Replacement of Fine Aggregate by Iron Ore Tailing (IOT) in Concrete for Sustainable Development

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Abstract. An increase in iron ore processing to meet the global demand has resulted in the generation of billions of tons of iron ore tailings (IOT). Also, the increase in construction activities has led to the over exploitation of river beds for sand. In this present study, fine aggregates are replaced by iron ore tailings in M20 grade concrete at varying percentages of 20%,30%,40%,50%,60%. The cubes and cylinders were casted and their compressive strength and split tensile strength were evaluated for 7 days and 28 days. It is observed from the test results that the iron ore tailings aggregate concrete exhibited a good mechanical strength compared to the control mix. The compressive strength has increased with the increase in replacement of iron ore tailings in concrete, which has shown an improvement of 18.41% over conventional aggregate concrete. An incremental increase of 10.3 % was observed in the case of split tensile strength for 60 % replacement of fine aggregate with iron ore tailings.

1. INTRODUCTION

Huge amount of mine tailings was generated worldwide due to the exploration, excavation, blasting, beneficiation and extraction of mineral ores. Every year million tons of Iron ore tailings (IOT) which is a by-product of iron ore processing are disposed in landfills, quarries, rivers, oceans which in turn creates environmental problems. In past decades the uncontrolled extraction for fine aggregates has adversely affected the environment and natural resources. The disposal of IOT in open-air contaminates the land, pollutes the environment, water and even threatens human health owing to its toxicity. The IOT can be considered as an alternative for sand in concrete which also minimize environmental problems, cost and natural resources depletion [1,2].

The IOT has a higher percentage of fine particles and a lower percentage of medium to coarse sand than the NS. IOT is angular and irregular in shape and has a rough and porous surface. The presence of IOT as an alternate material for cement or natural sand considerably affects the fresh properties of concrete. It can be used as a partial or full replacement of fine aggregate in concrete. And the slump value of concrete decreases with

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the increase of IOT content. The workability of IOT concrete is negatively affected mainly due to the small particle size compared with natural sand. The compressive strength increases with a low IOT content due to the filling effect of IOT and decrease when the IOT content exceeds the optimal replacement ratio. [2] Iron is considered as one of the fundamental metallic elements, playing an essential role in modern civilization. During the extraction process of the iron mineral from ore, abundant amount of iron ore tailings (IOT) is generated in separation process[3].

Sandy iron ore tailing can be considered as a replacement for natural sand in concrete production but this substitution is limited due to the fine granulometry.[4] The physical properties of the tailings have a significant impact on the workability, density, dimensional stability, strength, and durability of the concrete. The physical properties of the tailings have a significant impact on the workability, density, dimensional stability, strength, and durability of the concrete [5,6]. It is estimated that 400 kg of tailings is produced for each ton of beneficiated iron ore. This means there is a huge volume of tailings dumped from industrial plants over the years [7]. If mine tailings are considered as a partial or complete replacement of natural aggregates in concrete, majority of these tailings could be recycled and used sustainably, by turning these mine tailings into useful resource and providing cheaper alternatives in concrete production. [8]

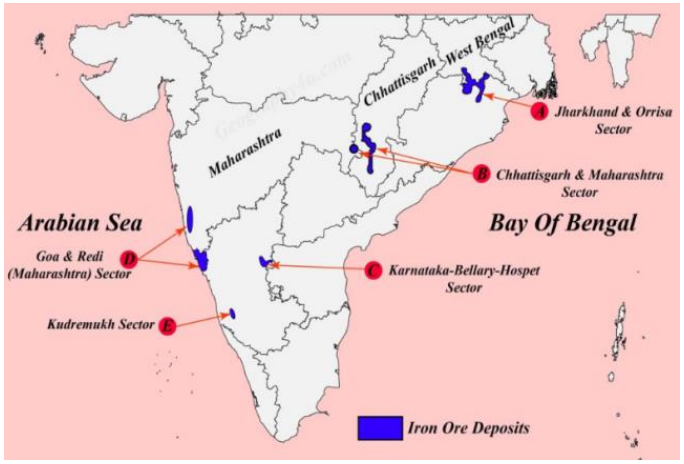

Fig:1 Major Iron ore deposits of India

2. MATERIALSANDMETHODOLOGY

2.1. Materials

Ordinary Portland cement of grade 43 which is available in market were used. River sand were used as fine aggregates for the study. Coarseaggregatesarethose passing through 20mm whichareretainedonISsievesize 4. 75mm.

2.2 IronOreTailings (IOT)

In presentstudy the Iron ore tailings collectedfromHospetSteelsPvtlimited. The Physical properties and chemical composition of the iron ore mine tailings weretestedand tabulated in table 1 and table 2. The particle size distribution curve for Iron ore tailings and the fine aggregates are plotted in fig :2

Table1 PhysicalPropertiesof the Iron Ore Tailings**.**

Tests	Result
Specific Gravity	2.65
Fineness modulus	2.79
Coefficient of uniformity, CU	20.54

Table2 Chemical Composition of Iron Ore Tailings

Composition	**Percentage**
Fe_2O_3	57.57
SiO_2	9.59
Al_2O_3	6.46
MgO	0.65
Loss of Ignition	2.23

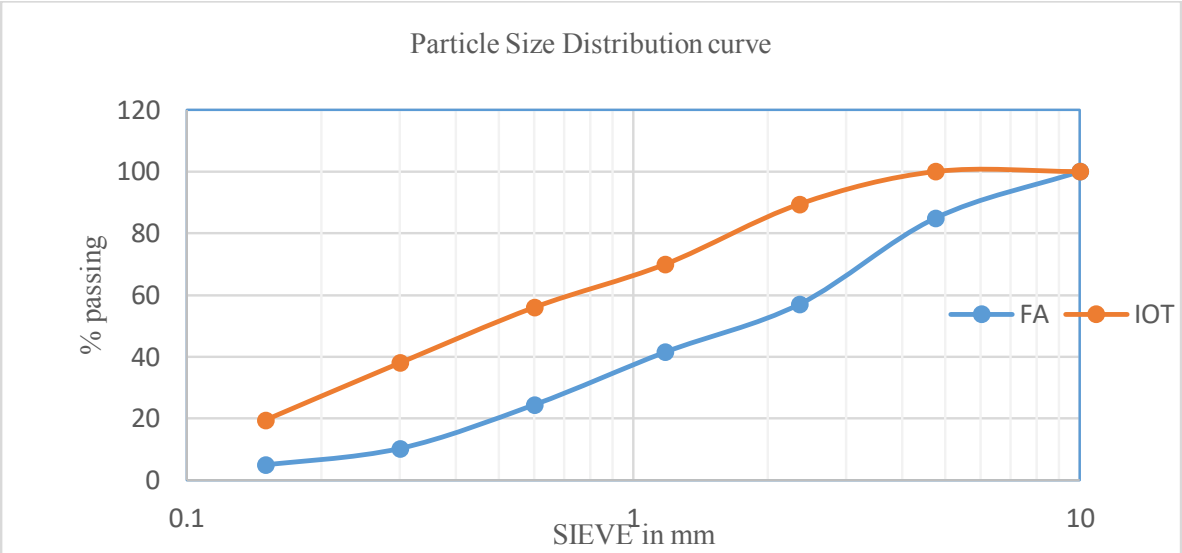

Fig 2 Particle Size Distribution curve

2.3. MixProportions

The concrete mix isdesigned as per IS 10262-2009, IS 456-2000 for the normal concretegiven table-3. The concrete mix grade of concreteis M20 with water cement ratio of 0.5 wasprepared in the laboratory.

Table3:MixProportions

Grade	**Cement (Kg)**	**FA(Kg)**	**CA (Kg)**	**W/Cratio**
M20	320	755.582	1096.146	0.5

Cubes of size 150x150x150mm werepreparedusing the standard moulds. The sampleswerecasted by partial replacement of fine aggregatewithiron ore tailing of 20%,30%,40%,50% and 60% and comparedwith normal concretestrength. The compressive strength test and split tensilestrength test wereperformedafter the concretehad been cured for 7 and 28 days. The tailings aggregatesconcrete have a brownishcolour as in fig 3 due to the browncolourof the iron ore tailings.[9]

Fig:2 Iron ore Tailings

Fig: 3 Concrete&Iron ore Tailings cubes

3. RESULTS & DISCUSSIONS

3.1. CompressiveStrength

Compressive strength of Concrete with Iron ore tailing was tested with compression testing machine. Three specimens were tested for varying percentage of iron ore tailing in the mix and the average of the values was used. The compressive strength was calculated by dividing the maximum load (force) observed from the compression machine by the cross-sectional area of the specimen tested. The 7 days and 28day compressive strength of both normal and tailings aggregates concretetestresultsaregiveninfig4

It was observed that the compressive strength is increasing with increase in the percentage of Iron Ore Tailings for all the curing ages than in the normal concrete. At age of 28 days the compressive strength of the tailing aggregates concrete was 28.67 MPa whiles that of the control mix was 23.39 MPa, which shows an improvement of 18.41% of tailings aggregates concrete over normal concrete for 60% replacement of sand replaced by Iron Ore Tailing. This increase in strength of the iron ore tailings aggregates concrete due to the chemical composition of the iron ore tailings. The iron compounds have the potential to accelerate cement hydration [8] and this could be the main reason for the improvement of compressive strength in the iron ore tailings aggregates concrete which has high content of iron compounds.

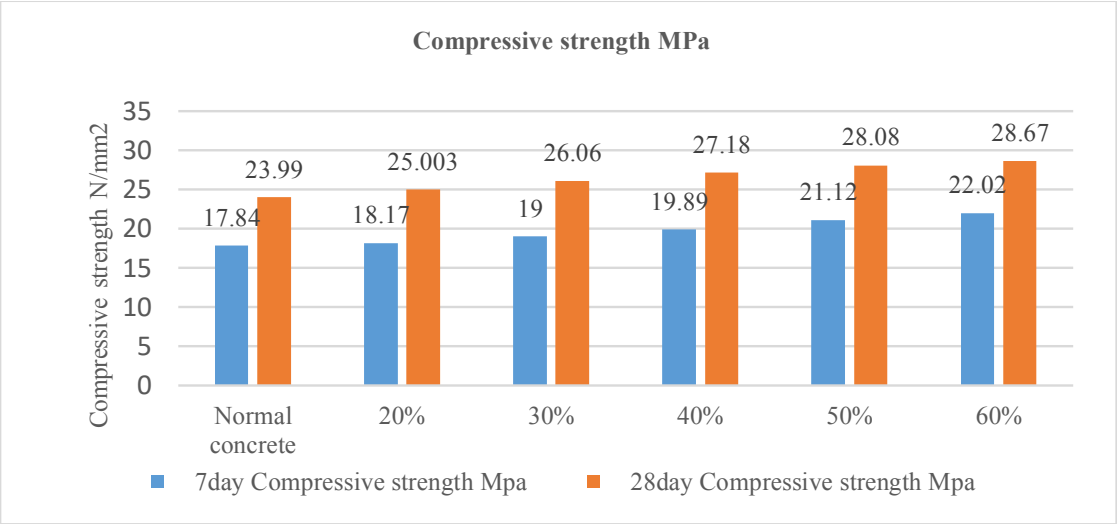

Fig:4 Compressive strength for Iron Ore Tailing concrete

3.2 Split TensileStrength

Tensile strength is another important mechanical property of concrete. The concrete structures are susceptible to tensile cracking and it becomes an important factor especially, when the concrete is intended to be used for the design of highway and airfield slabs. The indirect tensile strength test results will indicate the influence of the aggregates structure on adhesion and the strength of the bond between the concrete materials. Figure 5 shows Split tensile strength of both normal and tailings aggregates concretes for different curing periods from 7 and 28 days. It can be observed from the results that the tensile strength increases with the curing period for both normal (control mix) and tailings aggregates concrete. It is also observed that tensile strength increases with increase in percentage of Iron ore tailings aggregates in the concrete. At age 28 days, the control mix achieved split tensile strength of 2.96 MPa while that of the tailing aggregates concrete was 3.3 MPa showing 10.3% increase in the strength for 60% replacement

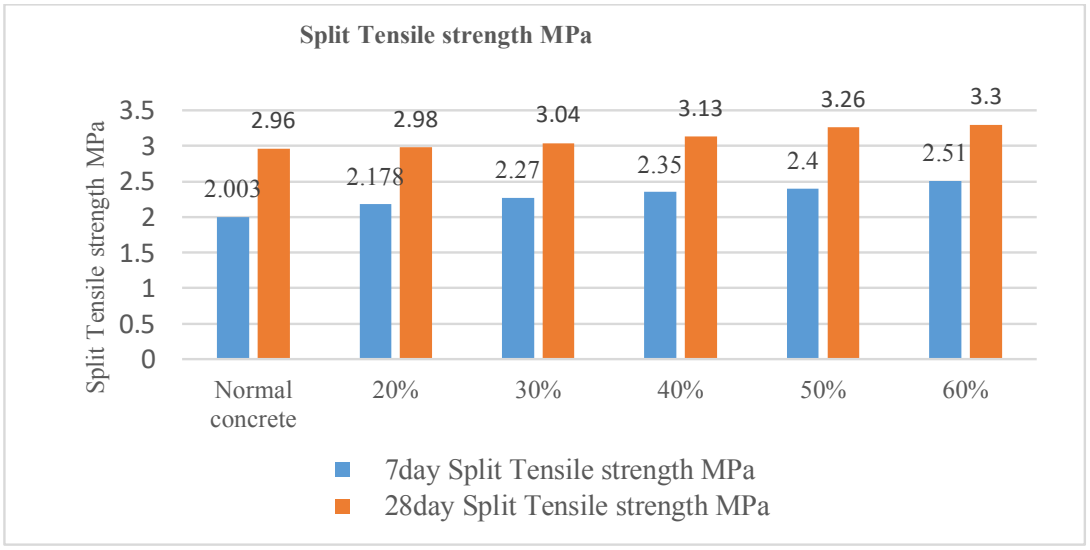

Fig 5: Split tensilestrengthresults for 7 and 28 days

4. CONCLUSION

The result of current study, can be concluded in following points:

- Iron ore tailings can be efficiently used in place offineaggregatetogain good strengthinconcrete.
- At age of 28 days the compressive strength of the tailings aggregates concrete was 28.67 MPa whiles that of the control mix was 23.39 MPa, which shows an improvement of 18.41% of tailings aggregates concrete over normal concrete for 60% replacement of sand replaced by Iron Ore Tailing
- The split tensile strength of 2.96 MPa while that of the tailing aggregates concrete was 3.3 MPa showing 10.3% increase in the strength for 60%replacement.
- The utilization of iron ore tailing as fine aggregate in concrete will provide cheaper alternative materials.

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