Experimental Investigation on Partial Replacement of cement and Coarse Aggregate by Rice Huskashand Steel Slagin Concrete

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***Abstract*- This study presents the experimental behaviour of Concrete with partial replacement of aggregates by steel slag and cement by Rice husk Ash and its comparison with controlled specimen. Replacement of steel slag up to 75% does not have any adverse effect on strength and replacement of RHA has shown an increase in strength up to 30%. Aggregates are replaced by steel slag for various percentage and cement with partial replacement of RHA for various percentage is to be used in combination and the strength is to be checked. Tests on hardened concrete such as Compressive strength test, tensile strength tests for controlled specimen and for concrete with various replacements are to be done. A comparative study on strength and cost effectiveness is to be done and the effectiveness on replacement is to be analysed. It is expected that the strength of specimen for various replacements will not have any adverse effect on strength and there might be slight improvement in strength. This replacement would prove to have some environment benefits and would be an economical or a cost-effective technique in concreting for the future. The aim of this project is to utilize the solid waste materials in the best way in construction field without any hazardous effect on strength.**

Keywords- Ricehusk, steelslag, concrete, economic, Flexure, compression strength

I.INTRODUCTION

Concrete plays a major role in the design and construction of infra structures. One third of the volume of concrete is composed by coarse and fine aggregates. The scarcity of the building material is increased every day. To meet this demand of building materials in future, it is necessary to find the suitable alternatives for preparing concrete. Therefore, the available natural aggregates and waste materials from industry and agriculture are becoming increasingly important. Slag is a co-product of steel making industry and also a waste material disposed from the industry. The use of steel slag aggregates in cement concrete by replacing natural material is a new concept.

The quantity of rice is produced in the world is about 600 million tons. From this huge quantity of the Rice Husk Ash (RHA) can be generated by burning the rice husk. It has a highly micro porous cellular structure, which helps to pozzolanic reactions in a mixture Containing Portland cement.

A. Scope of Work

The main scope of this work is to study the properties of fresh and hardened concrete at different mix proportion level. There are many tests are conducted to find the strength of the concrete like compressive test, split tensile strength etc. This replacement was done in 25% increments until all natural aggregates were replaced by the steel slag. Thus, replacing the natural aggregates in concrete applications with steel slag would lead to considerable environmental benefits and would be economical.

II. MATERIAL USED

A. Cement

molten metal in the ladle is around 1400 degrees centigrade and above. When this metal flows from ladle to tannish, the temperature drops to around The type of cement is used in the study was Ordinary Portland Cement 53 Grade. The type of cements is only desired the strength of concrete, and it is compound composition of cement affects the rate of hydration.

B. Fine Aggregate

The aggregate which passes through a IS sieve of size 4.75mm is known as fine aggregates. The sand is naturally obtained from the gravels and rocks. Locally available clean and dry river sand was used. The silica presents in the form of quartz. The sand should be free from impurities. Depending upon the particles size distribution the fine aggregate has divided in to four grading zones sand is used as a filler material in the concrete. Sand gives the impact strength to the concrete [IS 383-1970].

C. Coarse Aggregate

The aggregates which are retained on the 4.75mm in IS Sieve, it's known as the coarse aggregate. The properties of coarse aggregates are decided the strength of the concrete. Therefore, the aggregate should free from the minerals and chemical impurities. Crushed granite aggregate with specific gravity of 2.6 and passing through 20 mm sieve and retained on 12 mm will be used for casting all specimens. The selection of coarse aggregate contains many properties are to be considered. The specific gravity, water absorption, size distribution is found in the laboratory and listed below.

D. Rice Husk Ash

Rice Husk is agro - based waste. From the paddy about 70% of the weight is received as rice, remaining 22% of paddy is husk. The Rice Husk is used as a fuel in various industries. The husk contains 75% of the volatile mater and 85-92% amorphous silica. India is rice producing country, 20 million tons of RHA is produced annually. Rice husk ash substitution for Ordinary Portland Cement up to 30% was recommended. This will decrease the weight of the finished project, also the cost, and dispose of the rice husk ash waste product. This is the best option where rice production is prevalent. The cheaper cost of concrete can lead to more secure and longer lasting infrastructure. RHA acts as a very good Insulator. RHA is also used for insulation of molten metal in tannish and ladle in slab caster. The temperature of 1250 degrees. This reduction in temperature leads to choking and causes breakdown in the slab caster. RHA is also used for soil stabilization.

Fig.1-RiceHuskAshCollectedFrom MannachanallurRiceMill

E. *SteelSlag*

Theuseofindustrialwastes incement concrete isan economicalandenvironmentally friendlymaterial. The steelslagisanindustrialwasteproduct,wecanuse asanaggregate inthecementconcrete. Inthe productionofsteelmanufacturingelectricarcfurnace doesnotusehotmetalsandthematerialsareheated uptoliquidstatebymeansofelectrochemicaleffects onthemetal.Duringthemeltingtime,othermetals arealsobeaddedtomaintain therequiredchemical composition. Steelslagisusedforvarious purposes likemanufacturing ofPortlandcement,aggregatein hotmin asphalt, andforsoilstabilization. In theworld-widesteelslagproductionapproximately fifty milliontonsperyear.

Fig.2-SteelSlagCollectedfrom HariharIndustries

III.MATERIALPROPERTIES

Theproperty oftheCementandRHAistabulated below

TableI–Propertyofcement

Property	Value
Initialsettingtime	28 minutes
Final settingtime	10 hours
Specificgravity	3.15
FinenessofCement	7.5%

A. PropertyofFine aggregate

The propertyof the Fineaggregate istabulated below,

Table II–PropertyofFine aggregate

Property	PercentageofContent
SilicaasSiO2	85.63%
Aluminiumas Al2O3	0.09%
IronOxideasFe2O3	0.37%

B. PropertyofCoarseaggregate

The propertyof thecoarseaggregateistabulatedbelow,

TableIII -PropertiesofCoarseaggregate

Property	Value
Specificgravity	2.81
Finenessmodulus	4.39

C. PhysicalPropertiesofRiceHuskAsh

SomeofthephysicalpropertiesofRHAaretestedin thelaboratory.Theresultsare showsbelow.

TableIV- PhysicalPropertiesofRiceHuskAsk

Property	Value
Initialsettingtime	28 minutes
Final settingtime	10 hours
Specificgravity	1.99
FinenessofCement	2%
Consistency	28%

D. ChemicalPropertiesofRiceHuskAsh

Accordingtochemicalcompositionof RiceHusk Ash, it's the pozzolanicstatus was foundto besilica contentin ashis up to 86%.In high temperature amorphousstateisconvertedtoAl_2O_3,CaO,K_2O, SO_2, etcare presented. Some of thechemical propertiesarelistedbelow.

Table V- Chemical Properties of Rice Husk Ash

Property	Percentage of Content
Silica SiO_2	85.63%
Aluminum as Al_2O_3	0.09%
Iron Oxide as Fe_2O_3	0.37%

E. PhysicalPropertiesofSteelSlag

Steelslagaggregates arenormally rough andangular shaped.So,it'sprovidingagoodbonding strengthto theconcrete.Therough textureandshapearefeasible touseinconstruction.Someofthe positivefeatureof steelslagisstrong, durable, goodangular shapeand high resistance to abrasion. Physical propertiesof steelslaglistedbelow.

TableVI- PhysicalPropertiesofSteelSlag

Property	Value
Specificgravity	2.6
WaterAbsorption	Upto4%
Approx.DryUnit Weightkg/m3	847-870

F. ChemicalPropertiesofSteelSlag

Steel slagnormally containssilica,iron,andlime.Other elements arepresentedlow amountlikesulphur, manganese,etc.thiscomposition expressedinoxide forms. Themineralogicalformoftheslagisdepending on rateof cooling. Some of the tested chemical propertiesarelistedbelow.

TableVII-ChemicalPropertiesofSteelSlag

Property	PercentageofContent
SilicaasSiO2	73.35%
CalciumOxideas CaO	0.36%
IronasFeO	16.72%

G. MechanicalPropertiesofSteelSlag

Before using the steel slag, some of the mechanical properties were tested for steel slag.

Table VIII- Mechanical Properties of Steel Slag

Property	Value
LosAngelesAbrasion%	18-24

IV. TESTING ON FRESH CONCRETE

A. Slump cone test on fresh concrete

Slump cone test is conducted on the fresh concrete, the workability of the different mixes having 20% of RHA and 25%, 50%, 75% & 100% of Steel Slag is observed and it is compared with the workability of the conventional concrete mix. The results are tabulated below,

TableIX –SlumpConetestonfreshconcrete

RHA	Steel Slag	Slumpvaluein (mm)
0%	0%	95
20%	25%	100
20%	50%	105
20%	75%	97
20%	100%	95

B. Compaction factor test on fresh concrete

Compaction factor test is conducted on the fresh concrete the workability of the different mixes having 20% of RHA and 25%, 50%, 75% & 100% of Steel Slag is observed and it is compared with the workability of the conventional concrete mix. The results are tabulated below,

TableX- Compactionfactorteston freshconcrete

RHA	SteelSlag	Compactionfactor
0%	0%	0.83
20%	25%	0.85
20%	50%	0.81
20%	75%	0.79
20%	100%	0.76

IV. RESULTSANDDISCUSSIONS

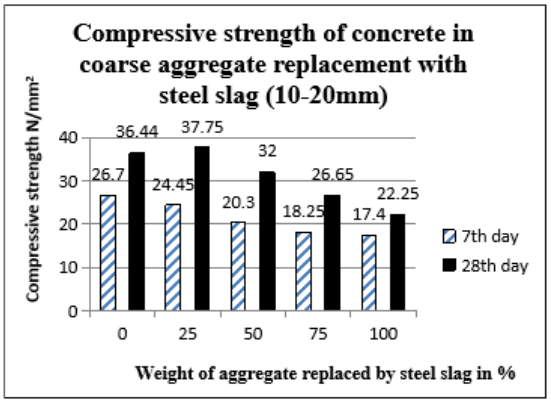
The results and discussions about the various tests are as follows,

A. CompressiveStrengthTest

Determination of compressive strength of the concrete is an important parameter. For each, set nine standard cubes were casted to determine 7- and 28-days compressive strength after curing and also nine number of control cubes are casted to know the original strength of the concrete. The cube size is 150X150X150mm as per the IS 10262 –1982the 7th and 28th days compressive strength value is given the Table.

TableXII-ReplacementofCoarseAggregate withSteelSlagin CompressiveStrength(10-20mm)

Coarse Aggregate replacement in %		Compressive strength in N/mm²	
		7th day	28th day
0		26.70	36.44
25	20% of cement replaced with RHA	24.45	37.75
50		20.30	32.00
75		18.25	26.65
100		17.40	22.25



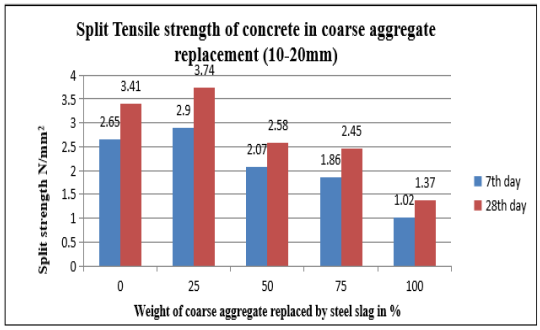
B. Split Tensile Strength Test

It is very difficult to directly measure the tensile strength of concrete; therefore, the splitting tensile test, an indirect method, was adopted. To determine the split tensile strength the cylinders were cast. The size of the cylinder is 150mm of diameter and 300mm of length. The cylinder is cured properly and tested on 7th and 28th

day. Control concrete cylinder specimen is also cured and tested as per IS specification. Combinations of test results are compared with control concrete specimens.

Table XII -Replacement of Coarse Aggregate with Steel Slag in Split Tensile Strength (20mm)

Coarse aggregate replacement in %		Split strength N/mm² 7th days	Split strength N/mm² 28th days
0		2.65	3.41
25	20% of cement replaced with RHA	2.90	3.74
50		2.07	2.58
75		1.86	2.45
100		1.02	1.37

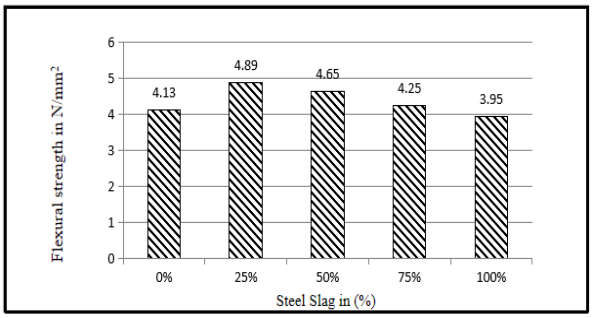


C. Flexural strength test

Flexural strength of Concrete, also known as Modulus of rupture, is an indirect measure of the tensile strength of unreinforced concrete. Modulus of rupture can also be defined as the measure of the extreme fibre stresses when a member is subjected to bending.

Table XIII -Replacement of Coarse Aggregate with Steel Slag in Split Tensile Strength (20mm)

Coarse Aggregate replacement in %		Flexural strength N/mm2
		28th day
0	20% of cement replaced with RHA	4.13
25		4.89
50		4.65
75		4.25
100		3.95



VI. CONCLUSION

From the above findings, the following conclusions may be made out of the study:

- The result shows that cement can replaced by RHA (20%) and Steel slag as a coarse aggregate in concrete up to 25% is possible.
- While using RHA (20%) and Steel Slag as a Cement and Coarse aggregate replacement, 28th day compressive strength is found to marginally increase up to 25% replacement level.
- While using RHA (20%) and Steel Slag as a Cement and Coarse aggregate replacement, 28th day Tensile strength is found to marginally increase up to 25% replacement level.
- 3.60% increment in the compressive strength is found at 25% replacement of Cement and Coarse aggregate by RHA (20%) and Steel Slag at 28th day when compared to normal concrete.
- 9.65% increment in the split tensile strength is found at 25% replacement of Cement and Coarse aggregate by RHA (20%) and Steel Slag at 28th day when compared to normal concrete.
- The optimum replacement level of Cement and Coarse aggregate by RHA (20%) and
  Steel Slag is 25% of Tensile Strength.

VII. REFERENCES

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