International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 14, Issue 6 (June Ver. I 2018), PP.07-16

Effect of Natural Sand Replacement by Fly Ash and Bottom Ash in Hybrid Fiber Reinforced Concrete

[1]Basavaraj N Itnal, [2]Ravi Patil, [3]H N Rajakumara
[1,2]Department of Civil Engineering, RR Institute of Technology, Bengaluru, India
[3]Department of Civil Engineering, Sri Venkateshwara College of Engineering, Bengaluru, India
Corresponding Author: Basavaraj N Itnal

ABSTRACT: In reviewing technology advances through the centuries it is evident that material developments plays a key role in. Considerable efforts are still being made in every part of the world to develop new construction materials. In the construction industry, concrete technology is heading towards entirely new era by the use of Fly ash, Bottom ash, Steel fibers and glass fibers in concrete. While conventional concrete has poor tensile strength, low resistant to tensile cracking, so its capacity to absorb energy is limited. The weakness in tension is conventionally overcome by strengthening their matrix with steel and more recently by reinforcing with fibrous materials. Concrete when mixed with fibres, give fibrous concrete. The mechanical property of fibrous concrete is superior to that of ordinary concrete. Fly ash and Bottom ash will be evaluated for use as supplementary Fine aggregate material in Fine aggregate based system, the performance of Fly ash and Bottom ash mixtures will be compared to controlled mixtures and mixtures incorporating Fly ash and Bottom ash as replacement for Fine aggregate.

The effects of coal bottom ash and fly ash as fine aggregates in place of sand was used and compressive strength, split tensile strength and flexural strength. The natural sand was replaced with coal bottom ash and fly ash by 0%, 10%, 20%, 30%, 40%, 50%,60%, 70%, 80%, 90% and 100% by weight , water absorption of coal bottom ash and fly ash was more so that quantity of water was increased to achieve 100mm slump. The results of shows that the compressive strength, split tensile strength and flexural strength decreased as the percentage of replacement coal bottom ash and fly ash increased as compared to controlled concrete. In this work slump was kept constant 100mm plus or minus 15mm. to achieve required slump water quantity was increased as percentage replacement increased. It was observed that up to 30% replacement the results of compressive strength, split tensile strength and flexural strength were determined at 28 days. The tests are approximately same as that of the controlled concrete.

KEY WORDS: fibers, natural sand, strength, concrete, weight, fly ash, bottom ash, slump.

Date of Submission: 01-06-2018 Date of acceptance: 16-06-2018

I. INTRODUCTION

Construction is a major part of development plan of developing countries including India. To meet the large demand for infrastructure development, maintenance and life enhancement of structures are very important. Concrete is the most widely used man- made construction material. It is a prime construction material composed mainly of cement, Sand, Coarse Aggregate, Water and Admixture.

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Conventional concrete does not meet many functional requirements such as impermeability, resistance to frost adequately. The presence of micro cracks at the mortar–aggregate in terface is responsible for the inherent weakness of plain concrete. Because of the poor tensile strength, cracks propagate with the application of load, leading to brittle fracture of concrete. Micro cracks are formed in concrete during hardening stage.

Natural disasters like earthquakes, cyclones, tsunami, etc. destroy the high rise buildings, bridges, monumental structures important structures, etc. These deficiencies have led researchers to investigate and develop a material which could perform better in areas where conventional concrete has several limitations. To protect the world from that kind of devastation, the field of civil engineering requires some innovations in both materials and construction techniques. One such development has been two phase composite materials i.e. fiber reinforced concrete, in which cement based matrix, is reinforced with ordered or random distribution of fibers. Fiber in the cement based matrix acts as cracks arrester which restricts the growth of flaws in the matrix, preventing these from enlarging under load, into cracks, which eventually cause failure. The weakness can be removed by inclusion of fibers in concrete. The fibers help to transfer loads at the internal micro cracks. Fibers like steel and glass have been tried. Combining fibers with different geometry and mechanical properties could

further improve the mechanical properties of fiber reinforced concrete. Such type of concrete is oftenly called hybrid fiber reinforced concrete (HYFRC).
River sand is the most commonly used fine aggregate in many parts of the world. The huge demand for concrete has made this natural resource to get impoverished. On one side extraction of river sand in excess has conspicuous environmental impacts, on the other side, large quantity of bottom ash& fly ash is being produced every day in Thermal Power Plants, leading to many environmental problems.

II. OBJECTIVES AND METHODOLOGY

In the present experimental investigation, hybrid fiber reinforced concrete of Grade M30 is studied by using of fly ash and bottom ash as partially or fully replacement by weight of fine aggregate. Steel fibers having aspect ratio of 50 and glass fibers are also used. The proportion of steel fibers and glass fibers is added at 1% as total volume of concrete. The various strength properties studied are compressive strength, split tensile strength and flexural strength.

(a) Objectives

The main objective of this study is to evaluate strength characteristics of hybrid fiber reinforced concrete replacing natural sand by fly ash and bottom ash. For this purpose hybrid fibers or a combination of glass fibers and steel fibers are added in the quantity of 1% of volume of concrete in which the both glass fibers and steel fibers are added in a proportion of 0.5% each to get hybrid reinforced concrete.

Then the natural sand is replaced by fly ash and bottom ash in the proportion of 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% separately the workability characteristics such as slump test, compaction factor test are studied for the fresh concrete and the near surface characteristics such as water absorption test and sorptivity test are studied for the hardened concrete and also the strength properties like compressive strength , tensile strength and flexural strength are also studied for all combinations of hybrid concrete.

(b)Methodology

The aim is to determine the characteristics of constituent materials and strength of concrete produced by replacing natural sand by fly ash and bottom ash. Several experimental works are carried out. Thus the work study is laboratory oriented.

1. The materials such as fly ash, bottom ash, fine aggregate, coarse aggregate, super plasticizer, M30 grade concrete and required slump are chosen.
2. The materials have been collected from a specific location and properties have been studied.
3. Using these properties, mix design is carried out with suitable w/c ratio for M30 grade of concrete.
4. Required slump is obtained experimentally by slump cone test and compaction factor test.
5. Concrete cubes, using fly ash as a partially and fully replacement of sand and bottom ash as a partially and fully replacement of fine aggregate will be cast to study the compressive strength of concrete. Then the cubes will be tested in compression testing machine.
6. The compressive strength of the concrete will be determined by using 150 mm concrete cube specimens. The specimens will be tested at 7 and 28 days age, in 200 tons capacity hydraulic type compression-testing machine. The cube compressive strength will be obtained by considering the average of three specimens at each age.
7. Using 150mm by 300mm Cylinders, fly ash as a partially and fully replacement of sand and bottom ash as a partially and fully replacement of fine aggregate will be cast to study the split tensile strength of concrete. The specimens will be tested at 7 and 28 days age, in 200 tons capacity hydraulic type compression-testing machine. The tensile strength will be obtained by considering the average of three specimens at each age.
8. Beam members (100mmX100mmX500mm), using fly ash as a partially and fully replacement of sand and bottom ash as a partially and fully replacement of fine aggregate will be cast to study the flexural strength of concrete.
9. Then the beams will be tested in single point loading, and deflections under the load points will be recorded.
10. All the beams will be tested in a universal testing machine of 1000kN capacity at a constant rate of displacement.
11. Using 150mm concrete cube specimen, durability property-sorptivity will be determined after 28days age.
12. Using 150mm concrete cube specimen, durability property-water absorption will be determined after 28days age.
13. The density of fly ash and bottom ash concrete will be observed and compared.
14. Using these test results suitable graphs is plotted.

15. Conclusions are drawn based on test results.

III. CHARACTERIZATION OF CONSTITUENT MATERIALS

The two major components of hybrid fiber reinforced concrete composites are the matrix and the fibers. The matrix generally consists of Portland cement, aggregates, water and admixtures. They are

1. Ordinary Portland cement (43 Grade
2. Fine aggregate
3. Coarse aggregate
4. Water
5. Mineral admixture (fly ash, bottom ash)
6. Chemical admixture (Conplast SP 430)
7. Steel & glass fibers

MIX DESIGN OF M30 CONCRETE

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with object of producing concrete of certain minimum strength and durability as economically as possible. For the present work a grade of concrete M30 suggested to be used in any RCC members is adopted. Mix design is based on IS: 10262:2009.Tests on trial mixes have been carried out. Finally a mix proportion that gives required 28 days cube compressive strength with minimum cement content and required workability of 100mm is selected.

Mix proportion

Cement: Fine Aggregate: Coarse Aggregate
440:672.282: 1096.00
1:1.52: 2.490
CA – Coarse Aggregate, FA – Fine Aggregate

Table 2: Details of Mix Proportion with Constant Cement, Super Plasticizer, Steel Fiber, and Glass Fiber and W/C Ratio for Replacemen of fly ash

FA Replacement	Mix proportion(kg/m^3)							
	Cement	Sand	Fly ash	CA	W/C	SP (%)	SF (%)	GF (%)
CC	440	672.28	-	1096.00	0.45	-	-	-
CCF	440	672.28	-	1096.00	0.45	-	0.5%	0.5%
10%	440	605.06	67.22	1096.00	0.45	0.8%	0.5%	0.5%
20%	440	537.82	134.45	1096.00	0.45	0.8%	0.5%	0.5%
30%	440	470.59	201.68	1096.00	0.45	0.8%	0.5%	0.5%
40%	440	403.36	268.91	1096.00	0.45	0.8%	0.5%	0.5%
50%	440	336.14	336.14	1096.00	0.45	0.8%	0.5%	0.5%
60%	440	268.91	403.36	1096.00	0.45	0.8%	0.5%	0.5%
70%	440	201.68	470.59	1096.00	0.45	0.8%	0.5%	0.5%
80%	440	134.45	537.82	1096.00	0.45	0.8%	0.5%	0.5%
90%	440	67.22	605.06	1096.00	0.45	0.8%	0.5%	0.5%
100%	440	-	672.28	1096.00	0.45	0.8%	0.5%	0.5%

Table 1: Details of Mix Proportion with Constant Cement, Super Plasticizer, Steel Fiber,Glass Fiber and W/C Ratio for Replacement of Bottom Ash

BA Replace Ment	Mix proportion(kg/m^3)							
	Cement	sand	Bottom ash	CA	W/C	SP (%)	SF (%)	GF (%)
CC	440	672.28	-	1096.00	0.45	-	-	-
CCF	440	672.28	-	1096.00	0.45	-	0.5%	0.5%
10%	440	605.06	67.22	1096.00	0.45	0.8%	0.5%	0.5%
20%	440	537.82	134.45	1096.00	0.45	0.8%	0.5%	0.5%
30%	440	470.59	201.68	1096.00	0.45	0.8%	0.5%	0.5%
40%	440	403.36	268.91	1096.00	0.45	0.8%	0.5%	0.5%
50%	440	336.14	336.14	1096.00	0.45	0.8%	0.5%	0.5%
60%	440	268.91	403.36	1096.00	0.45	0.8%	0.5%	0.5%
70%	440	201.68	470.59	1096.00	0.45	0.8%	0.5%	0.5%
80%	440	134.45	537.82	1096.00	0.45	0.8%	0.5%	0.5%
90%	440	67.22	605.05	1096.00	0.45	0.8%	0.5%	0.5%
100%	440	-	672.28	1096.00	0.45	0.8%	0.5%	0.5%

IV. EXPERIMENTAL TEST RESULTS

(a)Workability Test Result

(i) Slump Test Results

Following table 1 and 2 gives the slump test results of hybrid fiber reinforced concrete produced by replacing the natural sand by fly ash and bottom ash. The variation of slump is shown in figure1and 2.

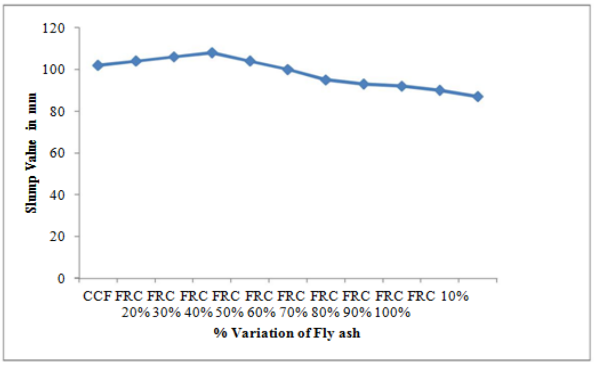

Fig. 1 Variation of Slump with Replacement of Fly Ash

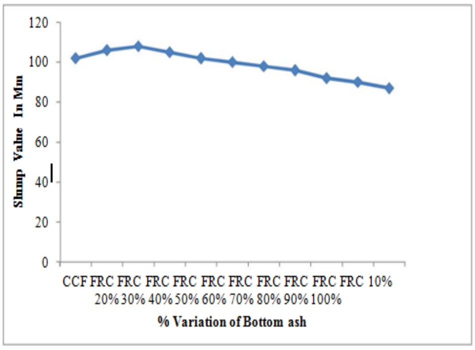

Fig.2 Variation of Slump with Replacement of Bottom Ash

(ii) Compaction Factor Test Results

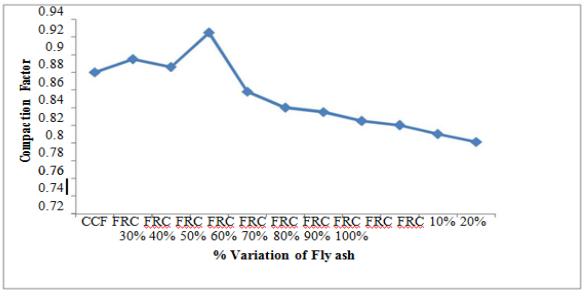

Fig. 3 Variation of Compaction Factor with Replacement of Fly ash

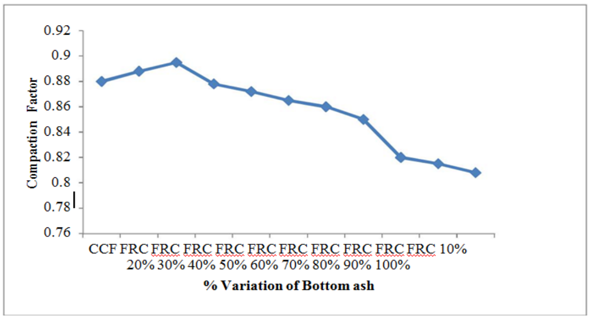

Fig.4 Variation of Compaction Factor with Replacement of Bottom as

(b) Near Surface Characteristic Test Results
(i)Water Absorption Test Results

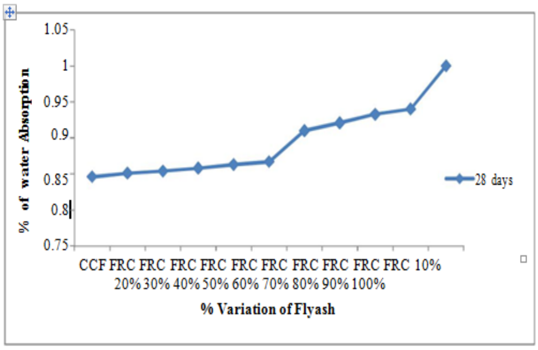

Fig.5 Water Absorption with Replacement of Fly ash

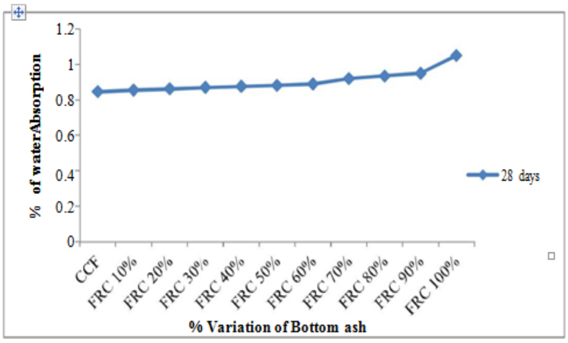

Fig. 6 Water Absorption with Replacement of Bottom ash

ii) Sorptivity Test Results

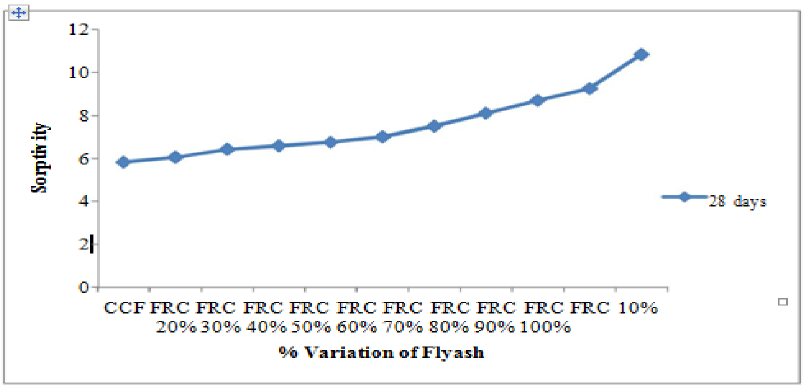

Fig. 7 Sorptivity with Replacement of Fly Ash

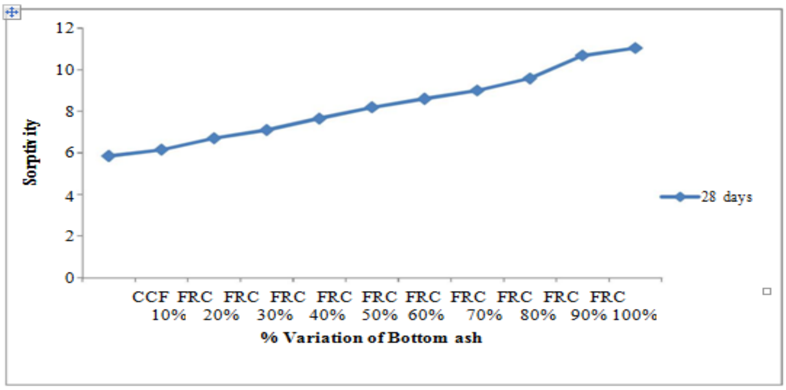

Fig.8 Sorptivity with Replacement of Bottom ash

(c) Strength Test Results

(i) Compressive Strength Test Results

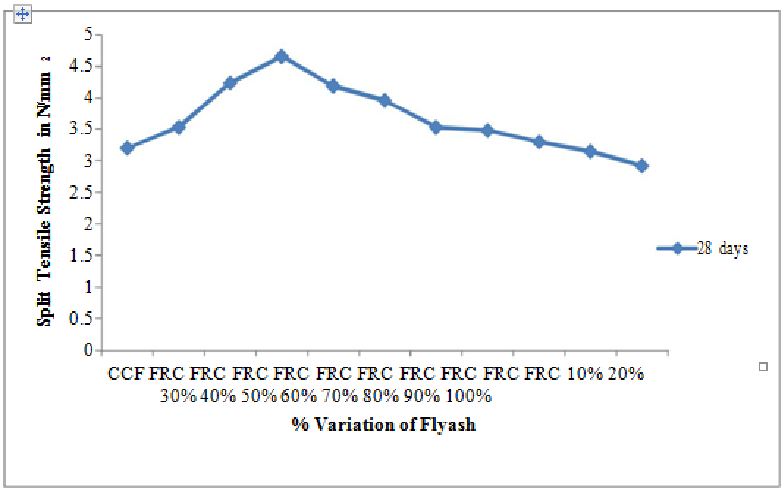

Fig. 9 Split Tensile Strength with Replacement of Fly ash

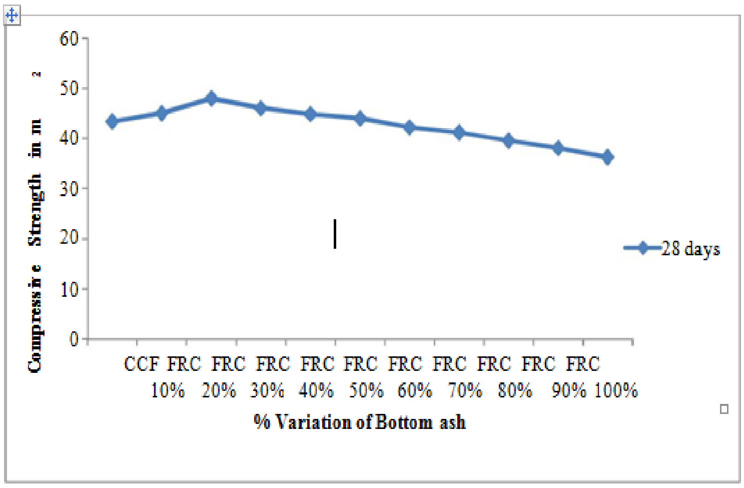

Fig. 10 Compressive Strength with Replacement of Bottom ash

(ii) Split Tensile Strength Test Result

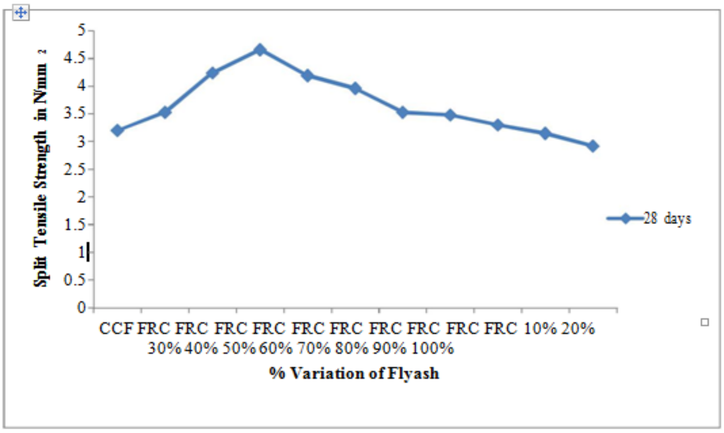

Fig. 11 Split Tensile Strength with Replacement of Fly ash

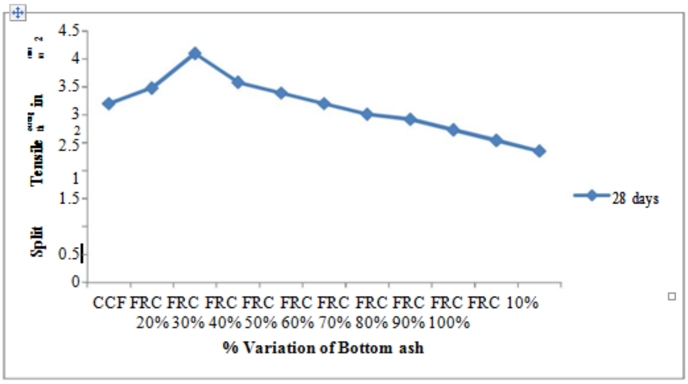

Fig .12 Split Tensile Strength with Replacement of Bottom ash

(iii) Flexural Strength Test Results

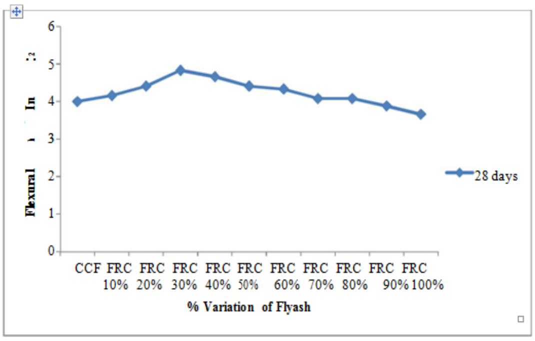

Fig. 13 Flexural Strength with Replacement of Fly Ash

V. OBSERVATIONS AND DISCUSSIONS

The following observations are made based on the study conducted on strengthCharacteristics of hybrid fiber reinforced concrete replacing natural sand by fly ash andBottom ash.

1. It is observed that the workability as measured from slump, compaction factor goes on increasing upto 30% replacement of natural sand by fly ash. After 30% replacement level workability starts decreasing gradually and there is not much variation in the workability as measured from the slump.
   This is due to the fact that beyond 30% replacement of natural sand fly ash will start to absorb more water resulting in harsh mix of the concrete. The fiber inters lock and enter angle around aggregate particles and considerably reduce the workability.
2. It is observed that the workability as measured from the slump, compaction factor goes on increasing up to 20% replacement of natural sand by bottom ash. After 20% replacement level workability goes on decreasing gradually and there is not much variation in the workability as measured from the slump.
   This is due to the fact that bottom ash has the rough texture which results in lesser workability
3. It is observed that the workability as measured from slump, compaction factor, is more for hybrid fiber reinforced produced by replacing natural sand by fly ash compared hybrid fiber reinforced concrete produced by replacing natural sand by bottom ash.
   This is due to the fact that bottom ash has rough texture as compared to fly ash which results in lesser workability.
4. It is observed that the water absorption test shows the increases in percentage of water absorption throughout for all the replacement level by both fly ash and bottom ash.
   This is due to the fact that both fly ash and bottom ashes require more quantity of water when replaced in natural sand due to the ball bearing effect.
5. It is observed that the sorptivity values have increased throughout for all the replacements levels by both fly ash and bottom ash.
   This is due to the fact that both fly ash and bottom ashes require more quantity of water often replaced in natural sand due to the ball bearing effect.
6. It is observed that compressive strength of hybrid fiber reinforced concrete produced by replacing natural sand by fly ash show the higher value at 30% replacement level. The percentage increase in compressive strength at 30% replacement level is 17.41 w. r. t reference may beyond 30% replacement level compressive strength goes on decreasing.
   This is due to the fact that at 30% replacement level leads to higher pozzolonic reactivity the pores of concrete are filled there by resulting in dense concrete and also due to the fact that the hybrid fibers are dispersed and are distributed randomly in the concrete in such a manner that property of concrete is improved in all directions.
7. It is observed that compressive strength of hybrid fiber reinforced concrete produced by replacing natural sand by bottom ash shows the higher value at 20% replacement level the percentage increase in compressive strength at 20% is 10.59 w.r.t references may beyond 20% replacement level compressive strength goes on decreasing. This is due to the fact at 20% replacement of natural sand by bottom ash may give rise to higher pozzolonic reactivity pores are also filled up with the bottom ashes resulting in dense concrete and also due to the fact that the hybrid fiber are dispersed and are distributed randomly in the concrete in such a manner that property of concrete is improved in all directions.
8. It is observed that the hybrid fiber reinforced concrete produced by fly ash, exhibit higher compressive strength as compared to concrete produced by replacing natural sand by bottom ash. This is due to the fact that fly ash contains more reactive silica as compared to bottom ash which will result in more pozzolonic reaction.

9. It is observed that split tensile strength of hybrid fibre reinforced concrete produced by replacing natural sand by fly ash show the higher value at 30% replacement level .The percentage increases in split tensile strength at 30% replacement level is 45.62 w. r. t reference may beyond 30% replacement level split tensile strength goes on decreasing. This is due to the fact that at 30% replacement level leads to higher pozzolonic reactivity the pores of concrete are filled there by resulting in dense concrete and also due to the fact that the hybrid fibres are dispersed and are distributed randomly in the concrete in such a manner that property of concrete is improved in all directions.
10. It is observed that split tensile strength of hybrid fibre reinforced concrete produced by replacing natural sand by bottom ash shows the higher value at 20% replacement level .the percentage increase in split tensile strength at 20% is 28.12 w. r .t reference may beyond 20% replacement level split tensile strength goes on decreasing.
    This is due to the fact at 20% replacement of natural sand by bottom ash may give rise to higher pozzolonic reactivity pores are also filled up with the bottom ashes resulting in dense concrete and also due to the fact that the hybrid fibre are dispersed and are distributed randomly in the concrete in such a manner that property of concrete is improved in all directions.
11. It is observed that the hybrid fibre reinforced concrete produced by fly ash, exhibit higher split tensile strength as compared to concrete produced by replacing natural sand by bottom ash. This is due to the fact that fly ash contains more reactive silica as compared to bottom ash which will result in more pozzolonic reaction.
12. It is observed that flexural strength of hybrid fibre reinforced concrete produced by replacing natural sand by fly ash show the higher value at 30% replacement level .The percentage increase in flexural strength at 30% replacement level is 20.75 w. r. t reference may beyond 30% replacement level split tensile strength goes on decreasing. This is due to the fact that at 30% replacement level leads to higher pozzolonic reactivity the pores of concrete are filled there by resulting in dense concrete and also due to the fact that the hybrid fibers are dispersed and are distributed randomly in the concrete in such a manner that property of concrete is improved in all directions.
13. It is observed that flexural strength of hybrid fiber reinforced concrete produced by replacing natural sand by bottom ash shows the higher value at 20% replacement level .the percentage increase in flexural strength at 20% is 16.5 w. r .t reference may beyond 20% replacement level split tensile strength goes on decreasing. This is due to the fact at 20% replacement of natural sand by bottom ash may give rise to higher pozzolonic reactivity pores are also filled up with the bottom ashes resulting in dense concrete and also due to the fact that the hybrid fibre are dispersed and are distributed randomly in the concrete in such a manner that property of concrete is improved in all directions.
14. It is observed that the hybrid fibre reinforced concrete produced by fly ash, exhibit higher flexural strength as compared to concrete produced by replacing natural sand by bottom ash. This is due to the fact that fly ash contains more reactive silica as compared to bottom ash which will result in more pozzolonic reaction.

VI. CONCLUSIONS

1. Workability goes on increasing upto the 30% replacement of natural sand by fly ash.
2. Workability goes on increasing upto the 20% replacement of natural sand by bottom ash.
3. Workability of hybrid fibre reinforced concrete is more for fly ash replacement than the bottom ash replacement.
4. Water absorption percentage has increased for both the replacement fly ash as well as bottom ash.
5. Sorptivity values have increased throughout for all the replacement levels by both fly ash and bottom ash.
6. Higher compressive strength values are observed for 30% replacement level of natural sand by fly ash.
7. Higher compressive strength values are observed for 20% replacement level of natural sand by bottom ash.
8. Hybrid fibre reinforced concrete produced by fly ash exhibits the higher compressive strength than the concretes produced by bottom ash.
9. Higher split tensile strength values are observed for 30% replacement level of natural sand by fly ash.
10. Higher split tensile strength values are observed for 20% replacement level of natural sand by bottom ash.
11. Hybrid fibre reinforced concrete produced by fly ash exhibits the higher split tensile strength than the concretes produced by bottom ash.
12. Higher flexural strength values are observed for 30% replacement level of natural sand by fly ash.
13. Higher flexural strength values are observed for 20% replacement level of natural sand by bottom ash.
14. Hybrid fibre reinforced concrete produced by fly ash exhibits the higher flexural strength than the concretes produced by bottom ash

REFERENCES

[1]. Aggarwal P., Aggarwal Y., Gupta S.M. ― "Effect of bottom ash as replacement of fine aggregates in concrete" Asian Journal of Ci vil Engineering (building and housing) Vol.8, (2007) pp. 49-62.

[2]. Kadam M.P., Patil.Y.D. — "Effect of coal bottom ash as sand replacement on the properties of concrete with different W/C ratio" In ternational Journal of Advanced Technology in Civil Engineering, Vol. 2, 2013 pp. 45-50.

[3]. Mark Whittaker, Rachel Taylor, Qui Li, Shuangxinli Li, and Dr.Leon Black — "The effects of bottom ash as a partial cement Repl acement" University of Leeds, School of Civil Engineering, e-Engineering, issue.1 (2009).

[4]. MohdSyahrul, Hisyambin and ZulkifliMuda "The p roperties of special concrete using washed bottom ash (WBA) as partial sand replacement" International Journal of Sustainable Construction Engineering and Technology Vol.1 Dec (2010) pp. 64-76.

[5]. Pofale A. D., and Deo S.V. — "Comparative long term study of concrete mix design procedure for fine aggregate replacement with fly ash by minimum voids method and maximum density method" KSCE Journal of Civil Engineering (2010) pp.759-764.

[6]. Rafat Siddique. "Effect of fine aggregate repl acement with class F fly ash on the mechanical properties of concrete" Journal of Cemen t and Concrete Research 33 (ELSEVIER) (2003) pp. 539–547.

[7]. Arumugam K., Ilangovan R. and James Manohar. " A study on characterization and use of pond ash as fine aggregate in concrete" International Journal of Civil and Structural Engineering Vol.2, Feb. 2011 pp. 466-474.

[8]. Anand Kumar B.G –"Effective utilization of fly ash and supplementary cementitious materials in construction industry" In ternational Journal Advanced Technology in Civil Engineering Vol.1 (2012) pp. 107-114.

[9]. Bahoria B.V., Parbat.D.K., Naganaik P.B. and Waghe U.P — "Comprehensive literature review on use of waste product in concrete" International Journal of Application or Innovation in Engineering and Management Vol. 2,(2013) pp. 387-394.

[10]. [10] Hardjito, D., Cheng, W.C., and Tanijaya.J., — "Controlled low strength materials (CLSM) utilizing fly ash and bottom ash" Indonesia Scientific Archieves, Dec-14 (2009).

[11]. Siddique, R. " Effect of fine aggregate repla cement with class F fly ash on mechanical Properties of concrete" Cement and Concr ete Research, 33(2003), 539-547.

[12]. P. Bhuvaneshwari and R. Murali- " characteristics of glass fibre on bottom ash based concrete" SASTRA Universiy, Thanjavur - 613401, India (*Corresponding Author)

[13]. TayfunUygunog, IlkerBekir, Topcu B., Osman Gencel and Wit old Bristow. — "The effect of flyash ash content and types of aggre gates on the properties of pre-fabricated concrete interlocking blocks" Journal of Construction and Building Materials (ELSEVIER) Vol -30 2012 pp.180-187.

[14]. DjwantoroHardjito, and Shaw Shen Fun "Paramet ric study on the properties of geopolymer mortar incorporating bottom ash" Concret e Research Letters, ISSR Journals Vol.1 (3) – September 2010 pp.115-124.

[15]. Rajarajeshwari B Vibhuti, Radhakrishna and Aravind N – "mechanical properties of hybrid fibre reinforced concrete for pavements"

[16]. IS: 10262 – 2009, —Concrete mix proportioning – Guidelines (First revi sion), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah Zafar Marg, New Delhi.

Basavaraj N Itnal. "Effect of Natural Sand Replacement by Fly Ash and Bottom Ash in Hybrid Fiber Reinforced Concrete." International Journal Of Engineering Research And Development , vol. 14, no. 06, 2018, pp. 07–16