EFFECT OF FERROCHROME SLAG AS PARTIAL REPLACEMENT OF COARSE AGGREGATE ON STRENGTH AND DURABILITY OF CONCRETE

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***Abstract*:** Concrete is the most regularly used man-made material on earth. It is an Important construction material used extensively in building, bridge, roads, and dams. The Ferrochrome slag (FeCr) is another material which can be used as coarse aggregate in concrete. Ferrochrome slag is the outgrowth of waste generated from the ferrochrome steel plant. The Ferrochrome slag having good mechanical and engineering properties acceptable for utilization as aggregate material in concrete. In the present study, Ferrochrome Slag is evaluated for its suitability to partly supersede the coarse aggregate in M25 and M35 Grade concrete. Current study is concentrating on the consequences of Ferrochrome Slag on the properties of concrete such as compressive strength, durability, water absorption, workability. The result foretells after using ferrochrome slag along with partial concrete shows higher strength and durability compared to conventional coarse concrete.

Keywords: *Ferrochrome Slag, Coarse Aggregate, Compressive Strength Test, Durability Test, RCPT, Water Absorption Test*

INTRODUCTION

Ferrochrome slag is one of the second materials which can be used as both coarse and fine aggregate for substitution of sand and crushed rock in concrete. Universally, generation of Ferrochrome slag is 6.5 to 9.5 million tons enlarge by 2.8 to 3 % per year long. The main components of the slag are silicon dioxide (SiO_2), Magnesium oxide (MgO), and Aluminium oxide (Al_2O_3). The slag also includes Chromium (Cr) and Ferric oxides (Fe_2O_3) and calcium oxide. In the present study, Ferrochrome Slag is assessed for its suitability to replace the conventional coarse aggregate partially and fully in M25 and M35 Grade concrete. The implementation of Indian ferrochrome slag as Coarse aggregate is not reported. Hence, an effort is being carried out to utilize the local ferrochrome slag as an alternate civil engineering material. The findings based on the limited laboratory tests of the basic material properties, physical properties, strength parameters and durability parameters intimate that ferrochrome slag has the likely to be used as an alternate coarse aggregate in concrete.

Ferrochrome slag sample were collected from the Ferrochrome Manufacturing Industries located in Thane, Mumbai.

II) Material Properties

1)Cement: Cement used in this experimental is Ordinary Portland cement (OPC) of 53-grade cement. The cement for the whole experiment is brought in a single batch and stored properly. Normal Consistency 30.5, Specific gravity 3.15

2) Fine Aggregate (Natural River sand) River natural sand - well graded passing through 4.75 mm sieve was used in this experimental program. The sand used as per IS 383:1970 specifications. Specific gravity 2.65, water absorption 0.45%

3) Coarse aggregate (20 downsize) Coarse aggregate used was crushed basalt is strong and durable aggregate. It is taken from Turbhe Navi Mumbai. The coarse aggregate used as per IS383:1970 specifications, the aggregate is angular in shape. The maximum size of aggregate was limited to 20mm. Specific gravity 2.78, water absorption 0.45%

4)Ferrochrome slag: ferrochrome slag is appeared to be dark in colour and is said to have granulated and crystalline texture. Whereas air cooled slag is grey in colour and is said to have a lumpy texture. Specific gravity 2.9, Water absorption 0.45%

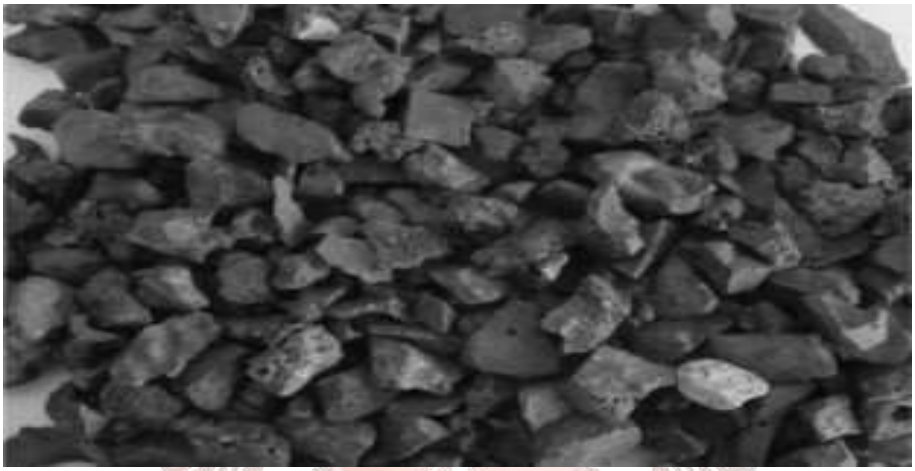

Table No 1 Chemical Composition of Ferrochrome Slag

Constituent	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Cr_2O_3
Composition (%) by wt.	30	4	26	2	23	15

III) EXPERIMENTAL INVESTIGATION*:* The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of required strength, workability as economically as possible is termed the concrete mix design.

M35 GRADE OF CONVENTIONAL CONCRETE MIX PROPORTION	M25 GRADE OF CONVENTIONAL CONCRETE MIX PROPORTION

Cement	350 kg/m³	Cement	440kg/m³
Water	145 kg/m³	Water	145 kg/m³
Fine aggregate	985 kg/m³	Fine aggregate	948 kg/m³
Coarse aggregate	1354kg/m³	Coarse aggregate	1301 kg/m³
MIX PROPORTION 1: 2.8: 3.8		MIX PROPORTION 1: 2.1: 3	

IV) EXPERIMENTAL METHODOLOGY

The following tests are conducted for experimental methodology.

1) Workability Test 2) Compressive Strength Test 3) Split Tensile Strength Test

4) Flexural Strength Test 5) Water Absorption Test 6) Rapid Chloride Penetration Test

Workability Test

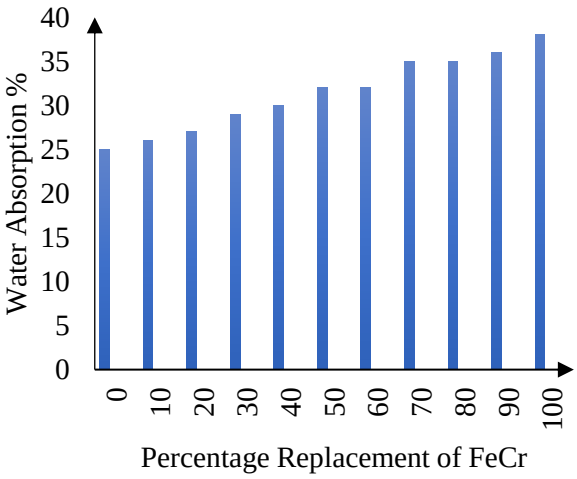

Figure 1 - Workability Test of M25 Concrete with FeCr

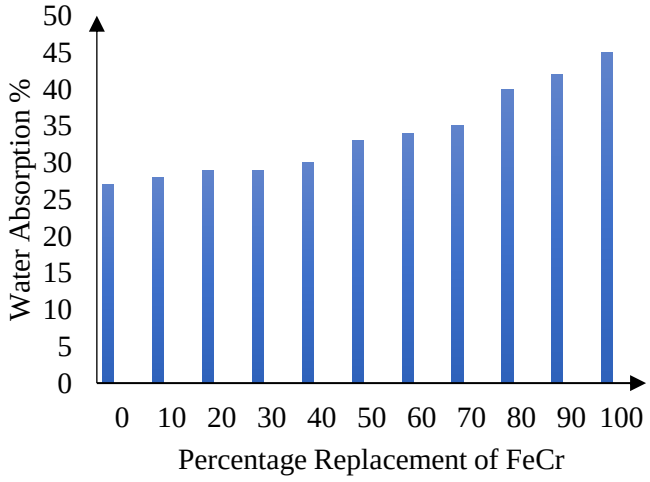

Figure 2 - Workability Test of M35 Concrete with FeCr

Compressive Strength Test

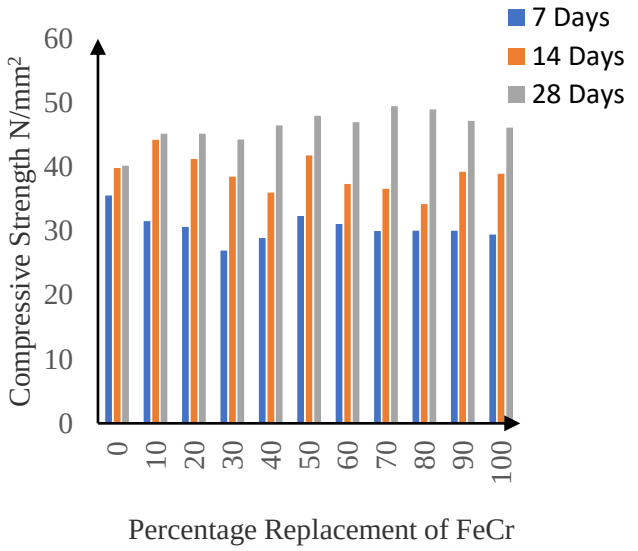

Figure 3 - Compressive Strength of M25 Concrete with FeCr

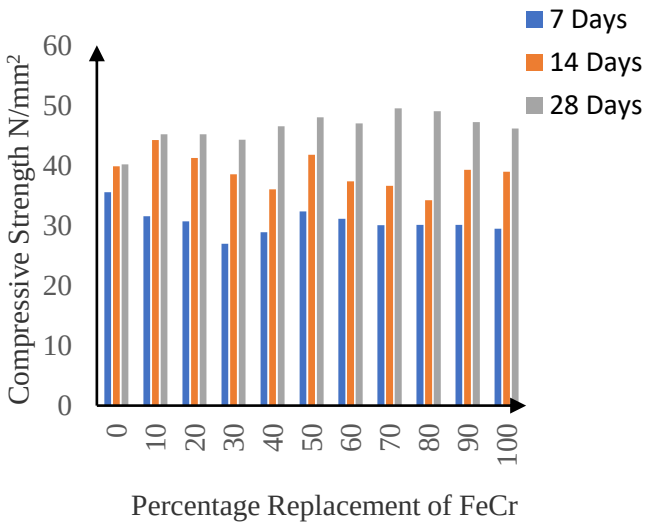

Figure 4 - Compressive Strength of M35 Concrete with FeCr

Flexural Strength Test

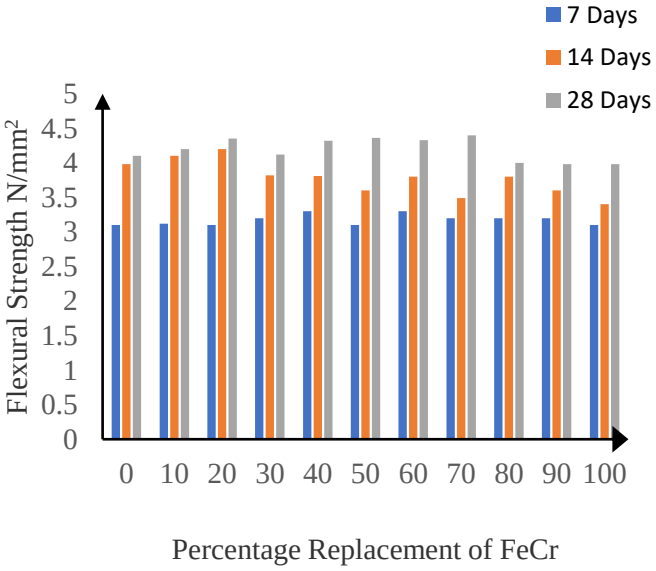

Figure 5 - Flexural Strength of M25 Concrete with FeCr

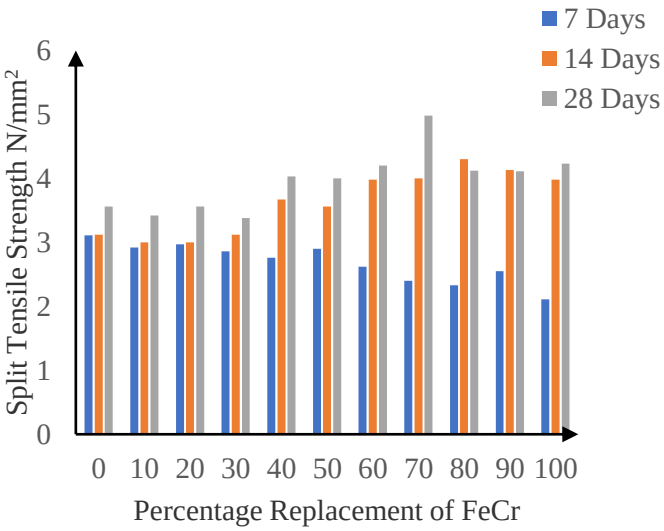

Figure 6 - Flexural Strength of M35 Concrete with FeCr

Split Tensile Strength Test

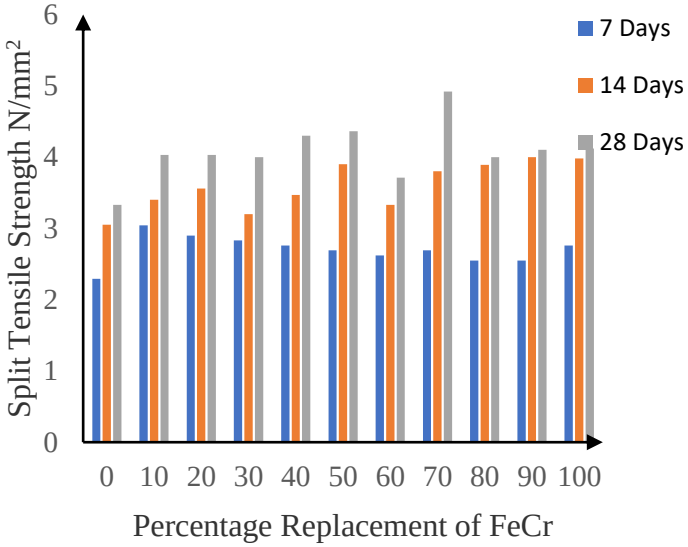

Figure 7 - Split Tensile Strength of M25 Concrete with FeCr

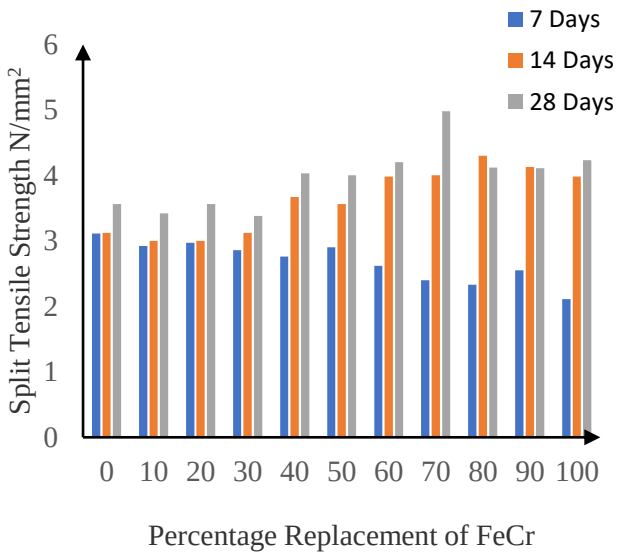

Figure 8 - Split Tensile Strength of M35 Concrete with FeCr

Water Absorption Test

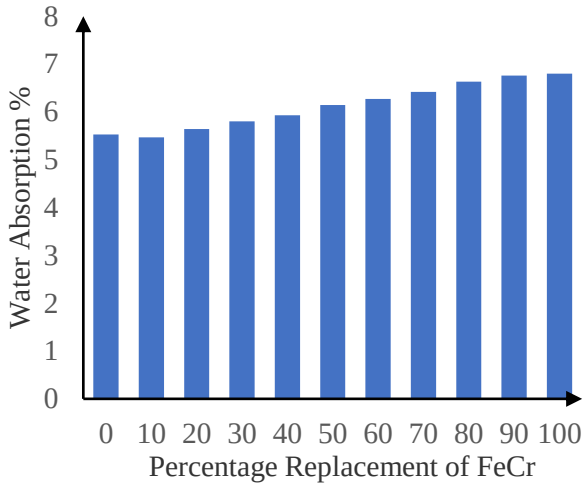

Figure 9 - Water Absorption Test of M25 Concrete with FeCr

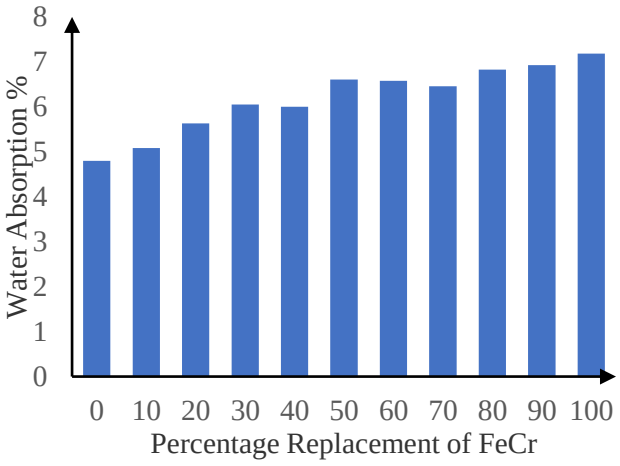

Figure 10 - Water Absorption Test of M35 Concrete with FeCr

Rapid Chloride Penetration Test

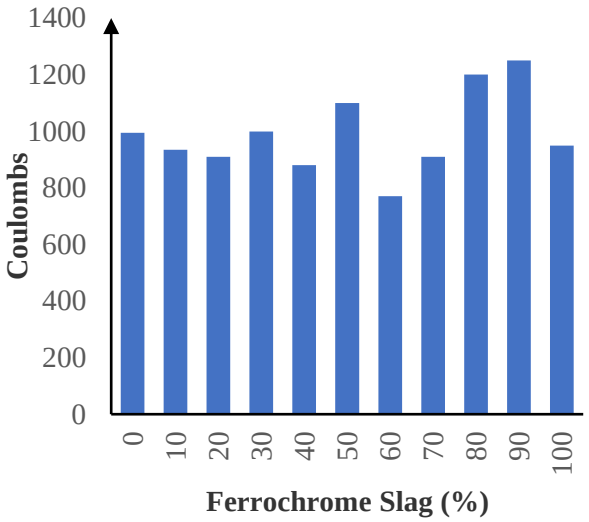

Figure 11 - Rapid Chloride Penetration Test of M25 Concrete with FeCr

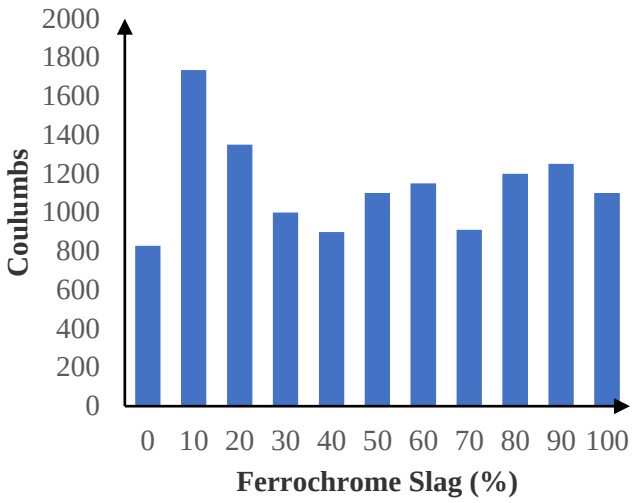

Figure 12 - Rapid Chloride Penetration Test of M35 Concrete with FeCr

V) CONCLUSION

Compering to the conventional coarse aggregate the FeCr slag has a better physical property like specific gravity, crushing strength. It is observed that concrete made with FeCr slag has better workability compared to the similar concrete made with conventional coarse aggregate. At 7 days ,14 days and 28 days maturity, an increase of compressive strength, split tensile strength, flexural strength has been observed for M25 and M35 concrete up to 70 % replacement level of FeCr slag. Above 70% replacement level of FeCr slag, the compressive strength decreases in M25 and M35 grades of concrete. It is observed that the water absorption properties of concrete are increase with increasing % replacement of Ferrochrome Slag. Here the maximum water absorption value of the concrete is 7.18% which is higher than the conventional concrete. The RCP test should not be used to accurately determine the permeability of concrete mixes containing supplementary cementitious materials or chemical admixtures. On comparing with the conventional coarse aggregate, the FeCr slag aggregate shows a better result, so it can be used as an alternate material for coarse aggregate in concrete. The usage of ferrochrome slag as coarse aggregate in concrete reduces the by-product waste of conventional coarse aggregate resulting in reduction of Environmental pollution.

VI)APPLICATION OF FERROCHROME SLAG

Based on the values of Specific gravity, Flakiness index and Elongation index and Mechanical properties and Ferrochrome Slag size is suitable for use as coarse aggregate in concrete making Due to high Compressive strength and due to availability of large boulder size slag material the ferrochrome slag is suitable for rip rap application to stabilize the slopes of earthen Embankment, highway Embankment, reservoir bunds and canal embankment.

Ferrochrome slag particles have more strength, toughness, and less abrasive. The slag is available with sizes ranging 6.3 mm to 50 mm. It has good Frictional characteristics so the ferrochrome slag can be advantageously used to support structure such as embankment and oil storage tank.

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(6) IS 516 (1959): Method of Tests for Strength of Concrete.

(7) IS 5816 (1999): Method of Test Splitting Tensile Strength of Concrete.

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