Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-9, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

An Experimental Study on Partial Replacement of Natural Sand with Spent Fire Bricks (SFB) and Washed Bottom Ash (WBA)

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Abstract: *Cement, sand and aggregate are basic needs for any construction industry. Fine aggregate (Sand) is a prime material used for preparation of mortar and concrete, which plays a major role in mix design. Being a solid, the sand can sustain shear stresses at rest but it can also undergo large plastic deformations without considerable change of its properties, it is behaving likes a fluid. In present scenario, the erosion of rivers and considering environmental issues, there is a scarcity of river sand. The non-availability or shortage of river sand will affect the construction industry. Hence there is a need to find the new alternative materials like stone dust, sheet glass powder (SGP), spent fire bricks (SFB), Demolition waste, foundry sand, washed bottom ash (WBA), and granulated blast furnace slag (GBFS) to replace the river sand, such that excess river erosion and harm to environment is prevented. Many researchers are finding different materials to replace sand and one of the major materials is quarry stone dust. Using different proportions of spent fire bricks (SFB) and washed bottom ash (WBA) along with sand the required concrete mix can be obtained. This paper presents a review of the different alternatives to natural sand in preparation of mortar and concrete. in this paper discussed about Compressive strength, Tensile strength and Flexural strength of different percentages of spent fire bricks (SFB) and Washed bottom ash (WBA) concrete.*

Keywords*- Sand, spent fire bricks (SFB) and washed bottom ash (WBA), Compressive strength, Tensile strength and Flexural strength.*

I. INTRODUCTION

Concrete is mostly used as a construction material which can be mould into different shapes. Concrete has been a brittle material and has dramatic disadvantage as poor deformability and weak crack resistance in practical usage. The concrete is made with the natural resources like Cement, fine aggregates, coarse aggregates and water. Sand is a major material used for preparation of mortar and concrete and it plays a most important role in mix design. In general consumption of natural sand is more, due to the large use of concrete and mortar. Hence the demand of natural sand is very high in developing to satisfy the rapid infrastructure growth. The developing country like India facing shortage of good quality natural sand and particularly in India, natural sand deposits are being used up and causing serious threat to environment as well as the society. Those natural resources should be replaced by the artificial resources in order to replace the natural resources of sand with spent fire bricks (SFB) and washed bottom ash (WBA). Such materials are dumped in land fill which becomes the environmental problem.

Even though, use of several types of industrial solid wastes like metallurgical waste, glass pieces, fly ash, quarry dust, tyre & rubber waste, crushed concrete waste and others in making good field concrete is being effectively done at European countries, U.S.A., U.K., and Australia. Asian countries could not gear up to that level to match with those countries, therefore, resource exploitation and waste disposal problems are currently rocking the sustainable development in those countries

II. MATERIALS USED

The world is resting over a landfill of waste hazardous materials which may substitutes for natural sand. Irrespective of position, location, scale and type of any structure, concrete is the essential for the construction activity. In fact, concrete is the second largest consumable material after water, with nearly 4 tonnes used annually for each person on the earth. India consumes an estimated 500 million cubic meter of concrete annually and which approximately comes to 1.4 tonne per Indian.

A. Cement

The cement can be described as a material with adhesive and cohesive properties, which is capable of binding mineral fragment in to compact mass. There are several types of cements available in market. Among which ordinary Portland cement

(OPC) is most well-known. The 53 grade Ordinary Portland cement conforming to IS 12269:1987 was used in this paper.

B. Fine aggregate

A fine aggregate is increase the flowing ability and segregation resistance when used at a suitable amount. Aggregate which is passed through 4.75 IS Sieve and retained on 75micron (0.075mm) IS Sieve is termed as fine aggregate. The sand increases the volume of concrete and thus makes it cheaper. It fills the voids in concrete and gives density to concrete. It makes the mass homogeneous and improves the strength of concrete. In this project, the natural river sand conforming to IS: 383-1970 was used as fine aggregate.

C. Coarse Aggregate

The size of aggregates is bigger than the 4.75mm; it is to be considered as coarse aggregate. It should be hard, strong, dense, durable, clean, and free from clay or loamy admixtures or quarry refuse or vegetable matter. The pieces of aggregates should be cubical or rounded shaped. Coarse aggregates containing flat, elongated or flaky pieces or mica should be rejected. The grading of coarse aggregates should be as per the specifications of IS 383-1970. In this project 20mm nominal size of aggregate was used.

D. Water

Water is an important ingredient of concrete as it is actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be taken very carefully. Water used should be free from impurities. Sea water shall not be used.

E. Spent Fire Bricks (SFB)

An experimental investigation on strength and durability was undertaken to use Spent Fire Bricks (SFB) (i.e. waste material from foundry bed and walls; and lining of chimney which is adopted in many industries) for partial replacement of fine aggregate in concrete. Fire bricks are the products manufactured (as per IS: 6 and IS: 8 specifications) from refractory grog, plastic, and non plastic clays of high purity. The different raw materials are properly homogenized and pressed in high capacity presses to get the desired shape and size. Later, these are fired in oil-fired kiln at a temperature of 1,300°C.

Physical Properties of Spent Fire Bricks (SFB)
1. Fineness modulus-2.34
2. Specific gravity-2.65
3. Water absorption-0.9%

Fig-1 Spent Fire Bricks (SFB)

F. Washed Bottom Ash (WBA)

Washed Bottom ash is part of the non-combustible residue of combustion in a furnace. In an industrial context, it usually refers to coal combustion and comprises traces of combustibles embedded in forming clinkers and sticking to hot side walls of a coal-burning furnace during its operation. The portion of the ash that escapes up the chimney or stack is, however, referred to as fly ash. The clinkers fall by themselves into the bottom hopper of a coal-burning furnace and are cooled. The above portion of the ash is referred to as bottom ash too. Currently India is producing in over 150 million tons of coal ash. From which total ash produced in any thermal power plant is approx 20 - 25 per cent of bottom ash and the rest is fly ash. Fly ash has found many users but bottom ash still continues to pollute the environment with unsafe disposal mechanism on offer. The properties of special concrete made with 30 per cent replacement of natural sand with washed bottom ash by weight has an optimum usage in concrete in order to get a required strength and good strength development pattern over the increment ages

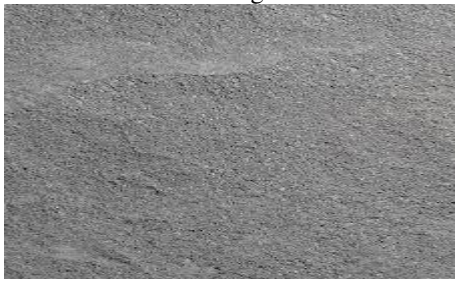

Fig-2 Washed Bottom Ash (WBA)

G. Mix Proportion

Mix design carried for M30 grade of concrete by IS 10262-2009 yielded a mix proportions of 1:1.452:2.774 with water cement ratio of 0.45. Specimens were prepared according to the mix proportion and by replacing cement with glass powder and sand replaced with crushed spent fire bricks in different proportions. To find out the compressive strength of cube with dimensions 150 x150 x150mm, split tensile strength of cylinder with dimension 200 x350 mm and flexural strength of prism with dimension 150 x150 x600mm were cast and tested. The principle of properties of concrete which are of practical importance are those concerning its strength; stress–strain characteristics; shrinkage and creep deformation; response to temperature variation; permeability durability. Of these the strength of concrete assumes a greater significance of hardened cement paste. The voids present in concrete mass have been found to influence greatly the strength of concrete.

III. EXPERIMENTAL WORK

Table 1 Compressive strength of concrete

S.NO	Percentage of SFB and WBA	Compressive strength N/mm2		
		7days	14days	28 days
1	10	15.22	18.52	21.33
2	20	23.45	23.94	24.12
3	30	26.91	26.46	28.34
4	40	30.21	29.3	27.37

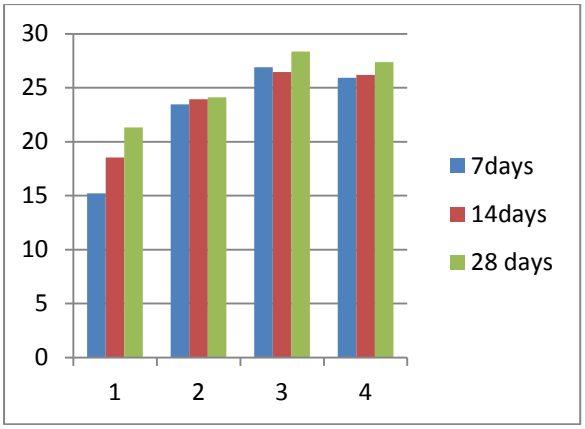

Fig-3

The compressive strength of prepared concrete is increased gradually up to 30% of SFB and WBA concrete and decreases at 40% of SFB and WBA concrete. So The optimizing percentage of SFB and WBA is 30% to be considered.

Table 2 Tensile strength of concrete

S.NO	Percentage of SFB and WBA	Tensile strength N/mm2		
		7days	14days	28 days
1	10	1.72	1.91	2.12
2	20	2.2	2.52	2.84
3	30	3.3	3.53	3.84
4	40	3.01	3.42	3.57

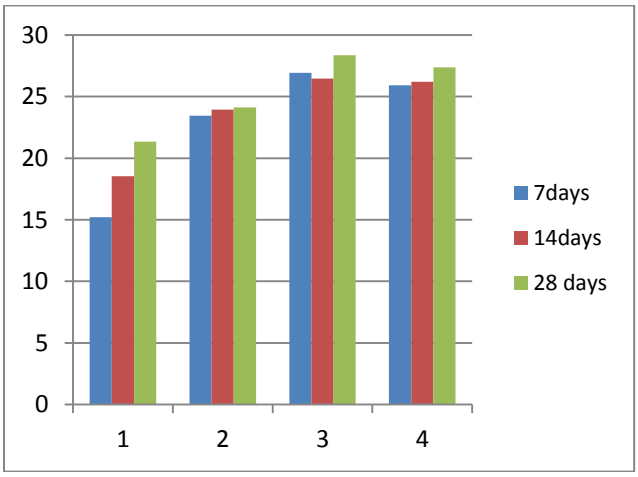

Fig-4

The Tensile strength of prepared concrete is increased gradually up to 30% of SFB and WBA concrete and decreases at 40% of SFB and WBA concrete. So the optimizing percentage of SFB and WBA is 30% to be considered.

Table 3 Flexural strength of concrete

S.NO	Percentage of SFB and WBA	Flexural strength N/mm2		
		7days	14days	28 days
1	10	3.21	3.54	3.9
2	20	4.12	4.65	4.76
3	30	4.97	5.2	5.38
4	40	4.43	4.9	5

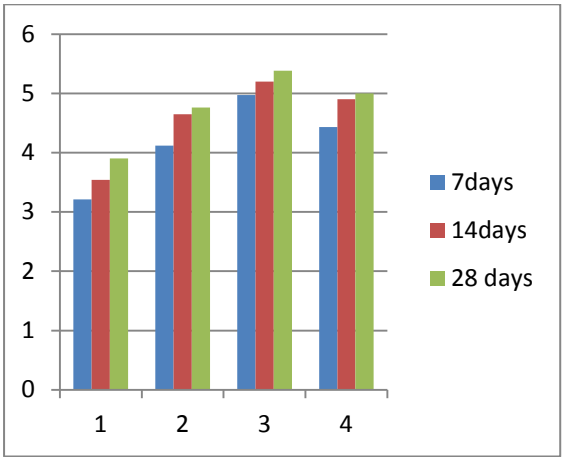

Fig-5

The Flexural strength of prepared concrete is increased gradually up to 30% of SFB and WBA concrete and decreases at 40% of SFB and WBA concrete. So the optimizing percentage of SFB and WBA is 30% to be considered.

III. CONCLUSION

Following observations are made regarding the resistance of partially replaced SFB and WBA.

1. The SFB and WBA is a locally available, low cost, and inert industrial solid waste whose disposal is a matter of concern likes construction waste.
2. On an overall, the SFB and WBA can be compared to the natural river sand.
3. The SFB and WBA satisfies the zone II gradation for not only to partially replace the sand, but for making good concrete,
4. Unit weight of SFB and WBA is higher than that of river sand aggregate in dense condition which, in turn, contributes to the increase in the unit weight of concrete containing SFB and WBA as a fine aggregate. From the obtained results we observe that the maximum strength is achieved by 30% of SFB and WBA replacement in concrete. The 30th% of SFB and WBA replacement in concrete indicates there is no Strength gaining after increasing the proportion.
5. The compressive, tensile strength and flexural strength of partial replacement of SFB and WBA, aggregate concrete is marginally higher than that of the river sand aggregate concrete at age of 7 days, 14 days, and 28 days, respectively.
6. The tensile strength of partial replacement of SFB and WBA aggregate concrete is higher than that of the river sand aggregate at all ages.
7. The modulus of elasticity of partial replacement of SFB and WBA aggregate concrete is marginally higher than that of the river sand aggregate concrete.
8. The partial replacement of WBA can be used effectively as fine aggregate in place of conventional river sand concrete production

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