Experimental Study On Strength Assessment Of Concrete With Partial Replacement Of Activated Carbon

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Abstract - Concrete is the most important and widely used construction material in the world .The production of large quantities of concrete requires extensive amounts of natural resources .Over the last several decades, research has been focusing on cement replacement materials .This study investigates the use of activated carbon in concrete, as binder. Activated carbon reduces the presence of pores in conventional concrete, which enhances the performance of concrete. This research will be focused on mechanical properties of concrete and identify the significant parameters which influence the strength of concrete. In the present study, activated carbon has been used in partial replacement of cement by 15% ,30% and 45% by weight. In addition, activated carbon granules were used in partial replacement of fine aggregates by 15%,30% and 45% by weight respectively. Based on the test results, the performance of concrete using activated carbon was predicted.
Key words : Normal concrete, Carbon material, Mechanical properties, Activated carbon.

I.INTRODUCTION

Concrete is a composite material which has relatively high compressive strength, but significantly lower tensile strength. At present, for a variety of reasons, the concrete construction industry is not sustainable. Firstly, it consumes huge quantities of virgin materials which can remain for next generations. Secondly, the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. Being a versatile material, presence of pores in concrete proves to be a major problem since ever it was discovered. Pores in turn attract water that leads to various ill effects such as freezing and thawing, acid intrusion, decreased resistance to chloride ion, reduced compressive strength etc. By considering this problem, a study is made to minimize the pores present using carbon black powder, a waste from rubber industry as filler. Due to their extremely small size they can fill the pores thereby it is expected to achieve the required benefits.

1.2. Materials:

The materials used in the study are as follows

1.2.1. Cement:

Ordinary Portland cement of 53 grade (JAYPEE) conforming to IS 8112-1989 is used. The basic properties of cement are specific gravity 3.15, standard consistency 35%, initial setting time 0hr 55mins, final setting time 2hr 50mins and fineness 3.53% respectively.

1.2.2. Fine aggregates:

In this study, Natural River sand of size below 4.75mm conforming to zone II of IS 383-1970 was used as fine aggregate. The basic properties of fine aggregates are specific gravity 2.60 and water absorption 1.45% respectively.

1.2.3. Coarse aggregates:

In this study, natural crushed stone with 20mm down size was used as coarse aggregates. These aggregates were tested as per Indian standard specifications IS 383-1970 and the basic properties of coarse aggregates are specific gravity 2.735 and water absorption 0.39%.

1.2.4. Activated Carbon:

Activated carbon is sometimes referred as carbon black. Carbon black is for all intents and purposes Unadulterated natural carbon in the type of colloidal particles are delivered by deficient burning or warm decay of vaporous or fluid hydrocarbons under controlled conditions. Its physical appearance is that of a dark, finely separated pellet or powder. It is a waste from elastic industry, discovers trouble in transfer. Regularly these elastic squanders are dumped into soil making soil contamination and sullying of water table.

The specific gravity of carbon black was determined by density bottle method and it was found to be 1.33. The pH value was found to be 6. This indicates that carbon black is almost an inert material.

1.2.5. Water:

For this study, potable water was used for both mixing and curing.

1.3. Experimental procedure:

The mix design for concrete is obtained from Indian standard specifications IS10262-2009 on different trail mixes and as shown in Table 1.M40 grade of concrete mix is considered for the study.

Table 1: *Values of control mix design*

Material	Weight
Cement	425 kg/m^3
fine aggregate	598 kg/m^3
coarse aggregate	1064 kg/m^3
Water	186 l/m^3

1.4. Preparation of test specimen and castings:

For the experimental study, 9 cubes of 100mm*100mm*100mm, 9 cylinders of 100mm diameter

and 200mm height and 9 prisms of 500mm*1000mm*1000mm were considered for control mix at 7 day,28 day and 56 days respectively for conducting compression test, split tensile strength and flexural strength. These specimens were cast and allowed for curing 7day,28 day and 56 days. After testing these specimens, the results were obtained to be satisfactory i.e, the strength obtained after testing of specimens are approximately equal to target mean strength. The work includes evaluation of strength parameters at 15%, 30% and 45% replacement of cement with activated carbon and fine aggregates with carbon granules at the same percentages.

1.4.1. Fresh concrete properties:

Fresh concrete properties such as slump, were determined for different type of mixes carried out in the experiment, according to Indian standard specifications IS 1199-1959. The results obtained are shown in Table 2

Table2*: Slump values for different mixes*

Mixes		Slump(mm)
Control mix		100
Replacement of cement with activated carbon	15%	118
	30%	125
	45%	110
Replacement of fine aggregates with activated carbon	15%	110
	30%	90
	45%	75

1.4.2. Hardened concrete properties:

After curing of specimens for 7, 28 and 56 days the following tests were conducted for hardened concrete.

For cubes –compressive strength test using compressive testing machine.

For cylinders –split tensile strength test using compressive testing machine.

For prisms –Flexural strength using flexural strength testing machine.

1.5. Results and Discussions

1.5.1. Compressive strength test:

Cubes were tested for compressive strength till failure by using compressive testing machine and the 7,28 and 56 days results were shown in the Table 3. From the table 3, it was observed that the compressive strength of control mix was found to be 50.6MPa at 56 days and the strength for concrete at 30% replacement of cement with activated carbon was 54MPa respectively. Compressive strength values decreased gradually for activated carbon granules used as partial replacement of fine aggregates at 15%,30% and 45% respectively.

Table3: *Compressive strength values*

Type of mix	**% of replacement with Activated carbon**	**Compressive strength in MPa**		
		7 days	**28 days**	**56 days**
Control mix	0	31.6	48.9	50.6
Replacement of cement with activated carbon	15	33.9	50.6	52.4
	30	34.6	52.0	54.0
	45	28.9	32.5	38.7
Replacement of fine aggregates with activated carbon	15	28.9	43.2	46.3
	30	24.5	40.6	42.7
	45	20.3	25.3	29.4

Fig 1 compressive strength values

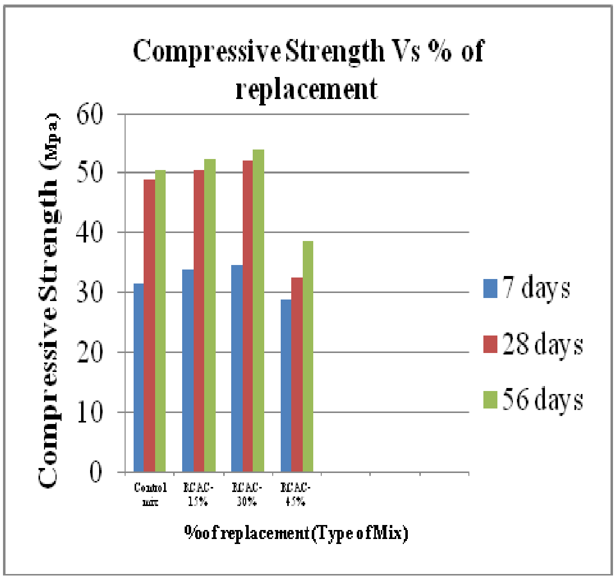

Fig 1 shows the graphical representation of compressive strength values for control mix, percentage replacement of cement and percentage replacement of fine aggregates with activated carbon.

1.5.2. Split tensile strength:

Table4: *Split tensile strength of concrete*

	% of replacement with Activated carbon	Split tensile strength in MPa		
		7 days	28 days	56 days
Control mix	0	1.58	3.02	3.62
Replacement of cement with activated carbon	15	2.33	3.50	4.19
	30	2.726	3.925	4.7
	45	2.02	3.25	3.53
Replacement of fine aggregates with activated carbon	15	1.28	2.54	2.72
	30	0.98	1.98	2.2
	45	0.42	1.23	1.74

Cylinders were tested for split tensile strength till failure by using compressive testing machine and the 7, 28 and 56 days results were shown in *Table4*. From the Table 4, it was observed that the split tensile strength of control mix was found to be 3.62MPa at 56 days and the strength for concrete at 30% replacement of cement with activated carbon was 4.657MPa respectively. Split tensile strength values decreased gradually for activated carbon granules used as partial replacement of fine aggregates at 15%, 30% and 45% respectively.

Fig 2 Split tensile strength values

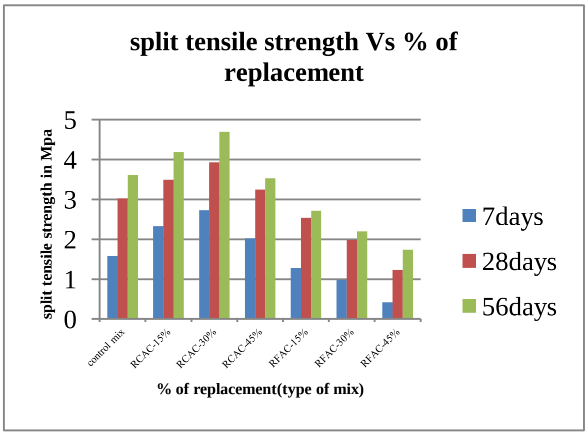

Fig 2 shows the graphical representation of split tensile strength values for control mix, percentage replacement of cement and percentage replacement of fine aggregates with activated carbon.

1.5.3. Flexural strength test:

Prisms were tested for flexural strength till failure by using flexural testing machine and the 28 results were shown in the Table 5. From the Table 5, it was observed that the flexural strength of control mix was found to be 4.93MPa at 28 days and the strength for concrete at 15% replacement of cement with activated carbon was 6.03MPa respectively. Flexural strength values decreased gradually for activated carbon granules used as partial replacement of fine aggregates at 15%, 30% and 45% respectively.

Table 5*: Flexural strength values*

Type of mix	% of replacement with Activated carbon	flexural strength in MPa
		28 days
Control mix	0	4.93
Replacement of cement with activated carbon	15	6.03
	30	5.4
	45	4.9
Replacement of fine aggregates with activated carbon	15	4.42
	30	2.87
	45	2.34

Conclusions

1. The optimum percentage of activated carbon was found to be 30% by weight of cement.
2. Compressive strength, split tensile strength values increase significantly for concrete at 30% activated carbon.
3. There was considerable reduction in compressive strength, when carbon granules were used as partial replacement of fine aggregates.
4. Similar trend was observed for tensile and flexural strength when carbon granules were used as partial replacement of fine aggregates.

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