Research on Cement Concrete by Partial Replacement of Coarse Aggregates with Steel Slag Aggregates and Cement with Rice Husk Ash

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Abstract— Concrete is the third largest material consumed by human beings after food and water as per WHO (World Health Organization). Concrete plays a vital role in the design and construction of the nation's infrastructure. Almost three quarters of the volume of concrete is composed of aggregates. These are obtained from natural rocks and river beds, thus degrading them slowly. This issue of environmental degradation, and need for aggregates demands for the usage of any other alternative source. Over 5% of global CO2emissions can be attributed to Portland cement production. Demand for cement continues to grow. The emissions caused by annual increases in production exceed gains to reduce emissions through manufacturing efficiencies and cleaner fuels. And also increase in the cost of conventional building materials and to provide a sustainable growth; the construction field has prompted the designers and developers to look for alternative materials for the possible use in civil engineering constructions. For this objective, the use of industrial waste products and agricultural by products are very constructive. These industrial wastes and agricultural by product such as Fly Ash, Rice Husk Ash, Silica Fume, and Slag etc can be used as cementing materials because of their pozzolanic behavior, which otherwise require large tracts of lands for dumping. Large amounts of wastes obtained as by products from many of the industries can be the main sources of such alternate materials. The world rice harvest is estimated at 588 million tons per year and India is second largest producer of rice in the world with annual production of 132 million tons per year. In the present investigation, a feasibility study is made to use Rice Husk Ash as an admixture to already replaced Cement with fly ash (Ordinary Portland Cement) in Concrete, and an attempt has been made to investigate the strength parameters of concrete. Steel slag is a by product of steel making processes of steel industry. It's also one of the biggest industrial waste which is being produced worldwide in a huge quantity during the steel-making operations which utilize Electric Arc Furnaces (EAF). Steel slag can be used in the construction industry as aggregates in concrete by replacing natural aggregates. In this research coarse aggregate were partially replaced with steel slag with different replacement percentage in concrete i.e. 0%, 15%, 30%, 35%, 40% and 45% and cement was partially replaced with rice husk ash with different replacement percentages i.e. 0%, 5%, 10%, 15%, 20% and 25%. In order to required workability and high strength concrete super plasticizers are used. This paper gives the behavior of concrete under flexure, tension and compression under natural loads. In this investigation I considered steel slag aggregates and rice husk ash separately and collectively.

Key words: Concrete, Fly Ash, Rice Husk Ash, Silica Fume

I. Introduction

Now-a-days Concrete is the most widely used construction material. Concrete plays vital role in the design and construction of nation's infrastructure. Almost of concrete volume is composed of coarse aggregates which are obtained from natural rocks. Due to this the degradation of natural resources occurs. To meet the global demand of concrete in the future, it becomes a more challenging task to find suitable alternatives to natural aggregates for preparing concrete. To overcome the above said problem wastes generated from alternative sources are used. Steel slag is an industrial byproduct obtained from the steel manufacturing industry. It is produced in large quantities in steel making operations which utilize Electric Arc Furnace (EAF) and can also be prepared by melting iron ore in the Basic Oxygen Furnace slag (BOF).Steel slag produced approximately equals to the 20% by mass of steel output. Steel slag can be used in the construction industry as aggregate in concrete replacing natural aggregates. Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Globally, approximately 600 million tons of rice paddies are produced each year. On average 20% of the rice paddy is husk, giving an annual total production of 120 million tones. In majority of rice producing countries much of the husk produced from processing of rice is either burnt or dumped as waste. Burning of RH in ambient atmosphere leaves a residue, called rice husk ash. For every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers, about 55 kgs (25 %) of RHA is generated

II. Literature review

A. I. Tamboli (2015) Investigated the effect of using steel slag as a replacement of course aggregate on the properties high strength concrete. four concrete mixtures were prepared with different proportions of steel slag ranging from 0% (for the control mix) to 30% Concrete mixes were evaluated for workability, density , compressive e strength, tensile strength, flexural strength and durability. The results indicate that there is a slight increase in the compressive strength of nearly 1.1 times than the conventional mix with the increase of steel slag up to 20% whereas the workability increased rapidly with increases in steel slag percentage. Addition of up to 30% of steel slag as aggregate replacement yield comparable strength with that of the control mix. However, further additions of steel slag caused reduction in the strength and workability.

Jigar P. Patel (2006) Investigated the effect of replacing some percentage of natural aggregates by steel slag on strength properties and Workability of concrete mixture when admixtures are used .The results showed that replacing about 50 to 75 % steel slag aggregates by volume for natural aggregates will not do any harm to the concrete and also it will not have any adverse effect on the strength and durability

Dr. K. Chinnaraju (2011) Investigated the effect of using steel slag as a replacement of course aggregate and eco sand on the properties of compressive strength of concrete. Various concrete mixtures were prepared with different proportions of steel slag ranging from 0% (for the control mixture) to 100% as coarse aggregates replacement. Cement mortar mixtures were evaluated for compressive strength, whereas concrete mixtures were evaluated for workability, density, compressive strength, tensile strength, flexural strength and durability. The results obtained were revealed that all mixtures with different steel slag proportions yielded comparable or higher compressive strength than that of the control mixture with 60% steel slag and 40% eco sand substitution. There was also reduction in the cost from 1.8% to 39.9%.

V. Subathradevi (2014) Presented the results of research on properties of the Concrete having the steel slag as replacement of course and fine aggregate. The workability and strength characteristics were assessed through a series of tests on six different mixing proportions at 10% interval .The results indicates The optimum percentage of replacement for fine aggregate is 40% and for coarse aggregate is 30%, beyond which the compressive strength decreases on further replacement.

R. padma priya (2015) Reported that most Industrial slag are being used without taking full advantage of their properties or disposed rather than used. The steel slag, which should be used as partial or full replacement for coarse aggregate rather than as bulk aggregates or ballasts because of the degradation of natural resources. They studied the strength properties of concrete with 20%, 40%, 60%, 80% replacement of industrial slag with coarse aggregate. It is found that 40% replacement gives the maximum strength.

III. Materials

A. Cement:

The cement used in the experimental work is ORDINARY PORTLAND CEMENT of 53 grade is used.The physical properties of the cement obtained on conducting appropriate tests as per IS:269/4831 and the requirements as per 1489-1991

B. Coarse Aggregate:

Aggregates of size greater than 4.75 mm are known as the coarse aggregate. The maximum size of coarse aggregate is 80 mm. 20 mm size aggregates are used in this Experimental work. Coarse aggregate occupies the maximum volume of concrete. Locally available crushed angular aggregates are used. The specific gravity of the aggregate is 2.7.The fineness modulus is determined by sieve analysis in the laboratory.

C. Fine Aggregate:

The aggregates whose size is less than or equal to 4.75 mm is known as fine aggregate. Locally available sand satisfying the requirements of ASTM C33-03 was used in the concrete mixes. The sand obtained from river beds or Quarries is used as fine aggregate. The fine aggregate along with the hydrated cement paste fill the space between the coarse aggregate. The sand passing through 2.36 mm is used in concrete. The specific gravity of the cement is 2.7 and it comes under ZONE II.

D. Slag:

Steel slag is by product of steel industry. For this experimental work secondary steel slag made electric arc furnace slag is used as coarse aggregate replacement. Steel slag aggregate of 20 mm size are used.

E. Rice Husk Ash:

The Rice Husk Ash used in the present experimental study was obtained from brick burning yards in chezerla, Guntur, Andhra Pradesh. First we collected samples from different brick burning yards and selected the best Rice husk ash sample which was dry and to use as a partial replacement of cement and then again we collected require amount of rice husk ash of 8 bags and again to make RHA as fine powder by using mixer and the powder is passed through 75micron sieve..

F. Water:

Water Available in our lab is used in this investigation.

IV. Results and Discussions

A. Compressive strength:

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes Place, in its vertical plane along the diagonal. The vertical cracks occur due to lateral tensile Strain. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate Further due to the lateral tensile strain. Test specimens of size 150×150×150 mm were prepared for testing the compressive Strength of both conventional as well as steel slag concretes. The Modified mixture with varying percentages of steel slag as a partial Replacement of coarse aggregate is cast into cubes. Compressive strength test results at curing ages of 7 and 28 days for conventional mix as well as for the Modified mixes are shown in the Table. For testing in compression, no cushioning Material was placed between the specimen and the plates of the machine. The load was applied axially without shock till the specimen was crushed. Fig shows the test setup for the compressive strength. Three specimens for each mix were tested and the corresponding values were observed and average value was taken for discussion. Table Shows the variation of compressive strength with varying percentage replacement of coarse aggregate with steel slag.

Mix	% of Steel Slag	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	34.23	47.23
	15	35.7	49.3
	30	38.44	52
	35	40.34	55.6
	40	37.7	51.2
	45	34	44.29

Table 1: Compressive strength (MPa) values for replacement of cement with steel slag

Mix	% of RHA	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	42.94	45.56

	5	43.21	48.21
	10	47.18	51.31
	15	50.19	53.56
	20	46.52	48.29
	25	42.94	45.47

Table 2: Compressive Strength (Mpa) Values for Replacement Of Cement With Rice Husk Ash

Mix	% of Steel Slag	% of RHA	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	0	34.26	42.76
	15	5	35.19	43.98
	30	10	36.54	45.46
	35	15	36.98	47.02
	40	20	33.62	44.34
	45	25	31.25	40.56

Table 3: Compressive Strength (Mpa) Values For Replacement Of Cement With Steel Slag And Rice Husk Ash

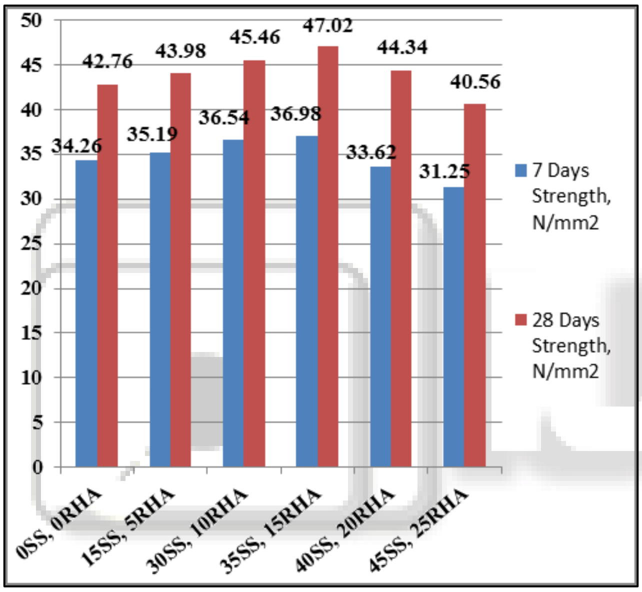

Fig. 1: Variation in Compressive strength for all the mixes.

B. *Split Tensile Strength:*

Split tensile strength is used to determine the tensile strength of the concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of the concrete to determine the load at which the concrete member may crack. It is performed on the cylinders of 150 mm diameter and 300 mm height. Take the wet specimen from water after curing. Wipe out water from the surface of load specimen. Set the compression testing machine for the required range. Keep the plywood strip on the lower plate and place the specimen in position and keep top strip. Bring down the upper plate to touch the plywood strip. Apply the load continuously and uniformly without any shock. Note down the breaking load.

Mix	Steel Slag %	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	3.26	3.5
	15	3.38	3. 67
	30	3.44	3.74
	35	3.67	3.78
	40	3.42	3.63
	45	3.23	3.45

Table 4: Split Tensile Strength (MPa) values for replacement of cement with rice husk ash

Mix	RHA %	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	1.16	2.37
	5	1.76	2.83
	10	2.33	3.56
	15	2.56	3.95
	20	2.17	3.05
	25	1.16	2.89

Table 5: Split Tensile strength (MPa) values for replacement of cement with rice husk ash

Mix	% of Steel Slag	% of RHA	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	0	1.98	2.47
	15	5	2.05	2.58
	30	10	2.16	2.76
	35	15	2.28	2.81
	40	20	2.21	2.62
	45	25	2.09	2.48

Table 6: Split Tensile strength (MPa) values for replacement of cement with steel slg and rice husk ash

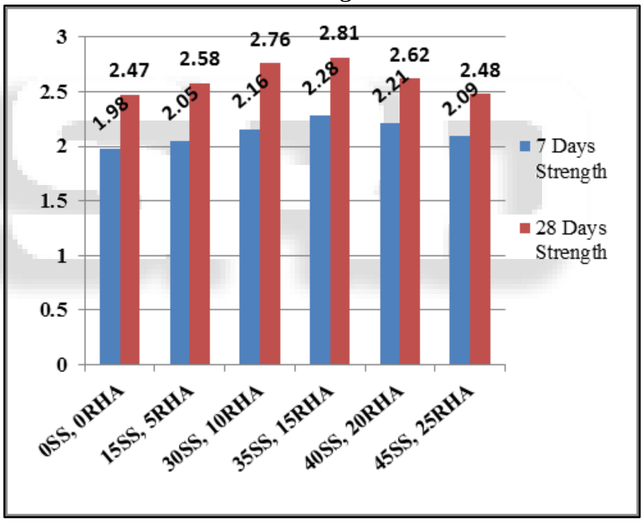

Fig. 2: Variation in Split Tensile strength for all mixes

C. *Flexural Strength Test:*

Concrete is relatively strong in compression and weak in tension. The tensile stresses in concrete likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons. Direct measurement of tensile strength is difficult .The system of loadings used in finding the flexural strength are central point loading and three point loading. The two point loading system is carried out in this experiment. The standard size of the specimen is 150 X 150 X 750 mm. The mould is filled with concrete and well compacted by vibrator. After 24 hours it is allowed to cure for 28 days. The bearing surfaces of the supporting and loading rollers are wiped clean and any lose sand or other material removed from the surfaces of the specimen when they are make contact with rollers. The specimen is then placed in the machine in such a manner that the load is applied to the uppermost surface as cast in the mould, along two lines spaced 20 cm apart. The load is applied without shock and increasing continuously at a rate of loading 400 Kg/min. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded. The flexural strength of the material is expressed as modulus of rupture f_s which if 'a' equals the distance between the line of fracture and the nearest support, measured on the centre line of tensile side of specimen, is calculated to the nearest 0.05 Mpa.

Mix	Steel Slag %	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	2.89	3.84
	15	4.9	5.07
	30	5.23	6.00
	35	5.75	6.30
	40	4.04	5.09
	45	3.89	4.56

Table 7: Flexural Strength (MPa) values for replacement of cement with rice husk ash

Mix	RHA %	7 Days (N/Mm^2)	28 Days (N/Mm^2)
M_{35}	0	3.05	5.1
	5	4.05	5.33
	10	5.44	6.24
	15	5.98	6.47
	20	4.28	6.12
	25	3.05	5.1

Table 8: Flexural strength (MPa) values for replacement of cement with rice husk ash

Mix	% of Steel Slag	% of RHA	7 Days (N/mm^2)	28 Days (N/mm^2)
M_{35}	0	0	2.95	4.84
	15	5	4.12	5.07
	30	10	5.43	6.02
	35	15	5.75	6.30
	40	20	4.35	5.09
	45	25	3.78	4.56

Table 9: Flexural strength (MPa) values for replacement of cement with steel slg and rice husk ash

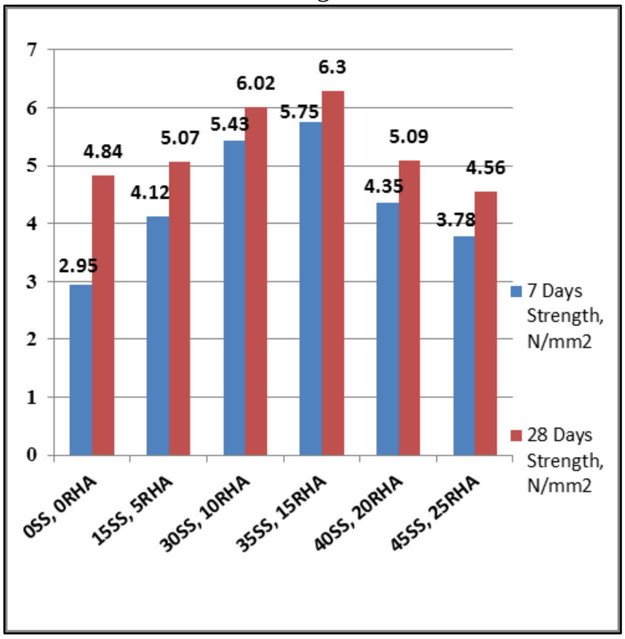

Fig. 3: Variation in Flexural strength for all mixes

V. CONCLUSION

The conclusion was drawn from the above experimental research are the optimum percentage of compressive strength of concrete for 28days with 35 % coarse aggregate replaced with steel slag is found to be given 17.8% increment in normal cube strength. The optimum percentage of split tensile strength of concrete for 28days with 35% coarse aggregate replaced with steel slag is found to be given 12.57% increment in normal cylinder strength. It was observed the increase of replacement level of RHA significantly decreases the initial suction of rates. The possible reason arises for this fact is that the porous characteristic of the block resulted in capillary action from the aggregates. This is also probably because of the presence of RHA in the block that absorbed any available water for the hydration process to take place. The high performance of concrete blocks can be produced using rice husk ash (RHA) as cement replacement material. It was found that optimum RHA replacement level is 15%. It shows the RHA replacement level exceeds 15% also indicates comparable results. There is influence of elastic modulus for concrete block when RHA was used as a partial cement replacement material from 0 to 20% to the cement. RHA20 block unit shows the lowest elastic modulus among the block i.e. RHA5, RHA10, RHA15 and OPC. Block unit shows significant increase in elastic modulus. By using this Rice husk ash in concrete as replacement the emission of greenhouse gases can be decreased to a greater extent. As a result there is greater possibility to gain more number of carbon credits. The optimum percentage of compressive strength of the concrete for 28 days strength is obtained with 35% coarse aggregate replaced with steel slag and 15% cement replaced with rice husk ash. The percentage increase in the strength is 9.96% compared to the normal concrete of M_{35} grade. The percentage increase in the split tensile strength of the concrete is 13.76 %, and increase in flexural strength is 30.16 %, we observed that there was a drastical increase flexural strength. This is due to the presence of rice husk ash.

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