Studies on Gold Ore Tailings as Partial Replacement of Fine Aggregates in Concrete

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Abstract: **River sand is becoming scarce and meeting the demand of fine aggregates in the construction industry is becoming a challenging task. In this investigation an attempt is made to utilize gold ore tailings as a partial substitute for river sand in producing concrete. River sand is replaced with 5%, 10%, 15%, 20% and 25% gold ore tailings and the resulting fine aggregates were used in concrete mix and it is compared with conventional concrete. Mix proportions for M_{20} concrete were obtained for five mixes as per guidelines given in IS: 10262-2009. Workability, compressive strength and flexural strength are reported. The strengths were obtained at the ages of 3, 7 and 28 days. Compressive and flexural strength increased marginally from 5% to 15% replacement. There is a slight decrease in the corresponding compressive and flexural strengths at 20% replacement. Good correlation was observed between compressive strength and flexural strength. It was observed that the addition of gold ore tailings that would replace the fine material at particular proportion has displayed an enhancing effect on mechanical properties of concrete. This investigation proves that gold ore tailings can be used as a partial substitute for river sand in preparing concrete.**

Keywords: **compressive strength, flexural strength, Gold ore tailings, workability.**

I. INTRODUCTION

Concrete is widely used material in the world. Based on the global usage, it is placed at second position after water. Fine aggregates are the essential component of concrete. The most commonly used fine aggregate is natural sand or pit sand. The global consumption of natural sand is very high due to extensive use of concrete.

Gold ore tailings are one of the primary waste products of mining operations. They comprise of fine grained particles of the parent rock from which the ore is extracted. The characteristics of tailings depend upon the composition of parent rock. The disposal of this material is a major environmental problem for the mining industry. Tailings when not utilized it will cause harm. When tailings waste is in dry state, can fly everywhere as tailings grain is very fine. It can damage human health and disrupt agriculture. Gold ore tailings are discharged into the tailings pond after a chemical treatment to remove free cyanide and other heavy metals. When tailings disposal is in the form of mud into the reservoir, treatment costs are huge. We have to build dam to accommodate the tailings slurry, environmental pollution due to seepage and dam maintenance after the ore is closed. Tailings disposal in the deep sea can pollute the environment due to the control that is not easy. Disposal of gold ore is one of the major problems in mining industry. Gold ore tailings are a common type of solid waste in KGF and have caused serious problems as landfill.

The gold mining industry at Kolar Gold Field, Kolar district of Karnataka, India has produced an abundant quantity of tailings which are unutilized for several years. There is no vegetation on dumps, which leads to release of fine particles into the atmosphere due to wind erosion. This causes air pollution in the area. The tailings have affected the landscape and topography of the area as well. Hence, it is essential to find some way to use the gold ore tailings.

This study has initiated to assess the suitability of gold ore tailings as partial substitute for fine aggregate in concrete. The evaluation was based on parameters such as gradation results, workability, compressive strength and flexural strength.

II. SCOPE OF PRESENT STUDY

In this study, concrete of M_{20} grade was obtained and the mixtures were modified by partially replacing river sand with gold ore tailings. The properties of concrete in the fresh and hardened state examined are workability and strength respectively. The workability of concrete mixtures was evaluated in terms of slump and compaction factor tests. The strength of concrete was evaluated in terms of compressive, flexural and splitting tensile strength.

III. COLLECTION OF SAMPLES

The gold ore tailings were collected from the dumps of Kolar Gold ores, Karnataka, after removing the grass and other weeds from the top surface.

IV. MATERIAL PROPERTIES

4.1 Gold Ore Tailings

The suitability of the material was determined by analyzing particle size distribution, specific gravity and chemical composition. The particle size distribution of gold ore tailings was evaluated as per IS: 383-1970 and conforms to Zone – II.

The chemical compositions of gold ore tailings were evaluated and are shown in Table 1.

Parameters	Result in %
SiO2	40.5
sAl_2O_4	0.5
P2O5	0.09
$K2O_4$	16.1
Cu	2.55ppm
Pb	0.04
As	<0.01
CN	Nill
SO3	0.05
S04	0.5
CaO	14.96
MgO	6.97

4.2 Fine Aggregates

Natural river sand is used as fine aggregates. The properties of fine aggregates are determined by conducting tests as per IS specifications.

4.3 Coarse Aggregates

Crushed granite obtained from machine crusher is used as coarse aggregate. The aggregate used is 20mm and downsize. Coarse aggregates conform to SSD condition.

4.4 Cement

OPC 53 grade conforming to IS: 8112-1989 is used.

The preliminary tests conducted and results obtained are tabulated as shown in table 2.

V. METHODOLOGY

The experimental work is broadly classified into three stages, namely

a) Sieve analysis

b) Evolving mix proportions

c) Strength studies

5.1 Sieve Analysis

The main objective of the investigation is to partially replace natural sand with quarry dust and study the behavior of concrete in the fresh and hardened state. The materials used for the investigation is first sieved and grading of aggregates is carried out then the zone value is obtained. Natural sand replaced with gold ore tailings at an interval of 5% up to 25%.

5.2 Mix Proportions

Water cement ratio is an important factor in the process of mix proportioning. Primary requirement of good concrete is satisfactory compressive strength in its hardened state. Many of the desirable properties like durability, impermeability and abrasion resistance is highly influenced by the strength of concrete. The strength can be considered to be solely dependent on water cement ratio for low and medium strength concrete mixes. Workability of concrete varies with water cement ratio and quantity of cementitious material. In this investigation, Mix proportions for M_{20} concrete were obtained as per the guidelines given in IS: 10262-2009. The proportions for concrete containing river sand, gold ore tailings and their combinations with water cement ratio of 0.5 is obtained as 1:1.72:3.19.

Table2: Preliminary Test Data

Preliminary Test Conducted	Result
Standard consistency test	36%
Initial setting test	35 min
Final setting time	6 Hours
Specific gravity of cement	3.09
Soundness of cement	0.3 cm
Specific gravity of fine aggregate	2.57
Specific gravity of coarse aggregate	2.676
Specific gravity of gold ore tailings	2.88
Fineness modulus of fine aggregates	2.67 (Zone III)
Fineness modulus of coarse aggregates	7.19
Fineness modulus of gold ore tailings	2.84 (Zone II)

5.3 Strength Studies

5.3.1 Compressive Strength

Standard moulds of 150mmx150mmx150mm size are used for casting concrete cubes. The cubes were compacted in three layers. Nine concrete cubes were casted for each mix. A total of forty five concrete cubes were casted. Cubes were immersed in water for curing till the date of testing. The specimens were prepared as per IS: 516-1989 and tested for uniaxial compressive strength at 3, 7 and 28 days. The results obtained are the average of three specimens tested and the results are presented in Table 3.

Table 3: Compressive strength with age

% of replacement of GOT	Slump in mm	Avg. Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
0	40	19.64	23.99	29.92
5	35	20.22	25.33	32.44
10	35	20.96	29.41	34.29
15	30	22.00	30.15	35.26
20	25	19.63	22.74	30.00
25	25	15.56	19.33	24.81

5.3.2 Flexural strength

Standard moulds of section 150mm x 150mm and length 700mm were used for casting beams. Nine beams were casted for each mix. The specimens were prepared as per IS: 516-1989 and tested for flexural strength at 28 days. Two point loading test was conducted using Universal Testing Machine (UTM) of 400KN capacity. The results obtained are the average of three specimens tested and the results are presented in Table 4.

Table 4: Flexure strength value at 28 days

% of replacement	Workability (Slump in mm)	Avg. Flexural Strength (N/mm2)
0	40	5.63
5	35	5.69
10	35	6.275
15	20	6.34
20	25	5.92
25	25	5.5

VI. RESULTS

Compressive strength and flexure strength variation is as shown in figure 1 and figure 2.

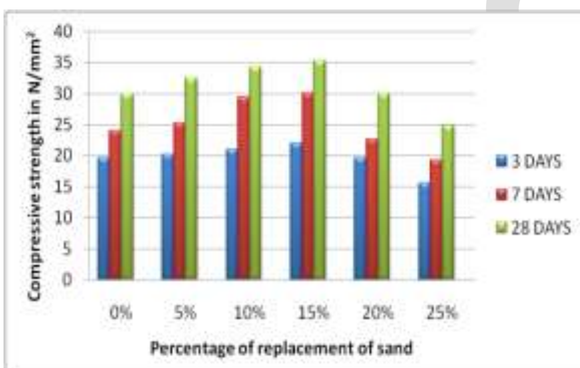

Figure 1: Graph of variation of compressive strength with age

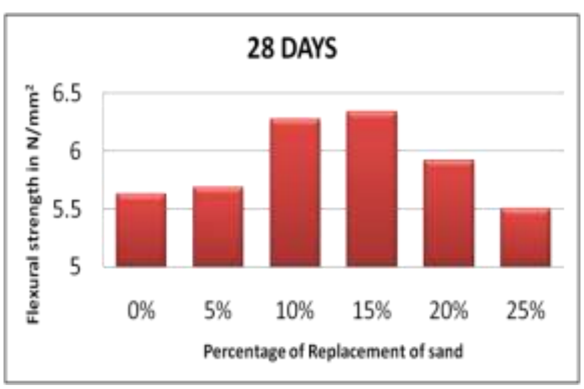

Figure 2: Graph of variation of Flexural strength value at 28 days

VII. CONCLUSIONS

In this experimental investigation, an attempt has been made use Gold Ore Tailings to replace the fine aggregates in concrete.

Following are some of the conclusions drawn from the results of this investigation:

1. Gold ore tailings are the finer materials which can reduce the voids in concrete.
2. Up to 20% replacement of fine aggregates by gold ore tailings, the results obtained are satisfactory.
3. From the above results 15 % replacement of GOT gives high Compressive and flexural Strength.
4. Kolar Gold Fields of Karnataka have 33 million tons of gold waste which can be utilized in construction resulting in conservation of around 19.8 million tons of sand and reduction in pollution.
5. By using these wastes instead of conventional materials, which would not only be preserving the natural precious resources, but also solving the problems of disposal of waste, which has become a problem.
6. Construction of buildings from ore waste is eco-friendly as it utilizes waste and reduces air, land and water pollution. It is energy efficient and also cost effective.
7. There is large scope for utilizing ore wastes for the manufacture of building materials and products. This ore wastes are used as fine aggregates in concrete can meet the demand for next few decades.

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