TEST Engineering & Management

May-June 2020
ISSN: 0193-4120 Page No. 10489 - 10495

Characteristics of Concrete using Coal Ash along with Crumb Rubber and Treated Water

Hemant Singh Parihar[1],Mohit Verma[2]

[1]Assistant Professor, Deparmtment of Civil Engineering, GLA University, Mathura, India.

[2]Assistant Professor, Deparmtment of Civil Engineering, GLA University, Mathura, India.

Article Info
Volume 83
Page Number: 10489 - 10495
Publication Issue:
May - June 2020

Article History
Article Received: *19 November 2019*
Revised: *27 January 2020*
Accepted: *24 February 2020*
Publication: *18 May 2020*

Abstract:

Production of rubber is excessively worldwide every year and so as Fly Ash. Decomposition of rubber and fly ash takes much time so both cannot be discharge off easily in the environment. The aim of this paper is reuse of rubber with coal ash. From this experimental work (Rubberized concrete) different compressive strength, durability is compared with ordinary concrete. Coal ash is also a waste & threat to our environment, so to use it partially as an aggregate in concrete will also help to consume the waste. This paper is focused on the study of concrete using coal ash & crumb rubber & finding out the possible outcome. Compressive strength of Ordinary concrete with coal ash based cement is high and having moderate tensile strength & very low toughness, therefore crumb rubber is mixed in fiber form with the concrete to get the rubberized concrete. The possible outcome of compressive behavior of concrete were examined using water after tertiary treatment From different past & present studies of concrete we can use this in the place where extreme loads are not applied in order to down the overall economy.

Keywords: *crumb rubber, coal ash, tertiary treated water, compressive strength, durability, environment prevention.*

I. Introduction

Concrete consists of sand, coarse aggregate and cement. As per the requirements, various types of cements are available in market like OPC43 grade (confirming to IS 8112:2013), OPC 53 grade (confirming to IS 12269:2013) and rapid hardening cement(confirming to IS 8041:1990) etc.Coarse aggregate is crushed stones or gravels which retains over the 4.75 mm sieve and passed for 80 mm sieve(Confirming to IS 2386 part 1:1963). Generally for concrete mix the size of coarse aggregate preferred less than 20 mm. The concrete mix design depends on the various factors such as Composition of cement, types of structures, strength, workability, durability, environmental exposer and resistant against acid attack.

Concrete mix is enough strong to resist the compression, as the aggregate significantly carries the compression load. However, concrete mix is weak in tension as the cement pastebind the aggregates in place can crack and allowing the structure to fail. To resist that tensile force an additional material is required to strengthen the structure. Steel is the most common and economic reinforced material in concrete mix. Based on various research works, many other reinforced concrete materials are as steel fibers, glass fibers, and plastic fibers, which resist tensile loads effectively.

Indian Standard code IS-10262:2009 gives the guidelines for concrete mix design by which we determine the quantity of cement, fine aggregate, coarse aggregate and water. Cement, FA and CA ratios for different grades of concrete are as for M15- 1:2:4, M20 -1:1.5:3, M25 -1:1:2 and for above M25 design mix adopted from IS 10262:2009. In this research work we replaced the

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fine aggregate with the coal ash and crumbed rubber then after determine the compressive behavior of concrete mix.

In India, Power houses left coal ash residue in high quality as it contains very less unburnt carbon and low sulphur (refer to Fig a.) .

These types of Coal ash is categorized as Pulverized Fuel Ash (PFA).Coalash reduces rate of heat of hydration, improves soundness of concrete massand reduces of thermal cracks. Use of coal ash in concrete mix minimize the cement quantity for same strength so it lead the cost effective approach. The major constituents of coal ash are Calcium Oxide, Alumina, Ferric Oxide and Silica while minor constituents are CaO, Mno, Na2O, K2O, MgO, SO3 and unburnt carbon.

Class F fly ash or siliceous fly ash have more than 70% of major three constituents SiO_2, Al_2O_3 and Fe_2O_3. Such type of fly ash is produced by burning of anthracite or bituminous coal and possess pozzolanic properties. Calcareous fly ash or class C fly ash has less than 50% of three major constituents SiO_2, Al_2O_3 and Fe_2O_3.Calcareous fly ash is commonly produced by burning of sub-bituminous or lignite coal and possesses both hydraulicand pozzolanicproperties. Many researchers reported that the graphene oxide (GO) and carbon nanotubes (CNTs) promotes the secondary hydration mechanism of fly ash [1-3].

Crumb rubber: Crumb Rubber Powder (CRP) in granular form (refer to Fig.b) used to replaces the fine aggregate. CRP is obtained from recycling the waste scrap rubber tyres converted into granular powder form by mechanical grinding process. During the grinding process, fluff and steel cord were removed and converted into granular powder form.

II. Background

Cement is basic material which used in construction. Production of Cement is causes the global warming and used the earth natural resources in the form of silica and alumina. Apart from that sand and coarse aggregate used for concrete mix. Exploration of aggregate leads the disbalance the earth natural resources. In this research we replaced the some aggregate with the coal fly ash and crumb rubber tyre powder (CRP). The main objective of sustainable development is toidentifies and develop a new oralternate technology, which minimize the adverse effect and ensure the elimination of explorationo resources.

Recently, researches have givenan overview on remarkable use of waste tyres' crumb rubber powder in concrete as replacement of the fine aggregate. The investigation contain determine the mechanicalproperties such as: durability, compressive strength, water and gas permeability,chloride diffusion, capillary absorption and resistance against spalling ofConcrete with coal ash and Recycled waste crumb rubber tyres powder in granular form.

Fig. a. Coal ash

Fig. b. Crumb Rubber Powder in granular form (CRP)

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III. Experimental Analysis

The proportion and material for making these test specimens are as the same concrete used in the field.
Specimen Size : 15 cubes of 150mm size

M20 Calculation of material for standard cube and after partial replacement cube.

In order to explore the effect of substitution of sand with rubber particles & coal ash, along with tertiary treated water three cubes of concrete mixtures prepared. First set of mixtures prepared with 10% of rubber & coal ash by total weight of sand by using tertiary treated water. Further the cycle was repeated by 15, 20 & 25% replacement of material along with tertiary treated water. Their experimental results are in table 1, 2, 3 respectively. After this experimental investigation the results were compared with standard concrete cubes to know their results.

Material Used:
1. Cement
2. Sand
3. Aggregates
4. Crumb rubber (0.5 -2.0 mm size)
5. Coal ash
6. Water (Tertiary treated)

For standard cubes each cube contains:

1.3608 kg of cement,
2.0412 kg of sand,
4.0824 kg of coarse aggregate
0.81648 liter of water.

For 10% replacement each cube contains:

1.3608 kg of cement,
1.837 kg of sand,
0.102 kg of coal ash,
0.102 kg of crumb rubber,
4.0824 kg of coarse aggregate
0.81648 liter of water.

For 15% replacement each cube contains:

1.3608 kg of cement,
1.735 kg of sand,
0.153 kg of coal ash,
0.153 kg of crumb rubber,
4.0824 kg of coarse aggregate
0.81648 liter of water.

For 20% replacement each cube contains:

1.3608 kg of cement,
1.632 kg of sand,
0.204 kg of coal ash,
0.204 kg of crumb rubber,
4.0824 kg of coarse aggregate and,
0.81648 liter of water.

For 25% replacement each cube contains:

1.3608 kg of cement,
1.530 kg of sand,
0.255 kg of coal ash,
0.255 kg of crumb rubber,

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4.0824 kg of coarse aggregate
0.81648 liter of water.

Table: 1 Compressive strength of different proportion of concrete cube after 7 days of curing

Sample name	Grade	Age (in days)	Section area cm.sq	Sample height(in cm)	Weight of cube(in gms)	Comp. load in KN	Comp. strength in N/mm.sq	Mean value of comp. strength
S.C. 1	M20	7	225	15	8164	385	17.11	
S.C. 2	M20	7	225	15	8254	395	17.55	17.03
S.C. 3	M20	7	225	15	7985	370	16.44	
10% Rep.1	M20	7	225	15	8116	335	14.88	
10% Rep.2	M20	7	225	15	8226	340	15.11	14.29
10% Rep.3	M20	7	225	15	7855	290	12.88	
15% Rep.1	M20	7	225	15	8658	185	8.22	
15% Rep.2	M20	7	225	15	8247	195	8.66	8.58
15% Rep.3	M20	7	225	15	7885	200	8.88	
20% Rep.1	M20	7	225	15	8316	165	7.33	
20% Rep.2	M20	7	225	15	8576	185	8.22	7.85
20% Rep.3	M20	7	225	15	8055	180	8	
25% Rep.1	M20	7	225	15	8658	190	8.44	
25% Rep.2	M20	7	225	15	8247	180	8	8.07
25% Rep.3	M20	7	225	15	7885	175	7.77	

Table: 2 Compressive strength of different proportion of concrete cube after 14 days of curing

Sample name	Grade	Age (in days)	Section area cm.sq	Sample height(in cm)	Weight of cube(in gms)	Comp. load in KN	Comp. strength in N/mm.sq	Mean value of comp. strength
S.C. 1	M20	14	225	15	9064	380	16.88	
S.C. 2	M20	14	225	15	8734	390	17.33	17.40
S.C. 3	M20	14	225	15	8805	405	18	
10% Rep.1	M20	14	225	15	8956	400	17.77	
10% Rep.2	M20	14	225	15	8426	410	18.22	17.99
10% Rep.3	M20	14	225	15	8555	405	18	
15% Rep.1	M20	14	225	15	8996	260	11.55	
15% Rep.2	M20	14	225	15	8758	265	11.77	11.84
15% Rep.3	M20	14	225	15	8810	275	12.22	
20% Rep.1	M20	14	225	15	8656	250	11.11	
20% Rep.2	M20	14	225	15	8575	260	11.55	10.88
20% Rep.3	M20	14	225	15	8778	225	10	
25% Rep.1	M20	14	225	15	8992	260	11.55	
25% Rep.2	M20	14	225	15	8514	200	8.88	9.92
25% Rep.3	M20	14	225	15	8551	210	9.33	

Table: 3 Compressive strength of different proportion of concrete cube after 28 days of curing

Sample name	Grade	Age (in days)	Section area cm.sq	Sample height (in cm)	Weight of cube (in gms)	Comp .load in KN	Comp. strength in N/mm.sq	Mean value of comp. strength
S.C.1	M20	28	225	15	8229	485	21.55	
S.C.2	M20	28	225	15	8445	470	20.88	21.25
S.C.3	M20	28	225	15	8667	480	21.33	
10% Rep.1	M20	28	225	15	8988	465	20.66	
10% Rep.2	M20	28	225	15	8647	460	20.44	20.36
10% Rep.3	M20	28	225	15	8227	450	20	
15% Rep.1	M20	28	225	15	8298	465	20.66	
15% Rep.2	M20	28	225	15	8332	440	19.55	19.69
15% Rep.3	M20	28	225	15	8521	425	18.88	
20% Rep.1	M20	28	225	15	8335	230	10.22	
20% Rep.2	M20	28	225	15	8741	225	10	9.92
20% Rep.3	M20	28	225	15	8958	215	9.55	
25% Rep.1	M20	28	225	15	8771	220	9.77	
25% Rep.2	M20	28	225	15	8668	210	9.33	9.32
25% Rep.3	M20	28	225	15	8229	200	8.88	

IV. Result & Discussion:

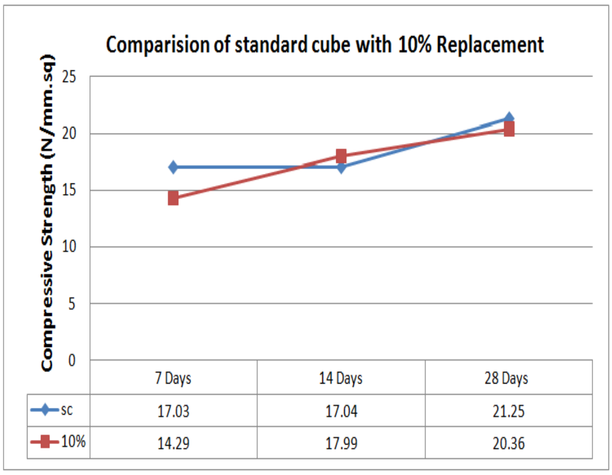

Fig.1. Graph between Compressive Strength & 10% Replacement ofmaterial at various days of curing.

In above graph i.e. Fig.1. it was found that with a 10%
replacement of material the strength at 14 days increaseswhen it was compared with standared cube .

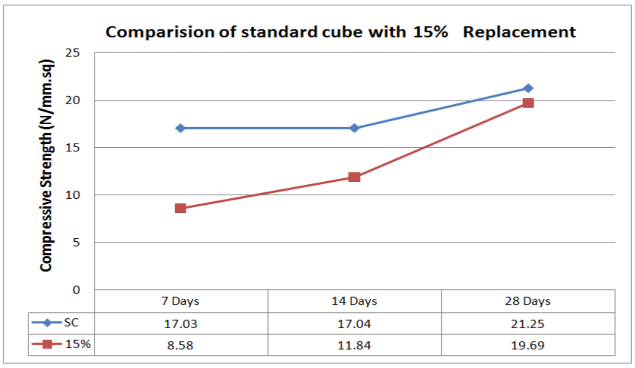

Fig.2. Graph between Compressive Strength & 15% Replacement ofmaterial at various days of curing.

In above graph i.e. Fig.2. it was found that with a 15%replacement of material the strength at 28 days slightlydecreases when it was compared with standared cube .

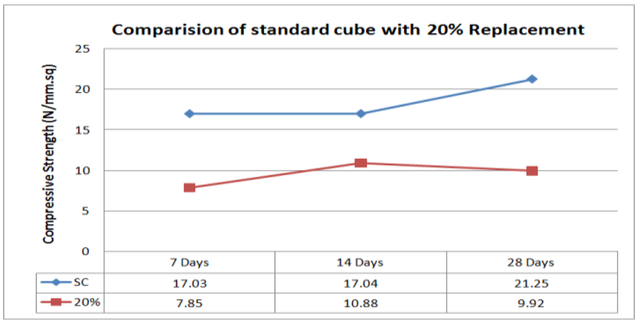

Fig.3. Graph between Compressive Strength & 20% Replacement ofmaterial at various days of curing.

In above graph i.e. Fig.3. it was found that with a 20%replacement of material the strength also decreases whenit was compared with standared cube .

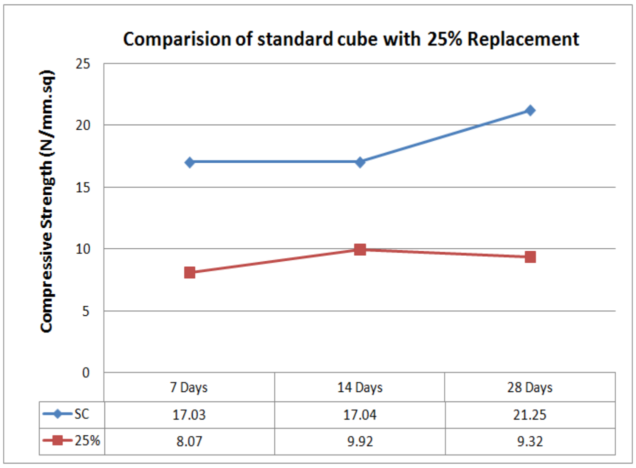

Fig.4. Graph between Compressive Strength & 25% Replacement ofmaterial at various days of curing.

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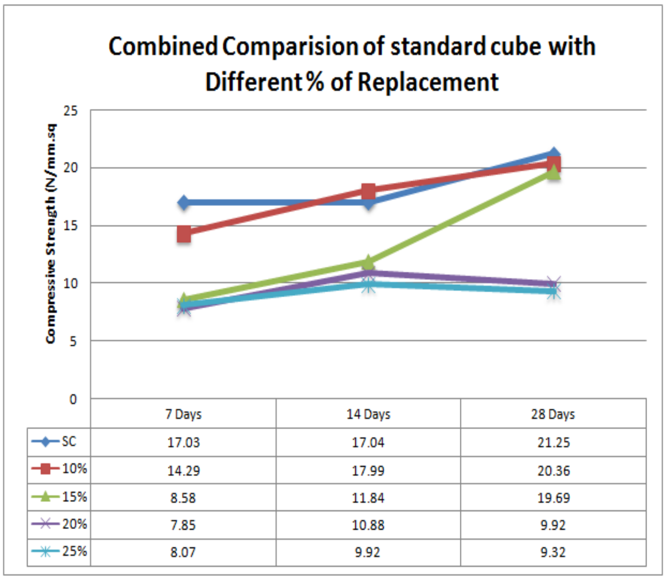
In above graph i.e. Fig.4. it was found that with a 25%replacement of material the strength also decreases whenit was compared with standared cube .



	7 Days	14 Days	28 Days
SC	17.03	17.04	21.25
10%	14.29	17.99	20.36
15%	8.58	11.84	19.69
20%	7.85	10.88	9.92
25%	8.07	9.92	9.32

Fig.5. Graph between Compressive Strength & different % age Replacement of material at various days of curing.

In above graph i.e. Fig.5. it was found that with a 10% replacement of material the 14 days strength observed increase & rest of the results found to be decreases when it was compared with standard cube

V. Conclusion

From the investigation It can be concluded that fine aggregate can be replaced by coal fly ash and CRP up to some extent level. Further increment in the amount of coal fly ash and CRP drawdown the compressive strength of concrete mix.

- The optimum compressive strength was obtained at 10% replacement of coal fly ash and CRP.
- It was observed that additionof coal fly ash and CRP also improved the toughness and deformability.
- It is also concluded that CRP concrete help to absorb the vibrations on base structure.
- CRP concrete may be used in the structures(bridgebarriers and road foundations) where deformabilityand toughness are more important than strength.

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