Experimental Study on the Partial Replacement of Cement by Coal Bottom Ash with Addition of Sisal Fibre in Concrete

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Abstract-The consumption of cement in concrete industries is increasing day by day. Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. In this present experimental work an attempt is made to replace cement by Coal Bottom Ash (CBA). The cement has been replaced by CBA in the range of 5%,10%,15% of weight of cement for M_{35} grade mix. Also 0.5%,1% and 1.5% of sisal fibre has been added to the concrete to make it stronger. The concrete was tested for 7,14 and 28 days in Compressive and Split Tensile strength test. The results were compared with those of conventional concrete to find optimum percentage of CBA. The optimum percentage is 5% coal bottom ash and 0.5% sisal fibre. The flexural strength of beam was tested for 28 days in optimum percentage.

Key words: coal bottom ash, sisal fibre, compressive strength, split tensile strength, flexural strength.

1. INTRODUCTION

1.1 GENERAL

Concrete is a material synonymous with strength and longevity and it has been emerged as dominant construction material for the infrastructure needs of the twenty-first century. Concrete industry is drawing upon enormous natural resources. Rapid increments in urbanization and construction work have resulted in greater demand for construction materials, i.e., materials for which natural resources and energy are further consumed in order to manufacture, which results in harmful materials such as greenhouse gasses being produced in the process. Major environmental problems around the world are usually due to the disposal of waste materials such as industrial waste, construction waste, household waste and etc. However, industrial waste, also known as production by-products. These consequences harnessed the attention of scientists and governments toward the idea of sustainability or clean production, such as incorporating by product waste as a replacement for cement.

1.2 COAL BOTTOM ASH

The thermal power plants operated on Coal as an energy source produce two types of waste products, one is coal fly ash (CFA) and another is coal bottom ash (CBA). However, the light form of coal ash that floats into the exhaust stacks is known as CFA and the heavier portion of coal ash that settles on the ground in the boiler is recognized as CBA. The current disposal practice of CBA in ponds poses a high risk to human health and the environment. Considering the environmental benefits, the reuse of industrial waste in concrete production is the best alternative. The burning of coal in a furnace of a power plant, results in the generation of noncombustible ashes.

1.3 SIAL FIBRE

Sisal (Agave sisalana) plant of the family Asperagaceae and its fibre, the most important of the leaf fibre group. Sisal is a long, soft, shiny plant fibre that can be spun into coarse, strong threads. Sisal is one of the cheapest natural fibres, and is second only produced and variety of uses. Sisal robes and twines are widely employed for marine, agricultural, shipping and general industrial use, and the fibre is also made into matting, rugs, millinery, and brushes The common concrete has two major deficiencies, a low tensile strength and a low strain at fracture. To overcome these deficiencies, sisal fibres are added to improve the performance of concrete.

2.LITERATURE REVIEW

Mohd Haziman Wan Ibrahim (2019) Concrete construction offers a great opportunity to replace the cement with a coal-based power plant waste—known as coal bottom ash (CBA). This study aims to recycle CBA in concrete and evaluate its particle fineness influence on workability, compressive and tensile strength of concrete. In which ground CBA with a different fineness was used as a partial cement replacement of 0% to 30% the weight of cement. At 28 days, a targeted compressive strength of 35 MPa was achieved with the 10% ground CBA. However, it required a longer time to achieve a 44.5 MPa strength of control mix.

Ramadhansyah Putra Jaya (2021) This study investigated the influence of Coal Bottom Ash (CBA) on the concrete. During concrete mixing, cement was replaced with CBA by 10% of cement weight. Initially, concrete samples were kept in normal water for 28 days. Next, the specimens were moved to combined solution of 5% Sodium sulphate (Na2SO4) and 5% sodium chloride (NaCl) solution for further 28 days. The experimental findings demonstrated that the concrete containing 10% CBA gives 12% higher compressive strength than the water cured normal concrete. The presence of 10% CBA decreases the chloride penetration and drying shrinkage around 33.6% and 29.2% respectively at 180 days

Wahyono et al., (2017) examines the effect of adding fly ash and bottom ash in the manufacture of concrete. The strength of the concrete will increase with the addition of fly ash and bottom ash by 2.5% to 17.5%. The best type of concrete is when the addition of 10% and 17.5% with average compressive strength values achieved between 31.79 to 34.04 N/mm².It was experimentally determined that concrete containing 10% ground CBA could meet the required workability, as M1, M4 and M7 gave satisfactory slump values of 50, 48 and 45 mm, respectively. Overall, it was observed from the current and previous studies that workability decreases as the ground CBA percentage increases as compared to CM. This occurs due to the absorption of more water by the fine particles of the ground CBA.

Prasannan.D.et.al Fibers such as sisal and banana fibers were used to enhance the properties of concrete. The natural fibers, having excellent physical and mechanical properties can be used more effectively in concrete. There addition of sisal and banana fibers significantly strength, tensile strength and flexural strength. The ability to resist cracking and spalling were also enhanced. Three different percentages of sisal fibers and banana fibers (0.5%,1%,1.5%) having 30 mm length were used. The addition of natural fiber in concrete gives higher flexural strength.

Dr.(Eng.).John.N.Mwero Concrete is the most widely used construction material because of its unique inherent properties, such as high compressive strength, good durability, fire resistivity, and low permeability. In this study Physical and mechanical properties of sisal fiber reinforced concrete is investigated. From the study it shows the performance of beam –column joint is improved for all fiber content. Acid attack on SFRC is very severe and results in significant weight and strength loss.

3.MATERIAL PROPERTIES

Fig1.COALBOTTOMASH

Fig 2. SISAL FIBRE

3.1 PROPERTIES OF MATERIAL CEMENT

OPC 53 grade (Ultra tech) cement is used for all concrete mixes. The cement is used fresh and free from lumps. The various tests were conducted on the cement and the results obtained are reported in table

Table 1.PROPERTIES OF CEMENT

S. No	Characteristics	Values obtained
1	Standard Consistency Test	29%
2	Specific Gravity	3.15
3	Fineness Test	8%
4	Initial setting Time	40 min

Table 2.PROPERTIES COAL BOTTOM ASH

S. No	Characteristics	Values obtained
1	Standard Consistency Test	48%
2	Specific Gravity	1.89
3	Fineness Test	10%
4	Initial setting Time	120 min

Table 3.PROPERTIES OF SISAL FIBRE

S. No	Characteristics	Values obtained
1	Tensile Strength (Mpa)	385-728
2	Diameter (mm)	0.5
3	Density(g/cm^3)	1.58
4	Young's Modulus (Gpa)	9-22
5	Moisture (%)	6.55

Table 4.MIX PROPORTIONS

Grade of mix	Cement Kg/m3	Fine Aggregate Kg/m³	Coarse Aggregate Kg/m³
M_{35}	425.7 1	596.17 1.4	1216.47 2.8
W/C	0.45- 191.58 l/m^3		

3.2 COMPRESSIVE STRENGTH

Size of the cube specimen is 100x100x100mm.

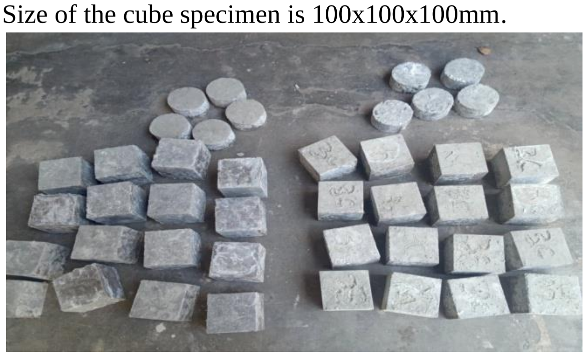

Fig 3.DEMOULDED CUBE

Fig4. TESTING OF CUBE

compressive strength of concrete at the age of 7, 14 & 28days.

Table 5.COMPRESSIVE STRENGTH RESULTS

S. No	Mix Proportions	Compressive Strength N/ mm²		
		7 Days	14 Days	28 Days
1	Conventional	22.8	37.92	44.24
2	5% CBA & 0.5% SF	31.58	38.40	48.71
3	5% CBA & 1 % SF	27.25	32.52	38.25
4	5% CBA & 1.5% SF	21.94	28.01	32.32

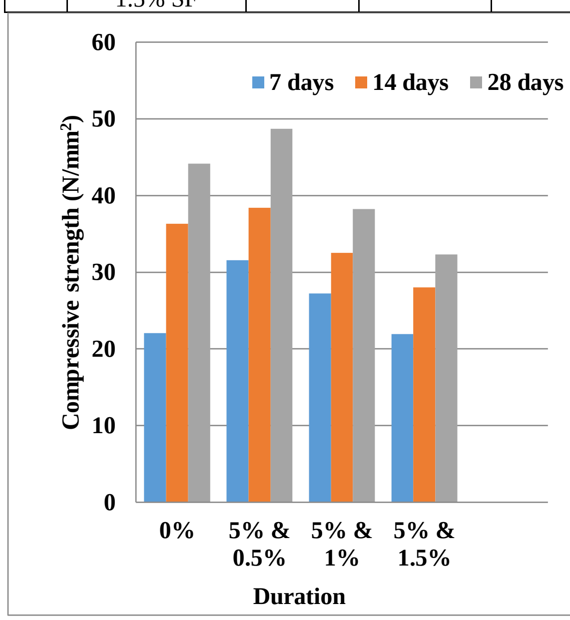

Fig 5.COMPARISON OF COMPRESSIVE STRENGTH TEST RESULTS

3.3 SPLIT TENSILE STRENGTH

Fig 6.DEMOULDING OF CYLINDER

Fig 7. TESTING OF CYLINDER

The Cylinder were casted in the size 150mm X 300mm and the cast specimens were removed from mould after 24 hours. After curing the specimens for a period of 7, 14 & 28days.

Table 6. SPLIT TENSILESTRENGTH RESULTS

S. No	Mix Proportions	Split Tensile Strength N/mm²		
		7 Days	14 Days	28 Days
1	Conventional Mix	2.68	5.71	6.4
2	5 %CBA &0.5%SF	3.52	6.34	8.5
3	5%CBA& 1% SF	3.34	5.2	7.29
4	5%CBA&1.5% SF	2.74	5.48	6.09

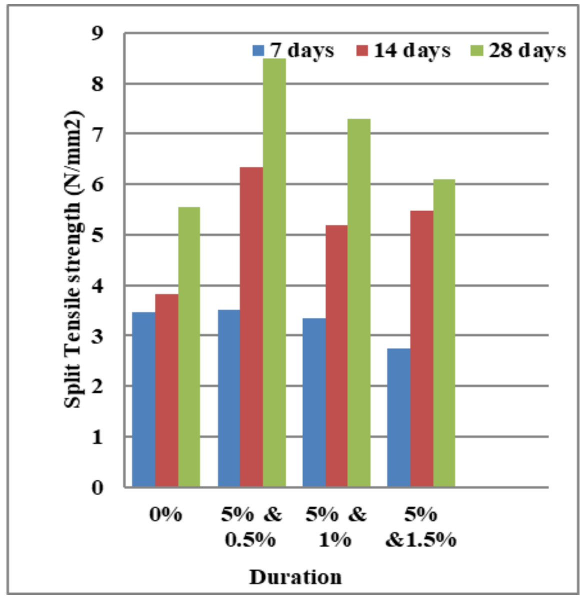

Fig 8.Comparison on Split Tensile Strength Test Results

3.4 FLEXURAL STRENGTH

The concrete beam mould length is 1000 mm, with a cross-section of 150mm x 150mm were used. The beam mould were cleaned thoroughly using a waste cloth and proper oiled along its face. 2 numbers of 10mm diameter bars and 2 numbers of 12mm diameter bars are provided at top and bottom of the beam and 2 legged stirrups of 8mm diameter at 150mm c/c spacing are provided. The concrete material was mixed in a mixture machine and concrete are then filled in mould and compacted using needle vibrator. The beams were cured for 28 days.

The modulus of rupture or flexural strength of concrete can be determined by the following formula,

Flexural Strength = Pl/bd^2 (N/mm^2)

Where,

P is maximum load applied to the specimen

l is the length of the specimen in mm

d is the depth of the specimen at the point of failure in mm

b is the width of the specimen in mm

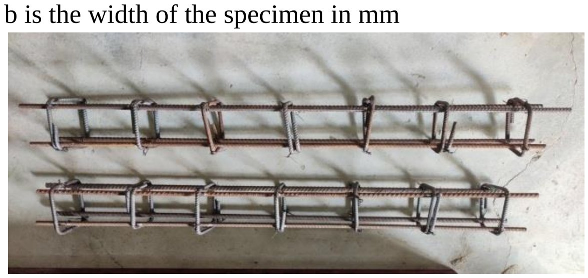

Fig 9.Beam Reinforcement

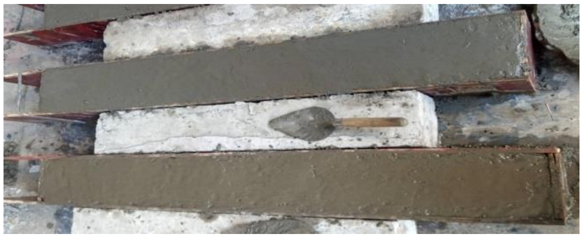
Fig 10.Casted Beam


Fig 11.Testing of Beam


Fig12. Failure of beam

Table 7.Load Vs Deflection of Conventional Beam

S.No	Load(kN)	Deflection(mm)	
		At L/2 Distance	At L/3 Distance
1	0	0	0
2	10	0.5	0.3
3	20	0.8	0.5
4	30	1.2	0.7
5	40	1.5	1
6	50	1.9	1.4
7	60	2.4	1.7
8	70	2.7	2
9	80	3.1	2.5
10	90	3.4	2.9
11	100	3.8	3.3
12	110	4.3	3.7
13	120	4.6	4.2
14	128	4.9	4.7
15	120	6.4	5.5

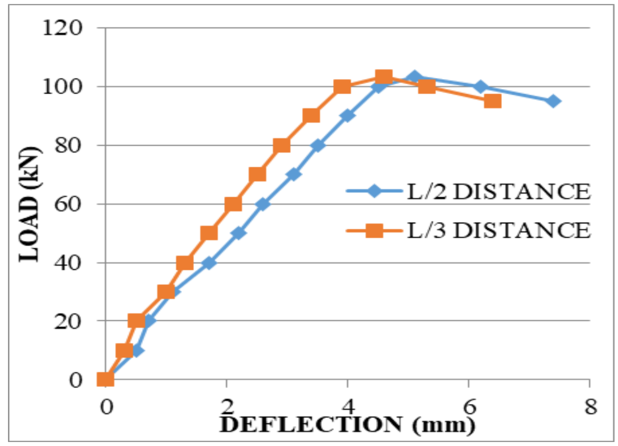

Fig 13.Graphical representation of conventional beam results

Table 8.Load Vs Deflection of Adding Sisal fiber Concrete Beam

S.No	Load(kN)	Deflection (mm)	
		At L/2 Distance	At L/3 Distance
1	0	0	0
2	10	0.5	0.3
3	20	0.7	0.5
4	30	1.1	1
5	40	1.7	1.3
6	50	2.2	1.7
7	60	2.6	2.1
8	70	3.1	2.5
9	80	3.5	2.9
10	90	4	3.4
11	100	4.5	3.9
12	103.4	5.1	4.6
13	100	6.2	5.3
14	95	7.4	6.4

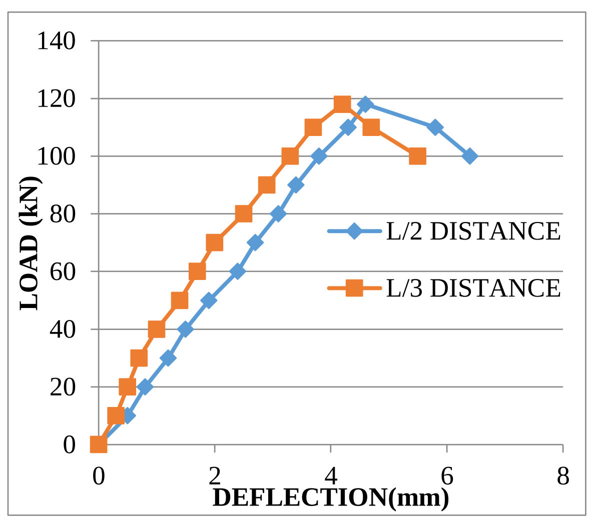

Fig 14.Graphical representation of adding sisal fiber concrete beam results

4. CONCLUSION

It is found that the use of fibre in the concrete decreases the workability of the fresh concrete to some extent. Addition of various percentage of Coal Bottom Ash (CBA) and Sisal Fibre was assigned. Maximum compressive strength is attained at 5% of CBA and o.5 % of Sisal fibre results in increase of compressive strength.

Also maximum split tensile strength is attained at same 5% CBA and 0.5 % of sisal fibre, after that strength starts decreasing. The concrete specimens with 5% CBA and 0.5% sisal fibre is found to be superior to the conventional concrete specimens from the experimental investigation conducted in the study. The beam specimen cast with 5%of Coal bottom ash and 0.5%of Sisal fibre as cement withstand Ultimate load of 128 kN with 4.9mm deflection, compared to conventional concrete the Ultimate load of 103.4 kN with deflection 5.3mm

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