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Partial Replacement of Fine Aggregate by Using Bottom Ash & Manufacturing Sand with Addition of Silica Fume in Concrete

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***Abstract:** Sand is the major material used in construction all over the world. Nowadays sand is highly demand for the construction. The main purpose of this project is to investigate the effect of bottom ash in concrete and hence improving the strength and durability of concrete. So the objectives of this study were to investigate the effect of use of coal bottom ash & m-sand as partial replacement of fine aggregates. Percentages {M-Sand (50%), bottom ash (5%, 10% , 15% , 20%) , silica fume(2% were added) for 25% of bottom ash}. on concrete properties such as compressive strength, splitting tensile strength test. The results of specimens with and without bottom ash, Manufacturing sand, silica fume were compared. The strength of concrete was increased upto 15% replacement of bottom ash instead of fine aggregate and the 25% replacement of bottom ash with 2% of silica fume increased the strength of concrete.*
***Keywords:** Bottom ash, silica fume, manufacturing sand*

I. INTRODUCTION

A. General

The challenge for civil engineers in the future is to design the project using high performance materials within reasonable cost and lower impact on environment. Large quantities of waste materials are produced from the manufacturing industry, service industry and municipal solid waste incinerators. The sense of using waste materials not only helps in getting them utilized in cement, concrete, and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in land-fill cost, saving in energy, and protecting the environment from possible pollution effects.

Coal is primarily used as a solid fuel to produce electricity and heat through combustion. It is one of the world's most important sources of energy, fuelling almost 41% of electricity worldwide. In India, over 70% of electricity generated is by combustion of fossil fuels, out of which nearly 61% is produced by coal-fired plants. The total coal production in the India at present is 557.45 Million Tons (MT) per year which rose 3.2% over the previous year, being the third largest producer in the world.

B. Need For The Present Study

Concrete is the most popular building material in the world. However, the production of cement has diminished the limestone reserves in the world and requires a great consumption of energy.

River sand has been the most popular choice for the fine aggregate component of concrete in the past, but over use of the material has led to environmental concerns, the depleting of securable river sand and deposits and a concomitant price increase the material. Therefore, it is desirable to obtain cheap environmentally friendly substitutes for cement and river sand that are preferably byproduct coal bottom ash are used extensively as a partial replacement of sand.

C. Objectives

1) To analyse the M- Sand & Bottom Ash effect in the concrete.
2) To analyse the compressive strength & split tensile strength of hardened concrete blocks.
3) To decreases the usage of river sand in the construction site.
4) To compare the results with the conventional concrete

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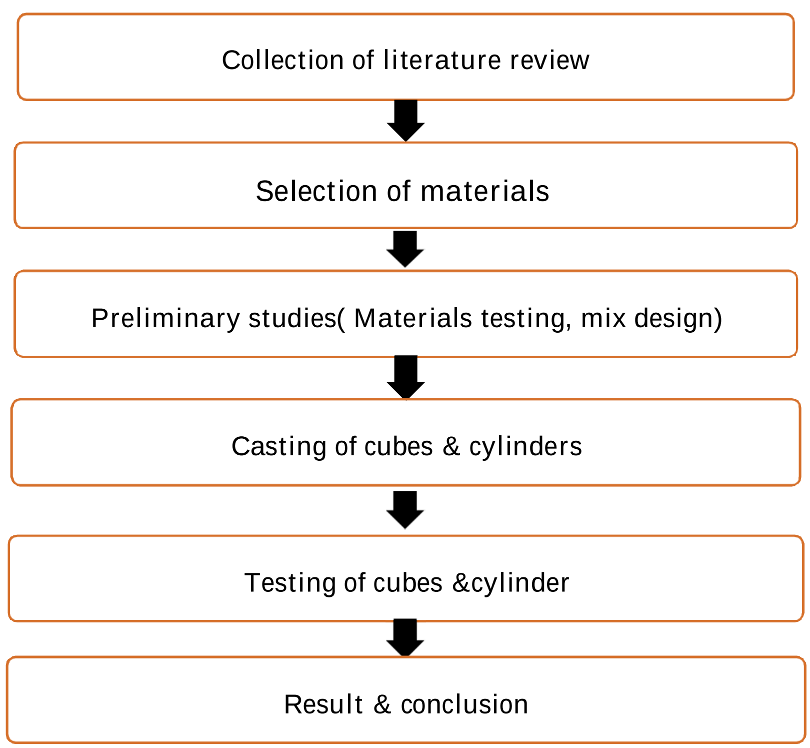
II. LITERATURE REVIEW

1) *Saurabh Kajal Er. Vedpal Er. Ravinder Kumar (2017):* The objectives of this study was to investigate the effect of use of coal bottom ash as partial replacement of fine aggregates in various percentages (10, 15, 20 and 25%), on concrete properties such as compressive strength.
2) *T. Subramani (2015):* Studied on the partial Replacement of Cement with Fly ash and Sand with M-Sand and Glass Used in Concrete. Partial Replacement of Cement with Fly Ash and Sand with M Sand and Glass used in Concrete by 30, 40, and 50 % to produce Concrete. The results are quite encouraging for use of Glass in producing Concrete.
3) *P. Aggarwal, Y. Aggarwal, S.M. Gupta (2015):* The strength development for various percentages (0-50%) replacement of fine aggregates with bottom ash can easily be equated to the strength development of normal concrete at various ages.
4) *Kiran M Sannakki & Sanjith J(Dec 2015):* Compressive strength of M40 grade concrete were studied with of bottom ash varying from 0% , 10%, 20%, and 30% replacement and at different curing periods.Analysis of results showed that maximum strength of 49.56 N/mm2 by replacing 20% of bottom ash as replacement fine aggregate.
5) *K. SathyaPrabha (2015):* Experimentally studied the properties of Concrete Using Bottom Ash with Addition of Polypropylene Fiber.Results showed that there was no degradation of strength for beams with bottom ash as replacement for fine aggregates.
6) *Remya raju, Mathews M. Paul & K.A. Aboobacker (2014):* The objectives of this study was to investigate the effect of use of coal bottom ash as partial replacement of fine aggregates in various percentages (0–30%), on concrete properties such as compressive strength, split tensile strength test, flexural strength and modulus of elasticity. Compressive strength of bottom ash concrete at the curing age of 28 days was increased compared to control concrete. Splitting tensile strength of concrete improved at percentages of replacement of bottom ash.
7) *M.P. Kadami, Dr.Y.D. Patil (2014):* The effects of coal bottom ash as fine aggregates in place of sand was used and compressive strength, split tensile strength, flexural strength, Modulus of Elasticity, Density and water permeability are studied. The natural sand was replaced with coal bottom ash by 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% by weight. In this work slump was kept constant 100 ± 10 mm. It was observed that up to 30% replacement the results of compressive, flexural, split and water permeability test are approximately same as that of the controlled concrete.

III. METHODOLOGY



A. Properties of Constituent Materials

1) *Cement:* Cement is the most important ingredient in concrete. One of the important criteria for the selection of cement is its ability to produce improved microstructure in concrete. Some of the important factors which play vital role in the selection of cement are compressive strength at various ages, fineness, heat of hydration, alkali content, tri calcium aluminate (C_3A) content, tri calcium silicate (C_3S)content, Di calcium silicate (C_2S) content etc. Different brands of the cement have been found to posses different strength development characteristics due to the variation in the compound composition and fineness. Hence it was decided to use cement from a single supplier. Ordinary Portland cement (OPC) is now available in three grades namely 33, 43 and 53 grades, the number indicating the compressive strength of standard cement sand mortar cubes in MPa at 28 days curing.

Table No: 3.1 Properties of cement

S. No.	PROPERTIES OF CEMENT	VALUE
1	Consistency	32%
2	Initial setting time	30 min
3	Final Setting time	600 min
4	Specific Gravity	2.05
5	Water Absorption (%)	0.14
6	Fineness modulus	6.85

3.1 Cement

B. Fine aggregate (River sand)

Fine aggregate used for concrete should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silk content and chloride contamination etc… the optimum gradation of river sand for concrete is determined more by its effect on water requirement than on physical packing. American concrete institute (ACI) committee reports that sand with fineness modulus below 2.5 gives concrete sticky consistency, making it difficult to compact and sand with fineness modulus of about 3 gives the best workability and compressive strength. Properties such as void ratio, gradation, specific gravity, fineness modulus, free moisture content, specific surface and bulk density have to be assessed to design a dense concrete mix with optimum cement content and reduced mixing water.

For this present investigation, graded river sand passes through 4.75mm micron sieve with fineness of 2.76 and specific gravity of 2.68 was used as a fine aggregate.

C. Quarry Dust (Mailam)

The introduction of quarry dust into concrete mixes, results in practical size distribution that in most case of close to graded materials that would tend to maximum minimizes voids however, the angular nature of the materials and the rough surface texture tend to increase voids in the sand. Higher levels of fines in quarry dust results in a highest specific surface area that is usually increases the water demand of the concrete on the other hand, the micro fines from the quarry dust “bulks” the mix paste volume, thus avoiding additional

It is generally stated that water fit for drinking is fit for making concrete. For this present investigation, potable water was used for making concrete.

3.2 – M-Sand

D. Bottom Ash

Bottom ash is part of the non-combustible residue of combustion in a furnace or incinerator. 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 refer 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.

Table No: 3.2 Properties of river sand, m- sand & Bottom ash

S. No.	Properties	Values of river sand	Values of m- sand	Values of bottom ash
1	Specific gravity	2.66	2.922	3.02
2	Bulk density(Kg/m^3)	1650	1788.07	950
3	Fineness modules	2.57	3.02	6.28
4	Water absorption (%)	3.50	5.85	15.20

3.3 Bottom Ash

E. Coarse Aggregate

The coarse aggregate is the strongest and the least porous component of concrete. It is also a chemically stable material .presence of course aggregate reduces the drying shrinkage and dimensional changes occurring on account of movement of moisture course aggregate contributes to impermeability concrete provided this is properly graded and the mix is suitably designed.

Table No: 3.3 Properties of coarse aggregate

S. No.	Properties of coarse aggregate	Test results
1	Maximum Size (mm)	20
2	Fineness modulus	7.20
3	Specific Gravity	2.84
4	Water Absorption (%)	0.35
5	Aggregate Crushing Value (%)	15.50

Coarse Aggregate

Table No: 3.6 Mix proportion calculation for cylinder

Ingredients	Mix1 kg/m^3	Mix2 kg/m^3	Mix 3 kg/m^3	Mix 4 kg/m^3	Mix 5 kg/m^3	Mix 6 kg/m^3
Cement	2.087	2.087	2.087	2.087	2.087	2.087
Coarse aggregate	6.0344	6.0344	6.0344	6.0344	6.0344	6.0344
M-sand	1.939	1.939	1.939	1.939	1.939	1.939
River sand	1.939	1.84205	1.7451	1.64815	1.5512	1.45425
Bottom ash	-	0.09695	0.1939	0.29085	0.3878	0.48475

IV. PREPARATION OF SPECIMENS

In dry-mix applications, all dry materials – including cement, aggregate, and ad-mixture – are mixed together, conveyed pneumatically through a hose and then, at the nozzle via a water ring, water is injected evenly throughout the mix as it is being projected.

Dry mixing

A. *Wet Mixing*

In a wet-mix application, all materials – including cement, aggregate, ad-mixture and water – are mixed together before being pumped through a hose and pneumatically projected.

Wet Mixing

B. *Placing of Mix in Moulds*

After mixing the proportions in the mixing machine, it is taken out into the bucket. The concrete is placed in to the moulds (cubes & cylinder), which are already oiled simply by means of hands only without using any compacting devices.

C. Curing

After 24 hours the specimen were removed from the moulds and immediately submerged in clean fresh water and kept there until taken out just prior to testing.

Curing

V. TESTING OF CONCRETE

A. Fresh Concrete Test

Slump test Procedure

1) Initially a known volume of concrete is required with a required proportion of ingredients.
2) Then the prepared concrete sample is filled into the mould which is fixed on non-porous plate by four layer with 25 blows for an each layer by standard tamping rod.
3) Then the mould is lifted up vertically that do not disturb the position of the concrete in the plate.
4) By using the tamping rod we get the measurement or slump value
5) The nature of slump is analyzed to get the workability of given content concrete sample.

Table.No.3.7 Slump test

S.no	M- sand	River sand	Bottom ash	Slump test
1	50%	50%	0%	90mm
2	50%	45%	5%	106 mm
3	50%	40%	10%	115mm
4	50%	35%	15%	121 mm
5	50%	30%	20%	133 mm
6	50%	25%	25%	140 mm

B. Flow Table Test

Procedure

The apparatus consists of flow table about 76 cm. in diameter over which concentric circles are marked

A mould made from smooth metal casing in the form of a frustum of a cone is used with the following internal dimensions. The base is 25 cm. in diameter upper surface 17 cm. in diameter and height of the cone is 12cm.

1) The table top is cleaned of all gritty material and is wetted. The mould is kept on the center of the table, firmly held and is filled in two layers.
2) Each layer is rodded25 times with the tamping rod 1.6 cm in diameter and 61 cm long rodded at the lower5 tamping rod.
3) After the top layer is rodded evenly the excess of concrete which has overflowed the mould is removed.

4) The mould if lifted vertically upward and the concrete stands on its own without support. The table is then raised and dropped 12.5 cm 15 times in about 15 seconds.
5) The diameter of the spread concrete is measured in about 6 directions to the nearest 5 mm and the average spread is noted. The flow of concrete is percentage increases in the average diameter of the spread concrete over the base diameter of the spread concrete over the base of the mould.
6) The value could range anything from 1 to 150 percent. A close look at the pattern of spread of concrete can also give a good indication of the characteristics of concrete such as tendency for segregation.

Table No.3.8 Flow table test

S.no	M- sand	River sand	Bottom ash	Flow table test
1	50%	50%	0%	89%
2	50%	45%	5%	83%
3	50%	40%	10%	80%
4	50%	35%	15%	79%
5	50%	30%	20%	75%
6	50%	25%	25%	71%

C. Hardened Concrete Test

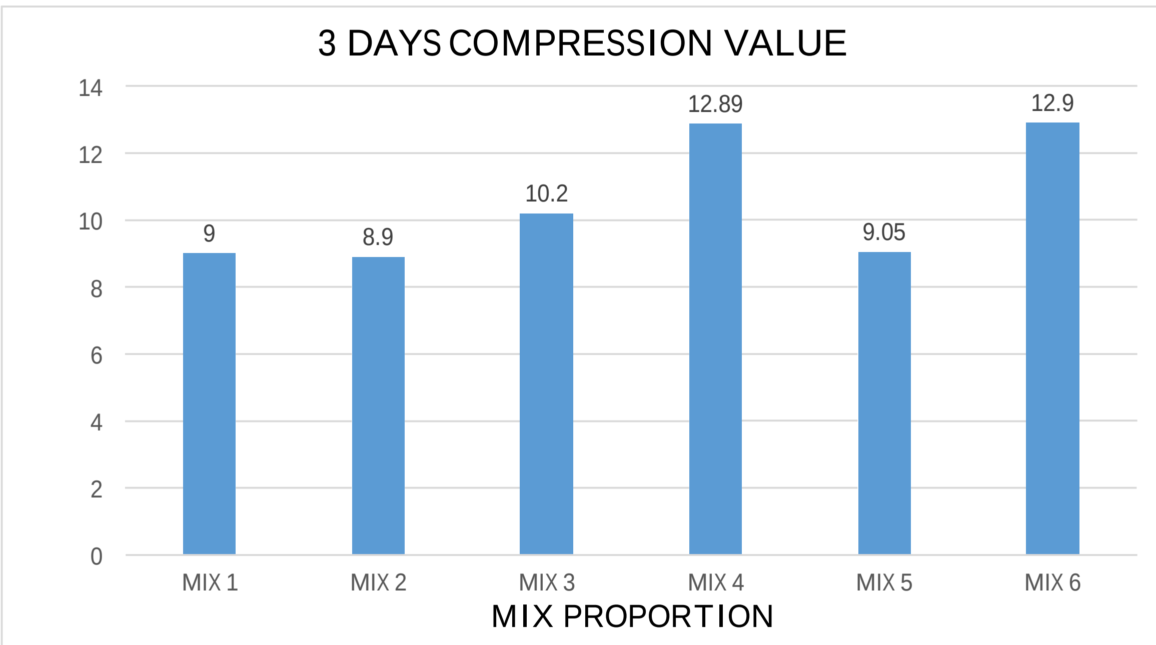
1) Compressive Strength Test: In the case of cubes, the specimen is placed in the machine in such a manner that the load is applied to opposite sides of the cubes ay cast. The axis of the specimen is carefully aligned with the center of thrust of the spherically seated plate. The maximum load to the specimen is then recorded. The results have been obtained from the table below. The compressive strength tests on the specimen were performed on a 1000 KN capacity hydraulic machine in the accordance to the relevant Indian standards. The 150 x 150 mm concrete cubes tested for every compressive strength test.

2) Procedure
a) Compressive strength of concrete is define as the load, which causes the failure of standard specimen (Ex; 150mm cube according to ISI) divided by the area of cross section in uniaxial compression under a given rate of loading.
b) The test of compressive test should be made on 150mm size cubes. Place the cube in the compression testing machine.
c) The green button is pressed to start the electric motor. When the load is applied gradually, the piston is lifted up along with the lower plate and the specimen application of the load should be 300 KN per minute and can be controlled by load rate control knob.
d) Ultimate load is noted for each specimen. The release valve is operated and the piston is allowed to go down. The values are tabulated and calculations are done.

Table No.3.9 Compression test result for 3 days

S.no	Composition percentage	Compression strength value (3 days)
1	Mix 1	9 N/mm^2
2	Mix 2	8.9 N/mm^2
3	Mix 3	10.2 N/mm^2
4	Mix 4	12.89 N/mm^2
5	Mix 5	9.05 N/mm^2
6	Mix 6	12.9 N/mm^2

Compression test result for 3 days



Compression test result for 7 days

S.no	Composition percentage	Compression strength value(7 days)
1	Mix 1	19 N/mm^2
2	Mix 2	19.78 N/mm^2
3	Mix 3	22.16N/mm^2
4	Mix 4	25.24N/mm^2
5	Mix 5	20.24 N/mm^2
6	Mix 6	24.99N/mm^2

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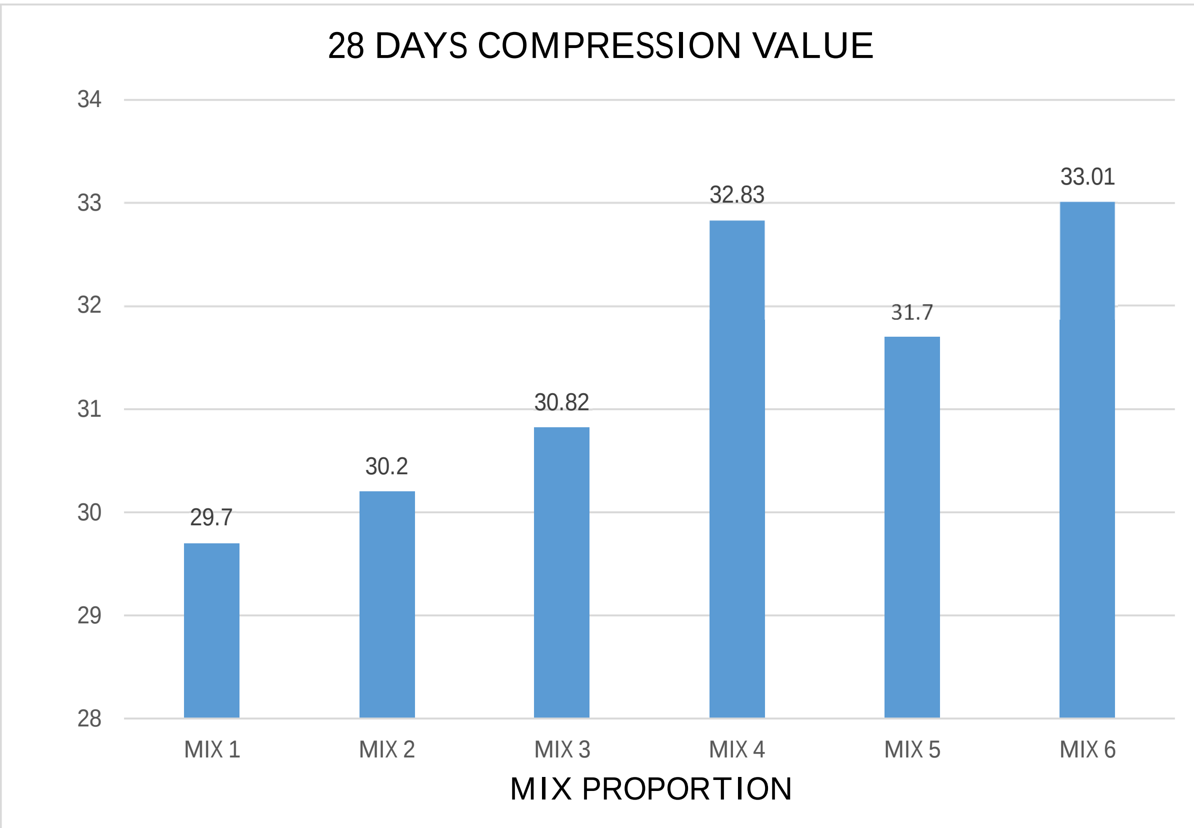
Compression test result for 28 days

S.no	Composition percentage	Compression strength value(28 days)
1	Mix 1	29.7N/mm^2
2	Mix 2	30.2 N/mm^2
3	Mix 3	30.82N/mm^2
4	Mix 4	32.83N/mm^2
5	Mix 5	31.7 N/mm^2
6	Mix 6	33.01N/mm^2



D. Split Tensile strength

In the case of cylinder, the specimen is placed in the machine in such a manner that the load is applied to opposite side of the cylinder at case the axis of the specimen is carefully aligned with the center of thrust of the spherically seated plate. The maximum load to the specimen is than recorded. The results have been obtained from the table below. The tensile strength test on the specimens were performed on the 1000 KN capacity hydraulic machine in accordance to the relevant Indian standards. The diameter of 150 mm and height 300 mm concrete cylinder were tested for every tensile strength test.

Ultimate load = tensile strength / area of specimen

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1) *Procedure:* A concrete cylinder of size 150mm dia, 200mm height is subjected to action of the compression force along two opposite edges by applying the force this manner. The cylinder is subjected to compression near the loaded region the length of the cylinder are subjected to uniform tensile stress

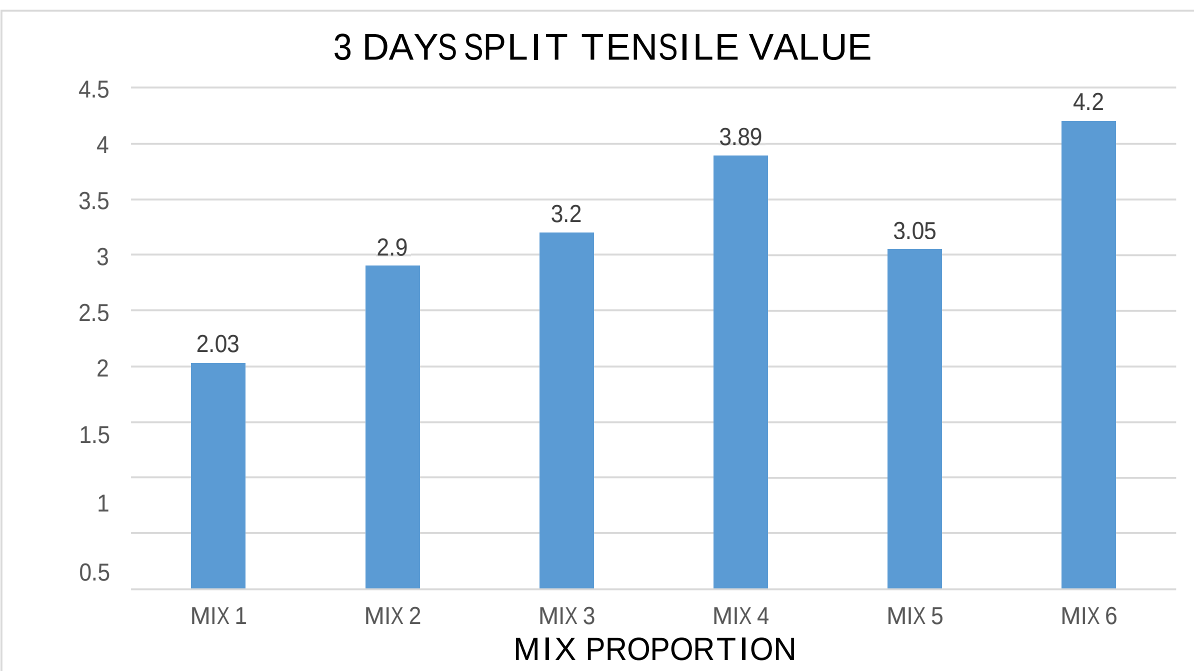
Horizontal stress = 2P/πDL Where,

P= compressive load on the cylinder L= length of the cylinder

D= diameter of cylinder

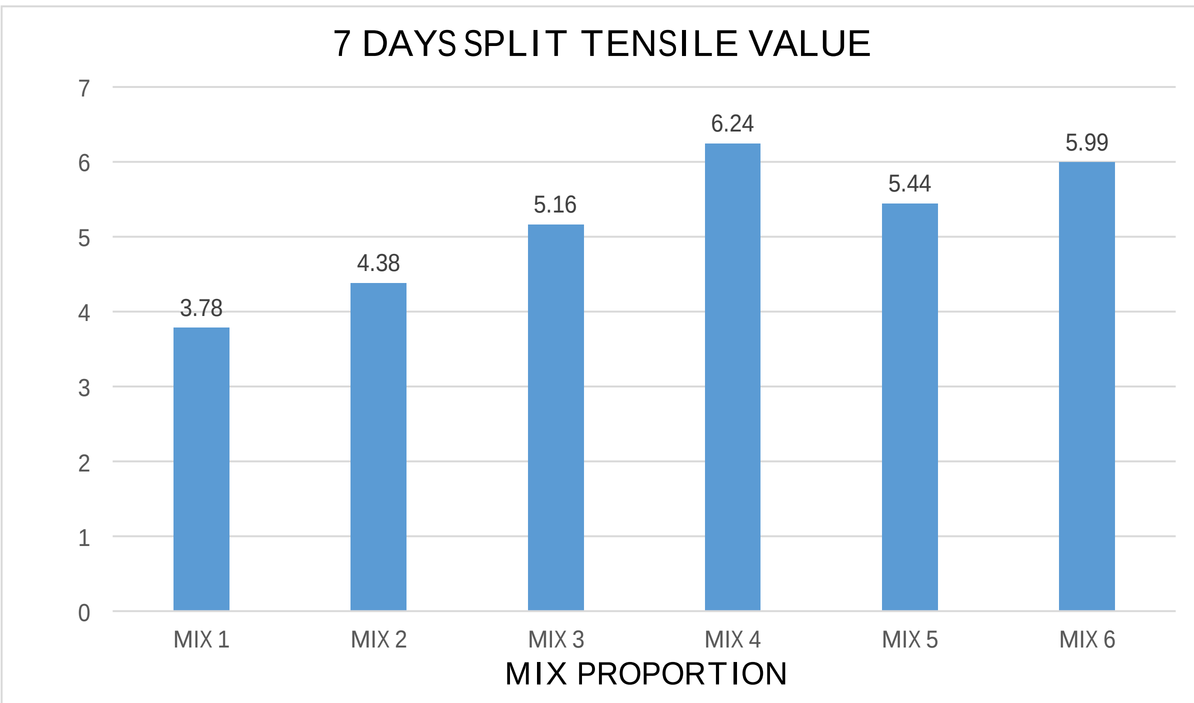
S.no	Composition percentage	Split tensile value (3 days)
1	Mix 1	2.03 N/mm^2
2	Mix 2	2.9 N/mm^2
3	Mix 3	3.2 N/mm^2
4	Mix 4	3.89 N/mm^2
5	Mix 5	3.05 N/mm^2
6	Mix 6	4.2 N/mm^2

Split tensile test result for 3 days



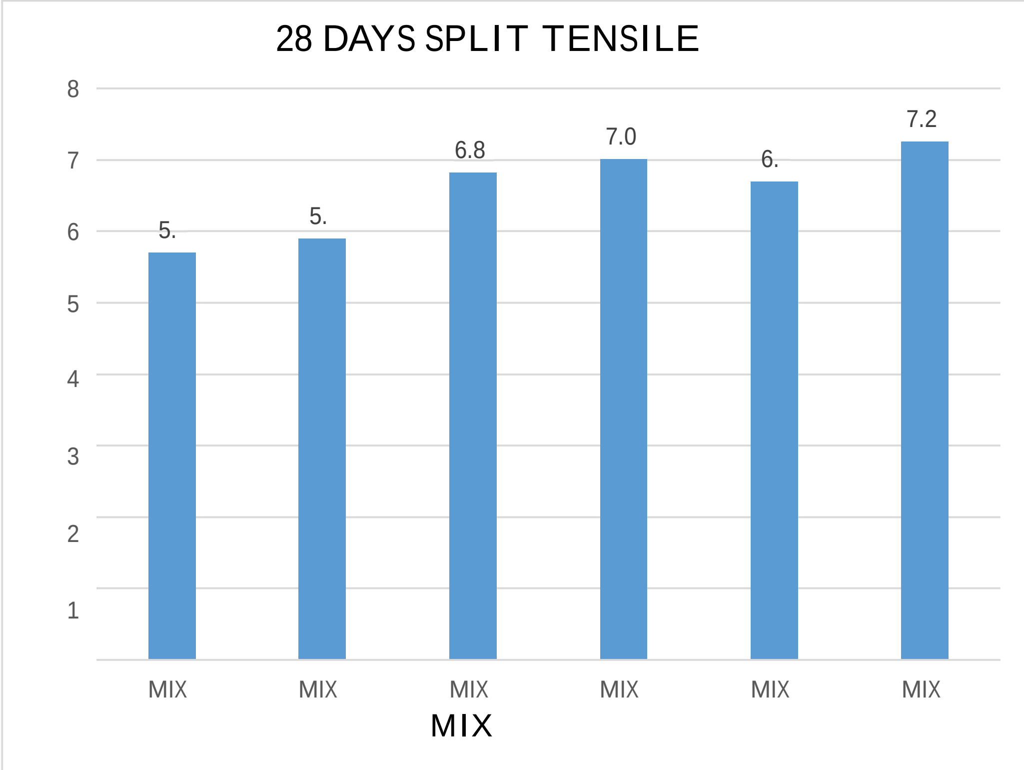
Split tensile test result for 7 days

S.no	Composition percentage	Split tensile value (7 days)
1	Mix 1	3.78N/mm^2
2	Mix 2	4.38 N/mm^2
3	Mix 3	5.16N/mm^2
4	Mix 4	6.24N/mm^2
5	Mix 5	5.44 N/mm^2
6	Mix 6	5.99N/mm^2



S.no	Composition percentage	Split tensile value (28 days)
1	Mix 1	5.7N/mm^2
2	Mix 2	5.9 N/mm^2
3	Mix 3	6.82N/mm^2
4	Mix 4	7.01N/mm^2
5	Mix 5	6.7N/mm^2
6	Mix 6	7.25N/mm^2

Split tensile test result for 28 days



VI. RESULTS AND DISCUSSION

A. General

In this chapter parameter studied on the coal bottom ash in concrete made with various partial replacement of bottom ash has discussed. Also the study made with standard percentage of M-sand with 50% and bottom ash with 5%, 10%, 15%, 20% & 25% replacement of fine aggregate in concrete. In the present chapter highlights the result obtained from the above experimental investigation.

B. Testing Results Discussion

1) At the end of 28 days compressive strength of 15% of bottom ash + 50 % of m-sand + 35% of river sand is 32.83N/mm2. It is higher than 50% of m-sand + 50% of river sand composition 29.7N/mm2.
2) At the end of 28 days the split tensile strength for 15% of bottom ash + 50 % of m-sand + 35% of river sand is 7.01N/mm2 .It is also higher than 50% of m- sand 50% of river sand composition 5.7N/mm2.
3) At the end of 28 days both the compressive and split tensile strength 20% of bottom ash + 50 % of m-sand + 30% of river sand value decreased. So we used silica fume 2% with 25% of bottom ash + 50 % of m-sand + 25% of river sand.
4) Hence silica fume 2% with 25% of bottom ash + 50 % of m-sand + 25% of river sand gives higher strength than 15% of bottom ash + 50 % of m- sand+ 35% of river sand.

VII. CONCLUSION

Bottom ash is used as a fine aggregates enables the large utilization of waste product. Fine aggregate is partially replaced by bottom ash, it increase the workability of concrete. If it is fully replaced it reduces the workability of concrete. Based on the experimental test result the optimum dosage of bottom ash found 15% [by weight] for M 30 grade concrete. **F**urther addition of bottom ash decrease the strength (20%). In order to increase the strength by using silica fume as a admixture**. A**fter the addition of silica fume again the strength increased. For developing sustainable concrete, bottom ash proves to be a good alternative. The 25% optimum dosage of bottom ash replacement saves a large consumption of river sand which is used in concrete.

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