Utilization of Cupola Slag as Partial Replacement To Cement And Coarse Aggregates In Concrete Mix

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Abstract- *In process of pig iron and cast iron production secondary raw materials and industrial wastes are formed The most abundant secondary product originating in these processes are furnace slag. Even only Coarse aggregate can not fulfill the requirements of constructions so there is a need to search a replacing material cupola slag in this study efforts are made to replace the natural aggregate with cupola slag aggregates in varying percentage of replacement from 0 to 100 percent for intervals of 20 percent for M25 grade concrete with 0.4 constant W/C ratio under accelerated concrete curing condition for 7 & 28 days are made to carry out impact on compressive strength and Rapid chloride permeability test of concrete.*

Keywords- Cupola Slag, Compressive Strength test, Rapid chloride permeability test.

I. INTRODUCTION

In the technological process of the steel plant not only are main products being produced, but simultaneously by-products are created too. They have the characteristics of secondary materials and of industrial waste. Some of the main products of iron and cast making are solid light ash, waste gases, technological fluids and mostly slag. A cupola furnace is a vertical shaft furnace used to produce cast iron by high temperature melting of metallic and mineral charge materials. Most of the cupola furnaces are of conventional design which produces a huge amount of slag due to the impurities present in the raw material. The problem of slag disposal is increasing day-by-day due to the decreased availability of free land which is creating a serious problem for the foundry industries.

Objective of the Study

- **a)** To study the compressive strength of concrete on using Cupola Slag aggregate as partial replacement of coarse aggregate.
- **b)** To study the compressive strength of concrete on using Cupola Slag powder as partial replacement of cement.
- **c)** To study the durability of all the specimens using Rapid Chloride Penetration Test (RCPT).

Scope of the Study

- **a)** The same work can be extended to higher grades of concrete with varying water/cement ratio.
- **b)** In the present work, the effect of replacement of coarse aggregate by cupola furnace slag has been studied on the strength characteristics. The study can be extended to durability properties as well.
- **c)** Analysis of the properties of concrete with Mix proportion use admixtures and fly ash.
- **d)** The effect of partial replacement of fine aggregate with that of cupola slag can also be studied for effect on both strength and durability characteristics.

II. EXPERIMENTAL DETAILS

Cement

ISI marked OPC 53 cement used in this study of Ordinary Portland cement that satisfies the requirements of Indian standards IS 12269:1987.

Coarse Aggregate

The coarse aggregates obtained from the locally available quarries with maximum size of 20 mm and satisfying the grading requirements of BIS (IS: 383-1970) is used during this work.

Fine Aggregate

The Size of aggregate 4.75 mm and smaller is called fine aggregate.IS:383-1970 has divided the fine aggregate in to four grading zones. The grading zones become progressively finer from grading zone I to grading zone IV. Zone III used during this work.

Water

Portable drinking water having pH value of 7 and conforming to IS 456-2000 IS used for concreting as well as curing of specimens.

Cupola Slag

Cupola Slag procured from, G.I.D.C. Makarpura is used in this work after crushing and sieving operation, Physical properties were find out as per IS 383.The slag was dumped in large lump forms. It was first dusted and isolated to remove the visible earth impurities. It was then crushed to sizes less than 20 mm with the use of jaw crusher.

Figure 1. Cupola Slag

A number of research works had been conducted on the successful use of cupola furnace slag to partially or wholly replace native coarse aggregate in concrete. Cupola slag has also been reported suitable for use as aggregate in asphalt mixtures and as roadbed, base course, or sub-base material for highways.

Table 1 Chemical composition of cupola slag

Sr. No.	Test Details	Test Resultof Cupola Slag (%)
1	Silicon dioxide (SiO_2)	56.30
2	Magnesium oxide (MgO)	2.26
3	Calcium oxide (CaO)	9.38
4	Aluminiumoxide (Al_2O_3)	10.20
5	Iron oxide (Fe_2O_3)	15.95
6	Sodium Oxide (Na_2O)	0.45

Table 2 Physical Properties of Cupola Slag

Sr. No.	Property	Results
1	Crushing value,%	27
2	Impact value,%	26.71
3	Specific gravity	2.50
4	Water absorption %	0.4
5	Bulk density	1640

Figure 2. Rapid Chloride Permeability Test

III. MIX DESIGN OF M-25 CONCRETE

Table 3 Mix Design of M-25 Concrete

Proportion	Water	Cement	Fine aggregate	Coarse aggregate
By weight (kg/m^3)	197	492.5	683.23	1067.55
Weight	0.4	1	1.387	2.1676

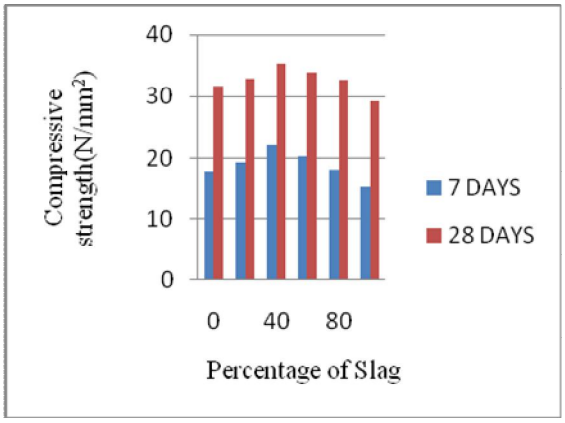
IV. RESULTS AND DISCUSSION

4.1 Compressive Strength Test Results

4.4.1 Replacement of coarse aggregate with cupola slag

Table 4 Result of Compressive Strength for Replacement of coarse aggregate with cupola slag

Type of Concrete	7 Days		28 Days	
	Compressive Strength N/mm^2	Average Compressive Strength N/mm^2	Compressive Strength N/mm^2	Average Compressive Strength N/mm^2
Conventional Concrete(M_{25})	17.60	17.6	31.23	31.68
	17.68		32.07	
	17.52		31.75	
Concrete(M_{25}) + 20% Cupola Slag	18.36	19.2	32.91	32.91
	19.51		33.58	
	19.73		32.25	
Concrete(M_{25}) + 40% Cupola Slag	22.18	22.15	36.05	35.33
	21.73		35.07	
	22.55		34.88	
Concrete(M_{25}) + 60% Cupola Slag	20.78	20.38	34.75	33.97
	20.93		32.77	
	19.45		34.39	
Concrete(M_{25}) + 80% Cupola Slag	19.30	18.14	30.91	32.69
	18.11		33.48	
	17.03		33.69	
Concrete(M_{25}) + 100% Cupola Slag	15.15	15.27	28.32	29.23
	14.88		30.47	
	15.78		28.91	



Graph 1 Compressive Strength for Replacement of coarse aggregate with cupola slag for 7 & 28 days

Discussion on Compressive Strength

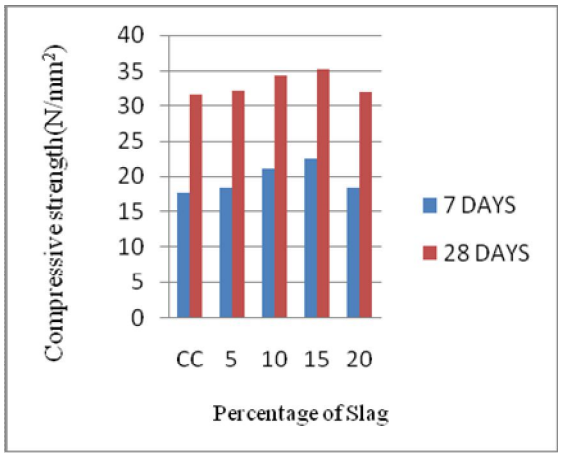
1. In conventional as well as Replacement aggregate concrete the compressive strength at 7 days and 28 days are found out and results are tabulated.
2. The maximum value of compressive strength obtained is 35.33 N/mm^2 for M25 grades of concrete respectively when the Coarse aggregate is replaced by 40% cupola slag.
3. The compressive strength of the concrete decreases beyond 40% replacement of coarse aggregate with cupola slag.
4. The required strength of M25 concrete is achieved for 20%,40%,60%,80% replacement in the case of M25 grade concrete.

Figure 3. Compressive Strength Test

4.1.2. Replacement of cement with cupola slag

Table 5 Result of Compressive Strength for Replacement of cement with cupola slag

Type of Concrete	7 Days		28 Days	
	Compressive Strength N/mm^2	Average Compressive Strength N/mm^2	Compressive Strength N/mm^2	Average Compressive Strength N/mm^2
Conventional Concrete(M_{25})	17.60	17.6	31.23	31.68
	17.68		32.07	
	17.52		31.75	
Concrete(M_{25}) + 5% Cupola Slag	17.80	18.25	32.45	32.18
	19.66		31.14	
	17.31		32.97	
Concrete(M_{25}) + 10% Cupola Slag	22.03	21.01	34.62	34.38
	19.86		34.78	
	21.16		33.75	
Concrete(M_{25}) + 15% Cupola Slag	22.71	22.5	35.87	35.19
	21.57		35.08	
	23.22		34.62	
Concrete(M_{25}) + 20% Cupola Slag	19.21	18.17	31.26	32.02
	17.97		31.64	
	17.33		33.17	



Graph 2Compressive Strength for Replacement of cement with cupola slag for 7 & 28 days

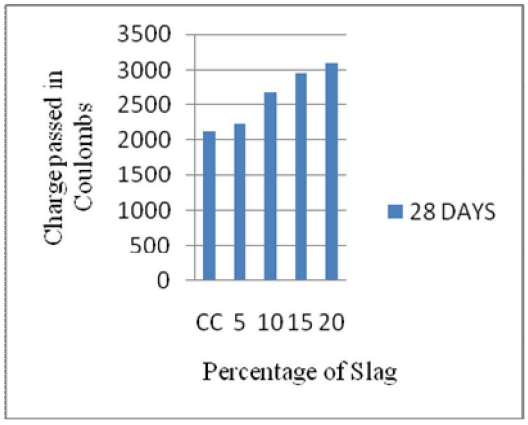
Discussion on Compressive Strength

1. The maximum value of compressive strength obtained is 35.19 N/mm^2 for M25 grades of concrete respectively when the Cement aggregate is replaced by 15% cupola slag.
2. The compressive strength of the concrete decreases beyond 15% replacement of cement aggregate with cupola slag.
3. The required strength of M25 concrete is achieved for 5%,10%,15% replacement in the case of M25 grade concrete.

4.2. Rapid Chloride Permeability Test Results

Table 6 Result of Rapid Chloride Permeability Test for Replacement of cement with cupola slag

Type of Concrete	28 Days		
	Charge passed in Coulombs	Average Charge passed in Coulombs	As per ASTM C1202: Chloride penetrating rate
Conventional Concrete(M_{25})	2152	2129	Moderate
	2105		
	2132		
Concrete(M_{25}) + 5% Cupola Slag	2221	2233	Moderate
	2226		
	2253		
Concrete(M_{25}) + 10% Cupola Slag	2642	2666	Moderate
	2695		
	2661		
Concrete(M_{25}) + 15% Cupola Slag	2973	2947	Moderate
	2915		
	2953		
Concrete(M_{25}) + 20% Cupola Slag	3115	3091	Moderate
	3065		
	3093		



Graph 3 Rapid Chloride Permeability Test for Replacement of cement with cupola slag for 28 days

Discussion on Rapid Chloride Permeability Test

1. As per ASTM C1202, the value obtained for cupola slag admixed concrete is graded under the category "Moderate". As such, it is indicating lesser permeability of slag admixture concrete .The important observation is that addition of slag definitely reduces the pores of concrete and makes the concrete impermeable.

V. CONCLUSION

In this paper, comparative studies of different controllers are studied and performance is evaluated according to time domain functions. It is observed that all controllers able to maintain the set point at the desired value but ZN-PID ,Fuzzy based controllers has slight overshoot, Model Reference Adaptive controller has no overshoot and settles quickly. So it conclude that Model Reference Adaptive Controller is the best controller then other controllers

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