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Experimental Studies on Ferrous Slag as a Replacement of Fin E Aggregate in Conventional Concrete

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ABSTRACT:

As a construction material, concrete is the largest production of all other materials. Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste material which is obtained by means of various industries. Slag is a by-product of iron smelting and hundreds of tons of it are produced every year all over the world in the process of refining metals and making alloys. Like other industrial by-product, slag actually has many uses, and rarely goes to waste. It appears in concrete, aggregate road materials, as ballast, and is sometimes used as a component of phosphate fertilizer. In appearance, slag looks like a loose collection of aggregate, with lumps of varying sizes. It is also sometimes referred to as cinder, in a reference to its sometimes dark and crumbly appearance. This substance is produced during the smelting process in several ways.

In this experimental investigation an attempt is made to study the effect of partial replacement of fine aggregate by iron slag in the mechanical properties of M25 grade concrete at different proportions of 0%, 10%, 20%, 30%, 40% and 50%. Here it is intended to study the cube compressive strength, split tensile strength, impact strength of concrete by varying the percentage replacement of ferrous slag as fine aggregate in concrete.M25 grade concrete mix with proportions of 1:1.35:2.65 with a water cement ratio of 0.45 has been adopted in the present work Standard specimens such as cubes, cylinders, beams &impact modes have been cast &tested for obtaining the above strength parameters a total of 120 specimens were cast using 6 different mixes out of where 36 were cubes, 36 were cylinders 36 were impact specimens &12 beams specimens. 7 days & 28 days curing periods were adopted and the average values have been compared with those of conventional concrete mix values.

From this experimental study it may be seen that the usage of ferrous slag which is an industrial waste could be used efficiently & effectively to obtain greater strength than conventional concrete mixes. Thus the use of ferrous slag in concrete could enhance the strength in concrete and also reduces environmental pollution.

Key Words:

By-product, Ferrous slag, Compressive strength, Split-tensile strength, Impact strength.

1.INTRODUCTION:

1.1.GENERAL:

Concrete's versatility durability and economy have made it the world's most used construction material. The India utilizes about 7.3 million cubic meter of concrete each year. Due to this the cost of construction increases and causes environment pollution. As the demand for concrete as a construction material increase, so also the demand for fine aggregate increases.In recent years, Global warming and environmental destruction have become major problems. Heightening concern about worldwide ecological issues, changeover the large scale manufacturing, mass-utilization, The iron and steel industry produces extremely large amounts of slag as byproduct of the iron making and steel making processes, And hence it is necessary to develop slag production and recycling technologies and intermediate treatment technologies. The ferrous slag is a suitable industrial waste material for partially replacing fine aggregate in concrete. By using this we can increase strength of concrete and reduce to environment pollution.

1.2 SLAG:

Slag is a by-product generated during manufacturing of pig iron and steel.

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In the production of iron and steel, fluxes limestone and dolomite are charged into blast furnace along with coke for fuel. The coke is combusted to give carbon monoxide, which decreases the iron ore into a molten iron product. Fluxing agents separate impurities and Slag is produced at the time of separation of molten steel.The slag consists of calcium, magnesium, manganese and aluminum silicates in different combinations primarily.

Inspire of the fact that, the composition of slag may stay unaltered, physical properties differ broadly with the changing procedure of cooling. The blast furnace (BF) is charged with iron ore, fluxing agents (usually limestone and dolomite) and coke as fuel and the reducing agent in the production of iron. The mixture of iron oxides, silica, and alumina is the iron ore.

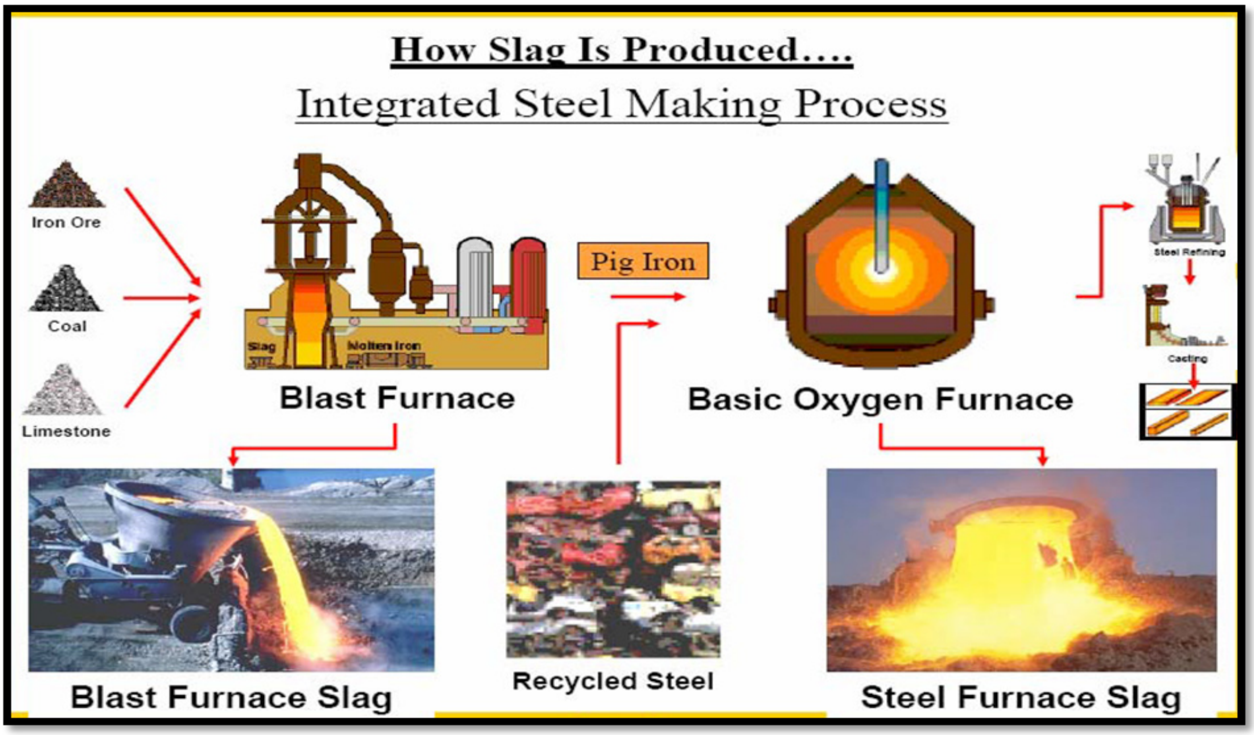

Fig 1: Manufacturing Process

1.3 USES OF FERROUS SLAG:

The ferrous slag is crushed, screened and used mainly as road metal and bases, asphalt paving, railway ballast, landfills and concrete aggregate. The expanded or foamed slag binds well with cement and is used mainly as aggregate for lightweight concrete. However, it is not delivered by domestic steel plants.

1.4 SCOPE:

Now a day due to rapid industrial growth, waste material management is challenging field. It possesses lot of environmental impact. Due to the rapid growth in construction field, construction material scarcities will arise. So we need to find some alternate material for construction.

1.5 OBJECTIVE:

The objective of the present work is to study the effect of partial replacement of ferrous slag. It is proposed to partially replace fine aggregates with ferrous slag and find its effect on the strength characteristics of concrete. Five percentage levels of replacement i.e. 10, 20, 30, 40 and 50 percent are considered for partially replacing sand with ferrous slag.

M25 concrete grade is initially designed without replacement and subsequently sand is partially replaced with ferrous slag. Standard cubes, cylinders, beams & impact specimens were cast to ascertain the cube compressive strength, split tensile strength, flexural strength & impact resistance.

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1.6 CRITICAL APPLICATION:

Ferrous slag which is used as partial replacement of fine aggregate is a by-product which is coming from the iron industry. Due to this waste, there is a lot of bad impact on the environment. Meanwhile the cost of the construction materials has been increasing day by day. Ferrous slag has the same physical properties, when compared to the fine aggregate (i.e., sand). So, an experimental study has been conducted to evaluate the results of partial replacement of fine aggregate with ferrous slag.

2. MATERIAL AND PROPERTIES
2.1 MATERIALS:

» PORTLAND CEMENT
» AGGREGATES
» FINE AGGREGATES
» COARSE AGGREGATES
» WATER
» FERROUS SLAG

PROPERTIES	RESULTS
Fineness	2.95
Specific Gravity	2.6
Bulk Density	10%
Moisture Content	8%
Grading	Zone -1

Table1: Properties of fine aggregate (is: 2386 (part i, iii)-1963) (is: 383-1970)

PROPERTIES	RESULTS
Impact test	8.06%
Aggregate crushing test	15.97%
Water absorption	1%
Specific gravity	2.64
Size	20 mm

Table2: Properties of coarse aggregate (IS: 2386 (Part I, III)-1963(IS: 383-1970)

PROPERTIES	RESULTS
Type	Industrial waste
Specific gravity	2.81
Water absorption	4%
Fineness modulus	3.04
Grading	Zone-I

Table3: Physical Properties of Ferrous Slag

PARTICULARS	RESULT
Cao	36.35
Mgo	9.59
Al2o3	16.21
SO_2	1.78
SiO_2	35.20
$Fe2O_3$	0.56

Table4: Chemical Properties of Ferrous Slag

3. DISCUSSIONS AND TEST RESULTS:
3.1 COMPRESSIVE STRENGTH:

Compressive strength in N/mm^2		
Mix	7 days	28 days
M_1-0% Slag	26.81	41.02
M_2-10% Slag	28.67	42.08
M_3-20% Slag	30.41	43.37
M_4-30% Slag	31.15	43.68
M_5-40% Slag	32	45.15
M_6-50% Slag	31.25	44

Table5: Compressive Strength of Different Mixes

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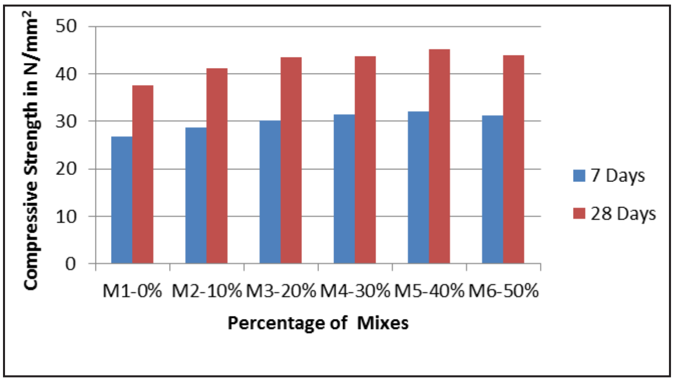

Fig 2: Variation of Compressive Strength V/S Various Percentage Replacement Of Ferrous Slag As Fine Aggregate

From the table 6.1 and the concerned figure, it is observed that for the mix containing 10%, 20%, 30% and 40% ferrous slag an increase in strength is observed at all ages as compared to the control mix. However, for 50% replacement levels, a decrease in strength is observed when compared to the standard 28 days strength of the related concrete mix,

This indicates that the loss of strength will be much larger, if the concrete is immersed in the solution for a larger period of time, the extent needs to be investigated and secondly, 40% slag is optimum from the consideration of resistance to sulphate attack as observed from the experimental results.

Fig 3: Compressive Strength Test

Split tensile strength N/mm^2		
MIX	7 days	28 days
M_1-0% Slag	2.221	2.310
M_2-10% Slag	2.640	2.782
M_3-20% Slag	2.687	2.830
M_4-30% Slag	2.782	2.923
M_5-40% Slag	2.971	3.018
M_6-50% Slag	2.830	2.876

Table 6: Split Tensile Strength

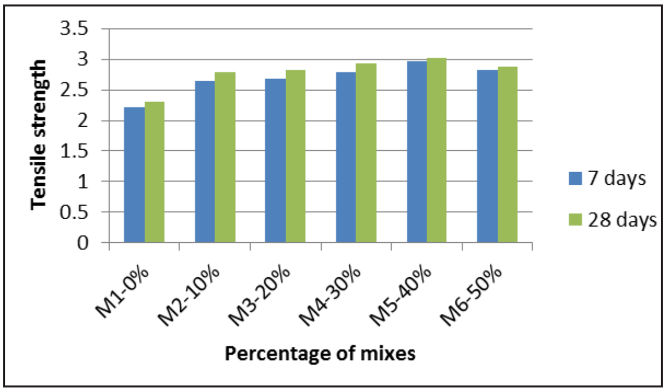

Fig 4: Variation of Spilt Tensile Strength V/S Various Percentage Replacement Of Ferrous Slag As Fine Aggregate

The split tensile strength results of concrete mix are also shown graphically in Figure. The split tensile results follow a pattern similar to compressive strength i.e. increase in the value with increase in percentage of slag replacement. However, the percentage increase in split tensile strength is smaller as compared to compressive strength. The split tensile strength increases with the percentage increase of ferrous slag as compared to control mix.

Figure shows the variation of percentage increase in split tensile strength with replacement percentage of ferrous slag. The split tensile strength is increases up to 40%, for 50% reduces the strength of concrete. From the strength point of view, it can be concluded that at early age presence of more amount of ferrous slag as sand replacement in concrete is beneficial for improving the strength characteristics.

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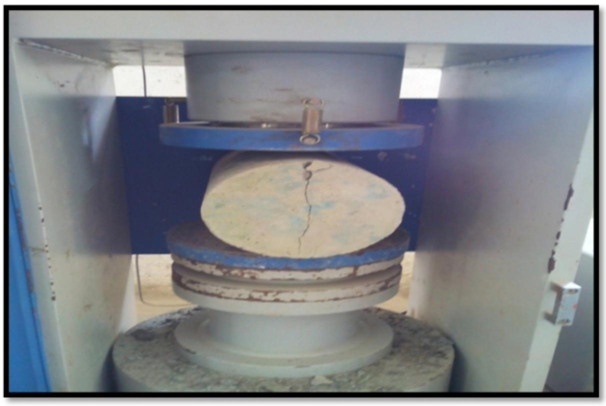

Fig 5: Split Tensile Strength Test

Impact Energy (EI =N*M*G*H) Nm		
Mix	7days	28days
M_1-0% Slag	1895.20	2853.00
M_2-10% Slag	3258.14	4298.01
M_3-20% Slag	4684.91	7943.05
M_4-30% Slag	5600.60	8730.97
M_5-40% Slag	6665.35	10221.62
M_6-50% Slag	6175.56	8943.92

Table 7: Impact Resistance Strength

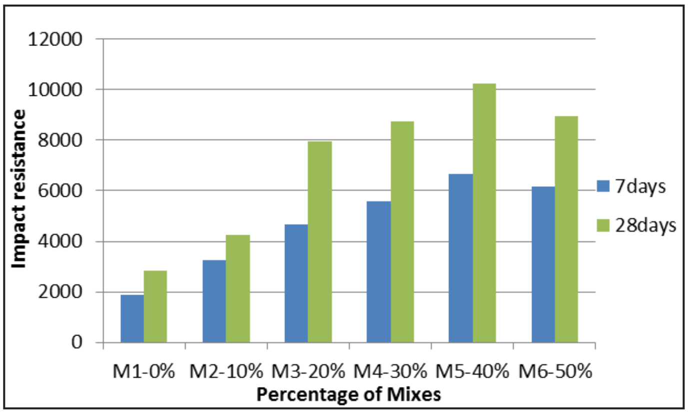

Fig6: Variation of Impact Resistance V/S Various Percentage Replacement of Ferrous Slag as Fine Aggregate.

The impact resistance strength also increases with increasing percentage ferrous slag same as compressive and split tensile strength of concrete.

From the table and the concerned figure, it is observed that for the mix containing 10%, 20%, 30% and 40% ferrous slag an increase in strength is observed at all ages as compared to the control mix. However, for 50% replacement levels, a decrease in strength is observed when compared to the standard 28 days strength of the related concrete mix.The extent needs to be investigated and secondly, 40% slag is optimum from the consideration of resistance to sulphate attack as observed from the experimental results. And 50% is reduces the strength of concrete.

Fig 7: Impact Resistance Test

Flexural strength N/mm2	
Mix	28 days
M_1-0% Slag	6.44
M_2-10% Slag	7.77
M_3-20% Slag	8.24
M_4-30% Slag	9.33
M_5-40% Slag	9.64
M_6-50% Slag	8.58

Table 8: Flexural Strength

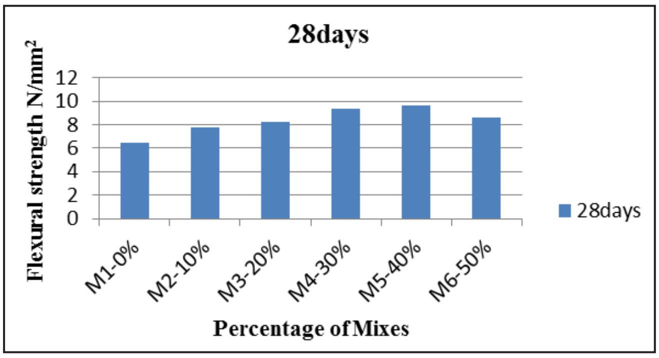

Fig 8: Variation of Flexural Strength V/S Various Percentage Replacement of Ferrous Slag as Fine Aggregate

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It is observed that flexural strength of concrete increases with the increase in the quantity of ferrous slag as a replacement of fine aggregate. Up to 30% of replacement by ferrous slag the flexural strength of concrete of all concrete mix increases but beyond 30% slightly decrease in the strength is observed. The maximum increases in the flexural strength are observed in 30% replacement criterion for all the concrete mix. But 40% and 50% of replacement the strength of beam is reduces.

Fig 9: Flexural Strength Test

SUMMARY:

» The test which is conducted in chapter – 4, the results and test procedures has been showed in this chapter.
» Graphical representation of the experimental results has been showed for each and every test.

4. CONCLUSIONS AND FUTURE RECOMMENDATIONS:

The behavior of ferrous slag seems to be similar to river sand for its use as fine aggregate in concrete mixes. The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 10%, 20%,30%,40%and 50% iron slag with the sand. On the basis of present study, following conclusions are drawn.

GENERAL CONCLUSIONS:

The ferrous slag is crushed, screened and used mainly as road metal and bases, asphalt paving, railway ballast, landfills and concrete aggregate.

The expanded or foamed slag binds well with cement and is used mainly as aggregate for lightweight concrete. However, it is not delivered by domestic steel plants.

SPECIFIC CONCLUSIONS:

» The replacement of fine aggregate with ferrous slag in concrete improves the environmental condition and economy too.
» The ferrous slag replacements in all mixes indicated higher strength gain properties considering the various strengths arrived in this investigation.
» The Compressive strength tends to increase with increase percentages of iron slag in the mix. At 40% slag replacement a maximum strength gain of 20% was seen for 7 days & 11% was increased for 28 days.
» The early age strength gain is higher as compared to later ages of 40% of fine aggregate are replaced by iron slag.
» The compressive strength is increased when it is replaced up to 40%and further it will reduce.
» Spilt tensile property of concrete has been constantly increased, and slag not affected the tensile property. At 40% slag replacement a maximum strength gain of 34% was seen for 7 Days ,30% for 28 days.
» So as 40% of slag replacement, would improve the compressive strength of concrete considerably, at early age presence of more amount of iron slag as sand replacement in concrete is beneficial for improving the strength characteristics.
» The experimental ultimate moment of the test beams are greater than the theoretical ultimate moment, the flexural results show that there is increase in cracking moment by increasing percentage of ferrous slag in the mix. At 40% slag replacement a maximum strength gain of 45% was seen for 28 days.
» The impact strength also tends to increase with increasing percentage of ferrous slag in the mix. At 40% slag replacement a maximum strength gain of 25% was seen for 7 days & 26% was increased for 28 days.
» The results of the hardened concrete properties such as Compressive strength, split tensile strength , the flexural tensile strength and impact strength of all the concrete mixes concluded that the mix having 40% Ferrous slag was optimum and developed higher strengths than that of the control mix for 28 days of curing period.
» However the mix of 50% showed decrease in strength compared to the 40% mix due to higher level of ferrous content present and slow strength gain in the early periods of curing.

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5. SUMMARY:

The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 10%, 20%, 30%, 40%and 50% iron slag with the sand. The Compressive strength tends to increase with increase percentages of iron slag in the mix. At 40% slag replacement a maximum strength gain of 20% was seen for 7 days & 11% was increased for 28 days. However the mix of 50% showed decrease in strength compared to the 40% mix due to higher level of ferrous content present and slow strength gain in the early periods of curing.

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