Partial Replacement of Fine Aggregate with Iron ORE Tailings & Glass Powder

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Abstract

Iron ore tailings are a common type of hazardous solid waste in India and have caused serious environmental problems and Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing, The safe disposal or utilization of such wastes remains a major unsolved and challenging task. Due to the high material consumption of the construction industry, the utilization of both iron ore tailings and crushed glass wastes as a partial replacement for fine aggregate in structural concreate is partially attractive. Iron ore tailings and crushed glass wastes have the potential to be used as fine aggregate because they are relatively inert and particle size of these wastes material is larger than that of the cement. This study aims to investigate the use of both iron ore tailings and crushed glass wastes to replace natural sand as fine aggregate and studied the impact that various replacement levels had on the mechanical properties of concreate.
Keywords: Iron ore tailings, Crushed glass, Compressive strength, Flexural strength

I. INTRODUCTION

As our standard of living is continually improving, the demand for natural resources has also continued to increase and more and more industrial wastes have been produced. In order to alleviate environmental pressures and attain sustainability, one feasible solution is to reuse waste materials as secondary resources. In this regard, the concrete industry has already absorbed millions of tons of industrial by-products that contain toxic elements. The iron and steel industry is one of the major industries in India. It has developed rapidly since India's reform and opening-up policy was implemented three decades ago. While it has produced great economic benefits, it has also resulted in the generation of a huge amount of industrial by-products. These untreated tailings not only occupy large amounts of land, pollute water resources and the air but also pose threat to human beings' safety.

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and $CaCO_3$ at high temperature followed by cooling where solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling. The use of recycled glass saves lot of energy and the increasing awareness of glass recycling speeds up focus on the use of waste glass with different forms in various fields. One of its significant contributions is the construction field where the waste glass was reused for concrete production.

Effective use of iron ore tailings and crushed glass as replacement for fine aggregates in concrete reduce the disposal problem of these wastes and cost of construction.

In this study, an extensive experimental work was carried out to find the suitability of use of these wastes in concrete with 0%, 10%, 20%, 30%, and 40% of replacement with both iron ore tailings and crushed glass. Nominal concrete approximately equal to the conventional concrete.

II. MATERIALS

A. *Cement*

Portland Pozzolana cement (Shankar Cement) conforming to IS: 12269-1987 is used in the present studies. The tests performed on this cement according to IS: 40311998 is summarized in table I.the specific gravity of cement is found to be 3.13.

Table – 1
Properties of Cement

DESCRIPTION	*VALUE*
FINENESS	*6.6 %*

STANDARD CONSISTENCY	34 %
INITIAL SETTING TIME	55 minutes
FINAL SETTING TIME	320 minutes
DENSITY	3.13 Kg/cm^3
SPECIFIC GRAVITY	3.13

B. Coarse Aggregates

Coarse aggregates are those which are retained on IS sieve size 4.75 mm. Crushed stone angular metal of 20 mm size from a local source was used as coarse aggregate. The specific gravity were found to be 2.82. The properties of coarse aggregate is summarized in table II.

Table – 2
Properties of Coarse Aggregate

DESCRIPTION	VALUE
SPECIFIC GRAVITY	2.8196
WATER ABSORPTION	0.05 %
FINENESS MODULUS	7.08
BULK DENSITY	1.49 Kg/l
IMPACT VALUE	27.045 %
AGGREGATE CRUSHING VALUE	24.39 %

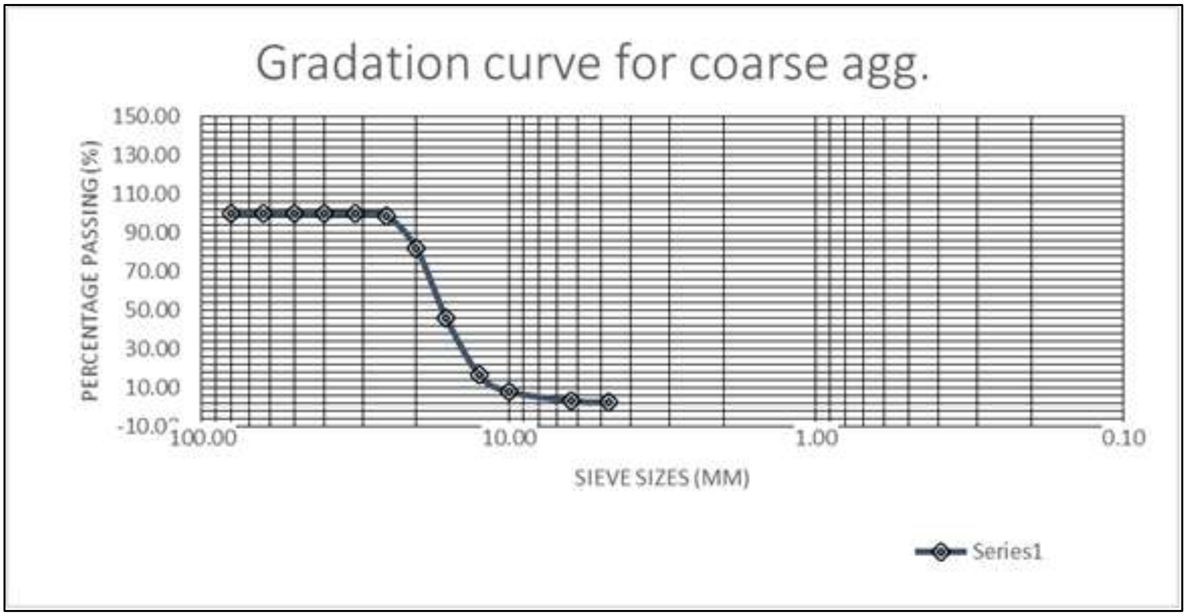

Fig. 1: Gradation Curve for Coarse Aggregate

C. Fine Aggregates

1) Iron ORE Tailings

Iron ore tailings used in this experimental work was obtained from Aceller steels pvt. LTD, Angamaly. Iron ore tailings was obtained as a by-product of iron ore mining. Mean particle size is about 0.003-0.05 mm, spherical particles, greyish black colour. The specific gravity, fineness modulus, and density of IOT-s are 3.21, 4.324, 1.43 Kg/L respectively.The properties of iron ore tailings is summarized in table III.

Table – 3
Properties of Iron Ore Tailings

DESCRIPTION	VALUE
SPECIFIC GRAVITY	3.21
BULK DENSITY	1.43 Kg/l
COLOUR	BLACK
FINENESS MODULUS	4.324

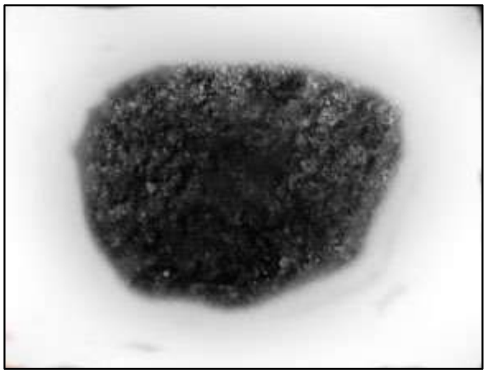

Fig. 2: Iron Ore Tailings

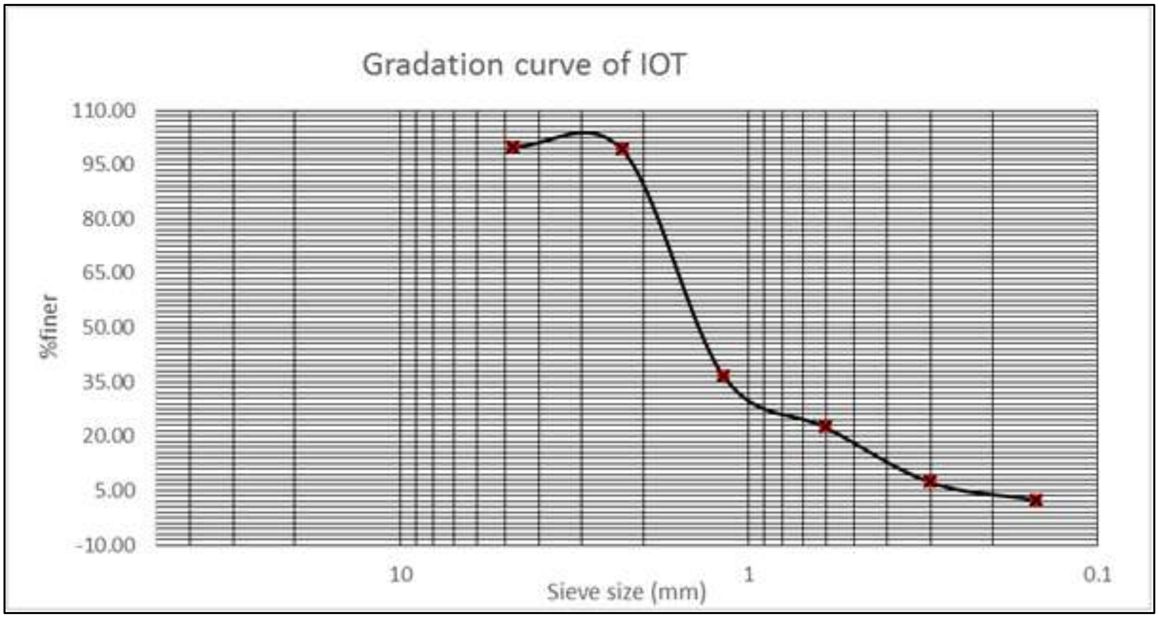

Fig. 3: Gradation curve for Iron Ore Tailings

D. Crushed Glass

Crushed glass used in this experimental work was obtained from demolished buildings. Glasses will be available in various forms. Specific gravity as well as fineness modulus of glass powder is 2.5 and 46 respectively. Glass is one of the oldest man-made materials. It is produced in many forms such as packaging or container glass, flat glass, and bulb glass, all of which have a limited life in their manufactured forms and therefore need to be recycled so as to be reusable in order to avoid environmental problems that would be created if they were to be stockpiled or sent to landfills.

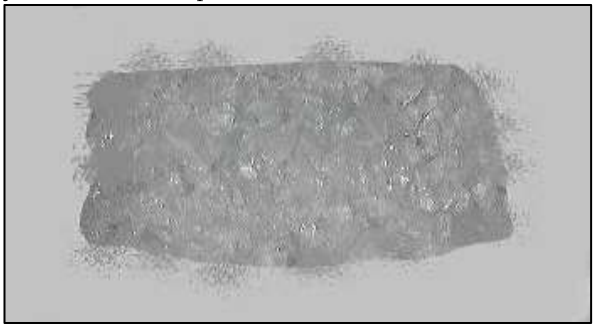

Fig. 4: Crushed Glass

E. M Sand

Locally available M-sand having fineness modulus 4.212, specific gravity 2.68 and conforming to grading zone-II as per I.S: 383 - 1970. Coarse aggregate is of angular shaped crushed granite with maximum size 20mm and its fineness modulus and specific gravity are 7.08 and 2.956 respectively. Potable water with pH value 7.15 was used for the concrete. Properties of m sand is summarized in table IV.

Table – 5
Properties of M Sand

DESCRIPTION	*VALUE*
SPECIFIC GRAVITY	*2.68*
BULK DENSITY	*1.767 Kg/l*
WATER ABSORPTION	*10.344 %*
FINENESS MODULUS	*4.212*

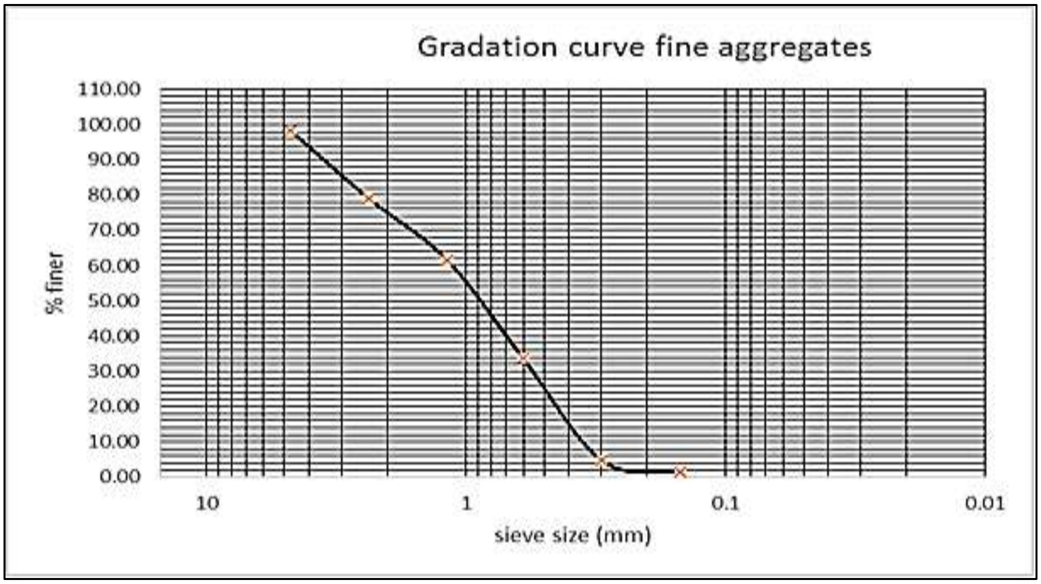

Fig. 5: Gradation Curve for M sand

III. EXPERIMENTAL WORK

A. *Mix design of concrete:*

The concrete mix is designed as per IS 10262 –2009, IS 456-2000 for the normal concrete. The grade of concrete which we adopted was M25 with the water cement ratio of 0.45. The mix proportions used for concrete are 1:1.7:2.5.(M2).

Table – 5
Mix Proportions

SL.N0.	*MIX*	*NO.OF CUBES*	*COMPRESSIVE STRENGTH (N/mm^2)*	
			7 days	*28 days*
1.	*M1*	*3*	*28.85*	*32*
2.	*M2*	*3*	*24.5*	*33.1*
3.	*M3*	*3*	*18.64*	*27.6*

B. *Test Specimen*

Cubes of size 150mm X150mm X150 mm were prepared using the standard moulds. The samples were casted using the five different percentage of fine aggregate mix proportions (0%, 10%, 20%, 30%, &40%). The samples were demoulded after 24 hours from casting and kept in a water tank for7 & 28 days curing. A total of 30 specimens are casted for testing the properties such as compressive strength. The details of the specimen and their notations are given below in table VI

Table – 6
List of Specimens

SL.NO	*Description*	*% REPLACED*
1.	*Mix 1*	*10 %*
2.	*Mix 2*	*20 %*
3.	*Mix 3*	*30 %*
4.	*Mix 4*	*40 %*

Fig. 6: Test Specimens

IV. RESULTS AND DISCUSSIONS

The results of fresh properties of concrete such as slump are determined and hardened properties such as Compressive Strength are presented and discussed below.

A. Rheology of Concrete

Fresh Concrete or Plastic Concrete is a freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregate and water mixed together to control the properties of concrete in the wet state as well as in the hardened state.

B. Compressive Strength

The cube specimens were tested in Compression Testing Machine as given in annexure3 after specified curing period for different percent of IOT replacement Mix1(10%IOT),Mix2(20%IOT),Mix3(30%IOT) and Mix4(40% IOT) and for normal concrete mix. The compressive strengths after respective curing periods are noted in table VII.

Table – 7
Compressive Strength

Mix	*Compressive strength (N/mm^2)*	
	7 days	*28 days*
Mix 0	*24.4*	*31.3*
Mix 1	*20.5*	*24.1*
Mix 2	*24*	*29*
Mix 3	*19.96*	*33.1*
Mix 4	*17.3*	*27.4*

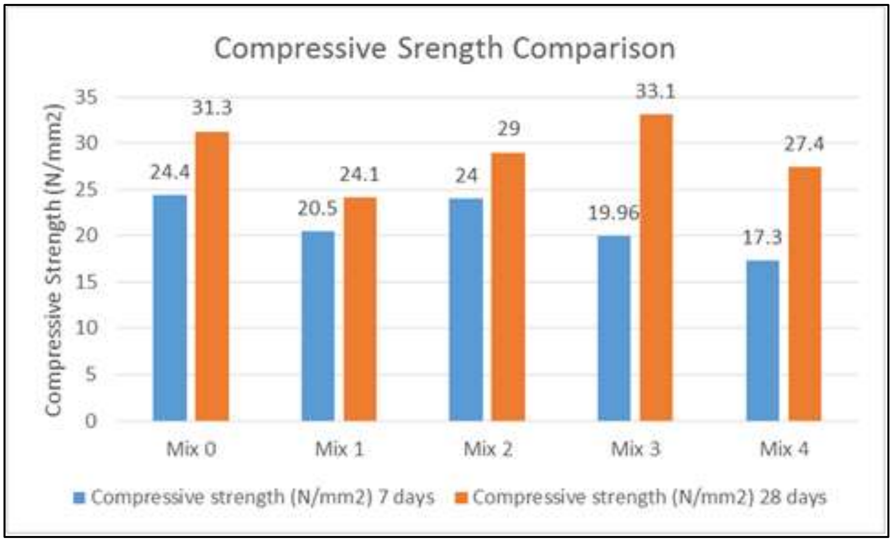

Fig. 7: Compressive Strength Comparison

V. DISCUSSION COMPRESSIVE STRENGTH

Table 5, shows the Compressive strength of concrete mixes made with and without fine aggregate replacement was determined at 7 days as well as 28 days. It was found that Compressive strength of concrete for mix 1, mix 2 is 20- 30% range and for mix 3 we have the optimum strength and it is 33.1N/mm^2 , for mix 4 it is found to be decreasing. Thus the optimum replacement is found to be within 30 % of IOTS + 30% of crushed glass replacement.

The results obtained from compressive strength tests at both 7 and 28 days appear to display inconsistent results. After 7 days of testing, compressive strength for the sample containing 20% glass and IOT aggregate replacement achieved a compressive strength 1.6% lower than the normal mix. Likewise, 28 day compressive strength for specimens containing 30% waste glass and IOT was 5.8% higher than that for 0% replacement. The compressive strength obtained for the sample with optimum level of replacement achieved higher compressive strength than the control. As such it is suggested that the discrepancies noted are due to variations in the properties of concrete specimens and as such do not diminish the validity of the identified trend.For the control set, the test results indicated that 28 day compressive strength increased 5% above the design value of 31.6 N/mm^2.

After careful scrutiny, it was concluded that the increase in compressive strength was due to the high quality of cement rather than experimental or equipment errors. Therefore the following observations and conclusions can still be drawn

The workability of concrete followed a decreasing trend with the addition of fine glass aggregate and IOT, due to the angular nature of the these particles. Despite this trend, the concrete was deemed workable and was within the specified tolerance intervals. The optimum percentage replacement of sand with fine glass aggregate and IOT was determined to be 30%.

VI. CONCLUSION

From the above findings, the following conclusions may be made out of the study:

– While using combination of iron ore tailings and crushed glass as fine aggregate replacement, 28 d strength is found to marginally increase up to 30% replacement level.
– Marginal decrease in strength is observed at 30 to 40% replacement level of IOT's and crushed glass with fine aggregate.
– Iron ore tailings as well as crushed glass can effectively be used as fine aggregate replacement.
– As percentage of replacement increases compressive strength decreases.
– The optimum replacement level for replacement is found to be at 30%.
– Compressive strength was found to increase with the addition of waste glass and IOT to the mix up until the optimum level of replacement. This can be attributed to the angular nature of these particles facilitating increased bonding with the cement paste.
– In proportions exceeding 30%, waste glass and IOT was found to negatively impact the development of compressive strength. It is suggested that in larger quantities, the angular nature of the glass aggregate reduces available cement paste and leads to the formation of microscopic voids within the concrete matrix.
– Thus these waste materials can be used for construction works, like small road pavements, small/minor residential buldings.

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