Comparative Study on Use of Waste Iron Ore Slag As Replacement of Coarse Aggregate For M20 And M30 Grade Concrete

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Abstract- *Concrete, a homogeneous mixture of cement, fine aggregate, coarse aggregate and water is widely been used in construction activities. Due to its composite nature concrete is weak in tension but strong in compression. Generally in design of concrete mix, cement, fine aggregates and coarse aggregates are using from a long years back. These three materials only play a crucial role in designing of a particular grade of concrete. But now a days there is a scarcity in aggregates. So, some new materials which are very near to our surroundings and some type of materials have to be introduce for replacing the fine aggregates, coarse aggregates and as well as cement to get the same strength as that these basic materials can give.With increasing capacities, disposal of large quantities of slag becomes a big environmental concern and a critical issue for Iron ore slag makers. Over the last few years, with a better understanding of slag, its functions and improvements in process technologies have led to a significant reduction in the volume of slag generated. At the same time, the re-use of iron and Iron ore slag making slag has also been expanded, and has led to a significant reduction in the environmental impact of these byproducts.M30 grade of concrete is designed and natural coarse aggregate is completely replaced by waste iron ore slag aggregate. In this study slag is replaced in concrete as coarse aggregate in the proportion of 0%, 5%, 10%, 15%, 20%. For knowing the effect of this slag replacement in concrete compressive strength test is conducted with replaced concrete on cubes of size (150x150x150) cm and cylinders of diameter 150cm and height 300cm. Flexural test carried out on beams which were casted with partially slag replaced concrete. The advantages of this project are that the replacement of iron ore slag is economically cheap as well as a superior concrete can be made.*

Keywords- waste iron ore slag, workability, compressive strength, split tensile strength test.

I. INTRODUCTION

Concrete is composite material which consists of cement, coarse aggregate, fine aggregate and water in required proportions. Concrete is a material which used for the purpose of construction in now a days. Due to its composite nature concrete is weak in tension but strong in compression. Basic Principle involved in the increase in strength of concrete is heat of Hydration. Generally in design of concrete mix, cement, fine aggregates and coarse aggregates are using from a long years back. These three materials only play a crucial role in designing of a particular grade of concrete. But now a days there is a scarcity in aggregates. So, some new materials which are very near to our surroundings and some type of materials have to be introduce for replacing the fine aggregates, coarse aggregates and as well as cement to get the same strength as that these basic materials can give.

Portland cement concrete is made with coarse aggregate, fine aggregate, Portland cement, water and in some cases selected admixtures (mineral & chemical). In the last decade, construction industry has been conducting research on the utilization of waste products in concrete; each waste product has its own specific effect on properties of fresh and hard concrete. Conservation of natural resources and preservation of environment is the essence of any development. The problem arising from continuous technological and industrial development is the disposal of waste material. If some of the waste materials are found suitable in concrete making, not only cost of construction can be cut down, but also safe disposal of waste materials can be achieved. The use of waste products in concrete not only makes it economical but also solves some of the disposal problems.

So, we have to search for different materials to reduce the quantity of basic natural materials in the concrete mix without changing any mix design procedure and considerations. We cannot replace the whole basic material in the concrete, but some extent we can replace with other materials. There are some research were done on waste materials which are very near to our surroundings like crushed plastic, Stone dust, over burnt bricks, M – sand , glass powder, coconut shells, waste tires, slag, fly ash produced from industries, broken glass pieces, rich husk ash, coconut shell ash, etc. to use them in concrete mix along with basic natural aggregates. In their methodologies, some of the above materials were used to replace the cement and some of the materials used to replace the aggregate. In those researches observed that these materials can be used in some extent percentages.

The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. Iron ore Slag is a byproduct of metal smelting and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. Iron ore slag slag can be use in the construction industry as aggregate in concrete by replacing natural aggregates.

This experimental study is based on the performance of concrete by replacement of aggregate with waste iron ore slag with different percentages 0, 10%, 20%, 30%, and 40%. This project describes the feasibility of using the waste iron ore slag in concrete production as replacement of coarse aggregate and effective percentage of Iron ore slag would be determined for obtaining maximum strength by conducting workability compressive strength and tensile strength tests.

The present proposal involves a comprehensive laboratory study for the newer application of this waste material in the preparation of fibrous concrete. The primary objective of investigation is to study the strength behaviour i.e. compressive strength, and impact resistance of concrete with different percentage replacements of Iron ore slag.

The proposed work is aimed to study the effect of Iron ore slag on:-

- Compressive Strength
- Split tensile Strength
- Flexural strength

II. REVIEW OF LITERATURE

The usage of industrial by-products especially industrial wastes in making of concrete is an important study of worldwide interest. Many researchers have investigated the possible use of Iron ore slag as a concrete aggregate. For this investigation, some of the important literatures were reviewed and presented briefly. This research is supported with the related reading material previous research about the Iron ore slag which had been done as the references to describe more and explain the characteristic and application of Iron ore slag as partial replacement in the concrete production. So far the reutilization Iron ore slag and has been practiced, but the amount of wastes reused in that way is still negligible. Hence, the need for its application in other industries is becoming absolutely very useful for getting benefit. Construction industry can be the end user of all tile wastes and in the same way can contribute Green building practices.

T. Subbulakshmi, et.al (2016), experiments were conducted to study mechanical properties of high performance concrete with different percentage replacement of mineral admixture and industrial byproducts such as silica fume, bottom ash and Iron ore slag slag aggregate. Presence of calcium hydroxide layer at the aggregate surfaces as reported extensively for conventional concrete is not seen in high performance concrete because of usage of combination mix of silica fume, bottom ash and slag by-products and presence of partially hydrated cement grains in conventional concrete matrix and the ITZ. It is widely reported that the permeability of concrete reduces drastically with inclusion of silica fume. Iron ore slag slag aggregate mix of concrete shows that the presence of ettringite in direct contact with aggregate of calcium hydroxide film in the ITZ of normal concrete. A combined model developed in ANN by using inputs from compressive strength of concrete predicts more accurately and it is recommended to be used alone to predict strength of concrete.

P.Sateesh Kumar, et.al (2015), this paper aims to study experimentally, the effect of partial replacement of fine aggregate by Iron ore slag slag (ss), on the various strength and durability properties of concrete by using the mix designs. the optimum percentage of replacement of fine aggregate by Iron ore slag slag is found. The compressive strength, flexural strength and split tensile strength of normal concrete and concrete with Iron ore slag slag as partial replacements are compared and observed that the strength of the normal concrete is slightly lower than the Iron ore slag slag replaced concrete. The compressive strength increases with increase in percentage of Iron ore slag slag up to 40% by weight of fine aggregate. The enhancement in compressive strength is about 32% for 7 days curing and 27.2% for 28 days curing. The split tensile strength increases with increase in percentage of Iron ore slag slag up to 40% by weight of fine aggregate. The enhancement in split tensile strength is about 48.2% for 7 days curing and 31.2% for 28 days curing.

P.S.Kothai, et.al (2014), this work relates the use of Iron ore slag slag, a waste cheap material used as fine aggregates in M20 grade of concrete and recommends the approval of the material for use in concrete as a replacement material for fine aggregates. The partial substitution of natural aggregates with Iron ore slag slag aggregates permits a gain of compressive, tensile and flexural strength and modulus of elasticity of concrete up to an optimum value of replacement .The following benefits can also be obtained: Cost reduction, Social benefits & Mass utilization of waste material is possible in construction by using Iron ore slag slag as a partial replacement material for fine aggregates in concrete.

P. Vignesh Kumar, et.al (2014), in this study of partial replacement of coarse aggregate with iron slag in the cement concrete have greater strength than the conventional concrete. As the self-weight of this concrete is higher. The polypropylene fibres are free from water absorption. With improved understanding of the link between fibre characteristics and composite or structural performance. In 25 % iron slag used the compressive strength decreased 1% and split tensile strength also decreased. If the addition of 30% and 35% of the iron slag used.Increased compressive strength in concrete. The compressive strength of the concrete is increased 4%and 5% compared then the conventional concrete. 30and 35 % of the addition of iron slag is 6% increased split tensile strength and flexural strength compared than conventional concrete.

R.Kalpan, et.al (2014), this research has shownthat replacing some percentage of natural aggregates by Iron ore slag slag aggregates causes negligible degradation in strength. It is shown that as the amount of Iron ore slag slag is increased beyond 75%. The results showed that replacing about 50 to 75% of Iron ore slag slag aggregates by volume for natural aggregates will not do any harm to concrete and also it will not have any adverse effects on the strength and durability. Whole study was done by both the aggregates were replaced by crystallized & granular aggregates. The coarse aggregate were partially replaced by Iron ore slag slag of about 10% and 20%. The fine aggregate were partially replaced by Iron ore slag mill scale of about 40%and 50%. This partial replacement of coarse and fine aggregates with Iron ore slag slag and Iron ore slag mill scale will increases the strength of about 30% to 50%. The main aim of this research was to study the behavior of concrete and changes in the properties of concrete with Iron ore slag slag and Iron ore slag mill scale by replacing the use of natural aggregates.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Water
5. Waste iron ore slag

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. Waste Iron ore slag

At present the use of Iron Slag in concrete gives environmental and economic benefits for concerned industries, especially in places where a considerable amount of Iron Slag is produced. Owing to the scarcity of sand for the preparation of mortar as well as concrete, partial and fully replacement of Iron Slag with sand have been attempted. Iron Slag are by-products obtained during smelting and refining of Iron Slag. Iron ore is crushed and allowed to pass through various processes in the manufacture of iron in mines and in this process large volume of coarse particles of iron ore is generated. They are known as iron ore slag. The slag obtained has properties similar to that of aggregatge and can be used for construction purposes. Ayano T, Sakata K. (2000), proposed a theory on concrete and this theory provides the feasibility of the usage of iron ore as hundred percent substitutes for Conventional Concrete.

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262-2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M20 and M30.

TABLE 4.1 shows the materials proportions for M20 grade.

Total weight of materials for 9 cubes

Cement	**12.313kg**
sand	18.468kg
Coarse aggregate	36.936kg
water	7.38 lit

Total weight of materials for 9 cylinders

Cement	**18.144kg**
sand	27.21kg
Coarse aggregate	54.43kg
water	10.8 lit

TABLE 4.2 shows the materials proportions for M30 grade.

Total weight of materials for 9 cubes

Cement	10.692kg
sand	26.73kg
Coarse aggregate	37.422kg
water	4.16 lit

Total weight of materials for 6 cylinders

Cement	9.84kg
sand	24.6kg
Coarse aggregate	34.44kg
water	3.8 lit

V. RESULTS AND DISCUSSIONS

This session provides a summary of the experimental results and endeavors to draw some conclusions. The test result covers the workability, mechanical properties and durability properties of concrete with partial replacement of coarse aggregate with waste iron ore slag. On replacing coarse aggregate with different percentages of waste iron ore slag the workability, compressive strength is studied for M20 and M30 grades.

The present work focuses on investigating mechanical properties of M20 & M30 grade cement concrete with partial replacement of coarse aggregate with waste iron ore slag by replacing cement viz. 10%, 20%, 30% and 40%. Cubes, cylinders and prisms are tested for compressive strength, split tensile strength and flexural test. All together three mix designations have been casted and tested for 7, 14, 28 days of curing duration.

5.1 VARIATION OF COMPRESSIVE STRENGTH FOR DIFFERENT MIXES

Compressive strength of concrete replaced waste iron ore slag for curing period of 7-days, 14-days and 28-days respectively and Table 5.1 and 5.2 shows the summarized Compressive strength Results for different curing periods– M20 grade and M30 Grade

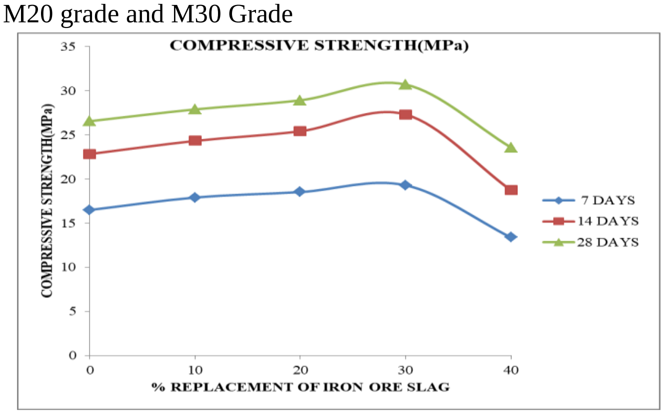

Fig 5.1: Variation in Compressive Strength For %Replacement of Iron ore slag for M20 grade

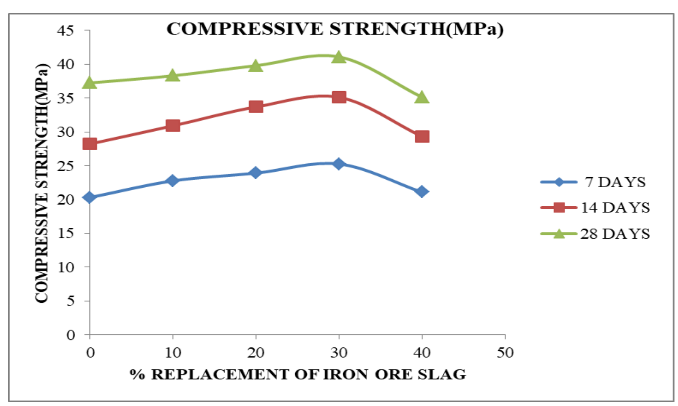

Fig 5.2 Variation in Compressive Strength For % Replacement of Iron ore slag for M30 grade

5.2 SPLIT TENSILE STRENGTH

The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cylinders are used to determine split tensile strength of concrete and were tested as per as per IS 516 (1959) and IS 5816 (1999).

The figure shows that the test results of splitting tensile strength of specimens after curing and the values for different curing periods was shown below.

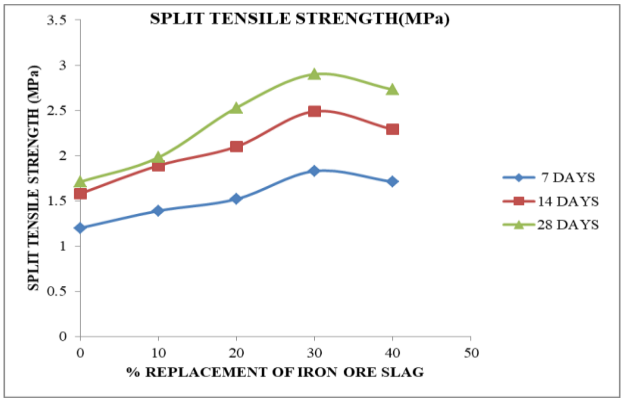

Fig 5.3: Variation in Split tensile Strength For % Replacement of iron ore slagfor M20 grade

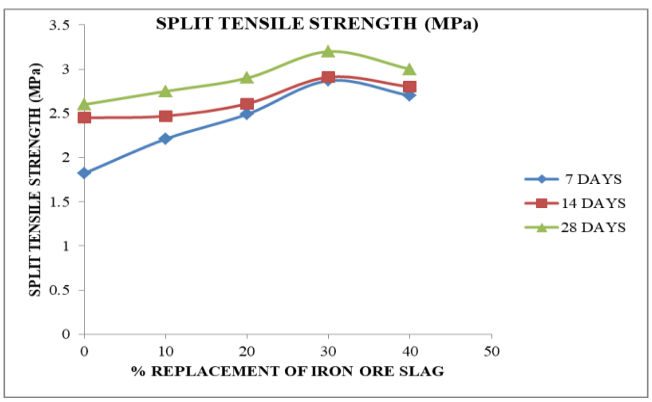

Fig 5.4: Variation in Split tensile Strength For % Replacement of iron ore slag for M30 grade

5.3FLEXURAL STRENGTH

The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in water. Concrete specimen beams are used to determine flexural strength of concrete and were tested as per as per IS 516 (1959).

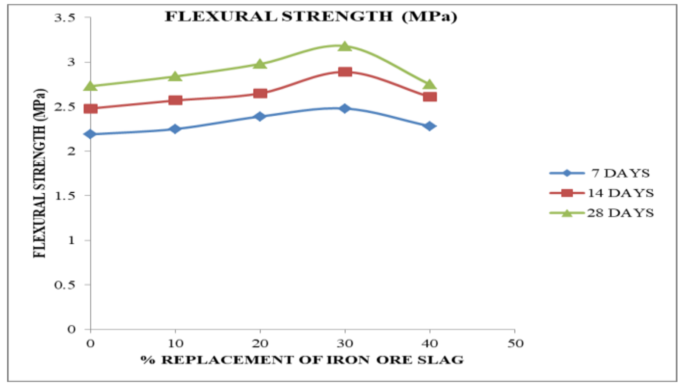

Fig 5.5 Variation in Flexural Strength For % Replacement of iron ore slagfor M20 grade

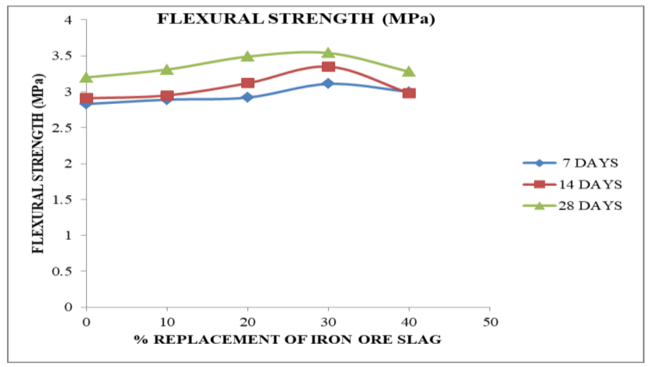

Fig 5.6 Variation in Flexural Strength For % Replacement of iron ore slag for M30 grade

VI. CONCLUSIONS

The Conclusions and Recommendations that could be drawn from the results of this project and experiments are summarized and the use of Waste iron ore slag as a coarse aggregate replacing material in concrete production was studied and after the research work is done, the following conclusions were made:

- By increasing the grade of Concrete i.e., M20 to M30, strength results are increased. The Compressive strength of concrete increased when coarse aggregate is replaced by Waste iron ore slag for M20 grade of concrete. At 30% replacement of coarse aggregate is replaced by Waste iron ore slag the concrete attained maximum compressive strength for M20 grade of concrete.
- The increase in compressive strength of concrete for higher percentage replacement of slag aggregate was found to be less significant. The split tensile strength of concrete is increased when coarse aggregate is replaced by Waste iron ore slag. The split tensile strength is maximum at 30% of replacement. The flexural strength of concrete is also increased when the coarse aggregate is replaced by Waste iron ore slag. At 30% replacement, the flexural strength is maximum.

- Compressive strength, Split Tensile strength and flexural Strength of concrete increased more with 30% coarse aggregate is replaced by Waste iron ore slag to M30 grade Concrete.
- After replacement of 30% coarse aggregate with Waste iron ore slag the Split Tensile strength of concrete increases with grade of concrete. For M30 grade concrete, when compared with M20 grade concrete compressive strength is increased by 36.7%, Split Tensile strength is increased by 6.45%.
- After replacement of 30% coarse aggregate with Waste iron ore slag, Flexural strength of concrete increases with grade of concrete. For M30 grade concrete, when compared with M20 grade concrete Flexuralstrength is increased by 7.96%.

From experimental results concluded that if we use Waste iron ore slag as a Coarse aggregate, it can possesses excellent Strength characteristics and durability for M30 Grade compare to conventional concrete.

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