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DURABILITY PROPERTIES OF STEEL FIBRE REINFORCED CONCRETE WITH BOTTOM ASH AS A PARTIAL REPLACEMENT FOR SAND

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ABSTRACT
A number of experimental works were carried out to analyse and assess different properties of concrete, which is the commonest building material. A main concern in producing concrete is the non availability of river sand. It is observed that river sand has become a depleting material. An alternate material has to be chosen and proved experimentally for replacement. Bottom ash is one such material which exhibits properties similar to those of sand and hence could partially replace river sand. Various research studies are currently being conducted on bottom ash as an alternative to river sand. In this particular paper, the durability aspect of concrete using bottom ash is studied by replacing one fourth of the quantity of sand. Steel fibres are introduced in the same concrete to improve the resistance to crack formation. Here, steel fibres at the rate of 2% of the weight of cement, were added. Resistance of this concrete to acid and alkali attack were studied. Rapid chloride penetration test and water absorption test were also conducted. The results exhibited are in a permissible range which suggests the use of bottom ash for replacing sand, partially

1. INTRODUCTION

The construction industry is one which is booming today. Concrete is the major consumable in construction. Production of concrete in large quantities involves the use of river sand considerably. This has become a major issue as sand has become scarce today. It has become the need of the day that a material other than from natural source has to be selected. M-sand is one such popular material used, however it is based on natural source. But, in this particular study, bottom ash, the waste by-product of thermal power plants has been used for replacing sand. This also becomes a partial solution for curtailing the environmental hazard of depositing bottom ash in low lying areas.

Based on studies on previous research work, a 25% replacement of bottom ash, for sand, has shown satisfactory results. Steel fibre reinforced concrete of M25 grade as per IS: 456 code with the mentioned percentage of bottom ash and steel fibres at the rate of 2% by weight of cement, is used for this research work.

The resistance of the concrete said is studied with respect to acid attack, alkali attack and chloride ingression. This is done by immersing the cubes in the respective acid and alkali solutions after a curing period of 28 days in potable water. Rapid Chloride Penetration Test is done on cylindrical samples, as per the test specifications. Water absorption test was also performed. The results of all these tests portray the appropriateness of using this concrete for construction.

Durability property and strength of concrete using bottom ash has been studied by IM Martins and others. It was observed that the concrete showed properties similar to those as when used with fly ash. Various tests were done to study workability, chloride diffusion, absorption etc.

J. Pera and others [3] have also used bottom ash in concrete. In their study, a replacement of gravel was done with treated bottom ash. A reaction was observed between Aluminium in bottom ash and hydrated OPC, which led to porosity and low strength. This drawback was solved by treating bottom ash in a solution of sodium hydroxide.

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Rafat Siddique [5] in his research work has used coal bottom ash in self compacting concrete. He has thereby studied the water absorption, sorptivity, permeability, abrasion resistance and compressive strength characteristics.

The moisture kinetic aspects of concrete with bottom ash were examined by L.B. Andrews and others. The absorption velocity and capillary water absorption showed higher values for higher content of bottom ash. An increase in drying time was also inferred.

2. METHODOLOGY

Concrete of grade M25 were cast by replacing one fourth portion of sand, with bottom ash. Steel fibres were added, quantity being 2% by weight of cement. Water cement ratio of 0.45 was adopted. Cubes of 150 mm side were cast and cured in normal potable water for 28 days. These cubes were then air dried for one day and weighed. The resistance to acid attack was tested by immersing the cubes in acid water for 90 days. Changes in the cubes were monitored at an interval 30 days. Care was taken to change the solution every week, to ensure that the acidity was maintained. The resistance to acid attack is measured by the loss in weight and compressive strength.

The extent of alkaline attack to concrete was determined in the same manner. The concrete cubes, were immersed in alkaline solution having 5% of NaOH, sodium hydroxide, after a curing period of 28 days. The air dried weight of cubes was recorded after curing in normal water. The cubes were then scrutinised for changes after every 30 days. The alkalinity of the solution was maintained by changing the same each week.

Rapid Chloride Penetration Test provides an indication of chloride ion penetration resistance. Cylinderical sliced specimens of 100 mm diameter are cast and cured for 28 days. The specimens are then conditioned and tested as per the code (ASTM C 1202). The current is read and recorded for every 30 minutes until 6 hours. The electrical conductance is measured by the total charge passed. The results can be used cautiously to predict the durability of the particular concrete, which in turn facilitates the longevity of the structure.

3. OBJECTIVES

The main objective of the research study is to analyse the durability properties of steel fibre reinforced concrete, with bottom ash as fine aggregate (25% replacement), M25 grade. Steel fibres used were of crimped type. Nominal mix 1:1:2 was adopted as per the relevant standards.

4. MATERIALS AND METHODS

The materials used for preparing concrete are cement, sand, coarse aggregate, bottom ash, steel fibres and water. Cement of OPC 43 grade was used. Locally available river sand was taken. Coarse aggregate conforming to IS standards were used. Bottom ash, collected from Ennore thermal power plant was utilised in this study. Sand was replaced by bottom ash to a percentage of 25. Crimped steel fibres were added to concrete (2 percent by weight of cement)

Hand mixing was done thoroughly and slump test was performed. It was observed that this concrete had less workability owing to the coarser nature of bottom ash. It was also noticed that there was a higher water absorptive property in bottom ash. The concrete was less dense compared to the standard control mix, devoid of bottom ash.

5. EXPERIMENTAL PROGRAMME

The casted cubes after 28 days of curing were tested for acid attack, alkali attack, sulphate attack and chloride penetration. The cured and surface dried cubes were weighed and then immersed in acidic water for 90 days. The acid used was Hydrochloric acid (HCl) at the strength rate of 5% by weight of added water, for immersing. Proper measures were taken to ensure that the acidity (pH) was maintained at all times. The resistance to acid attack was determined by the percentage loss in weight and compressive strength. Changes were scrutinised after every 30 days(Fig.1)

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The procedure was repeated to test the resistance to alkali attack. The cubes after curing and surface drying were immersed in alkaline water to which 5% NaOH solution was added. The weights were taken before immersing in the alkali solution. The changes were observed and noted at a 30 day interval, with respect to loss in weight and compressive strength(Fig.4).

The resistance to sulphate attack of the concrete cubes was also tested. After 28 days of normal curing, these were further cured in a solution of 5% Magnesium sulphate and 5% of Sodium sulphate. Observations were again noted as before with respect to the same parameters. Spalling of concrete surface, whitish appearance and exposure of aggregate was observed(Fig.2).

The concrete was further tested for chloride penetration which again is a measure of durability. Standard test procedures as per ASTM C 1202-12 were conducted on cylindrical slice specimens of 50 mm thickness and 100 mm diameter, which were cast for the test. One end of the specimen was immersed in NaCl solution and the other in NaOH solution. The duration of the test was 6 hours. Average value of the total charge passing through the three specimens accounts for the resistance to chloride ion penetration, which is accordingly measured(Fig.3).

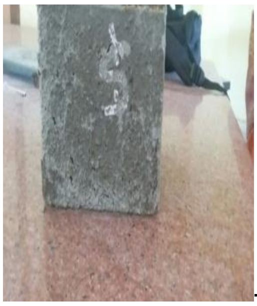

Fig.1

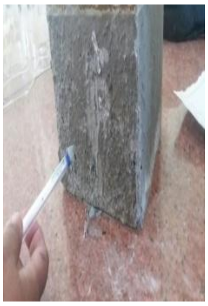

Fig.2

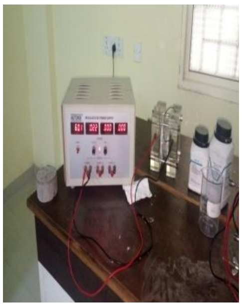

Fig.3

Fig.4

6. CONCLUSION

The result from the experimental study done in this paper reveals the following:
Concrete was observed to have a decrease in compressive strength by 20% for 30 days, 29% for 60 days and 35% for 90 days, when immersed in HCl solution. The loss in weight was 2%, 3.5% and 5.8%, respectively for 30, 60 and 90 days. A yellowish colour was observed on the surface. Spalling of the concrete face was also seen.

Concrete was observed to have a decrease in compressive strength by 18% for 30 days, 28% for 60 days and 37% for 90 days, when immersed in NaOH solution. The loss in weight was 1.7%, 3% and 5.2%, respectively for 30, 60 and 90 days.

Under sulphate attack, the concrete exhibited a decrease in compressive strength by 26 % for 30 days, 34% for 60 days and 45% for 90 days, when immersed in H_2SO_4 solution. The loss in weight was 4%, 6% and 11%, respectively for 30, 60 and 90 days. The effect seemed to be more severe in this case. A gel consistency was observed on the surface with a whitish layer.

Water absorption was tested and found to be 7% for bottom ash concrete. This shows a higher water absorptive nature.

The Chloride permeability is observed to be Moderate in this concrete.

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