

Experimental Study on Strength & Durability Characteristics of Light-weight Concrete with Coal Cinder as a Replacement for Coarse Aggregate

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Abstract—A greater challenge for any of the engineer is to make the concrete lighter in density without compromising the structural strength. One being such is Lightweight Concrete; most adopted by Civil Engineers all over the globe in modern construction techniques. Due to the increase in population, demand for infrastructure augmenting day by day. Paper Mill industries uses coal as an energy for firing boilers to produce steam upon which coal is burnt and leaves coal ash or coal cinder as a residue. Cinders are nothing but powder or pieces of burned or unburnt coal which cannot be reduced further. Coal Cinder being an inorganic waste product obtained in the boiler house by combusting black coal becomes a basic constituent as an alternative for natural fines in the manufacturing of bricks and concrete. An attempt has been made in replacing the conventional Coarse Aggregates by Coal Cinders to study mechanical properties and durability aspects of hardened concrete.

Index Terms— Ordinary Portland Cement, Coal Cinder, Compressive Strength and Durability.

I. INTRODUCTION

Because of globalization, huge demand has been created for the infrastructural facilities which relies more on the construction industries. In view of reducing the loads on the substructure, light weight concrete nowadays plays a vital role in modern construction industry can be prepared by using aggregates being lightweight such as gassing agents, lightweight mineral aggregates, plastic granules etc., adopted widely for manufacturing lightweight concrete. One being such is Coal cinder used as a replacement for conventional CA to study the properties of light weight concrete.

A. Ordinary Portland Cement

Being a basic ingredient used as an adhesive for the preparation of concrete, mortar or plaster. For the present work, OPC 43 grade cement is used.

B. Coal Cinder

An industrial by-product obtained as a residue by burning the coal for firing the boilers especially in paper mills used as an alternative for conventional CA passing from 20mm and retained on 12.5mm sieve adopted for the present work.



Figure 1. Coal Cinder

C. M-Sand

Manufactured sand is a crushed fine aggregate produced from a source material used as a filler material in preparing concrete mixes due to the non-availability of conventional river sand.

II. LITERATURE REVIEW

P S Raghu Prasad (2018) studied the strength behaviour of solid concrete block with a replacement of conventional CA with cinder. The tests results showed that, solid concrete block with 15% replacement of CA by cinder records more strength than the conventional one.

Dr. Bhaskar Desai et.al (2018) studied light-weight cinder aggregate concrete with different percentages of replacement 0, 25, 50, 75 & 100 by volume. The test results showed that, performance of concrete was better in terms of higher workability, strength up to 50% and thereafter it decreases considerably.

III. METHODOLOGY

An M20 grade concrete mix is designed as per IS 10262:2019 with replacement of conventional CA with Coal Cinder by 0, 25, 50 & 100% to determine the strength and durability aspects of hardened concrete.

TABLE I. TEST RESULTS ON CONCRETE INGRIDIENTS

Materials	Name of the Test Conducted	Test results
Cement	Specific Gravity	3.15
	Standard Consistency	31%
	Initial & Final Setting time	Initial = 43minutes Final = 600minutes
Fine Aggregate	Specific Gravity	2.65
	Sieve Analysis	Well graded Sample
	Water absorption	2%
Coarse Aggregate	Specific Gravity	2.68
	Water absorption	1.63%
	Fineness Modulus	4.72

TABLE II. CHEMICAL COMPOSITION OF CAOL CINDER

Property and composition	Cinder
Al ₂ O ₃	34.5
SiO ₂	48
Fe ₂ O ₃	7.8
CaO	4.7
MgO	0.3
C	4.7
Porosity (%)	65
Specific Surface area (cm ² /kg)	2500-4000
pH	8.2
Particle size (mm)	4-15

TABLE III. PHYSICAL PROPERTIES OF COAL CINDER

Specific Gravity	1.78
Water Absorption	6.4%

TABLE IV. MIX CALCULATION FOR M20 GRADE CONCRETE BASED ON IS10262:2009

Mix Calculations per unit volume of Concrete	Materials		Final Mix Proportion 1:2.15:3.14
	Cement	348.36 kg/m ³	
	Fine Aggregate	749.89 kg/m ³	
	Coarse Aggregate	1095.30 kg/m ³	
	Water	224.46 litres	

TABLE IV. PERCENTAGE REPLACEMENT OF COARSE AGGREGATE BY COAL CINDER

MIXES	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
COAL CINDER (%)	0	25	50	75	100

Mix 1: Conventional Concrete & Mix 2,3,4 & 5: Concrete with different percentages of replacement of CA with Coal Cinder

IV. RESULTS AND DISCUSSIONS

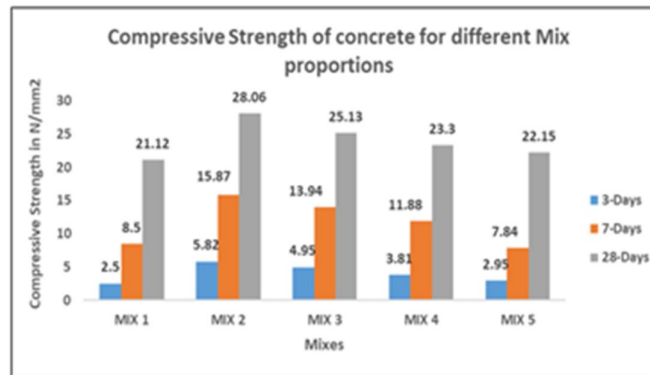


Fig 2. Average Compressive Strength Values for different mix Proportions after 3, 7 & 28 days of curing

The above graph shows the variation of compressive strength values for 3, 7 and 28 days of curing for Normal concrete and concrete mix with different percentages of replacement of coarse aggregate by coal cinder varying from 0, 25, 50, 75 & 100%. Test results for the above said concrete mixes shows that compressive strength values vary about 32.85, 18.98, 10.32 & 4.87% higher than that of conventional concrete.

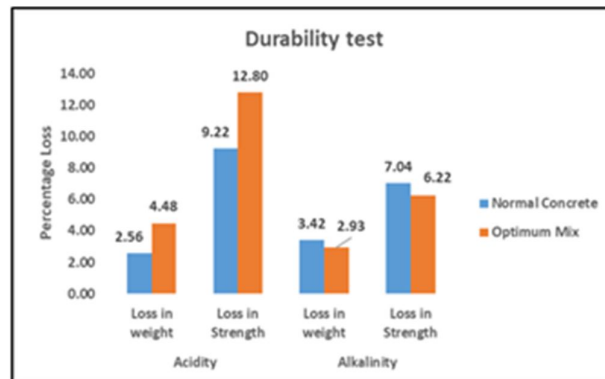


Fig 3. Percentage loss in weight & Compressive Strength Values treated acid & based for 28 days

The above graph shows that percentage loss of weight and loss of compressive strength values for optimum mix (concrete with 25% replacement of CA with Coal Cinder) is more in case of acidity test than compared to that of alkalinity test because when mineral composition of cinder reacts with acids it gets diluted and increases the porosity which in turn permeability increases.

V. CONCLUSIONS

1. Coal Cinder has higher absorptivity (Piotr Smarzewski Et. al) which keep the concrete moist for longer period of time in turn facilitates the hydration of cement and may improve the strength of the concrete.
2. The specific gravity of Cinder is less than compared to conventional aggregate (Anil Sinha Et. al) which reduces the density of concrete.
3. Coal cinder contains higher amount of silica and can be effectively utilized as a replacement for aggregate in preparing concrete mix which reduces the cost of construction.
4. Average Compressive strength values for concrete made with 25% replacement of CA by Coal Cinder shows promising results of 32.85% higher compared to that of conventional concrete.
5. Coal cinder as a replacement of CA in concrete paved the way for preserving the natural resources for future.

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