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Strength and Durability Studies of Light Weight Concrete Using Cinder as a Partial Replacement of Coarse Aggregate

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Abstract: The high self-weight of the concrete in increasing the dead load which lead to the development of light weight concrete..In this work experimental investigation was carried out to evaluate the influence on concrete by cinder as a partial replacement of coarse aggregate. A total of four concrete mixes were casted with replacement percentages of 0%, 10%, 30% and 50% for M20 grade concrete. These are evaluated for compressive strength, split tensile strength and flexural strength at different ages of 7days, 28 days and 56 days. Durability tests were also conducted for 30 days after obtaining 28days of strength. Durability characteristics such as acid attack test, acid durability factor of concrete mix for 30 days results are analyzed and compared with the conventional mix.

Keywords: High strength, cinder, compressive strength, tensile strength, flexural strength, durability

I. INTRODUCTION

1.1 GENERAL

Conventional concrete is proper mixture of cement, sand and aggregate. The aggregates occupy the almost 70-75 percent of the total volume of concrete. To meet the global demand of concrete in the future life, it is necessary to use an alternative material in construction which can fully or partially replaced for the natural aggregate without affecting the property of the fresh and hardened concrete. Properties of aggregate affect the durability and performance of concrete, so coarse aggregate is an essential component of concrete. Increased demand in the construction industry lead to increase in the cost of production of concrete. This increased cost of construction materials has paved the way for the researchers to introduce some new construction materials with low cost and high strength.

Due to the high self-weight of the concrete in increasing the dead load which lead to the development of light weight concrete. With reference to this there is an increase in the demand for light weight concrete due to low density and high strength.

1.2 LIGHT WEIGHT AGGREGATES

Light weight aggregate is the aggregate which weighs less than the rock aggregate**.** Types of light weight aggregates

1. Natural aggregates

2. Artificial aggregates

- Natural light weight aggregate consists of particles derived from natural rocks, primarily those of volcanic origin, namely volcanic cinders, diatomite, pumice etc..,

- Artificial light weight aggregate consists of particles derived as by-products of manufacturing iron and steel and processing of shale, Clay in rotary kiln. Such as foamed slag, exfoliated vermiculite, perlite etc..,

1.3. LIGHT WEIGHT CONCRETE

Light weight concrete is a special concrete which weighs lighter than conventional concrete**.** Density of LWA concrete is considerably low (300 kg/m^3 to 1850 kg/m^3) when compared to normal concrete (2200kg/m3 to 2600 kg/$m^{3)}$. The main specialties of lightweight concrete are its low density and thermal conductivity. Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. Sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete.

1.4 CLASSIFICATION OF LIGHT WEIGHT CONCRETE

Lightweight concrete can be prepared either by injecting air in its composition or it can be achieved by omitting the finer sizes of the aggregate or even replacing them by a hollow, cellular or porous aggregate. Particularly, lightweight concrete can be categorized into three groups

1. Structural light weight concrete
2. Aerated/foamed concrete
3. No fines concrete

1.5 CINDER

Cinder is a naturally occurring light weight rock of igneous origin. It is a pyroclastic material similar to that of pumice and has many cavities with low density. Volcanic cinders are having bubble like cavities called vesicles, measure not less than 2.0mm. Cinder is generally black, brown or red in color depending on its chemical composition.

OBJECTIVE OF THE PROJECT

The objectives of this experimental project study are

- To study the effect of concrete, when coarse aggregate is partially replaced with cinder.
- To study the workability, strength and durability properties of concrete of grades M20.

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This work presents the laboratory investigations carried out studies on fresh and hardened properties of concrete.

2. MATERIALS AND METHODOLOGY

2.1 EXPERIMENTAL PROGRAMME

Mix design for concrete M20 with partial replacement of coarse aggregate with cinder with 0%, 10%, 30% and 50% based on the IS: 10262-2009 was done. Conducting trail mixes as per designed workability and target mean compressive strength of concrete. Specimens were tested at the age of 7days, 28days and 56days of curing in water.
Casting cubes of size 150mm×150mm×150mm, for the determination of compressive strength of concrete, casting cylinders of size 300mm×150mm, for the determination of spit tensile strength of concrete and Casting beams of size 500mm×100mm×100mm, for the determination of flexural strength of concrete. a durability test such as placing in H_2SO_4 for 30 days had been conducted.

2.1.1 Physical properties of cinder

S. No	Property	Value
1	Specific gravity	2.01
2	Fineness modulus	8.02
3	Bulk density Loose Compacted	 995 kg/m^3 1001 kg/m^3
4	Nominal maximum size	20 mm
5	Water absorption	1.3%

2.1.2Sieve analysis of cinder (Sample 10kgs)

Sieve size	Retained	% retained	Cumulative % retained
20mm	0.870	8.7	8.7
16mm	2.800	28	36.7
12.5mm	2.920	29.2	65.9
10.0mm	2.50	25.0	90.9
480	0.91	9.1	100
240	---	---	100
120	---	---	100
60	---	---	100
30	---	---	100
15	---	---	100
Total			802.2

$$\text{Fineness Modulus} = \frac{\text{Cumulative \% reatained}}{100}$$

= 8.022

3. RESULTS & DISCUSSION

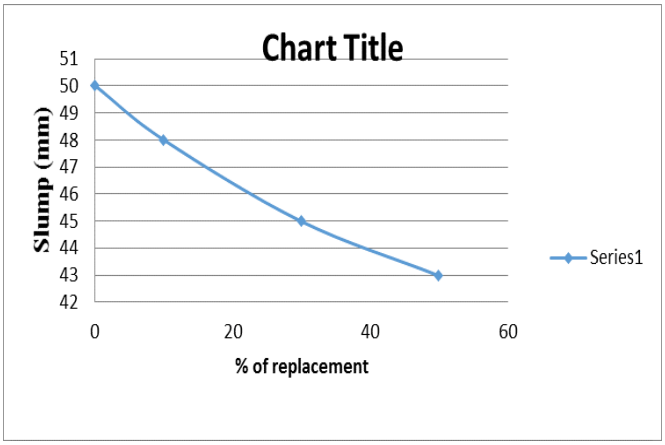
3.1STUDIES ON CONCRETE

SLUMP CONE TEST:

The slump cone test was conducted for all the four mixes. Slump for different mixes are shown below in a tabular form.

Slump cone results

S. No	Mix	% of replacement	Slump Value in mm
1	Mix 1	0	50
2	Mix 2	10	48
3	Mix 3	30	45
4	Mix 4	50	43

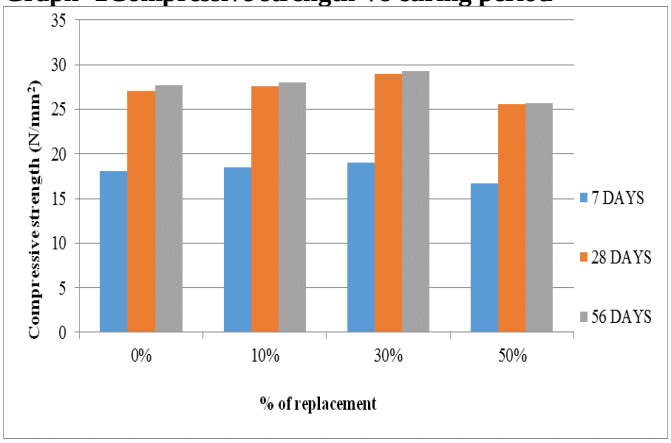


Graph -1: Slump Vs mix

COMPRESSIVE STRENGTH:

S.No.	% of cinder replaced in coarse aggregate	Compressive strength in N/mm^2		
		7 days	28 days	56 days
1	0	18.10	27.03	27.68
2	10	18.50	27.59	28.00
3	30	18.96	29.00	29.38
4	50	16.67	25.60	25.72

Graph -2Compressive strength Vs curing period



SPLIT TENSILE STRENGTH RESULTS

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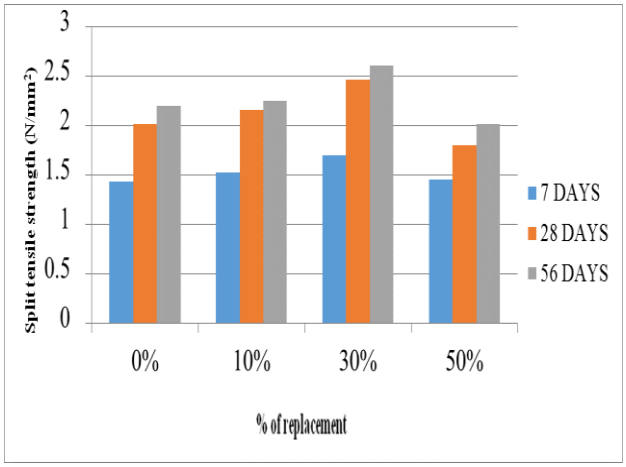
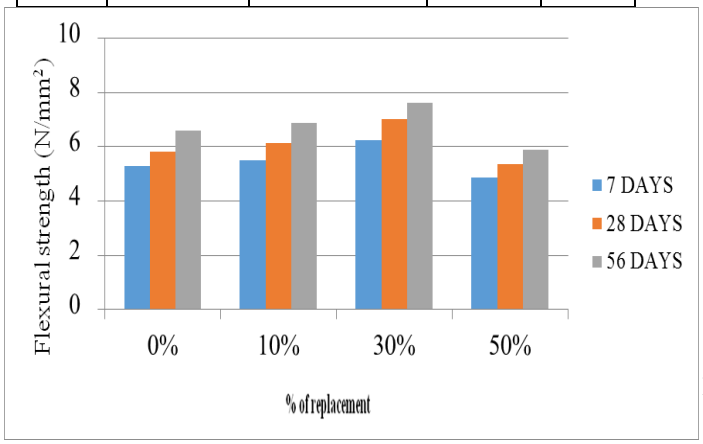
S.No.	% of cinder replaced in coarse aggregate	Split tensile strength in N/mm^2		
		7 days	28 days	56 days
1	0	1.43	2.01	2.20
2	10	1.52	2.15	2.25
3	30	1.70	2.46	2.60



Graph -3 Split tensile strength Vs curing period

FLEXURAL STRENGTH

S.No.	% of cinder replaced in coarse aggregate	Flexural strength in N/mm^2		
		7 days	28 days	56 days
1	0	5.30	5.83	6.60
2	5	5.50	6.12	6.87
3	10	6.25	7.00	7.62
4	15	4.87	5.37	5.87



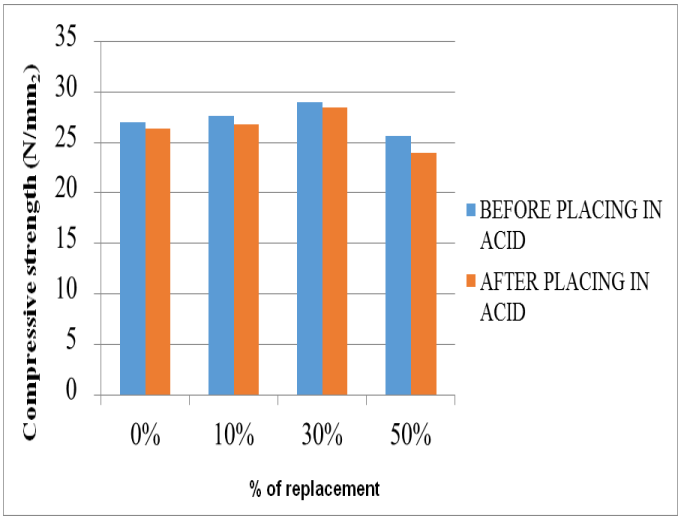
Graph-4 Flexural strength Vs curing period

3.1.1 DURABILITY TEST

3.1.1.1 COMPRESSIVE STRENGTH

Compressive strength loss for conventional and combined mixes

Percentage of replacement	Strength Before placing in H_2SO_4 acid (N/mm^2)	Strength after placing in H_2SO_4 acid (N/mm^2)	Percentage of loss
0	27.03	26.37	2.44
10	27.59	26.81	2.82
30	29.00	28.45	1.89
50	25.60	24.00	6.25



Graph -6 shows the percentage loss of compressive strength for conventional and combined mixes at age of 28 days of immersion of cubes in acid (H_2SO_4).

3.1.1.2 WEIGHT

Replacement of fine aggregate (%)	Average weight of cube before immersion in kg	Average weight of cube after immersion in kg	Loss of weigh t (%)
0	8.450	8.325	1.4
10	8.325	8.225	1.2
30	8.060	7.875	2.3
50	7.860	7.650	2.6

Loss of weight for conventional and combined mixes

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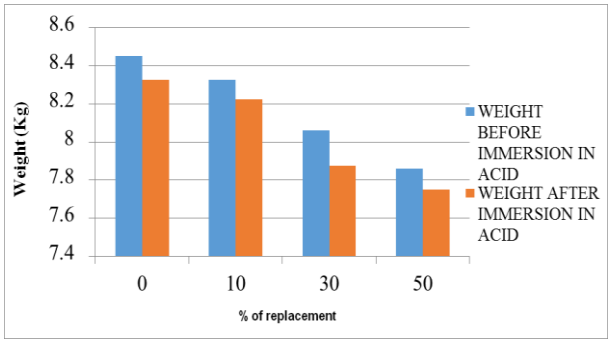
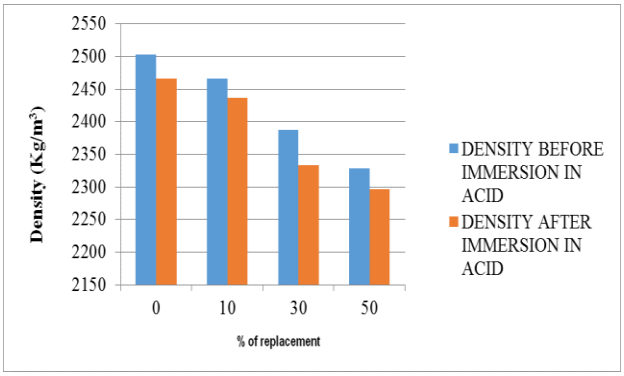


Graph -7: shows the percentage loss of weight for conventional and combined mixes at age of 28 days of immersion of cubes in acid (H_2SO_4).

3.1.1.3 DENSITY

Loss of density for conventional and combined mixes

Replacement of fine aggregate (%)	Average density of cube before immersion in acid (Kg/m^3)	Average density of cube after immersion in acid (Kg/m^3)	Loss of density (%)
0	2503	2466	1.4
10	2466	2437	1.2
30	2388	2333	2.3
50	2328	2266	2.6



Graph-8: shows the percentage loss of density for conventional and combined mixes at age of 28 days of immersion of cubes in acid (H_2SO_4).

3.1.1.4 ACID DURABILITY FACTOR

Acid durability factor results for both conventional and combined mixes

3.1.1.5 ACID ATTACK FACTOR

Concrete mixes	30 days			
	Sr	N	M	ADF
Conventional mix	97.50	28	30	91.00
10 % replacement	97.10	28	30	90.62
30 % replacement	98.10	28	30	91.56
50 % replacement	93.75	28	30	87.50

Concrete mixes (% of replacement)	Acid Attack Factor at 30 Days
0	0
10	0.1
30	0.15
50	0.18

Acid attack factor results for both conventional and combined mixes

4.CONCLUSIONS & SCOPE FOR FUTURE STUDIES

4.1.Conclusions

Based on the study, following conclusions may be drawn.
Slump values are slightly decreases as the % of coarse aggregate replacement by cinder increases. Workability of the concrete is slightly decreases with increases in the percentage of cinder in coarse aggregate. Replacement of 30% coarse aggregate by cinder gives the optimum value for compressive strength, split tensile strength and flexural strength. From above results and discussions, the material can be replaced up to 50% in coarse aggregate, further replacement leads to decrease in strength as compared to normal concrete strengths. On 30% replacement of coarse aggregate with cinder reduced the weight up to 4.6% by which for every metric cube of concrete the weight reduces by 115.55 kg. It is concluded that percentage loss in strength, weight and densities is more for replaced mix when compared to the conventional mix when immersed in sulphuric acid for 30days.

4.2 SCOPE FOR FUTURE STUDIES

In the present study only up to 50 per cent replacement ofcoarse aggregate by cinder has been considered. The other percentages i.e. above 50 percent need investigation. In the present study only 0.5 w/c ratios have been considered. The other ratios i.e. 0.40, 0.5 and 0.55 need investigation.In the present work sulphuric acid used for the attack test, other solutions like hydrochloric acid sodium sulphate and magnesium sulphate can also be used.Double sulpahte attack test can be conducted. The durability properties like %weight loss etc can be extended to 90 days.

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