinders cast & same cured for 28 days in water at normal temperature. The test performed on each cylinder are split tension test and Modulus of Elasticity.

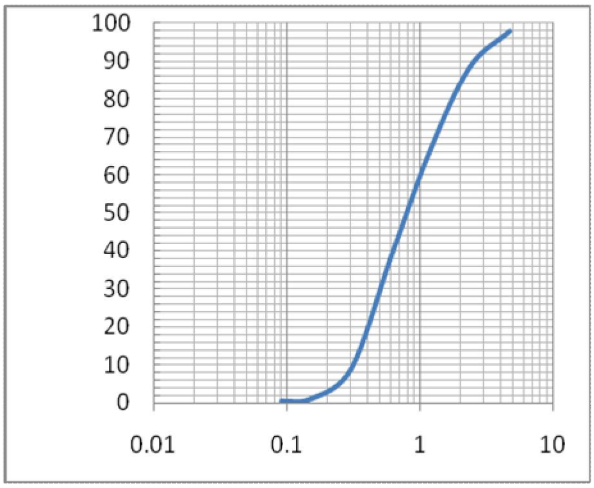
C. Abrasion Blocks

Abrasion block of size 7.5x7.5x3.5 cm prepared & same cured for 28 days in water at normal temperature.

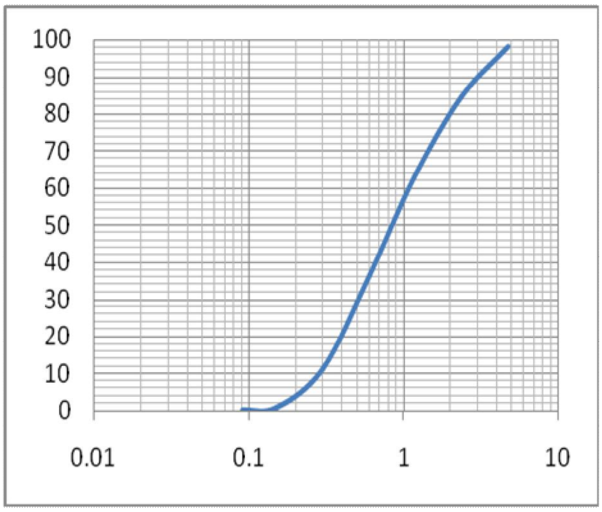
VI. RESULT AND ANALYSIS

The laboratory test involving Sieve analysis compressive strength, tensile strength, workability, abrasion and dynamic modulus of elasticity is presented in the tabular forms.

Sieve analysis test was carried out on fine aggregate and 20 % replacement sample to find particle size distribution and S-curve.



A. Figure 1. S-curve sand

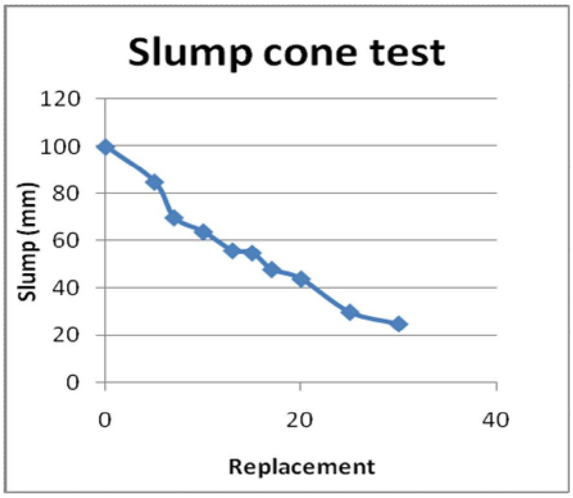


B. Figure 2. S-curve (20% Replacement of IOT)

Workability of the mixes was measured by using slump cone test.

TABLE II. SLUMP VALUE

Sample No	% Replacement	Slump value (mm)
A	0	100
B	5	85
C	7	70
D	10	64
E	13	56
F	15	55
G	17	48
H	20	44
I	25	30
J	30	25



C. Figure 3. Slump value

Compression test, Split Tension test and abrasion test is carried out on each set of concrete blocks. The test carried out on 28th day from casting. The result obtained is represented in table and graphical form.

Table III.COMPRESSIVE STRENGTH

Sample No	% Replacement	Compressive strength (N/mm^2)
A	0	41.87
B	5	37.48
C	7	37.48
D	10	38.82

E	13	38.75
F	15	39.17
G	17	40.07
H	20	44.64
I	25	40.76
J	30	40.2

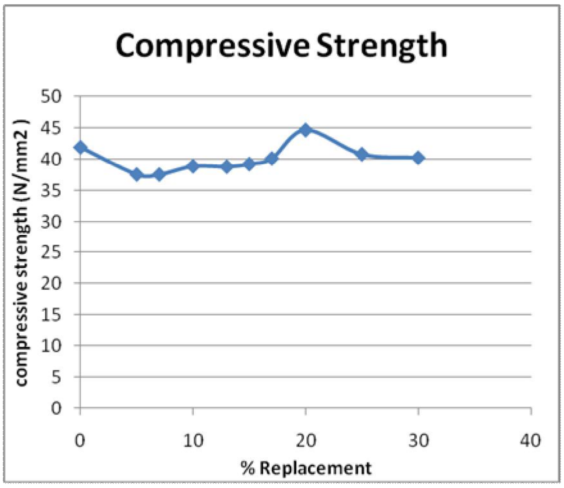


Figure 4. Compression Strength Comparison

Table IV.TENSILE STRENGTH

Sample No	% Replacement	Tensile Strength(N/mm^2)
A	0	3.06
B	5	2.34
C	7	2.43
D	10	2.67
E	13	2.92
F	15	2.72
G	17	2.64
H	20	2.75
I	25	2.46
J	30	2.49

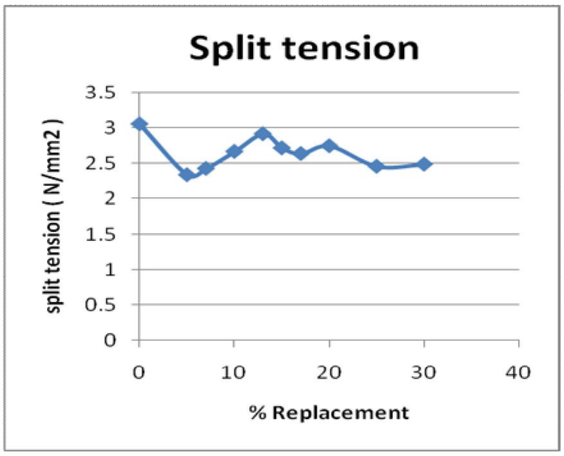


Figure 5. Tensile Strength Comparison

Table V.ABRASION

Sample No	% Replacement	Abrasion (mm)
A	0	0.2911
B	5	0.4179
C	7	0.1937
D	10	0.3377
E	13	0.3839
F	15	0.2363
G	17	0.3107
H	20	0.5030
I	25	0.3225
J	30	0.5113

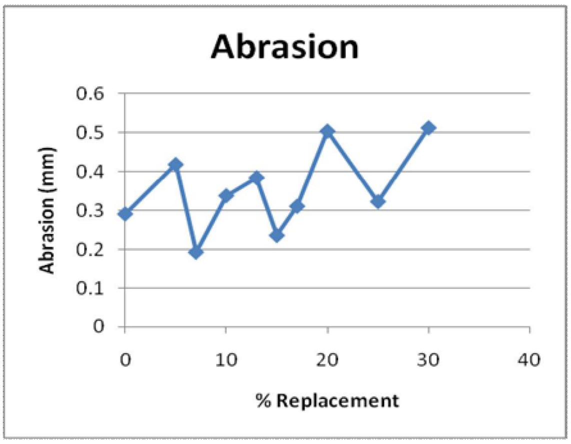


Figure 6. Abrasion Comparison

Table VI. E-Value

Sample No	% Replacement	E-Value(Gpa)
A	0	40.1
B	5	37.2
C	7	33.6
D	10	37.9
E	13	37.9
F	15	37
G	17	33.7
H	20	32.7
I	25	31.5
J	30	31.9

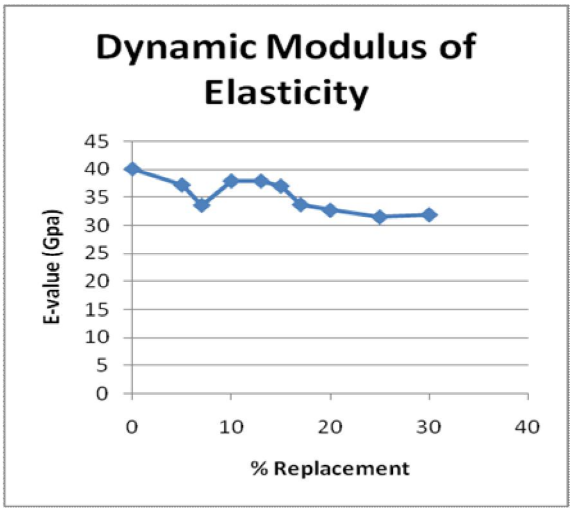


Figure 7. E-Value Comparison

Analysis:

G. *Compressive Strength*

M25 grade concrete was cast in all the mixes including the control mix. The design strength of the concrete is 32.25N/mm^2.It was observed that all the mixes achieved the target strength, the highest being with 20 % replacement getting 44.47N/mm^2.

H. *Tensile Strength*

It was observed that all the mixes had almost same tensile strength, the range varying between 2.33-2.9 N/mm^2. The control specimen had strength 3.07 N/mm^2.

I. *Workability*

Admixture used in all the mixes including the controlled specimen was 300 ml/50kg of cement. There was a linear proportion in results. As the proportion of the tailings increased, the workability decreased.

J. *Abrasion*

Abrasion of all the mixes including the control was almost same ranging between 0.1937 to 0.5313 (0.1937mm for 7 % replacement and 0.5313mm for 30 % replacement).

K. *E-Modulus*

There wasn't much variation in E value of control and mixes, ranging from 40.1 GPa of control to 31.9GPa of 30 % replacement and 37.9 GPa for 13 % replacement.

VII. CONCLUSION

From the above result and analysis the following can be concluded

1. Concrete with iron ore tailings is a sustainable solution as it reduces sand by as much as 15% by iron ore tailings in concrete
2. As compared with control mix, important properties such as workability, compressive strength and elastic modulus are well within the range that it can be used in construction and not compromised so IOT concrete can be used.
3. Iron ore tailings are a waste material being dumped in open land, the use of waste material makes it Green Concrete.

Can be successfully used for constructing low volume rural roads, minor/small residential structures etc.

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