

Study on Strength Properties of Ferrochrome Slag Aggregate as Partially Replacement of Coarse Aggregate

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ABSTRACT: Concrete is the commonly used construction material due to its structural stability, durability and strength. The demand on concrete is increasing day by day due to growing population, urbanization, transportation and industrialization. To conserve the natural resources and effective utilization of industrial waste. Industrial waste can be used in concrete for saving environment from the industries. Ferrochrome slag can be used as an alternate material for coarse aggregate in concrete. Ferrochrome slag is a major by-product got during the manufacturing of Ferrochrome alloy (FeCr). The Ferrochrome slag has good mechanical properties suitable for utilization as a aggregate material in concrete. In this experimental study, M30 grade concrete is used and replaced ferrochrome slag with conventional coarse aggregate in concrete for every incremental of 10% and up to 50%. The fresh properties of concrete are determined by slump cone test, compaction factor test, flow table test. To determine the hardened properties of concrete by casting cubes, cylinders and prisms for compressive strength, split tensile strength and flexural strength for 3 days, 7 days, 14 days and 28 days curing. The results are obtained and compared with conventional coarse aggregate concrete.

KEYWORDS: Ferrochrome slag, compressive strength, split tensile strength, flexural strength

I. INTRODUCTION

Concrete is the commonly used construction material due to its structural stability, durability and strength. The demand on concrete is increasing day by day due to growing population, urbanization, transportation and industrialization. Due to the scarcity of naturally obtainable fine and coarse aggregate required for making concrete and on other side speedy growth of industrialization contributed to different types of waste by-product which is environmentally risky. So the industrial wastes are effectively used in the concrete to save the environment. In civil construction some industrial wastes are utilized in various works. Ferrochrome (FeCr) slag is a major by-product got during the manufacturing of FeCr alloy. It is a basic element in stainless steel manufacturing. In India, the current production capacity of FeCr is 3.36 million tonnes per annum from 118 plants operating more than 229 furnaces. The constituent in FeCr is SiO₂, Al₂O₃ and MgO with minor traces of ferric oxide and CaO. FeCr is a good alternate material for coarse aggregate in concrete. The FeCr slag has a good mechanical property, so it is used as an alternate material for coarse aggregate in concrete. The mechanical properties and chemical characterization indicates the technical acceptability and environmental safety of the slag as the coarse aggregate. The waste material used in a construction industry can solve the shortage of natural aggregate

II. MATERIAL PROPERTIES

2.1 Materials

In concrete the selection of proper evaluating the material properties. In this study, the relation between different materials plays a major role in performance of the concrete. The ingredients used are cement, Flyash,

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Ferrochrome slag (FeCr), manufacture sand, coarse aggregate, super plasticizer. The performance requirements of concrete enhancement of the following

1. Simplicity of placement and no segregation in compaction.
2. Good mechanical properties.
3. It attains early strength.
4. Hardness.
5. Volume constancy.
6. Good durability properties.
7. Improves service life.
8. The efficiency of concrete is improved by proper selection, controlling and proportioning the ingredients of concrete.

2.2 Cement

In this experimental study the Ordinary Portland Cement of grade 53 is used. The physical properties of cement like specific gravity of 3.15, then the fineness is about 2.5%, the standard consistency is 30%. Initial and Final setting time of cement is 120 minutes and 300 minutes.

2.3 Manufacturing Sand

Manufacturing sand is used as an alternate material for river sand. It can be manufactured by crushing of stones. The specific gravity of manufacturing sand is about 2.83 and fineness modulus is about 2.93, then the water absorption is 2%.

2.4 Fly ash

Fly ash is an industrial byproduct and it can be used as a mineral admixture in the cement and concrete. Fly ash increases concrete's workability, pumpability, cohesiveness, finish, ultimate strength. It solves the many problems practiced with concrete and less cost. The specific gravity of fly ash is about 2.42 and is available in the powdery form. The size is of 0.1 micron and light grey in color.

2.5 Ferrochrome

Ferrochrome slag is obtained from the manufacturing process of FeCr alloy. It is a basic element in stainless steel production. FeCr slag is obtaining great mechanical property. FeCr slag has a high specific gravity and good bonding with other ingredients. The physical properties like the specific gravity of the FeCr are about 7.16 and its size is of 15 to 50 mm. It is grey in color.



Figure 2.1 Ferrochrome

2.6 Super plasticizers

Conplast SP430 super plasticizer is used. It can reduce water cement ratio up to 30% of water, thus increasing the compressive strength of concrete. The Conplast SP430 super plasticizer is based on the Sulphonated Naphthalene Formaldehyde based super plasticizer. The properties of Super plasticizers is solid content of 43% and specific gravity is of 1.21

III. MIX DESIGN

3.1 GENERAL

It is the process of selection of suitable materials for concrete and determining the required strength and workability of concrete as economically as possible, is termed as concrete mix design. The proportioning of material of concrete is governed by the performance of concrete in two states, like the plastic and the hardened states. If the plastic state concrete is not workable, it cannot be easily placed and compacted. The property of workability of concrete therefore becomes very important.

3.2 MIX PROPORTIONS

Cement	= 425 kg/m ³
Fly Ash	= 70 kg/m ³
Water	= 160 kg/m ³
Fine aggregate	= 740 kg/m ³
Coarse aggregate	= 1140kg/m ³
Chemical admixture	= 17 kg/m ³

The table 3.1 shows the mix proportion of concrete.

Mix proportions	Cement kg/m ³	Fine Aggregate kg/m ³	Coarse Aggregate kg/m ³	Water kg/m ³	Chemical Admixture kg/m ³	Fly ash kg/m ³	Ferrochrome kg/m ³
Mix 1(0%)	425	740	1140	160	17	70	0
Mix 2(10%)	425	740	1026	160	17	70	114
Mix 3(20%)	425	740	912	160	17	70	228
Mix 4(30%)	425	740	798	160	17	70	342
Mix 5(40%)	425	740	684	160	17	70	456
Mix 6(50%)	425	740	570	160	17	70	570

Table 3.1 Mix proportion.

IV. EXPERIMENTAL PROGRAM

4.1 MECHANICAL PROPERTIES

4.1.1 Compression Test

Compression test is the most commonly conducted test on hardened concrete, because it is a very easy test to conduct, because most of the enviable characteristics properties of concrete are qualitatively linked to its compressive strength. Compressive strengths were obtained by conducting the compressive test on the cube specimens of size 150mm x 150mm x 150mm. Cube was placed on the compression testing machine. Gradually apply the load till the concrete cubes get failed. The compressive strength is defined as the ratio of crushing load to the area of the specimen expressed in N/mm². Therefore the compression strength values of all the cubes are obtained.

4.1.2 Split tensile strength Test

Split tensile strength of concrete is obtained by testing concrete cylinders. Cylinders in size of 150mm x 300 mm were casting using M₃₀ grade concrete. In casting process the conventional concrete cubes are manually compacted by using damping rods. The specimens were removed from the mould after 24 hours and allowed to water curing for 28 days. After curing, the specimens were tested and split tensile strength of concrete cylinders are obtained by using a calibrated compression testing machine.

$$\text{Split tensile strength of concrete } f_t = \frac{2p}{\pi dl}$$

Where,	P	=	Maximum load in N
	L	=	Measured length in cm of the specimen
	D	=	Measured diameter in cm of the specimen

4.1.3 Flexure Test

The highest stress experienced by the material at its moment of rupture is called the flexural strength. It is measured by stress, it is denoted as f_{cr} . The flexural strengths of the specimens have been determined from the flexural tests conducted on the prism specimens of size 100mm x 100mm x 500mm. The flexural strength tests are conducted using a two point loading frame machine as per standard.

The load should be applied centre and tensional stresses and restraints are not subjected to the specimen. The specimen axis should be carefully aligned with the loading device axis. The load should be applied without any shock and increasing the load gradually. Therefore the flexural strength of the specimen is obtained.

V.RESULTS AND DISCUSSION

5.1 GENERAL

In this study the results were obtained from the various experiments conducted on the specimens to access mechanical properties. The main aim of this study is to determine the compressive strength, flexural strength and split tensile strength. The discussion of the result is also presented in this chapter.

5.2 MECHANICAL PROPERTIES

The compressive strength, flexural strength and split tensile strength are the mechanical properties of concrete are obtained by conducting standard experiments. They are as follows.

5.2.1 Compressive Strength

The compressive strength of replacement of FeCr is obtained. The compressive strength value for replacement of FeCr. Chart 5.1 Shows compression test results.

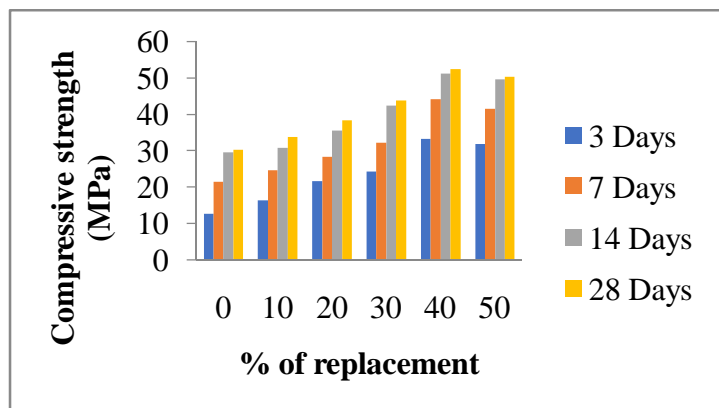


Fig. 5.1 Compressive strength

5.2.2 FLEXURAL STRENGTH

The flexural strength of replacement of FeCr is obtained. Chart 5.2 shows flexural strength test results

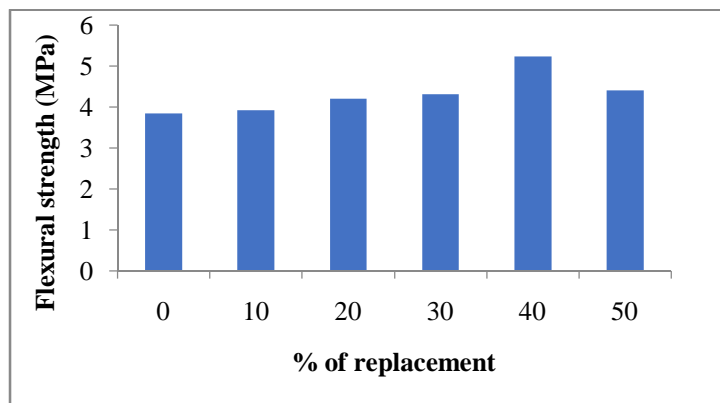


Fig. 5.2 Flexural strength

5.2.3 SPLIT TENSILE STRENGTH

The split tensile strength of replacement of FeCr is obtained. The split tensile strength value for replacement of FeCr. Chart 5.3 Shows split tensile strength test results.

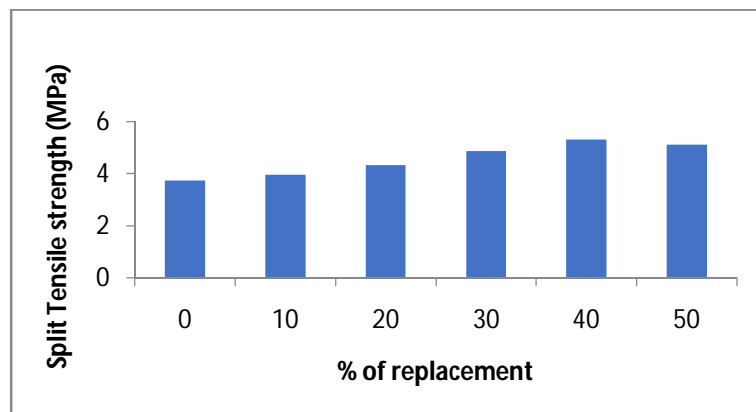


Fig. 5.3 Split tensile strength

VI. CONCLUSION

In this experimental study, to save the natural resources by using the industrial waste. Industrial waste can be effectively used as a construction material. FeCr is a good alternate material for coarse aggregate in concrete. It should have high strength. Comparing to the conventional coarse aggregate the FeCr slag has a better physical property like specific gravity, impact strength and crushing strength. The water absorption and density of conventional coarse aggregate is similar to FeCr slag aggregate. The strength in compression, split tensile and flexure strength can be increased at a replacement of 40% replacement of FeCr slag as a coarse aggregate in concrete. On comparing with the conventional coarse aggregate, the FeCr slag aggregate shows a better results, so it can be used as an alternate material for coarse aggregate in concrete. The FeCr slag used as a coarse aggregates in concrete it can reduce the usage of conventional coarse aggregate and it can also prevent the environmental pollution.

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